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TÜBİTAK







## **Atlas Laboratuvar Cihazları Ve Medikal Malzemeler Ticaret Ltd.Şti.**

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### **ÜRÜN GRUBU**

#### **\*ETÜVLER**

İnkübatörler (80°C)  
Soğutmalı Etüvler  
Vakumlu Etüv  
Karbondioksitli Etüv

#### **\*SU BANYOLAR**

Benmari Su Banyosu  
Çalkalayıcı Su Bany.  
Sirkülasyonlu Su Bany.  
Soğutmalı Su Bany.  
Ultrasonik Banyolar

#### **\*SANTRİFÜJLER**

Rutin Santrifüj  
Hematokrit Santrifüj  
Soğutmalı Santrifüj  
Mikro Santrifüj  
Gerber Santrifüj

#### **\*STERİLİZASYON**

Kuru Hava Sterilizatörleri  
Sulu Sterilizatör  
Otoklav  
U.V. Sterilizatörü

#### **\*MİKROSKOPLAR**

Monoküler Mikroskop  
Binoküler Mikroskop  
Trinoküler Mikroskop  
Stereo Mikroskop

#### **\*KARIŞTIRICILAR**

Manyetik Karıştırıcılar  
Isıtıcı Manyetik Karıştırıcılar  
Mekanik Karıştırıcılar  
Flokülatörler (jar test)  
Vortex Karıştırıcı  
Rotatörler

#### **\*ÇALKALAYICILAR**

İnkübatörlü Çalkalayıcılar  
Orbital Çalkalayıcılar  
Isıtıcı Çalkalayıcılar

#### **\*ISITICILAR**

Isıtıcı Tablalar  
Mantolu Isıtıcılar  
Blok Isıtıcılar

#### **\*SOĞUTUCULAR**

Derin Dondurucular  
Kan Dolapları  
Soğutucu Kabin

### **\*ANALİZ,ÖLÇÜM CİHAZ VE APARATLARI**

Hassas Teraziler

Ph metreler

EC metreler

Oksijen metreler

Spectrofotometre

Viskozimetre

Klor Komparatörü

BOD ve COD cihazı

Azot Protein Tayin Cihazı

Selüloz Tayin Cihazı

Yağ Tayin Cihazı

Refraktometreler

Kül Fırını

Termohigrograf

Saf su Cihazı

Mikropipetler

Analiz Elekları

Elek Sarsma Cihazı

Beton Numune Kalıpları

Beton Termometreleri

Vakum Pompası

Peristaltik Pompa

Koloni sayım cihazı

Nem Tayin Cihazı

### **\*KİMYASAL VE CAM MALZEMELER**

(MERCK-SİGMA-ALDRİCH-FLUKA-RIEDEL-CARLOERBA-OXOİD)

The obtained coefficients of correlation ( $r$ ) and determination ( $R^2$ ) of the linear regressions between  $dT_s$ ,  $dT_c$  (at 13 o'clock) and soil water content at all depths (except of 0,7 - 1,0 m) and soil water reserves for all measurements during two years were higher than 0,8 and 0,6 respectively. More of them ( $r$ ) were higher than 0,8

**Table1.** Correlation coefficients of the relationships between  $dT_s$ ,  $dT_c$  and  $/SWS/$  for maize during the period "10-12<sup>th</sup> leaves – tasseling" and during milk ripeness

Relation	hour	During the period "10-12 <sup>th</sup> leaf – tasseling"		during milk ripeness	
		$r$	$R^2$	$r$	$R^2$
$dT_s$ - $SWS_{0-0,2}$	9	0,92	0,85	0,77	0,6
"-	13	0,86	0,74	0,79	0,63
$dT_c$ - $SWS_{0-0,2}$	9	0,52	0,27	0,81	0,66
"-	13	0,90	0,81	0,78	0,61
$dT_s$ - $SWS_{0,2-0,4}$	9	0,90	0,81	0,79	0,62
"-	13	0,83	0,69	0,80	0,64
$dT_c$ - $SWS_{0,2-0,4}$	9	0,54	0,29	0,82	0,67
"-	13	0,89	0,80	0,79	0,63
$dT_s$ - $SWS_{0,4-0,7}$	9	0,87	0,75	0,88	0,77
"-	13	0,81	0,66	0,87	0,76
$dT_c$ - $SWS_{0,4-0,7}$	9	0,60	0,36	0,80	0,64
"-	13	0,84	0,70	0,81	0,66
$dT_s$ - $SWS_{0,7-1,0}$	9	0,85	0,73	0,88	0,77
"-	13	0,85	0,72	0,84	0,71
$dT_c$ - $SWS_{0,7-1,0}$	9	0,64	0,41	0,83	0,68
"-	13	0,77	0,59	0,87	0,75

The lower values of  $r$  and  $R^2$  at the deeper layers were caused by early growth stage of the crop. In the later growth period,  $r$  and  $R^2$  at the 0,7 – 1,0m layer increased.

The values of the  $R^2$  of the relationships  $dT_c$  –  $SWS$  and  $dT_c$  –  $SWC$  at 9 o'clock were usually lower than 0,5. This confirmed that the optimal time for measuring plant surface temperature minus air temperature differences was when the temperature difference was greatest.

The soil and plant surface dynamics depends on evapotranspiration (ET) also. A surface with higher rate of ET will be cooler. The value of  $R^2$  of the relationship  $dT_s$  – ET is 0,997 and for  $dT_c$  – ET  $R^2 = 0,784$  in 1999.

On the base of the obtained data we can conclude that the surface soil and plant minus air temperature measured by IRT at 13 o'clock can be use to evaluate soil and plant water regime and avoid the plant water stress.

This will be accurately after studying of the other factors, which influence on the measurements: solar radiation, wind speed, air humidity, and soil type.



## Estimation of Soil Water Content by Infrared Thermometry

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The aim of the present study was to describe the relationships between soil surface-minus-air temperature, crop surface-minus-air temperature differences and soil water contents or soil water reserves in the different soil layers and the evapotranspiration in mm/day.

Two years (1999-2000) field study was conducted with maize on a leached meadow-cinnamonic soil on the experimental station of "Nikola Poushkarov" Institute of Soil Science in Tzalapitza, situated in the South-eastern Bulgaria. The experiment was with 5 variations of the irrigation regime: 0.3, 0.6, 0.8, 1.0, 1.3 relative irrigation depths and a non-irrigated variant. The four replications for each variant were realized in a Latin square of design. The size of the experimental plot was 44.8 m<sup>2</sup>. The plant population was 5 plants per m<sup>2</sup>. Four irrigation treatments were realized by furrow irrigation (short furrows) after 10-12<sup>th</sup> leaf.

Gypsum blocks(GB), designed at "N.Poushkarov" ISS, placed at 0.20, 0.40, 0.70 and 1.00 m depth in 4 rows of the crop in the plot center were used to measure soil water content (SWC) in the all variants.

Three days after irrigation treatments were realized measurements in all variants and replications of: canopy temperature ( $T_c$ ) and soil temperature ( $T_s$ ) at 9 and 13 h by Infrared thermometer type Raynger II and air temperature ( $T_a$ ) in the same time. The differences  $dT_c = T_c - T_a$  and  $dT_s = T_s - T_a$  was calculated. Diurnal mean of air temperature, rainfall, pan evaporation, air humidity were measured during the period May-September. The grain yield was determined for all variants and replications. Soil water store (SWS) for the 0-1,15m soil layer and the 0-0.20,0.20-0.40,0.40-0.70, 0.70-1.00 m soil layers was calculated by the measured SWC at the 4 depths. Correlation coefficients of the differences  $dT_s$ ,  $dT_c$  and SWC or SWS at the given above depths was calculated by correlation matrix.

The experiment was conducted in two very different climatic years.

Diurnal means air temperature for the period April-September was higher from 0.5 to 1.5 in 1999 and from 0.4 to 3.4°C in 2000). The sum of precipitation during the same period was lower (with 83,9 mm for 1999 and 177.7mm in 2000) than the mean for 70-year period (1925-1994). The second year was very warm and dry (during the period May-Sept), 15 days was with air humidity below 45% and 6 of them-below 40%. As a result of that the yield in the non-irrigated variant was twice lower than in 1999.

criteria for each soil quality elements. Doran and Parkin (1996) proposed a minimum data set for characterizing and monitoring soil quality. Quantitative indicators of soil quality in the proposed minimum data set includes soil attributes and properties such as; texture, soil and rooting depth, bulk density, infiltration, water retention characteristics, soil organic matter, electrical conductivity, extractable N, P, and K, microbial biomass, and soil respiration. Another descriptive approach, The Wisconsin Soil Health Scorecard developed by the University of Wisconsin's Soil Health Program, was suggested by Romig et al. (1996). In this approach soil's quality or health is assessed as a function of soil, plant, animal and water properties identified by the farmers. In the soil health scorecard there are: 24 descriptive properties related to soil including; erosion, soil depth, soil structure, soil texture, compaction, surface crust, drainage, water retention, aeration, biologic activity, organic matter, soil fertility, pH, and soil test values, 14 descriptive properties related to plants including; crop appearance, nutrient deficiency, growth rate, seed germination, yield and feed value, 3 descriptive properties related to animals; human health, animal health and wildlife, and 2 descriptive properties related to water; chemicals in groundwater and surface water. The scorecard is a field tool to determine and monitor soil quality based on field experience. It provides a high to low scoring mechanism for each soil quality indicator based on soil's behaviors. Functional assessment of soil quality and health indicator data requires integration of soil quality and soil health indicator properties with land use, landscape, and climate characteristics. Such database provides the information needed to develop site-specific management plans for maintaining or improving soil quality and soil health (Harris et al., 1996). Briefly, the assessment of soil quality has vital importance in agricultural production and maintaining environmental quality since it is the primary indicator of sustainable management.

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## Assessment of Soil Quality

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### Abstract

Rapid increase in human population increased the stress on natural resources including soil. Soil degradation impacts on agricultural production and adversely affect on other natural resources. It is important to define the processes, factors and causes of soil degradation, and to assess the quality of soil that indicates the capacity of soil to sustain biological productivity and promote plant and animal health, for sustainable resource management. Assessment of soil quality, therefore, is useful for evaluating the effects of different management practices on soil and, is needed for measuring changes in soil resources within a specific period.

### Introduction

Soil degradation refers to a decline in soil's productivity through deterioration of the physical, chemical and biological soil properties (Oztas, 1997). Common degradative processes and causes are water and wind erosion, compaction, crusting, salinization, alkalization, acidification, leaching, fertility depletion, loss of organic matter, and soil pollution. Soil quality is strongly dependent on the degree of these soil degradation processes, land use and management practices.

Soil quality is broadly defined as the capacity of a living soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran, 2002). Soil quality assessment is important for measuring changes in soil properties over time that helps to define effective management strategies. Although, the definition and quantitative assessment of soil quality is complicated by the fact that it is not directly consumed by human and animals as are air and water (Doran and Parkin, 1996), it should be defined because of its importance in ecosystem and environmental quality.

### Quantitative Indicators for Soil Quality

Soil quality indicators are physical, chemical and biological properties, processes, and characteristics that can be measured to monitor changes in soil (Muckel and Mausbach, 1996). Although there is no single soil attribute or property that can be used to estimate soil quality, a group of soil attributes or properties that are sensitive and reliable for obtaining changes in soil physical, chemical and biological properties can be used to estimate soil quality.

There are different approaches and proposals that can be used to quantify soil quality. Doran and Parkin (1994) described a soil quality index that consisted of six soil quality elements; food and fiber production, erosivity, ground water quality, surface water quality, air quality and food quality. This approach can be used to provide an evaluation of soil function based on specific performance



suitability of surface and ground waters used in irrigation in Çanakkale region and then if there were salinity or toxicity problems to inform the farmers and extension service people, to take necessary precautions.

### **Results and Discussion**

Irrigation water analysis results given at table 1 compared and evaluated according to standard irrigation water quality criteria (Anonim,1991 and US Salinity Lab. 1954). Also chemical composition of some irrigation water in Çanakkale Region analysed by State Hydraulic Works Laboratory are given at table 2 for comparison. Some well waters of the farmers evaluated according to drinking water standards (Anonim, 1991).

Evaluation of the research results are the following; Sarıçay Creek water salt content was rather high at the down stream and classified as  $C_4S_1$ .  $SO_4^{--}$  content varied from 240 to 340 ppm and considered 3<sup>rd</sup> class irrigation water (Şener,1983) (sample no:1). But at the upstream of the same stream conductivity is very low (465 micromhos / cm) and classified as  $C_2S_1$  (numbered, 18). The main pollutants for the downstream of Sarıçay creek might be industrial waste waters and discharge waters from settlements.

Water analysis results showed that; Irrigation water samples collected from the locations (numbered; 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22) were suitable for irrigation when compared with standard parameters mentioned above. But on the other hand well waters from Halileli Village (numbered 3 and 4), and Umurbey area (numbered 10) showed high  $NO_3$  and  $NO_2$  contents especially in the water samples collected in July. Almost two to three times more  $NO_3$  and  $NO_2$  levels at the end of irrigation season showed that overuse of well waters during the summer period caused to lower water levels in the wells and as a result of seepage from the sewers and other organic pollutants nearby increased the  $NO_3$  and  $NO_2$  contents of the well waters. These kind of waters should not be used continuously for irrigation.

pH values from 6,5 to 8,4 are considered permissible range for irrigation waters and pH values of the waters sampled varied from 7,2 to 8,0 which is suitable for the most crops (Tok, 1997; Hoffman at all 1992).

Temperature of irrigation waters is an important factor for germination of the seeds and for the plant development. Irrigation water temperatures lower than 10°C and over than 30°C may retard growing and cause some hazardous developments in most crops (Ayyıldız, 1983). Temperature values of the waters sampled, varied from 13°C to 18°C in the well waters and 21°C to 25°C in the surface waters (table 1).

Evaluation of the water quality measurements at table 1 and table 2; show that surface waters are mostly have low salt and toxic material content and suitable for irrigation in Çanakkale Region. But some of the ground waters are contaminated with organic pollutants and should not be used continuously for a sustainable irrigation.

## A Research on Irrigation Water Quality of Çanakkale, Ezine and Lapseki Provinces

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### Abstract

This research was carried out to determine the irrigation water quality of Çanakkale, Ezine and Lapseki provinces. Irrigation water samples were collected from surface waters, reservoirs and well waters in the research area, during the Irrigation period. EC, pH, temperature,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$ ,  $\text{K}^+$ ,  $\text{Na}^+$ , (Ca+Mg), RSC and SAR measurements were carried out at all samples.

The data obtained from the research results showed that all samples collected from surface waters, reservoirs and well waters were suitable for irrigation purpose, except, three samples from Halileli Village, Yeni Mahalle and Umurbey well waters contained high levels of  $\text{NO}_3^-$ , which is not suitable for a sustainable irrigation. Even though the results of the measurements indicate that surface water is better than ground water in terms of chemical quality, surface water is more likely to be contaminated with domestic and industrial disposals especially when big settlements are close to the stream.

**Key Word:** Irrigation Water, Water Quality, Çanakkale Region

### Introduction

Total agricultural farm lands are 333 573 hectares in Çanakkale Region. 120 000 hectares of this land is suitable for irrigation but only 60 000 hectares are under irrigation today. This research was carried out Çanakkale, Ezine and Lapseki provinces which covers 79 050 hectares of agricultural land which is approximately 24 percent of the total agricultural area of the Çanakkale Region. Generally mesothermal climate prevails in the region, which is relatively dry and hot in the summer, cool and rainy in winter. Relative humidity is about 64 percent in summer month and 78 percent in January, yearly average is 71 percent. The annual average temperature is 14.8°C. The average monthly maximum and minimum temperatures are 24.6°C in August and 6.2°C in January. The average annual rainfall is 610 mm in Çanakkale province (Anonymous,2001).

Since the irrigated area has been in creasing every year in the region, utilization of the lower quality surface and ground water is also increasing. But this situation creates salinity and toxicity hazards for agricultural crops and soils (Ayyıldız, 1976). The aim of this research was to determine the quality and



usually affect the yield of the crop but it can have a negative effect on crop quality (Beegle, 1995). Low magnesium contents in soils affect plant growth and health. Magnesium fertilization may favorably influence the yield and mineral contents of plants. When levels of this nutrient in soils are low, the addition of Mg to a fertilizer program will frequently improve crop yields (Durlach, 1993).

#### **Material and Methods**

In this research was used three-day-old pure *Rhizobium* bacteria culture (F7, F15). These bacteria were incubated at 28 °C in YMA (Yeast Extrakt Mannitol Agar) solid medium and determined as Gram (-) by using Gram Dying Method. (Brown et al., 1964; Haktanır, 1986). Culture suspensions were diluted as  $1 \times 10^9$  cells in each milliliter by using Dilution Method (Gürğün and Halkman, 1988). Sugar bean seeds were exposed with 5 %  $H_2O_2$  solution. Three of these sterilized seeds were put in pots. After sprouting, only one plant for each pot permitted to leave and the others were taken out (Kızıloğlu ve Bilen, 1997). Moisture level of soil was measured by mercury tansiometer. After two months of experimental period, crops were harvested.. The amount of nitrate and total nitrogen in the ground root, shoot and leaves parts is measured by Kjeldahl Method (Carter, 1993) and total amount of this N is used as criteria of  $N_2$  fixing capacity of bean plants. Analysis of variance (ANOVA) was performed and grouped by LSD procedure.

#### **Results and Discussion**

The results of the variance analysis belonging to the amount of the dry matter, nitrate and total nitrogen of Sugar bean plants which *Rhizobium phaseoli* inoculation and different doses of the magnesium applied are shown in Table 1.

Inoculation of *Rhizobium phaseoli* isolates and different doses of magnesium fertilization increased dry matter, nitrate and total nitrogen of Sugar bean plants. Inoculated with *Rhizobium phaseoli* isolates and fertilization increasing magnesium doses of Sugar bean plant were better than not inoculated in terms of dry matter, nitrate and total nitrogen contents. According to increasing magnesium doses had been seen increasing in dry matter, nitrate and total nitrogen in non inoculated, inoculated and nitrogen applications of Sugar bean plants.  $F83 \times Mg_4$  combinations had the best effect on root, shoot and leaves regarding with dry matter, nitrate and total nitrogen content. As dose of magnesium doses increased, dry matter, nitrate and total nitrogen contents of the plant in root, shoot and leaves increased. Between average dry matter, nitrate and total nitrogen contents of the root, shoot and leaves were more significant ( $p < 0.01$ ). Similar results were also reported that inoculation *Rhizobium* isolates of some leguminacea were obtained increasing in the number of nodulation, weight of nodulation and nitrogen content of plant and seed (Brocwell et al., 1985; Sepetoğlu, 1994; Tellawi et al., 1986; Howle et al., 1987). High level magnesium in soil increased nodulation and nitrogen fixation of plant (Kızıloğlu, 1995).



## Effects of Inoculation *Rhizobium* Isolates and Different Dozes of Magnesium Fertilizer on Dry Matter, NO<sub>3</sub>-N and Total N Contents of Beans (*Phaseolus vulgaris*)

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### Abstract

The objective of this study was to determine the effects of inoculation with *Rhizobium* isolates and magnesium fertilizer on dry matter, NO<sub>3</sub>-N and total nitrogen contents of beans (*Phaseolus vulgaris*) of greenhouse conditions. Soil samples taken from 0-20 cm depth were sterilized and put in pots. Six kg da<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> TSP (40-46 % P<sub>2</sub>O<sub>5</sub>), and 5 kg da<sup>-1</sup> K<sub>2</sub>O K<sub>2</sub>SO<sub>4</sub> (50-53 % K<sub>2</sub>O) were applied to all pots, and additionally 5 kg da<sup>-1</sup> N urea (45 % N) was added to non-inoculated pots. Soils in pots were inoculated by microbial fertilizer (*Rhizobium phaseoli* F7, F83 isolates) and different doses of magnesium (0, 3, 6, 9, 12 kg da<sup>-1</sup> Mg, magnesium sulfate fertilizer) fertilizer on non inoculation, inoculation and nitrogen application. During the growing period, soil moisture content was kept on field capacity. After two months, crops were harvested, dried and analyzed for dry matter, NO<sub>3</sub>-N, total nitrogen contents of root, shoot and leaves. Result indicated that amount of dry matter, NO<sub>3</sub>-N and total nitrogen contents of root, shoot and leaves of plants increased with microbial inoculation and increasing doses magnesium application.

### Introduction

Quantity of fixed nitrogen as biological had been changed with soil, variety of seed, climate and efficient of bacteria which was used in inoculation. *Rhizobium* bacteria have been fixed 4-12 kgda<sup>-1</sup> nitrogen (Alexander, 1961). Gök and Martin (1993) reported that inoculation of bacteria increased N<sub>2</sub> fixation and plant dry matter in vetch and trifolium. Brocwell et al. (1987) claimed that inoculation with bacteria and applied 5 kgda<sup>-1</sup> nitrogen had been increased 15 % yield in bean. Howle et al. (1987), Tellawi et al. (1986) and Sepetoğlu (1994) obtained that inoculation of bacteria in different soybeans increased dry matter, seed yield, weight of nodulation and number, content of nitrogen in plant and seed. Kızıloğlu (1995) found out less inorganic nitrogen compound caused for increase in nodulation. Magnesium is the structural element of chlorophyll molecule. It is also a cofactor in the process of fosforilization in enzyme activity. Result of fertilization Mg<sup>+2</sup> increases nodulation and nitrogen fixation. Beegle (1995) reported that calcium and magnesium are essential secondary nutrients required by crops. Legumes in particular have a high demand for calcium and magnesium. High soil potassium can have a negative effect on the uptake of calcium and magnesium by crops. This antagonism does not

Leaf samples collected three times (before harvest, the first harvest and the second harvest) and analysed for  $K^+$  level. When the leaf sample of  $K^+$  analysis of before harvest evaluated, the highest  $K^+$  levels determined in the II. and III. dose parcels.  $K^+$  levels of I. and II. harvest leaf samples were the highest in I. dose potassium application and the effect of different  $K_2O$  doses on melon leaf  $K^+$  level was not significant (Table 3).

Also, fruit samples collected two times (the first harvest and the second harvest) and analysed for  $K^+$  level. When the effect of different  $K^+$  doses on melon fruit  $K^+$  level was evaluated, the highest level was determined in III. dose parcel as % 0,30 at harvest and I. dose as % 0,29 at II. harvest. But both of them was not significant (Table 4).

A typical feature of  $K^+$  is its high concentration in the phloem sap. Indeed here it is the most abundant cation, amounting to about 80 % of the total cation sum. Plant organs preferentially supplied with phloem sap such as young leaves, meristematic tissues and fleshy fruits are therefore high in  $K^+$  (Mengel & Kirkby, 1987; Seer & Ünal, 1990).

In this study, the sugar content (sucrose, fructose,  $\beta$ -glucose,  $\alpha$ -glucose) of fruits were also measured. Sugar fractions were ranged as sucrose, fructose,  $\beta$ -glucose,  $\alpha$ -glucose respectively, that is, sucrose was dominant sugar fraction. When the total sugar, sucrose and fructose contents of fruits were evaluated, the increase due to the different potassium applications compared to control parcel. In addition, III. dose of potassium application was the highest for total sugar content. The effect of different potassium doses on melon fruit sugar fractions were not significant (Table 5).

It was reported that Çeşme melon's dominant sugar fraction was sucrose (Hakerlerler et al., 1998) and melon sugar fractions were sucrose, fructose and glucose (Trautner et al., 1989).

It is concluded that different doses of potassium applications increased melon yield and average fruit weight. In addition, the fruit characteristics, sucrose, fructose and total sugar content increased by potassium applications however  $\alpha$ -glucose and  $\beta$ -glucose were not affected. Furthermore, increasing potassium doses were decreased leaf  $K^+$  level and not affected fruit  $K^+$  level.

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## Effects of K<sub>2</sub>SO<sub>4</sub> Applications on Fruit Yield and Some Quality Parameters in Melon

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### Abstract

This research established to study the effects of different potassium doses on melon yield and some fruit qualities. Four different doses (80, 160, 240, and 320 kg K<sub>2</sub>O/ha) applied as K<sub>2</sub>SO<sub>4</sub> to melons grown in Alaşehir Province. The highest yield and average fruit weight were determined in III. dose parcel (240 kg K<sub>2</sub>O/ha) as 22710 kg/ha and 1652 g respectively. It is found that sucrose was the dominant sugar fraction in fruit.

**Key Words:** Melon (*Cucumis melo* L.), Potassium, Fertiliser, Yield, Quality.

### Introduction

Anatolia is one of the important genetic centres of melon. Turkey has been growing approximately 1,8 million tons melon and sharing % 10 of world melon exportation as a second exporter after the China all over the world, annually. Melon is producing very large quantities in Aegean Region in Turkey (Sarı et al., 2000).

In other hand, it is obvious that by means of fertilisation, melon yield and quality will be increased. Next to nitrogen, potassium is the mineral nutrient required in the largest amount by plants. The potassium requirement for optimal plant growth is in the range 2-5% of the plant dry weight of vegetative parts, fleshy fruits, and tubers. In other cases, quality disorders are related indirectly to potassium deficiency (Marschner, 1995; Mengel, 1984, Mengel & Kirkby, 1987).

In addition, melon and watermelon have been producing about 800 tons annually in 500 ha area of Alaşehir Province which has got poor soil for potassium.

This investigation was conducted to determine the effect of potassium on yield and fruit quality of open field melons grown in Alaşehir Province.

### Results and Discussion

It is considered that the average yield and average fruit weight were the maximum in the III. dose application and the minimum in the control parcels. The effect of different potassium doses on the yield was not significant although average fruit weight was significant at a level of 5 % (Table 2).

Valenzuela et al.(1996), obtained that increasing NPK doses were enhanced the melon yield. Applying to melons growing in water culture was increased melon yield and fruit weight (Yuari-SiQing et al., 1999).



Index) for both the original and matched images was performed. However, the calculated NDVI did not relate to yield within the field.

Therefore, the question that remained involved whether subtle differences were lost in converting the original images to match the reference image, or if the matched images provided greater separation between the spectral reflectance values of the cornfield. Several ground control points were used in this part of the research. These points were used due to detailed ground-truth and yield data for the particular locations within the field. Results indicated that by considering the multi-temporal response of the corn according to the infrared (band 4), differences in yield could be detectable with the matched images. In terms of the original images, no patterns could be seen in the multi-temporal response that indicated any difference in yield for the ground control points (Figure 3a). However, for the matched images, clear distinctions between the areas with good yield and areas with poor yield were observable in the results, as shown in Figure 3b.

### **Conclusions**

Radiometric correction with histogram matching has proven to be a useful tool in correcting differences between atmospheric and scene characteristics with multi-temporal images taken throughout the growing season of a particular crop. The atmospheric, sensor, and scene characteristics are sure to differ between remotely sensed images acquired throughout a growing season, suggesting the usefulness of a simple radiometric correction scheme. More specifically, reflectance values for PIF features remained relatively invariant throughout a four-month period after histogram matching was performed to relate the images to a reference scene. In addition, the matched images proved useful in distinguishing between different areas of crop yield within the field, especially when compared to the original images. Many factors may be contributed to these results, all of which may not be completely known. Therefore, further investigation into the techniques, principles, and processes of both histogram matching and multi-temporal classification needs to be performed in order to make more generalized conclusions, not dependent on the particular area under research. In addition, further work needs to be carried out to understand more detailed and promising ways of calculating yield, especially in figuring out the problems with the NDVI calculations for this particular field.

axis in terms of the average reflectance values for three of the four bands. From this figure, it is easily seen that radiometric correction is necessary in order to adjust the images to a normalized scene more appropriate for direct comparison. Therefore, radiometric correction was determined to be necessary, and the next question then shifted to the appropriate method for correction. However, before moving directly into the next step, the ancillary data for the area, especially in terms of the rainfall and moisture content data, was investigated to determine if the differences in reflection values for the roads were due to these variables. Daily rainfall amounts were obtained and investigated for the area, and from this investigation, it was concluded that no rainfall had fallen on or at least three days before the time in which the images were taken. In addition, the times in which the images were taken were relatively dry periods in an otherwise wet growing season. Therefore, no rainfall interactions were seen between changes in reflectance values for the roads in the four images. Thus, the images had approximately equivalent moisture contents, and no water was standing on the paved-road surfaces. Two main correction procedures were identified in order to perform simple radiometric corrections on images. Physical based models were not considered possible alternatives due to a lack in atmospheric, sensor, and scene data required by these models. The first technique is a function available in the ERDAS image processing software called histogram matching. Histogram matching attempts to correct for atmospheric and scene characteristics independent of any relationship between the images. In fact, histogram matching is a purely statistical technique that relates the cumulative density function of one image to the density function of another.

Because the July 2 image was determined as the most valuable in predicting crop yield and other vegetation properties within the growing season, this image was selected as the reference image. Histogram matching was performed on the other images, referencing each back to the July 2 image. Results of the correction process are shown in Figure 2. Exactly the same point samples were taken along the road, and the 100 samples were averaged to determine the overall reflectance values shown in Figure 2. As can be seen in the figure, radiometric correction performed well, adjusting the reflectance values of the selected PIF feature.

The final step in the study involved investigating the usefulness of the matched images in possibly delineating yield or determining coarse-level management zones within the field. By investigating the original spectral profiles of the corn, the difficulty of using unsupervised and supervised classifications was occurred. In addition, an attempt to calculate the NDVI (Normalized Difference Vegetation



## **Radiometric Correction and Multi-Temporal Classification for Digital Aerial Images of a Cornfield**

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### **Abstract**

Four digital images acquired during the 1998-growing season of a cornfield were used to test and evaluate the radiometric correction process of histogram matching. The digital images were acquired with a new digital aerial system (ADAR 5500). The study focused on determining if radiometric correction was necessary for these digital images, which were acquired in four different times during the growing season (June 1, July 2, September 11, and September 25). Point samples of pseudoinvariant features (road surfaces) were taken to determine average spectral responses in each band of the four images. Plots of average spectral reflectance versus the date of the aerial image yielded multi-temporal classifications that demonstrated that radiometric correction was necessary. Due to the simplicity of the process and the lack of detailed measurements required in other physical based models, histogram matching was chosen as the most appropriate method. Three of the images were referenced to the July 2 scene using this technique. Multi-temporal classifications demonstrated that radiometric correction was accurate in delivering an invariant radiometric reflectance for the road surfaces. The usefulness of the matched (i.e. radiometrically corrected) images was then investigated by attempting to distinguish variations in yield for several ground control points. The matched images displayed improved separation between different yield values showing definite distinctions between areas of high and low yield.

### **Results**

The first step in the procedure required locating possible PIF features that could be used to investigate changes in reflectance values. The roads that are located around the cornfield are PIF features that should exhibit a common reflectance for the various time periods. These roads are common in all four images in terms of the extent to which they are seen in the image. In addition, the roads form a nice boundary around the field of interest. Therefore, by investigating changes in the reflectance values of this invariant feature, any changes that occur should be related to non-scene-dependent changes. Point samples were taken along the stretch of the roads at particular latitude and longitude points. A total of 100 point samples along the stretch of the road yielded different average reflectance values in each band throughout the growing season. The results are shown in Figure 1, with the vertical

Table 2 shows: the calculated values for *grad W* from the alteration  $\Delta R$  ( $\text{grad}W = \frac{\Delta R}{S_w \Delta L}$ ) in the separate layers, the values of *grad T*, received for the respective periods and the calculated according (5) values of the quantity  $\partial C / \partial W$ .

The results in Table 2, showing a difference in content of easily absorbed forms of N -  $\partial C / \partial W$ , almost reach those received in the laboratory. An obligatory condition for an exact definition is the graduation of the conductometric transducers for the measuring range. Another important condition is the soil type used for the research. With soil with heavy mechanical content and a strong dry-up in result of cracks, it is possible to destroy the contact between the transducers' electrodes and the soil. The experiment was conducted upon smolnitza (clay content – 72-77%), with very heavy mechanical content and specific gravity – 2.68-2.7%. However, there were no such disturbances of the cultivated layer during the observed period. The results from table 1, for both variants, show that applying herbicides, the maize root system uses easily absorbed N forms from the lower layers. By weeding, with a competition between weeds and crops, the root system is weak and uses feeding elements from higher layers (here the maize biomass in a “tasseling” period is 7 times smaller compared to the herbicide variant).

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When there is an insufficiency of salts, the soil concentration  $C$  in determined limits depends on  $W$  or  $\partial C / \partial T = 0$  (unsaturated solution); the contrary is under surplus of salts, which is practically rare case (Kanwar, 1980, Thinker, 1981). Replacing (2) in (1) results in equation (3), which gives the full dependency between examined quantities.

$$\frac{dR}{dL} = \frac{dW}{dL} \cdot \left( \frac{\partial R}{\partial W} + \frac{\partial R}{\partial C} \frac{\partial C}{\partial W} \right) + \frac{dT}{dL} \cdot \left( \frac{\partial R}{\partial T} + \frac{\partial R}{\partial C} \frac{\partial C}{\partial T} \right) \quad (3)$$

A thermodynamic balance in a profile layer ( $dR/dL = 0$ ). Means a lack of diffusion, which is obtained under the following correlation between  $grad\ W$  and  $grad\ T$ .

$$\frac{dW / dL}{dT / dL} = - \frac{\partial R / \partial T}{\frac{\partial R}{\partial W} + \frac{\partial R}{\partial C} \frac{\partial C}{\partial W}} \quad (4)$$

The temperature dependence of electric resistance  $R$ , measured with conductometric transducer  $S_T = \partial R / \partial T$  [ $k\Omega\ ^\circ C^{-1}$ ], is experimentally defined. It depends on soil type and on measuring conditions. Same applies to the sensitivity of conductometric transducer  $S_W = \partial R / \partial W$  [ $k\Omega\ \%^{-1}$ ] and to dissolved mineral salts  $S_C = \partial R / \partial C$  [ $k\Omega\ kg\ soil\ mg^{-1}$ ]. The measuring conditions with conductometric transducer depend on the form, constructive dimensions of the electrodes and the measuring range. After replacing the parameters characterizing the conductometric transducer's sensitivity to the measuring conditions in (4), we receive

$$S_C \frac{\partial C}{\partial W} = -S_W - S_T \frac{grad\ T}{grad\ W} \quad (5)$$

Expression (5) gives a possibility to define the change in dissolved salts concentration  $\partial C / \partial W$  in dependence of  $grad\ T$  and  $grad\ W$ . Reading the positive value of the private derivative in (5) -  $\partial C / \partial W$ , it is clear, that the non - isothermal transfer of salts and water in the soil could be stopped when the temperature and moisture gradients have different values.

## Results and Discussions

In the process of experimental research, the following values for temperature-moisture concentration sensibility of the system "conductometric transducer - ohmmeter" are received:

$S_W = 2$  [ $k\Omega\ \%^{-1}$ ];  $S_T = 0,2$  [ $k\Omega\ ^\circ C^{-1}$ ];  $S_C = 0,7$  [ $k\Omega\ kg\ soil\ mg^{-1}$ ].



# Method and Investigation of the Soil Moisture Migration under the Effect of the Temperature Gradient

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## Abstract

The non-isothermal rate in root-inhabitable soil layer influences water transfer and soluble compounds in a complicate and versatile way. Many authors have investigated the problem with non-isothermal transfer of salts and water in soil, but because of the complex processes, the purely analytical way for solving it is very difficult. As the water and salts migration under a temperature gradient in the soil profile is an important factor, connected to the agro-technics type, our research consists on one hand in determining parameters, characterizing the diffusion of soil moisture in non-isothermal conditions. On the other hand, the research is focused on finding an analytical connection between these parameters and the change in soluble salts concentration for the examined profile.

## Introduction

The introduced method includes a definition of parameters, which directly or indirectly characterize water migration and absorbed forms of the basic feeding elements for the plants (Vishnoi, 1980, Joshua, 1973). During the research, some of these parameters are defined in field conditions, and others – analytically. In the analysis, it is accepted approximately, that there is a linear distribution of temperature in the examined soil layer. A basic quantity in the research is the temperature gradient in the root - inhabitable soil layer  $grad\ T = dT/dL$  [ $^{\circ}\text{C}\ \text{m}^{-1}$ ], where  $L$  is the profile's depth. An information indicator for the moisture gradient  $grad\ W = dW/dL$  [ $\% \text{ m}^{-1}$ ] is the active electrical resistance  $R$  [ $\text{k}\Omega$ ], measured at discreet profile depths by conductometric transducers.

It is known that the moisture increase in the profile and the concentration of dissolved mineral salts  $C$  ( $\text{NH}_4 + \text{NO}_3$ ), leads to a change in  $R$ . On the other hand,  $R$  depends on the environment temperature and this functional dependence of  $R = f(W, T, C)$  could be presented as a total differential as follows:

$$\frac{dR}{dL} = \left( \frac{\partial R}{\partial W} \right)_{C,T} \cdot \frac{dW}{dL} + \left( \frac{\partial R}{\partial T} \right)_{C,W} \cdot \frac{dT}{dL} + \left( \frac{\partial R}{\partial C} \right)_{W,T} \cdot \frac{dC}{dL} \quad (1)$$

The concentration  $C$  of the dissolved salts depends also on  $W$  and  $T$  and this dependency could be similarly expressed by a differential:

$$\frac{dC}{dL} = \frac{\partial C}{\partial W} \cdot \frac{dW}{dL} + \frac{\partial C}{\partial T} \cdot \frac{dT}{dL} \quad (2)$$

## **The Relationships between Heavy Metal Contents and Microbiological Characteristics in Bafra and Çarşamba Plain Soils**

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### **Abstract**

In this study, the relationships between soil heavy metal contents and soil microbiological characteristics were investigated in Bafra and Çarşamba Plain. For this purpose, overall 36 surface soil samples, 20 samples from Bafra Plain and 16 samples from Çarşamba Plain, were used. It has been determined that, total heavy metal contents of Bafra Plain soils varied among 1.83-2.73 µg Cd/g, 19.80-42.33 µg Co/g, 50.38-141.18 µg Cr/g, 25.53-58.50 µg Cu/g, 46.79-144.15 µg Pb/g, and 76.10-210.43 µg Ni/g; on the other hand heavy metal contents of Çarşamba Plain soils varied among 0.95-3.20 µg Cd/g, 17.10-37.10 µg Co/g, 18.43-88.53 µg Cr/g, 23.05-96.68 µg Cu/g, 19.30-60.20 µg Pb/g, and 80.03-152.85 µg Ni/g.

Soil microbiological characteristics such as, dehydrogenase activity, catalase activity, urease activity, CO<sub>2</sub> production and microbial biomass-C were determined as 123.4-420.4 µg TPF/1g dry soil, 9.3-37.2 ml O<sub>2</sub>/5g dry soil, 19.7-749.3 µg N/1g dry soil, 4.8-33.4 mg CO<sub>2</sub>/100g dry soil and 15.0-135.4 mg C/100g dry soil in Bafra plain soils respectively. Same characteristics for Çarşamba Plain soils were 23.9-313.4 µg TPF/1g dry soil, 2.7-61.1 ml O<sub>2</sub>/5g dry soil, 16.9-594.4 µg N/1g dry soil, 6.3-33.7 mg CO<sub>2</sub>/100g dry soil, 6.3-33.7 mg C/100g dry soil respectively. Consequently, the significant statistical relations were determined between the heavy metal contents and microbiological characteristics in the soils.

**Key Words:** Soil, Microbiological characteristics, Heavy metal, Bafra plain, Çarşamba plain.

thickness and properties of the soils and subsoils which are subjected to erosion, and on the correlation between the rates of soil loss and soil formation. The most wide erosion-dependent spectrum of soils is formed in humid tropics and subtropics where the different horizons of the thick soil and saprolite profiles are exposed as a result of long-term natural and human induced erosion. The new soils derived from material of various exposed horizons inherit properties of substrata and differ in acidity, texture, mineralogical composition, the reserve of nutrient elements, and other ecologically important features.

On eroded hills and terraces of the east coast of the Black Sea the following spatial-erosional soil sequence is formed: Stagnic Acrisols and Haplic Nitisols, derived from red clayey soft saprolite; Eutric Cambisols, derived from loamy brown saprolite, and Lithic Leptosols as a final component, derived from coarse brown saprolite or desintegrated rocks. Generally, erosion sequence includes soil profiles from strongly acid clayey kaolinite to weakly acid or neutral polymineral coarse textured, and this fact determines the ways of agricultural activity in the region. Distribution of managed ecosystems correlates with soil pattern very closely. As soil erosion advances, acid-tolerant plants such as tea are changed by lime-loving and xerophyte crops on young soils, and the final ecosystems are pine or shrub stands or badlands.

The main goals of soil science related to the problem of sustainable mountain development are:

- to study local and regional spatial distribution of the soil and regolith mantle, particularly their total thickness and store, fine earth content and quality;
- to define the rates of fine earth generation processes (weathering, pedogenesis, sedimentation) in different environments;
- to explain to mountain stakeholders the extremely important life-supporting role of the loose soil and regolith mantle for the long-term sustainable development.



## **Soils and Regolith Mantle as Obligatory Factors of Sustainable Land Use in Mountain Regions**

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Soil is a main life-supporting factor in mountain regions. At the same time the soil is the most fragile and vulnerable component of the mountain nature. The main reasons of the mountain soil vulnerability are: a) the shallow total thickness of the mountain regolith usually underlined by consolidated rocks; b) shallow and stony soils limited by regolith depth; c) high rates of the natural denudation and human-induced erosion; c) the general discordance between the relative low rates of fine earth substances generation by weathering and high rates of these substances loss by denudation, particularly by anthropogenic erosion. It means that any loss of the fine earth from the mountain soils and regoliths are practically unrenewable and irreversible within the human time-scale. Accordingly, in mountain regions the fine earth properly and the whole regolith mantle including the soil cover are the strategic unrenewable natural resource for human habitat, agriculture, forestry, etc. It is the essential peculiarity of mountain soils as distinct from lowland ones, which are usually developed on thick loose deposits and, as a result, have an unrestricted resource of fine-earth mineral materials.

The perception of the fine-earth finiteness and unrenewability in the mountains means that not only soils should be an object of conservation, but all kinds of regolith mantle covering mountain watersheds and slopes. Just whole regolith is the main object of human impact and "victim" of many natural catastrophes (slides, avalanches, mud flows). The irreversible loss of the whole loose mantle seriously damaged or even ruined the social and economical life in many mountain regions (Caucasus, Central Asia, Mediterranean, India, Ethiopia, etc.). The natural regeneration of fine earth in mountains depends on different factors such as rocks properties, climate, topography, but in the most cases needs centuries and thousands years, which is too much for the human expectations. The importation or making of fine-earth for mountain soils are extremely expensive and not available for mountain communities even in developed countries. So, the sustainable development of mountain regions tightly related to the existence and conditions of their soil and whole regolith mantle, primarily to the total thickness and fine earth content.

Soil variability in mountain regions often is a result of successive erosion loss of surface loose matter and involving of deep horizons of regolith mantle into soil formation. The soil diversity within erosion sequence depends on the

than the second year values. These differences indicated that the positive effect of applied waste compost on stalk yield dramatically declined in the second year.

In grain yield, like stalk yield, waste compost application considerably enhanced grain yield comparing with control in the first year (Table 4). Grain yield at control dose was 8.90 kg/plot while it was 14.30 kg/plot at the highest two compost levels (120 and 160 t/ha). In the second year, addition of compost to the soil had a positive effect on grain yield when compared to control plots. The lowest yield (3.6 kg/plot) was obtained from the control whereas the highest yield (9.9 kg/plot) was obtained from 100 t/ha compost dose. Figure 2 also shows that compost application resulted in an increase in grain yield for both years.

Several researchers also stated that adding waste compost to soil improved the yield of several crops (Assche et al., 1982; Tiwari et al., 1989; Chattopadhyay et al., 1992; Hue et al., 1994). As a conclusion, the addition of waste compost into soil enhanced barley yield and the best doses among applied doses were 120 and 160 t/ha. However, in the second year, the yield decreased when compared to the first year. Therefore, to obtain a sufficient stalk and grain yield in the second year, some additional waste compost and mineral fertilizers should be applied.

## **The Effects of Waste Compost on Barley Yield**

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### **Abstract**

In this research, the aim of this study was to determine effect of different concentrations of municipal waste compost (0, 20, 40, 80, 100, 120 and 160 t/ha) on barley growth and yield. This two year study showed that waste compost application to soil resulted in an increase in both stalk and grain yield of barley. The best doses among applied doses were 120 and 160 t/ha. Effectiveness of applied waste compost declined in the second year, therefore, the differences between the first and second year results were found to be significant. Therefore, to obtain a sufficient stalk and grain yield in the second year, some additional waste compost and mineral fertilizers should be applied.

### **Results and Discussion**

In order to determine the effect of waste compost on barley growth, the results of variance analyses for stalk and grain for both two years were presented in Table 3. It can be seen in Table 3, that the differences between years in terms of both characters were found to be highly significant. Similarly, the effect of waste compost on both characters measured was highly significant. However, their interaction was not significant.

Mean values for stalk and yield grain obtained from first and second year experiments were given in Table 4. According to the first year results, in general, increasing levels of waste compost resulted in an increase in stalk yield. At control level, mean stalk yield was 16.9 kg/plot whereas at the highest level of waste compost (160 t/ha) it reached up to 27.5 kg/plot. This increase was about 63 %.

As a result, all waste composts applications had a positive contribute on stalk yield when compared to the control. When the second year results were discussed, the stalk yield results were similar to first year results (Table 4). At control level, the stalk yield was 2.60 kg/plot while the mean yield reached up to 6.6 kg/plot with 100 t/ha waste compost application.

For comparison first and second year results, Figure 1 shows that the addition of waste compost to the soils improved stalk yield comparing with the control for both years. These results were in line with the results obtained by Bahtiyar (1985). However, the first year yield values for all compost doses were higher



and 80 t ha<sup>-1</sup> compost levels were the most effective treatments to decrease wilting point according to Duncan's LSD test .

In general, adding waste composts to soils positively affected on soil physical properties of Non-calcareous Brown soils. However, addition of waste compost to Vertisol soils with heavy clay did not significantly change soil aggregate stability, field capacity and wilting point. Therefore effects of waste compost applications on physical properties of course soils were greater than those of clay soils. Numerous researchers showed positive effects of waste compost on physical properties of course soils (Andres, 1965; Bahtiyar, 1985; Kotze and Joubert, 1992; Serra et al, 1996, Tester, 1990). More and long-term researches need to be done to understand the effects of compost on physical properties of clay soils.

Additions of waste composts on soils, significantly reduced soil bulk densities (Table 3). Bulk density value of control soils was average  $1.59 \text{ g cm}^{-3}$  and bulk density value of  $160 \text{ t ha}^{-1}$  waste application treatment was average  $1.51 \text{ g cm}^{-3}$  for Vertisols soils. These values reduce from  $1.51 \text{ g cm}^{-3}$  (control) to  $1.44 \text{ g cm}^{-3}$  ( $160 \text{ t ha}^{-1}$ ) for Non-calcerous Brown soils. Numerous studies reported that the additions of waste compost to soils reduced soil bulk densities due to their high organic matter contents (Shiralipour et al., 1992, Tester, 1990, EPA and TVA, 1993). Variance analysis showed that compost application levels on soil bulk density was found to be significant at the level of  $p < 0.01$ .  $160 \text{ t ha}^{-1}$  compost levels was the most effective treatment to reduce soil bulk density according to Duncan's LSD test.

Increasing waste composts additions to soils also increased soil porosity (Table 3). Porosity value changed from average 40.19% (control) to 42.09% ( $160 \text{ t ha}^{-1}$ ) for Vertisols soils. Average porosity value for control soil was 42.40% and it increased to 45.25% with application of  $160 \text{ t ha}^{-1}$  compost for Non-calcareous Brown soils. Variance analysis showed that compost application levels were found to be significant on soil porosity at the level of  $p < 0.01$ .  $160 \text{ t ha}^{-1}$  compost levels was the most effective treatment to increase soil porosity according to Duncan's LSD test. Adding soil waste compost to heavy clay soil increased pore volume and porosity (Gupta et al., 1986 and Giusquiani et al., 1995).

Additions of waste composts did not significantly change field capacity of soils (Table 3). Field capacity value was greater than the control only at the  $40 \text{ t ha}^{-1}$  application level for Vertisols and at the  $160 \text{ t ha}^{-1}$  level for Non-calcareous Brown soils. However these differences were found to be statistically not significant. Because of high clay content of research soils the amount of water at field capacity was already high. Therefore addition of waste compost did not change field capacity values of these soils.

Additions of waste composts significantly reduced wilting point values of Vertisols. In contrast, 120 and  $160 \text{ t ha}^{-1}$  compost applications increased wilting point values compared to control for Non-calcareous Brown soils. The reason for this contrariness is due to high clay content of vertisol soils compared to Non-calcareous Brown soils. As a matter of fact, reduction of wilting point and field capacity water contents of heavy clay soils are desired for agricultural practices (Bahtiyar, 1997). Variance analysis showed that compost application levels on the reductions of wilting point were found to be significant at the level of  $p < 0.01$ . 40

## **The Effects of Waste Compost on Some Physical Properties of Vertisol and Non-Calcerous Brown Soils**

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### **Abstract**

The objective of this study was to determine effect of different concentrations of municipal waste compost (0, 40, 80, 120 and 160 t/ha) on soil physical properties of Vertisol and Non-calcareous Brown Soils. According to results of soil that sampled from pots, waste compost application to soil increased soil porosity, reduced bulk density. In general, adding waste composts to soils positively affected on soil physical properties of Non-calcareous Brown soils. However, addition of waste compost to Vertisol soils with heavy clay did not significantly change soil aggregate stability, field capacity and wilting point. The best compost application levels among applied doses were 120 and 160 t/ha.

### **Results and Discussions**

Additions of waste composts to soils were more effective on soil aggregate stability for Non-calcareous Brown soils than those of for Vertisols. 160 ton ha<sup>-1</sup> compost application to Vertisol soils increased soil aggregate stability more than the control, however all compost application levels increased soil aggregate stability compared to control treatment for Non-calcareous Brown soils. Maximum soil aggregate stability value was obtained (84.13%) with the applications of 80 t ha<sup>-1</sup> waste compost on Non-calcareous Brown soils. Waste compost addition was not an efficient application to stabilize soil aggregates for Vertisol soils. The reason for that is high clay contents of Vertisols and naturally, even before the experiment these soils had stable soil aggregates. Besides, Bahtiyar (1997) reported that additions of organic matter on clay soils were not effective to increase soil aggregate stability. Variance analysis showed that compost application levels on soil aggregate stability was found to be significant at the level of  $p < 0.01$ . 80 and 160 t ha<sup>-1</sup> compost levels were the most effective treatment on soil aggregate stability according to Duncan's LSD test.



$Y_3$  is the content of gluten;  $Y_4$  is the strength of the wheat - flour in J;  $Y_5$  is the volume of the volume of the bread.

The influence of the fertilizers on the agronomical soil properties is described by the following equations:

$$Y_6 = B_0 + B_1P + B_2P^{0.5} \quad (10) \quad Y_7 = B_0 + B_1K + B_2K^{0.5} \quad (11)$$

Here one has:  $Y_6$  is the content of the available Phosphorus, mg/100g of soil;  $Y_7$  is the content of the metabolic Potassium, mg/100g of soil. We remark that the soil parameters influence on the optimal  $N$ ,  $P$  and  $K$  fertilization norms. With help of the above equations, one can account for the influence of  $N$ ,  $P$  and  $K$  fertilization, and prescribe some recommendations. In this way the optimal fertilization norms are calculated to be as follows. For Chromic Luvisols one has  $N = 19 \text{ kgda}^{-1}$ ,  $P = 11 \text{ kgda}^{-1}$  and for Plano-chromic Luvisols. One has  $N = 19 \text{ kgda}^{-1}$ ,  $P = 13 \text{ kgda}^{-1}$ .

The many-factor regression equations give as a rule only an empiric fit, and the coefficients have not always an agrotechnological sense. But nevertheless using the equations one can numerically predict the crop also for values of the variables different from the experimentally tested ones. The investigation of the regression equation shows different effectivity of the  $N$ ,  $P$  and  $K$  fertilization that depends on the predecessor. The role of  $N$  fertilizer is important since the formation of high quality yield depends mainly on it. Then the role of the  $P$  fertilizer is important with the background of  $N$  fertilizer. There is a linear dependence between the fertilizers and crop rotation yield discussed in Table 3. The data correspond to mean values of yield and fertilizers per year.

The dispersion analysis of crop rotation productivity gives that the climate influence on yield corresponds to 61% - 97%, the fertilization influence corresponds to 2.8% - 32.2% and the influence of the rest of the factors - 0.2% - 16%. The correlation coefficient between yield and climate is 0.77 - 0.99 and between yield and fertilizers is 0.14 - 0.45. A similar tendency is observed for other soils of the same region (Todorova et al., 2001). One has the following gradation of factor's importance: moisture > fertilization > arrangement of plants > sort of plant > soil parameters etc.

### Conclusion

The complexity of the ecosystem to be modelled and the lack of an exhaustive information about it at present time implies the impossibility to construct a general (universal) agroecosystem model. At present the description of this complex system is possible by use of partial models at different levels of generalization.

mineral fertilization is applied at three levels:  $N = 0; 12; 24 \text{ kgda}^{-1}$ ,  $P = 0; 8; 16 \text{ kgda}^{-1}$ ,  $K = 0; 8; 16 \text{ kgda}^{-1}$ . (Where is  $N$  - Nitrogen,  $P$  - Phosphorus and  $K$  - Potassium). We analyze 4-field crop rotation: wheat-maize-wheat-maize (Todorova, 1997).

## Results

Among a variety of investigated functions, we have chosen three types of them: quadratic, one-half and linear as follows.

$Y = C + \sum a_i X + \sum b_j X^j$  [ $\text{kgda}^{-1}$ ], where  $j = 0; 0.5; 2$ .

The above function takes the following four forms [ $NPK$  (1); Climate (2);  $NPK +$  Climate (3); Soil +  $NPK +$  Climate (4)]:

$$Y = B_0 + B_1N + B_2P + B_3K + B_4N^2 + B_5P^2 + B_6K^2 + B_7NP + B_8NK + B_9PK \quad (1)$$

$$Y = B_0 + B_1V_{May} + B_2V_{June} + B_3T_{may} + B_4T_{June} + B_5V_{May}^2 + B_6T_{June}^2 + B_7H \quad (2)$$

$$Y = B_0 + B_1N + B_2P + B_3K + B_4N^2 + B_5P^2 + B_6NK + B_7V_{May} + B_8V_{June} + B_9T_{May} + B_{10}T_{June} + B_{11}H \quad (3)$$

$$Y = B_0 + B_1P + B_2P_2O_5 + B_3Hm + B_4M + B_5N^2 + B_6P^2 + B_7(P_2O_5)^2 + B_8NP_2O_5 + B_9NM + B_{10}T_{June} + B_{11}PP_2O_5 \quad [100\text{kgha}^{-1}] \quad (4)$$

The coefficients of equations (1) - (4) are given in Table 1 and Table 2. The data in the 2-nd and 3-rd rows (marked with stars) correspond to a regime of irrigation, while all other data correspond to absence of irrigation.

**Remark:** The data in 1 - 4 rows of Table 1 correspond to one-year experiment. The rest of data correspond to 10 years experiment.

For all equations the experimental errors  $\sigma_e$  are comparable with the model adequacy  $\sigma_m$ . For example in case of equation (4) one has  $\sigma_e = 2.7$  and  $\sigma_m = 3.15$ . The value of  $R^2$  (adequate fit) varies between 0.75 and 0.96 (see Table 3).

The influence of fertilization on the grain quality in case of winter wheat is well described by the following one-half model equation and linear equations. The values of the coefficients are given in Table 2, and the meaning of  $Y_i$ ,  $i = 1-7$  is explained at the end of the equations:

$$Y_1 = B_0 + B_1N + B_2K^{0.5} \quad (5); \quad Y_2 = B_0 + B_1N + B_2N^{0.5} \quad (6)$$

$$Y_3 = B_0 + B_1N \quad (7); \quad Y_4 = B_0 + B_1N + B_2P + B_3K \quad (8);$$

$$Y_5 = B_0 + B_1N^{0.5} \quad (9)$$

Here one has:  $Y_1$  is the mass of 1000 grains;  $Y_2$  is the content of the proteins in %;

## Study of the Wheat and Crop Rotation Yield Dependence on the Forming Factors for Chromic Luvisols and Plano-Chromic Luvisols in South Bulgaria

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### Abstract

On the basis of many-factor experiments a possibility is shown to model the dependence between wheat crop, climate and fertilization for the South Bulgarian Chromic Luvisols and Plano-chromic Luvisols.

We apply a regression analysis to fit the existing data of a many-factor analysis of experiments for a period of ten years with following input data. The mean values of rainfalls for a month -  $V$ ; the temperature -  $T$  during the vegetation period; the spring moisture supply -  $H$ , a meteorological coefficient -  $M$  accounting for the integral influence of the climatic factors, and the following soil parameters: humus -  $Hm$  [%], available Phosphorus ( $P_2O_5$  mg /100g soil), metabolic Potassium ( $K_2O$  mg /100g soil) and mineral fertilization. It is applied at three levels: Nitrogen-  $N = 0; 12; 24 \text{ kgda}^{-1}$ , Phosphorus-  $P = 0; 8; 16 \text{ kgda}^{-1}$ , Potassium-  $K = 0; 8; 16 \text{ kgda}^{-1}$ . and  $K^-$ ). We analyze 4-field crop rotation: wheat-maize-wheat-maize.

Three types of functions are used: quadratic, one-half and linear as follows:

$$Y = C + \sum a_i X + \sum b_j X^j \text{ [kgda}^{-1}\text{]}, \text{ where } j = 0; 0.5; 2.$$
 The influence of fertilization on the grain quality in case of winter wheat is well described by one-half model equation.

### Introduction

On the basis of the many-factor experiments a possibility is shown to model the dependence between the wheat crop, climate and fertilization for the South Bulgarian Chromic Luvisols (Lc) and Plano-chromic Luvisols (LcP).

### Material and Methods

The present report is part of a complex evaluation for crop prediction and concerns the factors climate and fertilization in forming the crop.

We apply a regression analysis to fit the existing data of a many-factor analysis of experiments for a period of ten years. We used the following input data. The mean values of rainfalls for a month -  $V$ ; the temperature -  $T$  during the vegetation period; the spring moisture supply -  $H$ . Furthermore we use a meteorological coefficient -  $M$  accounting for the integral influence of the climatic factors, as well as the following soil parameters: humus -  $Hm$  [%], available Phosphorus ( $P_2O_5$  mg /100g soil), metabolic Potassium ( $K_2O$  mg /100g soil) and mineral fertilization. The



Pepper yield increased by the application of manure. Maximum yield was in 8 t da<sup>-1</sup> application. When compared to that of the control, 48% increase has been recorded.

Maximum number of fruit in plant was determined in 2 t da<sup>-1</sup> application dose and the maximum fruit length was in 8 t da<sup>-1</sup> treatment. Average fruit weight, fruit thickness and fruit width varied in different application on doses and when compared to that off control they decreased. Treatments has been determined significantly (1%) affected the yield and fruit properties excluding fruit width. Selvaraj et al. (1998), reported higher yields when cattle manures are used in pepper growing.

Bayraktar (1981), recommended 3-5 t da<sup>-1</sup> cattle manure for pepper. The same researcher has determined 10-40 fruit number and 100-1000g fruit weight per plant and 3000-3500 kg yield per decar. Küçük (1992), determined that maximum yield in 12 kgN da<sup>-1</sup> application in his investigation with different N doses.

## Effect of Manuring on Yield, Quality and Mineral Content of Red Pepper

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### Abstract

The study was carried out in Ödemiş District of İzmir, Ege University Ödemiş Technical Training College. Experimental side, where red 'yağlık' pepper was used as the best crop. Cattle manure was applied in different Rate as: control, 2, 4 and 8 t da<sup>-1</sup> with 3 replications. Planting density was 70x30 cm with 35 plants in each parcel. Seeds were sown on 15 May 2000. Manure was analyzed according to Kacar (1990).

Texture (Selvaraj et. al.1998), Total soluble salts (Vural et. al., 2000), pH (Kacar and Katkat, 1999), CaCO<sub>3</sub> (Soil survey staff,1951), Total N (g), available P (Bingham,1949), available K, Ca and Mg contents of the experimental soil were analyzed according to NH<sub>4</sub>O AC method (Kacar and Katkat, 1999) and organic matter (Soil survey staff,1951), available Fe, Cu, Zn and Mn according to DTPA method(Loue' 1968).

Kjeldahl method was used to determine the total N content of the leaf samples. Total P was measured spectrophotometrically; K and Ca with flame photometes (Kacar,1972) and Mg, Fe, Cu, Zn and Mn with atomic absorbtion spectroffhotometer.Yield and fruit quality properties were determined and the results are evaluated statistically.

According to the table, pH of the soil is slightly acid, low in organic matter and lime and has no salinity problem. Similar results were found by different researchers (Jackson, 1967; Küçük,1992; Schlichting and Blume,1966; Vural et al,2000). Soil texture is sandy loam and has low N, P, K contents and Zn is in critical level. C/N ratio of the composted cattle manure is 19 . And also similar contents and C/N ratio were found in some experiments (Aydeniz & Brohi, 1991).

Results show that primary and secondary leaf nutrients increase which cattle manure rates increase compare to that of the control. Nitrojen contents of the leaves are found sufficient while P, Ca and Mg high and K low. Copper and Mn were sufficient in all of the leaf samples and Zn low in only the control and 2 t da<sup>-1</sup> cattle manure application (Bergman,1986) The effect of cattle manure applications on leaf N, K, Fe and Ca contents were statistically significant at 5 and 1% levels. No effect was found in other studied leaf nutrients.

clayminerals and silt organic matter. The stabilization role of the phosphorous and carbonates consist in formation of solid calcium-phosphorous humic coagulation complexes. Their further humification and mineralization is difficult owing to more quantity limits of zonal humic accumulation. The chemical elements accumulation degree in separate parts of landscape cascade-geochemical systems depends on a mutual combination of humification processes, pedogenesis and of chemical units migration features.

There is a strong lateral effluent of substance in mountains but there are not favourable conditions for drowing of phosphate disperse areals. Carbonatic geochemical farrier represented by products of tranformation of dolomites and limestones has developed around geosystems under investigation. A very little content of mineral phosphorus in the water of Hubsugul lake and rivers of Prihubsugul region, where are a lot of phosphorite deposits, is probably in direct connection with this. No changes were noted in the composition of typomorphic elements, from tundra to dry steepes there. This is supported by the data of botanic observation of adjacent biogenozes state.

## Conclusion

The unique natural complexes of Baikal and Hubsugul basins, its unusual biogeochemical properties of soils and landscapes invironmental historical and estetic value creations conditions for development of education, science and culture cause the needless of the solving the problems of rational nature managment, development of the programs of sustainable use of natural resourses evaluation of landscapes recreational loads biological, geological resourses, etc; considerable participation together with other countries scientiests in projects for more comprehensive account of antropogenic effects on nature and environment conservation, unique objects of nature and their biodeversity. In light of this, a system of large national parks in the Baikal and Hubsugul lakes areas should be created. In addition to protecting the unique ecosystems of lakes, the parks would allow preservation of standard natural complexes typical for Baikal and Khangai-Khentei mountainous systems.

Lakes Baikal, Hubsugul and the parts of the lake's basins, directly adjacent to it, should be designated as special state area with a particular regime of land use and environmental protection in the form of a Baikal State National (Nature) Park. It is recommended by a comprehensive Programe of Land Use Policies of Lake Baikal Region to expand of Pribaikalsky National Park and with Khamar Daban National Park and Okinsky, Olchon, Tunkinsky and Zakamensky natural antropological reservs, should be joined with Mongolia's Lake Hubsugul national park to form an international peace park. International cooperation & rich world experience can give a large support to do this.



## **Introduction**

Today the preservation of different soil differences on the representative areas appears one of the central problems. The success in the solution of this problem directly depends on maintenance of the indispensable reasons of the special soil conservation and, first of all such as: well-timed creation of the World Soil Red data Book; mining of the theory of a soil and nature conservation as a whole from stands of the functional approach; the termination of further nonrational development of unrenovable natural resources; recovery broken down landscapes etc. To keep a biological diversification, it is necessary to secure(discharge) samples of all ecosystems in national parks, reservations or other guarded terrains.

## **Materials and Methods**

The researches were directed on analysis of biocenoses Hubsugul region and their significance for economy MHP. The large attention was given to research of landscapes of a unique field of phosphorites of Mongolia. For objects of learning were soils of geosystems of main high-altitude natural zones: tundra, forest and steppe, advanced on native outputs on a diurnal surface of Ongolignur deposit Hubsugul phosphorites basin.

## **Results and Discussion**

The learning of natural ecosystems advanced on phosphorites and dolomites with marl and chlorite and illite layers of shales deposits of Hubsugul phosphorite deposits basin of Mongolia vend-kembrium of age represents doubtless interest.

The diversity of litological composition of pedogenic rocks appreciably determines development of a wide spectrum of litological soils in this terrain formed on rather loose cover derivations, structure and constitution of which are complicated by course of cryosolifluction processes. Alongside with «geomorphological» zonality» of pedogenesises complicated of litological matrix is realized. In conditions of Hubsugul mountain ecosystems with the open-ended circulation of materials, litological matrix determines directions of pedogenesis by its virtue of bioclimatic reflexivity. On the rocks with different degree of carbonates and phosphates, defined by stratigraphy variability of phosphate-carbonate deposits, there have been formed a litogenic spectrum of soils. Carbonate components «shades» influence of phosphate rocks materials. The common trend of the weathering carries on to formation of the hydroshale-chlorite-illite composition of a clay part of soils with bad crystallization and superdisperse features of illites.

The weathering of phosphorite rocks of southwest Hubsugul lake area produce to significant accumulation of silicate compounds as decomposition and carrying out of carbonate component and else to residual accumulation of

## **Unique Phosphorites Soils of Mongolia: Emphasis on Their Ecological Functions and Necessity of Preservation**

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### **Abstract**

The complex learning of morphogenetic and ecological features of Hubsugul lake basin soils, processes of pedogenesis and migration of phosphorus in main types of mountain soils developed on the outputs of phosphorites of Hubsugul phosphorites deposits of Mongolia is conducted. The new actual information about the weakly investigated soils, complete information of their genesis and properties, potential ecological stability of soils, advanced on phosphorous-carbonate rocks of deposit is obtained.

The behaviour of phosphorus on an example of natural laboratory - deposit of phosphorites, reaching in limens of all high-altitude landscape zones of Prihubsugul area: tundra, forest, steppe - is investigated. Investigated soils are characterized by a plenty of total and mobile phosphorus, that determine their original properties.

The influence of mountain-zone component, intrazonal factors and cryogenesis on pedogenesis, pedochemistry and biogeochemical migration of phosphorus and other units, humus state of soils and biological efficiency of biocenoses, natural-resource potential of terrain of research is established. The possibilities for further development of exhibiting litogenic matrix representations on pedogenesis in mountain conditions on the Hubsugul area example are exhibited.

The representations about possibilities of topsoil evolutionary development and soil body existence ecological balance both in conditions of natural development of geosystems, and under destabilization effect of an anthropogenic factor are broden. In aspect of possible mastering of a deposit possible consequences of intensified technogenic press on unique in natural and cultural attitude Hubsugul lake ecosystem are predicted.

The mechanisms of natural - historical biosphere conservation and strategies of rational usage of natural resources in the basin of unique ecosystems of Hubsugul lake are considered. It's exhibited, that work out and implantation on the scientific recommendations basis of the special status with the circumscribed mode of nature management and environmental control, complex programs of land use policy are necessary for sustainable development of the area. The deep study of a situation with engaging of scientific and public, including international, forces is necessary and the large support can be rendered by experience of joint international complex research works.

**Keywords:** Phosphorites soils, Mongolia, Baikal-Hubsugul basin, phosphorous deposits, pedogenesis, weathering, mountain landscapes, preservation, national park.



salinity on plants. Despite the lack of evidence indicating that N applied to saline soil or media above a level considered optimal under non-saline conditions improves plant growth or yield, a number of laboratory and greenhouse studies have shown that salinity can reduce N accumulation in plants (Pessarakli, 1991). Champagnol (1979), reviewed 17 publication and reported that, P, added to saline soils, increased crop growth and yield in 34 of the 37 crops studied. Similar to the effect of added N, added P did not necessarily increase crop salt tolerance. In most cases, salinity decreases the concentration of P in plant tissue (Güneş et al., 1999), but the results of some studies indicated salinity either increased or had no effect on P uptake. The role of K is vital for osmoregulation and protein synthesis, maintaining cell turgor and stimulating photosynthesis (Peoples and Koch, 1979). Higher levels of  $K^+$  in young expanding tissue is associated with salt tolerance in many plants (Gorham, 1993; Khatun and Flowers, 1995). NaCl also changes the anion concentrations in plants. A lowered supply of nitrite to growing leaves may be responsible for inhibition of growth under saline conditions (Hu and Schmidhalter, 1998). Maintaining an adequate supply of  $Ca^{2+}$  saline soil solutions is an important factor in controlling the severity of specific ion toxicities, particularly in crops which are susceptible to sodium and chloride injury (Maas, 1993). Salinity stress has stimulatory as well as inhibitory effects on the uptake of some micronutrients by plants. The uptake of Fe, Mn, Zn and Cu generally increases in crop plants under salinity stress (Alam, 1994). The detrimental effects of NaCl stress on the nutrition of bean plants are reflected in higher concentrations of Cl and Mn in roots and Cl, Fe and Mn in leaves and Cl and Fe in fruits (Carbonell-Barrachina et al., 1998). Briefly, it is reasonable to believe that numerous salinity-nutrient interactions are occurring at the same time but whether they ultimately affect crop yield or quality depends upon the salinity level and composition of salts, the crop species, the nutrient in question and a number of environmental factors.

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## Effect of Salt Stress on Plant Nutrition Uptake

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### Abstract

Plant growth is limited with different environmental conditions. One of these conditions is salt stress that causes plant dies depending on the type of crops. Soil salinity is one of the most important agricultural problems in arid and semiarid climate conditions in different parts of the world. Almost 1/3 of irrigated lands in the world is under the salinity problem. In Turkey approximately 1.5 million ha agricultural land has salinity problem because of mismanagement and environmental conditions. The rehabilitation of saline soils is time consuming and very expensive.

### Introduction

Salinity has been recognized as a major agricultural problem in arid and semi-arid regions and mismanagement land and irrigation areas. Differences in salt tolerance among plant species have also been long recognized; however, the role that salt tolerance plays in causing differences in nutrient uptake and metabolism between various plants, among plant species, at different stages of growth is still a major concern among investigators, and has not been fully understood. So it requires joint effort of agronomist, biochemist, geneticist, plant physiologist, soil scientists among others (Pessarakli, 1991; Kawasaki et al., 1983). Plant performance usually expressed as a crop yield, plant biomass or crop quality, may be adversely affected by salinity-induced nutritional disorders. These disorders may result from the effect of salinity on nutrient availability, competitive uptake, transport or partitioning within the plant. For example salinity reduces phosphate uptake and accumulation in crops grown in soil a primarily by reducing phosphate availability. Salinity dominated by  $\text{Na}^+$  salts not only reduces  $\text{Ca}^{2+}$  availability but reduces its transport and mobility to growing regions of plant, affecting the quality of both vegetative and reproductive organs. Salinity can directly affect nutrient uptake as  $\text{Na}^+$  reducing  $\text{K}^+$  uptake or by  $\text{Cl}^-$  reducing  $\text{NO}_3^-$  uptake. High concentration of  $\text{Na}^+$  and  $\text{Cl}^-$  in the soil solution may depress nutrient-ion activities and produce extreme ratios of  $\text{Na}^+/\text{Ca}^{2+}$ ,  $\text{Na}^+/\text{K}^+$ ,  $\text{Ca}^{2+}/\text{Mg}^{2+}$  and  $\text{Cl}^-/\text{NO}_3^-$ . Salinity can cause a combination of complex interactions affecting plant metabolism or susceptibility to injury.

**Macro and Micro Nutrient Uptake:** Salt salinity affects plant physiology through changes of water and ionic status in the cells (Kashem et al., 2000; Hasegawa et al., 2000). Ionic imbalance occurs in the cells due to excessive accumulation of  $\text{Na}^+$  and  $\text{Cl}^-$  and reduces uptake of other mineral nutrients, such as  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mn}^{2+}$  (Lutts et al., 1999). External supplied  $\text{Ca}^{+2}$  has been shown to ameliorate the adverse effect of salinity in plants, presumably by facilitating higher  $\text{K}^+/\text{Na}^+$  selectivity (Hasegawa et al., 2000). In many field studies, horticulturists and agronomists set out to test the hypothesis that N-fertilizer additions alleviate, at least to some extent, the deleterious effect of

In the 1996 when the precipitation was 49.2 mm in combination with high effective temperature sum (ETS), was observed a highest weed control in all of the treatments, while in 1995 the low weed control level due to high precipitation. The herbicide application influenced more strongly on infestation degree in comparison to the quantity of the dry weed biomass in 1994. After manual weed cleaning in the end of "7-9 leaf" stage, the second infestation was mainly by *Amarantus retroflexus* L. *Setaria glauca* (L.) P. B. and *Echinochloa crus-galli* L. The small amount of rainfall water in 1996 during "7-9 leaf-tasseling" period leads to the best weed control in "tasseling" phase. In 1994 was obtained the less weed control as a result of the numerous weed seed population in the cow manure, while in 1995 the low weed control level due to high precipitation. The herbicide treatments increased the total yield independent of the kind of maize planting. The highest yield was obtained in the variants with organic and mineral fertilization ( $N_{70}P_{60}$ ). During the experimental period the maize yield was as follows: In 1994 was obtained the highest yield as a result of the precipitation during "12-13 leaf-tasseling" phase - 95.2 mm; in 1995 the yield was poor due to the little ETS levels. From sowing to the phase 7-9 leaf the crop was infested by weeds from different biological groups with main representatives from the summer dicotyledonous, followed by early spring weeds, summer and winter-spring ephemerals. In control (no treated) variants during the phenophase "7-9 leaf-tasseling" weed infestation decreased considerably and in was realised of *Amaranthus retroflexus* and *Setaria glauca*. Significant differences in weed control was observed in atrazine + nicosulfuron depending on the meteorological condition, organic and mineral fertilization. The best weed control was determined in the variants no treated with cow manure. The herbicide treatments increased the total yield independent of the kind of maize planting. The highest yield was obtained in the variants with organic and mineral fertilization ( $N_{70}P_{60}$ ). During the experimental period the maize yield was as follows: In 1994 was obtained the highest yield as a result of the precipitation during "12-13 leaf-tasseling" phase - 95.2 mm; in 1995 the yield was poor due to the little ETS levels.

norms of fertilization and their values were lower in the variants without fertilization. The cow manure application in 1993 provoked an increase of the degree of weed infestation and the quantity of weed dry biomass in the variants with and without mineral fertilization. That was strongly manifested during the first year of investigation. During the above mentioned period "sowing - 7-9 leaf" the highest degree of infestation sowed *Amaranthus retroflexus* L. in hand weeding variants. The obtained of percent participation in the total degree of weed infestation varied from 43.1 to 65.2, depending on the norms of mineral and organic fertilization and precipitation. The effect of atrazine + nicosulfuron on weed flora varied and depended mostly on the precipitation in the period "sowing - 7-9 leaf. In phase "7-9 leaf" of maize vegetation the weed control by atrazine + nicosulfuron was better in years with 50-55 mm precipitation on the period "sowing - 7-9 leaf" (1994 and 1996) and it became less in the time of investigation more with 2-3 times rainfalls during the same period (1995). Weed control in treatment with herbicides depends mostly on organic fertilization. Independent of rainfalls the degree of weed infestation and the dry weed biomass was lower in plots without organic fertilization compared to the variants with cow manure application. Weed control in variants with herbicides depended on the norms of mineral fertilization. The best weed control was observed in treatments without mineral fertilization and that control was less in variants with mineral fertilization.

**Table 1** Quantity of weed infestation in maize field

Years	1994				1995				1996			
	without cow manure		with 40 t ha <sup>-1</sup> cow manure		without cow manure		with 40 t ha <sup>-1</sup> cow manure		without cow manure		with 40 t ha <sup>-1</sup> cow manure	
	n/m	d.b/m	n/m	d.b/m	n/m	d.b/m	n/m	d.b/m	n/m	d.b/m	n/m	d.b/m
Phase "7- 9 leaf"												
N <sub>0</sub> P <sub>0</sub>	99	72	118	82	81	64	87	65	111	62	133	53
N <sub>0</sub> P <sub>0</sub> *	9	14	23	30	32	24	41	29	-	-	-	-
N <sub>50</sub> P <sub>40</sub>	116	84	134	100	100	109	112	110	128	88	135	110
N <sub>50</sub> P <sub>40</sub> *	11	17	18	30	37	29	50	63	-	-	-	-
N <sub>70</sub> P <sub>60</sub>	127	94	158	104	115	112	118	111	116	94	138	121
N <sub>70</sub> P <sub>60</sub> *	13	19	19	42	38	30	50	59	-	-	-	-
Phase "tasseling"												
N <sub>0</sub> P <sub>0</sub>	31	12	42	23	30	14	30	16	2	0.001	0.03	0.003
N <sub>0</sub> P <sub>0</sub> *	3	4	7	8	12	7	13	8	0.03	0.001	-	-
N <sub>50</sub> P <sub>40</sub>	40	26	52	52	32	22	35	28	0.7	0.004	1.4	0.001
N <sub>50</sub> P <sub>40</sub> *	6	7	12	13	19	12	15	17	-	-	0.9	0.001
N <sub>70</sub> P <sub>60</sub>	49	34	61	63	37	30	44	29	1.4	0.001	0.7	0.001
N <sub>70</sub> P <sub>60</sub> *	7	9	17	16	21	16	19	19	0.06	0.001	0.6	0.008
n- number of weeds m <sup>-2</sup> ; d. b. - weed dry biomass g m <sup>-2</sup> ; * - atrazine + nicosulfuron												



## **Influence of Weed Management Strategies on Weed Flora and Maize Yield**

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The aim of this study was to determine weed control strategies in maize, affected by rate of organic and mineral fertilization. The aim of this study was to determine weed control strategies in maize, affected by rate of organic and mineral fertilization. A field experiment on Pelic Vertisol in the period 1994 - 1996 in Sofia district was carried out. Three years monoculture of maize randomized complete block design in four replications with plot size 200 m<sup>2</sup> was investigated. The following scheme was used: Factor A - treated with organic fertilizers: a<sub>1</sub> - without organic fertilizers, a<sub>2</sub> - treated with cow manure (40 t ha<sup>-1</sup>) once for three years (in November 1993); Factor B - treated with N, P fertilizers: b<sub>1</sub> - N<sub>0</sub>P<sub>0</sub>; b<sub>2</sub> - N<sub>50</sub>P<sub>40</sub>; b<sub>3</sub> - N<sub>70</sub>P<sub>60</sub>; Factor C - weed control: c<sub>1</sub> - hand-weeding; c<sub>2</sub> - atrazine 1500 g a.i. ha<sup>-1</sup> +nicosulfuron 480 g a.i. ha<sup>-1</sup>. The maize field was not irrigated; cow manure and phosphorus fertilizer was applied during the main soil ploughing in the autumn and nitrogen fertilizer was applied with the last presowing cultivatin. The crop was sown between May 5 and 10. Maize density was 47000 plants ha<sup>-1</sup>, spaced 70 cm between the rows. The atrazine was applied pre-emergence of the maize for selective control of broad-leaved weeds and nicosulfuron was applied of 3-5 leaves of maize and 1-3 leaves of grasses weeds. The first hand-weeding of the control and herbicide variants was made in the growth stage "7-9 leaf", and was repeated in "tasseling" after determining the degree of infestation and the quantities of the dry biomass. In all trial treatments, according to the factors A, B and C, weed spp., and weed dry biomass was determined as number m<sup>-2</sup> and g m<sup>-2</sup>. Maize yield in all variants of the trial were obtained in four replicatas complete factorial treatment arrangement. Data were subjected to analyses of variance and all main effects and interaction tested for significance. The growth of weed flora in combination with the slow development of crop habitus was positive influenced by the sufficient soil moisture due to the winter and spring rainfalls and the propitious condition of the meteorological elements in the period - "emergence to 7-9 leaf" of the maize vegetation, weeds from different biological groups infest the control variant (without herbicides). The main part of the weeds population belongs to the summer dicotyledonus followed by summer monocotyledonous, early spring and winter-spring ephemerals. In the control variant the degree of infestation and the quantities of the weed dry biomass depend on the norm of mineral fertilization. During the three years of investigation these two parameters were highest in the variants with the highest

Each pepper varieties are grown at 2 blocks (each block was 90 m<sup>2</sup>). For the basic fertilizers as 50 kg/da DAP (18-46) and 35 kg.da<sup>-1</sup> K<sub>2</sub>SO<sub>4</sub> are applied.

All the pepper are sewed as 2500 shoots.da<sup>-1</sup> (interrow spacing is 100 cm and intrarow spacing is 40 cm) on 27.10.1997. Fruit harvest were done between February 15 - July 10, 1997. Each tomato variety is grown at 2 blocks which was 269 m<sup>2</sup>. Plant nutrients of tomato varieties were given with irrigation water as MKP, KNO<sub>3</sub>, NH<sub>4</sub>-N, MgNO<sub>3</sub>, MnSO<sub>4</sub>, ZnSO<sub>4</sub>, Borax, CuSO<sub>4</sub>, Na-Molibdat, Squstrine, fosforic acid and nitric acid with the quantities are 75, 600, 200, 100, 1.69, 1.15, 1.69, 0.18, 0.12, 15, 150, 100 g.t<sup>-1</sup>, respectively.

Some physical and chemical analyses are done on soil samples, collected from the greenhouse were given in Table 3.

Some characteristics of irrigation water were analysed as 28 °C, 7.70, 785 µmhos cm<sup>-1</sup>, 91.5, 0.47, 150, 110.2, 41.1, 90.2, 16.2 and 1.7 mg.l<sup>-1</sup> for heat, pH, EC, Cl<sup>-</sup>, NH<sub>4</sub>-N, CaCO<sub>3</sub> and HCO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>-2</sup>, Na<sup>+</sup>, Ca<sup>+2</sup>, Mg<sup>+2</sup>, F, respectively. NO<sub>3</sub>-N, Fe and B weren't found.

### Result and Discussions

In this research, average and total yields additionally some physical properties of tomato and pepper varieties such as plant weights, diameters and lengths were determined. Data were given in Table 4.

It is clear that, the highest yield, both total and per plant, were obtained from the pepper variety Sirena, and tomato variety Elif-190 (Table 4).

This is the first study which is achieved in GAP Region. But the research results are not expessed for the all region. For this reason more studies, using other plant varieties such as ornemental plants, should be done under greenhose conditions in the other part of GAP region.

Some possible advantages were given below with the end of similar research in the Region.

- More income can be supplied especially, from the little or uncultivated soils,
- Fresh and economical vegetable consumption can be possible in the region,
- Products can be submit inside or outside of region. End of this activity, new shopping or marketing units can be established,
- Production will be affected minimum, from the climatic factors e.i. heat, wind, heavy rain or drought because of controled conditions,
- Unemployment problem will be reduced,
- Application of new and the latest agricultural technics and technologies will be possible,
- New investments will be possible mainly on agricultural services and equipments
- Producing of other greenhouse plants e.i. ornemental plants will be possible



Some of the climatic factors belong Şanlıurfa were given in Table 1 (Anonymous, 2001). After using of geothermal water to the heat the greenhouses, plant production activities have been developed significantly in the Karaali village, Şanlıurfa. Other systems, such as fuel-oil and LPG, geothermal heat systems need more initial investments. But, management expenditure is constituted only for circulation of water inside pipe in the geothermal heat systems. This is about 20 % of the other heat systems.

Pepper and tomato varieties are riched respect nutrients (Bergmann, 1988), which are produced prevalently in Turkey (Anonymous, 2000). Sufficient nutrient contents of tomato and pepper varieties were given in Table 2.

100 g pepper fruits have included 1.5 % protein, 5.4 % carbohydrates and 1 % lipid with the 38 calories while tomato varieties are included 0.89 %, 4 %, 0.2 % and 26 calories, respectively (Vural et al., 2000). Tomato and pepper varieties are also rich respects some vitamins such as A, thiamin B<sub>1</sub>, riboflavin B<sub>2</sub>, ascorbic acid and niacin. All these specialties are very important for region people's health. There are significant meat consumption, mainly sheep. So, cholesterol and obesity are appeared of major health problems among the region people due to especially excessive consumption of sheep meat.

#### **Material and Methods**

Melis F<sub>1</sub>, Sirena F<sub>1</sub> and Balo pepper additionally, Fantastic-144 and Elif-190 tomato varieties were used in this research all varieties were grown first time in the greenhouse, GAP region. Some properties of tomato and pepper varieties were given below.

**Sirena:** It is a kind of Charleston pepper and has strong plant structure, with its excellent fruit set. It has long, thin and white fruit. Its fruit lengths are changed between 18-22 cm. It is resistant to tobacco mosaic viruses.

**Balo:** It is a kind of stuffing pepper variety. Balo is excellent due to its thin fruit inside. It is resistant to tobacco mosaic viruses. It is suitable to produce in winter and autumn.

**Melis:** It is a wintery pepper variety. It has thin fruit with its green color and its fruit lengths are around 20 cm. It is resistant to tobacco mosaic viruses.

**Elif-190:** Elif-190 is suitable to be grown for autumn and spring season. It has excellent fruit shape and homogenous red color. At the same time, it is strong versus transportation and splitting. Average fruit weights are around 180 g.

**Fantastic-144:** It has high fertility and uniform fruit structure. It has a suitable variety for autumn season and strong to some disease such as verticillium, fusarium and tobacco mosaic viruses.

Greenhouse was heated with the geothermal water. Geothermal water was used for irrigation after rest in pool.



## **Determining Yield Level and Some Physical Properties of Some Pepper (*Capsium Annuum L.*) and Tomato (*Lycopersicon Esculentum L.*) Varieties Grown at Greenhouse Conditions and Its Possible Profits to Gap Region**

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### **Abstract**

The greenhouse in which this study was established is located in Karaali Village, 45 km far from Şanlıurfa. At the end of this study, the highest yield as total (10238 kg/da) and per plant (4.1 kg) was obtained from the pepper variety of Sirena. In the study, fruit weights were determined between 26 and 56 g for Sirena; 30-39 g for Melis and 40-64 g for pepper varieties of Balo. Additionally, fruit diameters were measured 28.4-37.6; 20.2-30.2 and 41.0-57.6 mm for Sirena, Melis and Balo, respectively. Fruit lengths were found as 157-224; 194-262 and 71.9-90.5 mm for pepper varieties of Sirena, Melis and Balo, respectively. According to the results the highest yield as total (23038 kg/da) and per plant (9.68 kg) was obtained from the tomato variety of Elif-190. While fruit weight of Elif-190 was 125-154 g, fruit width was 55.7-73.9 and plant height was 50.5-63.5 mm. Fruit weight, fruit width and plant height of Fantastic-144 ranged between 129-154 g; 60.2-68.7 and 50.4-61.5 mm, respectively. With the making of similar studies a lot of profits will be supply such as more income, reducing of unemployment, attaining of new technics and technologies and using of uncultivated or little soils in the Region.

### **Introduction**

Earning more income from the unit area, depending on quantities and qualities of production, is the basic propose of agricultural activities.

Plant production is done mainly in fields while some plants such as vegetables are grown under cover. Factors, such as land fragmented, legacy, salinization or rocky soils force people to grow plants in greenhouses. At the same time, in the winter because of climatic restrictions, different kind of vegetables are produced in greenhouses. This kind of plant production is more profitable.

Southeastern Anatolia Project (GAP) region has widely geographic area (73863 km<sup>2</sup>) and population (7.2 million). Principle advantages of GAP Region are expressed as mines, soils, sun energy and water sources (Bilen, 1991; Yücel, 1991). The biggest outcome point is sourced come from the heat systems and used materials in greenhouse conditions. Heat outcome of the greenhouses can reach to 75 % of the total expenditure in the GAP Region. Nevertheless, Şanlıurfa have many advantages to for production greenhouse plants including climatic factors.

value, this area would suffer from P deficiency and lower yields. A 1.05 ha area (28.3%) was high in P, and there was no need for P fertilization for this class. And the remainder of the field (41%) was very high in P, and fertilization of this area with P would carry some serious environmental risks. Thus, uniform P fertilizer applications would underestimate P needs in some portions of the field.

For agricultural research standpoint, we are in a stage of fine-tuning. Increased usage of agricultural chemicals within the last 50 years has caused environmental problems. We must seek new methods to increase effectiveness of agricultural inputs. Site specific management or precision agriculture has great potential to increase effectiveness of agricultural inputs.

**Key Words:** Phosphorus, variability, site specific management

## Measuring within Field Variability for Phosphorus: A Site Specific Approach

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The dramatic increase in worldwide fertilizer use has raised concerns regarding possible negative impact of fertilizers on the environment and renewed interest to seek new methods to manage fertilizers in a more efficient manner.

Advances in technology, global positioning systems (GPS), and geographical information systems (GIS) have driven a recent movement toward precision agriculture or site specific management. Site specific management is defined as applying the right management at the right time, at the right place, and in the right way or simply managing by soil condition.

Defining soil spatial variability is the first step for site specific fertilizer management. Then, the question how to manage this variability should be addressed. It is generally accepted that a more detailed soil sampling will result in more precise fertilizer recommendations. Grid soil sampling is intensively used for this purpose. In this study, the objective was to measure field variability of Olsen's phosphorus based on a 20.5 m grid in a cotton field in the Narli Plain of Kahramanmaraş. Grid soil sampling is intensively used for this purpose.

Based on the summary statistics of soil P analysis, the mean value for Olsen's P was 14.5 mg/kg. If we were to make our P recommendation for the whole field based on the mean value, no P fertilizer would be recommend. However, coefficient of variation for P was quite high (cv 31%) suggesting that there was a high within field variability. The Olsen's P values ranged from 5.5 to 24 mg/kg in the field, and the range was 18.6 mg/kg. These findings suggest that field was heterogeneous for P, and uniform P management would lower yield in some part of the field.

If soils were uniform, there would be no need for site specific management. Currently, a field as big as 4-5 ha in size is accepted as a homogeneous area for making fertilizer recommendations. A composite soil sample is collected by taking 15-20 separate cores, at random, in a zigzag pattern across a field. This sub-sample is thoroughly mixed in a bag to represent the whole field. Then, according to the test results, a uniform fertilizer recommendation is made for the field.

Relative levels of Olsen's P are classified as very low, low, medium, high, and very high. A 1.14 ha area (30.7%) in the field is considered low and medium in P and needed P fertilization. If P fertilizer recommendation was based on the mean P



Anonymous, 1983; Çoban and İtler, 1996). Two methods have been used in order to determine the color differences of the raisins seedless. In the first method, 'D 25 Hunter Color Difference Meter' device has been used. In this analysis; (L) means 'brightness', (100) and (0) values indicate 'full white color' and 'full black color' respectively. When (a) values become (+), (-) and they indicate red, green and grey colors, respectively. Similarly, as (b) values become (+), (-) and (0), they indicate yellow, blue and grey colors (Köylü and Karagözoğlu, 1995; Çoban and İtler, 1996). The second method has been determined according to Turkish Standards Institution (TS 3411) (Anonymous, 1983).

### Results and Discussion

The effects of zinc applications from soil and foliar at different levels on some quality characters of raisins seedless (drying yield, brilliance of the color and type numbers) were given in Table 2.

It was found to be significant relationships between Zn applications from soil and foliar for drying yield, brilliance of the color and type numbers.

Drying yield related to amount of dry matter is one of important factors which affected the quality of raisins. Drying yield increased as dose increased with Zn applications from soil and fluctuations were observed with applications from foliar. A significant difference among doses was not found by the result of statistical analysis.

The doze x application interaction, however, was significant at the 0.05 probability level. The highest values in the applications from soil and foliar were 5.0 g/vine Zn at third level (21.84%) and 0.05 Zn% at third level (24.90%) respectively. The lowest values were determined in the control for both applications. These results have supported the view that Zn increased the dry matter and yield of grape (El-Shamy and Haggah, 1987; Strakhav, 1988; Er *et al.*, 1998).

The color of raisin was one of most important factors determined the quality of raisin. The relationships among the doses were found to be not significant at evaluation of color by first method considering the statistical analysis of L, a and b values. The difference between the applications from soil and foliar for L and b values was significant at the 0.05 probability level. The doze x application interaction was significant at 0.05 level. The results similar to this were found for type number and the highest values (45, 9<sup>1/2</sup>) for raisins seedless's standard color values and type numbers in the application from soil were obtained from third level of Zn (5.0 g/vine). The highest values for some characteristics in the application from foliar was 73 and 10<sup>1/2</sup> at third level of Zn (0.05%). These results were in agreement with the values of standard for raisins seedless of number 3411 (Anonymous, 1983).

As a result, it was determined that the Zn applications from foliar were more effective on the quality of raisins seedless than those of applications from soil.

## The Effect of Zinc Applications from Soil and Foliage on Some Quality Characters in Grapevine (*Vitis Vinifera* L.)

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**Abstract:** This study was carried out to determine the effects of zinc applications from soil and foliar at different levels on some quality characters of raisins (drying yield, brilliance of the color and type numbers) which revealed the market value of raisins seedless.

In experiment which was conducted with four replications, zinc applications were made from soil (0-2,5-5,0-7,5 g/vine) in one time and from foliar (0-0,025-0,05-0,10%) in three times as  $ZnSO_4 \cdot H_2O$  for both applications. It was found that zinc applications from soil and foliar caused to be significant differences for maximum drying yield, brilliance of the color and type numbers and foliar application was more effective in comparison with soil application.

**Key Word:** Grapevine, raisins seedless, zinc, soil application, foliar application

### Introduction

Turkey takes an important position in the viniculture of the world and ranks 6<sup>th</sup> place in fresh production and 4<sup>th</sup> place in the vineyard area. The most important provinces in raisin production is in Aegean region. Raisin production, mostly for export (80%), is at the amounts to 250.000 tons annually (Anonymous, 2001)

The high and quality yield which would be obtained from vineyards as it was for all the crops may be possible provided that all the nutrients were given at the time when it needed in addition to the managements. The zinc which is a micro nutrient has an important effect on the grape quality because it plays an important role in the synthesis of oxcin which is a plant growth hormone and increases the use efficiency of other nutrients. Moreover, the great number of researchers determined that zinc applications increased the yield and quality of grape (El-Shamy ve haggah, 1987; Strakhov, 1988; Er ve ark.,1998).

### Material and Methods

This experiment was carried out in Çakırcalı region, under farmer conditions, in 2001. 15 years aged ungrafted *Vitis vinifera* L. Cultivar Round seedless variety was planted as 'Y' training system. The soil structures of these vineyard are homogenously and sandy-loamly and the routine cultural processings such as soil management, fertilization and plant protection were done.

The study were conducted in randomized blocks with four replications and the statistical analysis were done according to Yurtsever (Yurtsever, 1984). Zinc applications were made from soil (0-2,5-5,0-7,5 g/vine) in one time and from foliar (0-0,025-0,05-0,10 %) in three times as  $ZnSO_4 \cdot H_2O$  for both applications. For determining the effect of zinc applications from soil and foliage on some quality characters in raisins seedless drying yield, brilliance of the color and type numbers (expertise value) were investigated (Winkler *et al.*, 1974;



other soil formed on marl parent material is classified as Inceptisol order, Xerepts suborder, Haploxerepts great group according to the soil taxonomy.

Color of Profile 1, developed from granodiorite of volcanic rocks is 10 YR hue. Since this profile include between 48% and 59 % sand; it is the coarsest texture in all pedons soil, pH values range from 7,65 to 8,17. Lime content increased and organic matter become less thought the depth. However organic matter accumulated in Ap horizon as result of excessive fertilizing and low leaching. In generally, the CEC is lower in the surface horizon and increasing with depth as compared with subsurface horizon. As a result they are low soluble salt and  $\text{CaCO}_3$  throughout the profile depth, the soil is not affected by salt toxicity. Kaolinite that is present in Ap horizon was found considerable higher amount in fine fraction than in coarse fraction. This case indicates that kaolinite formed from weathering of smectite. Depending on this information, this soil formed on granodiorite is the beginning of soil formation. Since it is shallow and has high slope, it was thought that soil was transported by erosion. There is not a significant difference in iron oxide percentages among the horizons. This shows that physical weathering was more effective than chemical weathering in soil formation. Based on the morphological properties were examined, Profile 2 was formed on Neocene aged limestone. Along the profile, hue, value and chroma were found to be 10 YR, 5-7 and 3-4 respectively. It is the deepest in all research soils. Clay content of soil is increasing though depth but after 110 cm, this amount is slightly decreasing and texture turned to silty clay. Owing to insufficient illuviation of clay and absence of clay cutans in B-horizon of soil profile, cambic subsurface diagnostic horizon was observed. In the value of  $\text{CaCO}_3$  is high level for all horizons. However, owing to calcification  $\text{CaCO}_3$  accumulated between 44 cm and 140 cm according to this case. It was determinate that this pedon has been still inherited from effect of parent material. Depending on the clay analysis in coarse and fine fractions of the profile, it was found that the dominant clay mineral was smectite and followed by kaolin and illite. Moreover chlorite was found in coarse clay fractions of C1k horizon and fine clay fractions of C2k horizon. Profile number 3 is formed on basalt parent rock. When the soil is air dry, hue, value and chroma are 10YR, 4-5 and 2 respectively. Soil depth is 62 cm between Ap and C-horizons. Free iron oxide percentage is high for each horizon. If we compare both horizons in 3.profile it was found that  $\text{Fe}_2\text{O}_3$  is high in C horizon due to effect of parent material, high weathering degree and cracking. In addition that, another important reason for illite that commonly exist in soil is that this mineral is resistance to weathering. Resistance to weathering is especially related to chemical events.

### **Conclusion**

Depositions don't have a significant effect on three studied soil system formed on three different parent material and losses from the soil were not observed. Very little transportation exists in three soils under semi arid climate conditions and mesic soil temperature regime, and very little changes were observed in these weathering conditions. Three soils formed on granodiorite, limestone and basalt parent rocks in semi-arid climate conditions are also in development stage. Morphological, physical, chemical and mineralogical results of this research show that soils are young, effect of weathering on soil formation is slow, and effect of parent material is significantly important for the soil development.



## Clay Mineralogy and Genesis of the Three Different Soils from Beypazari Region, Ankara

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### Abstract

In this study, the clay mineralogy and genesis of the soils, originated from three different parent materials, in Beypazari, Ankara, were investigated by using some morphological, physical, chemical and mineralogical analysis. Attempts were made to clarify the mineralogical characteristics of the soils that developed on the granodiorit, marl, and basalt and to elucidate both the proportional contribution of each soil forming factors to the soils and the effect of soil formation processes on the soils. The soils developed on granodiorit and basalt were classified as Entisol order, Orthent suborder and Xerorthent great soil group and the soil developed on marl corresponded to Inceptisols order, Xerepts suborder, Haploxerepts Great Soil Group, according to the Soil Taxonomy (1999). Simectite was found to be the dominant clay mineral of both coarse and fine clay fractions of all soil samples. In addition to, kaolin, illite and mixed layered clay minerals were determined in each of three soils. It couldn't find out any differences among the compositions of clays and their ratios in the coarse and the fine clay fractions of all the soil samples.

### Introduction

Soil is characterized by factors of soil formation. So that, it has different properties in different environment that is constituted by external factors of soil formation (Tanju,1996). For example, it is revealed that all soil formation process of the soil originated from fluvial terrace of Tormes River (Spain) doesn't have a stabile development and horizontal difference is bounded time (Alonso et al,1993). Vegetation was not developed in Arid and Semiarid region, so it has a secondary role in soil formations. Parent material has more effect on the soil formation of studied pedons in the semi arid climate region. In this study, the clay mineralogy and genesis of the soil, originated from three different parent materials. In Beypazari, Ankara, attempts were made to clarify the mineralogical characteristics of the soil that developed on the granodiorit, marl and basalt and to elucidate both the proportional contribution of each soil forming factors to the soils and the effect of soil formation processes on the soils.

### Materials and Method

Beypazari is located in Ankara Province, Turkey, approximately 150 km northwest of Ankara City. Three pedons were selected to study from three different parent materials. Geology of the pedon 1 consist of Paleozoic age granadiorite layer, pedon 2 consist of upper Miocene age marl and then Middle Miocene age basalt. Climate in the study area is characterized by dry and hot summer and a warm, wet winter. The moisture regime is Xeric and temperature regime is Mesic. For laboratory methods: Practical size distribution was determined by hydrometer method, Free iron oxide determined by the dithionite-citrate-bicarbonate method (Soil Survey Staff, 1996); Clay samples ( $< 2\mu\text{m}$ ) selected from surface and removal of cementing agents and dispersion, prepared for XRD analysis after fine clay ( $< 0,2\mu\text{m}$ ) and coarse clay ( $> 0,2\mu\text{m}$ ) collected by centrifugation (Jackson,1965 and Whitting et al 1986).

### Result

The Study pedons were classification; soils that originated on granadiorit and basalt rocks are Entisol order, Orthent suborder, Xerorthent great soil grub and the

## Results and Discussion

After field work which is applied by using slope classes map overlaid color composite image as a preliminary soil map, six soil series formed on two different physiographic units were determined and mapped in 27 mapping units. Due to fact that, the Arız and Turgut soil series usually located on summit position with nearly flat to gentle slope, they have moderately deep, well developed profiles with A, B, C horizon designation and  $\text{CO}_3$  accumulation with the depth. In spite of these, Behzat, soil series located on back slope position with moderate to steep slope. So it has shallow, weak developed profile due to severely erosion with A, C horizon designation and high amount  $\text{CaCO}_3$  throughout to profile. The Çal and Karakuş Soil Series have very deep, weak developed profile with A, C horizon designation and in clayey texture while Kışladere series has very deep to, moderately well developed profile with A, B, C horizon designation and loamy clay in texture. Based on morphological and physicochemical properties, the soils of the Karacabey–Arız and Doğla agricultural lands have been classified as Entisol, Mollisol, Vertisol and Inceptisol according to Soil Taxonomy (1994). Agricultural potential of the soils restricted by the steep slope, shallow soil depth, and high amount of  $\text{CaCO}_3$  content of the subsurface horizon.

The major photo-interpretation elements such as land forms, relief, slope etc. are the base-stones of the both monoscopic and stereoscopic interpretation of satellite images as well as aerial photographs for delineation of soil boundaries. The disadvantages caused by the absence of stereovision of the Landsat images during the image interpretation for soil survey were eliminated by using slope classes map and shaded relief map derived from 10-m DEM. The slope classes map from 10-m DEM overlaid Landsat images can easily be used for soil survey with extensive ground truth where there are proven close relationships between soils and topography and soils are situated hilly terrain. 3D-View with slope classes boundaries overlaid Landsat images or shaded relief map as a color map, can be used to define physiographic units, to select possible site of soil profile pits and to distinguish distribution of the soils. The soil survey efficiency can be increased by using large-scale geological map, high-resolution satellite data or black and white aerial photographs.

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procedures that use slope, relative relief and profile to define different landform and tested them in New Mexico using a 200 m cell size DEM. Brabyn (1997) developed a new automated landform classification processes to eliminate classification problem caused by microrelief effect of Dikau's automated processes. Brabyn used a circle neighborhood analysis window effect (NAW) and a 500 m cell size. Hammer et al. (1995) used 10 m DEMs and 30 m DEMs with GIS to investigate precision and accuracy of computer generated slope class map for soil survey and land use planning. They suggested that slope class maps produced from the 10 m DEM appear to have great potential use for soil survey and land use planning. Bayramin (2001) tested the use of non-soil data (DEMs satellite images, digital geological data) for improving mapping efficiency and quality of soil maps and developed a pre-model for soil mapping for countries that conventional soil surveys are not being finished.

## **Material and Methods**

GDRS was decided to establish upland irrigation project for the Ariz-Doğla villages' agricultural lands in 1998. Due to this project, detailed soil survey and mapping works using by satellite and digital terrain data were applied in order to produce soil, land capability classification and irrigation suitability classification maps and to test the usage probability of slope class map overlaid color composite images as a preliminary map for soil survey in hilly terrain. The study area located 4455000-4460000 m north latitude and 593000-596000 m east longitude. It is at the north west of Bursa and it covers an area of 7500 decares. Materials used for the study include; i- Topographic maps, scale 1:25.000, 1977, ii- Landsat TM, June 1993, iii- Soil map of the Bursa province, scale 1:100.000, GDRS, 1995.

The satellite data was geo-referenced to UTM map projection through ILWIS 1.4 and subsequently enhanced for improving the visual aspect of the images (ITC, 1993). The color composites were prepared by Landsat 5 TM bands (in combination 3,5,7 band as RGB). The contour lines 10 m interval of the topographic map were digitized and slope map with six slope classes (0-2, 2-5, 5-8, 8-15, 15-30, >30 %) was made by ILWIS using a DEM 5\*5 smooth filter was applied to eliminate speckle effect, and then slope classes map produced with screen digitizing in vector format. The vectorized slope class map overlaid color composite image was used to delineate soil boundaries and other land features as preliminary soil map.

DEM data were also used to produce 3D-view with slope class boundaries superimposed Landsat image and shaded relief map as a color map in order to select possible site of soil profile and to define physiographic units. After extensive field checking/sampling and corrections of the preliminary soil map, final soil map was produced and published in 1:25.000 scale. The soil series and their important phases, in this case these were slope, texture, depth and stoniness, were considered as a basic mapping units. 27 mapping units were determined after the fieldwork. Soil profiles were described and sampled according to Soil Taxonomy (1975). Necessary analysis for classifying and determining physical and chemical properties were done according to Soil Conservation Service (1972). On the basis of morphological and physicochemical characteristics, the soil profile classified according to Soil Taxonomy (1994).



## **Detailed Soil Survey and Mapping Works at the Karacabey-Ariz and Dođla (Bursa) Agricultural Lands Using Dem**

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### **Introduction**

Only 24 % or 3,2 billion ha of the World's total ice-free area is potentially arable, i.e. land that can be cultivated and/or maintained in productive pasture of these about 40 % or 1,3 billion ha is high to moderately productive and 60 % is of low productivity currently the best of these lands are already used for cropland, i.e. 1,5 billion ha, and the remainder are in permanent pasture, forest and woodland (Buringh and Dudal, 1987).

Increasing demands for food and material expectations of growing population can only be meet by integrated land resources planning and management rather than from bringing new lands into cultivation if considered currently used land coverage for cropland. Soil surveys are the base-stone activity in integrated land recourses planning and management practices. To describe actual condition or states and to detect changes of the soils have vital importance for their sustainable use and management. In the past these data could only be collected in the field but advances in computer technology and techniques have introduced new group of tools, methods, instrument and systems especially for to improve acquisition, processing, transforming, displaying, mapping and use of geo-information (or spatial data).

In order to describe actual condition, to detect changes and find out characteristics and distribution of the soils that one of the most important unrenewable resources, for sustainable use and management, soil surveys are the best and essential way especially in developing countries. Used base maps and applied methods can be varied due to available instruments, data, experienced person, hardware and software, etc. In our work, available base maps were topographical maps in 1:25.000 scale and Landsat TM data, while software program was ILWIS 1.4 (Integrated Land and Water Information System developed by ITC, in 1993) Remote Sensing and GIS program. That is why during the soil survey and mapping works the false color composite image (Landsat TM 357 bands used for RGB) superimposed DEM were used to delineate the physiographic units and to find out the characteristics and distribution of the different soil types. In this study, our objectives were to produce soil map by using integrated satellite and Digital Terrain data and to evaluate the use of slope class map derived from 10 m. DEM overlaid color composite images for detailed soil survey in the hilly terrain. A DEM can be manipulated to provide many kinds of data that can assist the soil surveyor in mapping and giving a quantitative description of landform and of soil variability. By itself the DEM can yield maps of slopes, aspects, rate of change of slope, drainage networks on catchment areas. Computers have been used for extracting terrain information from digital elevation model (DEM) for at least last 20 years. Dikau et al. (1991) developed automated processes that essentially simulate Hammond's manual methods which are based on quantitative

opposite of ammonium contents of the soil and acquired due to the conversion of ammonium to nitrate following mineralization

As for the mean values, 1% tobacco waste determined to be the most effective according to CO<sub>2</sub> production and DHA activity, which was followed by 1% green manure and 1% stubble application. For nitrate development 1% tobacco waste was again the most effective and followed by 1% green manure respectively. Tobacco waste (1%) and 1% green manure treatment showed significant effects however other treatment revealed relatively low values (Table 1).

**Table 1.** The effects of different organic substrate incorporation on NO<sub>3</sub><sup>-</sup>-N and NH<sub>4</sub><sup>+</sup>-N contents, CO<sub>2</sub> production and DHA activity in soil

	NO <sub>3</sub> <sup>-</sup> -N (□g g-ds <sup>-1</sup> )*	NH <sub>4</sub> <sup>+</sup> -N (□g/g-ds <sup>-1</sup> )	CO <sub>2</sub> (mg.100 g ds <sup>-1</sup> 24 h <sup>-1</sup> )	DHA (□g TPF/10 g ds <sup>-1</sup> )
Wheat stubble (0.5%)	9.68 G	5.61 C	32.38 D	298 D
Wheat stubble (1%)	14.43 F	6.20 C	41.47 B	398 BC
Tobacco waste (0.5%)	39.32 D	5.81 C	33.22 D	363 C
Tobacco waste (1%)	58.79 A	9.16 A	46.41 A	486 A
Green Manure mix. (0.5%)	35.81 D	5.25 D	31.73 D	309 D
Green Manure mix. (1%)	49.52 C	8.58 AB	42.68 B	405 B
Control	9.50 G	5.50 CD	19.48 E	170 F

ds: dry soil

In all treatments the control treatment value was significantly lower than the other. Results revealed that the properties of organic matter, which is added to soil, are quite important for enhancing soil quality.

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## **The Effects of Different Organic Substrates on Nitrogen Mineralization and Some Microbiological Properties in the Soil**

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Soil organic matter is the major component for physical, chemical and biological productivity of the soils. However, the organic matter contents of the widely arable lands of Turkey are insufficient (%1-2). Mono cultural production, stubble burning, instead of using as organic fertilizer, the gathering and removing the harvest remains for various purposes, rare use of additional organic fertilizer and the climatic conditions (especially semi-arid) have special role on the insufficient organic matter contents of the soil (Diercks, 1983; Gök et. al., 1998).

The effects of incorporation of different amounts (0.5%, 1.0%) of wheat stubble, tobacco waste, green manure plants (vetch, oat, horse bean and vetch & oat mixture) with significant differences in C, N contents and C/N ratio, on nitrogen mineralization (nitrate and ammonium occurrence) and the biological activity of soil (CO<sub>2</sub> production and dehydrogenase activity) in laboratory condition as a function of incubation time were studied.

The C and N contents, along with the C/N ratio of the soils were 46.8%, 0.70%, 66.9 for wheat stubble; 38.4%, 2.40%, 16.0 for tobacco waste; 30.5%, 2.57% and 11.9 for green manure plants mixture. The soil samples were incubated (30 °C, field capacity) for 63 days and analyzed for their nitrate and ammonium contents as an indicator of mineralization as well as CO<sub>2</sub> production and DHA activity as an indicator of biological activity in regular intervals (Schlichting and Blume 1952; Gök et. al., 1999). The soils which wheat stubble applied were enriched by nitrogen (KNO<sub>3</sub>) in calculation as 1 unit N for 200-unit stubble (w/w).

Results revealed that there was positive correlation between mineralization speed and the composition of organic matter (C, N and C/N ratio). Thus, green manure plants with high and low C/N ration following the first week of treatment the CO<sub>2</sub> production was significantly higher than the other mixtures. Ammonium values measured in first week was also parallel to CO<sub>2</sub> production, which might be due to the amonification of the mineralized N. The mineralization rate was significantly decreased for the green manure plant when 1<sup>st</sup> week was compared to the following periods. Tobacco waste treatment sustained high level of mineralization for longer periods than the green manure plant mixture.

The nitrate contents of soil were significantly increased contrarily ammonium contents following the 3<sup>rd</sup> week of incubation, which was assigned as the



Factor	The K factor WEG *	The T	Rating		
No visible 8-7-6	<0,05	5	10	Well drained	10
				Moderately well	8
Slight 5-4	0,05-0,10	4	8	somewhat excessively drained	7
Moderate 3	0,10-0,20	3	6	Somewhat poorly drained	5
Severe 2	0,20-0,40	2	4	Poorly drained	4
Extreme 1	>0,40	1	0	Excessively or very poorly drained	0

\*Wind erodibility group

**6F-** Rating on soil structure.

The rating is calculated to sum the rating of 6F-A with the rating of 6F-B. The rating of 6F-A multiply by 2, if there isn't any subsurface horizon.

6F-A The structural shape of epipedon	Rating	6F-B The structural shape of subsurface horizons	Rating
Strong granular, blocky	5	Granular, blocky, prismatic	5
Moderate granular, blocky	4	Weak platy	3
Weak granular, blocky	3	Moderate, strong platy; columnar	2
Platy	2	Massive, single grain	1
Massive, single grain	1		

**6G-** Rating on  $\text{CaCO}_3$  content.

The rating is calculated to sum the rating of 6G-A with the rating of 6G-B. The rating of 6G-A multiply by 2, if there isn't any subsurface horizon.

6G-A The lime of epipedon	Rating	6G-B The lime of subsurface horizons	Rating
Lime 5,0-10,0 %	5	Lime 5,0-10,0 %	5
Lime 1,0-5,0 %	4	Lime 1,0-5,0 %	4
Lime 0,0-1,0 %	3	Lime 0,0-1,0 %	3
Lime 10,0-25,0 %	2	Lime 10,0-25,0 %	2
Lime 25,0-50,0 %	1	Lime 25,0-50,0 %	1
Lime > 50,0 %	0	Lime > 50,0 %	0

**6H-** Rating on Cation- Exchange Activity classes (CEAC; CEC,  $\text{cmol k}^{-1}/\text{clay}$ , %)

The rating is calculated to sum the rating of 6H-A with the rating of 6H-B. The rating of 6H-A multiply by 2, if there isn't any subsurface horizon.

6H-A The CEAC of epipedon	Rating	6H-B The CEAC of subsurface horizons	Rating
CEAC, > 0,60	5	CEAC, > 0,60	5
CEAC, 0,60-0,40	4	CEAC, 0,60-0,40	4
CEAC, 0,40-0,24	3	CEAC, 0,40-0,24	3
CEAC, <0,24	1	CEAC, <0,24	1

**6I-** Rating on nutrient level.

The rating is calculated to sum the rating of 6I-A with the rating of 6I-B. The rating of 6I-A multiply by 2, if there isn't any subsurface horizon.

6I-A The nutrient level of epipedon	Rating	6I-B The nutrient level of subsurface horizons	Rating
High	7	High	8
Fair	6	Fair	7
Poor	4	Poor	3
Very poor	3	Very poor	2

**Factor 4. Stones, boulders and/or rocks fragments.**

The rating is calculated to sum the rating of 4A with the rating of 4B. The rating of 4A or 4B multiply by 2, if there isn't 4B or 4A conditions.

4A- Stone, boulder or rock fragments in the soil	Rating
Stone, boulder or rock fragments 0-5 %	50
Stone, boulder or rock fragments 5-15 %	40
Stone, boulder or rock fragments 15-35 %	30
Stone, boulder or rock fragments 35-60 %	20
Stone, boulder or rock fragments >60 %	10
4B- Stone, boulder or rock fragments at the surface	Rating
Stone, boulder or rock fragments 0-0,01 %	50
Stone, boulder or rock fragments 0,01-0,1 %	48
Stone, boulder or rock fragments 0,1-3 %	45
Stone, boulder or rock fragments 3-15 %	35
Stone, boulder or rock fragments 15-50 %	25
Stone, boulder or rock fragments 50-90 %	10
Stone, boulder or rock fragments >90 %	5

**Factor 5. Rating on salinity, alkalinity and reaction (pH, 1/ 2,5 H<sub>2</sub>O).**

The rating is calculated to sum the rating of 5A, 5B, 5C and 5D. The rating of 5C multiply by 2, if there isn't any subsurface horizon.

5A- Peresent salinity	Rating	5B- Peresent alkalinity	Rating
Salt, <0,15 %; EC, <4ds/m	25	ESP, < 10	25
Salt, 0,15-0,35 %; EC, 4-8 ds/m	15	ESP, 10-15	20
Salt, 0,35-0,65 %; EC, 8-16 ds/m	10	ESP, 15-30	10
Salt, >0,65 %; EC, >16 ds/m	5	ESP, 30-50	5
		ESP, > 50	2
5C- The reaction of epipedon	Rating	5D- The Reaction of subsurface horizons	Rating
pH, 6,1-7,8	25	pH, 6,1-7,8	25
pH, 7,9-8,4; 6,0-5,6	20	pH, 7,9-8,4; 6,0-5,6	20
pH, 8,5-9,0; 5,5-4,5	15	pH, 8,5-9,0; 5,5-4,5	15
pH, >9,0; <4,5	10	pH, >9,0; <4,5	10

**Factor 6. Rating on various properties.**

The rating is calculated to sum the rating of 6A, 6B, 6C, 6D, 6E, 6F, 6G, 6H and 6I. The rating of 6F, 6G, 6H and 6I multiply by 2, if there isn't any subsurface horizon.

6A- Rating on rainfall (annual)	Rating	6B- Rating on physical root restriction or cementation or induration or fragipan character or hardpan.	Rating
<i>If land irrigate, the rating is 15</i>		No problem	10
>700 mm	15	<i>If there is a problem in 75 cm depth:</i>	
650-700 mm	13	Fragipan character	8
600-650 mm	11	Non cemented plough pan	6
550-600 mm	9	Any kind of hard pan	5
500-550 mm	7	<i>If there is a problem deeper than 75 cm depth:</i>	
<500 mm	5	Fragipan character	9
		Any kind of hard pan	7
6C- Rating on present degree of erosion	Rating		
No visible evidence of erosion or very slight sheetwash (<10 t/ha/y)	10		
Slight- slight sheetwash. Shallow rills affecting less than 10% of plot (10-25 t/ha/y)	8		
Moderate- moderate sheetwash. Rills affecting 10-25 % of plot (25-50 t/ha/y)	6		
Severe- severe sheetwash. Gullies or rills affecting 25-50 % of plot (50-100 t/ha/y)	2		
6D- Rating on potential risk of rosion		6E- Rating on drainage and hydromorphy.	Rating

# The Complex Square Root Parametric System for Land Evaluation Method on Soils of the Thrace Region

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The Thrace Region has a great agricultural production potential arising out of ecological and climatological condition, land property and high productive soils. The dominant soils in thrace are of Entisol, Inceptisol, Alfisol, Vertisol Ordos. Also Mollisol and Spodosol Ordos spread on the narrow local areas. The northern humid belt along the Black leas of Thrace has udic moisture regime. The centre and North sides of Thrace has mesic temperature regime. The other temperature regime is thermic. This paper propose a complex square root system for land evaluation method was applied a framework suitable in the investigation and mapping of land resources in agricultural reform, in land consolidation projects and in land evaluation projects for development planning.

**Productivity index=  $R \max \times \sqrt{A/100 \times B/100 \times C/100}$**

**The first two maximum rating+Various properties rating**

**R max= Avarage maximum rating=**

**3**

**A, B, C= Other rating besides the rating of R max**

**Factor 1. Rating on textural classes.**

The rating is calculated to sum rating of 1A with the rating of 1B. The rating of 1A multiply by 2, if there isn't any subsurface horizon.

1A- The texture classes of epipedon	Rating	1B-The texture classes of subsurface horizons	Rating
vfSL, L, SiL, Si, CL, SCL, SiCL	50	vfSL, L, SiL, CL, SCL, SiCL	50
SC, SiC, C-60%	45	SC, SiC, C-60%	45
SL, fSL	40	LS, fSL	40
cSL, C+60%	35	cSL, C+60%	30
LS	30	LS	25
S	25	S	15

**Factor 2. Rating on slope.**

	Rating		Rating
Level, nearly level 0-2%	100	Nearly level, undulating 0-2%	97
Gently sloping 2-6%	95	Gently sloping, undulating 2-6%	90
Sloping 6-12%	85	Strongly sloping 12-20%	75
Moderatly step 20-30%	50	Steep 30-45%	40
Very step > 45%	20		

**Factor 3. Rating on depth (solum (A+B)).**

	Rating		Rating
150 cm+	100	100-150 cm*	95
75-100 cm*	90	50-75 cm*	85
20-50 cm*	60	0-20 cm*	30

\*If there are parent material and/or transitional horizons and/or combination horizons that deeper than 50 cm and C; BC; AC; CA; B/C horizons have porous medium and/or cracks for easily root penetration; at this conditions the rating is calculated to sum the rating of above value with rating of below value:

0-20cm	+30;	20-50cm	+20;	50-75cm	+5;	75-100	+5;	100-	+5
						cm		150cm	



indigenous and selected *G. clarium* mycorrhiza accessions on citrus growth as well as P (phosphorus) and Zn (Zinc) uptake.

### Material and Methods

The experiment was carried out in a greenhouse at the Department of Soil Science, Çukurova University, Adana, Turkey. Two different mycorrhizal species and two different growth media were tested.

The growth media used was Konya and Sultanönü soils. Arbuscular mycorrhizal species used were *G. clarium* and Indigenous (collected from citrus rhizosfer). Under greenhouse conditions, following the germination of citrus seeds (*Citrus sinensis* L.), the seedlings were transplanted to 3 L containers. Before transplantation, each seedling received 1000 spores. Non-mycorrhizal plants also received the same amount of medium free of mycorrhizal spores. Zn doses applied were 0, 5, 10 mg kg<sup>-1</sup> soil, while P doses used were 0 and 100 mg kg<sup>-1</sup> soil. The roots were analyzed for the degree of mycorrhizal inoculation in the root cortex was assessed by the method of Koske and Gemma (1989). Root colonization was determined using a gridline intersect method (Giovenetti and Mosse, 1980). Also at Harvest, plant dry matter, plant height, mycorrhizal infection and P and Zn contents were determined.

### Results and Conclusions

The results showed that the mycorrhizal inoculation significantly increased dry matter production (Table 1). Plant growth was different between the two soils. Compared to Konya soil, selected mycorrhizae and indigenous mycorrhiza inoculation significantly increased plant shoot growth of Sultanönü soil. In non-inoculated Konya soil, plants grew up to some extent but in Sultanönü soil, plants did not grow as expected. Differences in plant growth between the two soils may depend on soil fertility. In both soils at 0 mg P kg<sup>-1</sup> soil and 5 mg Zn kg<sup>-1</sup> soil application plant growth was higher than in the respective control. *G. clarium* inoculation increased plant growth and nutrient uptake more than the indigenous inoculums. In general plants grown in Sultanönü soil developed better than those grown in Konya soil. Mycorrhizal inoculation also affected the percentage of root infection. Mycorrhizal inoculation also significantly increased the plants P and Zn uptake.

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## Determination of Various Mycorrhizae Species and Growth Media on Nutrient Uptake of Citrus

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### Abstract

The aim of study was to investigate the effect of indigenous and selected *G. Clarium* mycorrhizae species on citrus growth and P (phosphorus) and Zn (Zinc) uptake. The experiment was carried out in a greenhouse at the Department of Soil Science , Çukurova University, Adana, Turkey. The growth media used were Konya and Sultanönü soils, which are poor in P and Zn availability. Arbuscular mycorrhizal species used were *G. Clarium*, and *indigenous* (collected from citrus rhizosfer). Zn used was 0, 5, 10 mg kg<sup>-1</sup> soil. P used was 0 and 100 mg kg<sup>-1</sup> soil. Each seedling received 1000 spores. Non-mycorrhizal plants also received the same amount of medium mycorrhizal spores. The results showed that the mycorrhizal inoculation significantly increased dry matter production, root infection and nutrient uptake. In both soils at 0 mg P kg<sup>-1</sup> soil and 5 mg Zn kg<sup>-1</sup> soil application plant growth was higher. In general plant grown in Sultanönü soil was better than Konya soil.

### Introduction

Citrus is commonly grown in the Çukurova Region, located on the East Mediterranean coast of Turkey. As the soils of the Çukurova region lack in P and Zn it is important to test them for their suitability for citrus production. For an optimum growth and balanced nutrition, fertilization some time is needed. In order to reduce unnecessary amount of fertilizer, mycorrhizal inoculation is very important . This will contribute to reducing both pollution of the environment and the cost of citrus production. Mycorrhizal citrus plants grow better than non-mycorrhizal ones (Menge *et al.*, 1982; Antunes and Cardoso, 1991; Syvertsen and Graham, 1999). Kleinschmidt and Gerdemann (1972); Menge *et al.*, (1978) reported that following fumigation of soils for the production of citrus in North America, nutrient-deficiency symptoms and stunting were observed related to the elimination of arbuscular mycorrhizal fungi.

Several greenhouse experiments have shown that citrus trees are dependent on mycorrhizal colonization (Vinayak and Bagyaraj, 1990; Camprubi and Calvet, 1996; Ortaş *et al.*, 2002 a b). Subsequently, it has repeatedly been reported that citrus plants need mycorrhizal infection for their maximum growth. Since most of the citrus orchards in the eastern Mediterranean region are nutrient deficient, it was targeted to investigate the effect of mycorrhizal inoculation on citrus seedling for better plant growth. The aim of this study was to investigate the effect of

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were observed between all chemical extraction methods, except 1 N  $\text{NH}_4\text{OAc}$  method and the biological indices (dry matter yield, Fe concentration, Fe uptake, relative dry matter yield, relative Fe concentration, relative Fe uptake) at 1 % level (Table 2).

According to Table 4, the highest correlation coefficients were determined between 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA and 0.005 M DTPA + 1M  $\text{NH}_4\text{HCO}_3$  methods and biological indices. Similar results were reported by Aydemir (1981)

According to Table 4, the highest correlation coefficients were determined between 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA and 0.005 M DTPA + 1M  $\text{NH}_4\text{HCO}_3$  methods and biological indices. Similar results were reported by Aydemir (1981)

### Conclusion

Eight chemical extraction methods were used in this research for the determination of available Fe content of soil samples. The order of significance of these methods are given below; 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA; 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$ ; 0.01 N  $\text{Na}_2\text{EDTA}$  + 1 N  $\text{NH}_4\text{OAc}$ ; 0.01 M  $\text{Na}_2\text{EDTA}$  + 1 M  $(\text{NH}_4)_2\text{CO}_3$ ; 0.01 N  $\text{Na}_2\text{EDTA}$ ; 0.05 N HCl + 0.025 N  $\text{H}_2\text{SO}_4$ ; 2 N  $\text{MgCl}_2$  and 1 N  $\text{NH}_4\text{OAc}$ .

The 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA and 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$  methods, among the others, can be used confidently to determine the available Fe content of calcareous soils in Thrace region because the highest correlation coefficients determined when these methods used (Table 2). These methods were also suggested for various regional soils (Aydemir, 1981; Haddad et al. 1993; Elinç, 1997). Our suggestion and suggestion of the others on the use of 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$  method is based on the fact that the shaking times are comparatively shorter, shaking time of this method is only fifteen minutes and the cost of chemical compounds used is lower. However, the method of 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA shaking time of which is two hours and resulted in the highest correlation coefficient can also be used in the determination of the available Fe content in this region calcareous soils if the time is not a limiting factor and zinc (Zn), copper (Cu) and manganese (Mn) contents are to be determined in addition. The characteristic of this method therefore is to be taken into consideration when selecting a method.

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Soil samples were taken at 0- 20 cm depth from 12 different cultivated soils in Thrace region (Jackson, 1962). The soil samples collected were of varying physical and chemical properties.

pH values of soil samples were between 7.27 and 7.83; organic matter contents were between 0.77 % and 2.45%;  $\text{CaCO}_3$  contents were between 3.21 % and 26.14 %; CEC values were between 17.8 and 25.6  $\text{cmol kg}^{-1}$ ; texture of soils samples were between clay (C) and sandy loam (SL).

The available Fe contents of the soil samples were determined through eight different chemical extraction methods

The experiment was done in greenhouse conditions with three replications and barley was grown. Four different doses of Fe ( $\text{Fe}_0$ : 0;  $\text{Fe}_1$ : 10;  $\text{Fe}_2$ : 20; and  $\text{Fe}_3$ : 30  $\text{mg kg}^{-1}$ ) were applied to soils as Fe-EDDHA compound. Fifteen plants were left on each pot after the germination. Plants were harvested after 60 days and prepared for analysis (Kacar,1972). Fe contents of plants were determined with AAS (Kacar,1995). The result of the experiment were evaluated statistically (Yurtsever,1984).

## **Results and Discussion**

### **Effect of Increasing Fe Application Rates on Barley Yields, Fe Concentration and Fe Uptake**

Dry matter yields of barley increased with Fe application up to  $\text{Fe}_2$  dose and then decreased with  $\text{Fe}_3$  dose. Fe concentration and uptake of Fe amount of barley increased with Fe applications. The increasing and decreasing effects of Fe application on biological indices (dry matter yield, Fe concentration and Fe uptake) of barley were determined to be statistically significant at level of 0.01. Similar results were observed by previous researchers (Aydemir, 1981; Elinç, 1997).

### **The Fe Contents of Soils According to Different Extraction Methods**

Eight extraction methods were used for the determination of available Fe content of the soil samples. According to these methods, available Fe content of the soil samples determined were given in Table 1.

As shown in Table 1, higher available Fe content of soil samples were determined with 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$  and 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA methods in comparison to other extraction methods. On the other hand, the least available Fe content of soil samples were determined with 1 N  $\text{NH}_4\text{OAc}$  and 2 N  $\text{MgCl}_2$  methods. These results are in the same line with other results reported earlier for different regions in Turkey (Elinç,1997; Gedikoğlu et al.1998).

### **The Relationships Between Chemical Extraction Methods and Biological Indices**

The correlation coefficients determined between chemical extraction methods and biological indices are given in Table 2. Significant correlation coefficients

# Determination of Suitable Chemical Extraction Methods for Available Iron (Fe) Contents of Calcareous Soils in Thrace Region

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## Abstract

The aim of this research was to determine the available iron (Fe) content of calcareous soils in Thrace region and the most suitable chemical extraction method. Eight chemical extraction methods (0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA; 0.05 N HCl + 0.025 N  $\text{H}_2\text{SO}_4$ ; 1 N  $\text{NH}_4\text{OAc}$  (pH: 4.8); 0.01 N  $\text{Na}_2\text{EDTA}$  + 1 N  $\text{NH}_4\text{OAc}$ ; 2 N  $\text{MgCl}_2$ ; 0.01 M  $\text{Na}_2\text{EDTA}$  + 1 M  $(\text{NH}_4)_2\text{CO}_3$ ; 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$  and 0.01 N  $\text{Na}_2\text{EDTA}$  methods) and six biological indices (dry matter yield, Fe concentration, Fe uptake, relative dry matter yield, relative Fe concentration, relative Fe uptake) were compared. Biological indices were determined with Barley (*Hordeum vulgare* L.) grown under greenhouse conditions. At the end of the experiment the highest correlation coefficients were determined to be between 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA method and biological indices and between 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$  method and biological indices. The correlation coefficients for 0.005 M DTPA + 0.01 M  $\text{CaCl}_2$  + 0.1 M TEA method were  $r:0.642^{**}$ ;  $r:0.820^{**}$ ;  $r:0.794^{**}$ ;  $r:0.446^{**}$ ;  $r:0.548^{**}$  and  $r:0.652^{**}$  and for 0.005 M DTPA + 1 M  $\text{NH}_4\text{HCO}_3$  method are  $r:0.620^{**}$ ;  $r:0.532^{**}$ ;  $r:0.687^{**}$ ;  $r:0.518^{**}$ ;  $r:0.492^{**}$  and  $r:0.632^{**}$ , ( $^{**}:p<0.01$ ) respectively. These extraction methods, among all the methods tested were suggested for the determination of available Fe content of calcareous soils in Thrace region.

**Key words:** Fe, extraction methods, barley, biological indice.

## Introduction

Fe deficiency is one of the trace element problem in the world nowadays. This element deficiency was determined as about 26.87 % Turkey's soils (Eyüpoğlu et al. 1998).

Despite the fact that several Fe extraction methods have been developed none of them was suitable to be a standard method (Loeppert and Inskeep, 1996).

The 0.001 M EDDHA method was suggested for the determination of available Fe content in the USA. Because this method has produced the highest correlation with biological indices (Johnson and Young, 1973).

Fe deficiency is a major plant nutrition problem in Edirne calcareous soils. In this research, suitable method(s) for the determination of available Fe content of calcareous soils in Thrace region was investigated.

## Materials and Methods



The most pronounced effects of microbial inoculation were found in the phase of flowering. In amended with manure soil, strain 201 stimulation on mycorrhizal infection was confirmed. Root N-concentration significantly increased. *Glomus mosseae* inoculation enhanced mycorrhizal infection by 55%. As a result, plant dry weight and N-uptake increased. The effect of mixed inoculation *Glomus mosseae*+201 was highly positive. Shoot dry weight rose by 53%. Nodule formation was markedly stimulated and plant N-uptake was enhanced. Mycorrhizal infection exceeded the control level (Table 1).

In manure+superphosphate fertilized soil, increased mycorrhizal infection and N-uptake were noticed in both 201- and *Glomus mosseae* treatments. The mixed inoculation had significantly positive influence on plants, similarly to the effect in manure amended soil. Nodule number, N-uptake and root infection level considerably increased.

Data obtained suggested a synergistic interaction between *Glomus mosseae* and strain 201, resulting in better plant growth and nutrient uptake.

**Table1** Microbial inoculation effects on plant growth and nutrient uptake. Treatments: 1- uninoculated control, 2- strain 201, 3- *Glomus mosseae*, 4- *Glomus mosseae*+201. LSDs at 5% level are given

	Treat ment	6-10 leaf phase				Flowering phase			
		manure		manure+superph		manure		manure+superph.	
		shoots	roots	shoots	roots	shoots	roots	shoots	roots
Dry weight (g/plant)	1	0.92	0.13	1.02	0.17	2.39	0.66	3.19	0.81
	2	0.90	0.14	0.99	0.20	2.67	0.81	3.43	0.80
	3	1.13	0.28	1.38	0.22	3.33	0.71	3.72	0.88
	4	0.95	0.20	0.99	0.15	3.67	0.79	4.28	0.92
	LSD	0.14	0.07	0.15	0.06	0.84	0.29	1.01	0.35
P-conc. in tissues (%)	1	0.100	0.030	0.176	0.070	0.220	0.190	0.200	0.264
	2	0.140	0.090	0.160	0.168	0.172	0.180	0.180	0.120
	3	0.116	0.120	0.163	0.120	0.200	0.182	0.182	0.206
	4	0.111	0.100	0.180	0.080	0.160	0.160	0.140	0.180
	LSD	0.027	0.028	0.032	0.026	0.031	0.021	0.030	0.037
N-conc. in tissues (%)	1	1.65		1.65		0.53	1.15	0.73	1.24
	2	2.02		1.80		0.53	1.58	0.75	1.62
	3	1.65		1.43		0.45	1.43	0.76	1.47
	4	1.80		1.58		0.83	1.59	0.97	1.76
	LSD	0.25		0.27		0.24	0.26	0.21	0.20
Mycor rhizal Infec tion (%)	1		52		46		56		69
	2		64		51		76		83
	3		67		64		87		90
	4		68		56		79		88
	LSD		8.17		12.9		18.8		8.52
Nodule number	1						0.33		0.66
	2						1.00		2.00
	3						0.66		1.30
	4						6.00		3.00
	LSD						1.21		2.03

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## Interaction between Phosphate Solubilizing Bacteria and Mycorrhizal Fungi in Soybean Rhizosphere

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Mycorrhizal association between roots and arbuscular mycorrhizal fungi (AMF) contribute substantially to sustained plant productivity and soil conservation (Jeffries & Barea, 1994). The efficient mycorrhizal symbiosis depends on many agro-ecological factors, as well as on relations with soil microflora.

The aim of the work was to study the efficacy of soybean inoculation with phosphate solubilizing bacteria and mycorrhizal fungi on plant growth and nutrient uptake.

The study was carried out on leached chernozem (pH – 6.14, organic matter – 2.68%, available phosphorus – 2.2 mg  $P_2O_5$ /100g,  $NH_4^+$ -N – 10 mg/kg,  $NO_3^-$ -N – 5.0 mg/kg,  $K_2O$  – 24.5 mg/100g). Before sowing soil was fertilized with manure (0.83 g/kg) and manure+superphosphate (13.3 g/kg). Pots were replicated three times. Two plants (*Glycine max* L.) per pot were sown. Inoculation was done at the moment of setting the experiment. Soybean seeds were coated with bacterial suspension of phosphate solubilizing bacteria of strain 201 ( $10^6$  cells/seed). 50 g/pot of the inoculum of arbuscular mycorrhizal fungus *Glomus mosseae* was introduced on a layer under the soil surface. There were four treatments in the experiment: 1- uninoculated control, 2- strain 201, 3- *Glomus mosseae*, and 4- *Glomus mosseae*+201. Plants were grown in a fitotrone chamber under a light power of 18000 lux, 16 h day ( $t^\circ$  – 26°C) and 8 h-night ( $t^\circ$  – 15°C). Pots were watered daily to maintain 60% of water holding capacity.

Analyses were made in 6-10 leaf and flowering phases. Root and shoot dry weights, N- and P-concentrations in plant tissues, the number of nodules and mycorrhizal infection in roots were determined. Data were analyzed by ANOVA.

In 6-10 leaf phase in amended with manure soil, significant effects of inoculation in all treatments were noticed. Inoculation with strain 201 increased plant N- and P-uptake and had positive effect on mycorrhizal colonization. In this treatment, as well as in the controls, plants were colonized by indigenous AMF. The 23% increment of root infection indicated that strain 201 stimulated mycorrhiza development in soybean roots. The effect was probably due to growth promoting substances in bacteria metabolites, which was shown in other works (Azcon-Aguilar & Barea, 1985). Plant dry weight was highly positively influenced by *Glomus mosseae* inoculation. Mycorrhizal root colonization increased by 29%, which resulted in better P-uptake than control plants. Mixed inoculation *Glomus mosseae*+201 increased plant P-uptake (Table 1).

In the soil amended with manure+superphosphate, strain 201 increased root P-uptake. *Glomus mosseae* affected positively shoot dry weight, root P-uptake and mycorrhizal infection.

# POSTER PRESENTATIONS



**Table 1.** Nitrate nitrogen concentrations ( $\text{mg L}^{-1}$ ) in water and soil samples observed during 2000 and 2001 at different water table depths

Water sampling periods	Sampling depth (cm)	Water table depth (cm)					
		0.6	0.9	1.2	0.6	0.9	1.2
		Water samples 2000			Water samples 2001		
1 <sup>st</sup> irrigation*	0.3	23.2	27.1	39.1	40.2	56.1	68.4
	0.6	17.6	20.2	25.4	37.6	48.7	54.1
	0.9	12.5	18.6	23.7	22.5	38.1	35.1
	1.2	8.6	12.2	16.3	17.6	21.1	16.1
3 <sup>th</sup> irrigation	0.3	6.1	13.4	4.7	16.1	23.0	14.0
	0.6	13.2	6.5	14.2	15.9	34.3	32.3
	0.9	10.5	17.9	16.9	13.5	17.1	36.1
	1.2	7.4	5.4	12.1	6.9	2.1	17.9
4 <sup>th</sup> irrigation**	0.3	37.9	48.6	56.2	45.1	63.1	68.2
	0.6	45.4	32.2	21.9	61.2	51.2	36.1
	0.9	28.1	22.5	18.2	20.1	24.8	21.3
	1.2	5.8	10.1	17.5	21.7	31.1	17.2
6 <sup>th</sup> irrigation	0.3	12.6	25.0	19.2	35.1	24.4	13.1
	0.6	29.3	29.2	26.4	31.0	39.0	56.3
	0.9	25.6	18.8	24.3	25.1	22.6	27.0
	1.2	1.4	13.6	9.2	9.9	18.1	28.1
8 <sup>th</sup> irrigation	0.3	8.8	15.2	8.9	20.0	25.1	06.4
	0.6	14.5	17.2	20.2	12.1	27.5	20.5
	0.9	6.5	8.9	16.1	16.9	18.1	22.8
	1.2	2.4	5.8	11.2	18.1	15.3	17.7
Last irrigation	0.3	4.5	1.2	6.1	5.1	6.7	4.4
	0.6	2.3	4.5	3.3	0.3	2.2	6.1
	0.9	1.4	6.1	8.7	6.1	12.0	12.2
	1.2	1.8	2.2	4.1	9.1	6.4	11.1
		Soil samples 2000			Soil samples 2001		
Samples taken before fertilizer application	0-0.3	0.6	0.9	0.6	0.5	0.1	0.7
	0.3-0.6	0.8	1.0	0.1	2.1	1.5	0.9
	0.6-0.9	1.1	3.3	1.9	1.3	4.0	1.9
	0.9-1.2	0.1	2.1	3.5	0.6	0.5	1.3
Samples taken after fertilizer application	0-0.3	39.5	40.6	105.1	46.2	81.7	66.4
	0.3-0.6	62.0	67.5	85.4	33.0	29.1	41.3
	0.6-0.9	28.1	30.7	27.7	24.9	21.9	30.9
	0.9-1.2	12.6	12.0	31.8	16.1	18.2	18.2
Samples taken after harvest	0-0.3	1.9	0.8	3.1	2.5	4.1	3.2
	0.3-0.6	3.1	0.2	3.1	7.3	2.1	4.6
	0.6-0.9	1.1	2.3	6.1	4.4	11.1	8.2
	0.9-1.2	3.1	1.4	1.5	2.2	6.6	1.1

\*First dose of fertilizer applied, \*\*Second dose of fertilizer applied

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different at different water table depths during growing season. The overall data shown in this table indicate that the concentrations at shallower water table depths of 0.6 m were lower than those at 0.9 m and 1.2 m depths for both years. A possible reason for decreased nitrate concentration at shallow water table depth is increased rate of denitrification because of anaerobic conditions that help the denitrification of nitrate nitrogen in the soil profile. Also the average nitrate nitrogen concentrations decreased with increased soil depth for all water table depths. The data show that nitrate concentrations were higher at the time of fertilizer application and generally decreased with increased depth and time during the growing season. It was also observed that flood irrigation expedited movement of nitrates into the soil profile, which resulted in higher concentrations at deeper soil depths at the time of harvest. Since heavy doses under flood irrigation cause deep percolation that enhances the leaching potential of fertilizers from surface layers to deeper depths, therefore higher concentrations at these depths could be anticipated. The presence of nitrate nitrogen in excess of  $10 \text{ mg L}^{-1}$  at deeper depths, in particular, is dangerous because nitrate will keep moving towards shallow ground water tables and will consequently contaminate them. The population living in the rural areas that use these contaminated ground waters for drinking are likely to experience substantial health risks.

Data on cotton yield (not shown here) were collected during both study years. The yields were higher at deeper water table depths. The highest yields of  $2820 \text{ kg ha}^{-1}$  were observed at 1.2-m water table depth as compared to  $2552 \text{ kg ha}^{-1}$  and  $1946 \text{ kg ha}^{-1}$  at 0.9 and 0.6 water table depths, respectively during 2000. Almost similar trends were observed during 2001 and the highest yields were obtained at 1.2-m water table depths. The yields obtained during this year were 2678, 2423, and  $1898 \text{ kg ha}^{-1}$  at 1.2, 0.9, and 0.6-m depths respectively.

## Conclusions

Results from two years data show that nitrate nitrogen concentrations were lower at shallow water table depths during the growing season. The average nitrate nitrogen concentrations generally decreased with increasing depth and time during the growing season. Results reveal that significant amounts of nitrogen are being leached below the root zone that might become a potential threat to shallow ground water. The average nitrate concentrations were higher than the EPA's water quality standards of  $10 \text{ mg L}^{-1}$  under all water table depths. The presence of concentrations in excess of safe drinking limit at deeper soil depths warns that it will continue to leach-down blow root zone into shallow ground water tables and contaminate them, which is hazardous for human health. The population living in the rural areas using these contaminated ground waters for drinking is likely to experience substantial health risk.



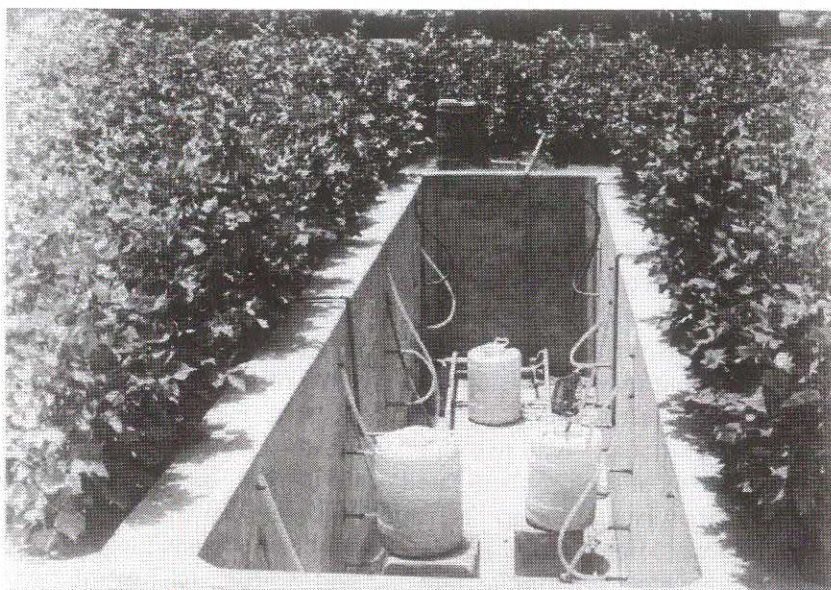
The lysimeters were checked for seepage or leakage before soil filling. They were completely filled with water and left for 72 hours. During this period they were covered with a plastic sheet to minimize the evaporation losses. The lysimeters were filled with soil excavated earlier. At the bottom of each lysimeter, a 5-cm thick layer of well-graded boulders with 10-25 mm diameter was placed around the perforated drainage pipes. Another layer of 5-cm thick gravel with 1-10 mm diameter was placed over the boulders. A 5-cm thick third layer of river sand was placed over the second layer. This combination provided a 15-cm thick filter at the bottom of each lysimeter. Water was infiltrated from the bottom to provide proper settling of the filter material. Once the filter material was placed, the soil filling process was initiated. Each lysimeter was filled with a representative soil layer. After the placement of each layer, water was allowed from the bottom to move upward until it appeared on the top of the soil. Soil was allowed to dry up for one week or when it reached to the plastic limit. Samples were taken for bulk density determination. If the bulk density differed from the original one, the soil was gently compacted until the desired bulk density of the layer was achieved. A 2-cm thick layer of fine graded hill sand was also placed around the network of perforated PVC pipes installed at 60, 90, and 120 cm.

All the lysimeters were equipped with piezometers, made up of 25-mm diameter PVC pipes, to collect water samples. The piezometers were installed at 30, 60, 90, and 120-cm depths. Water samples were collected before fertilizer application and continued until harvest. The piezometers were pumped out one day before sampling, the water samples were collected on the following day and stored in a cold chamber at 4° C for later analysis. Soil samples were also collected from the 0-30, 30-60, 60-90, and 90-120-cm depths. They were collected before fertilizer application, after 15 days of fertilizer application and at the time of harvest. Urea nitrogen fertilizer was surface applied in two equal splits at the rate of 200 kg-N ha<sup>-1</sup> during every year. The first dose was applied at the time of first irrigation while the second dose applied at the time of fourth irrigation. A single dose of Di-Ammonium Phosphate (125-kg ha<sup>-1</sup>) was applied during seedbed preparation. The seeds of cotton variety Nayyab-78 were manually sown on 17 May 2000 and on 10 May 2001. The seeds were soaked overnight and were sown in three rows spaced at a distance of 60 cm with a 30-cm plant to plant spacing. This arrangement resulted in a total of 18 plants in each lysimeter. Pesticides were sprayed whenever an attack of pests was witnessed during both study years.

## Results and Discussion

Table 1 gives the average nitrate nitrogen concentration at various depths for three water table depths for both years. The nitrate nitrogen concentrations were

was laid at the bottom of pit and was filled with 20-cm thick mortar of cement and concrete. The pit was divided into three sections and the lysimeters were constructed in the outer sections of the pit while the middle section was used to install water-controlling mechanism, to collect water samples, and to fix measurement equipment. Each lysimeter has been bounded by 15-cm thick masonry wall. To minimize the seepage from the bottom and leakage from the walls, caustic soda was added with the mortar. In addition, the walls were also coated with bitumen. Four pieces of Galvanised Iron (GI) pipe with 1.27-cm diameter were fitted at 60, 90, 120, and 150-cm depths in the inner wall of each lysimeter. The pipes installed at 60, 90 and 120-cm depths were used to control water levels as well as to collect water samples. These pipes were connected



**Photograph Showing a View of Lysimeters with Cotton Crop Grown**

with perforated poly vinyl chloride (PVC) pipes extending inside the lysimeters. The perforated PVC pipes were wrapped by nylon cloth to restrict silt entry. The pipes located at 150-cm depth (at the bottom of lysimeter) were connected to perforated PVC pipes at the inner sides and connected to water supply tanks at the outer sides. The tanks were equipped with a float mechanism that controls water level in the lysimeter and regulates the water flow in the tank. A water meter has been fitted in the pipe supplying water to the tank. This supply pipe also extends to the surface of each lysimeter to provide water for surface irrigation.



allows deep percolation of water, but may also cause leaching of nutrients below root zone depths. It is almost impossible to control the volume of percolating water under conventional flood irrigation; however, some efficient and improved irrigation methods, such as trickle and sprinkler, have the potential to reduce leaching of chemicals. Minimizing leaching losses out of the root zone could decrease the pollution potential of nitrogen fertilizers without decreasing the profitability of crop production. Therefore, it is necessary to study the better management practices that would reduce these losses into shallow ground water by minimizing their movement below root zone depths. The introduction of modern irrigation methods and development of better management practices necessary to prevent contamination of surface and groundwater by nitrates will require knowledge of soil nitrogen dynamics and the development of models that accurately predict nitrate movement in soils on a site-specific basis. Movement of field-applied nitrate into surface and ground water is a complex process and is dependant upon the weather, nitrogen application method, farm management practices, soil properties, and hydrologic factors.

A large proportion of irrigated land in Pakistan is affected by water logging due to continuous irrigation in the absence of appropriate drainage. Water tables have risen from 8 m depth to about 2 m in many areas (Tarar, 1995). According to recent reports quoted by Mirjat et al. (1999) nearly 2.4 million hectares have water tables located within 2 m or less of the soil surface during summer season. In such areas, irrigation by conventional flooding is not only decreasing water table depth but may be causing fast leaching of nitrate to shallow ground tables and contaminating them. It is believed that over 70 percent of the population living in such areas use this source for drinking purpose without knowing the hazards of such contaminated water. To the best of our knowledge, very little work has been done to determine the potential for nitrate leaching under conventional flood irrigation. Therefore, this study was aimed to determine the movement of nitrate into the soil profile and towards shallow ground waters under conventional flood irrigation.

## **Materials and Methods**

The experiments were conducted at the research station of Sindh Agriculture University Tandojam to determine the movement of nitrate nitrogen under conventional flood irrigation. Nine field lysimeters were used to control ground water levels at 0.6, 0.9, and 1.2-m depths. The square-shaped field lysimeters, as shown in photograph, with each side measuring 1.83 m, were constructed during 1999 at the research site. A rectangular pit measuring 9.5 x 6.5 m was excavated to 2-m depth in layers of 30 cm each. Each layer was separated placing a plastic sheet between them so that it could be used to refill the lysimeter after construction with the same soil. A double layered plastic sheet



## Introduction

Agriculture is a dominant economic activity that contributes over 36% to the gross domestic product (GDP) of Pakistan. About 70 percent of the population living in rural areas is directly or indirectly engaged in agriculture. Agriculture is mainly practised in the Indus Plain formed by the mighty Indus and its tributaries. The increasing population requires that agricultural production must be increased to meet the food and fibre needs of the population. In order to increase agricultural production, the efficient use of fertilizers along with other chemicals has become integral to achieve this goal. As a result of their use, crop quality and quantity have improved substantially in the past few decades. But some questions on the impact on surface and groundwater still remain unanswered. There is growing public awareness over the long-term threat to both surface and ground waters due to leaching of agro-chemicals, which is becoming a serious threat to human health, wild and aquatic life. Particularly, nitrate leaching into ground water has become one of the major pollution concerns facing agriculture in the world today. Active research is being carried out in the United States and in other parts of the world to identify the best possible alternatives, which will not hamper the crop production system either qualitatively or quantitatively, but will reduce their potential threat to environment. Several studies have been conducted to measure the loss of nitrate nitrogen leaching below the root zone down to subsurface drainage (Baker and Johnson, 1981; Kanwar et al., 1988, 1991, 1996; Wright et al., 1992; Mirjat et al., 1997, 1998). Most of these studies indicate that, on average, an equivalent of 20 to 40 percent of the applied nitrogen fertilizers are being lost below the root zone to subsurface waters. Hallberg et al. (1986) even reported the losses of nitrate nitrogen in excess of 50 percent. The current practices of fertilizer application methods and rates are believed to be contributing significantly in the contamination of groundwater. Although it is practically impossible to reverse the environmental pollution caused by fertilizers, the growth of this problem can be mitigated through efficient soil and water management practices. In irrigated areas, the irrigation method, amount of water applied and time of application can play a significant role in reducing the downward movement of these chemicals. They can minimize the leaching of chemicals to groundwater. There is a need to develop alternative strategies, such as improved water, soil, tillage, and nitrogen management practices that will improve the sustainability of agriculture and protect the environment.

In Pakistan, the crops are usually irrigated by conventional flood irrigation. This means that the fields are either partly inundated, in the case of furrow irrigation, or entirely inundated, in the case of border or basin irrigation, which require large amounts of water. This increases the opportunity time for infiltration that

## **Ground Water Quality Concerns under Conventional Flood Irrigation**

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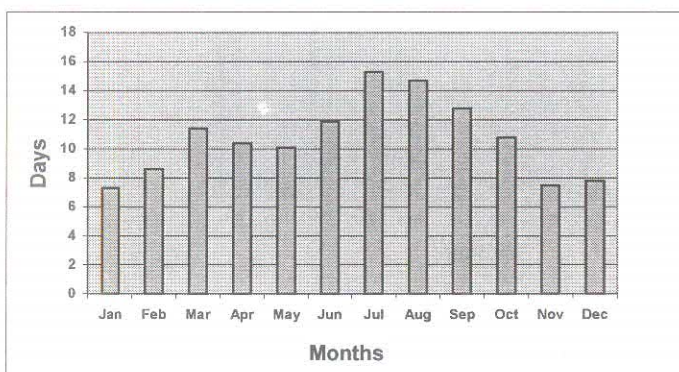
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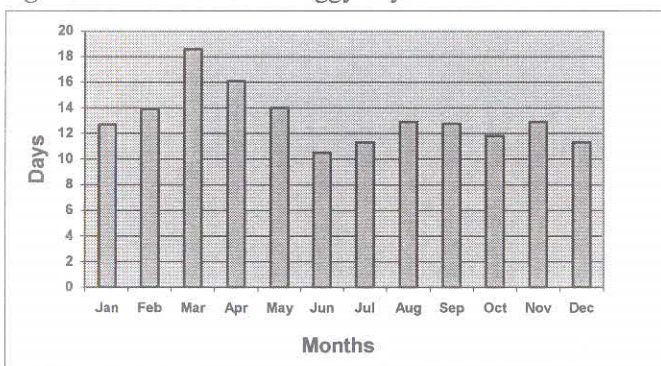
### **Abstract**

The ever-increasing population of the world requires that agricultural production must be increased to meet the food and fibre needs of the population. Fertilizers along with other chemicals are believed to be integral for sustainable agriculture. As a result of their use, both the quality and quantity of crops have improved substantially in the past few decades. But there is a growing awareness about their impact on surface and groundwater quality in developed as well as in developing countries. The public, in these countries, is concerned over the presence of these chemicals in groundwater bodies, which is becoming a serious threat to human health, wild and aquatic life. Particularly, leaching of nitrate into groundwater has become one of the major pollution concerns facing agriculture in the world today. The current practices and excessive rates of fertilizer application are believed to be contributing significantly to the contamination of groundwater in developing countries. In irrigated agriculture, conventional irrigation methods might be the source of nitrate leaching. Although it is practically almost impossible to reverse the environmental pollution problems caused by fertilizers, their leaching potential can be ameliorated through efficient use. In irrigated areas, the irrigation method, amount of water applied and time of application can play a significant role in reducing the downward movement of these chemicals.

The present study reports preliminary results on nitrate nitrogen leaching into soil profiles under conventional flood irrigation in Pakistan. The study was conducted at the research station of Sindh Agriculture University Tandojam to determine the movement of nitrate nitrogen under conventional flood irrigation in the presence of a shallow water table. The results reveal that significant amounts of nitrogen are being leached below the root zone that might become a potential threat to shallow ground water. Concentrations of nitrate nitrogen in excess of  $10 \text{ mg L}^{-1}$ , a threshold limit for health concerns to infants, were observed at 1.2-m soil depths. The research at this stage is still continuing. However, the trends of nitrate concentrations measured below root zone depths reveal that they will continue to leach down towards shallow groundwater tables and consequently contaminate this source. The population living in the rural areas that use these contaminated ground waters for drinking are likely to experience substantial health risks.

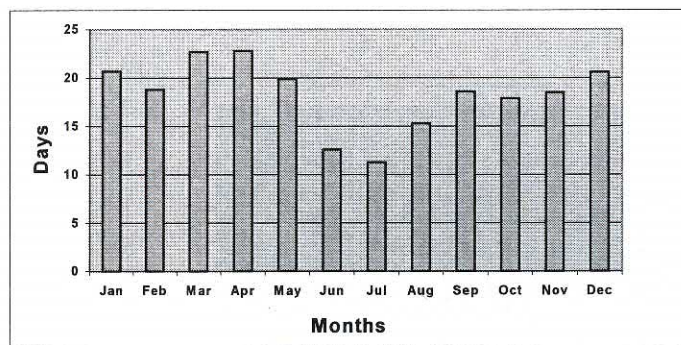


**Figure 5.** Distribution of foggy days in Bandar Abbas.

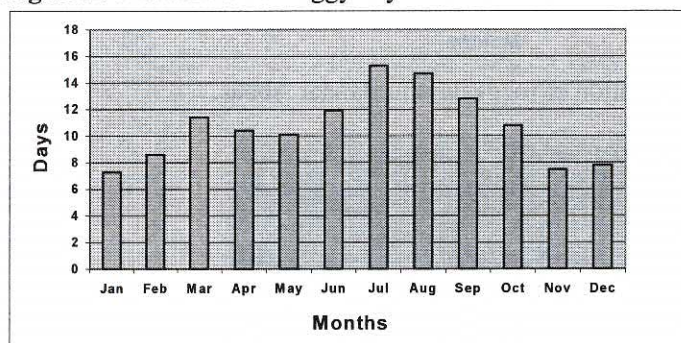


**Figure 6.** Distribution of foggy days in Qaem Shahr.

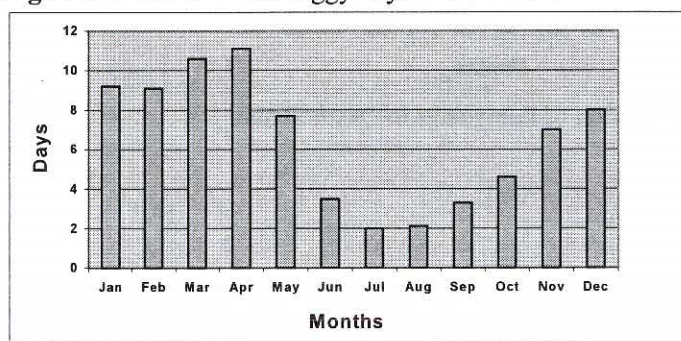




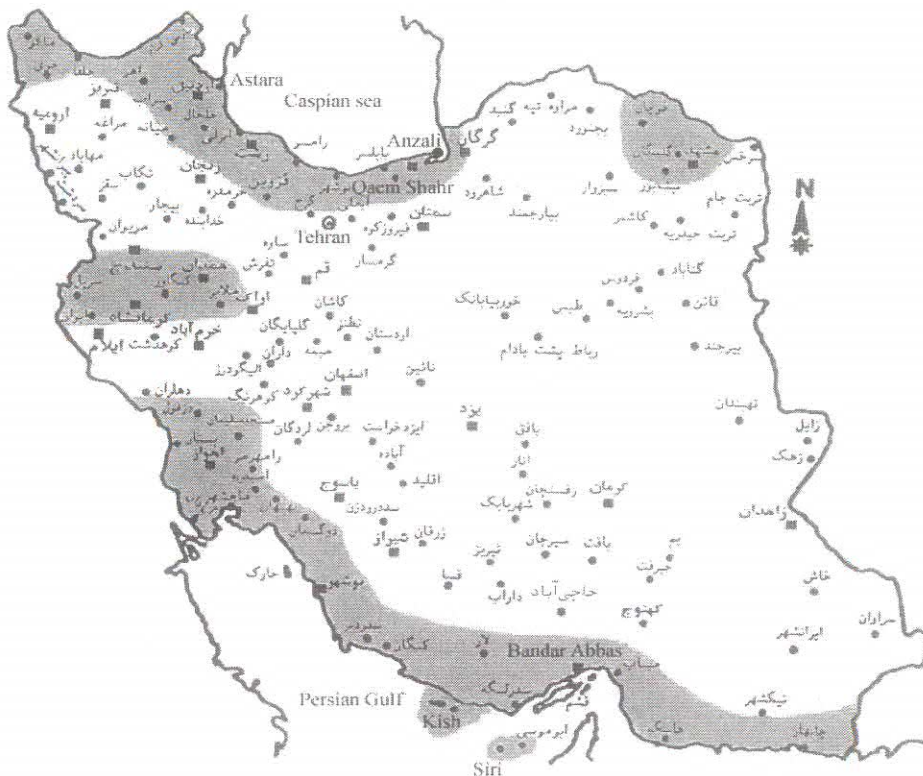
**Figure 2.** Distribution of foggy days in Astara.



**Figure 3.** Distribution of foggy days in Kish island



**Figure 4.** Distribution of foggy days in Anzali.



**Figure 1.** Regions with 50 foggy days or more.

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## Acknowledgment

Hereby we would like to thank Dr. Robert Schemmner from environment Canada as great pioneer of such projects for his kind support and cooperation.

in the West Coast of Caspian Sea. The average length of fog season in Astara is 220 days in year. Figure 2 shows distribution of foggy days in Astara throughout the year. Fog forms all months of year but because of advection and orographycal fogs in cold season we have more foggy days in these months. The regions shown in T1, are suitable places for performance evaluation experiment by standard  $1\text{m}^2$  fog collectors. We are going to start this step in Iran and we hope that we can define suitable places for water collection projects from fog. In islands fog occurs at warm months. F 3 shows the foggy days throughout year in Kish island. In Northern coastline of Iran, fog mostly occurs in cold months. The distribution of fog season length in Anzali shown in F 4. In Southern coast of Iran, fog occurs mostly in warm months. F 5 shows the fog season length in Bandar Abbas. In some regions fog forms equally in all months. F 6 shows the foggy days in Qaem shahr.

## **Conclusion**

Fog collection by man-made collectors may be a non-conventional source of water, but it is not unproven. Applications exist in many countries where conventional methods can not provide an adequate supply of water.

It has been shown in the literature that the water can be delivered in large quantities, that it is potable and that the cost of other potable water systems in rural arid regions. The cloud deck bring an essentially unlimited amount of water to the mountain sites, so in principle the amount of water that can be collected is limited only by the number of collectors that one chooses to install. The water source is sustainable over periods of hundreds and probably thousands of year because the driving forces for the formation of the cloud decks are global in nature and will change only slowly. The collectors themselves are simple, require no energy other than wind and deliver their water by gravity flow.

Countries located in arid and semi arid zones, such as Iran and Turkey can use this divine gift, fog, for water collection to be supplied for irrigation and forestry project. The authors would like to recommend the water resources planners and managers to take the issue in more consideration and hopefully initiate water collection project from fog in different locations.



length of fog season in 42 stations is 50 or more. Most frequently fog collection projects are not successful in those regions that length of fog season is less than 50 days. However the length of fog season in highlands and mountainous areas is more than synoptic and airport stations. The list of these stations is shown in T 1. Also the distribution of these stations in the map of Iran has shown in F 1.

## Results

As it is seen in T 1 and F 1 there are found three different categories:

- ◀ Coastal regions such as Astara, Bandar Abbas, and Abadan. Most of fogs that form in these areas are advection fogs.
- ◀ Islands include Kish and Siri islands. Advection fogs mostly form in islands especially in nights because lands coming to be cold sooner than sea weather and condensation occur sooner.
- ◀ Highlands such as Parsabad and Ardabil. These areas experience radiation fogs frequently due to low temperature and high altitudes and consequently Orographical fogs are formed.

**Table 1.** The length of fog season in 42 synoptic meteorological stations.

Row	Station	Length of fog season	Row	Station	Length of fog season
1	Astara	220	22	Dogonbadan	83
2	Kish island	213	23	Boostan	83
3	Konarak	191	24	Jiroft	79
4	Qaem shahr	159	25	Masjed soleyman	78
5	Siri island	154	26	Ahar	78
6	Pars Abad	152	27	Omidieh	77
7	Booshehr coast	151	28	Mashad	72
8	Ardabil	146	29	Lar	70
9	Rasht	143	30	Ramsar	67
10	Bandar Abbas	128	31	Hamedan	66
11	Jask	117	32	Abadan	65
12	Safi Abad	110	33	Ahvaz	63
13	Booshehr	106	34	Kangavar	62
14	Ravansar	103	35	West of Isfahan	61
15	Dezfool	103	36	Makoo	60
16	Bandar lengeh	100	37	Nozheh Hamedan	58
17	Chabahar	99	38	Goochan	55
18	Minab	94	39	Golmakan	55
19	Noshahr	89	40	Gazvin	51
20	Bandar Mahshahr	87	41	Myaneh	50
21	Agajari	85	42	Gorveh	50

In some regions all kinds of fog form together and increase the length of fog season. Astara is a good example for this case. Astara is located in the Northwest highlands

Through travel in a region, discussion with the population, and meetings with government officials and meteorologists, an idea can be obtained whether there are high elevation regions with a water requirement and frequent fog (2).

A more sophisticated program uses standard fog collectors of  $1\text{m}^2$  to measure the fog water production rates on specific terrain features.

Because fog collection is a non-conventional method of obtaining water, a public education program should be started early in any project.

The next step is to design system of collection, transport and distribution of the fog water.

### **Collector**

The fog collectors are flat rectangular nets supported by a post at either end and arranged perpendicular to the direction of the prevailing wind. They can be simple units that made up of a series of collection panels joined together. The collection surface is a fine-mesh net made from a nylon material (1).

As water collects on the net, droplets join to form larger drops that fall under gravity toward a trough or gutter located at the bottom of the panel. The collector itself is completely passive and water is pulled by gravity through the system to the site where it will be used (1).

### **Quantity of Collected Water**

Amount of collected water is different. For example the average water collection rates during the fog collection seasons in Chile, Peru, and Oman were 3, 9, 30 Liter/ $\text{m}^2$ /Day respectively(2).

### **Quality of Collected Water**

Water in the incoming fog and from the fog collectors can be expected to be of good quality. It will contain some marine salts and soil dust but little contamination from anthropogenic sources given the remote locations of most proposed sites. The ion and trace element concentration in the fog water at the El Tofo collection site in Chile have been studied in details and found to meet Chilean and WHO drinking water standards (3).

### **Materials and Methods**

In current investigation data of more than 115 stations are used to define the length of fog season. Data included foggy days in each month throughout the year. The

largest projects has provided, since March 1992, an average of 11000 liters of water per day to a village of 330 people in arid coast desert of North Chile (2).

There were 22 countries on six continents where literature references to the collection of fog by trees or small collectors would support and evaluation of the amount of water that could be produced by operational fog collection arrays.

A broader look at the meteorological and oceanographic condition on a worldwide basis, as well as the topography, will lead to the conclusion that many other countries may have the potential to benefit from fog collection programmers (2).

### **Geographical Considerations for Choosing Fog Collection Site**

Since the clouds are carried to the site by the wind, and the fog is then moved through the collectors by the wind, the interaction of the large- and small- scale topographical features with the wind will largely part determine the success of the site chosen. A number of the most important geographical factors will be briefly reviewed here. Persistent winds from one direction are ideal for fog collection.

- A field of dunes or a mountain range that rises high enough is necessary to intercept clouds of fog that are advanced into the region.
- The region of the stratocumulus cloud, which normally has the highest liquid content, is between 400 m to the direction of the wind bringing cloud and fog from the ocean.
- One should try and work as close to the coast as possible, ideally within 5 km but possibilities exist up to at least 25 km inland.
- It is very important that there be no major obstacle to the wind within a few kilometers of the site.
- An upwind ridgeline that there be no major obstacle to the wind within a few kilometers of the site.
- The presence of an inland depression or basin that will heat up during the day will cause a local low-pressure area. This will enhance the sea breeze and increase the wind speed with which marine cloud decks flow over the terrain (2).

### **Guidelines for Initiating a Fog Collection Program**

There are a number of logical steps one can follow at the inception of a fog collection program.

First of all we have to know how long is the length of fog season in a region. Analyzing the data of foggy days from synoptic meteorological stations meets the ends.



## **Fog Collection as a New Method of Water Supply**

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### **Abstract**

In some regions because of special meteorological and topographical characteristics fog occurs regularly. The leaves of trees collect the droplets in fog. Recently technology helps man to get more water by artificial fog collectors. Many of Arid and Semi Arid countries supply their water for domestic, agriculture and forestry uses from fog collection projects. Since Iran is one of these countries, fog collection has been noticed and it takes initial steps. The fog collection concepts and also theoretical analysis of fog collection in Iran has been discussed in this paper.

### **Introduction**

It is generally accepted that there is an ever-going need to identify new source and methods for collecting fresh water in both the developed and developing countries specially Arid and Semi Arid regions. With and ever increasing population and the intensified use of land for agriculture purpose it is clear that serious consideration needs to be given to unconventional water supplies (1).

Trees or other tall vegetation collect the droplets from fog. They can also be collected by appropriately designed man made collectors, to provide large volumes of water for domestic, agriculture or forestry uses (2).

### **Fog Collection**

The potential for extracting water from fog is a function of the amount of water it contains, how often it occurs, and wind speed. The fog water content depends upon its altitude. Its frequency of occurrence depends on regional atmospheric circulation, the temperature of the ocean water and the stability and intensity of the thermal inversion processes (2).

If the climatic phenomenon that produces the fog is stable, fog will form regularly; however, its behavior may vary from one area to another and specific seasonal variations may occur. On South America's Southwest coast, especially in Chile, the fog-producing condition are constant throughout the year, although more intense during the spring and summer months and less during fall and winter. One of the

## Conclusion

According to the survey results in the years of 1964 and 1965, there were 11 769 ha saline and only 23 ha alkaline soils in the area. Ground water problems ( 0-2 m ) were encountered in 2747 ha. Akçakale Groundwater Irrigation area ( 5000 ha ) is taking place in the south part of the Harran Plain even though there were 0,100-0,200 % TDS in 274 ha, 0,200-0,400 % TDS in 50 ha and no sodic soil in the project area. According to surveys has been done in the period from 1990 to 1993, 1 428 ha of land contains 0,100-0,200 % TDS, 1 099 ha of land contains 0,200-0,400 % TDS, 130 ha of land contains 0,400-0,600 % TDS, and 86 ha of land has ESP higher than 15 %. To observe the salinity changes 62 location were selected and soil samples taken by drainage engineer from Şanlıurfa Regional Directorate of DSI, in 2000. The analyze results show that 29 % of the soils salt content were increased. According to observation done by DSI Operation and Maintenance Department in 2001, ground water problems are observed to be increasing. 768 observation wells were augured to represent approximately 100 000 ha. In the peak irrigation period (July, 2001), depth of the groundwater was observed to vary between 0.00-1.00 in 5195 ha and 1,00-2,00 m in 35 583 ha (DSI., 2002). According to data collected, ground water and soil salinity problems have been increasing in irrigated area.

## Preventive Measures and Suggestions

- Extension education is necessary for water users in irrigated agriculture,
- Main drainage network must be examined and developed if necessary,
- Subsurface drainage system should be constructed wherever it is necessary,
- Infrastructures, such as land leveling and surface inlets, must be completed,
- Real cost of water should be charged in volume base from water users.

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### **Streams and Floods**

The main stream is Cullap Creek in the project area. Cullap Creek bed is used as a main discharge channel and discharge capacity is expanded by the development. It can be said that there is no risk of flooding in the area.

### **Irrigation**

Trapezoidal open irrigation canal system has been built and mostly furrow irrigation method is used in the project area. Proposed crop pattern could not be realized and mostly cotton (approximately 85 %), some vegetable species and cereals are being grown in irrigated area. Irrigation water quality class is  $C_2S_1$  and it is very good compared to the quality of the most of the other irrigation projects. With TAM values being used and MAD being taken as 70 %, RAM value for the root zone was calculated to be 110 mm.

The reason of drainage problem is irrigation. The causes are given below:

- i. Excessive water use,
- ii. Lack of knowledge about irrigation and agriculture,
- iii. Carelessness about irrigation and drainage structures.

### **Seepage**

There is no seepage from the adjacent areas because there is no existing irrigation and also adjacent high areas don't have soil depth enough to store moisture. There could be some leakage and seepage from irrigation canals because of deterioration.

### **Groundwater**

According to data taken from the Southeast Anatolia Project Urfa-Harran Plain Planning Drainage Report there were ground water problem (0-2 m) in 2 747 ha of land located in the south part of the plain and near Akçakale and Harran Towns urban areas. In Akçakale Ground Water Project area; ground water problems were observed in 2 160 ha (0.00-1,00 m ), 309 ha ( 1,00-1,50 m ) and 206 ha ( 1,50-2,00 m ) within the period of 1990-1993. According to the observations made in 2001 by DSI Operation and Maintenance Department, ground water problems were found to be increasing. 768 observation wells are augured to represent approximately 100 000 ha. In the peak irrigation period (July, 2001), depth of the groundwater was observed to be between 0.00-1.00 m in 5 195 ha and 1,00-2,00 m in 35 583 ha. Ground water analyses show that 83 % of the electrical conductivity values of the water is less than 2 500 micromhos/cm.



According to the survey done in the years of 1964 and 1965, total soluble salt values were found between 0,100-0,200 % in 5 406 ha, 0,200-0,400 % in 4 604 ha, 0,400-0,600 % in 1769 ha and more than 0,600 % in 23 ha of land has ESP values more than 15.

**Table 1. Land Classification.**

	Irrigable				Temporary non irrigable	Non irrigable	Total
Class	1	2	3	1+2+3	5	6	
Ha	152	152 349	24 740	177 241	15 101	8 219	200 561
%	0,08	75,96	12,23	88,37	7,54	4,09	100,00

Akçakale Groundwater Irrigation area ( 5 000 ha ) is located in the south part of the Harran Plain. even though there were 0,100-0,200 % TDS in 274 ha, 0,200-0,400 % TDS in 50 ha and there are no sodic soils in the project area. According to surveys carried out between 1990 and 1993, TDS values were found as follow: 0,100-0,200 % in 1 428 ha, 0,200-0,400 % in 1 099 ha, 0,400-0,600 % in 130 ha and ESP values were found to be higher than 15 % in this 86 ha land also.

In order to monitor salinity changes, 62 locations were selected and soil samples taken from these locations by drainage engineer from Şanlıurfa Regional Directorate of DSI, in 2000. The results of the analyses show that salt content was increased in 29 % of the soils.

### **Existing Structures Related With Irrigation and Drainage**

Şanlıurfa –Harran Plain is irrigated with the water taken from Atatürk Dam Reservoir by Şanlıurfa irrigation tunnels. Construction of the irrigation and main drainage system and related components has been mostly completed in about 130 000 ha. Also subsurface drainage system is being constructed by GDRS at the south part of the plain.

## **2. Drainage Requirement**

### **Climate**

Climate is arid and semiarid in the project area. Annual rainfall is about 300 mm in most of the plain but it is 460 mm in Şanlıurfa. Precipitation mostly occurs in winter and spring. Annual evaporation is 1 900 mm. Comparing the precipitation and evaporation values, it is understood that irrigation is absolutely necessary for most agricultural crops. Rainfall is not an important factor in drainage.

# **Ground Water and Soil Salinity Problems in Operation Stage in Sanliurfa - Harran Plain**

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## **Introduction**

Harran Plain is almost 200 000 hectares and recently 130 000 hectares of it irrigated from the source of Atatürk Dam and the rest of the area is under construction for irrigation.

So far, there are three relevant reports prepared by the General Directorate of State Hydraulic Works. The first report is Lower Euphrates Project Urfa – Harran Plain Planning Land Classification Report which covers 200 561 hectares of land, the second is Southeast Anatolia Project Urfa - Harran Plain Planning Drainage Report which covers the same land with the previous report and the third report is Lower Euphrates Project Akçakale Ground Water Irrigation Detailed Land Classification and Drainage Report which covers 5 000 hectares of land. Based on the reports mentioned above, characteristics of soil, topography, salinity and alkalinity, and ground water are given in the following paragraphs.

### **1. Topography**

The general direction of the slope in the plain is from north to south and varies between 0-2 %. Surface slope is rather flat around Harran and Akçakale Towns and low-lying areas cause outlet problem. Slopes in the north are mostly higher than that of the south part of plain and surface and subsurface drainage problems are rarely encountered.

### **Soil Characteristics**

The soils of the plain are alluvial and residual. Soil profiles are deeper than 150 cm in 77 % of the area and in the rest of the area, they are shallow and underlying materials are sand, gravel, lime and rock. Land classes are given in Table 1. 95 % of soils have heavy texture in tillage layer and only 5 % of soils have medium texture also sublayers of soils are heavy textured. Soil colors are mostly brown and reddish brown. pH values are mostly between 7,5 and 8,0. Hydraulic permeability of disturbed soil samples vary but values are mostly higher than 0.5 m/day. Hydraulic permeability values were found between 0,22 and 3,51 m/day by using Auger-Hole Method at Akçakale Ground Water Irrigation area.

**Table2.** Water table monitoring studies relating to years (Water table level 0-1m)

Years	Irrigation Networks (ha)	Water Table Monitoring Areas (ha)	The Highest (ha)	%	The Lowest (ha)	%	The Most Intensive Irrigated Month	%	Water Table Salinity	%
1981	773 410	228 079	118 969	52	3 784	2	33 440	15	8 996	4
1982	813 585	335 160	171 966	51	9 732	3	49 221	15	18 164	5
1983	879 210	377 152	164 459	44	4 603	1	56 866	15	28 096	7
1984	964 565	475 769	230 505	48	9 933	2	78 218	16	20 438	4
1985	1 060 440	463 551	194 819	42	8 280	2	80 464	17	24 973	5
1986	1 115 240	527 332	195 458	37	6 667	1	74 427	14	23 661	4
1987	1 156 990	523 138	185 017	35	7 399	1	57 231	11	20 392	4
1988	1 201 340	593 841	196 732	33	12 511	2	73 555	12	29 074	5
1989	1 231 100	777 550	211 730	27	8 302	1	72 077	9	25 125	3
1990	1 251 251	896 189	247 300	28	10 568	1	84 938	9	33 895	4
1991	1 269 571	918 580	224 053	24	12 068	1	82 564	9	49 178	5
1992	1 300 561	943 284	240 102	25	13 493	1	90 554	10	43 389	5
1993	1 341 495	1 011 606	264 452	26	17 088	2	102 045	10	45 565	5
1994	1 455 896	1 075 924	218 724	20	19 183	2	73 218	7	58 678	5
1995	1 603 428	1 097 914	247 385	23	18 247	2	89 844	8	58 959	5
1996	1 673 109	1 103 654	265 017	24	20 036	2	96 227	9	51 666	5
1997	1 724 477	1 087 167	226 893	21	20 587	2	74 278	7	49 256	5
1998	1 809 687	1 153 031	263 974	23	13 456	1	78 032	7	48 112	4
1999	1 842 906	1 180 509	264 277	23	17 972	1	86 712	7	51 242	4
2000	1 875 104	1 194 353	230 270	19	15 913	1	94 504	8	47 261	4



**Table 1. 2000 Year' s water table measurements results**

Water table Level						
Depth Categories (m)	The Highest		The Lowest		The Most Intensive Irrigated Month	
	Areas(ha)	Ratio(%)	Areas(ha)	Ratio(%)	Areas(ha)	Ratio(%)
0.0-0.5	47985	4	1 490	0	9 041	1
0.5-1.0	182 285	15	14 423	1	85 463	7
1.0-2.0	400 296	34	279 444	23	406 058	34
2.0-3.0	225 962	19	407 221	34	300 411	25
3.0>	337 825	28	491 775	41	393 380	33
TOTAL	1 194 353	100	1 194 353	100	1 194 353	100
Watertable Salinity						
Salinity Categories	Areas (ha)	Ratio (%)	Watertable Level 0-1m and Watertable Salinity>5000 micromhos/cm Areas			
0-2500	1 059 672	89	Areas	Ratio		
2500-5000	87 420	7	(ha)	(%)		
5000-7500	27 607	2				
7500-10000	12 856	1	5181	0,43		
10000<	6 798	1				
TOTAL	1 194 353	100				

**Explanation:**

Irrigation networks are opened to management by DSI in 2000 year's 1 875 104 ha

Water table monitoring areas in 2000 year' s  
1 194 353 ha

The ratio of water table monitoring areas to irrigation networks are opened to management %64

Numbers of observations wells: 10 812

Some irrigation areas which have suitable topographic conditions (gradient> %3-5) and do not require watere table observation. For that reason there is a difference between irrigation networks are opened to management by DSI 1 875 104 ha and water table monitoring areas 1 194 353 ha.

2000 year' s evaluation results compared with last year' s, reveal that the area of problematic soils have not been changed. Drought seasons and clearing of drainage canals are main factors of this no change. In 1986, drainage rehabilitation works were initiated in pilot irrigation projects under World Bank Loan. Rehabilitation works positively effected drainage performance of these schemes.

Water table level management is critical for soil conservation and enables desired productivity. Continued monitoring of water table levels is therefore inevitable.

- 2) Depth to lowest water table map: one year's recording result and lowest water table values are used relating to each well. If water table is between 0-1m, this location requires farm drainage
- 3) Lines of equal the most intensive irrigation map; this map is drawn, measurements are done when irrigation is the most intensive in a month. And it shows how irrigation influences water table.
- 4) Water table quality map; salt concentration ( $EC \times 10^{-6}$   $25^{\circ}C$  values) is measured with an electrical conductivity meter at each well. By plotting all the  $EC \times 10^{-6}$   $25^{\circ}C$  values on a map, lines of equal electrical conductivity (equal salinity) can be drawn. Usually critical watertable salinity is more than 5000 micromhos/cm.
- 5) Locations which show with high water table level and salinity; on the lines of equal the most intensive irrigation map, locations where water table is 0-1m and on the water table quality map, locations where water table has more than 5000 micromhos/cm salinity are determined. These locations are drawn one map and show with high water table and salinity.
- 6) Water table contour map; a water table contour map is a map of the phreatic surface; it can be prepared for a specific date, but preferably as a mean for a longer period.

To prepare this type of map, all water table well's elevations were taken and these values are decreased from highest water table measurements. Values between the observation points must be interpolated. This map shows the direction of water movement by the shape and position of the contour lines, indicate the areas of recharge and discharge.

End of the year these maps are drawn relating to irrigation schemes and results are evaluated.

## Conclusions

According to 2000 year's evaluation results; locations which show with high water table level and salinity has a little ratio (% 0,43). Water table observation areas have 94 504 ha high water table (% 8). This high water table is, at the most intensive irrigated month. 47 261 ha areas has water table salinity problem which they are > 5000 micromhos/cm.

the voids. The proper balance between soil moisture and oxygen is maintained to a considerable extent by adequate drainage.

Studies of the water table produce information necessary for the solution of a drainage problem. Areas where a high water table has developed or is anticipated must be mapped. Information concerning depths, trends and movements is essential for an understanding of the problem. The water table investigation provides data on the position, extent, and fluctuations of the water table; the quantity and direction of movement of the groundwater, and an indication of water sources and areas of discharge. The investigation is made using observation holes and piezometers, and analyses of periodic measurements.

### **Materials and Methods**

General Directorate of State Hydraulic Works (DSI) has 2 251 625 ha irrigation networks are opened to operation. 360 775 ha irrigation networks are managed by ground water irrigation cooperatives. Water table monitoring of these networks are not being conducted by DSI. They are small networks and irrigation is done with groundwater. In other schemes water table is controlled by DSI. Most of these schemes have significant drainage problems as they are large irrigation schemes (Çukurova, Gediz, Konya basins with GAP project areas). Some irrigation areas which have suitable topographic conditions and do not require observation wells. Operation and Maintenance Department of DSI is responsible for water table management. Water table monitoring has been done in 128 irrigation schemes covering 1 194 353 ha. These schemes were placed 10 812 observation wells. Observation network is designed with observation wells which performance per 100 ha has to have one. Selection of the location for wells should be made in the field, where conditions that might affect water table can be readily observed. Wells should be located to eliminate the effect of ponds, lakes, road, border ditches, canals, laterals, rivers and similar water holding reservoirs on water table. Each well perform per 100 ha, and measurements are done once in a month. Water table level is measured with a water level indicator.

The objective of the measurements is to establish a record of the water table fluctuations over a period of time that will reflect all factors affecting the water table. After recording the measurements, lines of equal water table maps are drawn. These maps;

1) Depth to highest water table map: One year's recording results and highest water table values are used relating to each well. This map shows where water table is highest level. If water table is between 0-2m, this location has drainage problem.



## **Water Table Management in DSI Projects**

Nadide Demir

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### **Abstract**

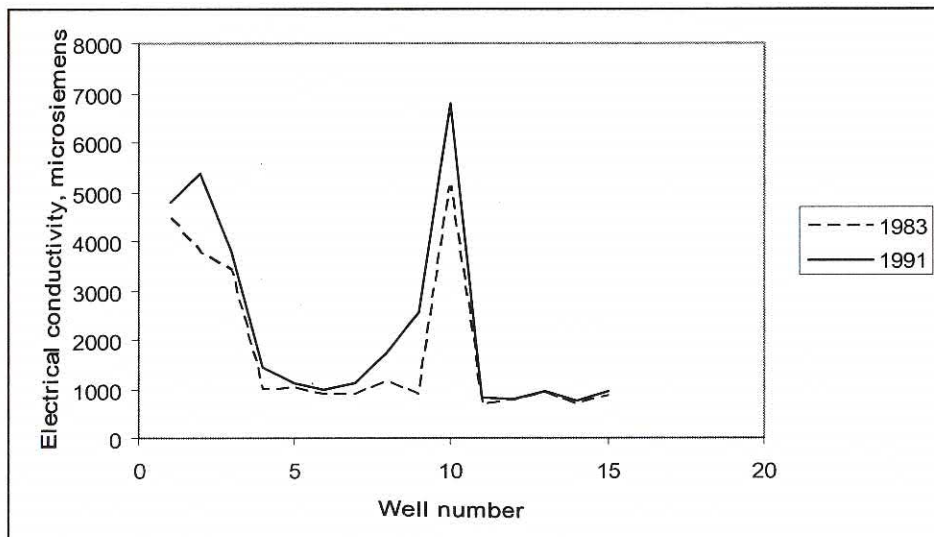
An essential requirement for successfully irrigated agriculture is the development and maintenance of a soil zone in which the moisture-oxygen-salt balance is favorable for plant growth. Plants require both moisture and oxygen to live. If a saline water table rises and remains in the root zone, it results high saline moisture condition. Agricultural production is negatively affected by this condition.

For sustainable irrigated agriculture, drainage is equally important. Water table observations and evaluations are critical to check whether drainage systems are functional or not. And water table level indicates that excessive water is harmful for plant root zone. For that purposes, continuous monitoring of water table level and it's quality and controlling of expected water table depth are required. These practices have still been carried on 1 194 353 ha areas, by DSI managed schemes that covers 2 251 625 ha areas.

### **Introduction**

A prime requirement for successfully irrigated agriculture is the development and maintenance of a soil zone in which the moisture-oxygen-salt balance is favorable for plant growth. Plants require both moisture and oxygen to live. When a saline water table rises and remains in the root zone than about 48 hours, resulting in an abnormally high saline moisture condition, agricultural production is usually seriously affected.

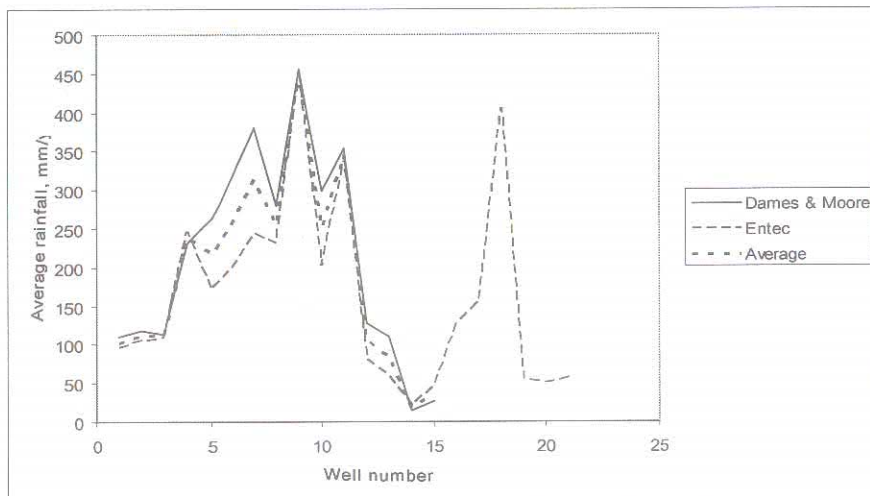
The presence of oxygen in the interstices of the soil in the root zone is as necessary as water for both seed germination and plant growth. The oxygen content of soil is governed by the rate of diffusion of oxygen through the soil pores. Also, the oxygen content is markedly affected by the moisture content of a soil. Soils with initially low moisture content normally can be expected to have relatively open pore structures between soil particles, allowing oxygen to freely permeate through the interstices. As the moisture content increases, air in the pores is displaced by water, thus forcing the air upward and subsequent expulsion to the atmosphere. However, once the oxygen has been expelled, the oxygen content recovery rate is extremely slow in a soil that is in transition from a moist or wet state to a dries state. This is because of the inherently slow rate of diffusion of gases through such soils and the phenomenon of capillary stresses which develop in soils when the water content does not completely fill



**Figure 2.** Electrical conductivity of pumped groundwater

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**Figure 1.** Annual rainfall data from Entec and Dames and Moore studies

**Table 3.** Comparison of Entec and Dames and Moore (1992) water balances for Salalah.

	Component	Entec estimate, Mm <sup>3</sup> /yr	Dames & Moore estimate, Mm <sup>3</sup> /yr	Average, Mm <sup>3</sup> /yr
Inflows	Jebel front GW inflow and springs	43.2	31.8	37.5
	Rainfall on plain	4.3	0.6	2.45
outflows	Agric. consumption	44.9	31.7	38.3
	Potable system losses	4.3	7.1	5.7
	Net outflow to sea	-1.7	1.5	-0.1
Change in storage	(outflow minus inflow)	0	7.9	3.95

There is some saline water intrusion in addition to the decline of groundwater storage. Sea water intrusion is a problem of concern since lots of farms are situated along the coastal line of Salalah area. So, additional solutions should be provided to resist this problem. The use of treated wastewater and construction of several dams to enhance the filtration rates from the rainfall may appear to be valid solutions.



the Entec study as shown in Table 3. The saline water intrusion leads to a concern about the water quality knowing the high demand needed for irrigation.

**Table 2.** The Jebel Groundwater inflow estimates.

Source	The Jebel Groundwater inflow estimates, $\text{Mm}^3/\text{y}$
Sir William Halcrow & Partners (1977), in Tetrtech (1978)	10-141
John Taylor & Sons (1976), in Tetrtech (1978)	29-128
Hydrotechnica (1986)	24-31.6
Dames and Moore (1992)	31.8
Entec Europe Limited (1998)	43.2
Average	51.3

### Groundwater Quality

The results from Dames and Moore show decline in the storage water of  $7.9 \text{ Mm}^3/\text{yr}^{-1}$ . This is considered high compared to Entec estimate of  $1.7 \text{ Mm}^3/\text{yr}^{-1}$ . However, both studies prove that saline water intrusion exists in the area. Figure 2 shows some electrical conductivity of pumped groundwater in 1983 and 1991 (Dames and Moore, 1992). The increase in saline water intrusion does not appear to have significant affect on the EC profile in the main freshwater zone which has an average EC of about  $1000 \mu\text{Scm}^{-1}$ . Sea water intrusion is expected to continue its increasing which will cause serious problems if no solutions are implemented.

### Conclusions

The study covers a total area of  $789 \text{ km}^2$ ,  $253 \text{ km}^2$  of Salalah Plain and  $536 \text{ km}^2$  of the Jebel. Studies have evaluated the situation in the Salalah area since 1970's. Some records are since 1940's such as the one in Salalah airport area. The locations of the records gauges and monitoring wells are mainly along the well fileds with others from different locations on Salalah plain and the Jebel. Some records of very high value are likely to be biased. However, recent studies are of more reliability since they consider several important parameters such as infiltration from different sources, impact of fog in enhancing precipitation, evaporation and evapotranspiration, leakage from water supply network, geology of the area, etc.

The average value for the recharge to the groundwater is  $37.5 \text{ Mm}^3/\text{yr}^{-1}$  from Jebel inflow and  $2.45 \text{ Mm}^3/\text{yr}^{-1}$  from rainfall. The total discharge is about  $44 \text{ Mm}^3/\text{yr}^{-1}$ . Thus, the groundwater in Salalah catchment is extensively declining and a policy will be required to protect against the high pumping which makes 87% of the discharge. Another policy is required to protect the groundwater of the Jebel since it makes 93.9% of the recharge. This recharge may reach over along term an average of  $45 \text{ Mm}^3/\text{yr}^{-1}$ . This groundwater must support both well fields and the extensive abstraction of irrigation water on the plain.

be determined in order to estimate the saline water intrusion. In addition, electrical conductivity for several samples taken from Dames and Moore study collected in 1991 will be compared with samples taken from similar locations in 1983. Then, the quality of groundwater can be determined and thus the use of this water.

## Results

Studies about the groundwater in Salalah were done by several consultant companies along the past 30 years for the Ministry of Water Resources. Some of these companies are: Sir William Halcrow & Partners (1977), in Tetrattech (1978), John Taylor & Sons (1976), in Tetrattech (1978), Hydrotechnica (1986), Dames and Moore (1992) and Entec Europe Limited (1998). Table 2 shows estimates of groundwater inflow of the Jebel by the mentioned companies and an average value for all these studies.

**Table 1.** Salalah data summary.

Data Type	Details of Records	
Rainfall	11 stations on plain + 12 stations on the Jebel	Salalah airport record from 1942, most records up to December 31, 1996
Wadi Flows	Wadi Jarziz	1983- 1994
	Wadi Sahalnawt	1983-1994
	Wadi Rzat	1983-1994
	Wadi Ain Hamran	1992-1994
Spring Flows	6 stations on plain (+ 9 on the Jebel)	Monthly data, 4 started in 1977, 2 in 1991, records up to 1995
Abstractions	Monthly data	13 individual Dhofar Municipality wells 1991 to 1996, Salalah well field 1972 to 1987
	Yearly data	Salalah, Sa'ada and military well fields 1972 to 1987
Static Water Levels	21 boreholes on plain	1980's to 1996
	14 boreholes on Jebel front	1980's to 1996
Aquifer Parameters	T and K: 25 locations	Various tests including 4-day tests
	6 storage coefficients	Tests with observation wells
	Calibrated model results	MacDonald (1990)
Well Inventory	44 wells	36 completion logs

If the most recent studies were considered, Dames and Moore (1992) and Entec Europe Limited (1998), a better comparison can be established since they took more considerable factors in their studies. Figure 1 shows this comparison and average value for their results. The annual average rainfall on the plain is around 110 mm whereas in the Jebel it is about 260 mm (Dames and Moore, 1992). The annual average rainfall is 84.8 mm on the plain and 275 mm on the Jebel (Entec, 1998).

The fractions of recharge due to rainfall are 2.5% from the plain and 25% from the Jebel according to Dames and Moore study, compared to 20% and 35% in

are a large number of private groundwater abstractors in the area to provide water for irrigation. Other water supply for this area comes from perennial springs that issue from the edge of the Jebel. These are tapped off near the source and channelled to several large farms.

Salalah area has a very different climate from the rest of the country. It has a hot and arid climate during the winter and a cooler summer monsoon period (Kharif) between June and September. The monsoon winds come from the south and result in persistent fog and light rain, much of the rain falling on the southern slopes of the Jebel. These winds are largely the result of the extreme summer heating that occurs in the vast inland desert of the Rub Al Khali or Empty Quarter (Schemenauer, 1989). The monsoon clouds are prevented from moving inland by mountains and are pushed against the Jebel forming extensive areas of high elevation fog. The cloud bank associated with the monsoon is about 140 km long and less than 80 km wide (Price et al, 1988). However, heavy rains may occur at any season during rare cyclonic storms.

The regional geology of Salalah area is characterized by two distinct regions separated by a major fault, which divides the Salalah Plain from the Jebel. The Jebel consists of a thick sequence of limestone with some shales and rises to 1000 m above sea level. There are four main limestones units: the Tertiary Dammam, Ru and Umm Er Rahhuma, which form Hadramaut Group, and the Cretaceous limestones. Salalah plain has a uniform slope of approximately 0.01 and is crossed by a number of shallow wadi systems (Flint and Rippon, 1986).

### **Methodology**

The available data from the Jebel and the plain were collected from different locations as shown in Table 1. Several studies have been made to estimate the recharge and discharge rates on this area along different periods since 1976. The recharge of the fresh groundwater of the Salalah plain can be derived from four alternative mechanisms. Subsurface flow from the Jebel, the infiltration of springs at the foot of the Jebel and the infiltration of rain falling on the plain directly are the main recharge mechanisms. Infiltration due to wadi flood flow is the fourth mechanisms, though it is of much less importance due to its rarity. This study compares some of these previous results of estimating the recharge and the abstraction rates in the Salalah area. These studies cover the Salalah plain and the Jebel. Salalah plain area is 253 km<sup>2</sup> and the Jebel area is 536 km<sup>2</sup>. The average results will be determined for final comparison in order to determine an average rate for the difference between the inflows and outflows of the groundwater.

Groundwater quality will be checked to identify its possible uses. The main issue of discussion will be the salinity of the groundwater since the area is near the southern coast of Oman. The amount of inflow and outflow to the sea will



## **Sustainability of Groundwater in Salalah Catchment Area, Sultanate of Oman**

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### **Abstract**

This study is an introductory stage for a current research project on the sustainability of groundwater in Salalah Area, Sultanate of Oman. The Salalah plain extends over a 253 km<sup>2</sup> area to the north of the Omani coastline of the Arabian Sea to the Mountains of Dhofar. The area is recharged by rainfall on the mountains and on the plain. The annual recharge is estimated at 40 Mm<sup>3</sup>yr<sup>-1</sup>. About 94% of this amount comes from the mountains. Water is being abstracted from the Salalah aquifers to meet the increasing domestic and agricultural demands of the city. Average annual discharge is estimated at 44 Mm<sup>3</sup>yr<sup>-1</sup>. Agriculture consumes about 87% of this amount. From these estimates, it is obvious that the area will face a major crisis if these rates are maintained or increased and no management plans are implemented. Over abstraction from the aquifers caused saline water intrusion in addition to the decline of groundwater storage. Present studies showed that the salinity of water is increasing but not to the extent to prevent its use for agriculture. However, this rate of increase is alarming of a serious quality problem the area might face in few years from now. Policies have to be implemented to protect the Salalah area groundwater and the supplying aquifers, i.e. the Jebel. Other solutions to enhance the infiltration rates and resist the saline water intrusion, such as constructing dams and the use of treated wastewater, are required.

### **Introduction**

Salalah, the southern capital of Oman, is on the southern coast of Sultanate of Oman. It lies on a flat coastal plain to the north of which rise the Jebel or mountains. Water is supplied to this town through two well fields situated to the north of the coastal plain. The main Salalah well field was drilled in 1970's. Due to the increase in water demand, the Sa'ada well field was drilled in 1986 with 3 wells to the north of the Salalah well field.

The region can be divided into three main areas: the Salalah coastal plain, the Jebel and the Nejd. The plain extends to about 10 km from the coast with an elevation rising to 100 m. The Jebel, a mountain rising to 1000 m above sea level, borders the plain and extends along the southern coast of Oman. The range is about 20 km wide north of Salalah. The Nejd, a flat arid area, lies inland of the Jebel at an elevation of about 650 m above sea level and slopes gently to the north. There is extensive agriculture on the coastal plain and there

Profile	0-25	7.9	0.58	1.4	0.09	15.5	3.2	15.28	0.84	36.8	29.3	3.9	2.1	2.0	100
<i>Profile 8, Ap</i>															
Bw	25-40	7.9	0.50	0.8	0.06	13.3	4.5	11.56	0.85	42.1	34.8	4.1	1.9	1.9	100
Ck	40-74	8.0	0.44	0.0	0.0	0.0	5.8	9.39	0.76	31.3	24.2	4.2	1.8	1.8	100
<i>Profile 9, Ap</i>															
Bw	18-50	7.9	0.60	1.5	0.09	16.7	2.8	13.92	0.78	34.2	27.0	4.0	2.0	2.1	100
Ck	50-75	8.0	0.55	0.0	0.0	0.0	6.1	7.17	0.75	30.8	23.7	4.3	1.7	1.8	100
<i>Profile 10, Ap</i>															
Bw	15-38	7.8	0.58	1.6	0.10	16.0	3.6	12.11	0.81	38.7	31.4	4.1	2.2	1.9	100
Ck	38-80	8.0	0.42	0.0	0.0	0.0	5.5	8.08	0.79	35.6	28.6	4.3	1.7	1.6	100
<i>Profile 11, Ap</i>															
Bw	20-40	7.8	0.51	1.7	0.11	15.4	2.8	16.04	0.83	41.5	34.0	4.2	2.3	1.9	100
Ck	40-70	7.9	0.43	0.0	0.0	0.0	4.8	13.92	0.84	47.7	40.1	4.3	2.0	1.8	100
<i>Profile 12, Ap</i>															
Bw	24-52	7.7	0.62	1.3	0.08	16.2	3.3	19.43	0.79	36.5	29.2	4.0	2.0	2.1	100
Ck	52-78	8.0	0.50	0.0	0.0	0.0	6.5	15.75	0.82	42.2	35.3	4.1	1.8	1.8	100
								11.88	0.77	32.1	25.3	4.3	1.6	1.7	100

**Table 3.** The chemical properties of irrigated Vertisols.

Table 3. The chemical properties of irrigated vertisols.																
Horizon (FAO/ Unesco)	Depth (cm)	pH 1:2 soil water	EC (dS m <sup>-1</sup> )	Org. C (%)	Total N (%)	C/N	CaCO <sub>3</sub> (%)	Available P <sub>i</sub> ppm	CEC/ Clay	CEC	Exchangeable cations				BS (%)	Free Fe <sub>2</sub> O <sub>3</sub> (%)
											Ca	Mg	K	Na		
Profile 1, Ap Bw Ck	0-15	7.7	0.51	1.8	0.12	15.0	2.3	22.14	0.82	45.2	38.8	3.8	2.0	1.8	100	1.02
	15-60	7.9	0.42	1.5	0.11	13.6	2.9	20.02	0.84	48.4	41.6	3.9	1.8	1.7	100	0.96
	60-95	7.9	0.40	0.0	0.0	0.0	4.5	16.63	0.79	39.7	32.7	4.2	1.7	1.7	100	0.85
Profile 2, Ap Bw Ck	0-20	7.8	0.56	1.9	0.12	15.8	2.5	27.35	0.85	49.5	42.3	3.9	2.1	1.9	100	0.90
	20-45	7.9	0.40	1.6	0.11	14.5	3.3	24.22	0.85	52.7	46.0	4.0	1.8	1.7	100	0.87
	45-80	8.0	0.34	0.0	0.0	0.0	5.0	20.17	0.83	45.3	38.7	4.1	1.6	1.6	100	0.83
Profile 3, Ap Bw1 Bw2 Ck	0-25	7.7	0.47	2.0	0.13	15.4	2.0	19.72	0.82	42.1	35.4	3.7	1.9	1.7	100	1.14
	25-50	7.9	0.43	1.7	0.12	14.2	2.8	15.58	0.83	47.0	40.7	3.8	1.8	1.6	100	1.05
	50-75	7.9	0.40	1.0	0.08	12.5	3.6	13.05	0.85	50.9	44.4	3.8	1.8	1.6	100	1.00
Profile 4, Ap Bw1 Bw2 Ck	75-105	8.1	0.32	0.0	0.0	0.0	6.4	10.27	0.75	39.2	32.6	4.0	1.7	1.5	100	0.90
	0-18	7.8	0.60	1.9	0.13	14.6	3.1	30.54	0.84	50.7	43.6	3.6	2.2	2.0	100	0.87
	18-40	7.9	0.57	1.5	0.11	13.6	4.2	26.39	0.86	55.8	48.7	3.7	2.0	1.9	100	0.86
Profile 5, Ap Bw1 Bw2 Ck	40-65	7.9	0.52	0.7	0.06	11.7	4.8	24.47	0.87	59.1	52.3	3.7	1.9	1.9	100	0.85
	65-100	8.0	0.43	0.0	0.0	0.0	6.0	19.30	0.81	45.6	38.6	3.9	1.9	1.8	100	0.79
	0-30	7.7	0.55	2.1	0.15	14.0	2.8	35.08	0.85	54.0	47.3	3.7	2.1	1.8	100	0.82
Profile 6, Ap Bw1 Bw2 Ck	30-55	7.8	0.46	1.8	0.13	13.8	3.5	30.44	0.86	57.1	50.5	3.8	1.9	1.6	100	0.77
	55-90	7.8	0.42	1.1	0.08	13.7	4.7	27.52	0.86	60.5	53.9	3.8	1.9	1.6	100	0.74
	90-125	7.9	0.28	0.0	0.0	0.0	5.9	22.14	0.81	47.4	40.9	3.9	1.8	1.4	100	0.72
Profile 7, Ap Bw1 Bw2 Ck	0-34	7.8	0.49	1.9	0.12	15.8	2.4	24.62	0.85	51.8	45.5	3.5	2.0	1.7	100	0.85
	34-52	7.8	0.38	1.3	0.09	14.4	3.8	19.38	0.85	57.3	51.1	3.6	1.8	1.5	100	0.81
	52-78	7.9	0.30	0.8	0.06	13.3	4.9	15.14	0.89	61.5	55.3	3.7	1.8	1.5	100	0.79
Profile 7, Ap Bw1 Bw2 Ck	78-105	8.0	0.22	0.0	0.0	0.0	6.8	12.73	0.85	47.1	41.2	3.7	1.6	1.3	100	0.74
	0-28	7.8	0.52	1.6	0.10	16.0	2.9	18.70	0.79	38.2	31.1	3.9	2.2	1.9	100	1.10
	28-42	7.9	0.43	0.7	0.05	14.0	4.0	15.63	0.81	43.6	36.7	4.0	2.0	1.8	100	0.95
Profile 7, Ap Bw1 Bw2 Ck	42-85	7.9	0.38	0.0	0.0	0.0	4.7	11.07	0.81	34.0	27.0	4.0	1.9	1.8	100	0.90



Table continued

Profile 11, Ap	0-20	18.1	30.7	50.2	C
Bw	20-40	17.4	25.3	56.8	C
Ck	40-70	32.0	18.8	48.5	C
Profile 12, Ap	0-24	20.2	32.9	46.3	C
Bw	24-52	23.4	24.5	51.7	C
Ck	52-78	42.7	15.2	41.4	C

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Table continued

Profile 7, Ap	0-28	10YR 3/2	C	2f, sbk	f	c, f	g
Bw	28-42	10YR 3/3	C	3m, abk	f	c, f	w
Ck	42-85	10YR 3/3	C	2c, sbk	f	---	w
Profile 8, Ap	0-25	10YR 3/3	C	2f, sbk	f	c, m	g
Bw	25-40	10YR 3/4	C	3m, abk	f	f, f	g
Ck	40-74	10YR 3/4	C	2c, sbk	f	---	w
Profile 9, Ap	0-18	10YR 3/4	C	3f, sbk	f	c, m	g
Bw	18-50	10YR 2/3	C	3m, abk	f	c, m	s
Ck	50-75	10YR 2/3	C	2c, sbk	f	---	s
Profile 10, Ap	0-15	10YR 3/3	C	2f, sbk	f	c, f	g
Bw	15-38	10YR 2/3	C	3m, abk	f	c, f	w
Ck	38-80	10YR 2/3	C	2c, sbk	f	---	w
Profile 11, Ap	0-20	10YR 3/4	C	3f, sbk	f	c, m	g
Bw	20-40	10YR 3/3	C	3m, abk	f	f, f	s
Ck	40-70	10YR 3/3	C	2c, sbk	f	---	w
Profile 12, Ap	0-24	10YR 3/2	C	2f, sbk	f	c, m	s
Bw	24-52	10YR 3/3	C	3m, abk	f	c, f	w
Ck	52-78	10YR 3/3	C	2c, sbk	f	---	w

Structure: 2 = moderate, 3 = strong. Type: c = coarse, f = fine, m = medium. Class: abk = angular blocky, sbk = subangular blocky; Consistency: f = firm. Roots; abundance: f = few, c = common. Thickness: f = fine, m = medium; Boundary: g = gradual, s = smooth, w = wavy.

**Table 2.** The particle size distribution of irrigated Vertisols.

Horizon (FAO/Unesco)	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture
Profile 1, Ap	0-15	14.9	28.7	55.2	C
Bw	15-60	11.2	30.2	57.8	C
Ck	60-95	25.4	22.9	50.0	C
Profile 2, Ap	0-20	17.1	23.5	58.4	C
Bw	20-45	11.9	25.8	61.7	C
Ck	45-80	24.5	20.1	54.2	C
Profile 3, Ap	0-25	18.6	28.4	51.5	C
Bw1	25-50	12.2	30.1	56.7	C
Bw2	50-75	12.9	26.7	59.9	C
Ck	75-105	25.7	21.5	52.0	C
Profile 4, Ap	0-18	16.2	22.2	60.3	C
Bw1	18-40	9.5	25.1	64.5	C
Bw2	40-65	11.1	20.4	67.8	C
Ck	65-100	25.8	17.2	56.0	C
Profile 5, Ap	0-30	16.3	18.1	63.8	C
Bw1	30-55	11.8	20.3	66.7	C
Bw2	55-90	13.6	15.7	69.9	C
Ck	90-125	27.3	13.5	58.1	C
Profile 6, Ap	0-34	16.9	20.2	60.9	C
Bw1	34-52	7.8	23.4	67.3	C
Bw2	52-78	12.1	17.7	69.0	C
Ck	78-105	27.8	15.0	55.4	C
Profile 7, Ap	0-28	20.2	30.1	48.4	C
Bw	28-42	23.6	22.2	53.7	C
Ck	42-85	42.9	14.1	42.1	C
Profile 8, Ap	0-25	24.9	28.4	45.8	C
Bw	25-40	28.5	20.7	50.3	C
Ck	40-74	39.9	17.8	41.2	C
Profile 9, Ap	0-18	22.2	33.4	43.7	C
Bw	18-50	24.2	26.2	49.3	C
Ck	50-75	36.8	21.3	40.9	C
Profile 10, Ap	0-15	22.9	28.5	47.5	C
Bw	15-38	25.7	22.7	51.0	C
Ck	38-80	38.0	16.4	44.8	C

values slightly decreased with depth. Base saturation is 100% throughout all the soil profiles due to the presence of free  $\text{CaCO}_3$ . The organic C and total N values varied from 0.5% to 2.1% and from 0.04% to 0.15% respectively decreased with depth. C/N ratios ranged from 11.7 to 16.7. The  $\text{CaCO}_3$  concentration varied from 2.0% to 6.8% and increased with depth. The high CEC values indicate high fertility potential for all the studied soils. The high CEC/clay ratio (Table 3) indicated that smectite is the contributor to the high CEC values. Electrical conductivity values showed that the highest value was  $0.62 \text{ dS m}^{-1}$  in the profile 12. Values of EC ranged from 0.22 to  $0.62 \text{ dS m}^{-1}$  indicating that these soils are not saline. Free iron oxide values varied from 0.72 to 1.14% and decreased with depth. Available phosphorous values ranged from 7.17 to 35.08 ppm and decreased with depth. The upper horizons showed highest values and levels of phosphorous were adequate in the studied soils.

## Conclusion

Generally, these irrigated soils are non-saline and slightly alkaline with pH around 7.8. The studied soils have high cation exchange capacity that is contributed largely by clays despite the low organic matter content. Clay content is high in the soils. The high CEC/clay ratio suggests montmorillonitic and mixed mineralogy. The similar distribution of soil properties indicates the low leaching rate, eluviation, illuviation processes, slow rate of weathering and soil development within these irrigated sites. All the studied soils were classified according to FAO/UNESCO (1990) as Eutric Vertisol and USDA Soil Taxonomy (1998) as Typic Haploxerert.

**Table 1.** The morphological features of the irrigated profiles.

Horizon (FAO/Unesco )	Depth (cm)	Munsell Colour (moist)	Texture	Structure	Consistency (moist)	Roots	Boundar y
Profile 1, Ap	0-15	10YR 3/2	C	2f, sbk	f	c, f	w
Bw	15-60	10YR 3/3	C	3m, abk	f	c, f	w
Ck	60-95	10YR 2/2	C	2m, sbk	f	---	s
Profile 2, Ap	0-20	10YR 3/3	C	3f, sbk	f	c, f	w
Bw	20-45	10YR 3/4	C	3m, abk	f	f, f	s
Ck	45-80	10YR 2/3	C	2m, sbk	f	---	s
Profile 3, Ap	0-25	10YR 3/3	C	2f, sbk	f	c, m	w
Bw1	25-50	10YR 3/4	C	2m, abk	f	c, m	w
Bw2	50-75	10YR 3/4	C	3m, abk	f	f, f	s
Ck	75-105	10YR 2/3	C	2c, sbk	f	---	s
Profile 4, Ap	0-18	10YR 3/3	C	3m, sbk	f	c, m	g
Bw1	18-40	10YR 3/4	C	3c, abk	f	c, f	s
Bw2	40-65	10YR 3/4	C	3c, abk	f	f, f	s
Ck	65-100	10YR 2/2	C	2m, sbk	f	---	g
Profile 5, Ap	0-30	10YR 3/2	C	3m, sbk	f	c, m	w
Bw1	30-55	10YR 3/3	C	3c, abk	f	c, f	w
Bw2	55-90	10YR 3/3	C	3c, abk	f	f, f	s
Ck	90-125	10YR 2/3	C	2c, sbk	f	---	s
Profile 6, Ap	0-34	10YR 3/3	C	3f, sbk	f	c, f	g
Bw1	34-52	10YR 3/4	C	3c, abk	f	c, f	g
Bw2	52-78	10YR 3/4	C	3c, abk	f	f, f	s
Ck	78-105	10YR 2/3	C	2m, sbk	f	---	s



reported were to assess the potential of the irrigated Vertisols of the Bursa plain, Turkey to provide basic information for agricultural development; and to characterize the soils, on basis of their properties, according to the FAO/UNESCO (1990) and USDA Soil Taxonomy (1998).

## Material and Methods

Twelve sites were chosen in this research. The soil profiles were located on west side of the Bursa plain in northwestern Turkey. Soil pits excavated to parent material and samples were collected according to different horizon. The profiles were described according to Soil Survey Manual (Soil Survey Division Staff, 1993). The soils were analyzed for particle-size distribution (Gee and Bauder, 1982), pH in a 1:2 soil:water ratio (McLean, 1982), organic carbon (Nelson and Sommers, 1982), total nitrogen (Bremner and Mulvaney, 1982), calcium carbonate (Nelson, 1982), EC (SCS, 1972), free iron oxide (SCS, 1972), CEC (Rhoades, 1982), exchangeable cations (Thomas, 1982) and available phosphor (Olsen, 1982). Horizon nomenclature and classification of the soils carried out according to FAO/UNESCO (1990) and USDA Soil Taxonomy (1998).

## Results

The morphological properties of the soils are given in Table 1. These soils were formed on marl parent material and irrigated with ground water in the research area. The soils occur in a climatic zone with strongly contrasted seasonal climate. During the wet season, soils are almost saturated conditions and become dry and desiccated throughout the profile in the summer season. The cracks were developed to a depth of about 90 cm in all the studied profiles. Their width at the soil surface ranged from 3 to 6 cm. Slickensides were observed and the paralleled structures were attributed to the soil texture, swelling, and shrinkage and pedoturbation in these soils. The soils are deep and dark coloured in the studied profiles. The all horizon had 10YR hue with value 2 to 3 and chroma 2 to 3.

The data on particle size distribution is presented in Table 2. Data on particle size distribution support the observations made during the morphological studies. All the soils are clay textured, containing clay between 40.9 to 69.9%. Clay increases with depth in all the soil profiles and highest at the Bw horizons. Sand fraction varied from 9.5 to 42.7% and highest in the Ck horizons.

Some chemical properties of soils are presented in Table 3. The soil pH ranged from 7.7 to 8.1 and values increased with depth. The CEC values varied 30.8 to 61.5 cmol (+) kg<sup>-1</sup>, and, along with clay content of the soils, increased with depth (Table 2). Ca values ranged from 23.7 to 55.3 cmol (+) kg<sup>-1</sup> and increased to Bw horizons. Mg values varied from 3.5 to 4.5 cmol (+) kg<sup>-1</sup> and increased with depth and highest in the Ck horizons of all the studied soils. K and Na values ranged from 1.6 to 2.3 and from 1.3 to 2.1 cmol (+) kg<sup>-1</sup> respectively, and

# **Physical, Chemical and Morphological Properties of Irrigated Vertisols in the Bursa Plain of Turkey**

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## **Abstract**

Vertisols were identified in a soil survey of the area of Bursa plain in northwestern Turkey. These are generally deep, dark colored with well-developed structure, high in CEC and base saturation, and can hold and supply sufficient amounts of water and nutrients for crops. Vertisols occupy quite large and important part of the agricultural land in the western part of the plain where rain-fed agriculture practiced. Some of the area is also irrigated for valuable crops in the region. The soils of the plain have a great potential for field crops such as wheat, sunflower and sugarbeet, as well as for horticultural crops such as tomato, pepper and melon. The aim of this research was to determine physical, chemical and morphological properties of irrigated Vertisols under intensive agricultural activities in the region. Twelve irrigated sites were selected to present Vertisols. All the studied soils had high clay contents and CEC values throughout the profiles. The high CEC/clay ratio suggests montmorillonitic and mixed mineralogy. Calcium (Ca) was the dominant cation followed by magnesium (Mg), potassium (K), and sodium (Na) in all the soil profiles. The electrical conductivity values are low throughout the soil profiles indicate the low leaching rate, eluviation and illuviation process within these soils. The studied soils were also classified according to FAO/UNESCO (1990) as Eutric Vertisol and USDA Soil Taxonomy (1998) as Typic Haploxerert.

## **Introduction**

This paper focuses on Vertisols occurring in the Bursa province of Turkey. The province occupies an area of 1.104.301 ha. Vertisols comprise 23.436 ha of the land area and occur in the western side of the plain (Anonymous, 1995). These soils derived from marl parent material in the region. They have been mapped and described in limited resource surveys (Anonymous, 1971), but details of soil morphological, physical, chemical and mineralogical characteristics have been documented for only a few studies in this region (Aydınoalp, 1996 and 2001). In recent years, land use has changed dramatically from agricultural use to urbanization and industrialization. Vertisols are under intensive agricultural activities in the region. Most of the arable land has dry farming system for wheat, sunflower and sugarbeet production. The soils with irrigation facilities enable high quality crops such as tomato, pepper, melon etc., in the region. The Nilüfer River, the Ayvalı Canal and ground water sources are the main irrigation water resources in study area.

The detailed studies of the morphological, physical and chemical properties of selected soils were performed. The primary objectives of the work herein

1240 m above mean sea level and used as forest and non irrigated field. This soil group was classified as Eutric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Typic Xerochrept (USDA Soil Taxonomy, 1998).

Non Calcic Brown Forest soil in the profile 16 was formed on greyish calcareous residual colluvium. The soil has moderate deep profile, which was located on 1280 m above mean sea level and used as dense forest. This soil group was classified as Eutric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Typic Xerochrept (USDA Soil Taxonomy, 1998).

Rendzina soil in the profile 17 was developed on residue of limestone. The soil has shallow profile that was located on 240 m above mean sea level and used as shrubbery. This soil group was classified as Rendzic Leptosol (FAO/UNESCO, 1990), Rendzina (FitzPatrick, 1988) and Typic Calcixeroll (USDA Soil Taxonomy, 1998).

## Conclusion

Many soil types were developed in the basin according to different parent materials and geomorphological surfaces. The main differences were occurred according to different climate zone where the soils developed. The climate was the dominant soil formation factor which caused many differences at each soil type. The work was obtained different user to understand and evaluate all data easily which were classified according to three different soil classification systems of great soil groups in the Seyhan basin, Turkey.

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Brown Forest soil in the profile 7 was developed on clayey and sandy deposit. The soil has moderate deep profile that was located on 230 m above mean sea level and used as shrubbery. This soil group was classified as Calcaric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Calcixerollic Xerochrept (USDA Soil Taxonomy, 1998).

Chestnut soil in the profile 8 was formed on gravely neogene deposit. The soil has moderate deep profile, which was located on 1560 m above mean sea level and used as pasture. This soil group was classified as Calcic Kastanozem (FAO/UNESCO, 1990), Kastanozem (FitzPatrick, 1988) and Typic Calcixeroll (USDA Soil Taxonomy, 1998).

Colluvial soil in the profile 9 was developed on clay and residual colluvium from limestone. The soil has deep profile that was located on 50 m above mean sea level and used as dry farming field. This soil group was classified as Calcaric Regosol (FAO/UNESCO, 1990), Fluvisol (FitzPatrick, 1988) and Typic Xerorthent (USDA Soil Taxonomy, 1998).

Red Mediterranean soil in the profile 10 was formed on conglomerate. The soil has moderate deep profile, which was located on 1560 m above mean sea level and used as forest. This soil group was classified as Chromic Luvisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Typic Rhodoxeralf (USDA Soil Taxonomy, 1998).

Red Brown Mediterranean soil in the profile 11 was developed on calcareous conglomerate. The soil has moderate deep profile that was located on 25 m above mean sea level and used as vegetable, olive and citrus fruit fields. This soil group was classified as Chromic Luvisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Typic Rhodoxeralf (USDA Soil Taxonomy, 1998).

Red Brown soil in the profile 12 was formed on residual colluvium from limestone. The soil has moderate deep profile, which was located on 1530 m above mean sea level and used as field. This soil group was classified as Calcaric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Calcixerollic Xerochrept (USDA Soil Taxonomy, 1998).

Non Calcic Brown soil in the profile 13 was developed on yellowish-green gravely sandy calcareous clay. The soil has moderate deep profile that was located on 1490 m above mean sea level and used as non irrigated field. This soil group was classified as Eutric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Typic Xerochrept (USDA Soil Taxonomy, 1998).

Non Calcic Brown soil in the profile 14 was formed on residue of andesite. The soil has moderate deep profile, which was located on 1560 m above mean sea level and used as pasture. This soil group was classified as Eutric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Typic Xerochrept (USDA Soil Taxonomy, 1998).

Non Calcic Brown Forest soil in the profile 15 was developed on clayey schist and residual colluvium. The soil has moderate deep profile that was located on

B22	27-57	29.5	18.1	52.4	C	0.51	7.40	0.57	0.06	9	---	35.22	0.15	0.24	---	35.61
C	57-	34.7	22.9	42.4	C	0.45	7.80	0.30	---	---	11.68	27.09	0.19	0.21	---	27.49
Non Calcic Brown, <i>Profile 14</i>																
A1	0-18	44.3	35.2	20.5	L	0.99	6.80	3.32	0.34	10	---	28.03	0.18	0.98	0.48	29.67
B21	18-54	51.1	18.6	30.3	SCL	0.97	6.80	0.87	0.10	9	---	24.35	0.27	1.44	0.51	26.57
B22i	54-58	26.3	13.0	60.7	C	0.72	7.40	0.70	---	---	---	43.07	0.61	1.94	---	45.62
Non Calcic Brown Forest, <i>Profile 15</i>																
A1	0-5	45.1	38.9	16.0	L	1.65	7.05	2.97	0.20	15	---	16.43	0.13	0.30	---	18.86
B	5-28	42.1	32.3	25.6	L	0.63	6.65	0.57	0.07	8	---	11.90	0.17	0.14	0.91	13.12
C	28-60	35.5	34.9	29.6	CL	0.38	6.60	0.32	0.06	5	---	13.74	0.18	0.10	0.97	14.99
Non Calcic Brown Forest, <i>Profile 16</i>																
A1	0-9	59.1	24.7	16.2	SL	1.69	6.75	4.28	0.25	17	---	28.04	0.21	0.46	0.65	29.36
B21	9-58	50.7	24.7	24.6	SCL	0.54	6.60	0.65	0.09	7	---	14.87	0.11	0.33	0.93	16.24
B22	58-70	54.7	19.7	25.6	SCL	0.25	6.70	0.25	---	---	---	20.66	0.15	0.08	0.97	21.86
Rendzina, <i>Profile 17</i>																
A1	0-9	28.9	47.3	23.8	L	1.08	7.22	1.75	0.12	15	35.28	17.03	0.17	0.29	---	17.49
C1	9-47	24.0	51.2	24.8	SiL	0.89	7.42	0.54	0.04	13	33.39	15.27	0.21	0.14	---	15.62

**Table 2.** Equivalence of great soil groups in the Seyhan basin according to FAO/UNESCO (1990), FitzPatrick (1988) and USDA Soil Taxonomy (1998) systems.

Old Classification (Thorpe et al., 1949)	FAO/UNESCO (1990)	FitzPatrick (1988)	USDA Soil Taxonomy, 1998				Great Group	Subgroup
			Ordo	Subordo	Orthent	Ustorthent		
Alluvial	Calcic Fluvisol	Fluvisol	Entisol	Entisol	Aquent	Fluvaquent	Vertic Ustorthent	
Hydromorphic Alluvial	Salic Fluvisol	Subgleysol	Entisol	Entisol	Ochrept	Xerochrept	Typic Fluvaquent	
Brown	Calcic Cambisol	Altosol	Inceptisol	Inceptisol	Ochrept	Xerochrept	Calcixerollic Xerochrept	
Brown Forest	Calcic Cambisol	Altosol	Inceptisol	Inceptisol	Xerol	Calcixerol	Calcixerollic Xerochrept	
Chestnut	Calcic Kastanozem	Kastanozem	Mollisol	Mollisol	Orthent	Xerorthent	Typic Calcixerol	
Colluvial	Calcic Regosol	Fluvisol	Entisol	Entisol	Orthent	Xerorthent	Typic Xerorthent	
Red Mediterranean	Chromic Luvisol	Argillosol	Alfisol	Alfisol	Xeralf	Rhodoxeralf	Typic Rhodoxeralf	
Red Brown Mediterranean	Chromic Luvisol	Argillosol	Alfisol	Alfisol	Ochrept	Rhodoxeralf	Typic Rhodoxeralf	
Red Brown	Calcic Cambisol	Altosol	Inceptisol	Inceptisol	Ochrept	Xerochrept	Calcixerollic Xerochrept	
Non Calcic Brown	Eutric Cambisol	Altosol	Inceptisol	Inceptisol	Ochrept	Xerochrept	Typic Xerochrept	
Non Calcic Brown Forest	Eutric Cambisol	Altosol	Inceptisol	Inceptisol	Ochrept	Xerochrept	Typic Xerochrept	
Rendzina	Rendzic Leptosol	Rendzina	Mollisol	Mollisol	Xerol	Calcixerol	Typic Calcixerol	

A12	4-42	26.2	42.6	31.2	CL	0.63	7.60	0.89	0.08	11	15.90	37.93	0.20	0.29	---	38.42
A13ca	42-69	28.9	42.4	28.7	CL	0.58	7.75	0.44	---	---	16.05	30.83	0.28	0.14	---	31.25
C	69-88	31.8	40.5	27.7	CL	0.85	7.65	0.45	---	---	23.37	32.82	0.17	0.13	---	33.12
<i>Brown Forest, Profile 7</i>																
A1	0-14	28.7	33.8	37.5	CL	1.19	7.35	2.41	0.18	13	23.20	31.40	0.07	0.40	---	31.87
B1	14-24	29.2	31.9	38.9	CL	0.68	7.55	0.84	---	---	24.66	26.15	0.16	0.24	---	26.55
B2	24-46	33.3	33.1	33.6	CL	0.57	7.42	0.40	0.05	8	22.47	26.22	0.15	0.18	---	26.55
CL	46-62	23.4	37.8	38.8	CL	0.71	7.55	0.25	---	---	23.93	26.58	0.14	0.15	---	26.87
<i>Chestnut, Profile 8</i>																
A1	0-35	33.2	24.4	42.4	C	0.63	7.60	1.93	0.23	9	0.29	33.81	0.16	0.39	---	34.36
B	35-59	30.8	24.8	44.4	C	0.64	7.70	0.87	0.14	6	0.58	31.50	0.17	0.19	---	31.86
CLca	59-70	39.6	22.3	38.1	CL	0.41	8.00	0.37	---	---	7.97	23.44	0.17	0.13	---	23.74
C2	70-	47.9	16.7	35.4	SCL	0.44	7.90	0.27	---	---	5.37	21.60	0.17	0.09	---	21.86
<i>Colluvial, Profile 9</i>																
1	0-31	15.9	38.7	45.4	C	0.76	7.35	0.59	0.08	7	19.31	29.80	0.21	0.29	---	30.30
2	31-66	16.9	37.6	45.5	C	0.62	7.70	0.34	0.05	7	21.92	31.06	0.27	0.22	---	31.55
3	66-102	22.4	38.7	38.9	CL	1.14	7.55	0.25	0.04	6	21.92	26.07	0.29	0.19	---	26.55
4	102-150	21.0	40.9	38.1	CL	0.69	7.85	0.25	---	---	24.97	25.83	0.52	0.20	---	26.55
<i>Red Mediterranean, Profile 10</i>																
A11	0-2	30.0	35.8	34.2	CL	0.62	7.85	1.65	0.15	11	1.00	31.40	0.22	0.55	---	32.17
A12	2-9	29.3	22.8	47.9	C	2.13	7.20	1.38	0.11	12	0.87	38.10	0.66	0.61	---	39.37
B	9-44	18.4	19.8	61.8	C	0.67	7.10	0.79	0.05	16	0.14	44.83	0.29	0.49	---	45.61
<i>Red Brown, Mediterranean, Profile 11</i>																
A1	0-15	24.2	22.8	53.0	C	0.73	7.65	1.07	0.11	10	0.14	49.00	0.22	0.78	---	50.00
B21	15-37	19.4	21.7	58.9	C	0.54	7.35	0.67	0.06	11	0.14	52.80	0.24	0.33	---	53.37
B22	37-68	18.6	21.9	59.5	C	0.65	7.60	0.58	0.06	10	1.43	51.17	0.21	0.17	---	51.55
B23ca	68-81	17.1	25.2	57.7	C	0.85	7.50	0.50	---	---	11.40	48.10	0.31	0.34	---	48.75
<i>Red Brown, Profile 12</i>																
A1	0-5	47.7	25.0	27.3	SCL	0.87	7.60	0.82	0.11	7	14.17	23.65	0.15	0.56	---	24.36
B21	5-26	35.9	30.9	33.2	CL	0.75	7.60	0.94	0.11	8	16.66	30.01	0.19	0.41	---	30.61
B22	26-43	39.9	20.0	40.1	C	0.62	7.70	0.70	0.09	8	17.97	29.27	0.14	0.26	---	29.67
CLca	43-69	48.8	20.4	30.8	SCL	0.58	7.80	0.52	---	---	25.72	21.26	0.16	0.15	---	21.87
C2	69-	3.5	29.8	66.7	C	0.50	7.80	0.42	---	---	22.36	23.73	0.20	0.12	---	24.05
<i>Non Calcic Brown, Profile 13</i>																
A1	0-14	28.5	19.9	51.6	C	0.59	7.20	0.87	0.10	9	---	34.91	0.16	0.54	---	35.61
B21	14-27	30.8	19.1	50.1	C	0.51	7.30	0.86	0.08	11	---	33.90	0.16	0.30	---	34.36



**Table 1.** The some physical and chemical properties of the Seyhan basin (Anonymous, 1974).

Horizon (Old classification)	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	ECx10 <sup>-1</sup> , 25 °C mmhos/cm	pH 1:1 soil: water	Org-C (%)	Total N, (%)	C:N	CaCO <sub>3</sub> (%)	Ca+Mg	Na	K	H	CEC
-----me/100g-----																
<b>Alluvial, Profile 1</b>																
A11	0-18	9.8	34.7	55.5	C	0.55	7.80	0.64	0.07	9	17.22	28.02	0.36	0.69	---	29.07
A12	18-63	6.2	34.4	59.4	C	0.69	7.80	0.55	0.08	7	21.45	28.26	0.25	0.44	---	28.95
A13	63-115	6.5	32.3	61.2	C	0.64	7.85	0.50	---	---	19.70	28.43	0.31	0.33	---	29.07
C1	115-150	11.8	36.1	52.1	C	0.82	8.00	0.35	0.04	9	16.49	26.13	0.53	0.26	---	26.92
<b>Alluvial, Profile 2</b>																
Ap	0-22	5.9	33.2	60.9	C	1.82	7.92	1.14	0.11	10	12.26	31.43	2.70	0.54	---	34.67
A12	22-57	8.2	29.4	62.4	C	2.11	8.45	0.67	0.08	8	11.53	24.39	9.60	0.26	---	34.25
A13	57-88	5.1	25.4	69.5	C	2.82	8.60	0.47	---	---	13.72	21.24	10.13	0.18	---	31.55
AC	88-123	33.7	41.9	24.4	L	2.04	8.90	0.42	0.05	8	14.74	20.75	10.63	0.17	---	31.55
C1ca	123-150	6.9	42.2	50.9	SiL	1.75	8.70	0.28	0.03	9	16.78	22.01	5.34	0.15	---	27.50
<b>Hydromorphic, Alluvial, Profile 3</b>																
1	0-16	6.6	37.3	56.1	C	23.04	7.60	1.09	0.15	7	11.96	24.78	4.60	0.74	---	30.12
2	16-53	4.0	37.7	58.3	C	41.36	7.65	0.50	0.07	7	13.86	22.84	7.03	0.28	---	30.15
3	53-88	8.4	28.6	63.0	C	40.15	7.65	0.47	0.04	12	12.26	24.06	15.59	0.35	---	35.00
4	88-111	5.8	31.0	63.2	C	38.04	7.60	0.44	0.04	11	16.20	24.26	7.18	0.43	---	31.87
5	111-137	14.8	65.1	20.1	SiL	71.83	7.45	0.25	0.03	8	16.20	15.81	4.60	0.09	---	20.50
6	137-155	3.6	33.5	62.9	C	34.90	7.78	0.37	0.03	12	12.26	25.52	8.50	0.35	---	34.37
<b>Brown, Profile 4</b>																
A1	0-7	31.7	17.7	50.6	C	0.75	7.60	1.04	0.11	10	10.26	52.50	0.21	1.02	---	53.73
B2	7-29	26.5	24.2	49.3	C	0.99	7.50	0.86	0.11	8	8.33	52.36	0.18	0.56	---	53.10
B3ca	29-52	30.5	23.9	45.6	C	1.25	7.60	0.59	0.06	10	20.46	24.27	0.38	0.23	---	45.61
Cca	52-	29.2	28.3	42.5	C	0.68	7.60	0.40	---	---	23.38	42.07	0.21	0.20	---	42.48
<b>Brown, Profile 5</b>																
A11	0-17	11.3	68.0	20.7	SiL	0.81	7.50	1.83	0.19	10	13.59	44.08	0.14	0.78	---	45.00
A12	17-38	5.3	32.6	62.1	C	0.91	7.60	1.85	0.16	11	12.86	44.76	0.19	0.67	---	45.62
C1ca	38-58	17.8	28.3	53.9	C	0.68	7.60	0.70	0.07	10	24.26	32.60	0.21	0.31	---	33.12
C2	58-	19.9	34.4	45.7	C	0.53	7.50	0.42	---	---	27.47	30.30	0.18	0.15	---	30.63
<b>Brown Forest, Profile 6</b>																
A11	0-4	36.3	42.2	21.5	L	1.15	7.10	2.63	0.27	10	18.68	30.77	0.41	0.99	---	32.17

## Results

The selected physical and chemical properties of the soils were presented in Table 1. The equivalence of great soil groups according to FAO/UNESCO (1990), FitzPatrick (1988) and USDA Soil Taxonomy (1998) were also presented in Table 2.

Alluvial soil in the profile 1 was developed on fine textured alluvial material. The soil has deep profile that was located on 150 m above mean sea level and used as irrigated land. This soil group was classified as Calcaric Fluvisol (FAO/UNESCO, 1990), Fluvisol (FitzPatrick, 1988) and Vertic Ustorthent (USDA Soil Taxonomy, 1998).

Alluvial soil in the profile 2 was formed on heavy textured alluvial material. The soil has deep profile, which was located on 150 m above mean sea level and used as irrigated land. This soil group was classified as Calcaric Fluvisol (FAO/UNESCO, 1990), Fluvisol (FitzPatrick, 1988) and Vertic Ustorthent (USDA Soil Taxonomy, 1998).

Hydromorphic Alluvial soil in the profile 3 was developed on fine textured alluvial material. The soil has deep profile that was located on 155 m above mean sea level and used as pasture. This soil group was classified as Salic Fluvisol (FAO/UNESCO, 1990), Subgleysol (FitzPatrick, 1988) and Typic Fluvaquent (USDA Soil Taxonomy, 1998).

Brown soil in the profile 4 was formed on conglomerate mixed with gravel. The soil has moderate deep profile, which was located on 52 m above mean sea level and used for fallow land. This soil group was classified as Calcaric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Calcixerollic Xerochrept (USDA Soil Taxonomy, 1998).

Brown soil in the profile 5 was developed on soft calcareous clay deposits. The soil has moderate deep profile that was located on 1540 m above mean sea level and used as pasture. This soil group was classified as Calcaric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Calcixerollic Xerochrept (USDA Soil Taxonomy, 1998).

Brown Forest soil in the profile 6 was formed on clayey schist, residual old colluvium from marl and unconsolidated limestone. The soil has moderate deep profile, which was located on 980 m above mean sea level and used as forest. This soil group was classified as Calcaric Cambisol (FAO/UNESCO, 1990), Altosol (FitzPatrick, 1988) and Calcixerollic Xerochrept (USDA Soil Taxonomy, 1998).

# **Classification of Great Soil Groups in the Seyhan Basin of Turkey, According to Different Soil Classification Systems**

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## **Abstract**

The aim of this work was to classify great soil groups in the Seyhan basin according to different soil classification systems. The basin report was used which prepared by General Directorate of Soil-Water for this aim. Previously, the basin soils were classified according to old soil classification system and therefore this system is no longer in use presently. Nowadays FAO/UNESCO (1990), FitzPatrick (1988) and USDA Soil Taxonomy (1998) systems have been using in many countries as well as in Turkey. The physical, chemical and morphological features of the 17 profiles at 12 great soil groups were investigated and evaluated according to FAO/UNESCO (1990), FitzPatrick (1988) and USDA Soil Taxonomy (1998) systems in this work. This study was carried out useful information to use these data for user in Turkey and as well as in many other countries.

## **Introduction**

The Seyhan basin comprises 2.7% of Turkey and area situated on southern side of country between 36° 33' - 39° 12' N longitudes and 34° 24' - 36° 56' E latitudes (Anonymous, 1974). The total area is 2.106.304 ha. The basin is surrounded by Konya, Kızılırmak, Doğu Akdeniz, Ceyhan and Fırat basins. The Seyhan basin contains Alluvial, Brown, Brown Forest, Chestnut, Colluvial, Hydromorphic Alluvial, Non Calcic Brown, Non Calcic Brown Forest, Red Mediterranean, Red Brown Mediterranean, Red Brown and Rendzina soils which were classified according to old soil classification systems (Thorp et. all. 1949). The annual precipitation in the basin varies from 350 to 1500 mm. The mean annual temperature is 13.1 °C. Agriculture is important in the plains and the highlands being used mainly for forestry in the basin. This study was carried out to classify great soil groups according to three different soil classification systems.

## **Material and Methods**

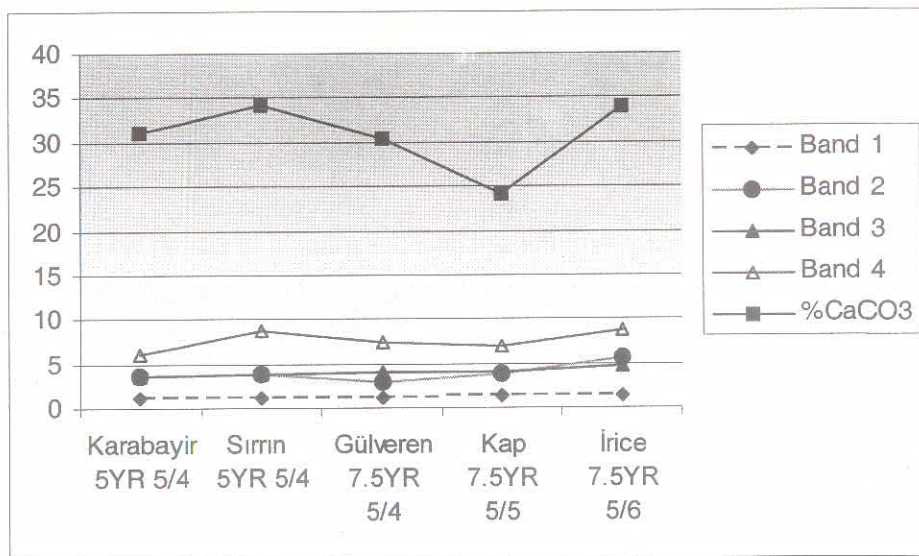
The Seyhan basin report was used in this work (Anonymous, 1974). The soils were classified according to the system of FAO/UNESCO (1990), FitzPatrick (1988) and USDA Soil Taxonomy (1998).



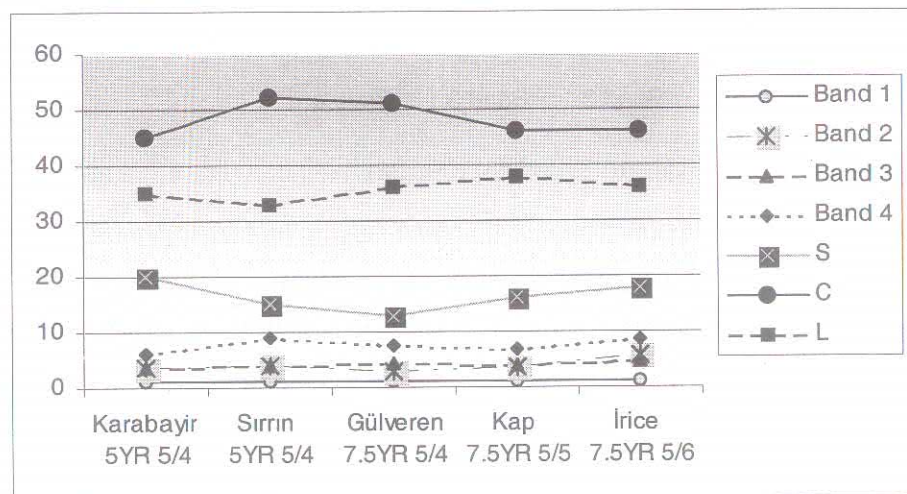
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texture of soils which were measured could not be used for discussions on the reflectance curves.



**Figure 2.** Relationship between  $\text{CaCO}_3$  contents (%) and reflectance curves

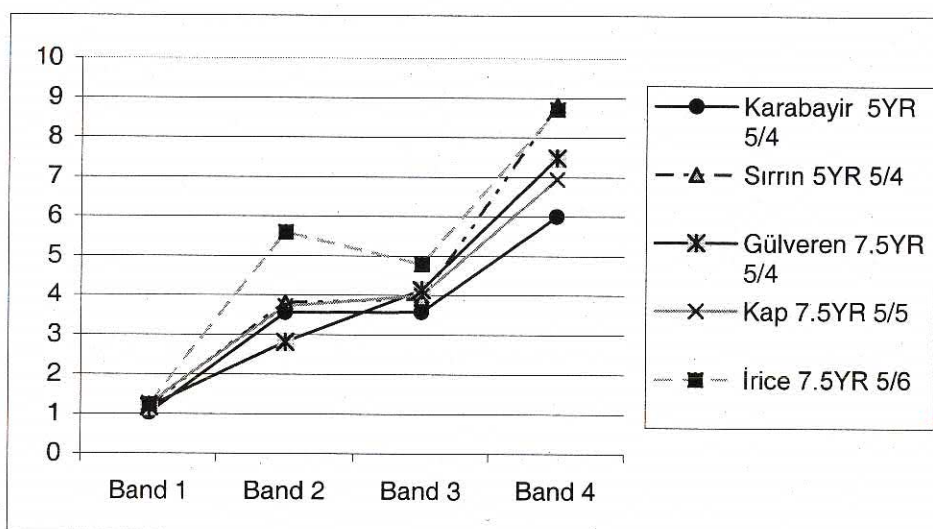


**Figure 3.** Relationship between soil texture and reflectance values

The reflectance values of the Karabayir series are lower than the other series which was formed on Basalt parent material. The color of the series 5 YR according to Munsell (Figure1).

**Tablo 3.** Reflectance values of the series

Series	Band 1(μm)	Band 2 (μm)	Band 3(μm)	Band 4(μm)
Karabayir	1.02	3.55	3.57	5.99
Kap	1.25	3.71	3.99	6.94
İrice	1.24	5.59	4.79	8.71
Gulveren	1.17	2.81	4.13	7.48
Sirrin	1.18	3.81	3.9	8.81



**Figure 1.** Reflectance curves of the series(μm)

%  $\text{CaCO}_3$  Contents also effects reflectance values. Increases in  $\text{CaCO}_3$  contents increase the reflectance values. İrice and Sirrin series has high  $\text{CaCO}_3$  contents therefore show higher reflectance values ( Figure 2).

The texture of the soil is known to have significant influence on reflectance from soils. The effect of the texture on the reflectance values from soils could not be determined because there was no significant differences between the texture of the soil series when the measurements were taken ( Figure 3).

## Conclusion

In this study, Organic matter content and Fe % content have not significantly affected the reflectance values of the soil because the percentage of these material are very low. Increases in  $\text{CaCO}_3$  contents increased the reflectance values. The texture is a significant factor that influences the reflectance but the ratio of the clay, sand and loam of the series are similar. For this reason the



therefore GPS was used to determine the coordinates. The average error of the GPS localization points is approximately 10 m.

## Results and Discussion

Some properties of the soils which are measured are given below.

**Karabayir Series.** This soil was formed on Basalt parent material and lies on flat ground. There are 10-30 cm diameter basalt stones on the surface. The texture of the series soils is clayey throughout the profile. The area which was measured is the phases of the Karabayir series. General properties of that soils are 3-6 % slope, moderate deep(60-90cm) moderate stony(10-50%).

**Sirrin Series.** This soil was formed on mud flow flat parent material(coluvial), generally they are very deep, and contains few 0,5-1cm diameter stones on the surface. The texture of the series soils is clayey throughout the profile. The area where the measurement was taken is the phases of the Sirrin soil series. The area has 3-6 % slope.

**Kap Series.** This soil was formed on Miocene limestones parent material, moderately deep generally flat, and contains few 3-10 cm diameter stones throughout profile. The texture of the series soil is clayey. The area where the measurement was taken is the phases of the Kap soil series. The area has 3-6 % slope, soil depth very shallow(0-30cm) and stony(2-10 %).

**Gulveren Series.** The soil was formed on limestone parent material, moderately 4-10 cm diameter stones on surface. The texture of the series soil is clayey and so calcerious. The area where was the measurement was taken is the phases of the Gulveren soil series. The area has 3-6 % slope, deep 90-120cm

**İrice Series.** The soil was form on Bajada, lies on flat ground. The texture of the series soil is clayey and calcerious. The area where was the measurement was taken is the phases of the İrice soil series. The area has 0-2 % slope.

The Chemical and Physical analyses of the series were given Table 2.

**Table 2.** Chemical and physical analyses of the series

Series	Horizon	Color	Texture			CaCO <sub>3</sub> %	Organic matter %	Fe %
			S	C	L			
Karabayir	Ap	5 YR 5/4	20	45	35	31.1	2.0	0.8
Kap	Ap	7.5 YR 5/5	16	46	38	24.2	1.1	0.7
İrice	Ap	7.5 YR 5/6	18	46	36	33.9	1.5	0.7
Gulveren	Ap	7.5 YR 5/4	13	51	36	30.5	1.3	0.8
Sirrin	Ap	5 YR 5/4	9	55	36	34.2	1.0	0.9

Reflectance values of the all soils are series taken in 25 m intervals in which 8 or 9 values are registered the exact reflectance values of the soils were determined by the average of reflectance values. Reflectance values of the soils from different bands are given below (Table3).

organic matter and water content is revealed by their typical effect on color (Taylor 1982 and Bigham and Ciolkosz 1993).

Soil organic matter content and the composition of organic constituents are known to have a strong influence on soil reflectance. A general observation has been that as organic matter content increases soil reflectance decreases throughout the 0.4-2.5  $\mu\text{m}$  wavelength range (Hoffer and Johannsen 1969). Baumgardner et al(1970) found that organic matter content drops below 2.0 % it becomes less effective in masking the effects on reflectance of other soil constituents.

In this study, reflectance values of the soil surface was determined by a spectroradiometer (EXOTECH 100 BX-TS). The reflectance values are discussed in relation to physical and chemical soil properties .

### Materials and Methods

Soil survey of the study area were completed by Çukurova Universty Agricultural Faculty Soil Science Department ( Dinç et al. 1988).The study area was choisen becauseof wide distrubition of similer soils between Şanlıurfa and Mardin where placed on Harran Plain. The reflectance values of the soil series surfaces were determined by a radiometer. These series are Karabayir, Sirrin, Kap, Gulveren and Irice.

Radiometric mesurments were determined 8<sup>00</sup>-10<sup>00</sup> o'clock because of approximate time of satellite pass over the study area. The radiometer 100BX-TS s/n 3668 was used to determined reflectance values of the soil Bandpass of the radiometer is show in Table 1. It was calibrated a table which covered BaSO<sub>4</sub>. Reflection values were similar the bands of Landsat TM 1,2,3 and 4 . Soil samples were taken between 10-15 cm from soil surface.

The soil texture analysis were done according to the hydrometer method (Bouyoucos, 1951); CaCO<sub>3</sub> % with the Scheibler Calcimeter (Schlichting ve Blume, 1966); Organik Matter (O.M.) contents according to Allison (1965); For the Fe % colorimetric orthofenentrolin method was used (Jackson 1979)

**Table 1.** Currently available filters and ID codes

TYPE	SATELLITE NUMBER	CHANNEL	BANDPASS ( $\mu\text{m}$ )	100BX CHANNEL NUMBER	ID CODE	CORRECTION FILTER I.D. CODE
TM	TM2		0.45-0.52	A	T.	7-63
			0.52-0.60	B	T..	1-58
			0.63-0.69	C	T...	NONE
			0.76-0.90	D	T....	NONE

A board which covered BaSO<sub>4</sub> was used for the calibration of the Spectroradiometer. Right position of the coordinate points are very important

## **Radiometric Reflectance Values of Chemical and Physical Soil Properties**

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### **Abstract**

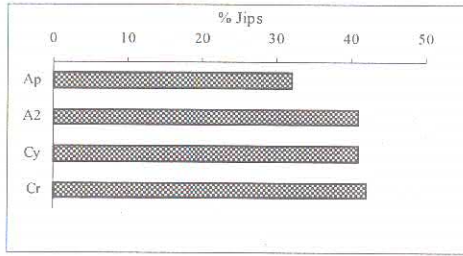
In this study a spectroradiometer( EXOTECH 100 BX-TS) was used to measure reflectance values of 5 different soil series. The samples were taken from soil surface. Physical and chemical analyses were done in order to determine which soil properties are affecting the reflectance values from soils. Some chemical and physical properties of soils are affecting reflectance values significantly. Iron oxide directly affects the reflectance values. Results have shown that increases in reflectance values are affected by the carbonate contents. Organic matter contents had no significant effect on the reflectance values due to very low amounts.

### **Introduction**

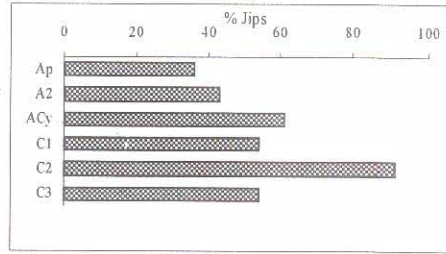
The aim of the whole studies done from the past to present and also for the future is just for the well being of the human population. It is obligated to know the capacity the uses of these sources. In the recent years it is agreed that the research by using satellite technology is not completely usable without the support of field measurements. Meanwhile the field measurements increase in importance with the cooperation of satellite technology. Today spectroradiometers are specially used for the field measurements. Most of the spectroradiometer measurements have the same spectral fields as the satellites. The multiband receivers used in the satellites and also for the field measurement devices, the working principle depends on sunlight, received from the materials. Moreover that, we could imagine the exact time for examining the field materials with satellites by the cooperation of the field measurements. The reflection values of the materials counted from earth help us to identify them when received with remote sensing. Another use of the field measurement system is in agriculture mostly for the crop yield and agricultural area identification.. A study which was done on this area, an Exotech Model 20C spectroradiometer was used outdoors under solar illumination to obtain spectral response from dry and moistened field plots with and without corn residue cover, representing the different soils. Results indicate that laboratory measured spectra of moist soil are directly proportional to the spectral response of that same field measured moist bare soil over 0,52-to 1,75  $\mu\text{m}$  wavelength range (Stoner E.R et al). There are a lot of factors affecting soil reflectance values. The presence of some soil constituents , for example iron oxides, limestone,



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Nalbantoğlu Series



Altınova Series

**Figure 1.** Gypsum % contents of Nalbantoğlu and Altınova Soil Series

**Table 3.** Classification of the soil series according to Soil Taxonomy and FAO/UNESCO.

Series	Order	Suborder	Great and Subgroup	FAO/UNESCO
Altınova	INCEPTISOL	Xerept	Gypsic Haploxerept	Haplic Gypsisol
Nalbantoğlu	INCEPTISOL	Xerept	Gypsic Haploxerept	Haplic Gypsisol
Kalecik	ENTISOL	Orthent	Lithic Xerorthent	Eutric Leptosol

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**Table 2.** Some important physical and chemical properties of the soil series.

Horizon	DEPTH (cm)	pH	Ece dS m <sup>-1</sup> in paste	CaCO <sub>3</sub> (%)	O.M. (%)	Ava. P (kg da <sup>-1</sup> )	Ava. K (mg kg <sup>-1</sup> )	CEC (mol kg <sup>-1</sup> )	Exchangeable Cations (mol kg <sup>-1</sup> )			Particle Size Distribution (%)			TEX. CLASS
									K <sup>+</sup>	Na <sup>+</sup>	Ca <sup>++</sup> +Mg <sup>++</sup>	SAND	SILT	CLAY	
ALTINOVA SERIES															
Ap	0-17	7.65	3.7	36.5	1.67	7.3	936	31.9	1.08	0.35	30.5	26.6	35.7	37.7	CL
A2	17-27	7.66	3.4	26.1	1.06	1.8	746	29.6	0.33	0.35	28.9	22.2	33.7	44.1	C
ACy	27-44	7.65	2.9	17.7	0.58	0.6	732	20.4	0.25	0.38	19.8	60.9	25.6	13.5	SL
C1	44-58	7.72	2.8	18.3	0.42	0.6	540	17.3	0.22	0.40	16.7	61.2	23.2	15.6	SL
C2	58-77	7.72	2.8	15.5	0.44	0.5	376	16.8	0.21	0.40	16.1	63.2	21.6	15.2	SL
C3	77-110	7.76	2.4	16.6	0.33	0.4	518	18.2	0.21	0.31	17.7	68.1	20.7	11.2	SL
KALECIK SERIES															
A	0-15	7.67	2.1	4.3	0.71	0.1	467	17.0	0.17	0.06	16.7	GYPSUM			
AC	15-25	7.62	2.3	2.2	0.61	0.1	416	15.5	0.13	0.03	15.3				
NALBANTOĞLU SERIES															
Ap	0-11	7.62	2.8	50.5	1.71	13.6	302	24.2	0.65	0.16	23.4	38.0	42.3	19.6	L
A2	11-25	7.65	3.1	48.6	1.32	7.1	226	21.4	0.35	0.19	20.9	44.0	39.1	16.9	L
Cy	25-40	7.66	2.6	22.9	0.58	1.0	420	11.3	0.18	0.14	10.9	GYPSUM			
Cr	40-68	7.66	2.0	23.1	0.23	0.7	205	5.8	0.10	0.07	5.7				



## Conclusions

Conclusions to be derived from this study as fallow;

1. It was understood that soils of TRNC face an important problem in terms of erosion. Because, typical dry climate properties of the region, parent material of soils and steep slope make up suitable conditions for water erosion.
2. These three soil series have high level of gypsum. However there is no problem for plant growth in terms of soluble gypsum toxicity.
3. Due to the hydrometer method used to determine soil texture (Table 2) results could not be compared with the field observations because of high gypsum contents of soils.

**Table 1.** Morphological properties of the soil series.

ALTINOVA SERIES		
Horizon	Depth (cm)	Definition
Ap	0-17	Dull yellowish brown (10 YR 4/3) moist; clay loam; moderate thin granular structure; while moist friable; while wet very sticky and very plastic; high calcareous; rare fine roots; wavy gradual boundary.
A2	17-27	Dull yellowish brown (10 YR 4/3) moist; clay; moderate thin granular structure; while moist friable; while wet very sticky and very plastic; high calcareous; rare fine roots; wavy gradual boundary.
ACy	27-44	Dull yellowish brown (10 YR 4/3) moist; clay; massive; while moist friable; while wet very sticky and very plastic; high calcareous; thick gypsum crystals; wavy gradual boundary.
C1	44-58	Dull yellowish brown (10 YR 4/3) moist; clay; massive; while moist friable; while wet sticky and plastic; high calcareous; thick gypsum crystals; wavy gradual boundary.
C2	58-77	Dull yellowish brown (10 YR 4/3) moist; silty clay loam; massive; while moist friable; while wet sticky and plastic; high calcareous; thick gypsum crystals; wavy gradual boundary.
C3	77+	Light yellow (2,5 Y 7/3) moist; clay loam; massive; while moist strong; while wet slight sticky and slight plastic; high calcareous; thick gypsum crystals.
KALECİK SERIES		
Horizon	Depth (cm)	Definition
A	0-15	Yellowish brown (10 YR 5/6) wet; sandy loam; weak thin granular structure; while moist slight sticky and slight plastic; few calcareous; dense fine roots; gypsum fragments on the surface; wavy gradual boundary.
AC	15-25	Yellowish brown (2,5 Y 5/6) wet, sandy loam; massive; while moist slight sticky and slight plastic; few calcareous; moderate dense fine roots.
R	25+	Planty gypsum
NALBANTOĞLU SERIES		
Horizon	Depth (cm)	Definition
Ap	0-11	Dull yellowish brown (10 YR 5/3) moist; loam; thin weak granular structure; while moist friable; while wet slight sticky and slight plastic; high calcareous; dense fine roots; wavy gradual boundary.
A2	11-25	Dull yellowish brown (10 YR 5/4) moist; loam; thin weak granular structure; while moist friable; while wet slight sticky and slight plastic; high calcareous; rare fine roots; clear smooth boundary.
Cy	25-39	Dull yellow orange (10 YR 7/3) moist; clay loam; massive; while moist strong; while wet slight sticky and slight plastic; high calcareous; stoneless; thick gypsum crystals; wavy gradual boundary.
Cr	39-68	Dull yellow orange (10 YR 7/2) moist; clay loam; massive; (original rock structure); high calcareous; marl fragments.

field were determined according to the Soil Survey Staff (1993) and FAO (1977).

## **Results and Discussion**

### **Interpretation of the Morphological, Physical, Chemical and Mineralogical Characteristics of the Soil Profiles**

The horizon orders of the profiles in study area were defined to be A-C form (Table 1). Kalecik series has no diagnostic horizon other than an ochric epipedon. In addition pedogenic processes is obstructed by severe erosion. Altınova and Nalbantoğlu series show moderate pedogenic development, more than the Kalecik series. These series have a gypsic horizon. The profile colors are 10YR in the upper strata and in the lower strata two of the profiles as 2.5Y according to Munsell soil color charts. These color characteristics of the soils are also supported by the high gypsum content. The structure of the soils is mainly to be of granular on the surface and masive on the subhorizons. The texture of Kalecik series is sandy loam throughout the profile. The other series are composed predominantly of clay, loam and clay loam. All of the profiles except Kalecik are high in carbonates. Boundaries between horizons are usually wavy gradual.

According to the results of chemical and physical analysis (Table 2) due to the prevailing climatic conditions, in all the profiles organic matter contents was low or very low (0.23–1.71%).

The Cation Exchangeable Capacity (CEC) of the soils was determined to be low and varied between 5.8 to 31.9 mol kg<sup>-1</sup>. In general the CEC is higher in the surface horizons and decreases with the depth gradually. Exchangable cations consist of mostly Ca<sup>+2</sup>+Mg<sup>+2</sup> and the values also decrease with the depth. Available potassium contents of soils in the all layers are sufficient and vary from 205 to 936 mg kg<sup>-1</sup> and phosphorus contents was low. Soil pH is slightly (7.4 to 7.8) alkaline throughout the profiles. There is no salinity or alkalinity problem in the profiles. According to EC values, all series are slightly saline. Contents of CaCO<sub>3</sub> range from 2.2% to 50% and decrease with depth throughout the profiles. The parent material of soil are rich in gypsum.

In respect of mineralogical analysis, contents of gypsum change from 32% to 91% (Figure 1). Kalecik series contain approximately 40% proportion of gypsum rock in soil surface.

### **Soil Classification**

The soils are classified according to the criteria proposed by Soil Taxonomy (Soil Survey Staff, 1999) and FAO/UNESCO (1990) based on morphological and physico chemical characteristics (Table 3). According to the meteorological data, the research area has Xeric soil moisture regime and Thermic soil temperature regime.



## Material and Methods

Turkish Republic of Northern Cyprus (TRNC) is situated in the north-eastern of the Mediterranean sea and located west of Syria and south of Turkey. The climate of the region is a typical Mediterranean climate with hot, dry summers and warm, rainy winters. The mean annual minimum and maximum temperature is 10,5°C in January and 27,6 °C in July and August, respectively. The total annual precipitation ranges approximately 310 mm. According to data obtained from 26 different stations in study area, the average annual relative humidity is 65% (Tarım İstatistikleri, 1998).

Cyprus island is separated into three main regions in terms of geologic-stratigraphical extension by Constantinou (1995), Yetiş et al (1995) and MTA (1998). These regions are : 1) Troodos Mountains which situated in central part of island generally consist of magmatic rocks. 2) Girne Mountains which parallel extended to coast in the north usually consist of Mesozoic rocks. 3) Mesaoria plain which usually consists of Neogen oldest Kuaterner deposits are situated between Troodos and Girne Mountains and extend from western Güzelyurt to eastern Gazimagusa gulf.

Sediments of rock salt, anhydrite and gypsum determined in the base of Mediterranean have indicated excessive evaporation in desert conditions (Cita, 1982., Ögrünç et al., 1999). These formations have meant that Mediterranean had dried and area located between Turkey and Nil delta changed to wide deserts and salt lakes (Hsu et al., 1978). Especially, parent material with Miocene limy precipitated in conditions of shallow and hot sea include high amount of gypsum. Gypsums were commonly encountered with crystals, foliated (laminae) and mixing (not pure) forms. Although gypsum is very soluble salt, due to the fact that it was not leaching from profile, it has seen that in this part of Cyprus island climate conditions has not changed too much since Holocen age.

According to detailed soil survey study and the existing maps and reports, three different soil profiles which formed on gypsum parent material were identified and sampled (Dinç et al, 2000). According to the genetic horizon principle; physical, chemical and mineralogical properties were determined in soils samples taken from each profile. The texture analysis were done according to the hydrometer method (Bouyoucos, 1951);  $\text{CaCO}_3$  % with the Scheibler Calcimeter (Schlichting and Blume, 1966); Organik Matter (O.M.) according to Allison (1965); Cation Exchangeable Capacity (CEC), Exchangeable Cations (EC), available  $\text{K}^+$ , pH, total soluble salts by method of the U.S. Salinity Laboratory Staff (1954); available P according to Olsen et al. (1954) and Gypsum mineralogy analyses in an X-Ray diffractometer (Jackson, 1979) using by disturbed soil samples. Morphological properties of the soil profiles in the



## **Genesis and Some Properties of Soils Formed on Miocene Gypsum in Turkish Republic of Northern Cyprus**

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### **Abstract**

In this research, three soil profiles developed on Miocene aged gypsum parent material in the Mesaoria plain has been studied in order to investigate their important properties and formation. The soil samples were obtained from each profile on horizon basis. Physical, chemical and mineralogical properties were determined in the laboratory. The results of analyses and field observations of these profiles had been classified as Inceptisol and Entisol according to Soil Taxonomy and as Leptosol and Gypsisol according to FAO/UNESCO.

### **Introduction**

Soil that composed of mineral and organic materials and living forms in which plants grow is a dynamic natural body. The properties of soil vary from place to place, but this variation is not random. Natural soil bodies are the result of climate and living organisms acting on parent material with topography and with time required for soil forming processes. In addition, according to Simonson (1959) after some soil forming processes, there are additions to soil, losses from soil, translocation and transformations within the soils have characterized. Whenever soil forming factors are the same, it is logical to expect that the soils developed will be alike, regardless of their location on the earth's surface. Similarly, soils separated by only a short distance can be quite different if one of these factors is different. This regularity permits prediction of the location of many different kinds of soil. The nature of the soil parent material has an important influence on soil characteristics. The degree of influence of the parent material on soil properties depends on the type of parent material and the developmental age of soil. The present study was conducted to investigate important properties and formation of Turkish Republic of Northern Cyprus soils formed on the Miocene gypsum parent material.

the least squares, on the basis of which the linear dependences of the electrical and thermal characteristics soil from their specific surface as the following expressions are received

$$\varepsilon' = 65 + 0,189S_0$$

$$10^3 \sigma = 43 + 0,039S_0 \quad (1)$$

$$10^4 K = 34,8 - 0,052S_0$$

$$10^4 \lambda = 20,6 - 0,038S_0$$

Hereinafter formulas of communication  $\varepsilon'$  ( $S_0$ ) and  $\sigma$  ( $S_0$ ) are resulted only for frequency of an electrical field  $f=0,4$  MHz.

The advantage of the received system of the equations (1) is, that she can be applied to soil of any type, into it enter only one argument  $S_0$ , on which size it is possible to define as electrophysical, and thermalphysic of the characteristic of a researched sample.

Deciding in common it is possible to find the equations of dependences of the electrical and thermal characteristics soil rather  $S_0$ , correlation communications between them. The received formulas look like

$$10^4 K = 58,85 - 0,37\varepsilon' \quad (2)$$

$$10^4 \lambda = 38,15 - 0,27\varepsilon'$$

$$10^4 \lambda = 62,31 - 0,97 \cdot 10^3 \sigma$$

Thus, defining size of a specific surface soil under the formula it is possible to find also meanings electro- and thermalphysic of parameters or, having estimated thermalphysic of property soil by an any way, it is possible to define and the size of the electrical characteristics can be decided and return task, i.e. to define size of a specific surface soil.

The results of the carried outresearches can be useful at an estimation soil and drawing up of the projects various soil - land - reclamation of measures.

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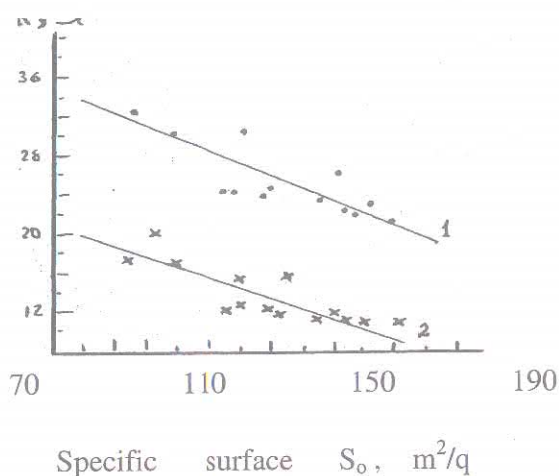
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f – frequency, W – humidity, r – correlation coefficient

1) f = 0,6 MHz	W = 25,2%	r = 0,956
2) f = 0,6 MHz	W = 19,6%	r = 0,958
3) f = 10 MHz	W = 25,2%	r = 0,961
4) f = 10 MHz	W = 19,6%	r = 0,980



**Figure 2.** Dependence temperature and conductivity from a specific surface soil  $S_0$  [ $\text{m}^2 \cdot \text{g}^{-1}$ ] at  $W=16\%$ ,  $\rho = 1,4 \text{ g/cm}^3$ , 1-temperature conductivity,  $\text{K} \cdot 10^4 \text{ cm}^2/\text{s}$ , 2 - heat conductivity  $\lambda \cdot 10^4 \text{ kcal/cm} \cdot \text{s} \cdot \text{degree}$ .

### Discussion and Conclusion

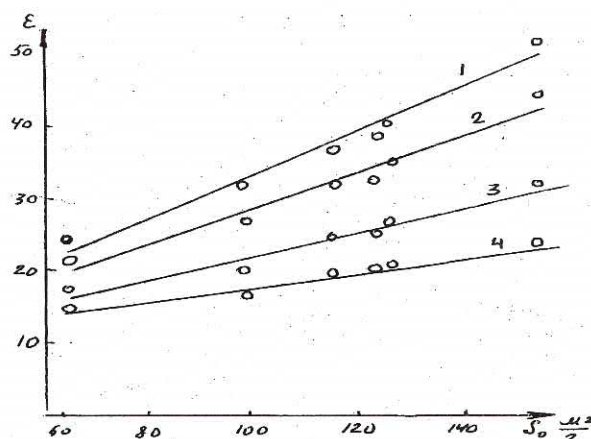
In the Table 2 the comparative results received  $S_0$  till a way Kutileka and on dielcometer to a method are shown.

The similar dependence is revealed ( Troitsky N.B., Gulaliev Ch. G.Gerayzade A.P. 1986 ; Troitsky and. B.,Stepanov JI 1980 ) for chernozem and South-Ukrainian dark - chestnut soil earlier. It is possible to explain linear dependence  $\epsilon''$  from  $S_0$  in general to that dielcometer of property of materials are defined by various kinds of polarisation them in an electrical field. For soils of particles most typical by a kind of polarization them in an electrical field the is migratory polarization directly proportional to a square of diameters of particles, and consequently, and size of their surface. Linearity of communication between  $\sigma$  and  $S_0$ , apparently than higher

electrical field  $f = 0,4$  and  $10$  MHz. As it is visible, with increase of meaning of a specific surface soil linearly grow both  $\epsilon'$ , and  $\sigma$ .

**Table 1.** (The part of the data is borrowed from job Qerayzade ,1982).

Soil	The size of particles, mm		
	1-0,01	0,01-0,001	< 0,001
Serious	24,90	38,70	36,40
Brown	22,10	31,40	46,40
Zheltozem (slit 1)	46,16	37,96	15,88
Zheltozem (slit 2)	45,28	32,60	22,12
Chernozem mountain	25,32	34,44	40,24
Chestnut mountain (slit 1)	30,64	45,96	23,40
Chestnut mountain (slit 2)	31,60	43,76	24,64
Meadow - sierozem (slit 1)	37,16	33,04	29,80
Meadow - sierozem (read. 2)	35,36	33,76	30,88
Serious – grassland (read. 1)	16,16	50,16	33,68
Serious- grassland (slit 2)	18,52	49,68	31,80
Meadow -- sierozem (slit 3)	56,76	18,88	24,36
Chestnut	68,44	19,40	12,16
Grey – brown	62,75	19,84	17,44
Serious-meadow (slit 3)	55,64	12,08	32,28
lake –meadow	29,32	36,96	33,12
Serious-meadow (slit 4)	61,20	35,04	13,76
Alkali soil	50,33	25,15	24,52
Chernozem ordinary	31,57	26,31	42,12



**Figure1.** Dependence permittivity  $\epsilon'$  and specific conductivity  $\sigma$  [ $\text{smCm}^{-1}$ ] from a specific surface soil  $S_0$  [ $\text{m}^2\text{q}^{-1}$ ] at  $W = 16\%$ ,  $\rho = 1,4 \text{ q/sm}^3$ ,  $t = 20^\circ\text{C}$ . 1 and 3 –  $f = 0,4$  MHz, 2 and 4 –  $f = 10$  MHz.

## Materials & Methods

The researches was spent in a Southeast part of the Large Caucasus and in a southern part of a strip of foothills and low mountains in Lenkoran province, mountain - chestnut, chestnut, brown, meadow - serous, serous, serous -meadow soils, yellow and salt-marsh. Mountain chernozems are distributed in Middling Mountain to a strip on the leveled slopes of a various exposition. Annual temperature of air here 6-10 °C, annual sum of rain of 400-600 mm. In a vegetative cover prevails motley grass steppe phytocenosis.

The content humus in mountain chernozem makes up 4-5 %. On granulometric structure it is average loamy ( Qasanov ,1978 ).

Of mountain - chestnut soil are formed on dealluvial carbonate - loamy adjournment, are distributed in stiffly steppe to a zone. Average annual temperature of air in this zone makes 10-12°C, annual sum of rain up of 300-400 mm. The content humus in these soils is equal 2,2-2,6 %. Granulometric structure middling – and loamy easy (Qasanov ,1978; Qerayzade ,1982).

Meadow - sierozem, sierozem, sierozem - meadows, lake - meadows soil are distributed in sierozem to a zone in limits the Kur - Araks of lowland and are formed on clay alluvial sediment. The climate of lowland concerns to seem-desert and deadwood to types. Natural humidifying poor, winter warm, summer hot and dry. Annual temperature of air is equal 14-15 °C, the sum of annual rain makes up 200-450 mm.

The natural vegetation submitted is ephemera. The agricultural grounds are used - cotton, grain, fodder and other kinds of cultures. Humus varies within the limits of 1,5-2,4 %. Granulometric structure soil varies from hardly clay up to light clay (Qerayzade ,1982; Mamedov ,1982; Gulaliev ,2000). Chestnut and grey - brown soils also are distributed in this area. The contents humus varies within 2,0-4,5 % (Qasanov 1978; Mamedov ,1982 ).

Zheltozem are advanced in areas with a damp subtropical climate in conditions of very contrast humidifying. The contents humus varies within the limits of 3-7 % (Qerayzade ,1982; Gulaliev ,2000 ). Investigation soils of considerably differ on grain - size to structure (Table 1). The contents of physical clay vary within of 37-84 %, i.e. changes more than in 2 times. Such large distinctions in the contents of particles of the different sizes are the essential factor influencing size of a specific surface soil, and also on them electro - and heat - transfer of the characteristic.

In a Fig. 1 the dependencies permittivity  $\epsilon'$  are submitted. Specific conductivity,  $\sigma$  [ $\text{cm}\cdot\text{m}^{-1}$ ] from a specific surface soil for meanings of humidity  $W = 16$  of %, density  $\rho = 1,4 \text{ g}/\text{cm}^3$ , temperature  $t = 20^\circ\text{C}$  at two meanings of frequency of an



## **To an Estimation of a Specific Surface Soil on The Data Elektro- and Thermalphysic of Definitions**

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### **Abstract**

It is shown that permittivity and electroconductivity linearly grow, temperature conductivity, and thermal conductivity linearly decrease with increase of a specific surface soil, disclosing the communication between electro - and thermalphysic by the characteristic soil for the fixed meanings of humidity, density, temperature, frequency of an electrical field.

### **Introduction**

At rational use of agricultural ground, the important meanings get exact and express methods an estimation of the basic physical -chemical characteristics soil. The most effective means of the decision of this task is to remember of tool physical and physical-chemical methods. Among these methods it is possible to allocate electro - and thermal methods of study of the soil characteristics, which represent significant interest by development soil much-parametrical measuring equipment. However of researches devoted communication between these characteristics soil ( Qarayzade ,1982; Gulaliev ,2000; Troitsky ,1986 ) very little. It is known, that communication between electrophysical and thermal in parameters reveal by study of their dependence from a specific surface soil. It is necessary to note, that the dependence of these parameters on a specific surface soil till now also deeply is not investigated This represents the very important agronomic characteristic of soil. With increase dispersion ability the superficial energy of substance determining such processes, as absorption mineral Sol of elements, steams, gases, moving of water and air raises also Thus some other physical and technological properties soil are improved.

In the present works are considered the results of study of dependence permittivity, specific electroconductivity, thermal conductivity and heat conductivity from a specific surface of soil.

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uptake of Mg by plant increase and this influence both crop yield and contents of plant nutrition. Mg is a major nutrient in plant chlorophyll consequently plant photosynthesis. Similar effect was determined from CaO+MgO mixed application. But in CaO application, so that the Ca:Mg ratio was very high, plant was not sufficient Mg uptake. Similar results were obtained by many researchers (Barber, 1984; Marschner, 1995; Güneş et.al., 2000).

**Table 4.** Mineral Composition of Plants

Lime Materials	Doses*	%					ppm				
		N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
MgO	0	2.71	0.27	4.03	0.46	0.46	0.14	176.5	70.7	108.0	22.3
	50	3.33	0.35	4.23	0.57	0.74	0.16	148.9	61.3	92.0	18.0
	100	3.46	0.43	4.21	0.68	0.97	0.15	142.2	56.0	80.0	15.0
	200	3.92	0.49	4.08	0.67	1.16	0.15	114.7	54.6	73.7	13.3
	Mean	3.36	0.39	4.14	0.60	0.83	0.15	145.6	60.7	88.4	17.2
CaO	0	2.73	0.27	4.06	0.45	0.47	0.15	170.4	69.3	108.6	21.3
	50	3.15	0.35	4.24	0.73	0.58	0.14	143.9	60.3	98.0	16.3
	100	3.26	0.44	4.18	1.07	0.65	0.15	114.1	58.0	89.3	13.7
	200	3.72	0.42	4.09	1.31	0.65	0.16	104.3	58.3	80.3	13.0
	Mean	3.22	0.37	4.14	0.89	0.59	0.16	133.2	61.5	94.1	16.1
CaO+MgO	0	2.73	0.28	3.96	0.45	0.47	0.14	173.8	72.3	109.3	21.7
	50	3.24	0.34	4.25	0.62	0.69	0.15	149.4	64.6	99.0	17.0
	100	3.48	0.43	4.29	0.74	0.76	0.15	134.8	59.7	87.6	14.3
	200	3.75	0.44	4.21	0.95	0.88	0.15	129.5	53.3	82.0	13.3
	Mean	3.30	0.37	4.18	0.69	0.70	0.15	146.6	62.5	94.5	16.6

\*: Lime doses of lime Requirement %

Nitrogen, P, K, Ca and Mg contents of plant increased by increasing rates of lime applications. This may be attributed to basal fertilizer and lime material application. Similar results were determined some others (Reith, 1983; Martini and Mutters, 1985a; Feger et al., 1991). While Fe, Mn, Zn and Cu contents of plants decreased all of the lime material application. These decreased was due to increasing soil pH degree and between pH and micronutrient relationships were negative correlation. Some researchers found similar results (Martini and Mutters, 1985 ab; Ponette et.al., 1996).

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**Table 2.** Dry Mater Content of Spinach ( 68°C, gr/pot)

Lime Material	Lime Doses of Lime Requirement %				Mean
	0	50	100	200	
CaO	1.54	2.57	3.91	3.66	2.92 c
MgO	1.56	2.91	4.23	4.16	3.22 a
CaO+MgO	1.57	2.74	4.06	3.95	3.08 b
Mean	1.56 c	2.74 b	4.07 a	3.92 a	3.07

As a result of statistical analysis , the most effective lime material was MgO, lime dose was 100 % lime requirement application on plant dry matter contents. Effects of lime application materials and doses on dry mater content of spinach were statistically significant ( $p < 0.05$  and  $p < 0.01$  respectively)( Table 3).

**Table 3.** ANOVA Table for dry mater content of spinach

Variation Source	Df	M.M	F
Lime Material (LM)	2	0.31	7.7 *
Lime Doses (LD)	3	11.94	298.5 **
LM x LD	6	0.02	0.5
Error	24	0.04	-

\*: $p < 0.05$  level, \*\*:  $p < 0.01$  level

### Effects of Lime material Application on Mineral Composition of Spinach

Mineral composition of spinach is given Table 4. N, P, K, Ca and Mg contents of plants generally increased by increasing rates of lime applications, but Fe, Mn, Zn and Cu content of plants decreased. The increased N, P, K, Ca and Mg content may be due to basal fertilizer and lime material application, and decreased plant Fe, Mn, Zn and Cu content of plants may be due to effect on the availability so that between pH, lime and micro nutrient interactions.

### Discussion

Result of this study indicated that application of different lime materials improved plant growth, amount of dry matter and nutrient balance of soil solution. As increasing rates of 100 % lime requirement doses, dry matter contents of spinach increased, but as lime application was over 100 % lime requirement doses plant dry mater contents decreased. The most effective lime material were determined MgO. It may be due to Ca:Mg ratio and increased soil pH degree and limited some toxic element levels. Initially Ca: Mg ratio contents of soil was 3.0 (0%), after lime application, this ratio was 1.33 (50%), 0.85(100%) and 0.47 (200%) in MgO application, but, in CaO application 3 (0), 4.33 (50%), 6.55 (100%) and 9.42 (200%). In CaO+MgO application to soils, Ca:Mg ratio was 3 (0), 2.17 (50%), 1.87 (100%) and 1.79 (200%). These result showed that as Ca:Mg ratio was narrow,

capacity was 23.20 cmol kg<sup>-1</sup>, exchangeable Ca+Mg, K, Al+H were 10.40, 0.3 and 12.10 cmol kg<sup>-1</sup>, plant available P was insufficient 3.2 kg da<sup>-1</sup>, Mn, Zn and Cu were sufficient or excessive for plant nutrition (Anon, 1980 and FAO, 1990).

**Table 1.** Some physical and chemical properties of soils studies.

Soil Properties	I.T*	Lime Doses of Lime Requirement %											
		CaO				MgO				CaO+MgO			
		0	50	100	200	0	50	100	200	0	50	100	200
pH(1:2.5)	4.2	4.2	6	6.9	7.7	4.2	5.7	6.70	7.30	4.20	5.80	6.70	7.40
Org.Mat. %	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.90	2.90	2.90	2.90	2.90	2.90
CaCO <sub>3</sub> kg da <sup>-1</sup> *	1770	1770	1770	1770	1770	1770	1770	1770	1770	1770	1770	1770	1770
KDK, cmol kg <sup>-1</sup>	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
Ca, cmol kg <sup>-1</sup>	7.8	7.8	9.75	13.1	17.9	7.8	7.2	7.00	6.50	7.80	8.15	9.65	12.4
Mg, cmol kg <sup>-1</sup>	2.6	2.6	2.25	2	1.9	2.6	5.4	8.20	13.6	2.60	3.75	5.15	6.90
K, cmol kg <sup>-1</sup>	0.3	0.3	0.30	0.25	0.22	0.30	0.28	0.25	0.20	0.30	0.28	0.23	0.20
Al+H, cmol kg <sup>-1</sup>	12.1	12.1	10.3	8.15	3.1	12.1	9.7	7.25	2.60	12.1	10.6	7.90	3.40
P, P <sub>2</sub> O <sub>5</sub> kg da <sup>-1</sup>	3.2	4.6	5.80	6.9	5.9	4.9	5.8	6.80	6.30	4.80	5.70	6.90	6.10
Fe, ppm	33.6	33.6	18.0	12.2	3.6	33.6	23.5	13.0	4.20	33.6	23.0	18.0	3.80
Mn, ppm	26.1	26.1	14.8	9.6	2.5	26.1	14.1	9.50	3.70	26.1	10.2	8.40	3.40
Zn, ppm	3.2	3.2	1.1	0.6	0.5	3.2	1.6	1.50	1.40	3.20	1.90	0.80	0.80
Cu, ppm	1.6	1.6	1.5	1.5	1.3	1.6	1.5	1.40	1.10	1.60	1.50	1.50	1.10
Sand, %	26.8	-	-	-	-	-	-	-	-	-	-	-	-
Loam, %	27.8	-	-	-	-	-	-	-	-	-	-	-	-
Clay, %	45.4	-	-	-	-	-	-	-	-	-	-	-	-
Texture Class	C	-	-	-	-	-	-	-	-	-	-	-	-

\* L:Lime requirement , I.T.: Initial soil test value

After lime applied to the soils, pH and exchangeable AL+H, K plant available Fe, Mn, Zn and Cu decreased, especially Fe and Mn decreased drastically. With CaO application, the maximum of the soils' pH, available Fe, Mn, Zn and Al was obtained at the highest dose ( 200 % lime requirement), but in view of the other soil properties, CaO and MgO effectiveness were similar.

### Effects of Lime Material Application on Dry Matter Content

The effect of lime materials application on dry matter contents of spinach were obtained and are shown in Table 2. Dry matter contents of spinach increased by increasing rates of 100 % lime requirement doses, but as lime application was over 100 % lime requirement doses, plant dry mater contents were decreased. As compared to control, increasing dry matter contents rates 89.6 % , 106.4 % and 96.2 % , for MgO, CaO and CaO +MgO mixed application, respectively. Average lime materials, increasing dry matter contents ratio were 75%, 161%, and 151%, by providing 50, 100, and 200 lime requirement ratio as compared to control, respectively (Table 2)

The objective of this study was to determine effect of different lime material and doses application on soil properties , nutrient balance of soil solution, and plant growth. It also is exposed to Mg is bring into action in acid soil management in addition to Ca.

### Material and Methods

Soil samples were taken at 0-20 cm depth in Rize province and spinach plant (*Spinacia oleracea*) were used. A pot experiment was performed in green house conditions. The experimental design was a factorial design with 3 lime material (CaO, MgO and CaO+MgO), four doses (0, 50, 100 and 200 % lime requirement ) and one plant and 3 replication ( $3 \times 4 \times 1 \times 3 = 36$  pots). Soils were sample from 0-20 cm depth and placed in 2 kg pots. After lime material applied to pots, soils were subjected to incubation. After incubation period, as a basal dressing 10 kg da<sup>-1</sup>N, 10 kg da<sup>-1</sup>P<sub>2</sub>O<sub>5</sub>, and 10 kg da<sup>-1</sup>K<sub>2</sub>O were added in the form of urea, triple super phosphate and potassium sulphate. Five seeds were sown in each pot. After germination, only two plants were left in the pots. Soil moisture was kept near the during experiment. During the eight weeks growing period following after germination about 2 liter irrigation water were used for each pot and plants were harvested and dried at 68°C in order to determine dry matter weight. Plant samples were chemically analyzed and data were statistically evaluated.

#### Soil Analyses

Soil texture was determined using Bouyoucos hydrometer method, pH and lime requirement using glass pH meter on 1:2.5 soil water mixture, organic mater by Smith-Weldon method, exchangeable cations and cation exchangeable capacity using ammonium acetate methods, exchangeable Al+H by barium chloride-triethanolamine method, plant available P by acid-floorur method, plant available Zn, Fe, Mn, Cu by DTPA method (Anon, 1982).

#### Plant Analyses

Total nitrogen was determined using micro-Kjeldajl method, after plant material were wet combustion, P by spectrophotometer of the P-vanadomoldo yellow color method, K, Ca, Mg, Fe, Mn, Zn, Cu by atomic adsorbtion spectrophotometer (Kacar, 1972).

### Results

Some physical and chemical properties of soil used in this study were shown Table 1. The soil was a clay ( 45.40 % clay, 27.80 % silt and 26.80 % sand), excessively acid (4.20), moderate in organic matter (2.90 %), and its cation exchangeable



Mutters, 1985a; Feger et al., 1991). Lime application to acid soils neutralized soil acidity, reduces toxicity levels of Al, Fe and Mn and improves physiological, chemical and biological properties of soils. It also improves soil productivity by providing Ca and Mg (Oster, 1982; Martini and Mutters 1985ab; Mulder et.al., 1989a,b; Smith et.al., 1994).

Some researchers found that as the lime application to acid soils increased plant available Fe, Mn, Zn and Cu, but B contents of soil decreased, whereas pH, Ca and Mg increased all of the lime application, available P increased lime requirements, but over that decreased as the amount of lime increased (Martini and Mutters, 1985 ab; Ponette et.al., 1996). Some author were reported that calcium compound used as lime material had higher leaching from the soil profile than that of magnezium compound, and  $\text{CaCl}_2$  and  $\text{CaSO}_4$  application in soils had higher leaching than  $\text{CaCO}_3$  (Dierolf, 1992;).

Between Ca and Mg uptake by plants has antagonistic effects and Mg to be high hidratation is lower affinity for plant root area and fertilizer with high contents calcium is inhibited Mg uptake by plant and to often cause Mg deficient (Marschner, 1995). On the contrary as high contents Mg fertilizer is applied, Mg:Ca ratio increased, thus crop yield was inhibited in many plant production. Dolomitic lime stone are often used for agricultural liming, but they are less reactive than calcitic limestones. In a summary of available data on the rates of decomposition of fractions of different limestones of equal particle size. Barber (1984) found that, on average, dolomitic limestone disappeared half as rapidly as calcitic lime stone. Thus, if the rate of decomposition of limestone particles in soil is proportion to the surface area of particles, a dolomitic lime stone would need to be ground enough more finely to have about twice the surface area of a calcitic lime stone. Alternatively, if the particle size distributions were the same, twice as much as dolomitic lime stone would be needed. The difference in decomposition between the two types of limestone would decreased with increasing time of content with the soil. Barber (1984) found that dolomitic and calcitic limestone had been compared for crop production in nine field experiments. In six experiments, the calcitic form was much superior and in three the dolomitic form gave the greater yield increase. In general,  $\text{CaCO}_3$  as lime material are used to acid soils. But, soil properties, soil nutrient equilibrium and plant pattern are not taken into consideration for improving soil pH. As nutrient leaching from the soil or uptake by plants, between nutrient ratio in soil (N:P:K:Ca:Mg) can be change. This variation in ratio of nutrient is very important for plant nutrition because of its dependence on between K:Ca: Mg: ratio, K and Ca not only limited Mg uptake but also Mg transport from the root to upward of plants.

## Effect of Different Doses of Lime Material on Soil Properties and Growth of Spinach (*spinacia oleracea*)

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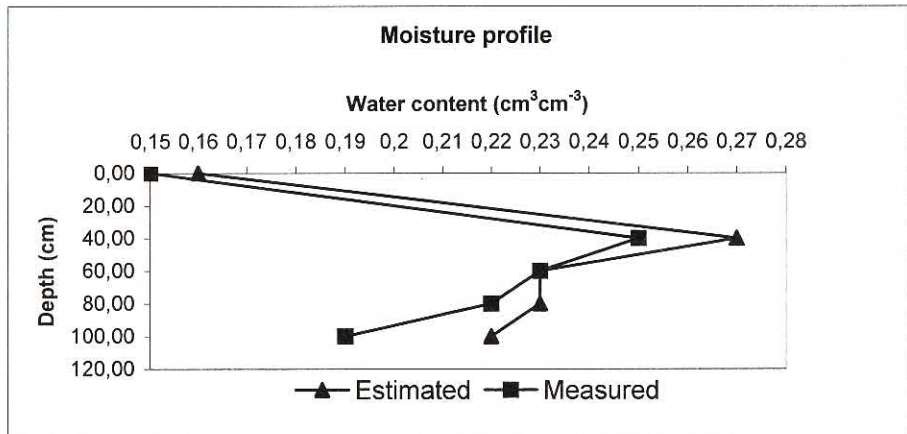
### Abstract

Improvement in soil properties and establishment of plant nutrition equilibrium are two important factors for soil productivity and plant production. The objective of this study was to determine the effect of different doses (0, 50 %, 100 % and 200% lime requirement) and type (CaO, MgO ve CaO+MgO) of lime material on some soil properties and dry matter and mineral composition of spinach. Result of this study indicated that soil pH, exchangeable Ca and Mg increased with increasing rates of lime doses but exchangeable Al+H, exchangeable K, and available Fe, Mn, Zn and Cu contents decreased with increasing doses. Dry matter content and N, P, K, Ca and Mg contents of plant increased with doses, but Fe, Cu, Mn and Zn contents decreased depending on lime material. Plant Na content did not show significant changes with lime application. Available P content of soil increased with doses except for highest lime doses. The most effective lime material on soil and plant mineral content was MgO, and the most effective doses was % 100 of lime requirement. Statistical results show that lime doses (  $p<0.01$ ) and type of lime material (  $p<0.05$ ) significantly affected on plant dry mater content and mineral composition.

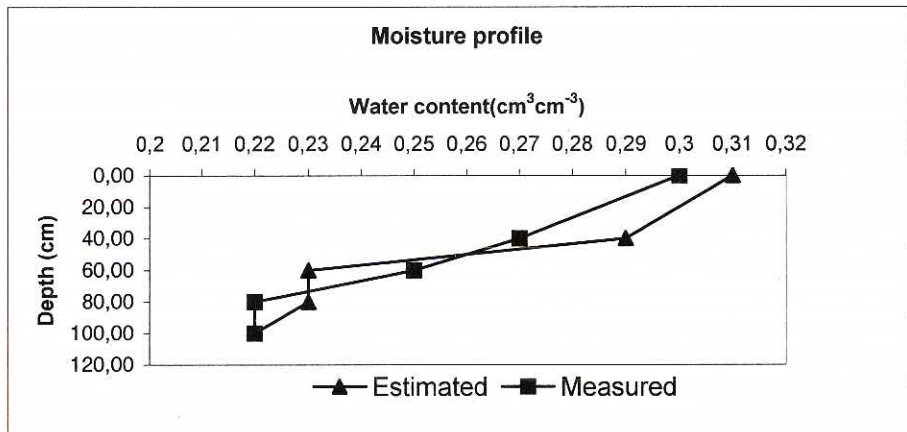
### Introduction

Improving soil condition and establishing the equilibrium among the plant nutrients are important for soil productivity and plant production in which produce high yield with best quality. Liming improves acid soils' physical, chemical and biological properties and increases plant production. However, high amount of lime application may produce some unproper effects. Soil productive conditions are related to soil properties, especially soil pH. Soil acidity arises from exchangeable H and Al ions on colloid surfaces but soil solute acidity is attributed to absorbed H and Al ions in colloids (Harvey, 1989).

Soil acidity is resulted from mineral leaching, excessive rain and irrigation, acidic fertilizer use and extensive agricultural production (Martini and Mutters, 1985a; Binkley and Sollins, 1990). Many outhor reported that, limited plant production in acidic soils is attributed to increase of the toxic levels of nutrients such as Fe, Mn, and decreases in some other nutrients such as Ca, Mg, P (Reith, 1983;Martini and



**Figure 2.** Measured and Estimated Soil Moisture Dynamics (26.10.1998) .



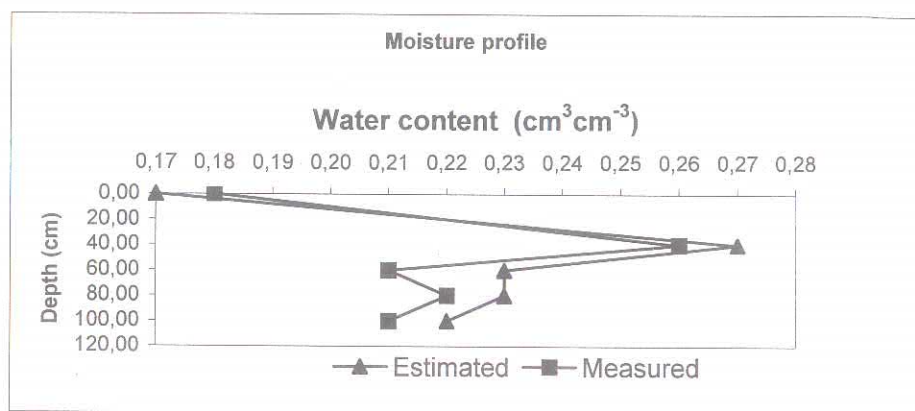
**Figure 3.** Measured and Estimated Soil Moisture Dynamics (Rainfall=1.8cm) (02.11.1998).

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## Conclusions

For the solution of soil moisture dynamic final differences method were used and stability state was observed in the solution. Results of investigated revealed that the model and field measurements are generally in accordance. Further studies conducted by the authors aim to integrate a model developed in this study into Energy-Mass Transfer and Plant Development Models in relation with other blocks, i.e the soil on movement Blocks and Plant Development Blocks. Two approach proposed in the study could be used for practical studies of bare soils water dynamic. Water budget was simplified on soil surface (runoff, deep infiltration, plant uptake were not included). This model could be used in arid and semi arid regions particularly fallowed land where no runoff occurs.



**Figure1.** Measured and Estimated Soil Moisture Dynamics (19.10.1998)

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to time, by utilising visual programming for Delphi 3.0 (Computer Program Language) software (Sariyev and Polat, 1999).

**Table 2.** Soil water characteristic values.

Depth (cm)/	0-20	20-40	40-60	60-80	80-100
Pressure (bar)					
0.01 (pF=0)	52.23	50.86	44.08	41.17	41.78
0.1 (pF=2)	42.58	39.20	35.58	34.15	33.41
0.333 ( pF=2.52)	40.06	36.60	33.22	31.72	31.13
1.0 (pF=3)	38.36	34.46	30.94	19.23	29.86
5.0 (pF=3.7)	18.06	18.20	17.49	15.68	14.63
15 ( pF=4.2)	17.09	17.16	16.89	15.11	13.94

By using the data in table 1 and 2, the equation 12 and 13 were used with the application of pF model bank in the simulation model. Equations (12-13) used in the model  $P_d = -5$  cm,  $W_d = 0.48$  cm<sup>3</sup>cm<sup>-3</sup>,  $A = 24$ ,  $K_f = 0.87$  cmh<sup>-1</sup>,  $m = 2.1$ ,  $\rho_a = 1.2 \cdot 10^{-3}$  gcm<sup>-3</sup>,  $D_s = 1$  cms<sup>-1</sup> values are used for identification. Besides, for the certain block the initial moisture contents of the input parameters below are used.

Depth, (cm)	Initial soil water content, (cm <sup>3</sup> cm <sup>-3</sup> )	Initial soil water potential, (cm H <sub>2</sub> O)
0-10	W(0) = 0.17	P(0)= -8932
10-20	W(1) = 0.30	P(1)= -394
20-30	W(2) = 0.29	P(2)= -501
30-40	W(3) = 0.28	P(3)= -637
40-50	W(4) = 0.31	P(4)= -310
50-60	W(5) = 0.28	P(5)= -637
60-70	W(6) = 0.24	P(6)= -1665
70-80	W(7) = 0.24	P(7)= -1665
80-90	W(8) = 0.24	P(8)= -1665
90-100	W(9) = 0.23	P(9)= -2116

Output parameters of the model are as follows:

- Soil moisture contents of each layers (cm<sup>3</sup>cm<sup>-3</sup>)
- Soil water potential of each layer (cm H<sub>2</sub>O)
- Unsaturated hydraulic conductivity of each layer (cmh<sup>-1</sup>)
- Evaporation from soil surface (cmh<sup>-1</sup>)

For testing the soil moisture dynamic in accordance with the results from the simulation model, field measurements at one-week intervals, at same time, the volumetric soil contents were measured from 3 parallels of each sample (moisture dynamics of the model are observed according to initial field value). Results obtained both from field and the model is interpreted in Figure 1, 2, 3.

Soil water potential and moisture contents are expressed as  $P_d$  and  $W_d$  respectively. In the equation,  $A$  and  $m$  are semiempirical coefficients. Soil evaporation, which is an effective factor on soil water flux, model is:

$$E_s = \rho_a * D_s (q_s(0) - q_a) \quad [\text{Eq. 14}]$$

where,  $\rho_a$  : density of air ( $\text{gcm}^{-3}$ ),  $D_s$  : molecular moisture conductivity ( $\text{cms}^{-1}$ ) between soil and atmosphere, to wind velocity,  $q_s(0)$  and  $q_a$  are the soil surface and atmosphere's absolute moisture contents respectively ( $\text{g H}_2\text{Og}^{-1}$  air). Generally absolute moisture content is a function of temperature ( $T$ ) according to Magnus law (Poluektov, 1991)

$$q(T) = 3.79 * 10^{-3} \exp(17.1 * T / (235 + T)) \quad [\text{Eq. 15}]$$

Initial condition of model is:

$$f(W_i) = W_i \quad [\text{Eq. 16}]$$

Mathematical model of soil water flux should be analytical in relation to depth at some periods of other blocks.

## Materials and Methods

The physical and chemical properties of disturbed and undisturbed soil samples collected from the Experimental Farm of Soil Science Department, University of Çukurova were determined according to the following methods. Texture Bouyoucos (1951), Bulk density on undisturbed soil samples collected by 100 cc cylinders (Blake&Hartge1986), Hydraulic conductivity (Klute&Dirksen,1986), pF curve at plate apparatus (Klute,1986), Salinity (U.S. Salinity Laboratory Staff, 1954), pH (Schlichting and Blume, 1966) (Tabel 1).

**Table 1.** Some chemical and physical properties of soil series.

Depth (cm)	0-20	20-40	40-60	60-80	80-100
pH	7.96	7.98	8.10	8.11	8.22
Salinity %	0.065	0.056	0.054	0.05	0.04
Bulk Density $\text{gcm}^{-3}$	1.29	1.1.56	1.60	1.67	1.68
Hydraulic Conduct. ( $\text{cmh}^{-1}$ )	3.19	1.71	1.93	1.52	0.67
Sand %	21.92	17.73	16.20	22.63	26.43
Silt %	37.99	41.13	41.57	40.86	40.06
Clay %	40.09	41.14	42.232	36.51	33.51

## Results and Discussion

Soil water flux model, defined by equations 1-14, was used for simulating soil moisture contents of each 10 cm layers of 100 cm soil profiles, which is related



Then the final equation is :

$$[W_j(t_{k+1}) - W_j(t_k)]h_j = \left( K \left( \frac{P_{j+1} - P_j}{h_j} - 1 \right) \right) - \left( K \left( \frac{P_j - P_{j-1}}{h_j} - 1 \right) \right) \Delta t \quad [\text{Eq.6}]$$

If equation is simplified in expression as: ( $h=h_1=h_2=\dots=h_j$ )

$$[W_j(t_{k+1}) - W_j(t_k)] = \frac{K\Delta t}{h^2} (P_{j+1} - 2P_j + P_{j-1}) \quad [\text{Eq. 7}]$$

If,  $\frac{K\Delta t}{h^2} = A_t$  is symbolised as  $A_t$  ( $1\text{cm}^{-1}$ ).

$$[W_j(t_{k+1}) - W_j(t_k)] = A_t (P_{j+1} - 2P_j + P_{j-1}) \quad [\text{Eq. 8}]$$

For  $W_j$  layer the final equation is

$$W_j(t_{k+1}) = W_j(t_k) + A_t (P_{j+1} - 2P_j + P_{j-1}) \quad [\text{Eq. 9}]$$

The value of  $P$  is (cm and therefore  $W_j(t_{k+1})$  is dimensionless. Moreover, the conditions of upper and lower limits (at surface  $v=0$ ) can be expressed as follows at selected NR depth,  $X=XR$

$$-K(P)(\partial P/\partial X - 1) \Big|_{x=0} = E_s - R \quad [\text{Eq.10}]$$

$$-K(P)(\partial P/\partial X - 1) \Big|_{x=NR} = 0 \quad [\text{Eq. 11}]$$

Evaporated water and precipitation levels are expressed as  $E_s$  and  $R$ , respectively in the formula. Water moisture curve and hydraulic conductivity in the formula are expressed as:

$$P = P_d \exp(A^*(W_d - W)) \quad [\text{Eq. 12}]$$

$$K = K_r (P_d/P)^m \quad [\text{Eq. 13}]$$

## Theory

Definition of Soil Water Model: Soil suction curve and hydraulic conductivity should be determined initially for utilizing the model. Any changes of moisture content of certain layers at certain periods are determined by calculating water input and output of the layer. Energy and mass transfer in soils are expressed by diffusion processes, thus diffusion formulas used in mathematics and physics are used for determination of these transfer. Also, for adjusting heat flux, observation of soil moisture content, soil hydraulic conductivity and differential moisture content capacity are in accordance with above mentioned diffusion processes. Any change of soil moisture content ( $\Delta w$ ) at  $\Delta t = t_{k+1} - t_k$  time increment is equal to water input and output of a layer, and expressed as below;

$$\frac{\Delta W}{\Delta t} = -\frac{\Delta V}{\Delta x} \quad [\text{Eq. 1}]$$

Water flux level in soil is calculated according to Darcy law.

$$V = -K \left( \frac{\Delta P}{\Delta x} - 1 \right) \quad [\text{Eq. 2}]$$

where,  $V$  is water flux in soil. Change in moisture content at  $(t_{k+1} - t_k)$  time is  $h_j$ ;  $F$  is the thickness of the layer, area;

$$[W(t_{k+1}) - W(t_k)] h_j F = (V_{j+1} - V_j) F \Delta t \quad [\text{Eq. 3}]$$

$(V_{j+1} - V_j)$ : change of flux in the layer when flux is measured in layers  $j-1$ ,  $j$  and  $j+1$  according Darcy law in equation (3) then equation below is attained

$$V_{j+1} = -K_{j+1} \left( \frac{P_{+1j} - P_j}{h_j} - 1 \right) \quad [\text{Eq. 4}]$$

where,  $h_j$  : constant. When,  $K_{j+1} = K_j = K_{j-1} = K$ , is accepted as constant and  $(V_j \text{ ve } V_{j+1})$  flux, mentioned above is taken as:

$$V_j = -K_{j+1} \left( \frac{P_j - P_{j-1}}{h_j} - 1 \right) \quad [\text{Eq. 5}]$$

# Mathematical Modelling of Soil Hydraulic Properties and Numerical Analyses of Moisture Dynamic

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## Abstract

For determination of the state of soil water, which is a function of time and depth in soil system, water flux in soil should be modelled. Therefore, designating a suitable model yielding the interactions between soil moisture content (W), water potential (P) and hydraulic conductivity (K) is the prerequisite. Some samples collected from the some physical and chemical properties. Hydraulic conductivity and soil moisture characteristics of the studied soil were determined by utilizing SIMONA (SIMONA, is basic model describing physical and bio physical processes in agro ecosystem) software most suitable model known at present (Poluektov, 1991). For the solution of soil moisture dynamic equation finite differences method was used (Implicate). The soil water dynamics values obtained from the model and laboratory measurements were also correlated in the studies.

## Introduction

Soil is a very complex system due to the numerous individual and mutual factors effecting irrigation, soil amelioration, illuvation, evapotranspiration and on circulation of pollutant materials applied to soil, soil thus determination of quantity and direction of water flow is very important (Rollston et al, 1976), for sustainable land management. Plant development models are being widely used in recent years. Approaches for developing models may be different, however, the basic principle of models is generally based on block system. In all plant development models, soil water flow block is always used (Veries and Laar, 1982; Bonderenko et al., 1982, Anlauf, 2001). Thus, one of the important dynamic block is soil flux, and for modelling of time and depth dependant process, two basic soil hydro physical properties, namely soil moisture dynamic and hydraulic conductivity should be well defined for accurate determination.



which were represented by heavy metal rich nodules and single grains of aluminosilicate and/or sulphide chemical composition.

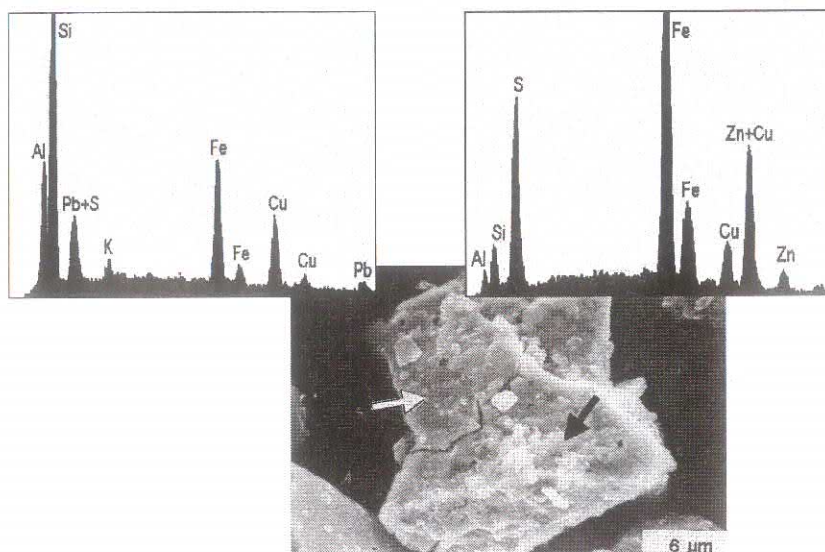
2. Examined particles of industrial origin contained heavy metals in forms not available for plants. Dark in colour soil aggregates contained more dispersed forms of heavy metals that can be more easily mobilised.
3. The range of scanning electron microscopy methods is seriously limited by relatively low sensitivity of X-ray chemical analysis, and more sensitive instruments must be used when dispersed forms of pollutants are being studied.

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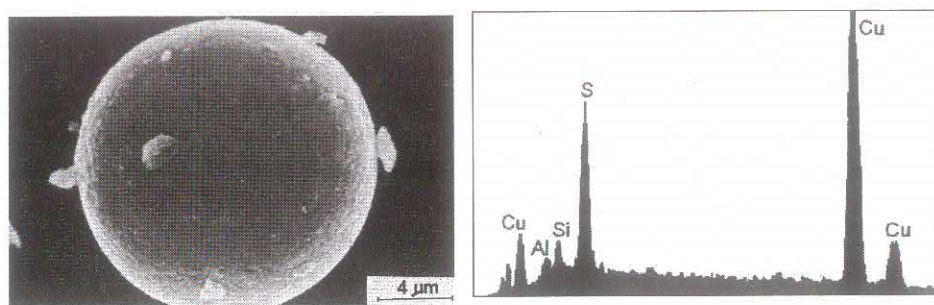
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Described examinations have provided some micromorphological details, but further submicroscopic research is needed to recognise distribution of heavy metals and processes operating in the soil environment polluted by industrial pollution. Investigation of the distribution of dispersed forms of heavy metals needs application of advanced techniques, such as synchrotron x-ray, to provide more information enabling better understanding the processes of soil degradation in heavy metal polluted areas. Synchrotron X-ray source seems to be the most promising technique (Schultze & Smith 1990, Schultze & Bertsch 1994).

but they revealed the presence of fine grains consisted from heavy metals (Fig. 6). In another aggregate fine grains containing lanthanum elements – characteristic for chimney emissions (Kabata-Pendias & Pendias 1992) – were found (Fig. 7).



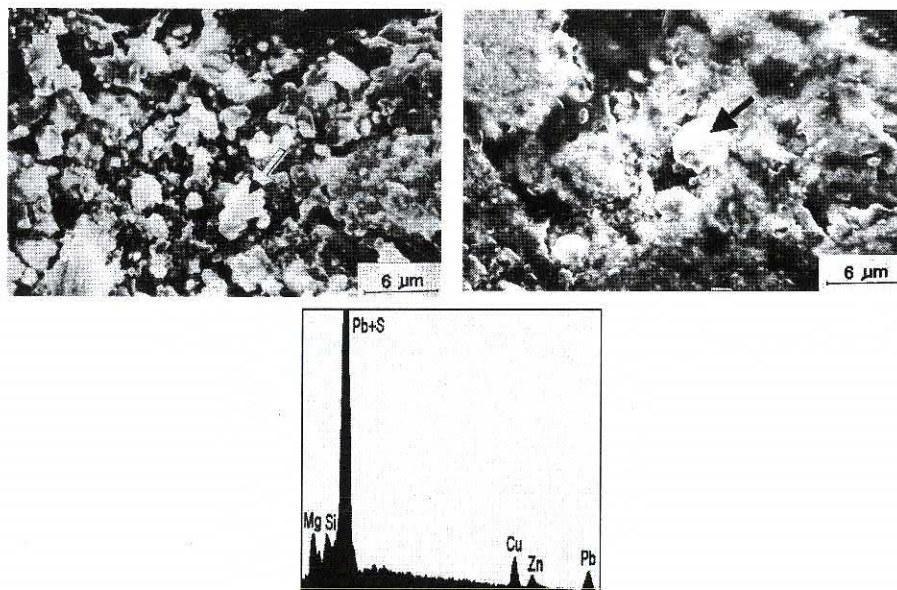
**Figure 4.** Heavy-metal-rich single grain selected from soil material. Scanning electron microscope image. Spectrograms of EDXRA analysis characterise the chemical composition of points indicated by the white arrow (left), and the black arrow (right).



**Figure 5.** Spherule of copper sulphide selected from the surface soil material. Scanning electron microscope image. Spectrogram of EDXRA analysis characterises the chemical composition of the area under observation.



and appeared sufficient to confirm their industrial origin on the basis of high content of heavy metals.

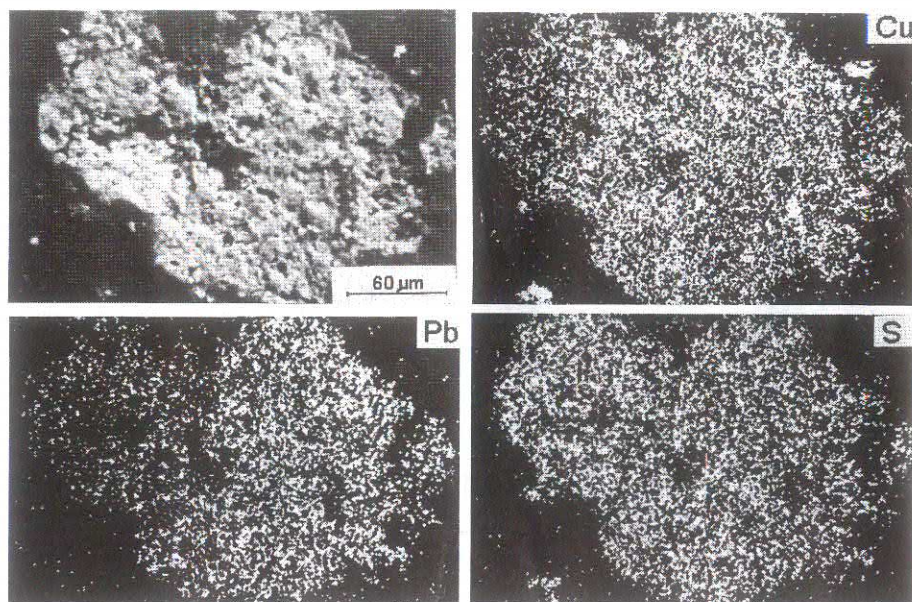


**Figure 3.** Different fragments of the nodule shown at Fig. 1, consisted of irregular grains (left) and amorphous material with glossy bubble-like grain (right). Spectrogram of EDXRA analysis characterises the chemical composition of the point indicated by the black arrow.

Samples of dust emitted by copper smelters were collected directly from the snow cover in the vicinity of smelter. Dust samples contained particles of very different size and shape, which were characterised by Weber (1995). The large distribution of sizes was characteristic for samples collected close to the copper smelter, as well as some distance away from the smelter. Presence of heavy metal rich particles was clearly marked in the chemical composition of the dust; however, the particles mainly consisted of silicate-like minerals that did not contain heavy metals. Investigation indicated, that dusts emitted by copper smelter consisted of particles that did not differ significantly from those selected from the soil material. This pointed out that previously characterised particles, selected from the soil material, represented primary nodules and grains, and soil processes had not modified them.

The secondary forms of pollutants, being transformed in the soil, were represented by dark in colour soil aggregates, distinguished during soil thin sections investigations with an optical microscope. The sensitivity of X-ray chemical analysis was not sufficient to detect dispersed forms of heavy metals,

melting processes. It was composed mainly of lead and sulphur, and indicated the same chemical composition as amorphous-like material, as well as irregular grains.



**Figure 2.** The nodule shown at Fig. 1 analysed with electron microprobe analyser (EMA). The general view, and X-ray images of the distribution of Cu, Pb and S on the area under observation. Density of white dots corresponds to content of copper, lead and sulphur.

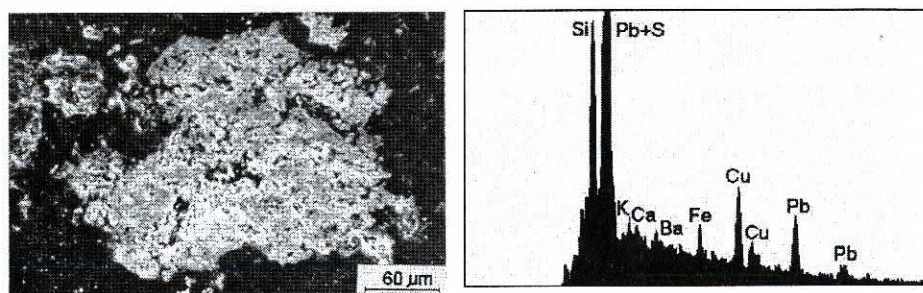
Examination of loose material selected from humus horizon pointed out that industry-originated particles could exist in the soil material as single grains, as well. They were of silt or fine sand size, and during investigation with binocular were distinguished from other grains by dark colour. They often consisted of iron, sulphur, and silicon, and contained different amounts of heavy metals. Although they were single grains, they were not homogeneous, and indicated different chemical composition from place to place (Fig. 4).

Specific and very characteristic loose grains are spherules, which developed as result of rapid cooling of drops of melted mass (Fig. 5). Since the EDXRA analysis characterised chemical composition of a very thin surface layer of examined object, investigations of loose material were not informative about the composition of a whole grain, as well as the internal structure. Nevertheless, observations provided morphological characteristics of particles,



## Results and Discussion

Surface layers of soils in the vicinity of both copper smelters contained high amounts of heavy metals. Copper and lead concentration in some places reaches 10,000 and 5,000  $\text{mg} \cdot \text{kg}^{-1}$ , respectively (Weber 1995). Traditional micromorphological investigations of soil thin sections revealed existence of opaque nodules, which cannot be chemically characterised with optical microscope. The application of submicroscopic techniques allows observations under much higher magnification, and determination of chemical composition of studied fragments of thin section (Fig. 1), as well as distribution of particular elements in observed area (Fig. 2).



**Figure 1.** The nodule of industrial origin existed in soil humus horizon. Scanning electron microscope image of soil thin section. Spectrogram of EDXRA analysis characterises the chemical composition of the area under observation.

Usually grains containing high amounts of heavy metals are observed in scanning electron microscope image as much brighter than other constituents of soil material. Nodule shown at Fig. 1 has sharp boundaries, and represents primary particles emitted by copper smelter. Its chemical composition was dominated by silicon, lead and/or sulphur. Sensitivity of X-ray fluorescence analysis of scanning electron microscope did not allow detecting lead and sulphur separately, however presence of both elements was confirmed by investigation under electron microprobe analyser (Fig. 2). X-ray image of the distribution of Cu, Pb and S indicated that copper and sulphur were dispersed uniformly through the nodule, while lead content was lower in the left part of the nodule.

The examinations conducted under higher magnification revealed more details and indicated that nodule did not show uniform structure (Fig. 3). In some places it was build up of small rounded and irregular silicate-like grains, as well as grains enriched with heavy metals, mainly sulphides. Another type of structure indicated places, where amorphous-like substance occurred. Glossy bubble-like grain shown at the right photo of the Fig. 3 is a remnant after



opened new possibilities, connected with determination of the distribution of heavy metals in the soil material. Scanning electron microscopy was used in the investigation of soil material contaminated with heavy metals in laboratory experiment (Robert et al. 1989), as well as in studies of fly ash particles (Dudas & Warren 1987) and fossil fuel combustion residues (Mattigod et al. 1990). Heavy metal distribution in sewage sludge and sewage sludge amended soils was detected by Essington & Mattigod (1991) and Lee & Kittrick (1984), while electron micro-beam analysis of hydromorphic soils contaminated with heavy metals enabled to indicate Zn and Pb migration to clay coatings (Brummer et al. 1991; Hiller & Brummer 1991). The soil environment polluted with heavy metals emitted by copper smelter was preliminary studied with submicroscopic methods by Kowalinski & Weber (1988), and Weber (1993, 1995). The object of this work was to characterise submicromorphological properties of soil components being the source of excess quantities of heavy metals in the soil environment contaminated by emissions of copper smelters.

## **Materials and Methods**

Soil located in the vicinity up to 1 km from two copper smelters, as well as samples of dust emitted were investigated. Legnica and Glogow copper smelters operate for 30 – 40 years at the Lubin Copper Belt, Lower Silesia, SW Poland. There are no other major industries in both area, thus soil contamination with heavy metals originates only from smelters. Annual rainfall in this area is approximately 600 mm (mostly as summer rainfall), while mean annual temperature is about 8°C. Both regions are characterised by relatively flat topography with slightly developed slopes.

Examined soils were previously used as arable soils, but due to pollution with dusts and gases, areas close to smelters have been changed into a waste land, where only occasional wild plants exist. Soils were limed and ploughed several times, to decrease the availability of heavy metals and to prevent the vanishing of vegetation. Presently, the vegetation covers most of the area.

Soil thin sections and loose material were analysed with a binocular, light polarising and scanning electron microscope. Samples were collected from the surface layer of the soil. Dust samples collected from snow cover in the vicinity of copper smelter were analysed as well. For soil thin section preparation, undisturbed soil samples were collected from each horizon. They were air-dried and vacuum-impregnated with polyester resin. Non-covered soil thin sections of size about 50 x 70 mm were examined with the polarising microscope, then selected fragments were cut off and coated with carbon film for submicroscopic investigations. The Stereoscan 180 Cambridge scanning electron microscope (SEM-EDXRA) and Jeol JXA-5A electron microprobe analyser (EMA) were used for submicroscopic investigation.

## **Scanning Electron Microscope Approaches to Heavy Metal Polluted Soils in the Vicinity of the Copper Smelter**

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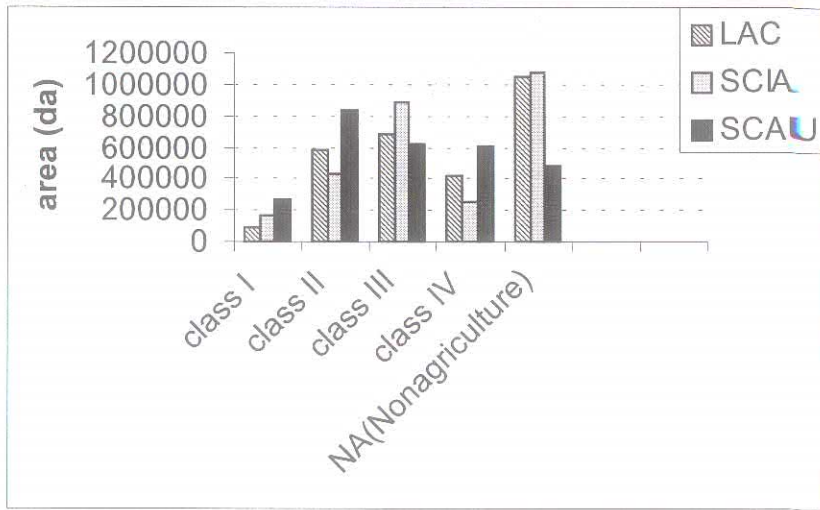
### **Abstract**

This paper deals with submicroscopic properties of the soil environment polluted by emissions of copper smelters in Poland. Soil thin sections and loose grains selected from the soil material as well as samples of emitted dust were examined with the scanning electron microscope with an energy dispersive X-ray analyser (SEM-EDXRA) and electron microprobe analyser (EMA). Submicroscopic methods provided new information on morphological forms and distribution patterns of soil components being the source of the excess quantities of heavy metals in contaminated soils. However, sensitivity of SEM-EDXRA chemical analysis was relatively low, and did not enable to examine dispersed forms of pollutants. Investigations indicated that heavy-metal-bearing components of industrial origin existed in the soil material as nodules, conglomerates of fine particles as well as single grains of different morphology, from irregular grains to spherules. They indicated chemical composition of sulphides and/or aluminosilicates, and represented primary particles emitted by smelters. Secondary components, being transformed in soil, existed as diffuse nodules and dark in colour soil aggregates, containing heavy metals in more dispersed forms that can be easier mobilised.

### **Introduction**

It has been found that heavy metal pollution has a harmful effect on life; therefore in recent years much attention has been given to such problems of the environment. Studies by numerous investigators have shown that atmospheric fallout from ore smelters can contribute significantly to soil properties. Most of the previous works on the soils polluted by smelting has attempted to assess the degree of contamination and to explain the trace elements distribution in the soil in terms of distance from the smelter and depth in the soil profile. Although quite a bit of literature is available on chemical forms of heavy metals, as well as their availability to plants, solubility, mobility and fixation with different components of soil material (Kabata-Pendias & Pendias 1992), there is very little information about micromorphological properties of polluted soils (McSweeney et al. 1994). Conventional microscopic methods were used to characterise changes in properties of soil polluted by emissions of copper smelter (Drozd & Kowalinski 1977), but this technique did not allow for characterising the chemical composition of soil components investigated in thin section. Application of submicroscopic methods by Bisdom et al. (1983, 1990)

region have to be protected from erosion. Therefore, soils should be used accordingly to its capability according to the results from land evaluation, which are determined by this study. Washing of in the profile is minimum due to the amount of precipitation, which is insufficient. Consequently, decomposed salts in water either are accumulated in profile or carried to basin areas. This condition is present especially in Mesaoria Plane (300 mm).



**Figure 5.** Distributions of the soils of TRNC are according to LAC, SCIA, and SCAU.

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**Table 2.** Areas (da) and percentage of the soils of TRNC are according to Suitability Classes for Irrigated Agriculture.

Suitability classes for irrigated agriculture (SCIA)	Area (da)	Percentage (%)
Class 1 (highly suitable)	164.843	5
Class 2 (moderately suitable)	435.115	13
Class 3 (low suitable)	881.168	26
Class 4 (suitable for special plants)	254.131	8
Class 6(not suitable)	1.068.197	32
Others	546.018	16
General Total	3.349.471	100

**Table 3.** Areas of the soils of TRNC are according to Suitability for Classification or Agricultural Uses (SCAU).

Suitability Classes for Agricultural Uses (SCAU)	Area (da)	%
1. Selected agriculture lands	259.328	8
2. Fairly suitable agriculture lands	833.327	25
3. Agriculture areas with problem	624.631	19
4. Agriculture areas with restricted uses	601.400	18
5. Nonagricultural lands	484.093	14
Others	546.018	16

## Results and Discussion

Distributions of class 1 soils are quite less, according to every evaluation method (LCC, SCIA and SCAU) (Figure 5). Selected Agriculture Lands (class 1) cover more area than other evaluation systems according to SCAU, because of SCAU evaluates soils according to ecological conditions of the study area. Therefore, in this study, soils are evaluated according to the principles, which are determined by FAO (1977). Classes V., VI., VII and VIII which are non-agriculture area (NA) according to LCC, class 6 according to SCIA and class 5 according to SCAU are evaluated together (Figure 5). SCIA is applied to evaluate the suitability for irrigated agriculture of the TRNC soils. However, LCC takes into consideration only the physical and chemical properties of the soils. Classes VI. and VII. according to LCC are merged together and evaluated as non-agriculture (NA) (Figure 5). Most of the land is classified as class II. and III. (for LCC, SCIA and SCAU). Also, class VI covers large areas according to LCC and SCIA. There are no class VI and VII., because of SCAU has only five classes.

Climate, topography, soil properties and parent material are contributing to the loss of soils by erosion, therefore soils of TRNC have significant problem with erosion. In the study area, arid climate, parent material of soils and slope are providing ideal conditions for water erosion. It's necessary that soils of the

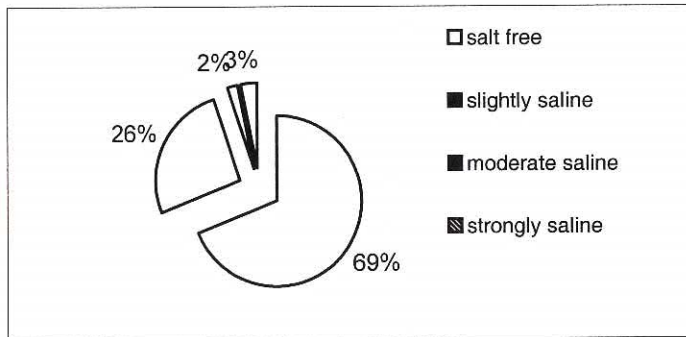
**Table 1.** Land capability classes, sub classes, total area and distribution of soils.

Class	Sub class	Area (da)	Total Area (da)	Percentage (%)
Class I		86.234	86.234	2,6
	I Ie	42.525		
Class II	I Ies	233.280	575.721	17,2
	I I s	299.707		
	I Iws	210		
	IIIe	117.665		
	IIIes	3.951		
Class III	III s	419.646	680.050	20,3
	IIIse	138.487		
	IIIws	301		
	I Ve	49.760		
Class IV	I Vs	291.044	411.672	12,3
	I Ves	17.689		
	I Vse	53.179		
Total agriculture area			1.753.677	52,4
	V Ie	103.635		
Class VI	V Is	241.648	796,71	23,8
	V Ies	166.791		
	V Ise	284.637		
	VII s	72.491		
Class VII	VIIes	162.138	253,065	7,5
	VIIse	18.435		
Others			546.018	16,3
Overall Total			3.349.471	100

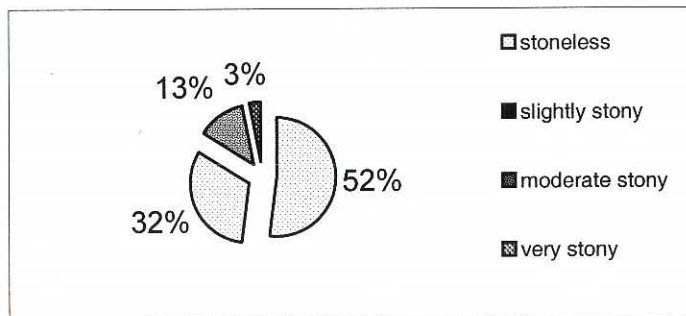
#### Suitability Classes for Agricultural Using (SCAU)

Land Suitable for agriculture is determined to be 259 328 da according to SCAU on TRNC soils. On the other hand, 484.093 da area is determined to be completely non-agriculture area. Areas (da) of agriculture and non-agriculture lands and its percentage are given in Table 3 according to SCAU.

classes) in TRNC is determined to be 1.753.677 da. On the other hand, non-agriculture areas are 1.049.775 da. Land capability classes, sub classes, total area and distribution of soils (%) are given in Table 1.



**Figure 3.** Distribution of salinity classes

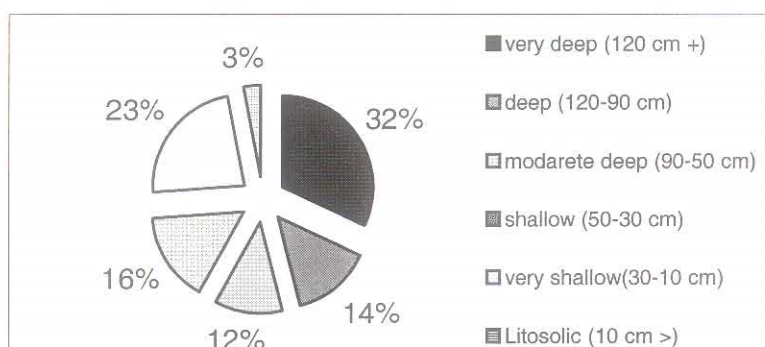


**Figure 4.** Distribution of surface stoniness % classes

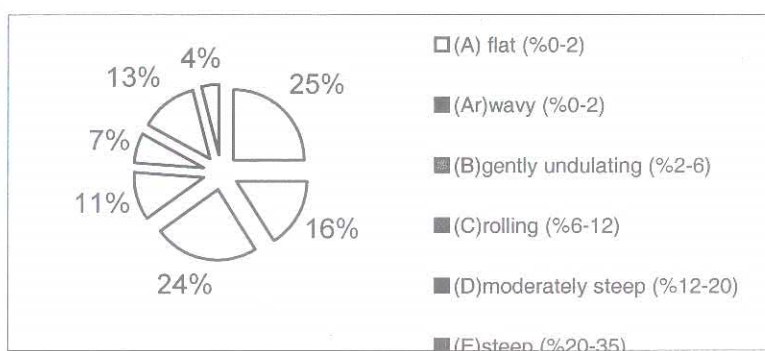
#### Suitability Classification for Irrigated Agriculture (SCIA)

It is determined that SCIA has shown similar distribution with LCC. Class 1 lands, which are very suitable for irrigated agriculture, cover 5% of the study area. Class 1 covers more area than SCIA according to LCC, because of soil depth is less limiting factor for irrigated agriculture. Class 5 (temporarily not suitable) is not present on soils of the study area according to SCIA. Land, which is not suitable for irrigated agriculture, covers 1.068.197 da (32%) of the study area. Some of these lands are included class 6 because it has more than 12% slope. Suitable irrigation techniques (drip irrigation) can be applied on these lands, which are not suitable due to the slope limitation. Areas (da), percentage and classes of the soils of TRNC are given in Table 2 according to SCIA.





**Figure 1.** Distribution of TRNC soils according to soil depth classes.



**Figure 2.** Distribution of the soils of TRNC according to classes of slope.

Salinity, a direct result of excessive evaporation and low precipitation distributed over large areas and it is a very important problem. In the study area 69% of soils have no salinity problem whereas 5% of total area is moderately and strongly saline. The remaining 26% is slightly saline. Distributions of salinity classes are given in Figure 3.

There is no stoniness in the 52% of the study area. On the other hand, there is stoniness problem on the 476.476 da (16%) of the study area (except for non-agriculture area). Distributions of surface stoniness are given in Figure 4.

Drainage is not an important problem on TRNC soils because of 3/4 of study area has moderately medium texture and soils with more than 6% slope covers 35% of the study area.

#### Land Capability Classification (LCC)

Land characteristics, which are affecting LCC, SCIA and SCAU on the soils of TRNC, are slope, soil depth, salinity, stony and rockiness. Class 1 agriculture area, which has no limitations, covers 86.234 da (2.6% of the study area). Total area of soils that are suitable for cultivated agriculture (I. II. III. and IV

evaluation studies as well. In this study, LCC, SCIA and SCAU classes of soils for the TRNC are determined by using detailed soil maps 1:25000 scale of TRNC. Agriculture areas cover 56.2% of total area of TRNC (Dinç et al. 2000). Consequently, land evaluation studies are more important for soils of TRNC. Aim of this study is to correct and optimize usage of soils in TRNC.

## **Material and Method**

The study was applied in TRNC that have 321.927-hectare total area. Detailed soil maps (1:25000) and the report compiled by University of Cukurova Faculty of Agriculture Department of Soil Science are used. Soil characteristics such as surface soil texture, slope, soil depth, surface stoniness, surface rockiness, drainage, salinity, pedogenic horizons, subsoil texture, subsoil structure, lime content, vertic property, soil color and stoniness in the profile were evaluated and Capability Classes and Subclasses according to Klingebiel and Montgomery (1961), Suitability Classes for Irrigated Agriculture (SCIA) according to USBR (1953) were determined. In addition, SCAU of soils were established according to Şenol Land Evaluation Method by ILSSEN (Şenol and Tekeş, 1995) software. Values of soil depth, slope classes, salinity classes, surface stoniness classes, LCC, SCIA and SCAU, which are given in figures and tables, are calculated by using Microsoft Excel software. Finally, results of land evaluation methods in soil of TRNC were compared with each other.

## **Results of Research**

### **Land Characteristics of Soils of TRNC**

Main soils characteristics are determined to be affecting land suitability are soil depth, slope, soil salinity, stoniness and rockiness according to studies of soil survey and land evaluations in TRNC. Besides, also climate is very important restrictive factor for agricultural usage of the soils in the region.

It's determined that insufficient precipitation is the most significant restrictive factor for the cultivation of soils for agriculture according to LCC. Deep (90-120 cm) and very deep (120 cm+) soils cover 46% and moderately deep soils covers 12% of the total area in TRNC. Shallow, very shallow and litosolic soils which are limiting factor for agricultural activity covers 42% of the total area in TRNC. In the study area, distributions of soil depth classes are given in Fig. 1. Land that has no slope problem are grouped in to class A (0-2%). Which covers 25% of the total area. Ar (areas with wavy topography) and A (flat areas) cover together 41%. Coverage of areas with moderately slope (B 2-6%) is 24% and 35% of study area have severe limitations or not suitable for agricultural usage. Distributions of slope classes are given in Fig. 2.

## **Application of Different Land Evaluation Methods for the Soils of the Turkish Republic of Northern Cyprus (TRNC)**

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### **Abstract**

Results from for the Land Capability Classification (LCC), Suitability Classification for Irrigated Agriculture (SCIA) and Suitability Classification for Agricultural Use (SCAU) for the Turkish Republic of North Cyprus (TRNC) soils were compared with each other. It is determined that total area which is suitable for agriculture (I., II., III. and IV. classes) covers 1.753.677 da (52.4%) and class I 86.234 da (2.6%). Total area for nonagricultural use is 1.049.775 da (31.3%) according to LCC, except for nonagricultural lands. Results of SCIA and LCC have shown similarities. Class I covers 164.843 da (5%) and lands, which are not suitable for irrigated agriculture, is 1.068.197 (32%). Class 1 covers according to SCAU 259.328 da and nonagricultural area is 484.093 da.

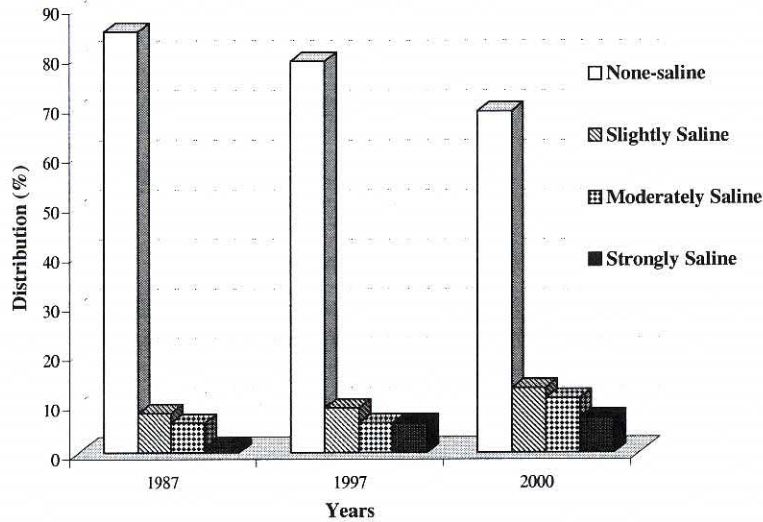
### **Introduction**

Land evaluation applications are carried out according to collected data from soil survey studies. The need for agricultural land is rapidly increasing for various reasons, especially with the increase in world population. The significance of the subject becomes more important when the obligations of a sustainable land management by preserving the plant productivity and potential of soils for the next generations are considered. Soils have different properties and attributes. Function of land use planning is to decide that how lands should be used by humans and also to sustain soils for the next generations (Dinç and Şenol, 1998).

The properties of land are affected by different land use. Misuses such as highways, factories and buildings on class I soils are damaging the structure of land. For this reason, other function of land evaluation is to explain that harmful results of improper land use, and to provide comparison of the best suitable land use (FAO, 1977). Land evaluation studies are the first step for land use planning. If there is no land evaluation of an area, problems can be seen about land use and land productivity. Besides, incorrect land uses brings on other incorrect uses. For example; if class 1 agricultural area is used as highway, other uses such as factories, buildings, etc., are build at the sides of highway. Consequently, an incorrect use of lands rapidly increases.

Land evaluation studies are not applied just for protection of agricultural areas. Suitable areas for nonagricultural uses should be determined through land

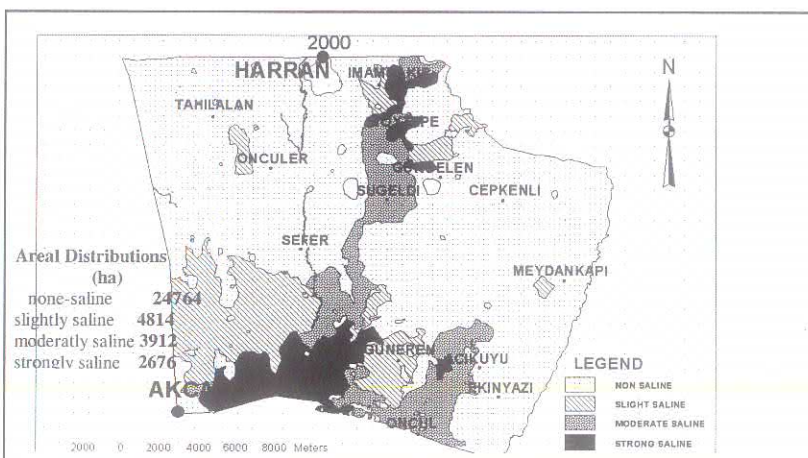
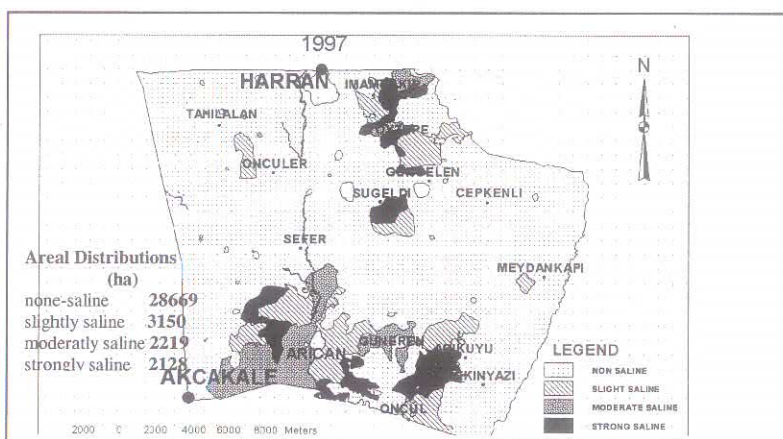
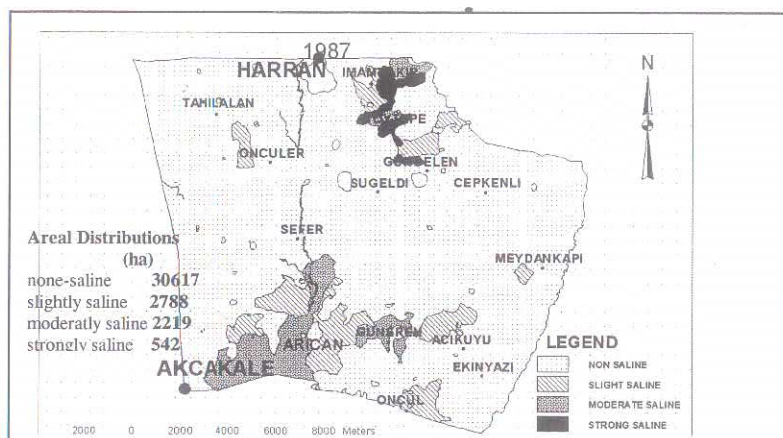




**Figure 3.** The Salinity Variation Between 1987-2000

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**Figure 2.** Salinity Distribution of the Study area for three different years (1987, 1997 and 2000).

2).Figure 2 shows significant increase on salt accumulation during 13 year period. Especially after 1995 when the flood irrigation was began, the soils build up about 1/3 more salt in 5 years. Figure 2 reveals that salinization showed a trend from none to strong between three different years. Mostly soils showed an alteration of salinization as from none to slight, slight to moderate and moderate to strong. Particularly, strongly saline soils was located at the north part of the study area in 1987, but same kind of soils was also appeared in the middle and south part in 1997 and almost all strongly salinized soils are located at the south part close to Akçakale in 2000.

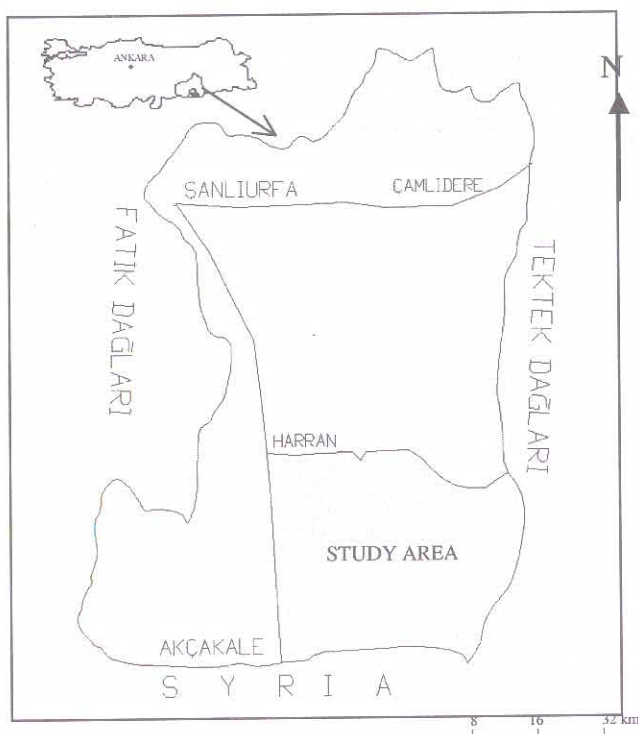
When salinity changes are compared as percent base between three different years, figure 3 indicates very clear and significant results to show the increase of the Aerial percentage of saline soils and decrease of none-saline soils. While the none-saline soils was about 90 % in 1987, the percentage decreased about 75 % in 2000. Levels of the saline soils from slight to strong also showed significant increase during the years. Especially strongly saline soils increased from 1 % to 8 % and increase was about 6 % for slightly saline soils in 13 years. Akçakale series is the one that is most effected with salinization resulted from the location of the soils which are at the lowest elevated part (about 350 m from sea level) in the study area. This results in shallow saline ground water and accumulation of salt at the most level due to the capillary movement of the water with the great evaporation from the soil surface (Figure 2 and Table 1

The use of temporal soil analysis results for determination of salinity on agricultural lands has always been thought of as a fast and cost-effective method to monitor salt problems affecting crop yields. So, the use of GIS for monitoring salinity has proved feasible in large areas where salinity already a serious problem.

Overall it can be concluded that soils of the southeast part of the Harran Plain especially after beginning of the irrigation show a significant salinity increase trend due to increase of groundwater level (range about 50-100 cm) in particularly south part of the study area. To bring the salinity accumulation to a reasonable level the excess of water needs to be removed from the system by selection of a proper drainage method and applied most efficient water with a proper irrigation method as well, and salinity level also needs to be monitored in certain times for sustainable agriculture in the area.



water depth from the surface fluctuate (80 cm to 2 m) between seasons, May and August period gives the lowest depth (e.g. 80 cm in Akçakale) indicating shallow ground water with intensive irrigation.



**Figure 1.** Location of the Study Area

## Results and Conclusions

**Table 1.** Selected Chemical Properties and their Average Values of the Soils in the Study Area in 2000.

Soil Series	pH (Sat. Ext.)	EC (dS/m)	ESP (%)	CEC (cmolc/kg)	Ground Water	
					Depth (cm)	EC (dS/m)
Akçakale	7.6-7.9	13-40	16-42	30-37	80-110	8-31
Ekinyazi	7.8-8.2	3-4	1-4	19-24	100-140	2-4
Harran	7.7-8.3	1-2	1-2	27-31	200 +	0-1
Cepkenli	7.7-8.2	5-13	6-12	23-24	130-180	8-25
Gürgelen	7.8-8.0	9-27	21-26	23-27	140-170	5-8

In order to delineate salinity changes of the study area, salinity maps were established using integrated GIS approach for 1987, 1997 and 2000 (Figure

method that is best adapted in any particular case depends upon a number of conditions: the crop to be grown, topography, soil characteristics, availability of water, soluble-salt content of the water, and salinity status of the soils (US Salinity Lab. 1954). Understanding the changes of salt in the soil profile is a prerequisite for devising appropriate management strategies to improve land productivity of salinized regions. In the Harran Plain slight decrease was observed in structure stability and aggregation indexes after irrigation, however decrease in hydraulic conductivity was significant. Moreover, salinity was significantly increased in soils and there were no changes in clay mineral contents (Çullu et al., 2000).

There is a clear need for the development of cost-effective, quantitative salinity monitoring techniques. The initial diagnosis of the soil salinity conditions within a field typically represents just the first step in a long-term reclamation project or salinity management process (Lesch et al., 1998). Geographic Information System (GIS) helps to provide solutions and particularly management solutions for the problems. Data stored in GIS, therefore be rapidly manipulated, reconfigured, updated, compared, displayed and mapped in a suitable scale format (Chagar and Plunkeft, 1993).

The objective of this study was to monitor soil salinity changes of the Harran Plain between 1987 and 2000 years using GIS techniques.

### **Material and Methods**

The study area (36167 ha) was located in the Southeast part of the Harran Plain, in Şanlıurfa (Figure 1). The Harran Plain has a semiarid climate with practically no precipitation takes place between June and September. Generally, salty ground water level remains close to the soil surface during the year. At the most part of the plain cotton is the major crop produced. It has been proved that when Sahara originated dusts are put in cultured environment in certain conditions an extraordinary amount of fungi colonies appear and it has been detected by satellite images that the dust from Sahara spreads over Anatolia in different dates (Saydam and Şenyuva, 2000; Şenyuva, 2001).

In this study, detailed soil map prepared in 1987 by Dinç et al. (1988) was digitized and based on the salinity data determined in three different years 1987, 1997 and 2000, salinity classes and their distributions applied to the map using GIS, ArcView software to monitor and compare the salinity changes between 1987 and 2000 (Çullu et al., 2000).

This research was conducted in the southeast part of the Harran Plain that has shallow groundwater and potential salinity problem. Some selected chemical data of five common soil series are given for 2000 in Table 1. Data in the table reveal that soils sampled form 0-30 cm depth reflect calcareous characteristics (pH 7.6-8.3); series especially Akçakale, Cepkenli and Gürgelen showed wide range with high EC of soil extract and ground water and ESP values. Ground

## **Application of GIS for Monitoring Soil Salinization in the Harran Plain, Turkey.**

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### **Abstract**

The Harran Plain as the biggest plain of Southeastern Anatolia Project (GAP) has 152000 ha irrigable area. The plain is under the semiarid climate regime and it is dominated by clay-textured soils. Due to excess irrigation with a minor control, salinization problems are becoming prevailed in the plain. Salinization maps were prepared in GIS by using the salinity values of 1987, 1997 and 2000 to determine changes and distribution over the study area (36167 ha). The study investigated an increasing trend of salinization in 13 years. Especially the increase was almost doubled after beginning of the surface irrigation in the plain. Results showed that total salinized area was 5550 ha in 1987, 7498 ha in 1997 and 11403 ha in 2000, respectively. It was observed that capillary movement of shallow saline ground water with very high evapotranspiration to the upper horizons or soil surface results in accumulation of salt in the system. To bring the salinity accumulation to a reasonable level, amount and type of the water application and removing of the excess water needs to be considered for sustainable agriculture in the plain.

**Key Words:** Harran Plain, GIS, Monitoring, Soil salinization, Salinity

### **Introduction**

Salinized soils are a major constraints for agricultural production in the irrigated arid and semiarid regions. Periodic monitoring salt-affected areas are essential for developing reclamation and management strategies. The most important factors effecting soil productivity are soil salinity, alkalinity and shallow ground water levels. Movement of salty water to topsoil and excess evapotranspiration can cause salt accumulation at the different soil horizons ( Mehanni, 1998; Çullu et al., 2000; Aydemir, 2001).

Soil salinity and alkalinity are mainly caused by natural and cultural factors. While climate, natural drainage, topographic properties, geological structure, parent material, distance to the sea are the natural factors; unsuitable irrigation methods and water quality, insufficient drainage, poor land management are agricultural factors (Mehanni, 1998; Özcan and Çetin, 1998). The selection of an irrigation method for applying water to the soil is related to salinity. The



threatens the existence of wetlands even the existence of the Uluabat Lake. We can say that the major threats to wetlands of the Uluabat Lake are changed flow patterns as result of river regulation and water extraction for agriculture and industry, and expansion of irrigated agriculture. Sedimentation that caused mainly water erosion due to upland farming and mining activities in the catchments and pollutions are the other important threats.

To protect the Uluabat Lake and its wetlands from further degradation and loss the following recommendations are given:

- finalize the management plan as soon as possible and enforce a restriction
- monitoring Uluabat Lake RAMSAR site and catchments of the Mustafakemalpaşa River by using remote sensing and GIS techniques and establish Uluabat Lake information system (ULUBIS)
- establish soil and water management plan for the Uluabat Lake catchments area
- introduce new irrigation methods and land use types to reduce excess water withdrawal from the lake
- investigate of the effects/threats of second highway which is still under construction and Uluabat Lake section is not constructed, on water pollution and breeding birds.

### **Acknowledgements**

We wish to thank to DHKD (Society for the Protection of Nature Turkey) and Ministry of Environment for Satellite data, digitizer and aerial photographs supply and support.

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from topographical map 1:25000 scale, the rate of decline will be about 14%. In spite of this situation, the coverage of the delta has been increased as a rate of 75 % from 2135.8 ha to 3747.6 ha in the same period. The proportion of the agricultural lands in the delta has also been increased from 578 ha to 1737 ha due to conversion of the reed areas to agricultural lands.

The coverage and percentages Land use/cover classes of The Uluabat Lake RAMSAR site which is cover an 21136 ha area, gathered from visually interpreted 1985, 1993 and 1998 Landsat images as summarized in table 1.

**Table 1.** Coverage and Percentage of Land Use/Cover Classes in RAMSAR Site.

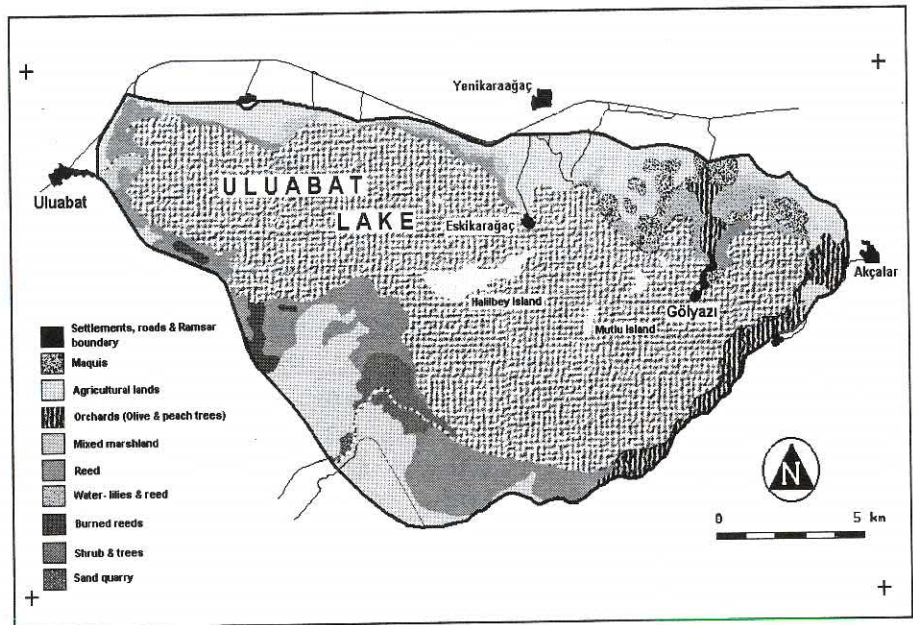
Years	1984		1993		1998	
Land Use/Cover Classes	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Settlements & roads	33.7	0.17	49.2	0.24	53.3	0.26
Maquis	759.9	3.77	521.0	2.59	448.1	2.23
Agricultural lands	2619.4	13.01	3127.8	15.53	3393.6	16.85
Orchards	492.0	2.44	731.8	3.63	772.7	3.84
Mixed Marshlands	139.0	0.69	188.5	0.94	268.4	1.33
Reeds	716.8	3.56	1602.9	7.96	1695.2	8.42
Water lilies & reed	1198.7	5.95	1150.0	5.71	891.0	4.42
Burned reeds	-	-	51.29	0.25	164.5	0.82
Shrub & trees	459.0	2.28	317.0	1.57	359.5	1.79
Sand query	-	-	-	-	29.4	0.15
Islands	304.2	1.51	304.2	1.51	304.2	1.51
Uluabat Lake	13310.7	66.10	12003.3	59.61	11685.7	58.03
Mkemalpaşa River	78.7	0.39	65.7	0.33	55.4	0.28
Uluabat River	24.0	0.12	23.5	0.12	15.1	0.07
<b>TOTAL</b>	<b>20136.10</b>	<b>100.00</b>	<b>20136.10</b>	<b>100.00</b>	<b>20136.10</b>	<b>100.00</b>

It is clearly seen that strong tendencies to decrease Uluabat Lake cover and corresponding increases in wetlands and agricultural lands. It can be also said that natural covers such as maquis, shrub&trees, water lilies&reed have been decreased while man-made covers such as agricultural lands, orchards, settlement &roads have been increased.

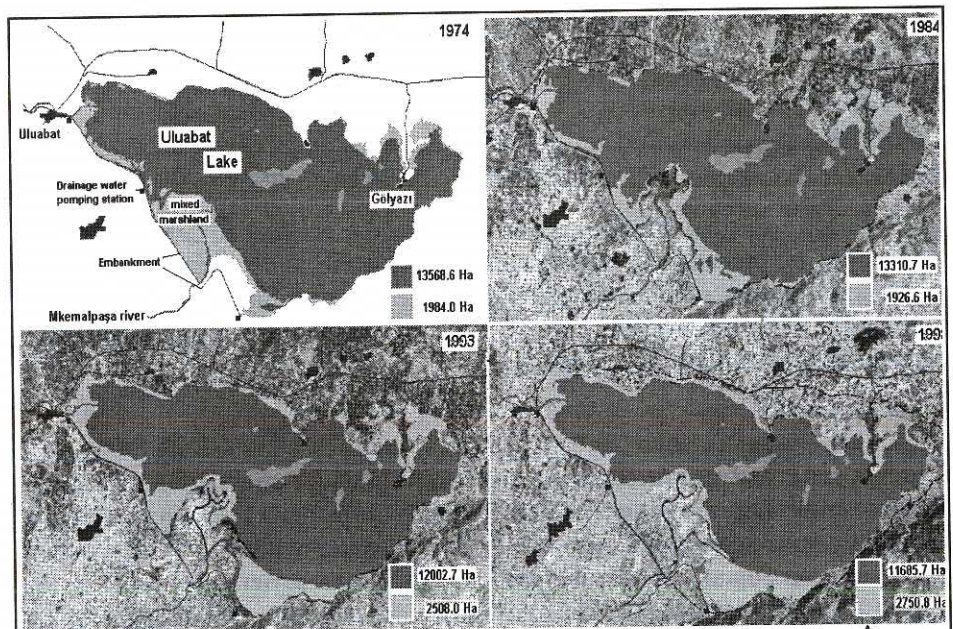
## Conclusions

Uluabat Lake and its surroundings are currently under stress from direct and indirect anthropogenic activities. The wetlands of the delta are being converted especially into agricultural use due to excess water withdraw in dry period (from June to September) for irrigation of 16,500 ha agricultural lands in the Mustafakemalpaşa plain. On the other hand, drought is a natural agent which



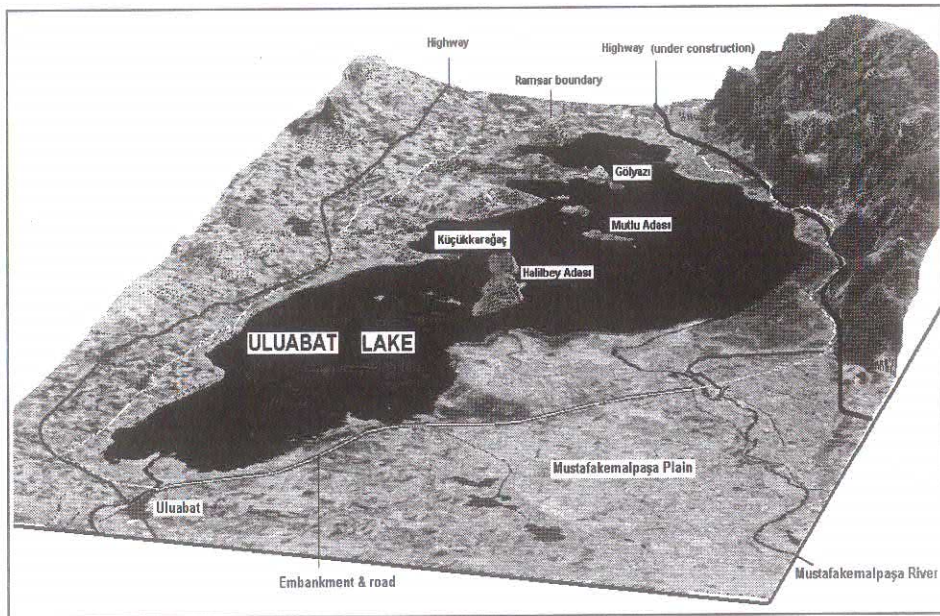


**Figure 2.** Land use/cover Classes Map of the Uluabat Lake Ramsar Site.



**Figure 3.** Shorline Changes of Uluabat Lake and Landsat Images





**Figure 1.** NFCC Composite images of Uluabat the Lake in 1998 rendered on DEM

## Result and Discussion

In the past, Uluabat Lake's coverage area was given a  $160 \text{ km}^2$ . Due to constructed embankment by the DSI in 1937-1993 for to protect low lying agricultural lands along the South –Southwest coast and silt deposition, it can be said that the coverage area of the Lake can not be rich again mentioned past coverage. In 1995, DSI's coverage and volume measurement works showed that the coverage areas of Uluabat lake was  $155 \text{ km}^2$  at the maximum level of water (4.3 m depth) and water volume of the lake was  $346 \text{ hm}^3$ . In contrary, the coverage and volume of the lake were measured at the same works as a  $161 \text{ km}^2$  and  $387 \text{ hm}^3$  respectively in 1965. Shoreline changes maps for 1984, 1993 and 1998 gathered visually interpreted Landsat images (Figure 3) also showed that decrease of the coverage and volume of the lake are in continue.

It can clearly be seen that the coverage area of the Uluabat Lake have been decreased at a rate of about 12 % from  $133.1$  to  $116.8 \text{ km}^2$  due to sediments transported by the surface water of surrounding irrigated agricultural land, tributary streams and mainly Mustafakemalpaşa river in a fourteen years period. If we consider Uluabat Lake coverage areas gathered

and mining activities residue form the watershed of the Mustafakemalpaşa River which covers an area of 10136 km<sup>2</sup>. The hidrological cycle of the Mustafakemalpaşa River is a major affecting all activities on the delta and wetland of the Uluabat Lake. The flow of the Mustafakemalpaşa River at Döllük station ranges from an avarage high of 825 m<sup>3</sup>/sn in March and an avarage low of 92 m<sup>3</sup>/sn in September. Due to hidrological cycle and over-abstraction of water, water level of theUluabat Lake changes in between 1.5 m and 3.5 m.

The used data as a base map were digital satellite data (Landsat TM , full frame, CD ROM, 16 June 1984, 26 June 1993 and 16 August 1998), aerial photographs (1:35000 scale, 1997), topographical map ( 1:25000 scale, 1974) and software programs (ERDAS Imagine 8.3.1, ILWIS 1.4). RS and GIS techniques i.e. creating false color images enhancement, rectification, screen digitizing and resolution merging have been employed to monitor shoreline changes along to Uluabat Lake costs and to determine Land cover/use changes of The Uluabat Lake RAMSAR site.

The satellite data from Landsat5 TM available on CD ROM was converted on to ILWIS and ERDAS format. The individual spectral band information was georeferenced through ILWIS program by selecting geographic coordinates from topographic maps and subsequently enlarged by using edge-enhancement filter and stretching for improving the visual aspect of the images (Rosenfeld and Kak, 1976, ITC, 1993).

The color composites were prepared by different band combinations of extracted Landsat-5 TM bands. The band combinations which are prepared using band 543 as a RGB were selected, due to best discrimination for multi temporal changes of Uluabat Lake and RAMSAR site.

Visual interpretation was applied to elaborate the morpho-dynamic shoreline and land cover/use changes maps. They were elaborated on the basis of interpretation of Landsat images enlarged to scale 1:100000. During the visual interpretation used FCC images for and land cover/use changes in 1998 was given as a sample image which is rendered on DEM as color map (Figure 1).

Visual interpretation was made on the bases of color, texture, pattern, shape, size and tone differences of Uluabat Lake on the color composite images in order to identify and classify shoreline and land use/cover changes in 1984, 1993 and 1998 (Sabins,1987 , Lillesand and Kiefer,1987).

The represented units in 1998 maps (Figure 2) were only checked and corrected by ground truth, comparison with aerial photographs and using geo-referenced information of 56 observation points gathered from breeding bird surveys of Uluabat RAMSAR site (Welch and Welch,1998). The interpreted units for shoreline and land use/cover changes were digitized both screen and tablet digitizing in order to derive raster based maps.



protection laws are not able to improve water quality of the lake and to protect wetlands of the lake themselves without helps and contribution of the all stakeholders and realistic and applicable management plan.

The wetlands of Lake Uluabat and Its catchments face a number of problems and threats which could these valuable resources change or degrade/disappear. Human activities both direct (discharges to the lake) and indirect (discharges to the watershed) are great contributors to degrade and loss of Uluabat Lake wetlands and to affect water quality. It is important to know what the major threats to the wetlands are, if they are to be managed effectively. The most serious threats to the wetlands of Uluabat Lake are:

- Lake regulation and water extraction for agriculture, industry and residential (from both lake and watershed)
- Sand and gravel mining and mineral extraction activities (amongst others sand mine, coal, borium, chromium ore)
- Water pollution
- Nutrient enrichments ( agricultural use of fertilizer and siltation)
- Conversion of wetland areas to agricultural use (mainly in the delta)
- Second highway construction on the south and southwest side of the lake

In 1998, DHDK( Society for the Protection of Nature Turkey) initiated a join project with the Turkish Ministry of the Environment to prepare an integrated management plan for Uluabat Lake (ULIMP). As a part of the ULIMP, this study was implemented to produce base maps for the Uluabat Lake RAMSAR site such as land cover/use map, shoreline changes map by using RS and GIS techniques, to show seriousness of threats for eliminating ignorance before the wetlands is irreversibly degraded. This study also implemented to identify the problems and threats associated with land use/land cover changes and sedimentation processes and to discuss solutions.

## **Material and Methods**

Lake Uluabat, the third largest freshwater body in the Marmara Region, is an tectonically depression lake, located between 4440000-4460000 N latitude and 620000-650000 S longitude. Mustafakemalpasa and Karacabey Districts are the two large residential areas around the Uluabat Lake. The main human activity at the lake is fishing. Also, agricultural lands and industry surround the Lake. The Mustafakemalpaşa plain is one of the most productive agricultural areas in Turkey due to its suitable climatic conditions, high quality soils, and developed irrigation scheme.

Uluabat Lake covers an area of between 135 to 155 km<sup>2</sup> depending on lake level. A large and expanding delta which is cover an 3747.6 ha area in1998 has been formed by silt deposition around the Mustafa Kemalpaşa River mouth in the Southwest section. The silt deposition is mainly resulted by water erosion



In the last decade, some of the most important unprotected and rapid increased environmental problems that faced to human being are the air, soil and water pollution, erosion and climate changes directed by human activities. Increase of environmental problems that affect human life directly and/or indirectly was caused to increase the work to be made for solving these problems and the investment.

Recently in all over the world, prevention of the environmental problems before the rising up, determining quality and quantity of biotic and abiotic elements of the ecosystems and keeping them alive in sustainable bases had become basic aims of the Environmental activities.

Worldwide good quality water is scarce. Water an essential element for life, agriculture and industry. It is estimated that the total volume of water in nature is about 1,386 million cubic kilometers. From these, 97.5 % are oceanic (saline water) and only 2.5% fresh water. The greater portion of the fresh water; 68.7 % are in the poles and mountainous region. Next 29.9 % are in the groundwater. Only 0.26 % of the total amounts of freshwater on the earth are concentrated in lakes, reservoirs, and river systems. They are the most accessible for economic needs and very important for water ecosystems. In many countries and regions of the world, irrigation is the principles water user (Shiklomonow, 1993).

Lakes are sensitive ecosystems and very attractive for human activities. All lake regions are also vulnerable to environmental pollution. Lake areas are not only man made landscape, recreation areas for tourists and drinking, irrigating water reservoirs. They are also gathering places for migratory birds and habitats of millions of animals and different plants. Uluabat Lake is one of the most important wetlands of Turkey. It is also one of the nine RAMSAR sites in the Turkey. It is surrounded, especially at the northern and Northwestern sides by wet meadows. Almost all shores of the lake are covered with submerged plants. The lake holds the largest white water lily beds which are the most important feeding and wintering area for the term in Turkey. These temporary wetlands are wet in most part of the year, becoming drier in summer. It is one of the most nationally and internationally important area for many aspects such as given below:

- Its rich biodiversity and valuable freshwater sources,
- Its location that on the migratory bird route,
- It is an important breeding, feeding and wintering site for significant amount of bird populations. Some of these are globally threatened species, the Dalmatian Pelican, Pygmy cormorant (DHDK,1998).

Due to its importance, Uluabat Lake was designated by the Ministry of Environment as a RAMSAR site in 1998 and consequently it was chosen as a partner of International Living Lakes Network in the 4<sup>th</sup> International Conference at EXPO 2000. The mentioned status of the lake and national

## **Investigation of Multi-Temporal Land Use/Cover and Shoreline Changes of the Uluabat Lake Ramsar Site Using RS and GIS**

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### **Abstract**

Multi temporal changes of the Uluabat Lake and surrounding areas within the recently declared RAMSAR site have been researched by using RS and GIS techniques. The objectives of this study were: to determine the shoreline and land use/cover changes of Uluabat Lake and surrounding, to determine recent situation of the Uluabat Lake and RAMSAR site, to decide which conservation and management practices will be taken for sustainable use

To rich mentioned objectives, multi temporal Landsat 5-TM data acquired ( in 1984, 1993 and 1997, aerial photographs (taken in 1997) and topographical maps (compiled in 1974 using aerial photographs taken 1966) were used. All the data were stored into the computer using ERDAS Imagine and ILWIS software program from CD-ROM, scanner and digitizer. Image subsetting, geographic correction, resolution merging and image enhancement procedures were applied for easy comparison, exact image on map and aerial photographs overlies and better visual interpretation.

The results show that Uluabat Lake covers an area of 133.1 km<sup>2</sup> in 1984, of 120.5 km<sup>2</sup> in 1993 and of 116.8 km<sup>2</sup> in 1998. It can clearly be seen that the coverage area of the Uluabat Lake have been declined at a rate of about 12 % from 133.1 to 116.8 km<sup>2</sup> due to sediments transported by the surface water of surrounding irrigated agricultural land, tributary streams and mainly Mustafakemalpaşa River in a fourteen years period. If we consider Uluabat Lake coverage areas gathered from topographical map 1:25000 scale, the rate of decline will be about 14%.

In spite of this, coverage area of the agricultural lands have been increased at a rate of 26 % from 2508 ha to 3393 ha, due to mainly changes of reed areas to agricultural use in the Mustafakemalpaşa river's delta

**Keyword:** Uluabat Lake, Land use / cover changes, RS and GIS

### **Introduction**

In the past 50 years, due to rapid increase of the world population and industrial development, the natural resources had been degraded with a great rate. During the same period the air, water and soil pollution increased as an unprecedented way and issues of environmental problems have become more important. Problem is not use of the nature; problem is the miss use of the nature. Destroying forest, overgrazing pasture, drying wetlands, consumption of the fauna with over hunting and fishing accelerate consumption of the natural resources and as a result of these activities, the natural balance formed over the thousand years have been destroyed.



used to size the collection and piping, ditching, pumping, or other conveyance facilities.

In any given year, there is a 4% probability that the 25-year storm will be exceed. A type of risk assessment or alternatives analysis should be carried out to determine if the benefits of designing for a storm event that would yield a greater volume and/or peak flow rate outweigh the risk of an overflow and, potentially, a permit exceedance. Factors to be considered in such a risk assessment include the water quality standards of the receiving water, the discharge permit limits, and the potential enforcement consequences.

### **Storm Water Retention**

Storm water retention facilities retain contaminated storm water until it can be treated to concentration limits specified in the appropriate discharge permit or to quality characteristics required for use of the process makeup water in the industrial plant. Retention can be accomplished in lined, earthen basin or in above or belowground concrete or steel tanks. An industrial plant in a non-urban location having large areas of unused land would consider the cost effectiveness of a lined, earthen basin first. On the other hand, a plant in urban location with limited available unused land might first consider an above-or belowground concrete basin.

Additional factors that must be included in sizing the storm water retention facility are the following

- Precipitation that falls directly into the retention device
- The rate at which water is taken out of the basin as it related to the probability of another storm event taking place very soon after the design storm has occurred

The rate at which water is removed from the retention basin a function of the capacity of the treatment system and the rate of use this water.

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For example, roofs that have a reasonable potential to become contaminated with dust or other fallout should be fitted with gutters and ancillary piping. The piping should segregate this runoff from any and all runoff that will not be contaminated. Paved and unpaved areas should be surveyed, and those areas that are not subject to contamination should be isolated. A safe approach would be to design a retention basin for runoff that is expected to be clean and to sample and analyze this water before it is discharged.

### **Stormwater Segregation, Collection and Retention**

The collection system for contaminated runoff consists of rain gutters, catch basins, pumping stations, open channels, and pipes. This system must always be well maintained, clean, and free of leaks. Easy access to the collection system for sampling and analysis should be designed and built into the system. Its volume should be minimized by careful segregation from uncontaminated storm water since this water undergoes retention and treatment. Careful segregation will also maximize the concentration of contaminants because the quantity of contaminants at a given industrial site at given time is fixed by the circumstances and events that have occurred before the storm event. Therefore, the smaller the amount of storm water in which the contaminants are dissolved or suspended, the more concentrated they will be.

Control of the quantity of the storm water discharges is possible only if effective segregation, collection, retention, and treatment facilities are in use. The effectiveness from both an actual physical perspective depends on proper design. Opportunities for segregation of clean runoff from contaminated runoff should be exposed as the first step in developing an effective storm water management program. Source segregation can be effective in reducing the volume of runoff to be collected and treated. The sizes of the collection, retention and treatment facilities are derived from precipitation records and selection of a design storm. It is also necessary to include within the design of the storm water management facilities provisions to prevent damage to those facilities or violations of permits since the concept of a design storm event implies periodic failure.

### **Design Storm**

The 25-year, 24-hour storm event has been shown to be an appropriate design basis for storm water management facilities for an industrial plant when conventional pollutants are the only substances of concern. A 50-year or 100-year storm would be more appropriate in situations where PCB's or other toxic substances are potential pollutants. The capacity of the retention device is determined by the total volume of runoff calculated by the rational method or another more sophisticated runoff modeling procedure. The peak runoff rate is

- An inventory of materials that can be exposed to storm water;
- An estimate of the quantity and type of pollutants likely to be contained in the storm water runoff;
- A history of spills or leaks of toxic or otherwise hazardous material for the past three years.

### **Best Management Practices**

Best Management Practices (BMP's) must be identified. BMP's should include good housekeeping practices, structural control measures, a preventive maintenance program for storm water control measures, and procedures for spill prevention and response. As needed, traditional storm water management controls, such as oil/water separators and retention/equalization devices must also be included.

- For facilities that are subject to EPCRA 313 reporting, the SP3 must address those areas where the listed Section 313 "water priority chemicals " are stored, processed, or handled. These areas typically require stricter BMP's in the form of structural control measures
- A certification of Non-storm water discharges. The facility must have piping diagrams that confirm no Non-storm water connections to the storm sewer. Otherwise, all outfalls must be tested to insure that there are no connections of sewers that carry other than storm water.
- A record keeping system must be developed maintained, as well as effective program for training employees in matters of controls and procedures for pollution prevention.

### **Prevention of Ground Water Contamination**

Measures and facilities to prevent contamination of groundwater should be developed concurrently with those that have the purpose of protecting against surface water contamination. The most important are listed below:

- Construction of impermeable barriers such as concrete pads to prevent percolations of storm water after it has become contaminated
- Installation of fool-proof automatic shut-off devices to prevent spills from overflowing tanks;
- Alarms;
- An aggressive preventive maintenance program to prevent occurrence of leaks;
- Control of particulate and aerosol emissions and routine cleaning of all surfaces on the industrial site

A thorough program should be carried out to eliminate leaks, spills, and uncovered storage areas. Also spill containment devices should be carefully designed and constructed.

### **Multi-Sector General Permit**

The Multi-Sector General Permit (MSGP) is the simplest form of NPDES permit coverage that industrial facilities can obtain, although there are circumstances that would cause a facility to be ineligible for MSGP coverage. Industrial facilities that have activities covered under one or more of the industrial sectors in the MSGP are eligible for coverage. To obtain MSGP coverage, the facilities must submit a Notice of Intent (NOI) for coverage and prepare and implement a Storm Water Pollution Prevention Plan (SP3). The MSGP contains industrial-specific requirements for storm water monitoring, reporting, and best management practices (BMP's) to minimize contamination of runoff.

### **Individual Permit**

The Individual Permit requires the preparation and submittal of NPDES forms 1 and 2F, which request specific information about the facility, the industrial operations, and the results of storm water sampling, analysis, and flow measurement. A facility-specific Individual permit is issued by NPDES permitting authority and typically contains discharge limits, monitoring, reporting requirements, and may require implementation of BMP's or pollution prevention measures. Because of the backlog of applications and lengthy application review and permit writing process for Individual permits, permitting authorities typically recommend that discharges seek coverage under the MSGP.

### **Construction General Permit**

The Construction General Permit is applicable to construction projects at industrial facilities that disturb one or more acres of land area. The permitting process is the same as for the MSGP: submittal of an NOI for coverage and implementation of an SP3 that focuses BMP's during construction.

### **Storm Water Pollution Prevention Plan (SP3)**

Amount the important requirements of the MSGP is the development and implementation of an SP3. The goal of the Sp3 is to reduce or eliminate the amount of pollutants in storm water discharges from an industrial site. The SP3 must be developed with input from a designated Pollution Prevention Team. The SP3 must identify all potential pollutant sources and include descriptions of control measures to eliminate or minimize contamination of storm water. The SP3 must contain the following:

- A map of the industrial facility identifying the area that drain to each storm water discharge point,
- Identification of the manufacturing or other activities that take place within each area;
- Identification of the potential sources of pollutants within each area;



gases will be dissolved in the runoff. Most, if not all, of that which percolates into the ground will eventually join the groundwater.

The quality and, in some cases, the quantity of the water that lives industrial site, whether via overland flow the surface waters or via percolation into the groundwater, is of importance in the context of compliance with environmental regulations more to the point, the quality and quantity of the storm water runoff before it lives the site is the subject of the storm water management, as it relates to a pollution prevention program, the design of the collection and treatment facilities, and regulatory compliance monitoring.

### **Federal Storm Water Regulations**

Federal regulation of storm water originated with the 1987 Clean Water Act amendments that established the authority for the U.S. EPA to developed a phased approach to storm water discharge permitting and management. To storm water rules follow in 1990 and 1992: The "Storm water application rule" and the "storm water implementation rule". The storm water application rule of November 1990 in identified the types of facilities subject to permitting under the National Pollutant Discharged Elimination System (NPDES) program (found at 40 CFR Part 1229), and the storm water implementation rule of April 1992 describe the requirements of NPDES permits.

Phase I of the storm water application rule applicable to heavy industrial discharges, as well as large and medium municipal separate storm sewers and operators of large construction sites

Industrial facilities are required to comply with the storm water rules if they meet the following criteria:

- Discharge storm water via one more point sources into waters of the U.S.
- If the facility falls within one of the following categories
  - Either engaged in industrial activity;
  - Already covered under an NPDES permit;
  - Identified by the EPA as contributing to a water quality violation

Note that the storm water rules are not applicable in the following situations.

- None point sources discharges of storm water;
- Discharges of storm water to municipal sewer systems that are combined storm water and sanitary sewers;
- Discharges the storm water to ground water.

The Multi-sector general permit and the Individual Permit are the to types of storm water discharged permits currently issued to industrial dischargers by the NPDES permitting authority.

# **Industrial Sites Stormwater Management: Regulations and Treatment**

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## **Abstract**

Precipitation of all types falls on industrial sites and, in so doing, transports chemicals and inert solids to other parts of the environment. Any industrial facility will have some contamination on all surfaces, including roof, parking lots, storage facilities, roads, sidewalks, and dirt or grassy areas.

Because all substances are soluble, to some extent, in water, any chemical substances in either liquid or solid form will become dissolved and will either percolate into the ground or be carried with the rainfall runoff. Some particles that are not dissolved will be carried along with the runoff, and some amount of gases will be dissolved in the runoff. Most, if not all, of that which percolates into the ground will eventually join the groundwater.

The quality and, in some cases, the quantity of the water that leaves the industrial site, whether via overland flow to surface waters or via percolation into the groundwater, is of importance in the context of compliance with environmental regulations. More to the point, the quality and quantity of the stormwater management, as it relates to a pollution prevention program, the design of collection and treatment facilities, and regulatory compliance monitoring.

Federal regulation of stormwater originated with the "1987 Clean Water Act" amendments that established the authority for the U.S. EPA to develop a phased approach to stormwater discharge permitting and management. Two stormwater rules followed in 1990 and 1992: the "stormwater application rule" and the "stormwater implementation rule". The stormwater application of November 1990 identified the types of facilities subject to permitting under the National Pollutant Discharge Elimination System (NPDES) program (found at "CFR Part 122"), and the stormwater implementation rule of April 1992 described the requirements for NPDES permits.

## **Introduction**

Precipitation of all types of falls on industrial sites and, in so doing, transports chemicals and inert solids to other parts of the environment. Any industrial facility will have some contamination on all surfaces, including roofs, parking lots, storage facilities, roads, and sidewalks and dirt or grassy areas.

Because all substances are soluble, to some extend, in water, any chemical substances in either liquid or solid form will be come dissolved and will either percolate into the ground or be carried with the rain fall runoff. Some particles that are not dissolved will be carried along with the runoff, and some amount of

**Table 2.** Chemical Compositions and Level of Groundwater of alluvial-meadow irrigated soils of the Southern Aral Sea Region.

Section number	Depth of groundwater, m	Concentrations of ions, g. liter						Salinity, g. liter
		HCO <sub>3</sub>	Cl	SO <sub>4</sub>	Ca	Mg	Na+K	
1960 year								
1	4.25	0.195	0.106	0.168	0.640	0.24	0.103	0.562
2	4.25	0.798	0.851	0.954	0.112	0.204	0.754	3.220
3	5.00	0.390	0.155	0.308	0.132	0.64	0.124	0.977
4	5.00	0.538	0.272	0.616	0.172	0.165	0.163	1.656
2000 year								
1	0.65	1.098	2.165	3.240	0.631	1.202	4.685	18.961
2	0.78	0.683	2.698	2.073	0.378	0.404	1.955	8.191
3	0.63	0.756	1.917	2.030	0.388	0.488	1.435	6.874
4	1.30	0.902	1.491	1.435	0.396	0.371	0.902	5.487
5	0.93	2.074	7.100	5.491	0.705	1.363	5.025	21.758
6	0.68	0.854	4.615	7.180	0.617	1.443	3.312	18.022
7	1.31	0.585	0.923	1.034	0.193	0.588	0.039	3.362

**Table 3.** Concentrations of Water-Soluble Salts and Humus of alluvial-meadow irrigated soils of the Southern Aral Sea Region

Section	Depth, cm	HCO <sub>3</sub>	Cl	SO <sub>4</sub>	Ca	Mg	Na+K	Total salts	Humus
1960 years									
3	0-50	0.043	0.057	0.140	0.024	0.015	0.065	0.322	—
6	0-50	0.043	0.019	0.049	0.020	0.010	0.010	0.129	—
8	0-30	0.043	0.170	0.076	0.020	0.010	0.169	0.566	—
2000 years									
4	0-10	0.732	1.182	2.469	0.343	0.566	0.759	6.061	0.876
	10-38	0.122	0.197	0.964	0.157	0.136	0.194	1.770	0.109
	38-78	0.231	0.078	0.740	0.078	0.056	0.295	1.478	0.058
	76-140	0.090	0.019	0.127	0.023	0.013	0.055	0.327	—
Well 3	0-10	0.052	0.177	0.241	0.044	0.032	0.137	0.683	0.11
	10-30	0.036	0.159	0.225	0.050	0.029	0.112	0.611	0.95
	30-50	0.104	0.124	0.336	0.039	0.023	0.190	0.816	0.041
	50-100	0.078	0.085	0.354	0.050	0.034	0.131	0.732	—
8	100-150	0.091	0.042	0.204	0.022	0.014	0.106	0.479	—
	0-1	0.338	1.913	1.94	0.264	0.320	1.386	6.162	0.569
	1-14	0.586	0.730	1.209	0.202	0.143	0.771	3.641	0.679
	14-49	0.112	0.208	0.408	0.081	0.059	0.160	1.028	0.040
	49-110	0.072	0.125	0.175	0.015	0.019	0.137	0.543	—
	110-142	0.067	0.156	0.489	0.033	0.058	0.212	1.015	—
	142-180	0.045	0.104	0.760	0.076	0.055	0.255	1.295	—



**Table 1.** Water mineralization and change of chemical type of Amu Darya river in 2000 year (near the Nukus City).

	CO <sub>3</sub>		HCO <sub>3</sub>		CL		SO <sub>4</sub>		Ca		Mg		Na+K		Σ salts		Dry Residuuum	Chemical type
%	%	mg equi v.	%	mg equiv.	%	mg equiv.	%	mg equiv.	%	mg equiv.	%	mg equiv.	%	mg equiv.	%	mg equiv.	%	
Jan.	-	-	0,19	3,12	0,249	7	0,502	10,46	0,115	5,76	0,068	5,568	0,231	9,256	1,355	1,359	CL-S	
Fer.	-	-	0,198	3,24	0,17	4,8	0,438	9,12	0,069	3,456	0,089	7,296	0,16	6,408	1,124	1,128	CL-S	
March	0,002	0,08	0,173	2,84	0,17	4,8	0,519	10,82	0,115	5,76	0,068	5,568	0,18	7,212	1,227	1,231	CL-S	
April	0,001	0,04	0,161	2,64	0,206	5,8	0,47	9,8	0,104	5,2	0,068	5,6	0,187	7,48	1,197	1,204	CL-S	
May	0,003	0,12	0,156	2,56	0,192	5,4	0,288	6	0,056	2,8	0,061	5	0,157	6,28	0,913	0,921	CL-S	
June	0,002	0,08	0,146	2,4	0,185	5,2	0,422	8,8	0,096	4,8	0,058	4,8	0,172	6,88	1,081	1,089	CL-S	
July	0,011	0,36	0,132	2,16	0,199	5,6	0,355	7,4	0,08	4	0,056	4,6	0,173	6,92	1,006	1,025	CL-S	
Aug.	0,005	0,16	0,127	2,08	0,234	6,6	0,331	6,9	0,088	4,4	0,063	5,2	0,153	6,14	1,001	1,009	CL-S	
Sept.	0,002	0,08	0,141	2,32	0,064	1,8	0,432	9	0,106	5,3	0,046	3,8	0,103	4,1	0,894	0,898	CL-S	
Octob.	-	-	0,166	2,72	0,277	7,8	0,355	7,4	0,104	5,2	0,063	5,2	0,188	7,52	1,153	1,159	S-CL	
Nov.	-	-	0,21	3,44	0,319	9	0,307	6,4	0,108	5,4	0,078	6,4	0,176	7,04	1,198	1,205	S-CL	
Dec.	0,004	0,13	0,164	2,68	0,206	5,8	0,402	8,37	0,095	4,73	0,065	5,37	0,171	6,84	1,104	1,112		

Extensive irrigation of the upper part of Amudarya within the territory of Uzbekistan has had following two consequences: On the one hand, an increase of agricultural production with an improvement of social conditions in the upper part of the river. On the other hand, disastrous shortage of fresh water in the lower Amudarya delta, causing considerable destruction of social and ecological conditions for people in the southern Aral Sea region.

Rational use of water and land resources in the ecological crisis zone of the Aral Sea can be achieved if the new countries of Central Asia overcome the following obstacles:

- Difficult ecological situation in countries, located in the Aral Sea Basin;
- Growing competition for use of water and land resources;
- Decrease of the ecological sustainability;
- Lack of inter-regional cooperation in environment protection and use of natural resources;
- Lack of finances for programs of increasing fertility of soils in the region;
- Lack of finances for programs for development and introduction of water-saving technologies in the region;
- Lack of finances for health programs for people living in the epicenter of the Aral Sea ecological crisis;
- Lack of finances for ecological education programs;
- Lack of finances for relieving poverty;
- Lack of scientific management of water, land, plant, animal, labor and energy resources in the Aral Sea Basin;
- Unnecessarily delayed development of agriculture; wasteless production, small, medium business and entrepreneurship in villages; automobile and railway transport; road network; road maintenance, communication infrastructure; land privatization; recycling of wastes; economic relations with other countries, reuse of water in industry.

Thus, use of water for irrigation, especially in a desert zone is a determining factor for the economy. Irrational use of natural resources, especially water and land will result in an accelerated degradation of the natural ecosystem, that supports human civilization.

Constantly growing competition for use of water and land resources among the new states of Central Asia may ultimately lead to an inter-national war.

## **Rational Use of Water and Land Resources in the Ecological Crisis Zone of the Aral Sea**

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Rational use of water and land resources is extremely important in all countries, located in the area of the Aral Sea Basin. The problem of achieving a sustainable balance in the economic growth, relieving poverty, social justice and preservation of land and water resources and food supplies is of the first priority.

There is more land in the Aral Sea Basin than water necessary to irrigate it. Food supply is a product of land and water resources. Increase of food production is possible only by increasing productivity for the amount of water. The most severe drought and lack of water during the last years struck the northwest regions of Uzbekistan, particularly, a very critical situation is being observed in Karakalpakstan. Crops of rice and cotton suffered great losses here, and serious losses of other food crops intended for sale have been observed.

One of the most critical ecological problems is salinization of soils, especially caused by raise of subsoil water and the fact that collector-drainage water run into the river. The collector-drainage water makes the ecological situation worse. Salt accumulated in deeper soil layers and subsoil water is brought up to the surface and spread unevenly along the territory. The number of agriculture workers is progressively decreasing because of severe lack of irrigation water, increase of salt in irrigation water, decrease of soil fertility and desertification. Only for the last 40 years, the level of the Aral Sea has sunk more than 20 m because of introduction of new farming techniques. The landscape has sharply changed, and water and land resources have been negatively affected. Currently, the Aral Sea Basin faces the following challenges:

- Shortage of drinking and irrigation water;
- Degradation of pastures;
- Contamination of river and subsoil water, and increase of its mineral content (table 1,2);
- Soil salinization (table 3);
- Decrease of soil fertility (table 3);
- Soil deflation as a result of wind erosion.



**Table 1.** The main characteristics of the investigated soils in the Srebarina Reserve.

Horizon	Depth, cm	Color	Humus %	pH (H <sub>2</sub> O)	Texture %		CaCO <sub>3</sub> %
					<0,001	Σ<0,01	
Profile 1 – Moderate Leached Chernozem or Haplic Chernozem, arable land of cereal.							
A p	0-20	10YR4/3	2,05	7,0	22,4	43,5	0,35
Ah	20-30	10YR4/3	1,88	7,1	22,4	42,8	0,42
AB	30-47	10YR5/3	1,22	7,0	23,4	45,3	0,35
Bk	47-70	10YR6/3	0,90	7,4	15,3	38,6	11,20
BCk	70-85	10YR6/3	0,71	7,4	17,5	34,8	14,32
Ck	85-110	10YR6/4	0,88	7,5	13,1	32,6	22,76
Profile 2 – Meadow Chernozem or Haplic Chernozem, arable land of maize, 350 m off the lakeshore							
Ap	0-19	10YR3/3	2,50	6,9	19,7	43,6	1,16
Ah	19-37	10YR4/3	2,36	6,8	23,4	32,8	0,84
AB	37-47	10YR4/3	2,16	7,0	19,9	46,6	0,84
B <sub>1</sub> k	47-60	10YR5/3	1,55	7,1	20,5	45,7	0,97
B <sub>2</sub> k	60-69	10YR5/3	1,17	7,4	20,9	46,1	8,84
BCk	69-79	10YR6/3	1,03	7,5	18,0	40,4	11,90
Ck	79-102	10YR6/4	0,71	7,5	10,7	32,1	14,32
Profile 3 – Deep Leached Chernozem or Haplic Chernozem, formed under forest							
Ah <sub>1</sub>	0-30	10YR3/3	2,43	5,8	21,2	42,2	0,42
Ah <sub>2</sub>	30-45	10Yr4/3	2,19	6,0	22,7	43,6	0,42
Ah <sub>3</sub>	45-60	10YR4/4	1,66	6,2	22,7	46,2	0,21
AB	60-78	10YR4/4	1,14	6,5	22,6	46,0	0,28
B <sub>1</sub>	78-92	10YR5/3	1,14	7,4	20,2	43,5	4,42
B <sub>2</sub> k	92-115	10YR5/3	1,10	7,0	21,5	45,3	4,58
Profile 4 – Meadow Swamp Calcareous or Calcic Greysol, the lacustrine beach							
A Ik	0-15	10YR5/2	2,64	7,5	15,9	43,8	6,1
A IIk	15-30	10YR5/3	2,33	7,4	11,5	23,0	14,9
AC IIIk	30-45	10YR6/3	1,14	7,5	9,2	18,9	11,5
AC IVk	45-60	10YR6/2	1,98	7,5	12,2	29,4	11,5

slopes with degree more than 2.5% and later on the slopes with degree more than 5-8%.

## Conclusion

1. As an initial step in monitoring the reserve area one should note that a significant coincidence can be traced between the terrain and soil peculiarities and that this manifests an approach for their conservation and management. Soil type determined as Leached Chernozem or Haplic Chernozem has been considered as the main soil type for the region.
2. At the arable land and in the forest ecosystem significant difference is revealed concerning the process of humification and carbonates leaching. Both are better pronounced in the forest ecosystem in comparison with arable lands.
3. The pressing task now is the soil conservation with minimum risk for run-off provocation on the nearest slopes towards the lake. The afforestation of the area has to be continued and the severely affected areas have to be fenced off by tree and shrub plantations.
4. In this region the tillage practice demands special management. Potential run-off and soil loss increase under the inter-rill erosion conditions and wheel traffic grooves has greater effect especially on long or steep slopes. For this reason on the slopes facing the lake all activities should be forbidden.
5. The tracks as well as the temporary steams of potential run-off that brings about soil loss by causing soil masses to slide into the lake and form sediments, should be prevented by planting trees and shrubs.

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depending on the re-deposited materials from the surrounding slopes. Soils are used for farming and grazing rotations.

- Mollic soils formed under deciduous forest are formed in more humid conditions, which contributed to the better-pronounced leaching process. By the Bulgarian classification they are Deep Leached Chernozems, or Haplic Chernozems (according FAO) these soils are characterized with thick humus horizon more than 80 cm. Favorable weathering conditions in situ formed thick metamorphic B horizon up to 120 cm of depth. Carbonates are leached under 80 cm and accumulated under 120 cm. Humus content is about 2.5% and gradually decreases along the soil dept. The humus type is fulvic-humic (with Cha/Cfa between 1 and 2). The degree of humification is low (18-20%) in the upper humus horizon and medium in the deeper horizons. The soil reaction is slightly acidic in the surface horizon and neutral in the depth of profile (pH in H<sub>2</sub>O 5.8-7.0), which corresponds with the distribution of carbonates. The lower pH 5.8 in the upper humus horizon can be explained with the presence of acidic products of litter decomposition.
- The local fluvial plane, that separates the Danube from Srebarna Lake, consists of both eolian loess that was reworked by water fluvial material and alluvial sediments. The relief is characterized with alteration of swells and swales, so the soil cover is complex as it depends on the influence of ground water in forming the soil profile. The spatial variation in soil parameters often differs with direction. The soil complex consists of a variety of Meadow-Chernozemic calcareous (or Calcaric Phaeozem after FAO), Alluvial Meadow (or Mollic Fluvisols) and Meadow Swamp Calcareous (or Calcic Gleysols). In the Alluvial Meadow Calcareous soil the humus content changes from layer to layer respectively: 1.53%, 1.35%, 0.66%, and 1.15%. The degree of humification varies from low (under 20%) to medium about and over 30%. The humus type is humic-fulvic (with Cha/Cfa between 1 and 0.5). The texture of different soils varies from loamy, clayey-loamy to silt-clayey. The soils are slightly alkaline. In all soil profiles no presence of salt or alkali was detected. Lacustrine marsh soils are under water.

Within the reserve boundary comparatively large tracts of steep bank slopes have been terraced and afforested in order to prevent severe erosion. At the same time, farmlands are put under intensive routine agricultural practices including tillage, planting, and fertilizer application and furrow irrigation. The human impact on the soils in cultivated lands was confined to the plough layer. Evidence of management practices such as drainage, terracing, embankment and melioration altered soil profile in a more pronounced way. Nevertheless, the problem of sheet and gully erosion is still an important one, respectively on the



- On the lands surrounding the Reserve prevail moderate Leached Chernozems or Haplic Chernozems, according to the FAO Revised Legend. They cover the well-drained plateau and gently sloping areas. Common thickness of humus horizon (A+AB) is about 40-50 cm, in soils slightly eroded it is 20-30 cm. The soils are characterized with not differentiated profile, which is confirmed by the data of the mechanical composition (table 1). According to texture data the soils are classified as silt loam. Structure is fine crumb, friable. Human influence is slight, confined to the plough layer. Humus content is 1,7-2,5%, gradually decreasing in the depth of soil profile. The degree of humification is low (under 20%). The humus type is fulvic-humic with Cha/Cfa (Carbon of Humic acids/Carbon of Fulvic Acids ratio) between 1 and 2. Predominating humic acids are 100% bound with calcium, forming almost insoluble microstructure fragments. Transitional "B" horizon is lighter in color than the upper Mollic horizon. It is slightly compacted, characterized with firm sub-angular blocky structure. Carbonates appear at the lower part of the "B" horizon as a mycelium-like accumulation. In the Ck horizon at the depth 80-90 cm carbonates accumulate as small soft nodules. CaCO<sub>3</sub> content is about 15-25%. The soil is neutral in Mollic humus horizon and slightly alkaline deeper in the profile (pH in H<sub>2</sub>O is 7.0-7.5). The physical properties are the best characteristic of the Chernozems features. Leached Chernozems are the prime agricultural lands and mostly cultivated. Favorable physical properties in these soils like structural composition, bulk density, porosity, water permeability are based on the textural class and relatively high organic matter content (1,7-2,5%). The porosity is about 35% to 47%. Earthworm activity produces dense mull-type welded casts of strongly homogenized humic and mineral components thus forming stable granular aggregates from a size 1-2 mm.
- Meadow Chernozems (according to the Bulgarian classification) or Haplic Chernozems (after FAO) cover the lowlands and blind creeks. These areas are characterized with level of ground waters 2-4 meters below the surface thus determining better moisture conditions. Typically they have a well pronounced humus "A" horizon, of about 60 cm, somewhere as a result of accumulation. Usually the process of erosion is not observed. Humus content is 2.0% to 2.9% but slightly changes deeper in the profile. The degree of humification in these soils is considered as medium, about 30%. Humus type is humic confirmed by the ratio Cha/Cfa more than 2. The humic acids are 100% bound by Calcium along the whole profile. Structure is fine crumb to granular. The texture is clay-silt-loam and is identical in all soil horizons. Carbonates appear below 65 cm in the lower part of the transitional "B" horizon. Deeper than 100 cm they accumulate as soft powder nodules and small concretions. The soil is neutral to slightly alkaline (pH in H<sub>2</sub>O is 6.9 to 7.5). Carbonates can occur on the soil surface

## Material and Methods

In order to contribute to the project idea of monitoring the area soil survey was carried out and soil samples of genetic horizons were collected. The investigated territory covered over 3 km off the lakeshore and included the protected areas, but also the hilly arable lands, meadow lowland, and the forest area. As a result, detailed soil map in a scale 1:5 000 has been especially elaborated. Samples were analyzed using standard characterization methods, humus content according Kononova (1963), and soil particle distribution according Kachinsky (1958).

## Results and Discussion

The relief of the area adjoining the Aidemir lowland is undulating, dissected, characterized with deep ravines. Plane watersheds usually are with slight slope degree. Common practice is slopes to be cultivated thus provoking active soil erosion. At some slopes and banks the underlying limestone parent material (bedrock named in Bulgarian 'kairatsy') is revealed. Human activities in the past were directed towards increasing the arable land instead of woodlands. For those days remind only preserved old names of country sites. The decrease of the woods (forest areas) and the increase of the arable land as well previous management or crop rotation contributed the enhancement of the erosion process. Main parent materials for the varieties of Chernozems at the plane are Quaternary loess like deposits. The Pliocene clays, clay marls and calcareous sandstone also occurred. Alluvial deposits and clay loess prevail as soil forming materials in the lowlands, whereas diluvial deposits appear as parent materials in the blind creeks. At the plateau areas groundwater is below 10 meters, at the lowlands it is usually 2-4 meters below the soil surface. Soils in the region are considered as not salinized.

The region belongs to the temperate-continental climatic zone. According to the Soil Taxonomy the temperature regime is *mesic* and moisture regime is *xeric*. The average annual rainfall is 500 mm; the average annual soil temperature is 12,4°C with the lowest value in January of -0,1°C at the depth 2-5 cm.

Soils from the northern part of Danube Hilly Plane are associated with southern forest-steppe zone of Chernozems distribution. The evolution of these soils strongly depends on the prevailing distribution of steppe grassy vegetation (*Graminaea sp.*) or the influence of deciduous forest (*Quergues sp.*). The grass formation produces a considerable amount of organic matter not only at the surface, but also particularly in the depth of the profile. This often indicates the depth of plant root system and thickness of humus horizon.

The following units of soil varieties characterize the area of Srebarna Biosphere Reserve:



## **Characteristic of the Soils on the Territory of the Reserve Srebarna.**

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### **Abstract**

The Srebarna biosphere reserve is among the well known protected territories not only in Bulgaria. Declared as a biosphere reserve of UNESCO, as a wetland of international importance (Ramsar site) its greatest public recognition is the inclusion in the Convention of the World Cultural and Natural Heritage. In this way, Srebarna has been ranked among the most important cultural and natural monuments of our Planet. During the last fifties in the region the human activities took place: the interrupted connection with the Danube river, because of a dike built in 1948, together with the pumping out of the underground waters, the a forestation and agricultural activities.

For the very first time a map of soil cover of the region was produced in a 1:1 000000 scale in a soil survey carried out in 1947. Since then a soil type determined as Leached Chernozem or Haplic Chernozem (according to the FAO Revised Legend) has been considered as the main soil type for the region.

### **Introduction**

The Srebarna reserve is situated in the Northern-East part of the Danube hilly plane in the region of Aidemir lowland, Northeast Bulgaria. It is located 16 km to the west from Silistra town, nearby the Danube River. The protected area is about 800 ha, which includes 542,8 ha buffer land zone. Forestlands are about 182,8 ha. However, the village Srebarna is situated on the lakeshore and the population historically is in close relation with the lake.

The project about monitoring of the reserve territory was conducted by the Central Laboratory of Ecology – Bulgarian Academy of Science. The reserve territory included soil continuum as an important factor of the lake surrounding the ecosystem. This imposed the creation of soil map in scale 1:5000.

For the very first time a map of soil cover of the region was produced in a scale 1:1 000 000 during the soil survey carried out in 1947 by the Soviet-Bulgarian expedition (Antipov-Karataev et al, 1948). A soil map in scale 1:400 000 provides a more detailed presentation of the soil varieties, with Carbonate Chernozem or Calcic Chernozem (after FAO, Revised Legend, 1990), as well Meadow Chernozem has been included. Large scale maps (1: 25 000 and 1:10 000) are quite representative of the existing soil units for the purpose of agricultural practice and land management (Characteristics of the soils of TKZS Srebarna, 1963, 1978).



As it was noted, one of the main consequences of grazing is formation of secondary spatial heterogeneity of plant and soil covers.

Such secondary spatial heterogeneity is a principle particularity of the pasture digression. It should be taken into account by pursuance of soil-ecological monitoring pasture. Otherwise it leads to wrong conclusion.

The set of such monitoring indices could be approximately following.

1. Floristic composition, stocks and structure of the biomass.
2. Plant covering of the soil.
3. Presence of the plant litter and its depth.
4. The Degree of sod covering.
5. Bulk density of soil.
6. The structure state of soil.
7. The content, stock and composition of humus.
8. The content of plant nutrition elements (N,P,K).
9. The depth of humus horizon.
10. The square of paths.
11. Presence linear erosion forms of relief and their dimensions.

All indices are necessary to define in terms of secondary spatial heterogeneity of plant and soil covers.

Majority of these indices is uncomplicated in determination, many of them can be determined right in field. Their checking needs to do once in 3 - 5 years, in some cases more often. In the absence of existing structures of soil-ecological monitoring their indices is possible to determine during agricultural chemistry examination of the territory. The humus composition needs to check more rare, once in 5 - 10 years, also agreeing the time with periodicity of the agricultural chemistry examination.

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## Soil Cover Degradation on the Pastures

One of the most important consequences of grazing is formation of secondary spatial heterogeneity of plant and soil covers. As a result of uneven animal influence fragments of different degree of degradation appear on pasture.

Usually it is possible to allocate the following elements of heterogeneity:

1. Animal path (sod is totally destroyed).
2. Partially destroyed (sod is partially destroyed).
3. No destroyed (sod is not destroyed).

Described spatial heterogeneity of the plant cover is connected with process of pasture degradation under influence of grazing. The stock and structure of the biomass greatly differ between chosen elements of heterogeneity, decreasing from no destroyed area to path. On the path part of cereals and partly of leguminous is more in contrast with no destroyed fragments.

The secondary spatial heterogeneity of soil cover, in the same way as plant one, is rather great. The fluctuations of some features between different fragments often exceed the differences between various pastures. So all conclusions about changing of soil and plant cover characteristic under grazing is expediently to do taking into account this circumstance. It is necessary to compare not simply different pastures, but different fragments of heterogeneity within each of them. (Table 2).

**Table 2.** Biomass, ( $10^{-1}$ t), bulk density ( $\text{g}/\text{cm}^3$ ) and humus content (%) on pasture soil, (Alayskiy ridge, 2600 m).

Fragment	Biomass	Bulk density	Humus content
Animal path	1.5	1.37	4.00
Partially destroyed	3.23	1.36	4.33
Nondestroyed	37.61	1.02	6.20

### Soil-Ecological Monitoring of Mountain Pasture.

The important problem is a checking and forecasting of mountain pastures state. At present does not exist the elaborated system of their monitoring, including soil-ecological one. It should be stressed that monitoring of mountain pasture ecosystem has a row of specific particularities. One of them is that usually it is very difficult to take into account the true pressure to the pastures.

Besides, the pressure is greatly differentiated on element of the relief (different kinds of slopes, different their steepness etc.). Finally, pasture digression, as it was noted, could run differently in different mountain system and separate their parts. This requires the differentiated approach to performance of soil-ecological monitoring of mountain pasture.

## The Grazing Influence on Chemical Properties of Soil

The most important change in chemical characteristic of soil as a result of grazing is the reduction of humus contents. The humus loss is due to two reasons. The first of them is that grazing greatly changes the character of the biological cycle; the significant share of the overground biomass, eaten animals, is excluded from sphere of humification that breaks the humus balance aside decreasing of its content. A quantity of organic material enters to soil with excrements, but this amount of organic matter can not compensate the appearing deficit of plant remains required for forming humus. Besides, organic material of excrements is extremely unevenly distributed on area of pastures. The second reason of the humus loss is soil erosion, destroying upper part of the soil profile.

The study of kashtanozems humus state on Tyan-Shan mountain pasture has shown, humus loss take place here very distinctly. The content of humus reduces in dark kashtanozem under moderate grazing influence in two, but intensive - in four times. Not so sharply, but wholly distinctly humus loss reveals itself in light kashtanozems. In humus reach black-brown soils relative losses of humus are not so significant (Karabaev et al., 1987). In the soils of the more humid mountain systems humus loss under grazing influence is not so large that is connected with smaller ecological stability of soils in the arid and semiarid mountain systems (Table 1). The humus composition, being more conservative in contrast with the total its contents, is changed under grazing in vastly smaller degree.

**Table 1.** The humus content in humus horizon of pasture soils (% C).

<b>Table 1.</b> The humus content in humus horizon of pasture soils (% C).	Control	Moderate grazing	Intensive grazing
Soil			
Alpine meadow soil	9,49	9,82	9,32
West Caucasus			
Dark kashtanozem	3,45	1,88	0,85
North Tyan-Shan			
Light kashtanozem	1,54	1,25	0,60
North Tyan-Shan			
Black-brown soil	14,90	12,55	9,14
West Tyam-Shan			



## The Grazing Influence on Physical Properties of Soil

The physical characteristics of soil strongly change under the influence of grazing. The essential effect of grazing is its compaction, occurring under animal hoof influence. Sometimes, the compaction is accompanied by displacement of soil mass, which particularly powerfully reveals itself during pasturage on moistened soil, in particular, early spring time. The hoof pressure reaches 1,5 - 2,0 kg/cm<sup>2</sup>, when animals stand, and 4 kg/cm<sup>2</sup> when walking that exceeds the pressure of tractor wheels (Docenko, 1960). During pasture season animals several times (before 10) pass on one and same place (Rabotnov, 1984). The significant value of the hoof pressure is sent on depth 8-12 cm. On compaction of soil sod has a great influence; she prevents deformation of soil and bulk density is changed not so vastly. The compaction of ground depends on intensity and length of grazing, way of its undertaking and characteristic of soil. For year of grazing with pressure 10, 15, 19 and 22 sheep per 1 ha bulk density of loamy soil increased from 0,89 g/cm<sup>3</sup> to 0,94 - 1,05 g/cm<sup>3</sup> (Willat, Pullar, 1984). Perennial unsystematic grazing with high pressure was the cause of compaction of light kashtanozems (Kirghiz Mountain ridge in Tyan-Shan) from 0,9 to 1,3 g/cm<sup>3</sup>. Controlled grazing compact soil in a lower degree. On compaction greatly affect the characteristic of soil, and in the first place - a contents of humus. Reach humus soils are packed down to a lesser extent.

The compaction of soil is connected with reduction of porosity. First of all decreases no capillary porosity, increases the share of the capillary pores. This worsens the air regime of soil and reduces its water permeability. The double reduction of noncapillary porosity leads to the reduction of water permeability also in two times. Increase of the pressure progressive reduces both these indices. Grazing within one year with pressure 10, 15, 19 and 22 sheep per hectare was responsible for the reduction of loamy soils water permeability from 19 mm/min to accordingly 13,5, 10,8, 6,0, 3,6 mm/min (Willat, Pullar, 1984). Soils with high content of humus are more stable to such impact.

Grazing greatly influences upon structure of soil. On early stage pasture digression or under moderate pressure occurs not as much destruction of soil aggregates as their repacking in consequence of which falls open grain porosity. The Study of kashtanozems of the Kirghiz ridge north slope has pointed that moderate grazing allows to save the quality of the structure. The content of aggregates with size 0,25 - 10 mm in humus horizon forms 66 % on moderate grazing area against 60% on the area without grazing. Intensive unsystematic grazing often leads to formation of blocky structure or to full its destruction.

On the first pasture digression stage floristic composition of plant communities is changed and the biomass stock decrease. The productivity reduction or full disappearance of grass cover as a result of grazing leads to soil erosion development. Subsequent development of soil erosion processes can lead to full removing of soil cover; after that subsoil and rocks can be destroyed.

Soil, as the most conservative component of mountain ecosystem is the base of their stability. Plant cover is much less stable. Under intensive grazing influence it can be changed for 4 - 5 years (Shikhotov, 1974). Comparatively quickly proceeds its reconstruction - anyway, in contrast with topsoil. Pasture productivity under their rational use can be restored for 5 years (Mamytov, 1985; Zotov, Sinikovskiy, Shvan-Guriyskiy, 1987). The stability of soils is a necessary condition of such reconstruction; their destruction does impossible a plant community restoration.

For soil cover restoration absolutely other periods are required - a hundreds of the years i.e. in real scale of time destroyed erosion soils is possible to consider lost forever. So soil stability is a necessary condition of ecosystem stability as a whole and, on the contrary, its destruction excludes the possibility of ecosystem reconstruction.

### **The Grazing Influence on Plant Cover**

The plant cover is the most sensitive to grazing component of ecosystem. Perennial unsystematic use of mountain pastures leads to their serious degradation. Grazing changes the main features of plant communities: biomass stock and its structure, floristic composition etc. that decreases pasture productivity and reduce stability of soil cover.

Different intensity grazing on West Caucasus sub alpine meadows was the cause of important changes in state of their plant communities. Parallel with general biomass stock reduction its overground stock strongly decreases. The underground biomass also decreases, but in smaller degree; this is the cause of biomass structure changing. Floristic composition of plant communities is strongly changed. The share of cereals sharply decreases. If subalpine meadow, not touched by grazing, has an absolute prevalence of cereal on the other species, under moderate grazing influence herbs becomes the most representative; under intensive grazing influence share of cereals decreases much more. This greatly reduces stability of soils because sod becomes thinner and less durable.

As pasture use mainly herbal ecosystems - meadows, steppes, semideserts. Much more rarely grazing take place in the woods.



# Soil-Ecological Monitoring of Pasture in Semiarid Mountains

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## Abstract

The distinctive property of mountain ecosystems, notably arid and semiarid ones, is their low stability. On the other hand, just arid and semiarid mountains have the most intensive pressure of grazing among whole diversity of mountain systems. One of the main forms of land use in mountain ecosystems, especially in upper part of mountain regions, is pasturing. The most part of mountain pastures is overgrazed to a variable degree. To prevent degradation processes is possible during the early stages, when degradation is reversible. Before the destruction of plant and soil covers there are several phenomena which seriously change plant and soil status but don't destroy them yet. For sustainable land use it is necessary to control the state of soil and plant cover to prevent their irreversible degradation by special monitoring system. The main objects of monitoring are the consequences of the negative processes in ecosystem, connected with plant and soil covers.

## Introduction

One of the main forms of land use in mountain ecosystems, especially in upper part of mountain regions, is pasturing. The most part of mountain pastures is overgrazed to a variable degree. To prevent degradation processes is possible during the early stages, when degradation is reversible. Before the destruction of plant and soil covers there are several phenomena which seriously change plant and soil status but don't destroy them yet.

The general peculiarity of agriculture, including pasturage, in mountain ecosystems is a prevalence of extensive forms of land use. This is the reason that great quantities of natural resources including land ones are involved into agriculture sphere. Limited natures of land resources in the mountains cause the high level of anthropogenic pressure. Unsystematic mountain pasture use leads to their degradation. On measure of the pressure increasing following three stages are consecutively changed:

1. Destruction of plant cover.
2. Destruction of soil cover.
3. Destruction of the lithosphere.

Depending on intensities of the pasture pressure and length of its influence pasture digression can stop on one or another stage.



However, surface horizon at the protected site had significantly higher amount of available P than that of the overgrazed site soil had.

On the other hand, it was determined that while the rate of canopy coverage at the overgrazed site was lower than 20 %, it was higher than 80 % at the protected range site.

Results were indicated that the protected site had at least four times biomass, higher amounts of clay content, low penetration resistance and bulk density, higher moisture and organic matter content, higher amounts of plant available P, and more water stable aggregates than those of the overgrazed range site. In conclusion, the results of this study support the idea that overgrazing causes low level of vegetation and poor soil properties.

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overgrazed range site may be resulted from soil compaction due to extreme pressure by heavy grazing.

**Table 3.** Some physical and chemical properties of soils sampled.

Depth cm	Mechanical analysis %				D <sub>b</sub> g cm <sup>-3</sup>	P <sub>w</sub> %	AS %	PR kg cm <sup>-2</sup>	PH	O.M. %	CaCO <sub>3</sub> %	P ppm
	Clay	Silt	Sand	Class								
Profile I												
0-20	17	31	52	SL	1.22	2.44	23	0.98	6.3	3.49	0.9	4.32
20-40	21	27	52	SCL	1.13	3.32	26	0.93	6.5	3.18	1.3	3.14
40-55	21	24	55	SCL	1.28	5.18	20	-	6.5	1.78	3.7	3.08
55+	20	35	45	L	1.03	4.66	14	-	7.3	1.46	18.4	1.47
Profile II												
0-33	29	26	45	CL	1.04	4.19	38	0.55	6.8	4.29	1.2	6.65
33-50	28	27	44	CL	1.00	4.38	32	0.60	6.2	4.08	0.9	3.34
50-70	35	25	40	CL	1.04	4.53	34	-	7.1	2.62	4.7	3.19
70+	17	29	54	SL	1.08	4.26	17	-	7.5	1.49	21.4	2.41

$D_b$ : Bulk density,  $P_w$ : Gravimetric water content, AS: Aggregate stability PR: Penetration resistance

Soil water percentages at the time of sampling showed significant differences between two sites. The overgrazed site was drier than the protected site. Soil water percentages were respectively constant throughout the soil profile at the protected site. However, soil moisture content decreased down to 2.44 % in the surface horizon of the profile at the overgrazed site. It could be concluded that soil water losses from the profile were higher in the overgrazed site because of lack of plant cover on soil surface.

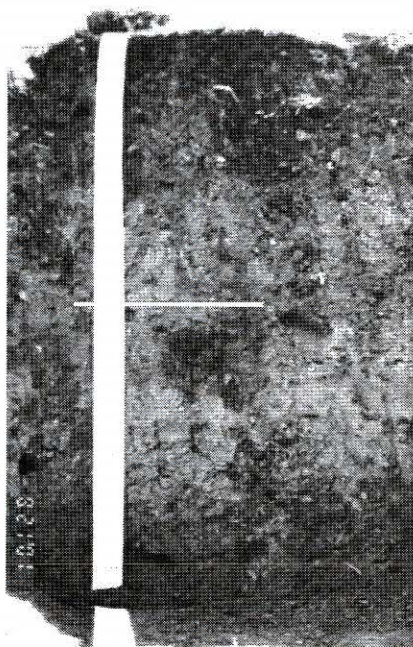
Aggregate stability of soils, which affects soil's resistance against erosive forces, was higher in samples from the protected site. This means that a higher amount of aggregates in soil at the protected site was water-stable as compared to that of soil at the overgrazed site. This may be a result of high amounts of clay and organic matter content in soil at the protected range site. On the other hand, penetration resistance that also effect water movement into soil as related to runoff losses was higher in soils at the overgrazed range site. It was almost twice in overgrazed site than the protected site had.

Organic matter content of soils at the overgrazed site was less than 3.5 % in the upper two horizons, but it was higher than 4 % at the protected site soils. This may be directly related to higher surface cover rate in the protected site.

$CaCO_3$  contents of the range site soils were quite similar in both sites. It increased with depth and reached the highest value at the deepest horizon. Low  $CaCO_3$  values at the upper horizons were resulted from leaching.

Similar to the variation of organic matter content, plant-available-P content was the highest at the surface horizon of both sites. There were no significant differences in plant available P contents of soil between lower horizons.

**Table 2.** Profile description of typical soil found in the protected range site.



Profile #: II

Location: Tuzcu village, 5 km

southwest of Erzurum province

Elevation: 1850 m

Landscape position: Bottom

Slope: 15 %

Parent material: Calcareous

Land use type: range

Stoniness: 1

Erosion: Slightly eroded

Moisture: moist after 10 cm

Root distribution: 70 cm  
(intense, medium and thick roots)

<u>Horizons</u>	<u>Depth, cm</u>	<u>Profile description:</u>
A11	0-33	Dark brown 10 YR 3/3 dry, very dark gray-brown 10 YR 3/2 moist; clay loam; very strong, medium granular structure; hard when dry, firm when moist; plastic and sticky when wet; diffuse boundary; no bubbles with 1/3 HCl.
A12	33-50	Dark brown 10 YR 3/3 dry, very dark gray-brown 10 YR 2/2 moist; clay loam; strong, coarse subangular structure; hard when dry, firm when moist; plastic and sticky when wet; clear boundary; no bubbles with 1/3 HCl. Presence of crotonineas
Bt	50-70	Brown 10 YR 5/3 dry, dark gray-brown 10 YR 4/2 moist; clay loam; very strong, coarse blocky structure; very hard when dry, very firm when moist; very plastic and sticky when wet; wavy boundary; slightly bubbling with 1/3 HCl.
C	70 +	Light brown, 10 YR 6/2 dry, gray-brown 10 YR 5/2 moist; sandy loam; massive; hard when dry, soft when moist; less plastic and less sticky when wet; very strong bubbling with 1/3 HCl.

Soil bulk density values of the samples representing the profile I were higher than those of the profile II. This may be related to soil texture. The profile I had around 50 % sand that may cause high bulk density values. Although bulk density values were almost constant and changed around  $1.04 \text{ g cm}^{-3}$  through the soil profile dug in the protected site, there was no such situation in the soil profile of overgrazed range site. High bulk density of the top horizon in the



protected range site by keeping plant cover on soil surface, which reduces raindrop impact and run-off.

**Table 1.** Profile description of typical soil found in the overgrazed range site.



Profile #: I

Location: Tuzcu village, 5 km southwest of Erzurum province

Elevation: 1850 m

Landscape position: lower backslope

Slope: 15 %

Parent material: Calcareous

Land use type: Range

Stoniness: 1

Erosion: Moderately eroded

Moisture: Moist after 10 cm

Root distribution: 50 cm

(very few fine roots)

<u>Horizons</u>	<u>Depth, cm</u>	<u>Profile description:</u>
A11	0-20	Dark yellow brown 10 YR 4/4 dry, dark brown 10 YR 3/3 moist; sandy loam; weak, medium subangular block mixed with weak, coarse granular structure; hard when dry, soft when moist; less plastic and less sticky when wet; wavy boundary; no bubbles with 1/3 HCl.
A12	20-40	Dark brown 10 YR 3/3 dry, very dark gray-brown 10 YR 3/2 moist; sandy clay loam; strong, medium blocky structure; hard when dry, soft when moist; plastic and sticky when wet; clear boundary; slightly bubbling with 1/3 HCl.
B	40-55	Pale-brown 10 YR 6/3 dry, gray-brown 10 YR 5/3 moist; sandy clay loam; weak, medium subangular blocky structure; very hard when dry, firm when moist; plastic and sticky when wet; clear boundary; slightly bubbling with 1/3 HCl.
C	55 +	Very pale-brown 10 YR 7/4 dry, light gray 10 YR 7/2 moist; loam; massive, very hard when dry, firm when moist; plastic and sticky when wet; very strong bubbling with 1/3 HCl.

The objective of this study was to evaluate soil properties of an overgrazed range site with those of a protected range site.

### **Material and Methods**

An overgrazed rangeland and a rangeland protected from grazing for ten years were selected to determine changes in some soil properties and biomass. The study sites are located in Tuzcu village, which is about 5 km southwest of Erzurum. Soils of both sites formed from calcareous parent material on similar topography. Sheep fescue was the dominant species in both sites. The study sites have never been cultivated. Average slope gradient in the study sites was about 15 %.

Both sites had similar grazing history until 1990. In the region farmers tend to graze range lands as long as climatic conditions are favorable for grazing. Grazing starts with the melt of snow in spring and continues until the snowfall in autumn (approximately 9 months). The study area has a semi-arid moisture regime with a mean annual precipitation of 446.2 mm and a mean annual temperature of 5.9 °C. The mean annual evaporation and relative humidity are 1059 mm and 63 % respectively (Anon., 1997).

After searching for typical profiles to represent overgrazed and protected sites, two soil profiles were dug. The profile I was located in overgrazed range site, and the profile II in protected site. There was only 500 m distance between two range sites. The range sites on which profile II was dug, was surrounded by wire about ten years ago, and it has never been grazed since 1990.

Morphological description of the soil profiles was performed according to the Soil Survey Division Staff (1993) and presented in Tablo1 & 2. Observation on topography of the site, the extent of erosion, and the degree of drainage and soil moisture status were reported. Disturbed and undisturbed soil samples were collected from different horizons, and analyzed for some physical and chemical soil properties including particle size distribution, bulk density, moisture content, aggregate stability, soil pH, organic matter content, plant- available P, and CaCO<sub>3</sub> content. Penetration resistance of soils was determined using field-type penetrometer.

### **Results and Discussion**

Measured physical and chemical properties of soils are given in Table 3. Clay content of different horizons in Profile I was almost constant, except the surface horizon which had about 20 % less clay content than those of the lower horizons. This may due to erosion losses. Although the profile II had greater amounts of clay content (around 30 %, except the deepest horizon) than the profile I, there was no changes in clay contents between the top horizon and the lower horizons. This clearly indicated that erosion losses were minimized in

## Overgrazing Effect on Rangeland Soil Properties

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### Abstract

Overgrazing is one of the main factors causing range degradation by leading erosion, reducing biodiversity, and altering soil properties. The objective of this study was to evaluate soil properties of an overgrazed range site with those of a protected range site. Two study sites had similar grazing history until 1990. But the protected site has never been grazed since after then. Soils of both sites formed from calcareous parent material on similar topography. In both sites, morphological description of the soil profiles was defined, and some physical and chemical properties including particle size distribution, bulk density, moisture content, aggregate stability, penetration resistance, soil pH, organic matter content, plant- available P, and CaCO<sub>3</sub> content were determined. Canopy coverage rate of soil surface was also measured. Results were indicated that the protected site; had at least four times biomass, higher amounts of clay content, low penetration resistance and bulk density, higher moisture and organic matter content, and more water stable aggregates than those of uncontrolled range site.

### Introduction

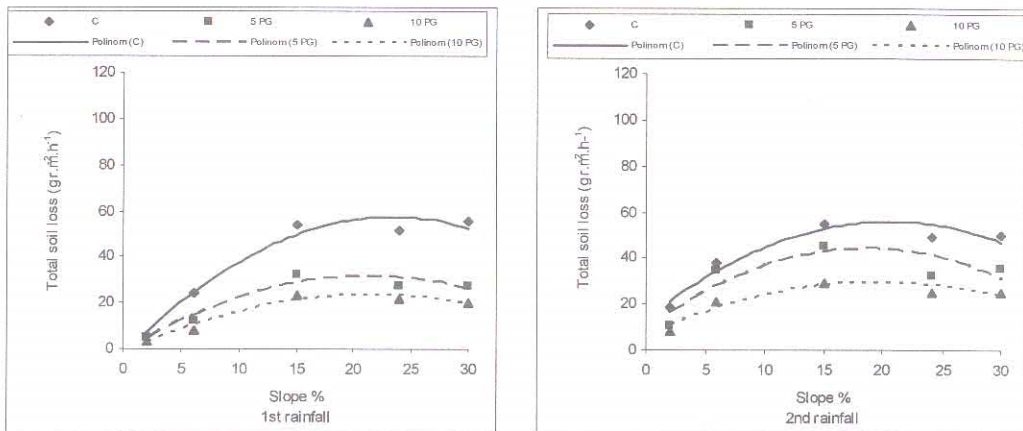
Rangelands have special importance in resource management. About 80 % of land under erosion risk in the world consists of rangelands (Thurow, 1991). Grazing is the most economical way of evaluating rangeland vegetation. But, overgrazing or uncontrolled grazing always reduces plant cover that protects the soil and finally causes soil erosion and compaction (Oztas *et al.* 2000). Overgrazing and its attendant effect of depletion of plant cover and litter and trampling of the soil is the most important factor contributing to erosion (Branson *et al.* 1981), which threats about 85 % of our lands in Turkey. The grazing lands of Turkey are subject to quite heavy, uncontrolled grazing pressure and the forage production capacities of these lands are gradually decreasing, therefore, ultimately reflecting typical examples of land degradation all over Turkey (Tukel&Hatipoglu, 1996). Overgrazing which led to deterioration of plant cover on rangelands was initiated in 1950s and has been continued up until today (Koc *et al.* 2000). As a result of increasing grazing pressure, Turkey's rangelands has lost about 90 % of their climax vegetation (Genckan *et al.* 1990). Koc (1995) emphasized that rangelands in our country were in poor and moderate categories with a canopy cover rate of 20 % on the average, and the degradation was too severe in lower altitudes.



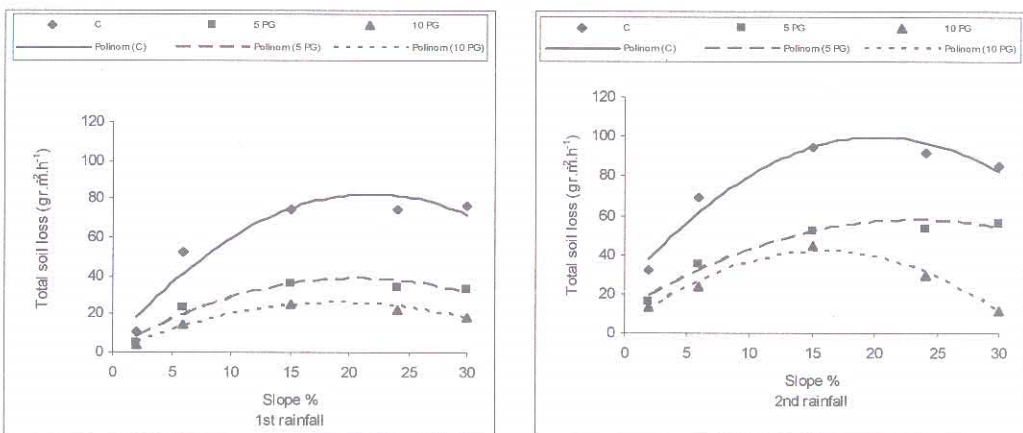
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will be convenient to apply PG on the soils have silty texture and moderate slope where runoff and erosion are more effective due to seal formation.



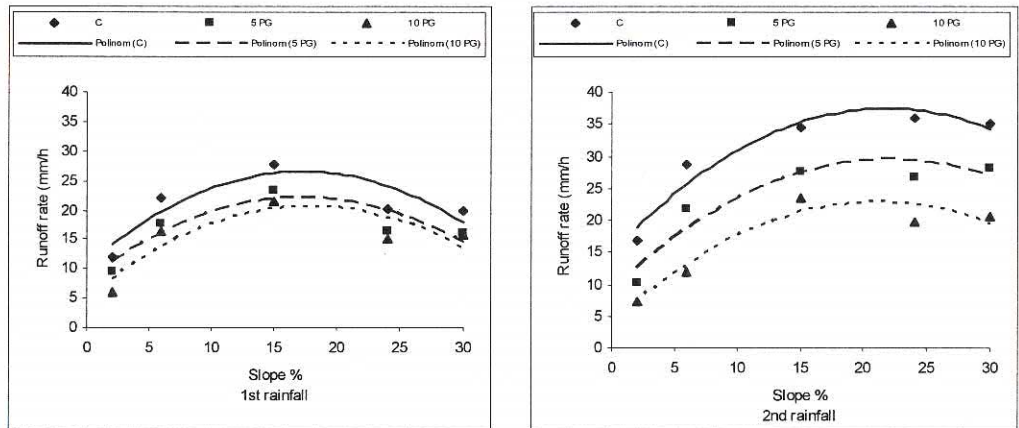
**Figure 5.** Total soil losses for the Kurupelit series.



**Figure 6.** Total soil losses for the Çiftlik series.

**Table 4.** Duncan test for total soil losses.

Slope	Mean	S.D.	PG	Mean	S.D.	Soil	Mean	S.D.	Rain	Mean	S.D.
2	1046 <sup>d</sup>	510	C	4843 <sup>c</sup>	395	K.pelit	2441 <sup>b</sup>	322	1	2816 <sup>b</sup>	131
6	2650 <sup>c</sup>	510	5	3026 <sup>b</sup>	395	Çiftlik	4027 <sup>a</sup>	322	2	3652 <sup>a</sup>	348
15	4515 <sup>a</sup>	510	10	1834 <sup>a</sup>	395						
24	4257 <sup>a</sup>	510									
30	3702 <sup>b</sup>	510									
	<b>0.01</b>			<b>0.01</b>			<b>0.01</b>			<b>0.01</b>	



**Figure 4.** Runoff rates for the Çiftlik series.

**Table 3.** Duncan test for runoff rates.

Slope	Mean	S.D.	PG	Mean	S.D.	Soil	Mean	S.D.	Rain	Mean	S.D.
2	4.760c	1.527	C	17.486a	1.183	K.pelit	12.274b	0.966	1	13.699b	0.603
6	15.64b	1.527	5	15.196b	1.183	Çiftlik	17.737a	0.966	2	16.312a	0.283
15	20.34a	1.527	10	12.334b	1.183						
24	16.329ab	1.527									
30	17.958ab	1.527									
	0.01			0.01			0.01			0.01	

Total soil losses increased up to slope 15% and then decreased at slopes 24 and 30%. Decreasing in the total soil losses for the second rainfall at that slopes were less and slower than the first rainfall. These two situations were the same for PG treatments in each soil series (Fig. 5 and 6). Total soil losses decrease 2.0 (2%, 1<sup>st</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 2.9 (6%, 1<sup>st</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Kurupelit series and 2.3 (30%, 1<sup>st</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 4.1 (30%, 1<sup>st</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Çiftlik series in respect of control treatments. According to analysis of variance and Duncan test for total soil losses (Table 4), slopes, phosphogypsum treatments, rainfall and soil were significant as statistically at level  $P \leq 0.01$ .

## Conclusion

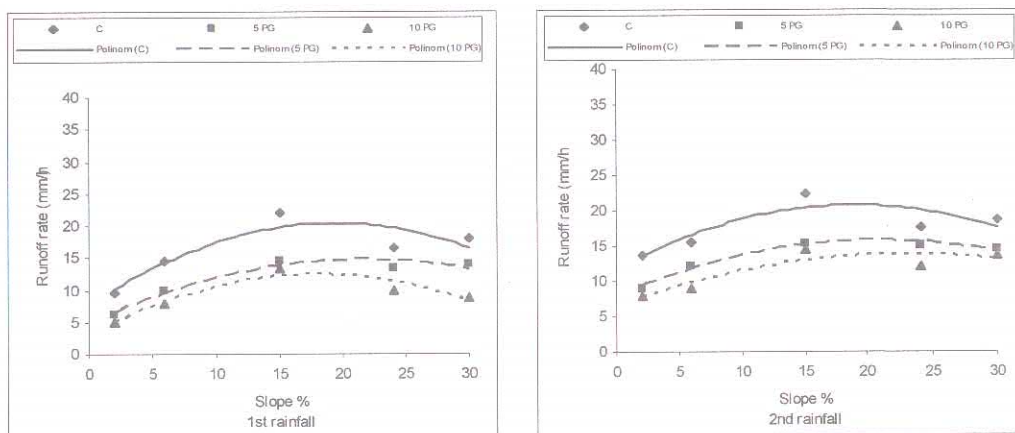
In order to prevent and decrease splash erosion, runoff and washed sediment caused by the consecutive simulated rainfall, PG applied on the soil samples, and expected results were obtained. The positive effects of PG spread over the soil samples at a rate of 10 t.ha<sup>-1</sup> were that splash erosion, runoff and washed sediment approximately decreased triple, twofold and fourfold, respectively. It



PG on sediment particle sizes in the runoff water, found the control soils 15 to 30% clay and 60 to 75% silt, whereas PG-amended soils showed no clay in the runoff water. PG treatments always enhance sediment deposition. In this study runoff rates increased continuously up to 15% and then decreased at 24 and 30% slopes. Normally thinking is that; runoff rates increase depending upon the slope but in practice, runoff rates decrease after 15% slope because of seal formation is disintegrated by the raindrops. Decreasing in the runoff rates for the second rainfall at that slopes were less and slower than the first rainfall. These two situations were the same for PG treatments in each soil series (Fig. 3 and 4).

**Table 2.** Duncan test for splash erosion values.

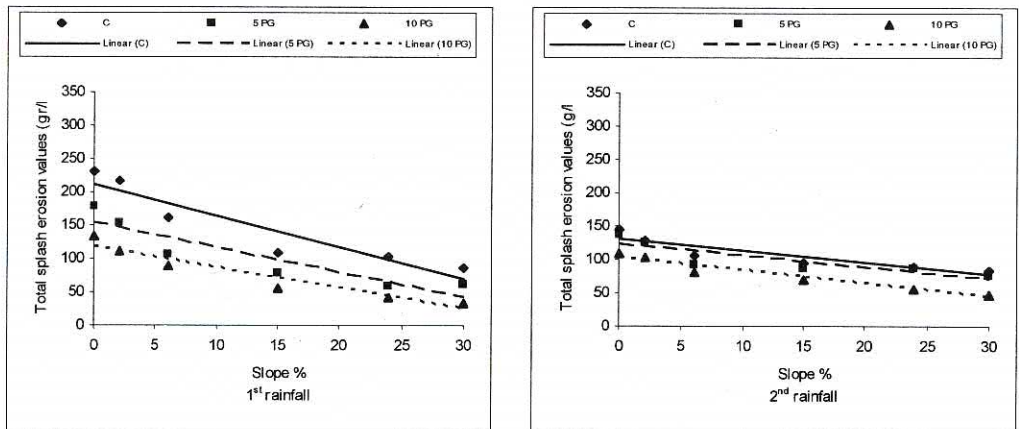
Soil	Mean	S.Dev.	PG °	Mean	S.Dev.
Kurupelit	11.254 <sup>b</sup>	0.771	C	15.072 <sup>a</sup>	0.945
Çiftlik	15.125 <sup>a</sup>	0.771	5	13.762 <sup>a</sup>	0.945
			10	10.735 <sup>b</sup>	0.945
<b>0.01</b>			<b>0.01</b>		



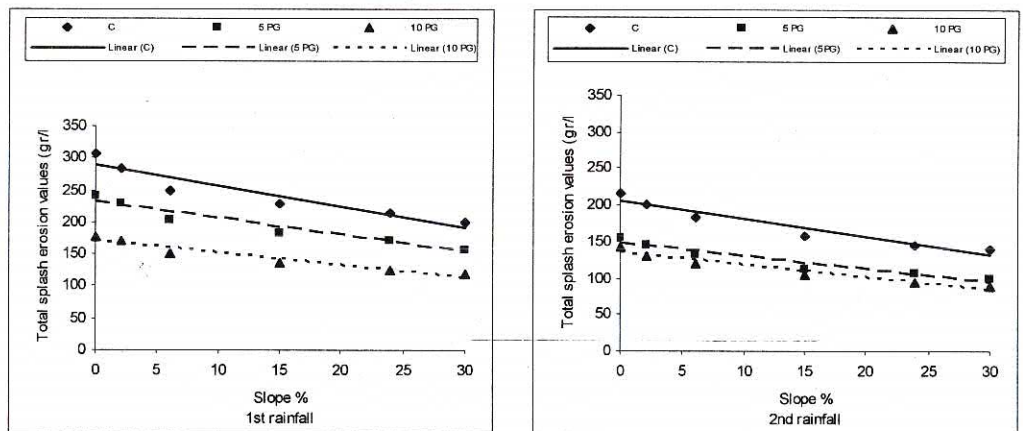
**Figure 3.** Runoff rates for the Kurupelit series.

Runoff rates decrease 1.6 (2%, 1<sup>st</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 2.1 (30%, 1<sup>st</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Kurupelit series and 1.6 (2%, 2<sup>nd</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 2.4 (6%, 2<sup>nd</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Çiftlik series in respect of control treatments. According to analysis of variance and Duncan test for runoff rates (Table 3), slopes, phosphogypsum treatments, rainfall and soils were significant as statistically at level  $P \leq 0.01$ .

percolating water (13). Increasing the electrolyte concentration prevents aggregate dispersion (10) and bigger particles are less erodible. Thus it is concluded that erosion by overland flow is reduced effectively by PG treatment. Since overland flow becomes the dominant mechanism as the slope angle increases, it is to be expected that the effectiveness of PG increases as the slope angle increases (13).



**Figure 1.** Total splash erosion values for the Kurupelit series.



**Figure 2.** Total splash erosion values for the Çiftlik series.

### Runoff and Erosion Measurements

Sediment deposition depends on the size of the particles. In the PG treatment, the concentrations of electrolytes, which are in the runoff water is high and the clay particles flocculate and are deposited. Miller (18), analyzing the effect of

cover was placed on the pan's apron in order to prevent raindrops adding to runoff (16). The volume of runoff and the mass of the soil it carried were measured at 5-min intervals. In order to determine the differences between splash erosion washed sediment and runoff values belonging to control and PG treatments for each rainfall were significant or not analysis of variance and Duncan tests were applied.

## **Result and Discussion**

### **Splash Erosion Measurements**

There are two effects of rainfall depending on the momentum conducted to soil by raindrops: (a) the compaction caused by the consolidation power; and (b) some soil particle is splashed up. When splashed soil particles drop to soil again, they conduct their momentum to another particles, and the splash event goes on during the rainfall (17).

The splash erosion values first increase and then decrease for two soils samples during the rainfall. As slope angle increases, the splash erosion values decrease. The other significant event at the second rainfall, the splash erosion values are lower than the first rainfall for each soil sample (Fig. 1 and 2). It was thought that the crust structure has formed during the seven days of drying period, but it was disintegrated quickly by raindrops of second rainfall. After the seal formation, thickness of a puddle or runoff occurred at the soil surface, raindrops can not disintegrate the seal formation so it reaches critical level which is a point that raindrops do not become a reason for splash erosion, as a result of puddle's or runoff's state. In addition to these, the soil particles dispersed easily and splashed up from the soil surface during the first rainfall, thus there was not enough susceptible material to be splashed up for the second one.

The total splash erosion values decrease 1.7 (24%, 1<sup>st</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 2.7 (30%, 1<sup>st</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Kurupelit series and 1.4 (0%, 2<sup>nd</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 1.8 (0%, 1<sup>st</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Çiftlik series in respect of control treatments. According to analysis of variance and Duncan test for splash erosion values (Table 2), PG treatments at 10 t.ha<sup>-1</sup> and soils for each series were significant as statistically at level  $P \leq 0.01$ . There was no interaction between each rainfall, slopes and splash erosion.

The capacity of water to cause sheet erosion depends upon its velocity and turbulence which, in turn, depend upon the slope angle, the depth of the runoff water, the tortuosity of its path, and the roughness of the soil surface. As the size of the soil particles increases, it is more difficult for overland flow to lift the particles from the soil surface. Treatment with PG affects each of these factors; PG reduces the volume of runoff and maintains the roughness of the surface, thereby decreasing the velocity of overland flow. PG treatment also increases the electrolyte concentration in both the runoff water and the



the soil surface increases the electrolyte concentration in the rainwater, prevents soil dispersion and crust formation, increases rain penetration, and maintains larger aggregates at the soil surface (12). It has been shown that PG reduces surface sealing by raising the electrolyte concentration in the solution at the soil surface, thus reducing the dispersion of the soil aggregates and the soil clays and preventing the formation of the "washed in" layer (14). Thus, the crusts form more slowly on the surface of soil treated with PG and are more permeable than the crusts of untreated soil, reducing the rate of runoff.

## Material and Methods

A clayey soil material (Typic Udorhent) from Samsun mm and a silty loamy soil material (Typic Calciorthid) from Ankara were used in this study. Each soil exposed to erosion. Soil samples were taken from the Ap horizon of each soil series (0-20 cm). Disturbed soil samples were collected, air dried, crushed to pass a 2-mm sieve for laboratory analysis and a 7-mm sieve for experiments (Table 1).

**Table 1.** Physical and chemical properties of the soils used.

Soil series and site	Int. Class.	Mechanical composition (%)			O.M (%)	Aggregat e stability (%)	pH (1/5)	Ex. Na <sup>+</sup> (%)	Hyd. Cond (cm/	CaCO <sub>3</sub> (%)
		S	Si	C						
<i>Kurupelit</i> Samsun	Typic Udorhent	23.2	28.4	48.4	4.09	90.40	6.58	1.97	6.25	0.10
<i>Çiftlik</i> Ankara	Typic Calciorthid	22.0	55.1	22.9	1.60	45.85	7.85	0.52	9.90	19.97

Soil materials, at 5-cm thickness, were packed into metal pans, 29 by 29.5 cm, over a filter paper. The filter paper allowed free drainage of water to an outlet pipe set in the base of the pan. The pans were placed in the rainfall simulator (15) located in the greenhouse. Five slope angles were examined (2, 6, 15, 24 and 30%) for both untreated and PG-treated soil samples. After spread over of PG at a rate of 5 and 10 ton.ha<sup>-1</sup>, at the ground of the soil surface 2 and 4-mm thickness of PG were formed respectively. The PG, a by-product of phosphate fertiliser industry, has a dry composition of: CaSO<sub>4</sub>, 97%; MgSO<sub>4</sub>, 1%; P<sub>2</sub>O<sub>5</sub>, 0.6%; fluorapatite and SiO<sub>2</sub> 1.4% (13).

The samples air-dried were subjected to two simulated rainfalls with an intensity of 45 mm.h<sup>-1</sup> for 60 minutes having 7 days intervals. Distilled water was used to simulate rainwater. Typical mechanical parameters of the applied rain were: median raindrop diameter, 5.09±0.03 mm; median drop velocity, 5.5 m.s<sup>-1</sup>; fall height, 2.75 m; and kinetic energy 15.07 J.mm<sup>-1</sup>.m<sup>-2</sup>. The pans were placed in the rainfall simulator splashboards also were placed two sides 6-cm apart from the pan (16). At the very beginning of the rainfall application, splash erosion samples were collected at 15-min intervals. When rill occurred, a glass

## **The Consecutive Simulated Rainfall, Slope and Phosphogypsum's Effects on Runoff and Erosion**

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### **Abstract**

In this study, consecutive rainfall, slope and phosphogypsum's (PG) effects on runoff and erosion have been investigated. Clayey soil of Samsun and silty loam soil of Ankara were used. Using a rainfall simulator, control and PG-treated (at a rate of 5 and 10 ton.ha<sup>-1</sup>) soil samples that have five different slope angles (2, 6, 15, 24 and 30 %) were subjected to two simulated rainfalls with an intensity of 45 mm for 60 minutes leaving seven days dry interval between two applications. It was found that in the PG-treated soil samples runoff and erosion were decreased. These decreases were significant as statistically at level 0,01. The consecutive simulated rainfall, slope and PG were effective on runoff and erosion at the same level. The positive effects of PG were observed significantly at the slopes of 24 and 30 %.

### **Introduction**

The first step in the water erosion process is the impact of the raindrop on the soil surface, and the importance of this has been clearly demonstrated (1). Young and Wiersma (2) found that raindrop impact was consistently the dominant force in initiating erosion and reducing infiltration. Many factors influence the quantity of soil splashed from a soil surface by raindrop impact. The excellent review of rainfall erosion by Smith and Wischmeier (3) examines in some detail the significant findings and many of the early studies of splash erosion. More recently Mazurak and Mosher (4, 5) reported on the marked effect of particle size on the quantity of splash material. According to Rose (6) and Foster (7), three processes affect sediment concentration in the runoff water continuously and simultaneously: (a) rainfall detachment of soil particles, in which raindrops splash soil particles from the soil surface into the water of overland flow; (b) soil particle entertainment by overland flow (or runoff detachment); and (c) sediment deposition, a continually occurring process owing to sediment settling out under gravity. This process depends on sediment size and fall velocity.

Breakdown of the soil structure and formation of a seal at the soil surface are enhanced by the impact energy of the raindrops and the low concentration of electrolytes in rainwater (8, 9). The beneficial effect of surface application of PG in maintaining high rate of infiltration, reducing runoff, and preventing soil loss has been demonstrated in the laboratory (10, 11, 12, 13). PG spread over

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winds, there is a great possibility that the material is originated from North Africa. However, the fungi number of the dust sample from Antalya is in contrast with the occasion that Saydam and Şenyuva pointed out in an article in 2000.

The data of the analyses are in harmony with the studies of Yaalon (1987), Muhs et.al. (1990), Altunbaş and Sarı (1998), Karaman and Kapur (1991), Kubilay et.al. (1997), Yaalon and Ganor (1973) and Bennett (1980).

## Conclusion

Although Antalya dust material showed some differences form Ankara and Adana dust materials, the colors, particle sizes, chemical analyses results, advanced mineralogical decomposition and meteorological data supports the thesis that they are carried out from North Africa by winds.

## Acknowledgements

We would like to thank to Mr. Mehmet Yayvan, the Analyses and Forecast Chief Section of Turkish State Meteorological Service for his help on the evaluation of the meteorological data during the execution of this study.

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**Table 5.** The  $\text{CaCO}_3$  %, organic matter % and total fungi and yeast amount of the material

$\text{CaCO}_3$ (%)	Organic Matter (%)	Total fungi amount	Total yeast amount
21.94	1.85	$40 \times 10^2/\text{g}$	$180 \times 10^3/\text{g}$

The  $\text{CaCO}_3$  %, organic matter % and total fungi and yeast amount of the material is 21.94, 1.85,  $40 \times 10^2 / \text{g}$ ,  $180 \times 10^3 \text{ g}$ , respectively (T 5). Color of the material (dried) is very pale brownish (10 YR 7/4) (T 4).

Being a Mediterranean country, mud rain incidents are one of the atmospheric incidents which are seen from time to time in Turkey especially in the southern and western regions. These incidents especially occur when a cyclone center happens in or comes to North Africa which has a coast to Mediterranean Sea and this follows its route to middle and eastern Mediterranean to our country. Cyclone center gains humidity during the time it passes Mediterranean. They sometimes create orographic, frontal or air mass rainfalls in our southern and western coasts. When the winds are strong on North Africa this causes the dust particles to be carried to the atmosphere and following the system the falling rain leaves yellow stains on things on the ground. According to the moving path and the speed of the North African originated system, it is possible to think that such incidents can occur in our southern regions in about 24-48 hours.

On April 12, 2000 the strong winds and dust particles seen on Egypt and Libya reached our southwestern coasts on April 13, 2000 with a cyclone center with the center value of 1400Mb. Together with the rain that the system caused a mud rain has occurred around Antalya region (T.S.M.S. 2000)

### Comparing the Materials of Antalya with Ankara and Adana

The total analyses results of Antalya show that although  $\text{Fe}_2\text{O}_3$  rate is higher than Adana (3.70%) lower than Ankara samples (8.09%),  $\text{Al}_2\text{O}_3$  rate of Antalya is both higher than Adana (9.80%) and Ankara samples (7.41%) (T 1). Antalya's material's clay and silt sized particles are more than both Ankara's material (80.20%) and Adana's material (94.90%) (T 2). The fine sand fraction of all three materials had all different minerals and weathered minerals were 69.45% in Antalya sample, 46.20% in Ankara sample and 27% in Adana sample (T 3).

In the previously made two studies while the dominant clay mineral was kaolinite, in Antalya smectite was the dominant clay mineral and kaolinite, illite and chlorite followed respectively.

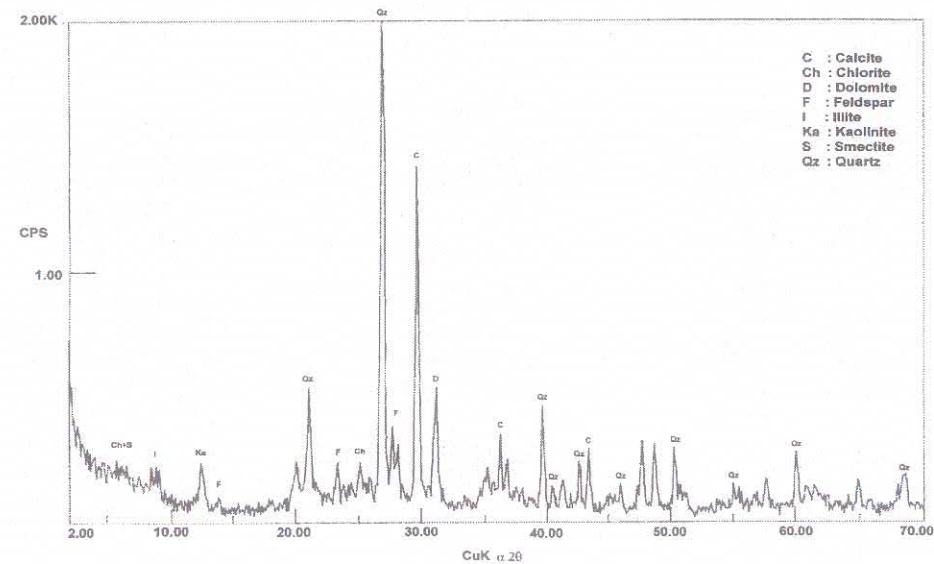
The lime content of Ankara and Adana (28.02% and 22.02% respectively) are higher than Antalya samples (T 5). The organic matter and the total fungi and yeast amounts were not determined in the previous studies. Because the material is poor in organic matter, the total fungi and yeast number is low and the particle sizes composed of clay-silt and are large enough to be carried out by

Crystal particles: Very little clinopyroxene, clinoamphibole and almost none zircon minerals are present.

Becoming silicification, argillaceous and chloritization are the incidents of weathering of minerals that can be seen.

Opaque and/or opaqued minerals: It is 3.70% in the material.

In all the mineral analyses made by XRD technique the dominant mineral was quartz and calcite, dolomite and feldspar followed respectively. XRD results support the results obtained for the polarizing microscope. Together with these, in the material there was smectite, kaolinite, illite, chlorite, chlorite+smectite mixed layered clay minerals were found (F 1).



**Figure 1.** Mineralogic composition of the material.

The dominant clay mineral found among the clay minerals is smectite and kaolinite, illite, and chlorite followed respectively (T 4).

**Table 4.** The relative distribution of clay minerals in the clay fraction that belongs to the material and the color of the dry material according to the Munsell Soil Color Charts.

Smectite	Kaolinite	Illite	Chlorite	Color (dried)
+++	++	+	+	Very pale brownish (10 YR 7/4)

(+: low, ++: moderate, +++: dominate)

Some of the chemical and biological features of the material are given in T 5.



The total analyses results show that  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  rates are high in the material. High  $\text{Al}_2\text{O}_3$  rate (10.80%) shows that there could be clay minerals in the material. However, high  $\text{Fe}_2\text{O}_3$  rate (6.30%) is reflected in the color of the material. The Ca, Mg and K rates of the material are higher than regular soils (T 1).

**Table 1.** The total analysis results of dried material at 105°C (%)

$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3$	$\text{CaO}$	$\text{MgO}$	$\text{Na}_2\text{O}$
39.50	10.60	6.30	17.60	4.50	0.40
$\text{K}_2\text{O}$	$\text{MnO}$	$\text{P}_2\text{O}_5$	Loss on ignition	Total	
1.80	0.10	0.20	18.02	99.02	

97.24% of the particle size of the material is composed of clay-silt sized particles (T 2).

**Table 2.** Mechanical analysis results made by wet-sieving.

Particle size (mm)	%
> 0.250	0.06
0.250-0.180	0.14
0.180-0.105	0.74
0.105-0.053	1.82
Total	2.76
<0.053	97.24 (clay+silt)

From the fine sand fraction of the material a thin section is made and percentage mineral composition is counted by eye on a polarizing microscope given in T 3.

**Table 3.** The mineral count results made by polarizing microscope to fine sand sized fraction (0.053-0.105 mm)

Minerals	(%)
Phlogopite	60,19
Carbonate minerals	11,11
Quartz	9,26
Weathered rock particles	8,33
Volcanic glass particles	3,70
Opaque and / or opaqued minerals	3,70
Feldspar	2,78
Biotite	0,93

The components that make up the sample are:

Mica group minerals: Mainly phlogopite, and very little amount of biotite. Phlogopite is plate like and is seen plenty in the shape of wheat ears.

Carbonate group minerals: Mainly calcite and very little dolomite is possibly seen and because the sample is made up of clay sized particles it is not completed with optical methods and mineral percentages are given as carbonate minerals.

spreads over Anatolia in different dates (Saydam and Şenyuva, 2000; Şenyuva, 2001).

In the studies which were made in order to determine the origin of the Red Mediterranean Soil which is very common in the Mediterranean Region in Turkey, (Karaman and Kapur, 1991; Altunbaş and Sarı, 1998) it was determined that other than the effect level of the parent material, the North African originated dust which is carried out by winds is also effective.

This study is carried out in order to find out the physical, mineralogical, chemical and biological features and the origin of the soil which was collected after the rainfall in Antalya on April 13, 2000 and to compare this to the material that rained in Ankara on April 16, 1976 (Mermut et.al. 1980) and to the materials that rained in Adana at different dates (Karaman et.al. 1996). Later on, with detailed studies on the dust that fall with rain, it will be possible to say what kind of effects this has on the farming lands and on the environment.

### **Material and Method**

The material that is used in this study is collected from the mud that fell with rainfall on April 13, 2000. The mud has been collected in the best way possible and it has been collected especially from bottom corners of cars' windows and from open metallic surfaces. The collected material was about 50 grams and the below analyses were made on the sample. To provide more samples we consulted the Turkish State Meteorological Service. However, because the rain gages of this institute were mixed with the material from the previous rainfalls we were not able to use them.

The color is determined according to the Munsell Soil Color Charts on the air dried material. Particle size distribution is determined by wet-sieving and centrifuge methods (Gee and Rauder, 1986).  $\text{CaCO}_3$  % analysis is determined by Nelson method (1982), organic matter (%) is made by modified version of Walkley-Black method (Nelson and Sommers, 1982), total fungi and yeast amount is determined by Parkinson method (1982) in dextrose-peptone agar. From the mineralogical analyses fine sand fraction is (0.053- 0.105mm) analyzed with polarizing microscope and composition percentages are set by mineral counting method (Erkan, 1994). The mineralogical compositions of clay sized particles are determined by the help of XRD (x-ray diffraction technique) (Jackson 1979; Whitting and Allardice, 1986). Total analyses are made by using the x-ray fluorescence (XRF) machine (Jones, 1982).

### **Findings and Discussion**

The total analyses results for the collected material made by wet-sieving and particle size distribution analyses by centrifuge methods are given below (T 2).

## **The Properties of the Mineral Dusts Reached with Precipitation in Antalya and Their Comparison with the Mineral Dust in Ankara and Adana on Origin-wise**

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### **Abstract**

The physical, chemical, biological and mineralogical analyses were carried out on the very pale brownish color material that precipitated on 13<sup>th</sup> April 2000 in Antalya. It was determined that this material compared with previous studies has some differences in terms of physical, chemical and mineralogical. The meteorological data and results of the analysis showed that these materials most probably transported from North Africa.

**Key Words:** Mineral dust, transportation, precipitation, deposition

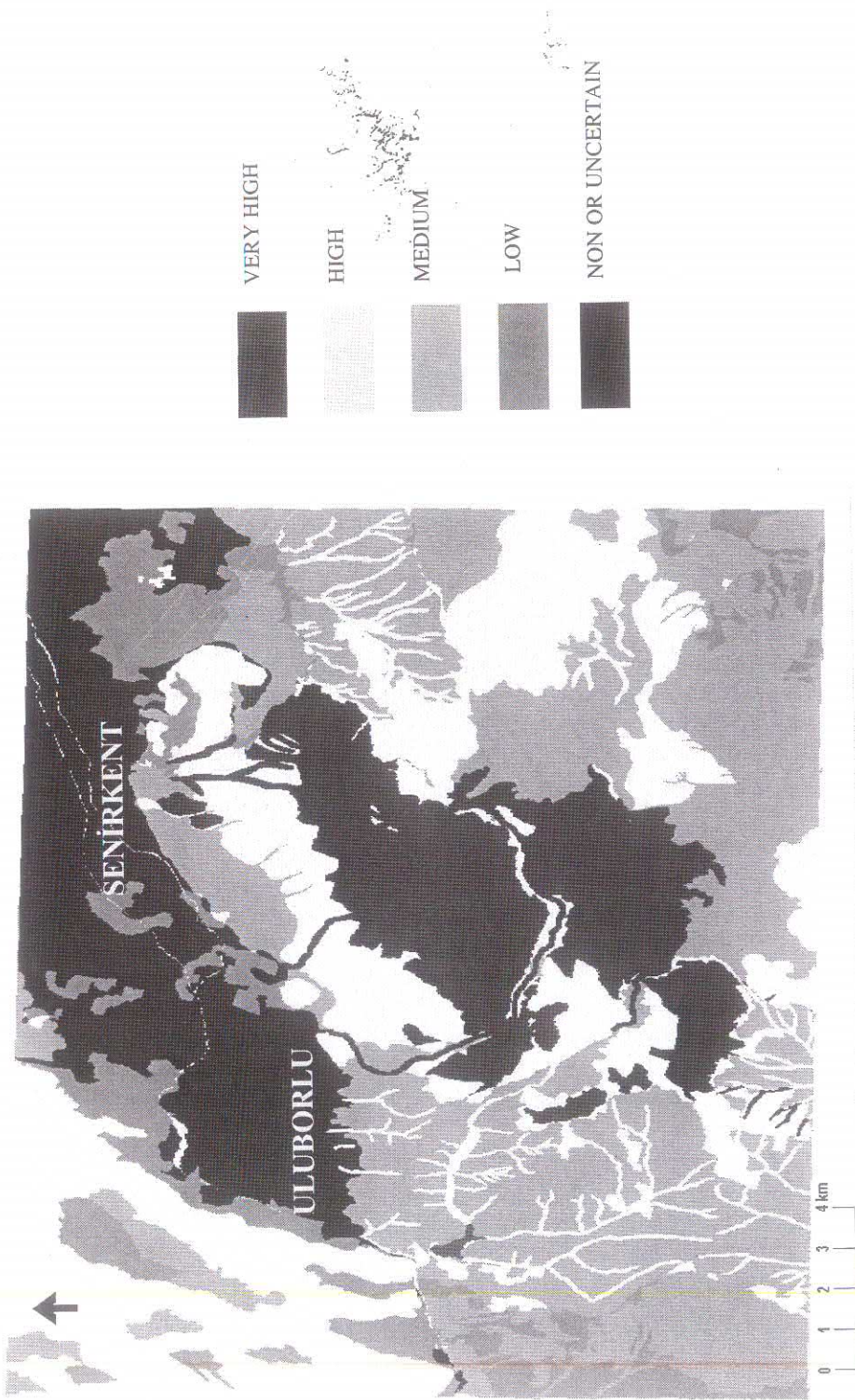
### **Introduction**

Many authors have contributed to the understanding of dust transport from the Sahara to the surrounding lands (Bennett 1980, Goudie 1984, Kubilay et al. 1997, McTainish 1985, Moulin et al. 1997, Muhs et al. 1990, Schuetz and Rahn 1982, Yaalon and Ganor 1973). It is well known that every year millions of tons of fine material leave the Sahara towards all directions. Yaalon (1987) has recognized three different forms of transport. First is, the global long distance transport of mainly medium and fine silt fraction. The medium distance transport of 50-200 km of material less than 100  $\mu$ m in diameter, in general, produces the desert fringes as well as the per glacial loess. Short distance transport is reported in periglacial environments and includes saltation transport of sand size particles.

In our country the first detection about this subject was made by Akalan (1957) because of the dust storm around and in Ankara on April 16, 1957. Later Mermut et al. (1980) made the first mineralogical and chemical analysis on the yellowish colored mud that rained in Ankara on April 16, 1976. In this research the records of Turkish State Meteorological Service have been examined and it has been determined that this material came from Africa and it was rich in loess like kaolinite minerals.

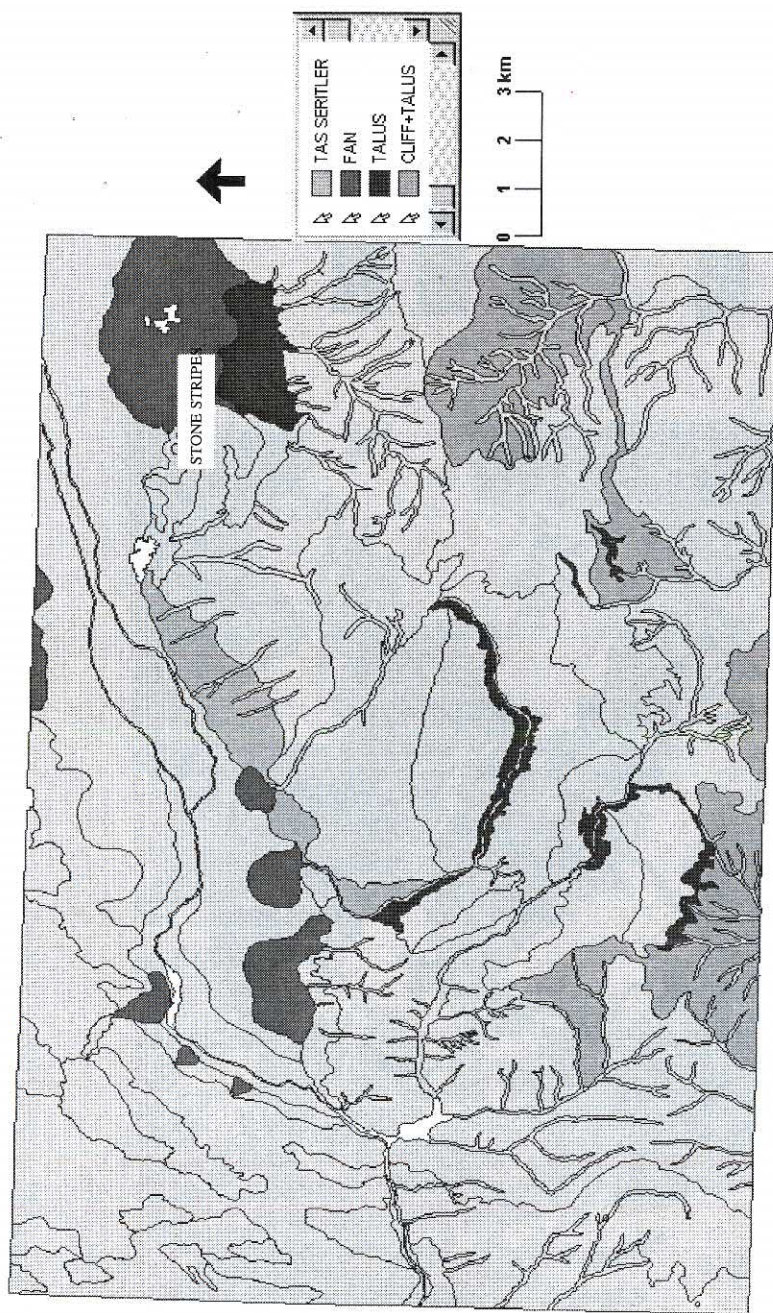
It has been proved that when Sahara originated dusts are put in cultured environment in certain conditions an extraordinary amount of fungi colonies appear and it has been detected by satellite images that the dust from Sahara





**Figure 4.** Mass Movement Hazard Zones





**Figure 3.** Resulting Mass Movement Features







## Conclusion

It can be inferred from the mass movement hazard zoning map that due to its proximity to the two very high susceptible gullies, Senirkent is the most vulnerable settlement in the study area, and any prospective mass movement threat most likely originate from the very high susceptible zones on the upper summits through the gullies and its tributaries.

From the stand point of analytic data, there is significant amount of montmorillonitic clay accumulation in the profile as from the depth of 80 cm in the soils within the close vicinity of Senirkent which is classified as moderate. Soils of this surroundings have also high plastic and liquid limits. In the case of heavy or extreme rainfall, depending on the water load and slope gradient, if soil moisture content reaches PL, slides will likely occur. Similarly, when soil is saturated with water up to its LL value, fluction might take place (Tarhan,1991). With the methodology followed in this study, the importance of geopedological approach in mass movement-related studies and the generation of a model adaptable to other regions were intended to emphasize. The study is not independent of each other in terms of content, however, it may be approached from two perspectives, one is the production of time-consuming geomorphological soil map, the other perspective is the cartographic model generation which could have been produced from data other than that introduced here. In this context, it is possible to express that both a) have distinct manner b) may calibrate each other c) can be considered complementary of each other.

Model introduces mass movement hazard zones by taking factors of potential risks such as slope, geology, land cover and soil properties into consideration regardless of mass movement features and types.

The fact that geomorphological approach enables the mapping of landforms characterized by mass movements provides a good understanding of the mass movement types being formed and the likelihood occurrences. If contributed by analyses, it makes interpretation and estimation towards prospective or past mass movements easier.

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Typic Xerorthent vineyard+fallow)	Dolomite	50 +	Bush and Shrubs (sparse +
Lithic Xerorthent	Conglomerate		Weak and overgrazed pasture
Lithozolik	Limestone-Flysch		Bare rocks

For soil susceptibility rating; rational weighed soil group was selected from taxonomic composition of each landform. In addition, pedologic evolution and the properties of taxonomic subgroups were taken into account for this purpose. As to lithological rating; resistance of the geological material to degradation was ranged in descending order as above. In this order, lime stones of different origin (pelagic, neritic and red limestone) were incorporated into same group, minor lithological units in the formation were included in this major formation. For the susceptibility of slope gradient; slope ranges of previously conducted researches of similar nature were considered. For land use rating; dominating land uses and land covers identified through the image processing of Landsat TM 5 satellite imagery were classified as regards their soil protection capability as well as other regional factors contributing to this capacity.

Attribute data of soil, geology and slope from above mentioned four factors were gathered under one file which enabled the generation of one layer of three factors. In this layer, several queries were executed by considering the susceptibility to mass movements.

For the purpose of determining hazard severity rating and risk factors, stationary factors such as slope steepness, properties of the rock substratum, land cover formations and taxonomic soil groups were used. Aforementioned factors were subjected to a series of queries in Geo-media 3.0. Slope was considered dominant factor and relations between slope-geology and slope-taxonomic soil groups were found out. After a relational query, five groups were generated. These groups were intersected with land cover producing a new layer for a new query. All possible combinations of the four factors were tried and 26 appropriate combinations were obtained. These files were classified in descending order of susceptibility. Finally hazard severity classes were established as follows; very high, high, moderate, low, non or uncertain (Fig. 4) Bare rocks, overgrazed and weak pastures on the Lithic Xerorthents and Lithosolic units with slope gradient of 50 % formed on the underlying lime stones and flyschs are expressed as very high susceptible zones. Due to its increased lithological resistance in proportion to limestone and flysch , dolomitic units having pastures, bushes and shrubs land cover are classified as highly susceptible zones, one category below the very high. Level or almost level (0-8 %) Typic Xerofluvents and Vertic Xerofluvents of alluvial origin under irrigated and non-irrigated agriculture, bushes and shrubs, and some colluvial soils are designated as non or uncertain.



## Processing and Results

1/35 000 scale 26 panchromatic aerial photos of 1991 were interpreted by making use of satellite imagery, geology and topographic information. 13 profiles representing sample areas were dug and sampled on the basis of genetic horizonation. For the purpose of final delineation, entire boundaries designated on the photo-interpretation map were checked, rectified where required, validated and extrapolation was full filled.

In order to generate attribute data, final soil map was digitized (Figure 2.) using Geo-media 3.0 software. Model inputs produced from the map for further processing are slope gradient by landform, taxonomic soil groups and lithomorphology.

Digital Terrain Model (DTM) was derived from 1/25 000 scale topographic data through Microstation-Terrain Analyst Module. Land use characteristics of the area were provided by a study of 4,5,3 bands combination of landsat 5 TM imagery taken in August 1998. Required rectification, image processing, enhancement and supervised classification procedures were executed using image Analyst Module.

**Geopedological approach:** "land form" was used as mapping unit in the geomorphology-based soil map, and taxonomic soil compositions of the each landform were described. In the methodology being applied, study area was differentiated by landscape properties (Mountain, plain, piedmont plateau), then each landscape was classified in itself by relief, lithology and landform being the smallest homogenous units. Observed morphodynamic features were tried to delineate within the landform in which they were described. Resulting morphodynamic features identified are the fans originated from mudflow, slumps bringing about debris-talus forms and stone-stripes formed by the conglomerated stones and rock fragments in the relatively shallow gullies (Figure 3).

The X-ray diffraction analyses revealed that the composition of clay minerals of the selected horizons in some profiles as follows; 35,87 % illite, 35,23 % kaolinite, 18,21 % montmorillonite, 6,92 % vermiculite or chlorite. These minerological values can be lined in order of amplitude as illite > kaolinite > montmorillonite > vermiculite > chlorite and correlate with liquid and plastic limits.

**Modelling:** For the purpose of defining risk factors and hazard severity rating being the basis for mass movement hazard zoning, stationary factors were classified in ascending order of degradation susceptibility as follows:

<b><u>Soil</u></b>	<b><u>Lithology</u></b>	<b><u>Slope</u></b>	<b><u>Land use</u></b>
Typic Xerofluvent	Alluvium	0 - 8	Irrigated + orchard
Typic Haploxeralf	Colluvium + Alluvium	8 -30	Dry Farming
Typic Haploxerept	Colluvium	30 -50	Forest



networks, telecommunication and highway systems. Some types of mass movement displace impressive volumes of soft or slightly consolidated rock materials over large, regional surface areas and long distance. Mass movement manifests itself, for example, as landslides; solifluction or mudflow, a downward movement of water-saturated soil, terracette and creep, a relatively slow downward movement of soil; slump, a downfall of disintegrated rock materials. The spatial distribution of the mass movement prone areas is strongly controlled by the rock-soil-slope-land use complex (Lopez and Zinck, 1991).

## Method

The study area is located in Senirkent township of Isparta province encompassing an area of about 300 km<sup>2</sup>. Direct mapping method and heuristic technique were used in the generation of hazard maps (Barredo et al., 2000). Since direct method requires to great extent a geomorphological approach, geopedological map of the study area was generated. To this end, an implementation program of two phases was adopted. First phase included reconnaissance of the area, interpretation of the aerial photos and satellite imagery with the emphasize on the geomorphology and morphodynamic characteristics of the area and developing field legend.

Second phase involved the generation and the acquisition of thematic maps such as slope, lithomorphology, land use and geopedology, determination of sample areas, soil survey activities including profile descriptions and mechanical, physical and chemical analyses, definition of risk factors, queries and modeling (Figure 1.)

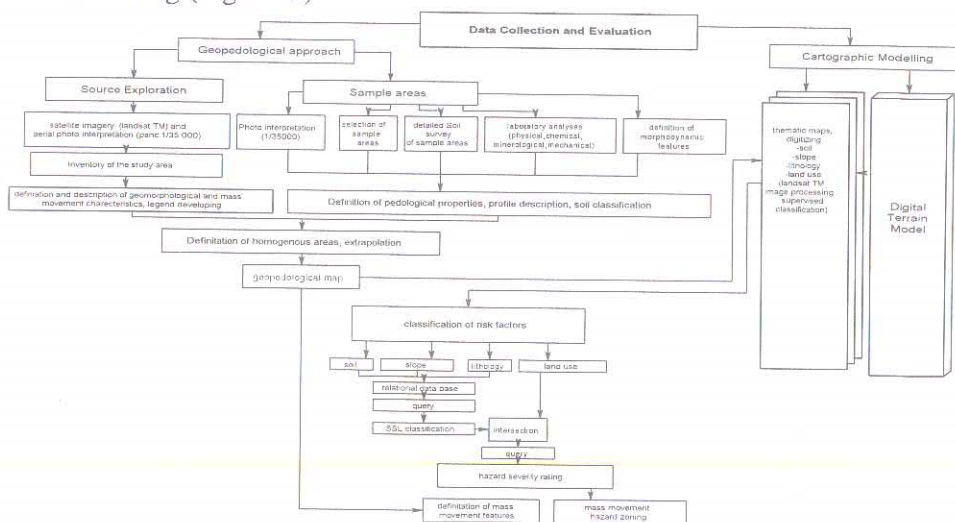


Figure 1. Flowchart Of The Direct - Heuristic Mass Movement Hazard Zoning

**Fig1.** Flow Chart of the Direct-Heuristic Mass Movement Hazard Zoning.

# **Estimation of Degradation Risk on Mass Movement-Prone Areas of Senirkent and GIS&RS-Aided Modelling and Mapping of Susceptible Zones Using Direct-Heuristik Technique**

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## **Abstract**

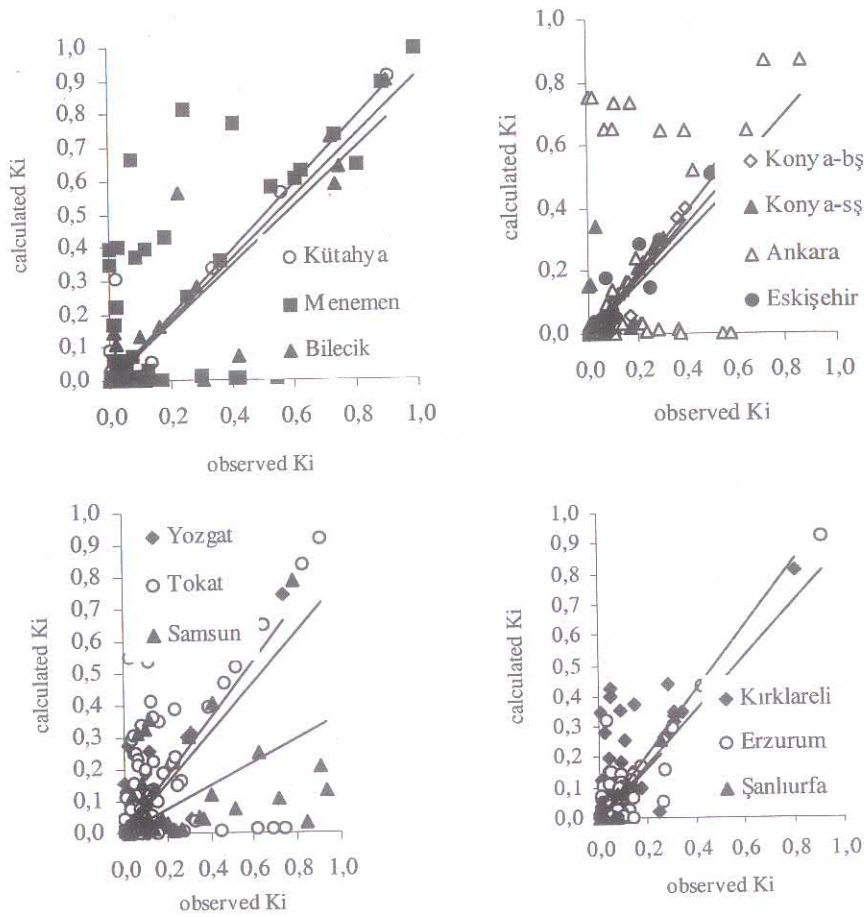
Among geographic regions apt to mass movement is Turkey that is liable to its diverse forms. The study aimed at generating a GIS and RS aided model that could be very useful tool in estimating mass movements leading to soil degradation and mapping susceptible zones. Within this context, expediently generated soil maps were given special emphasis for their usage in degradation studies related to mass movement and provision efforts.

Direct mapping methodology and Heuristic technique were applied in the study. Since direct method requires in large part a geomorphological approach, following a photo-interpretation based semi-detailed soil survey, a geopedological map of the study area was generated. Resulting mass movement features which were tried to delineate on the map are fans originating from mud flows; stone stripes located in relatively shallow gullies; debris and talus forms accruing from the disintegration and the slump of the rock substratum.

Model makes estimation of mass movement hazard zones possible through the manipulation of potential risk factors such as slope, geology, land cover and soil properties regardless of mass movement features and types. For the purpose of determining hazard severity rating and risk factors, stationary factors such as slope steepness, properties of the rock substratum, land cover formations and taxonomic soil groups were used. Aforementioned factors were subjected to a series of queries using Geo-media 3.0. Slope was considered dominant factor and relations between slope-geology and slope-taxonomic soil groups were found out. After a relational query, five groups were generated. These groups were intersected with land cover producing a new layer for a new query. All possible combinations of the four factors were tried and 26 appropriate combinations were obtained. These files were classified in descending order of susceptibility. Finally hazard severity classes were established as follows; very high, high, moderate, low, non or uncertain.

## **Introduction**

Among natural hazards, mass movements are the most frequent and have the largest geographic distribution, landslides alone, for example, cause greater loss of human lives and economic goods than any other single natural hazard. Moreover, they may result in unrepairable damages in irrigation and drainage



**Figure 1.** The plots of the observed Ki values versus the Ki values calculated by Eq. [3] for 13 research institutes.



analysis was promising but imposed a further study with regard to the effects of regional climate pattern on the soil susceptibility to erosion.

**Table 2.** Average soil erodibility factors calculated by Eq [3] for the natural runoff-erosion plots of 13 locations of 9 Research Institutes of General Directorate of Rural Service, Turkey.

Institute	$K_{av}$	$R^2$ (Figure 1)
Erzurum	0.04	0.11
Kütahya	0.48	0.33
Bilecik	0.28	0.39
Eskişehir	0.04	0.53
Menemen	0.50	0.57
Samsun	0.34	0.58
Yozgat	0.14	0.64
Tokat	0.40	0.78
Konya-Beyşehir	0.34	0.81
Konya-Seydişehir	0.17	0.83
Kırklareli	0.33	0.90
Şanlıurfa	0.02	0.90
Ankara	0.55	0.92

## Conclusion

Our analysis with the long-term data showed that the ability to more accurately predict the seasonal soil erodibility factors depends closely upon precisely delineating of cycles, in which soil erodibility greatly changes. This additionally requires integrating some climatic parameters in to the model.

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**Table 1.** Cases and corresponding formulae for determining the soil erodibility factor ( $K_i$ ) at any time ( $t_i$ ).

Case 1: $t_{\max} < t_{\min}$	
Case	Formula
If $t_{\max} < t_i < t_{\min}$	$K_i = K_{\max} (K_{\min} / K_{\max})^{(t_i - t_{\max}) / \Delta t}$
If $t_i < t_{\max}$ or $t_i > t_{\min}$ , and $T_{av} > 0^\circ C$ and $(t_i - t_{\min}) \leq 0$	$K_i = K_{\min} \exp[0.009(t_i - t_{\min} + 365)]$
If $t_i < t_{\max}$ or $t_i > t_{\min}$ , then for $T_{av} > 0^\circ C$ and $(t_i - t_{\min}) > 0$	$K_i = K_{\min} \exp[0.009(t_i - t_{\min})]$
$T_{av} \leq 0^\circ C$	$K_i = K_{\min}$
Case 2: $t_{\max} > t_{\min}$	
Case	Formula
If $t_{\max} > t_i > t_{\min}$ and $T_{av} > 0^\circ C$	$K_i = K_{\min} \exp[0.009(t_i - t_{\min})]$
$T_{av} \leq 0^\circ C$	$K_i = K_{\min}$
If $t_i > t_{\max}$ or $t_i < t_{\min}$ and $(t_i - t_{\max}) \leq 0$	$K_i = K_{\max} (K_{\min} / K_{\max})^{(t_i - t_{\max} + 365) / \Delta t}$
If $t_i > t_{\max}$ or $t_i < t_{\min}$ and $(t_i - t_{\max}) > 0$	$K_i = K_{\max} (K_{\min} / K_{\max})^{(t_i - t_{\max}) / \Delta t}$

$K_i$ : soil erodibility factor at any time ( $t_i$  in calendar days);  $K_{\max}$ : soil erodibility factor at time  $t_{\max}$  (in calendar days);  $K_{\min}$ : soil erodibility factor at time  $t_{\min}$  (in calendar days);  $T_{av}$ : average daily air temperature.

However, Rüttimann et al. (1995) recommended as many replications as possible for erosion plots to have representative data of erosion rates for a given location, and the data from replicated natural rainfall-erosion plots showed several important properties of erosion plot variance (Nearing et al., 1999, Risse et al., 1993). Therefore, it is very difficult to give a reason for these smaller values without having information on the data variability. For example, for these institutes the growing period would be expected to not greatly differ from 6 months, and it is extremely possible that  $K_{\max}$  and  $K_{\min}$  would be unrepresentative for the seasonal changes in the soil erodibility. Overall, the

## Methodology

The case formulae given in Table 1 (USDA-ARS, 1997) were used to estimate the soil erodibility factor at any time using long-term data from the direct measurements on natural runoff plots collected by 13 locations of 9 Research Institutes of General Directorate of Rural Service, Turkey (Oğuz et al., 2002). It is important here to note that the constant 0.009 of equations of Table 1 was obtained for the eastern United States, and it is much likely to be incompatible to Turkey climates. An analysis is thus required to determine the constant used in the equations, which is not included in this paper. Moreover, in our calculations, growing period was assumed to be  $\leq 180$  days, therefore, in locations where the growing periods are considerably different from 6 months, the calculated values need further adjusting, which is also not in the scope of the paper.

Using the estimated  $K_i$ , the average annual value of soil erodibility ( $K_{av}$ ) was calculated by:

$$K_{av} = \frac{\sum (EI_i) K_i}{100} \quad [3]$$

where,  $EI_i$  is the storm erosivity for a event at time  $t_i$ .

## Results and Discussion

The calculated average K values from seasonal soil erodibility factors ( $K_i$ ) are shown in Table 2, and Figure 1 also illustrates the plots of the observed  $K_i$  values versus the  $K_i$  values calculated by Eq. [3]. In the cases of Tokat, Konya-Beyşehir, Konya-Seydişehir, Kırklareli, and Şanlıurfa, the coefficients of determination,  $R^2$ , were reasonably well and more than 0.78 (Table 2). This result suggested that the data were in a good agreement with the time span between  $K_{max}$  and  $K_{min}$ , which was taken as 6 months. Obviously,  $K_i$  attained its minimum at the end of growing period. For the cases of Eskişehir, Menemen, Samsun and Yozgat, the calculated values of  $K_i$  explained more than 50% of the variations in observed  $K_i$  values. Nevertheless, those of Erzurum, Kütahya, and Bilecik, the  $R^2$  were 0.11, 0.33, and 0.39, respectively, meaning that the time span between  $K_{max}$  and  $K_{min}$  was significantly different from 6 months, and distinctly, the periodic changes in the calculated  $K_i$  did not agreed with the variability of the observed values. In fact, we had very limited data on statistical variability of the observed  $K_i$  values since they are obtained with no replicate.



The improved soil erodibility factor of RUSLE provides a great opportunity for making itself to be compatible with the physically based models (Römkens et al., 1986), and accommodates the spatial and temporal variability in topography, surface roughness, soil properties, and rainwater infiltration etc. Indeed, seasonal K values consider the changes in antecedent soil-water and soil surface conditions and the seasonal variations in soil properties and by this way, offers a prediction of soil vulnerability for specific events as well as for long-term averages.

Mutchler and Carter (1983) suggested a trigonometric cosine function to account for seasonal variations in K values:

$$K_r = 1 + a \cos(bt - c) \quad [1]$$

where,  $K_r$  is the ratio of the average monthly K value to the average annual K value;  $t$  is the mean monthly temperature;  $a$  is the peak value of soil erodibility for a given soil and for a given cycle;  $b$  is the cycle that the graph of function has through one period, and  $c$  is the phase shift of the periodic function. Clearly, magnitudes of  $a$ ,  $b$ , and  $c$  vary with the location.

The methodology of calculating K values for a given soil depends upon temporal variation in soil erodibility, and it is expressed as an exponential decay function:

$$K_i = K_{\max} e^{f(t)} \quad [2]$$

where,  $K_i$  is the soil erodibility factor at any time  $t_i$ ;  $K_{\max}$  is the maximum value of soil erodibility factor for a given soil;  $f(t)$  is the time function whose parameters are the times at which  $K_{\max}$  and  $K_{\min}$  occur and the length of growing period ( $\Delta t$ ). Time function varies with location and soil. In fact, Eq. [2] assumes an exponential decrease in soil erodibility as the growing season proceeds (USDA-ARS, 1997).

On the other hand, application of a model depends not only on versatility and suitability of the model to various conditions but also on availability of data. Our analysis for the seasonal K values is based on the direct measurements on natural runoff plots in different locations of Turkey, using case formulae developed for the eastern United States. Although the data is seemingly adequate for the required calculations, they were not designed for the seasonal K values, but average long-term K values, and obtained with no replications. That's why, this analysis is a preliminary and, to some degree, incomplete, but its future objective is to develop formulae for the seasonal K values adaptable to Turkey conditions.

# **Evaluating Long-Term Data of Natural Runoff Plots for Seasonal Soil Erodibility Factor**

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## **Abstract**

The Revised Universal Soil Loss Equation (RUSLE) is an attempt to improve the capability of USLE in portioning dynamic hydrological and erosional processes and the flexibility of USLE in adjusting process parameters to account for spatial and temporal changes. It is therefore expected from RUSLE that valuable information on complex interrelation of parameters or processes give rise to more accurate soil loss predictions by the model. The vulnerability of soil to the soil erosion is a multifaceted property that greatly influenced by the variations in antecedent soil-water and soil-surface conditions and consequently in soil properties. In this paper, we closely looked into the data obtained from direct measurement on natural runoff plots of 13 locations of 9 Research Institutes of General Directorate of Rural Service, Turkey to approximately calculate soil erodibility factor ( $K_i$ ) at any time  $t_i$ . The calculated  $K_i$  values were statistically compared with the observed  $K$  values of natural runoff plots. Finally, the average annual values of soil erodibility for each institute were estimated.

## **Introduction**

USLE is an empirically based erosion prediction technology in which factors affecting soil erosion are function of climate, soil properties, topography, soil surface conditions, and human activities (Wischmeier and Smith, 1978). These factors are expressed in an equation as the lumped parameters, mostly without delineating distinct processes. For example, the soil erodibility factor is a lumped value that stands for an average annual value of soil reaction to a large number of erosion and hydrologic processes (USDA-ARS, 1997), primarily to raindrop and runoff detachment and to the infiltration. Because of having the empirically derived and the lumped parameters, the USLE can only predict time-averaged, or long-term soil losses. In other words, some of the model parameters are insensitive to the spatial and temporal changes possible to occur during the projected prediction span (Nearing et al., 1990). However, precisely defining the processes and parameters considered influential on the soil erosion and their interactions plays very significant role in the process-based models. In this connection, RUSLE aims to make transition to a process-based model as new technologies have been used, and research has supplied a greater number of data about parameters for portioning hydrological and erosional processes.



plants while 15.0 and 13.8 ppm in the plants fertilized with lime in amounts of 50% and 100% of the lime requirements respectively. Cu content of the plants decreased as the amount of lime given to the soils increased (Table 3). Nutrient intake of the plants from 100 g soil is given in Table 4. As seen in Table 4, in average, nutrient intake of the plants which are not given lime is 85.2 mg, as is 135.9 mg and 176.5 mg for the plants which are given lime in amounts of 50% and 100% of the lime requirement. The increases in nutrient intake is more significant for the macro nutrients. Macro nutrient intakes of the plants is found to be 84.8 mg/100 g in the soils not applied lime while it is 135.3 mg and 175.9 mg per 100 g soil in the cases of lime application in amounts of 50% and 100% of the lime requirements. Micro nutrient intake of the plants are 0.39 mg, 0.52 mg and 0.60 mg for the same applications respectively. The changes in nutrient intake are 59.6% and 107.5% for macro nutrients; and 32.9% and 54.9% for micro nutrients respectively. As a result of the study, it was revealed that lime application increased the nutrient intake of the corn plant. The rate of the increase in macro nutrient intake is greater than that in micro nutrient intake. However, although there is an increase in micro nutrient intake this increase is less than that in macro nutrient intake. So, it can be concluded that availability of the micro nutrients for the plants decreases relatively with the lime application to the soils.

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and 100% of the Ca requirement of the plants respectively (Table 3). The decrease in the Mn contents of the plants can be explained with the decline of the Mn availability, which is dependent on the pH level. Thus, lime application causes higher pH levels, which limits the Mn availability, and in turn, Mn intake by plants.

**Table 4.** Effect of Lime Application on Plant Mineral Elements Uptake.

Soil No	Lime doses	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
		mg/100 g soil								
1	0	1.41	0.33	6.14	0.55	0.21	0.013	0.014	0.010	0.003
	50	3.84	0.51	9.00	0.98	0.35	0.020	0.017	0.012	0.004
	100	4.97	0.74	10.72	1.47	0.48	0.023	0.019	0.015	0.004
2	0	1.51	0.34	6.35	0.54	0.20	0.015	0.013	0.010	0.003
	50	3.50	0.63	8.57	0.99	0.39	0.016	0.016	0.013	0.004
	100	3.70	1.04	9.73	1.34	0.43	0.017	0.017	0.014	0.004
3	0	0.49	0.14	2.55	0.19	0.10	0.007	0.006	0.005	0.001
	50	2.55	0.38	5.92	0.65	0.22	0.015	0.013	0.010	0.003
	100	4.43	0.66	7.54	1.11	0.38	0.020	0.015	0.011	0.004
4	0	2.16	0.42	6.53	0.61	0.33	0.016	0.015	0.012	0.003
	50	3.54	0.69	9.22	1.09	0.50	0.021	0.019	0.016	0.004
	100	5.03	0.91	12.51	1.57	0.66	0.022	0.024	0.021	0.005
5	0	1.45	0.32	5.98	0.52	0.27	0.013	0.012	0.010	0.003
	50	3.54	0.61	10.25	1.22	0.43	0.021	0.019	0.015	0.005
	100	4.81	0.77	11.47	1.79	0.54	0.023	0.020	0.016	0.006
6	0	1.88	0.33	6.07	0.54	0.23	0.014	0.015	0.012	0.003
	50	3.05	0.44	8.14	0.88	0.40	0.017	0.016	0.014	0.004
	100	4.32	0.60	10.81	1.15	0.56	0.020	0.019	0.017	0.005
7	0	2.39	0.57	7.48	0.64	0.33	0.018	0.014	0.014	0.004
	50	4.02	0.90	10.79	1.20	0.50	0.021	0.021	0.019	0.005
	100	4.96	1.15	12.09	1.90	0.65	0.023	0.020	0.021	0.005
8	0	1.53	0.33	6.50	0.62	0.25	0.014	0.012	0.011	0.003
	50	2.51	0.54	7.57	0.94	0.33	0.016	0.015	0.012	0.004
	100	3.74	0.78	10.01	1.40	0.43	0.020	0.016	0.016	0.005
9	0	0.99	0.30	4.88	0.44	0.18	0.012	0.011	0.009	0.002
	50	2.34	0.48	7.70	0.77	0.25	0.017	0.014	0.012	0.004
	100	3.55	0.62	9.81	1.34	0.47	0.020	0.018	0.017	0.005
10	0	1.71	0.42	5.73	0.61	0.21	0.012	0.012	0.010	0.003
	50	2.73	0.63	7.40	0.93	0.32	0.013	0.013	0.013	0.004
	100	4.02	0.91	9.90	1.48	0.47	0.020	0.015	0.015	0.004

Zinc content of the plants shows differences according to the soil type and Ca rates applied. Average Zn content of the control plants is 54.8 ppm, which are not given lime while it is 50.1 ppm and 47.7 ppm for those plants Ca applied in amounts of 50% and 100% of the lime requirements respectively. Thus, Zn content of the plants decreased as the applied amounts of Ca increased. This can be explained with the higher soil pH due to lime application which cause Zn ions to form less soluble compounds and also with the increase of dry matter content of plants. Aydın et al, (1997) reports similar results. Cu content of the plants is between 12.9 and 18.2 ppm. and it varies according to soils and the rates of lime applied. Average Cu contents of the plants are 15.8 ppm in control

**Table 3.** Change in Mineral Element Content of Plants with Lime Application.

Soil No	Lime doses	N, %	P, %	K, %	Ca, %	Mg, %	Fe, ppm	Mn, ppm	Zn, ppm	Cu, ppm
1	0	0.76	0.179	3.31	0.298	0.113	68.6	75.0	53.4	18.2
	50	1.38	0.182	3.23	0.351	0.124	72.3	59.3	42.1	14.5
	100	1.45	0.215	3.13	0.428	0.140	65.9	54.1	44.3	12.9
2	0	0.80	0.179	3.36	0.286	0.108	78.4	66.7	51.0	15.5
	50	1.27	0.230	3.11	0.361	0.114	56.4	57.0	46.5	13.3
	100	1.24	0.350	3.26	0.449	0.143	58.5	56.5	46.5	12.7
3	0	0.56	0.158	2.90	0.217	0.118	82.6	71.1	55.4	16.3
	50	1.35	0.200	3.13	0.345	0.115	77.9	68.4	53.3	17.0
	100	1.68	0.251	2.86	0.420	0.144	76.4	58.1	43.3	15.7
4	0	1.01	0.197	3.05	0.283	0.152	75.6	72.0	56.6	15.7
	50	1.11	0.216	2.89	0.342	0.156	64.8	60.6	51.0	13.9
	100	1.27	0.229	3.16	0.397	0.166	56.4	61.5	53.2	13.7
5	0	0.78	0.172	3.18	0.279	0.142	67.5	65.1	55.4	17.0
	50	1.14	0.195	3.30	0.393	0.139	67.5	62.5	48.7	16.3
	100	1.30	0.207	3.10	0.484	0.145	61.5	54.9	43.2	15.0
6	0	0.89	0.156	2.87	0.256	0.108	68.2	71.7	56.4	16.5
	50	1.10	0.160	2.94	0.319	0.146	62.8	58.7	51.3	15.6
	100	1.22	0.169	3.05	0.423	0.157	56.8	52.2	48.7	13.2
7	0	1.02	0.241	3.19	0.273	0.139	77.7	59.6	59.9	15.6
	50	1.14	0.254	3.06	0.337	0.143	58.3	58.7	55.4	14.5
	100	1.23	0.284	3.00	0.471	0.160	57.5	51.1	51.0	13.9
8	0	0.74	0.158	3.14	0.301	0.120	68.7	58.4	53.4	15.3
	50	0.98	0.213	2.96	0.367	0.128	64.3	58.6	50.6	14.6
	100	1.12	0.234	3.02	0.418	0.136	60.1	48.7	48.7	14.2
9	0	0.61	0.181	2.99	0.270	0.108	71.4	65.9	55.9	13.9
	50	0.96	0.196	3.16	0.315	0.102	72.1	60.3	50.3	14.6
	100	1.09	0.190	3.01	0.411	0.143	60.6	58.1	52.1	13.6
10	0	0.89	0.218	2.97	0.316	0.110	63.6	60.6	50.6	13.8
	50	1.06	0.244	2.86	0.359	0.124	51.8	51.7	51.7	15.8
	100	1.18	0.266	2.90	0.435	0.139	59.7	46.3	46.3	13.3

Fe content of the plants is between 51.8 and 82.6 ppm and it varies with soil type and Ca contents of the soils. Plants Fe content decreased as the amount of Ca applied increased. Without lime application Fe content of the plants is 72.2 ppm, while it is 64.8 ppm and 61.3 ppm in the cases of lime application to the soil in amounts of 50% and 100% of the Ca requirement of the plants respectively. This result can be explained with the higher amounts of lime applied to the soils, which causes higher pH levels, and in turn, less availability of the Fe element for the plants. In general, average Fe contents of the plants grown in the soils with low pH levels is higher as is less for the plants grown in the soils of higher pH levels. This suggests that soil pH has an effect on Fe availability in the soils. On the other hand, it was found that Mn content of the plants is between 46.3-75.0 ppm. In general, Mn content of the plants (63.2 ppm) grown in the soils with low pH is higher than that of plants (57.1 ppm) grown in the soils of higher pH levels. Moreover, it was found that Mn content of the control plants, which are not given lime, is 66.6 ppm while it is 59.6 ppm and 54.2 ppm in the cases of lime application to the soils in amounts of 50%

Phosphorous content of maize plants ranged from 0,158% to 0,350%. Phosphorous contents of plants increased by lime application. Without lime application average phosphorous content of plants was 0,184%. When 50% of lime need was applied, phosphorous content was 0,184%, however 100% of lime need was applied this content raised up to 0,239%. Phosphorous content of plants was higher grown in higher phosphorous content and higher pH soils than lower phosphorous content and lower pH soils. It may result that, available phosphorous content and pH values affect the phosphorous uptake of plants from soil and phosphorous content of maize plants. Similar results was obtained by Aydın et. all (1997). K content of maize plants changes depending on different soil types and application doses and ranged between 2,86% and 3,36%. K content of maize plants decrease by lime applications, in general. Without lime application, average K content of plants was 3,10. when 50% lime need was applied, K content was 3,06%, however 100% of lime need was applied, this value reduced to 3,05%. Decrease in K content of plants may cause decrease in availability of K after lime application and difficulty of K uptake by plants. Also because of dry matter increase the relative content of K may also decrease and this may result the lower K content in maize plants. Lime application also increase Ca and Mg content of maize plants, in general. Changes in Ca and Mg content of plants depending on soil types and lime application doses ranged from 0,217 to 0,486% for Ca, and 0,102–0,166% for mg. Without lime application, average Ca content of plants was 0,278%, and Mg content was 0,122%. When 50% of lime need was applied, Ca content was 0,349%, and Mg content was 0,132%. However, when 100% of lime need was applied, Ca content was 0,434% and Mg content was 0,147% (Table 3). The reason for increase in plant Ca and Mg content was because of increase in lime application. Aydın et all (1997) had the same results.

**Table 2.** Effect of Lime Application on Maize Dry Matter Content in Acidic Soils, (g/pot)

Soil No	Lime doses, (%)			Average dry matter	Average dry matter increase, %
	0*	50	100		
1	3.71	5.57	6.85	5.38b	45.0
2	3.78	5.51	5.97	5.09bc	34.7
3	1.76	3.78	5.27	3.60d	104.7
4	4.28	6.38	7.92	6.26ab	46.3
5	3.76	6.21	7.40	5.79ab	54.0
6	4.23	5.54	7.09	5.62abc	32.9
7	4.69	7.05	8.06	6.60a	40.7
8	4.14	5.11	6.68	5.31b	28.7
9	3.26	4.86	6.52	4.88bc	49.8
10	3.86	5.16	6.43	5.15bc	33.4
Average	3.75c	5.52b	6.82a	5.36	43.0

PS. Values are averaged from four replications.



effect of soil type and lime application doses on maize dry matter content were significant and different from each other. On the other hand, change in N, P, K, Ca, Fe, Zn, and Cu contents of maize plants in East Black Sea Region soils has been shown on Table 3. While the N, P, Ca and Mg content of maize plants were increasing K content decreased with liming. Nitrogen content of maize plants ranged from 0,56% to 1,68% depending on soil type and lime doses (Table 3). In general, plants grown in high organic material have higher nitrogen content. There are many factors affecting the mineralization of organic matters in soils. However, soil organic matters are the main factors for nitrogen storage in plants grown in organic soils. Without lime application, average nitrogen content of plants was 0,81%. When 50% of lime need was applied, nitrogen content was 1,02%, however 100% of lime need was applied this content raised up to 1,28%.

**Table 1.** Some Physical and Chemical Properties of soils analyzed.

S.	L.D	TC	O.C	L.R	C.E.C	pH	Exchangeable.			Plant Available , ppm					
			%	kg/da	Cmol kg <sup>-1</sup>	1:2.5	Ca +Mg	Al +H	K	P	Fe	Mn	Zn	Cu	
1	0	C	3.2	2370	30.6	4.2	12.6	16.4	1.1	4.8	39.4	12.0	3.7	2.0	
	50					5.3	19.6	7.3	1.0	5.1	14.6	4.2	2.5	1.7	
	100					6.8	24.6	4.2	0.8	5.7	8.5	1.4	1.6	1.6	
2	0	C	1.2	1900	23.8	4.9	10.4	12.5	0.3	6.8	41.6	15.2	2.8	1.0	
	50					5.6	15.3	5.6	0.3	7.6	16.8	5.9	1.8	0.9	
	100					6.9	19.1	2.7	0.2	9.4	8.7	4.2	1.3	0.8	
3	0	C	3.7	4580	30.3	3.2	3.2	25.1	1.4	2.0	68.6	33.7	3.3	2.0	
	50					4.9	15.2	10.1	1.4	2.2	26.4	8.3	2.2	1.8	
	100					6.7	23.9	5.3	1.2	2.8	8.3	5.5	1.3	1.5	
4	0	L	2.8	2160	27.5	4.4	11.3	15.6	0.4	11.8	52.7	12.6	3.4	2.2	
	50					5.5	18.1	8.2	0.3	13.3	28.1	4.9	2.6	1.5	
	100					6.7	21.3	3.8	0.3	16.4	9.6	2.6	1.5	1.3	
5	0	L	2.3	1690	33.2	4.5	13.0	14.3	0.9	6.1	45.7	46.8	3.5	2.1	
	50					5.6	20.9	7.8	0.7	7.0	18.6	10.6	2.9	1.8	
	100					6.9	25.0	3.9	0.5	8.3	5.7	4.9	2.1	1.7	
6	0	L	1.0	1180	22.6	5.0	8.4	11.7	0.4	7.0	25.4	36.7	3.7	1.2	
	50					6.9	12.7	5.3	0.4	8.7	9.8	8.1	3.2	1.1	
	100					6.9	16.3	2.6	0.3	9.6	7.4	3.8	1.6	1.1	
7	0	CL	2.3	1300	28.1	4.8	18.9	7.1	0.8	13.5	23.2	11.5	2.6	0.5	
	50					5.8	20.9	6.2	0.7	15.1	10.0	4.9	2.0	0.4	
	100					6.8	24.7	1.6	0.7	17.2	6.5	2.3	1.4	0.2	
8	0	CL	2.0	1060	26.9	5.1	10.9	14.6	0.9	8.1	20.8	11.7	3.1	2.1	
	50					5.9	15.8	7.9	0.8	9.8	8.1	7.2	2.7	1.9	
	100					6.8	20.2	3.8	0.7	10.9	4.6	3.4	1.4	1.7	
9	0	L	1.1	1530	20.3	4.9	7.8	10.8	0.8	2.2	24.1	13.8	2.4	1.2	
	50					5.7	12.1	6.8	0.7	2.6	9.3	5.5	1.9	1.1	
	100					6.8	14.9	2.4	0.5	3.1	4.3	2.8	1.6	0.8	
10	0	L	2.1	670	21.7	5.7	11.1	9.2	0.6	11.4	13.6	8.3	2.9	1.8	
	50					6.2	14.5	4.3	0.5	13.1	5.6	4.2	1.5	1.5	
	100					6.9	18.3	2.1	0.5	15.7	3.7	1.6	1.2	1.2	

S: Sample No; L.D: Lime doses; T.C: Texture class; L.R: Lime requirement; O.C: Organic carbon; C.E.C: Cation exchangeable capacity.

(average 9.8 ppm) when complete lime requirement was applied into soil. When 50% of lime requirement was applied into soil, changeable K amount decreased from 0,75 cmol kg<sup>-1</sup> to 0,68 cmol kg<sup>-1</sup>, whereas when 100% of lime requirement was applied into soil, this level declined to 0,57cmol kg<sup>-1</sup>. When 50% of lime requirement was applied into soil, average levels of minerals in soil was determined as follows; 14,7 ppm Fe, 6,4 ppm Mn, 2,3 ppm Zn, 1,4 ppm Cu. When all lime need of soil was applied Fe, content was 6,7 ppm, Mn content was 3,3 ppm, Zn content was 1,5 ppm and Cu content was 1,2 ppm.

According to these results, lime application to acid soils increased the pH level, exchangeable Ca+Mg content, available Phosphorus, while decreased the changeable Al+H, K, Fe, Mn, Zn, and Cu. Increase in changeable Ca+Mg content of soils and pH level are natural result of lime application. In acidic soils, phosphorus forms hard-soluble compounds with Al and Fe and after lime application Fe and Al becomes oxide and hydroxide, and P becomes free and the concentration of P increases in soils.

The reason for decrease in changeable Al+H, P, Fe, Mn, Zn, Cu, contents in trial soils after liming soil pH increases and this minerals change into oxide and hydroxide and form insoluble elements at this pH. Similar results were obtained from many researchers ( Martini and Mutters, 1985a,b; Aydın and Sezen, 1990; Aydın et. all, 1997). Increase in changeable Ca+Mg content, and decrease in Al+H, Mn and Fe content of soils are more significant. For lime application, properties of Fe and Mn elements should have taken into account. Lime application in different rates to acidic soils and its effect on maize dry matter content has been shown on Table 2. With increasing lime application doses, dry matter content of maize plant has also been increased. As it was seen from Table 2 that, dry matter increase ranged from 28,7% to 104,7%. Dry matter increases depended also on soil type. Reason for that depended mainly on soil pH, and the other soil properties. Dry matter increase with liming more significant especially in low- pH soils. While dry matter increase is 32% in over pH 5,0 soils with liming, below pH 4,5 dry matter increase is 62,5%, and average dry matter increase is 43%. With liming soils pH increases, microbial activity increases, toxicity affect of some elements (Fe, Mn, Al, etc.) decreases, availability of phosphorous increases, insufficiency in Ca and Mg elements, improvement of aggregation and water-air movements in soil is arranged and these resulted in dry matter increase in maize plants. Similar results was obtained from many researchers (Martini and Mutters, 1985a,b; Aydın et. all,1997).

According to variance analyze results, effect of different soil type and lime applications on maize dry matter content were very significant statically ( $P < 0,01$ ). Averages of soil types and lime application doses belonging to trial have been subjected to Duncan Multiple Composition Test. Results shown that,



It has also been revealed that available P increase by application of necessary lime needs, while over-application of lime decrease the available of phosphorus (Martini and Mutters, 1985a,b; Aydın and Sezen, 1990; Zhu and Alva, 1993; Ponette et. all, 1996; Aydın et. all, 1997).

The aims of this research were to determine the effect of different levels of lime application on acid soil properties, and to determine the effect of lime application on dry matter and mineral content of corn plants.

## Materials and Method

Two kilogram disturbed soil samples on oven dry weight base and 0, 50, 100 % rates of lime doses were used in this study. Lime requirements were estimated based on  $\text{CaCO}_3$  amounts. For balancing soil pH of the sample moisture level was improved to field capacity and incubated for one month. As a result of incubation, maize seeds were shown according to 3 seeds for each pot. After germination, one plant for each pot was left. At the end of trial, dry matter and element contents in dry matter and mineral element uptake from soil of plants were determined.

Soil texture, pH, organic matter, cation change capacity, exchangeable cations (Soil Survey Laboratory Staff, 1992), lime requirement (Oruç, 1973), Fe, Mn, Zn, and Cu (Lindsay and Norwell, 1969) for plants were determined. Total nitrogen was determined using micro-Kjeldahl method, after plant material were wet combustion, P by spectrophotometer of the P-vanadomolibdate yellow color method, K, Ca, Mg, Fe, Mn, Zn, Cu by atomic adsorption spectrophotometer (Kacar, 1972).

## Results and Discussion

Some physical and chemical properties of soils and some analyze results after lime application were given on Table 1. Mean pH levels increased from 4.7 to 5.7 when 50% of lime requirement was applied to soils, whereas pH levels increased from 4.7 to 6.8 when complete lime requirement was applied to soils. Exchangeable Ca, Mg, and 41% and Al+H includes 52% of soil cation change capacity. When 50% of lime requirement was applied into soil, changeable Ca+Mg rate in total soil cation change capacity was increased to 63.4%, however; shown 100% of lime requirement was applied into soil, changeable Ca+Mg rate in total soil change capacity was increased to 78.5%. When 50% lime requirement was applied into soil; changeable Al+H level in total soil cation exchange capacity was increased to 26.2% ; however when 100% of lime requirement was applied this level decreased to 12.3%. Available phosphorous level in soils raised to 2.2-15.1 ppm ( average 8.5 ppm) when 50% of lime need was applied, however this level increased to 2.8-17.2 ppm



## **Effects of Lime Application on Some Soil Properties and Mineral Composition and Growth of Corn**

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### **Abstract**

Improving soil properties and establishing plant nutrition equilibrium in soils are important for plant production. The objective of this study was to determine effects of lime application of different doses (0, 50 and 100%) on some soil properties and dry matter content, mineral composition and nutrition uptake of corn in Eastern Black Sea Cost soils. Results indicated that soil pH increased with increasing doses of lime application, exchangeable Ca+Mg and plant available P also increased but exchangeable Al+H, exchangeable K and plant available Fe, Mn, Zn and Cu content decreased. The rate of increase in exchangeable Ca+Mg was higher than that of in available P. Similarly, the rates of decrease in exchangeable Al+H and available Fe and Mn were higher than these of available Zn and Cu. Plant dry matter content, amount of nutrient uptake from soil, and N, P, Ca and Mg contents of corn plant increased with increasing dose of lime application, but K, Fe, Mn, Zn and Cu content of plants decreased. As a result of this study it was determined that lime application to acid soils affected significantly on plant dry matter content, nutrient uptake and soil properties.

### **Introduction**

The main goal of agricultural production is to provide balanced and healthy nutrition for human being. While the population increases, it is necessary to increase yield and quality of agricultural products to feed the people. Lime application is effective in pH arrangement for availability and balance of elements in low-pH humid-land soils. In addition to that, lime improves physical, chemical, and biological properties of soils and also meets calcium and magnesium needs of plants (Summer, 1990).

Martini&Mutters (1985a), Binkley&Sollins (1990) pointed out that over-leaching depending on heavy rainfall, application of physiological acid fertilizers and intensive agricultural applications cause gradual decrease in pH and acidity in soils, soil texture, amount of organic material, clay type and amount, soil pH, pH need of plant, aggregate size and purity of liming material affect the application amount of lime in acid soils (Mulder et.al, 1989). In many studies it has been shown that by increasing of lime application to acid soils available Fe, Mn, Zn, Cu, B and changeable Al+H and K contents decrease whereas soil pH, Ca+Mg, and base saturation increase in acidity soils.

Therefore, should the effluent of wastewater treatment plant would be stored in Hotamış Lake this could help restoring recreational value of the lake as well as improving effluent quality by natural oxidation and provide irrigation water to about 5% of the grains field of Konya.

**Table 5.** Wastewater analyses results.

Parameter	Mean	Minimum	Maximum
Ec <sub>x</sub> 10 <sup>6</sup> (μmhos/cm)	1387	980	1980
PH	7.1	6.6	7.6
TDS (mg/L)	833	590	1190
SS (mg/L)	54.3	8.2	197
Turbidity (NTU)	46.2	16.4	103.2
BOD <sub>5</sub> (mg/L)	330	185	470
COD (mg/L)	655	400	1000
NH <sub>3</sub> -N (mg/L)	54	45	78
Total-N (mg/L)	79	60	92
PO <sub>4</sub> -P (mg/L)	16.4	13.5	19.8
Na (mg/L)	170.4	11.5	410.7
K (mg/L)	10.6	2.3	23.4
Ca (mg/L)	252	84	528
Mg (mg/L)	122.4	41.3	290.4
Cd (mg/L)	0.0020	0.0007	0.0050
Zn (mg/L)	0.1100	0.0600	0.1500
Cu (mg/L)	0.0090	0.0030	0.0200
Pb (mg/L)	0.0950	0.0200	0.2100
T-Cr (mg/L)	0.0960	0.0340	0.2500
Hg (mg/L)	0.0002	0.0001	0.0024
SAR (meq/L)	2.19	0.25	3.54

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potassium (K), calcium (Ca), magnesium (Mg) contents. In addition heavy metals such as cadmium (Cd), zinc (Zn), copper (Cu), lead (Pb), mercury (Hg) and total chromium (T-Cr) contents of wastewater samples were determined using CADAS-200 UV-Vis spectrophotometer and its ready kits.

Water demands of mostly cultivated crops such as grains were calculated according to Blaney-Cridle method which is a popular method calculating irrigation water demand. The Blaney-Cridle method relies on percent of daylight hours Per month and average monthly temperature.

The field area that could be irrigated was also calculated considering the amount of reclaimed wastewater, and irrigation water demand of common crops.

## Results

Characteristics of wastewater of Konya were determined by analysing water samples taken from sewerage outlet. Analyses results are summarised in Table 5. From Table 5, it can be seen that the wastewater of Konya within the range of heavy metals limits given in Table 1 even without treatment. However, activated sludge process will remove approximately 28% of cadmium, 30% of mercury, 55% of chromium, 70% of copper and 75% of zinc (WPCF, 1989). Microbiological quality requirements given in Table 2 for grains crops would easily be satisfied provided disinfection process employed after conventional activated sludge process and surface irrigation is applied. Grain crops are grown in about 50% of cultivated land of Konya and making up about 1 357 557 hectare. Irrigation water demands of grain crops are calculated approximately as total 2155 m<sup>3</sup>/hectar, consisting of 535 m<sup>3</sup>/ha in April, 1470 m<sup>3</sup>/ha in May and 150 m<sup>3</sup>/ha in June.

Effluent of wastewater treatment plant would meet irrigation water demand of 8352 hectare of grain crops if stored only three months of irrigation period. In case effluent is stored for a year, 33410 hectare of cultivated land would be irrigated until 2015. In the second stage of the treatment plant, 12529 hectare of crops would be irrigated if water is stored only three months, however, 50116 hectare can be irrigated if effluent water is stored for a year. Furthermore, N and P removal steps could be omitted from wastewater treatment plant since these constituents are beneficial as fertilizers when reclaimed wastewater is used as irrigation water. Thus, construction and operation costs of wastewater treatment plant are reduced. For a year storage of effluent of Konya wastewater treatment plant would require about 110x10<sup>6</sup> m<sup>3</sup> storage volume would be required. A natural dry lake called Hotamış Lake, with a storage capacity of nearly 300x10<sup>6</sup> m<sup>3</sup>, is located only about 40 km away the city.



**Table 3.** Reuse quality conditions according to crop type

Crop type	Restrictions
Orchard and vine yards	Spray irrigation is not allowed No fruits picked from ground Fecal coliform <1000/100 mL
Fibrous crops Seed crops	Surface and spray irrigation is possible Biologically treated and disinfected wastewater can be used in spray irrigation Fecal coliform <1000/100 mL
Feed crops Oil crops Floriculture Crops not eaten raw	Surface irrigation, mechanically treated wastewater

### Agricultural Reuse Potential in Konya

Municipal wastewater of Konya is currently discharged to Konya main drainage channel which is constructed by government water works (DSI) in 1974 in order to drain excess water from rainfall and from irrigation. Konya main drainage channel collects excess waters and wastewater of Konya and discharges them to Tuz lake which is about 150 km away. Pollution problems in Tuz lake because of this discharges are also widespread public concern.

Wastewater treatment plant of Konya is planned as classical plug flow activated sludge process in two stages consisting for the years 2015 and 2030 populations and design data are given in Table 4.

**Table 4.** Konya wastewater treatment plant design data

Parameters	Stage I, Year 2015	Stage II, Year 2030
Population	1000000	1600000
Dry weather flow (m <sup>3</sup> /day)	200000	300000
Wet weather flow (m <sup>3</sup> /day)	400000	600000

In this work, characteristics of Konya wastewater as well as its suitability for irrigation of agricultural land in Konya were investigated in addition to the evaluation of different nonpotable reuse applications and treatment and quality requirements for different reuses.

### Material and Methods

Wastewater samples were collected from Konya sewerage outlet once a week for three months period. Chemical analyses of wastewater samples were carried out as described in standard methods (APHA, 1989) in order to determine electrical conductivity (EC), pH, total dissolved solids (TDS), suspended solids (SS), turbidity, biochemical oxygen demand (BOD<sub>5</sub>), chemical oxygen demand (COD), ammonia (NH<sub>3</sub>-N), total nitrogen (total-N), phosphate (PO<sub>4</sub>-P), sodium (Na),

**Table 1.** Recommended limits for some constituents for irrigation reuse of reclaimed wastewater.

TRACE HEAVY METALS					
Constituent	Long-Term Use (mg/L)	Short-Term Use (mg/L)	Constituent	Long-Term Use (mg/L)	Short-Term Use (mg/L)
Aluminium	5.0	20	Arsenic	0.10	2.0
Beryllium	0.10	0.5	Boron	0.75	2.0
Cadmium	0.01	0.05	Chromium	0.1	1.0
Cobalt	0.05	5.0	Copper	0.2	5.0
Fluoride	1.0	15.0	Iron	5.0	20.0
Lead	5.0	10.0	Lithium	2.5	2.5
Manganese	0.2	10.0	Molybdenum	0.01	0.05
Nickel	0.2	2.0	Selenium	0.02	0.02
Zinc	2.0	10.0	Vanadium	0.1	1.0
OTHER PARAMETERS					
Constituent	Recommended limit		Constituent	Recommended limit	
pH	6.0		TDS	500-2000 mg/L	
Free chlorine residual	<1 mg/L				

Microbiological quality requirements for agricultural irrigation with reclaimed water are applied according to plant type in USA. California has developed the first reuse regulation in 1918 and modified this regulations throughout the years. The current criteria in California were given in table 2 adopted in 1978. These criteria were taken as base for reuse standarts by other states and countries (Crook, 1991).

**Table 2.** Treatment and microbiological quality criteria for agricultural application of reclaimed water in California (USA)

Type of use	Total coliform limits	Treatment requirements
Fodder, fiber and seed crops surface irrigation of orchards and vineyards	-	Primary
Pasture for milking animals, landscape impoundments, landscape irrigation (golf courses, cemeteries, etc.)	23/100 mL (median)	Oxidation and disinfection
Surface irrigation of food crops <sup>(1)</sup> Recreational Impoundments	2.2/100 mL (median)	Oxidation and disinfection
Spray irrigation of food crops landscape irrigation (parks, playgrounds, etc.)	2.2/100 mL (median)	Oxidation, coagulation, clarification, filtration ,disinfection
Nonrestricted Recreational Impoundments	23/100 mL (single sample)	

According to the irrigation water quality criteria in Turkish water pollution control regulations. Reuse quality conditions and treatment requirements of wastewater for irrigation changes according to the crop type (Table 3). In Turkish regulations, heavy metals concentration limits were accepted as the same values given in Tab. 1.

Organic matters are usually measured by biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total organic carbon (TOC). The determination of low levels organic constituents in water is possible only with sophisticated analytical instrumentation such as gas chromatography.

Some other parameters in reclaimed water are important especially for agricultural irrigation. These parameters of concern are salinity, sodium, trace elements, excessive chlorine residual and nutrients. Salinity is the most important parameter for determining irrigation water suitability (Pettygrove and Asano, 1985). The soil should be drained and leached properly to prevent salt build up. Leaching is over-application of irrigation water in excess of plant needs for removing water and salt downward away from the root zone. Salinity is usually measured by electrical conductivity (EC), or total dissolved solids (TDS). Salinity is concerned because of its influence on the soil osmotic potential, specific ion toxicity and degradation of soil physical conditions. Salinity reduces the water uptake of plants because of lowering the osmotic potential of the soil. The most important ions are sodium, chloride and boron in reclaimed irrigation water.

Detergents are usually the source of boron while the water softeners add sodium and chloride. Sodium salts effect the exchangeable cation composition of the soil causing lowered permeability. Sodium does not impair the plant uptake of water but reduces the infiltration of water into the soil. Plants are thus affected by deficiency soil water (Tanji, 1990). Trace elements are usually exist less than 100 µg/L in reclaimed water (Pettygrove and Asano, 1985). Some of them are necessary for plants but all of them can be toxic at higher concentrations (Tanji, 1990).

The most important elements of concern at higher concentrations are cadmium, copper, molybdenum, nickel and zinc. Nickel and zinc are of less important than cadmium, copper and molybdenum since they have obvious deleterious effect in plants at lower concentrations than the levels harmful animals and humans. However, cadmium, copper and molybdenum are harmful to animals at much lower concentrations than the levels that plants may be effected. Cadmium is particularly important because it can accumulate in the food chain. Free chlorine residual less than 1 mg/L concentration has no harmful effect to plants. However, chlorine concentration more than 5 mg/L causes severe damage to most plants. United States Environmental Protection Agency (EPA) has recommended limits for constituents in reclaimed water for irrigation reuse (Table 1)



habitat. Groundwater recharge using reclaimed water is carried out in order to establish saltwater intrusion barriers in coastal aquifers, to treat reclaimed water further for future use, to augment aquifers and to provide storage. Agricultural irrigation is the biggest fraction of the total fresh water demand. Mostly reuse systems supply reclaimed wastewater for agricultural irrigation. It is estimated that irrigation water demands exceed any other use by a factor of 10 (Pair et al., 1983). Reclaimed water quality is very important for any reuse in order to assure health protection, preventing environmental degradation and avoiding public nuisance. Protection of public health may be assured by reducing pathogenic bacteria, parasites and viruses, controlling chemicals and limiting public exposure. When human exposure is not limited in a reuse application reclaimed wastewater should be treated to higher degree before use. If public access is limited to the reuse site, lower level of treatment, without compromising worker safety, may be accepted. Toxic chemicals and pathogenic microorganisms in untreated wastewater have a potential for deleterious health effect and disease transmission. However, for most reuse applications, conventional wastewater treatment processes are able to reduce these constituents to acceptable levels. Epidemiological investigations on reuse of raw or minimally-treated wastewater for food crop irrigation provided evidence of infections disease transmission (Lund, 1980; Feachem et al, 1983; Shuval et al, 1986). Chemicals usually present in wastewater are also an important concern for reuse application especially for irrigation of food crops. The mechanisms of food crop contamination, by irrigation of reclaimed water may be either physical contamination, where evaporation and repeated irrigation may cause build up of contaminants on crops or uptake of the chemical constituents through roots from irrigation water or soil. Chemical constituents may also contaminate groundwater by percolation into the ground after the reuse applications such as irrigation and groundwater recharge. Chemicals are usually considered in two categories such as inorganics and organics. Concentrations of inorganic matters in reclaimed water depend on the source of wastewater and the degree of treatment. Residential use of water approximately adds about 300 mg/L of dissolved inorganic solids, although the added amount may change between 150 mg/L and 500 mg/L. Wastewater treatment can generally reduce many trace elements to acceptable levels for irrigation. The organic constituents in raw wastewater includes humic substances, fecal matter, kitchen wastes, detergents, oils, grease and other substances. Industrial and residential wastes can add considerable amount of synthetic organic compounds.

## **Using Reclaimed Municipal Wastewater for Irrigation**

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### **Abstract**

In this work, nonpotable reuse of reclaimed municipal wastewater was evaluated. Reclaimed wastewater quality criteria and treatment requirements according to different nonpotable reuse were investigated. Non potable reuse alternatives and applications in other countries were also considered. Characteristics of municipal wastewater of Konya were determined by analysing the samples in terms of sum parameters such as BOD, COD, TOC, TDS, nutrients N, P and heavy metals. Potential reuse alternatives of Konya municipal wastewater and treatment requirements according to various reuse purposes were evaluated.

### **Introduction**

The number of large cities is increasing. Although small communities can find the necessary water locally. Water demand of large cities are drawn from extensive drainage areas or aquifers. A lot of large cities have to draw waters from lower quality sources or from long distances. Furthermore, wastewater is discharged usually into a surface water source or to sea. Therefore, in order to prevent water quality degradation wastewaters should be treated properly prior to disposal.

Water supplied for cities are treated to comply with the requirements of potable use. However, potable use is only a fraction of the total daily water demand. The remaining fraction may be of lower quality. Usually water used for nonpotable purposes like irrigation are drawn from the same source of potable water. If reclaimed wastewater could be employed for nonpotable use, then the existing source could serve bigger population.

Various water use activities that reclaimed wastewater can be substituted for potable waters could be listed as urban, industrial, agricultural, recreational, habitat restoration, ground water recharge.

Urban use of reclaimed wastewater includes irrigation of parks, recreation areas, highway medians and shoulders, toilet flushing in commercial and public buildings. Reclaimed water is ideal for a lot of industries especially as cooling water, boiler-feed water and process water which always need not be in potable quality. Habitat restoration and recreational use of reclaimed water range from maintenance of landscape ponds, ornamental fountains to creation of marshland to serve as wildlife

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state water drainage (up to 300 mm) occurred with water supply at 85% of FC. Exceedance frequency of nitrogen uptake allowed to adjust more accurately the fertilizer rates and timing with studied situations. An environmentally oriented N-rate of 210 kg N/ha satisfied crop requirements in 75% of the years. Lowest fallow state N-leaching (below 2 kg N/ha) and maximum N uptake efficiency was achieved under any of these irrigation strategies and dressing of N-rate to 1/3 at sowing and 2/3 in the middle of development stage in 80% of the years when precipitation in the critical (15 July-15 September) period was less than 120mm.

3. Drainage-controlling irrigation treatment under non-limited fertilisation conditions reduced potential grain yield by 7-10% only in 12% of the years and N-uptake by 8-26 kg N/ha in 50% of them. This scenario saved irrigation water (up to 95mm/year) and reduced the drainage in medium wet to wet fallow states by 30-40% . An environmentally oriented N-rate of 200 kg N/ha under drainage controlling irrigation treatment was recommended. This rate would satisfy crop requirements and diminish fallow state N-leaching below 5 kg N/ha, if it is dressed 1/3 at sowing and 2/3 just before the most intensive crop uptake, in 75% of the years.

Obtained results should be confirmed with different technical and water application efficiency parameters of particular existing irrigation systems in Bulgaria. Small and frequent water application depths are possible only under stationary sprinkler irrigation and center pivot systems.

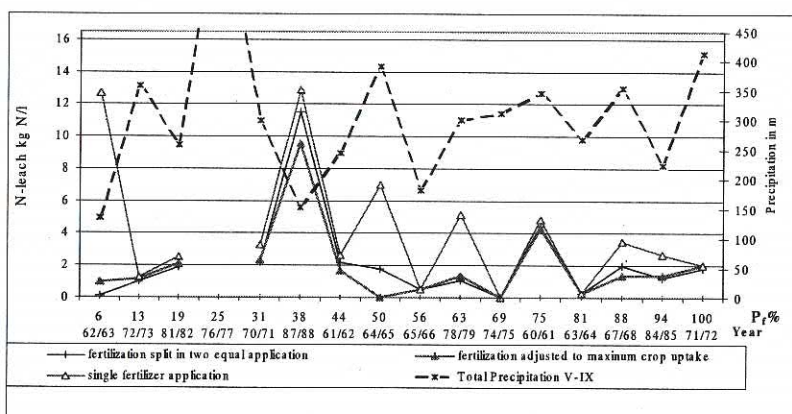
## Acknowledgements

We would like to thank Dr. Ghislain Gosse for securing financial support through INCO-COPERNICUS project ERBIC 15 CT 960101 on evaluation of risks and monitoring of nitrogen and pesticides fluxes at the crop level on the Romanian and Bulgarian plain of the fourth Framework Program of EC. We wish to thank Dr. Plamen Petkov, director of Research Institute of Irrigation and Drainage-Sofia, for the given possibility to work on four concrete lysimeters in the experimental field of Chelopechene for the purposes of this study.

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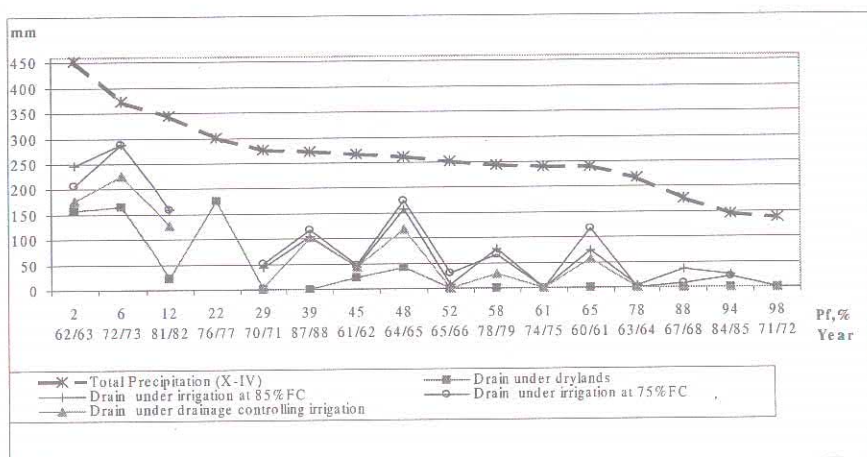
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Modeling of the soil-plant system by CERES-maize model was used. Adjusted and modified model was run with different crop growth strategies and thirty-year weather data. Scenario analyses proved that:

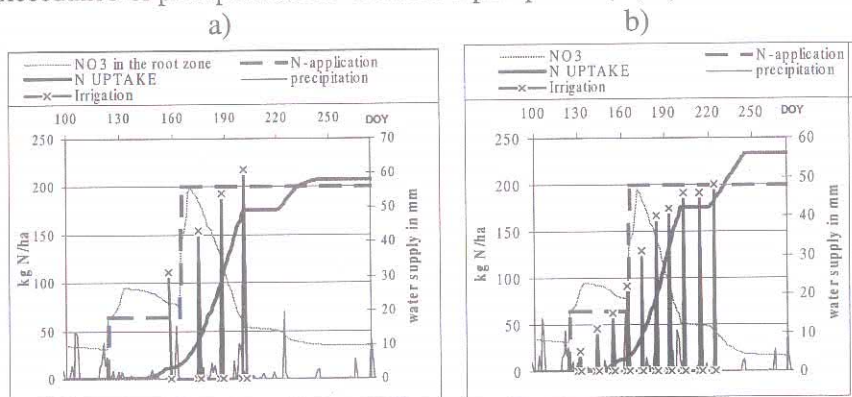


**Figure 6.** N-leach in fallow state resulted from simulations under irrigation at 85% FC and different fertilisation treatments ordered according to the probability of exceedance of "October-April" precipitation  $P_f$ , %

1. Grain yield and crop water/nitrogen uptake were severely affected on drylands under studied conditions. Drought indicators showed that irrigation was required in 70% of the years. The sensitivity of maize drylands' to precipitation in the critical (15 July – 15 September) period caused great variability of maize yield ( $C_v = 42\%$ ) and N-uptake ( $C_v = 25\%$ ) under non-limited fertilization conditions. In addition low vegetative precipitation proved to be a reason for fallow state leaching (up to 40 kg N/ha in the driest vegetation). Drainage below maize drylands varied from 0 to 62 mm in 97% of the vegetation seasons. Significant early seasonal N-losses (45.7 kg N/ha) were associated with precipitation extremes, that could potentially happen in the remaining 3% of the studied years, and single N-application of 200 kg N/ha at sowing. Such extreme loss could be halved by splitting N-rate and adjusting N-dressing to 1/3 of the total rate at sowing and the remaining 2/3 in the middle of development stage. The environmentally oriented rate of 170 kg N/ha satisfied crop requirements in 75% of the years under rainfed conditions.
2. Irrigation scheduling at 75 and 85% of field capacity (FC) under non-limited fertilisation conditions mitigated biological drought and significantly reduced year-to year variability of yield ( $C_v = 5.6-6\%$ ) and N-uptake ( $C_v = 5\%$ ). Highest fallow



**Figure 4.** Drainage in fallow state ordered according to the probability of exceedance of precipitation in “October-April” period (Pf,%)



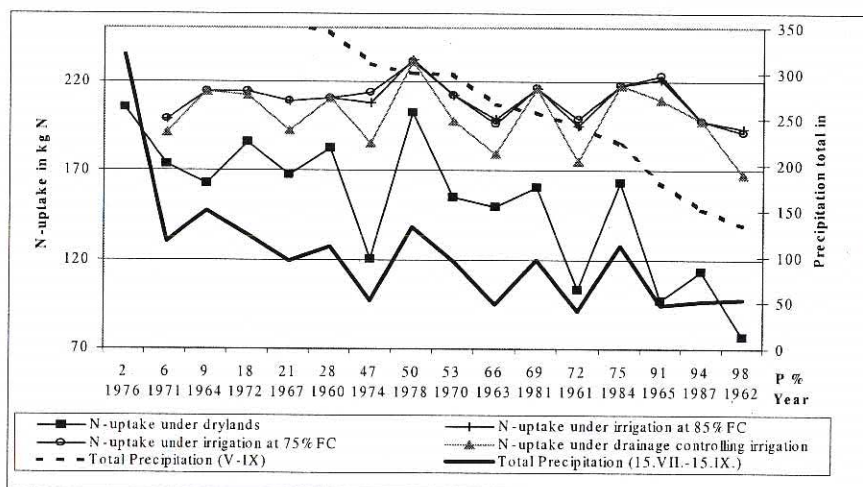
**Figure 5.** N-uptake and residual N simulated for the Day of the Year(DOY) after 1.1.1962 under adjusted split nitrogen application (1/3 at sowing and 2/3 in the middle of development stage) and two irrigation treatments: (a) drainage controlling irrigation (b) irrigation scheduling at 85% of FC.

## Conclusion

The long-term impact of irrigation scheduling and rates and timing of fertilization on water stress indicators, as evapotranspiration and productivity, nitrogen uptake and N-leaching was studied under maize on Chromic Luvisol (Sofia region).



coincide to the period of maximum crop uptake and irrigation scheduling of frequent and small water application depths (at 85% of FC) achieved maximal N-uptake efficiency and minimal N residual at the end of vegetation (fig.5-b). This strategy proved similar effect when precipitation the critical (15 July-15 September) period was less then 120mm. Obtained drainage and N-leaching should be conformed thought with different technical and water application efficiency parameters of particular existing irrigation systems in Bulgaria. Small and frequent water application depths are possible only under stationery sprinkler irrigation and center pivot systems.

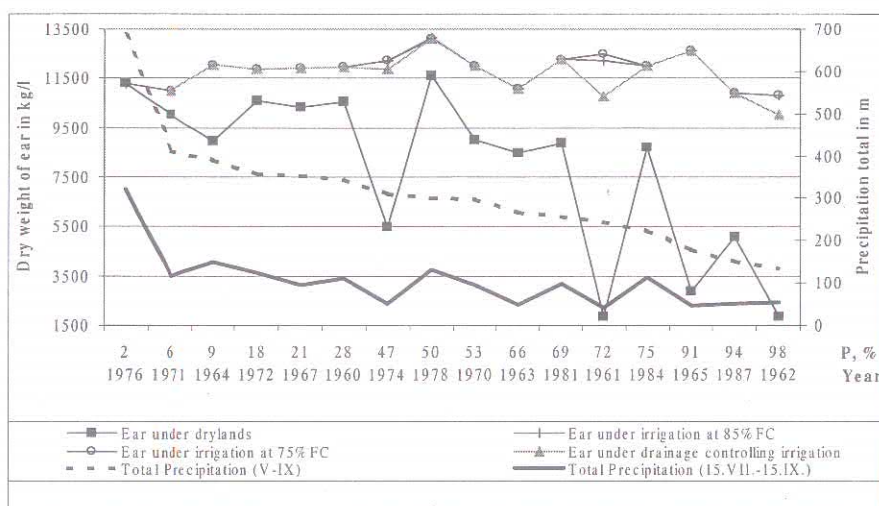


**Figure 3.** N-uptake with non-limited fertilisation and different irrigation scenarios ordered by the probability of exceedance (P, %) of precipitation for maize vegetation period (May-Sept).

Exceedance frequency of nitrogen uptake under non-limited fertilization conditions and different irrigation strategies (fig.3) was used to adjust more accurately the fertilizer rates and dressing time to the studied situations, soil and climate variability.

N-rate was evaluated to be 200 under drainage controlling irrigation treatment, 210 kg N/ha under other irrigation scenarios and 170 kg N/ha on drylands. These rates satisfied crop water requirements in 75% of the years. Stable productivity and best ground water protection from diffused N-leaching under maize fields could be achieved with N-dressing of the recommended rates 1/3 at sowing and 2/3 in the middle of development stage.

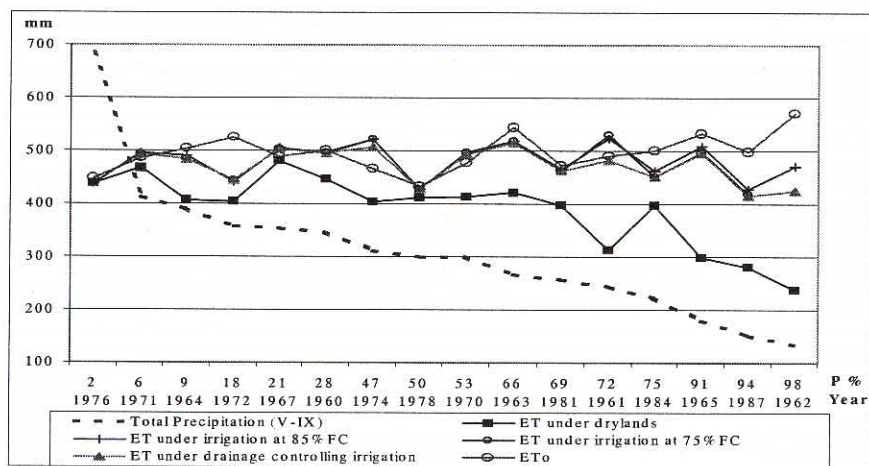
application scheduled at 75 and 85% of FC (fig.4). These irrigation treatments resulted in rise of available soil water at the end of vegetation and poor storage of possible post-vegetation precipitation. The drainage-controlling scenario saved irrigation water up to 95 mm/year by reducing drainage in medium wet to wet fallow states by 30-40% (Fig. 4). Obtained results should be conformed thought with different technical and water application efficiency parameters of particular existing irrigation systems in Bulgaria. Small and frequent water application depths are possible only under stationery sprinkler irrigation and center pivot systems.



**Figure 2.** Dry weights of ears under non-limited fertilization conditions and different irrigation scenarios dependent upon probability of exceedance of vegetation precipitation (P,%).

Highest early seasonal N-losses (45.7 kg N/ha/vegetation or up to 25% of the fertilization dose) were associated with single N-application treatment and precipitation extremes in 1976. Chances of such losses could be reduced to 23 kg N/ha/vegetation by applying the large N amount (2/3 of the total N) when the crop was well established in the middle of development stage. Low vegetative precipitation in 1962 (P=97% in fig.1 and fig.2) proved to be a reason for poor N-use by plants in drylands and leaching (40 kg N/ha or 20% of the total fertilization rate) during fallow state. Integrated management strategy of N-application timed to

in the studied soil-crop-climate combination. The sensitivity of rainfed maize to precipitation in the critical (15 July – 15 September) period caused great variability of maize yield ( $C_v = 42\%$  under non-limited fertilization) mostly in medium and dry years (Fig. 8). All tested irrigation scheduling mitigated drought and improved crop N-uptake efficiency. Variability of crop evapotranspiration (Fig.7), dry weights (Fig.8) and N-uptake (Fig.9) was significantly reduced ( $C_v = 5-6\%$ ). Precipitation in the critical “15-July to 15-September” period influenced not only drylands (in 97% of years in fig.8 and fig.9) but also N-uptake in half of the years under drainage controlling conditions (fig.9). Nevertheless yield associated with the latter strategy was practically reduced (by 7-10%) only in 12% of the years.



**Figure 1.** Totals (May-Sept) of reference surface evaporation ( $ET_0$ ) and crop evapotranspiration (ET) under non-limited fertilization conditions and different irrigation scenarios ordered by probability of exceedance of vegetation precipitation (P, %).

Drainage in vegetation ( $D_r$ ) that resulted from different simulated treatments and growing seasons varied from 0 to 98 mm in 97 % of the studied years (table 2). Exceptional early season precipitation events happened in the remaining 3% of the studied growing seasons and provoked 237 mm deep percolation (in 1976). Increased water application (I) in moderately dry and dry vegetation seasons resulted in larger quantity and increased variability of drainage over irrigation treatment. Fallow state water drainage varied from 0 to 300 mm in studied situations (Fig. 4). Higher fallow state water drainage occurred in case of water



irrigation scenarios and the studied conditions in average (1978), wet (1971) and dry (1987) maize vegetation seasons, which correspond to 50, 94 and 6% probability of exceedance of precipitation.

**Table 2.** Precipitation ( $P_r$ ), irrigation depth( $I$ ) and drainage resulted from CERES-maize simulations( $D_r$ ) in mm with different irrigation scenarios in the average(1978), wet(1971) and dry(1987) maize vegetation seasons.

Irrigation strategy	Average			Wet			Dry		
	$P_r$	$I$	$D_r$	$P_r$	$I$	$D_r$	$P_r$	$I$	$D_r$
Drylands		0	21.7		0	61.9		0	0.3
75% of FC		171	43.3		113	61.9		359	98.2
85% of FC		169	26.4		135	41.7		408	97.5
Drainage controlling	301	115	21.7	412	58	61.9	153	302	55.8

Each irrigation treatment was simulated with three different N-application scenario, one with a single fertilizer application (200 kg N/ha) in the spring, one with partial equal application at sowing and just before the period of maximum crop uptake and one with partial adjusted application: 1/3 of the total rate at sowing and 2/3 of it in the middle of development stage. Dates of sowing and duration of initial, development, mid season and late phenological phases (Doorenbos and Pruitt, 1984) of maize hybrid (FAO group 200-300) were found under local conditions on the grounds of the relationship between the sum of day-night effective temperatures and dates of germination, tasseling, milky and waxy ripening (Slavov, 1984).

CERES-maize simulations were performed for all treatments for representative 16 pairs of vegetation and post-vegetation seasons. They covered uniformly the whole range of precipitation totals over thirty years with probability of exceedance  $P(\%)$ :  $P=3-10\%$  (wet climate),  $P=20-30\%$  (moderately wet),  $P=43-53\%$  (medium),  $P=65-80\%$  (moderately dry),  $P=86-98\%$  (dry). Totals of water/N-uptake, N-leaching and dry weights calculated for each particular situation were sorted by probability of vegetative and post-vegetative precipitation sum. Simulated maize evapotranspiration was related to reference evaporation  $ET_o$ , calculated by Penman-Montaith eq. (Allen et al., 1998).

## Results and Discussions

Year-to-year differences between maize evapotranspiration resulted from CERES-maize simulation and reference surface evaporation  $ET_o$ (fig.7) and losses of ear dry weight on dry lands (fig.8) showed that irrigation was required in 70% of the years

characterized in terms of field capacity, saturated soil conductivity and texture in table 1.

Experimentally based data of water contents,  $N-NH_4$  and  $N-NO_3$  in the soil, dry weights and N-contents of the plant in irrigated and rainfed plots and lysimeters (INCO-COPERNICUS project final report, 1999), evapotranspiration and water fluxes (Popova and Shopova, 2001) proved acceptable agreement with model outputs after detailed calibration procedure (Popova et al 1999; Popova, Gabrielle, Leviel and Kercheva, 2001). Adjusted CERES-maize was used to evaluate the effect of different water and fertilizer application scenarios over a series of thirty independent growing seasons.

**Table 1.** Water retention capabilities, soil water conductivity at saturation ( $K_{sat}$ ) and soil texture, Chromic Luvisol, Chelopechene field.

Depth, cm	Field Capacity	$K_{sat}$	Soil texture classification	Soil particles, %		
	%w/w	cm/day		Clay <0,002 mm	Silt 0,002-0,05 mm	Sand 0,05-2,00 mm
0-28	20.05	93,30	clay loam	32	32	36
33-45	21.09	15,90	clay	43	27	30
61-71	20.75	20,20	clay	42	25	33
95-130	18.60	39.90	Sandy clay loam	24	15	61

Daily weather data for precipitation, maximum and minimum air temperature and solar radiation were provided from references (Meteorological annual and monthly references 1960-1984) and weather station of N.Poushkarov Soil science Institute (for the period 1985-1989). Four water supply treatments were considered in the analyses, one under rainfed conditions and three with varied irrigation application. Irrigation depths and timing in the different irrigation application strategies were determined by CROPWAT program (Smith,1992). The data for Kc-factors were determined for Bulgarian weather conditions (Popova and Feyen, 1996). This input for the CROPWAT program was constant for all runs of the program.

Water application in initial, development, and mid season growth stages was triggered at any day that soil water content fell to 75% of field capacity (FC) with one irrigation scenario and respectively 85% of FC with another one. These trigger points occurred respectively at 20% and 40% depletion of total available soil water in the root zone. Water application was scheduled in Late season whenever 80% of available water was depleted. Application depth was set equal to the depleted soil water in the root zone. The third drainage controlling scenario was developed on the basis of 75-80% of the required irrigation depth by satisfying predominantly the initial and the most sensible phases of maize development (Varlev et al.1995). Table 2 presents precipitation ( $P_r$ ) and irrigation rate ( $I$ ) under the different

## **Integrated Strategies for Maize Irrigation and Fertilization under Water Scarcity and Environment Pressure in Bulgaria**

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### **Abstract**

Integrated management of irrigation and fertilization could meet global increasing demand of maize production and environmental pressures under water scarcity. The objective of this paper was to evaluate the long-term impact of irrigation scheduling and rates and timing of fertilization on water stress, nitrogen uptake and leaching under maize on Chromic Luvisol (Sofia region). Modeling of the soil-plant system by CERES-maize model was used. Adjusted and modified CERES-maize was run with different irrigation and fertilization scenarios and thirty-year weather data. Scenario analyses proved that yield and N-uptake were severely affected on drylands under studied conditions. Drought indicators showed that irrigation was required in 70% of the years. The sensitivity of maize drylands to precipitation in the critical (15 July – 15 September) period caused great variability of maize yield ( $C_v = 42\%$ ) and N-uptake ( $C_v = 25\%$ ) under non-limited fertilization conditions. In addition low vegetative precipitation proved to be a reason for fallow state leaching on drylands. All tested irrigation scheduling improved N uptake efficiency, mitigated drought and significantly reduced yield and N-uptake variability ( $C_v = 5-6\%$ ). Integrated management strategy of N-application timed to coincide to the period of maximum crop uptake and irrigation scheduled at 85% of field capacity reduced N available for leaching. A drainage-controlling scenario, developed on 75-80% of the required irrigation depth and satisfying predominantly the most sensitive phases of maize development, saved water up to 95 mm/year and reduced drainage in medium wet to wet fallow states by 30-40%. Significant early seasonal N-losses (25% of applied nitrogen) were associated with precipitation extremes and poor N-dressing and could happen in 3% of the years. Exceedance frequency of nitrogen uptake under different irrigation strategies was used to adjust fertilizer rates and timing.

### **Materials and Methods.**

Modeling of the Soil-Plant System was used in this analysis. North American model Crop-Environment Resource Synthesis CERES-maize model (Jones&Kiniry, 1986; Gabrielle et al 1995 and Gabriel et al 1996) had been calibrated, modified and validated on the basis of specific experiments carried out on Chromic Luvisol in Chelopechene field, Sofia region. Soil conditions are



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## Acknowledgement

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**Table 3.** The Effects of 55-day Incubation on Ammonium ( $\text{NH}_4^+\text{-N}$ ) Contents ( $\text{mg kg}^{-1}$ ) of Soils.

	days of measurement				
	0	13 <sup>th</sup>	27 <sup>th</sup>	41 <sup>st</sup>	55 <sup>th</sup>
Doğancı	7	24	32	77	26
Geçitkale	14	19	16	29	21
Akdeniz	12	34	26	26	30
Balıkesir	24	22	19	44	25
Pamuklu	8	27	20	25	24
Zümrütköy	56	30	17	52	18
Türkmenköy	20	21	30	31	23

The soil nitrate contents were reduced as function of time in accordance with denitrification losses ( $\text{N}_2$  and  $\text{N}_2\text{O}$ ). In the Geçitkale, Akdeniz and Zümrütköy, the increments were significantly higher ( $P=0.05$ ). Ammonium contents showed relatively lower values than the nitrate contents due to the enrichment by nitrate-N in the beginning of experiment.

### Conclusion

The incubation study for the determination of the denitrification potentials of the widely distributed soil series of the Turkish Republic of Northern Cyprus (TRNC) related that soils with similar mineral N contents prior the incubation, the N losses ( $\text{N}_2\text{-N}+\text{N}_2\text{O-N}$ ) following  $\text{NO}_3\text{-N}$  fertilization were significantly differing from each other.  $\text{CO}_2$  production and  $\text{O}_2$  consumption also showed significant flux differences related both to amount and time. Moreover, great amounts of denitrification losses occurred with the presence molecular  $\text{O}_2$ . Significant differences both in denitrification and biological activity parameters should be most probably due to varying of soil properties, which also affected the biological properties as well. Abou Seada and Ottow (1988) suggested that denitrification losses are more closely related to waters soluble organic matter than the total organic matter content of the soil. Additionally, the presences of  $\text{O}_2$  along with mineralizable organic matter content are also important factors for the denitrification losses (Gök and Ottow, 1988). Results revealed that the determinations of present and potential denitrification losses are very important factors for fertilizer consumption and environmental pollution (degradation of ozone layer!).

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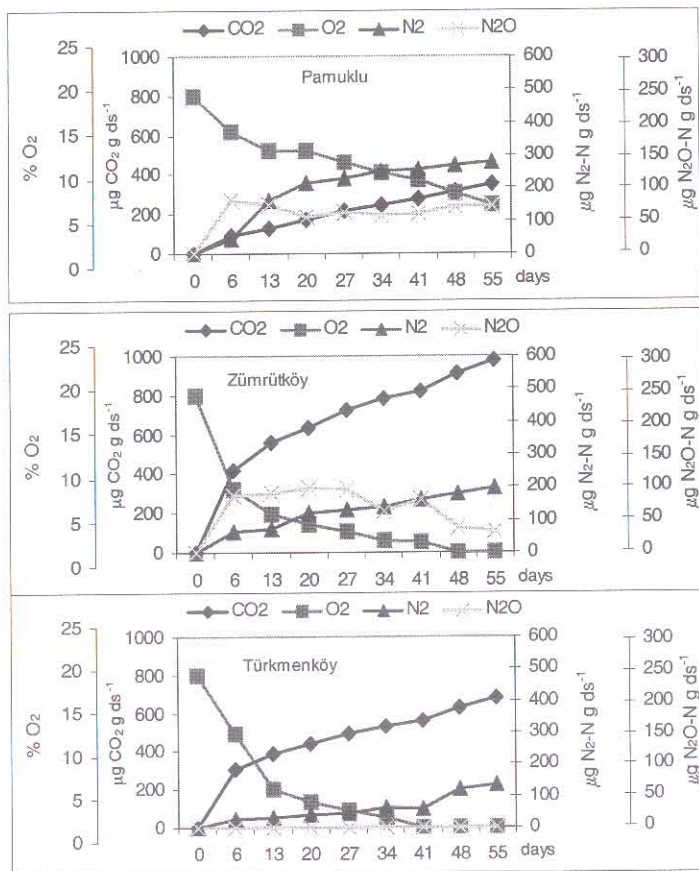
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increased rapidly; it was not significant ( $P=0,05$ ). The  $\text{CO}_2$  values on the last measurement were 257, 445, 510, 745, 347, 974 and 676  $\mu\text{g CO}_2/\text{g dry soil}$  for Doğancı, Geçtikale, Akdeniz, Balıkesir, Pamuklu, Zümrütköy and Türkmenköy soil series, respectively.

Results showed that the most of the denitrification products consisted  $\text{N}_2$ . The highest  $\text{N}_2$  was measured in Balıkesir series (498  $\mu\text{g N}_2\text{-N g ds}^{-1}$ ) where as the lowest was in 136  $\mu\text{g N}_2\text{-N g ds}^{-1}$  in Turkmenköy.

The lowest  $\text{N}_2\text{O-N}$  values were 0.7 and 0.4  $\mu\text{g N}_2\text{-$

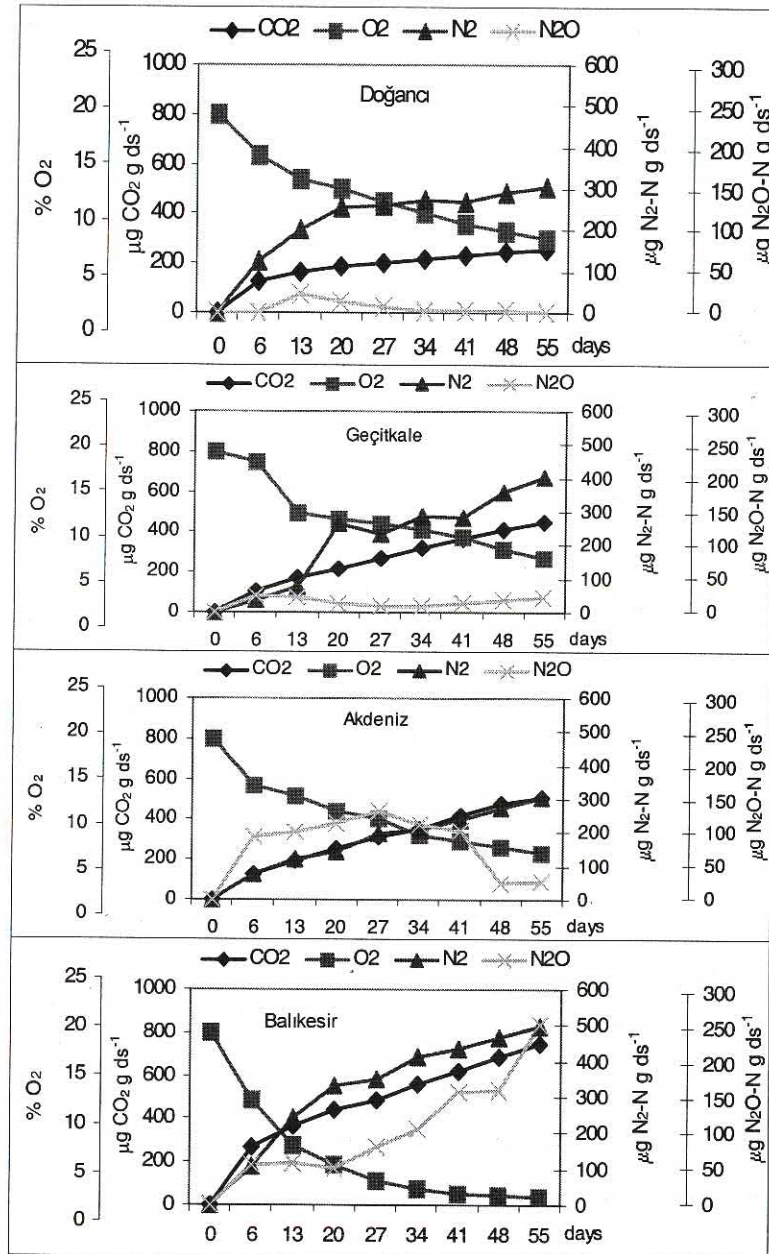




**Figure 1b.** Fluxes of O<sub>2</sub>, CO<sub>2</sub>, N<sub>2</sub>, N<sub>2</sub>O for the soil series of pamuklu, zümrütköy, türkmenköy through 55-day incubation.

Results revealed that, the initial 20% oxygen was reduced in all soil series as a function of time. Therefore, in Balıkesir, Zümrütköy and Türkmenköy, oxygen consumption was significantly higher ( $P=0.05$ ) than the other series. The measured oxygene percentage of Türkmenköy and Zümrütköy were decreased considerable in 13<sup>th</sup> measurement day and reached 0% in Türkmenköy on 41<sup>st</sup> day whereas Zümrütköy on 48<sup>th</sup>. In the last measurement, oxygen percentage of the series of Doğançıl, Geçitkale, Akdeniz and Pamuklu were 7.5%, 6.6%, 5.8% and 6.2%, respectively.

The CO<sub>2</sub> fluxes in Balıkesir, Türkmenköy and Zümrütköy were significantly higher than the others, in accordance with O<sub>2</sub> consumption. Although, the measured CO<sub>2</sub> fluxes in Doğançıl Geçitkale, Akdeniz and Pamuklu were



**Figure 1a.** Fluxes of O<sub>2</sub>, CO<sub>2</sub>, N<sub>2</sub>, N<sub>2</sub>O for the soil series of doğancı, geçitkale, akdeniz, balıkesir through 55-day incubation.

source. Fertilization with high levels of N ( $300 \text{ kg of N ha}^{-1}$ ) positively affected on the occurrence and amounts of the diazotrophic bacteria (Junior et. al, 2000). Low N use efficiency and high nitrate pollution potentials are the major problems in intensive agricultural production systems. Losses the denitrification in suitable condition accounted for ~25% of the applied nitrogen (Jackson et. al., 1994). Freney et. al. (1992) reported that, the use of an inhibitor for limiting nitrification, prevents nitrogen loss by denitrification, increases grain N and resulted in a 46% greater recovery of applied nitrogen in the plant-soil system at harvest. The aim of the research was to determine the denitrification capacity of widely distributed TRNC soils.

## Material and Methods

Some of physical and chemical properties of the sub soils (0-20 cm) of selected soil series were given in Table 1.

**Table 1.** Some Chemical and Physical Properties of the Soils.

Soil series	Sand	Clay	Loam	Texture	CaCO <sub>3</sub>	pH	organic matter	Salt	N <sub>min</sub>
	%			Class	(%)	(1:1 H <sub>2</sub> O)	(%)	(%)	mg kg <sup>-1</sup>
Doğancı	46.4	20.2	33.4	SCL	2.3	7.7	1.15	0.054	17.0
Geçitkale	27.2	43.0	29.8	CL	25.4	7.7	1.67	0.070	50.2
Akdeniz	76.3	11.7	12.1	SL	14.3	8.0	2.27	0.022	26.5
Balıkesir	26.6	39.3	34.1	CL	21.3	8.1	2.61	0.147	57.5
Pamuklu	41.2	24.0	34.8	CL	24.3	7.9	1.74	0.042	14.8
Zümrütköy	44.7	26.6	28.7	CL	5.8	8.0	2.43	0.096	64.5
Türkmenköy	33.6	30.0	36.4	CL	11.3	8.0	2.05	0.129	39.1

The selected soil samples were placed into anaerobic jars as soon as set to field capacity and enriched by  $300 \text{ mg NO}_3^- \text{-N kg}^{-1} \text{ dry soil}^{-1}$ . The atmosphere of the jar was adjusted for 20% oxygen and 80% helium (v/v). Samples incubated at  $30^\circ \text{C}$  for 55 days. The atmosphere of the jar was analyzed by gas chromatography (Hewlett Packard GC 5890) equipped with ECD (Electron Capture Detector) and TCD (Thermal Conductivity Detector). The gases of  $\text{CO}_2$  and  $\text{O}_2$  were measured using TCD ( $200^\circ \text{C}$  detector,  $54^\circ \text{C}$  oven and  $60^\circ \text{C}$  injector temperatures) whereas  $\text{N}_2$  and  $\text{N}_2\text{O}$  were measured by ECD ( $300^\circ \text{C}$  detector,  $54^\circ \text{C}$  oven and  $60^\circ \text{C}$  injector temperatures) (Benckiser, 1995). One parallel of the jars quashed on every other sampling day and the soils were analyzed for their nitrate (Fabig et. al., 1978) and ammonium (Deutsche Einheitsverfahren, 1983) contents.

## Results

### Oxygen Consumption and $\text{CO}_2$ , $\text{N}_2$ , $\text{N}_2\text{O}$ Fluxes

The effects of 55-day incubation on the gases of  $\text{O}_2$ ,  $\text{CO}_2$ ,  $\text{N}_2$  and  $\text{N}_2\text{O}$  for the soil series of Doğancı, eçitkale, Akdeniz, Balıkesir, Pamuklu, Zümrütköy, Türkmenköy were given in Figure 1a and 1b.



## **Determination of Denitrification Capacity of the Widely Distributed Soil Series of the Turkish Republic of Northern Cyprus (TRNC)**

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### **Abstract**

A laboratory experiment was carried out to determine the denitrification capacity of the Doğanç, Geçitkale, Akdeniz, Balıkesir, Pamuklu, Zümrütköy and Türkmenköy that are widely distributed soil series of Turkish Republic of Northern Cyprus. Soils are placed in anaerobic jars (20% initial O<sub>2</sub>, 80% He) with addition of 300 mg kg<sup>-1</sup> NO<sub>3</sub><sup>-</sup>-N. Produced gases (CO<sub>2</sub>, N<sub>2</sub> and N<sub>2</sub>O) along with O<sub>2</sub> consumption were determined by gas chromatography. Moreover, ammonium and nitrate concentration of the soils were measured at regular intervals.

The measured O<sub>2</sub> consumption and CO<sub>2</sub> production values as parameters of biological activities, revealed considerable differences among the soil series studied. The more rapid O<sub>2</sub> consumption and the higher CO<sub>2</sub> production were determined in Balıkesir, Zümrütköy and Türkmenköy soil series. Furthermore, O<sub>2</sub> level in the anaerobic jar was immediately dropped in early measurement intervals and was about 0% at the end of the last measurement, particularly above mentioned soil series. The Zümrütköy soil series has higher CO<sub>2</sub> production in all measurement periods than the others and reached 975 µg CO<sub>2</sub> g dry soil<sup>-1</sup>, at the end of experiment where others vary from 257 to 745. The measurements of N<sub>2</sub>O and N<sub>2</sub> gases revealed that the most of the denitrification product consists of N<sub>2</sub>. Additionally, the highest N<sub>2</sub>O and N<sub>2</sub> productions were determined in the Balıkesir series with 251 µg N<sub>2</sub>O-N g dry soil<sup>-1</sup> and 498 µg N<sub>2</sub>-N g dry soil<sup>-1</sup>. When all series compared, there were significant differences for the production of N<sub>2</sub> and N<sub>2</sub>O production.

Nitrate and ammonium analyses measured in relation to time, ammonium content was similar in all series, however, nitrate content significantly decreased according to the measurement period.

### **Introduction**

Efficient use of nitrogen fertilizer requires well understanding of nitrogen dynamics in the soil. Due to the many loss pathways, applied nitrogen fertilizer did not effectively used by plants. One of the major nitrogen losses progress, denitrification results economical and environmental impacts. The denitrification products, nitrous oxides, are effective as a "green house" and contribute to the formulation of tropospheric ozone (Barrow, 1994; Gök, 1988). Denitrification, therefore, occurs in many soil conditions, stimulated by nitrate and water contents of soil, temperature and insufficient oxygen diffusion (Gök et al., 1999; Boşgelmez et. al., 2001). The nitrogen fertilizers could easily convert to nitrate due to the nitrification progress and thus, denitrification would be triggered even in the case of utilization of ammonium as a nitrogen

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garbage compost had showed the lowest effect on C/N ratio. Mineralization rates of organic wastes added into the soil and amount of the released inorganic nitrogen amount were found to be inter related with C/N ratios of the organic wastes. When the C/N ratio of the organic wastes were high, mineralization process took longer time, whereas the C/N ratio of the organic wastes were low, mineralization took place in shorter times. The amount of mineral nitrogen released into the soil is higher as the mineralization process is realised in short time (Akalan, 1983; Gür, 1987; Zengin et al., 1999). In this work, it was found that there was a negative and significant correlation between the rate of nitrogen mineralization rates and the C/N ratios of the organic wastes added into the soil samples (Table 2).

**Table 4.** Effects of kind and doses of organic wastes on C/N ratio of the soil (n=3).

Kind/Level		Incubation Periods (days)													
		0		4		8		12		16		32		45	
GC	1	15.13	c	21.38	c	44.27	b	18.59	c	21.22	c	23.84	b	51.26	b
	2	38.13	b	35.73	b	33.45	b	25.70	b	67.86	a	23.23	b	71.27	a
	3	53.84	a	65.05	a	83.14	a	36.64	a	28.02	b	43.28	a	54.90	b
	Mean	35.70		40.72		53.60		26.98		39.03		30.12		59.14	
MC	1	15.13	c	21.38	b	44.27	b	18.59	c	21.22	b	23.84	b	51.26	a
	2	50.70	b	32.63	a	39.26	b	33.09	b	26.39	b	27.11	ab	29.86	b
	3	67.44	a	30.78	a	71.88	a	38.66	a	61.62	a	27.71	a	27.77	b
	Mean	44.42		28.26		51.80		30.11		36.41		26.22		36.30	
CM	1	15.13	b	21.38	a	44.27	a	18.59	c	21.22	b	23.84	a	51.26	a
	2	27.26	a	11.51	b	28.70	a	44.75	b	27.70	a	15.42	b	19.59	b
	3	33.25	a	16.78	ab	28.64	a	54.93	a	23.61	b	22.55	a	24.54	b
	Mean	25.22		16.56		33.87		39.42		24.18		20.60		31.80	
CNM	1	15.13	b	21.38	a	44.27	b	18.59	c	21.22	c	23.84	a	51.26	a
	2	33.32	a	10.66	b	84.37	a	36.07	a	29.24	b	19.26	b	19.50	b
	3	38.48	a	16.47	ab	55.49	b	25.55	b	49.01	a	13.55	c	24.94	b
	Mean	25.98		16.17		61.38		26.74		33.16		18.89		3190	
MS	1	15.13	b	21.38	a	44.27	a	18.59	b	21.22	b	23.84	a	51.26	a
	2	21.94	ab	9.71	b	51.32	a	25.18	a	32.02	a	11.68	b	20.01	b
	3	25.05	a	11.66	b	27.82	b	18.62	b	27.12	ab	11.72	b	12.98	c
	Mean	20.71		14.25		41.14		20.80		26.79		15.75		28.08	

Within a column, mean values followed by the same letter were not statistically different at the 5 % level.

According to the results, the effect of municipal sludge amendment upon the nitrogen mineralization was found to be higher than that of the other organic wastes used whereas the garbage compost had the lower effects upon the nitrogen mineralization. The same pat way was accomplished also for the interactions between C/N ratio and the nitrogen mineralization in the soil samples.



## Effect of Organic Wastes on C/N Ratio of the Soil

The effects of organic wastes on C/N ratio of soil were found significant statistically ( $P < 0.05$ ) in all of the incubation periods. In addition, the effect of garbage compost increased until 8. day but decreased at 12. day, and then increased until end of the incubation period. Some of the other organic wastes (mushroom compost, cattle manure, chicken manure and municipal sludge) increased but some of the others decreased C/N ratio of the soil. This increasing and decreasing changed depends upon the duration's incubation period. The highest (i.e. 59.14) effect on C/N ratio, among the organic wastes, was accomplished with garbage compost. Then it was followed by the mushroom compost (36.30), chicken manure (31.90), cattle manure (31.80) and municipal sludge (28.08), respectively (Table 4).

**Table 3.** Effects of kind and doses of organic wastes on mineral nitrogen contents of the soil (n=3).

Kind/Level		Incubation Periods (days)						
		0	4	8	12	16	32	45
GC	1	266.84	100.09b	85.84c	216.09b	204.35b	160.70c	100.26b
	2	189.38	128.92a	191.89a	307.63a	81.29c	317.93a	126.84b
	3	195.03	116.08b	128.87b	272.51a	248.84a	219.13b	212.46a
	Mean	217.10	115.03	135.50	265.40	178.20	232.60	144.50
MC	1	266.84	100.09c	85.84c	216.09c	204.35a	160.70c	100.26c
	2	176.18	190.23b	225.05a	275.55b	207.74a	278.27b	398.23b
	3	171.78	318.66a	148.86b	324.25a	195.77a	441.75a	491.96a
	Mean	204.90	203.00	153.20	272.00	202.62	293.60	330.20
CM	1	266.84	100.09b	85.84c	216.09a	204.35b	160.70c	100.26b
	2	213.08	358.40a	229.28b	180.73b	215.65b	448.01a	479.96a
	3	243.14	351.86a	261.74a	176.76b	360.84a	377.05b	477.72a
	Mean	241.00	270.10	192.30	191.20	260.30	328.60	352.60
CNM	1	266.84	100.09c	85.84b	216.09b	204.35b	160.70c	100.26c
	2	192.31	388.69a	83.02b	215.39b	238.90a	358.27b	502.77a
	3	180.33	338.05b	118.52a	356.32a	180.64c	561.41a	452.42b
	Mean	213.20	275.60	95.80	262.60	208.00	360.10	351.80
MS	1	266.84	100.09c	85.84c	216.09c	204.35b	160.70c	100.26c
	2	256.33	427.46b	123.93b	308.09b	211.80b	549.58b	504.74b
	3	260.73	529.72a	254.68a	487.19a	240.03a	737.41a	859.40a
	Mean	261.30	352.40	154.80	337.10	218.73	482.60	488.00

Within a column, mean values followed by the same letter were not statistically different at the 5 % level.

The effects of organic wastes' 'kindXlevels' interaction on C/N ratio was found significant statistically ( $P < 0.05$ ) at all the incubation period. The C/N ratio increased as the levels of the organic wastes increased, too. The highest value was determined with the municipal of chicken manure (3 t da<sup>-1</sup>) at the 8. day of incubation period. Furthermore, it was found that organic carbon content of the soil showed fluctuations with the changes in the C/N ratio of the organic wastes added into the soil.

On the other hand, C/N ratio of soil changed depending on kinds of organic wastes. The municipal sludge has showed the highest effect on C/N ratio, while

This research was planned and conducted according to the factorial experimental design of '1X5X3X3: soilXorganic wasteXdoseXreplication' with 45 pots. Organic wastes were applied at the levels of 0, 3 and 6 t da<sup>-1</sup> into the pots containing 500 g of oven dry soil. Then, the soil samples were at watered 70 % of the field capacity and incubated at 28 °C for 45 days. The soil water content was kept steady during the incubation period. Nitrogen mineralization rates and organic carbon contents were determined at the periods of 0, 4, 8, 12, 16, 32 and 45 days of the experiment.

**Table2.** Some physical and chemical properties of the organic wastes (Çetin, 2001).

	Garbage Compost	Mushroom Compost	Cattle Manure	Chicken Manure	Municipal Sludge
Water content (%)	5.41	7.70	6.05	19.29	7.30
pH	7.24	7.02	7.89	8.01	6.45
EC (µmhos cm <sup>-1</sup> )	8467	5970	5700	7160	3807
Org. C (%)	34.16	35.55	26.34	29.74	25.94
N (%)	2.52	2.11	1.49	2.05	0.82
C/N	13.57	16.90	17.72	14.51	31.90
P (ppm)	8549.67	5298.61	7076.39	24429.66	8091.17
K (ppm)	19667.06	21187.93	25606.35	28701.41	12939.42
Ca (ppm)	35500.71	24608.83	30298.11	92226.85	42379.18
Mg (ppm)	9650.70	4869.85	9105.10	8751.60	9636.61
Na (ppm)	6590.05	1393.57	3702.99	3031.56	1151.00

## Results and Discussions

### Effect of Organic Wastes on Mineral Nitrogen Contents of the Soil

The effects of organic wastes on the nitrogen mineralization rate showed significant fluctuations depending upon the incubation period ( $P < 0.05$ ). The highest mineralization value (488.00 ppm) was determined with the municipal sludge and it was followed by the cattle manure (352.60 ppm), chicken manure (351.80 ppm) mushroom compost (330.20 ppm) and garbage compost (144.50 ppm), respectively (Table 3). In addition, it was found that there was positive correlation ( $P < 0.05$ ) between the rate of nitrogen mineralization at the amounts of the organic wastes added. On the other hand, although the amounts of nitrogen mineralized decreased at the intervals of 8 and 16 days temporarily, then it carried on to increase for the rest of the incubation periods.

The highest levels of the nitrogen mineralized with the addition of the garbage compost was achieved at the end of the 12 days of the incubation period whereas it was accomplished with the amendments of mushroom compost, cattle and chicken manure and municipal sludge at the 35 days of the incubation.

by applications of barnyard manure, compost, various organic wastes and green fertilisers (Akalan, 1983).

The aim of this work was to determine the effects of different organic wastes on nitrogen mineralization and organic carbon contents of a soil under the laboratory conditions.

## Material and Methods

This study was conducted with a sandy clay loam soil taken from (0-20 cm depth) the research area of Agricultural Faculty of Selcuk University. Soil samples were sieved to pass 2 mm mesh, and mixed homogenously. Some physical and chemical properties of the soil were given in Table 1. The soil was characterized as sandy clay loam texture with a high pH (8.20). Organic matter and calcium carbonate contents of the soil were 0.53 % and 25.67 %, respectively.

**Table1.** Some physical and chemical properties of the soil (Çetin, 2001).

Soil Properties	Values
Clay (%)	21.53
Silt (%)	22.07
Sand (%)	56.40
Texture class	Sandy clay loam
pH (1:2,5 soil : distilled water)	8.2
ECx10 <sup>6</sup> (25 °C) (1:5 soil : distilled water)	148
Organic matter (%)	0.53
CaCO <sub>3</sub> (%)	25.67
Field capacity (%)	23.80
Total nitrogen (ppm)	12.62
Phosphorus (P <sub>2</sub> O <sub>5</sub> ) (ppm)	2.97
Potassium (ppm)	16.71
Sodium (ppm)	27.78
Calcium (ppm)	6.58
Magnesium (ppm)	18.92

Garbage compost (GC), mushroom compost (MC), cattle manure (CM), chicken manure (CNM) and municipal sludge (MS) were used as the organic wastes in this research. Some properties of the organic wastes used are given in Table 2.

The soil properties that were determined are as follows: texture (Bouyoucos, 1951), field capacity (Demiralay, 1977), pH and EC (Richard, 1954), CaCO<sub>3</sub> % (Hızalan and Ünal, 1966), Total nitrogen, ammonium nitrogen and nitrate nitrogen (Bremner, 1965), available phosphorus (Olsen et. al., 1954), organic matter (Smith and Weldon, 1941), potassium, sodium, calcium and magnesium (Bayraklı, 1987). The statistical analyses of the data were performed by MINITAB 12.1 computer packet program (Anonymous, 1985) and Duncan Test was realised (Düzgüneş et al., 1987).



## **Effect of Different Organic Wastes on Nitrogen Mineralization and Organic Carbon Contents of Soil**

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### **Abstract**

In this research, the effects of various organic residues on nitrogen mineralization and organic C content of the soil were investigated. For this purpose, mushroom and garbage composts, cattle and chicken manures and municipal sludge were used as organic wastes. This study was conducted as a pot experiment under laboratory conditions with a sandy clay loam soil. The organic wastes (0, 3 and 6 ton/da) were added into each pot and were incubated at 28 °C for 45 days. The soils were watered at 70 % of the field capacity. In the soil samples,  $\text{NH}_4\text{-N}$ ,  $\text{NO}_3\text{-N}$  and C/N rate were measured after 0, 4, 8, 12, 16, 32 and 45 days of the incubation period. According to the results, maximum nitrogen mineralization value was determined after 12 days of the incubation period in the soil treated with garbage compost. On the other hand, mushroom compost, farm manure, chicken manure and sludge gave the high nitrogen mineralization values after 35 days of incubation. The soil organic carbon content showed fluctuations in relation to C/N rates of added organic residues. In addition, the effects of the organic residues on the fluctuations in the nitrogen mineralization and organic C contents of the soil were found to be significant ( $p<0.05$ ).

**Key Words:** Nitrogen mineralization, organic carbon, garbage compost, mushroom compost, farm manure, chicken manure, municipal sludge.

### **Introduction**

Soil is a complex system composed of organic and inorganic matters and where plants are growing and micro-macro organisms are living. Organic matter in the soil contains died biological matters and 10-15 % vegetable and animal micro organisms.

Organic matter includes some plant nutrition such as nitrogen, phosphorus and potassium. In addition, it is used as biological manure and improves the properties of soil. Some organic materials like municipal sludge prevent environment pollution and as well as supply some plant nutrition (Kacar, 1984; Güzel, 1985; Gür, 1987; Zengin et al., 1999).

Organic matter is added into the soil to minimize the nitrogen lost in soil by means of leaching and denitrification and as well as to improve the physical and chemical properties of the soil. Organic material addition into the soil is done

In summary, proponents of fuel ethanol programmes point out to the overall social and economic benefits that are produced. These include:

- A reduced dependence on imports of foreign oil;
- Alternative market opportunities for agricultural crops;
- Rural economic development including job creation and increased rural income;
- Environmental benefits (reduced emissions of carbon dioxide, carbon monoxide emissions and ozone-causing gases);
- The displacement of dangerous and environmentally damaging components in gasoline, such as benzene and MTBE;
- The replacement of fossil fuel with renewable fuel; and
- The removal of concerns about environmental hazards associated with exploration of fossil fuels and with tanker movements of imported oil (LMC Report, 2002).

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a higher price for feedstock. It should be noted at this point that most of the newly created jobs, while they do occur in the farm belt, are non-farm jobs. However, many of the other jobs are tied directly to the farm sector, including manufacturing and selling seed, fertilizer, machinery purchases, repairs, and soon. In addition, a boost in farm income will result in an increase in non-farm goods and services as disposable income rises (Evans, 1997).

c) Increase in jobs due to operating biofuel plants: Using the industry estimate of 1 employee per 1 million liter per year plant capacity. The multiplier for food manufacturing averages is 2.77, which would generate a total of more than 3,000 additional jobs in Turkey given the fact that Turkey replaces its 10% of transportation fuel with biofuels. Effect on GDP would be very considerable.

d) Decline in budget deficit: The rise in increased tax revenues because of a higher level of GDP, minus the drop in unemployment benefits, minus the subsidy paid to gasoline refiners and blenders (Evans, 1997).

e) Improvement in foreign trade balance: The increased reliance on domestic sources of motor fuel reduces the dependence of the Turkish economy on foreign energy sources. This would give Turkey a strategic advantage in world politics.

## **Conclusion**

Turkey is a net importer of animal protein, which can be replaced with supply of feedstock by-products of corn and wheat. Ethanol is mainly produced from three different sources of feedstock: sugar based (sugar cane, sugar beet, molasses, food-processing liquors), starch based (corn, wheat, barley, potato, rice, etc.), and lignocellulosic based biomass (paper and wood waste). Major feedstocks used in ethanol production in the World today are corn, sugar, and wheat. Turkey is one of the world's major wheat exporters (MoAgriculture, website). Therefore, wheat is the most likely feedstock for ethanol production with 817.000 tones net export in year 2000. Economically, using wheat for ethanol production makes more sense, as it is the cheapest raw material with higher starch content. Other most likely feedstocks are sugar beet and barley. With Turkey's new Sugar Law in effect in September 2002, there will be surpluses of sugar beet, which can also be used for ethanol production. However, production costs of biofuels are still more expensive compared to gasoline and, therefore, it needs tax incentive or subsidies in order to promote production. Excluding Brazil, almost all countries in the world producing ethanol has some sort of tax credit system.



oil and gasoline prices soared, fuel users began to look for alternatives. Brazil, as the world's third most energy dependant country, in 1974 launched the world's first major ethanol program (proalcohol) for production of renewable fuels. The implementation of the program was based on several key factors as energy independence, currency savings as well as political reasons. Sugar from cane is the major feedstock use in Brazil. Besides reducing dependency on foreign oil Brazil's program was aid to support agriculture community. Today, Brazil is the biggest producer of ethanol in the world with 12.5 million liter, followed by USA with 7.1 million liter in 2001.

As seen in Table1, Turkey heavily depends on foreign oil. Approximately 86% of Turkey's oil demand is imported. Biofuels are an alternative to reduce oil imported countries trade deficits. It might be possible to establish a local industry to substitute for some portion of approximately 23 million tons of petroleum that Turkey currently import each year to meet its energy needs. Biofuels are produced domestically; they also provide the opportunity for local, regional, and national energy self-sufficiency across the Turkey. Turkey's agricultural community will stand to benefit as well when biofuels are made from crops and agricultural residues, providing options for new valuable crops and new uses for existing crops and residues (MoEnergy and Natural Resources web site, 2002).

**Table 1.** Turkey`s oil demand (tons)

	1996	1997	1998	1999	2000
Total Domestic Production	3,499,635	3,456,966	3,223,622	2,939,896	2,749,105
Imported Crude Oil	23,040,100	23,296,134	23,756,100	23,334,600	21,651,900
Crude Oil Supply	26,539,700	26,753,100	26,979,722	26,274,496	24,401,005
Total	26,457,305	26,714,008	27,149,314	26,175,000	24,227,000

If the economics were favorable, producing ethanol might provide a basis for establishing alternative uses for agricultural lands that are coming out of production and may generate new sources of employment in the agriculture sector. If the economics did not support production of ethanol as a single output, ethanol production might be a viable co-product with other agricultural-based products such as sugar, fiberboard, or diversified agriculture. Ethanol production from local feedstocks may offer an opportunity to develop new businesses and provide some economic diversification in rural areas (Shleser, 1994).

a) Increase in net farm income due to the demand for ethanol: The demand for ethanol has had two positive impacts on farm income. First, the demand for ethanol raises the price of feedstocks. Second, higher feedstock prices have increased the amount of feedstock acreage planted and harvested, thus boosting the size of the total crop.

b) Increase in jobs due to higher farm income: The increase in farm income stems from two sources: an increase in feedstock production, and

is considered CO<sub>2</sub> neutral. But, GHG debits arise during the process of crop production to consumption as a biofuel in vehicles because of the use of agricultural chemicals, fuelling of farm machinery, transport of the crop, processing of the crop, drying of liquid wastes, and transport of the ethanol. All this involve the use of fossil fuels and hence GHG emissions. The problem resembles the one about the net energy value off ethanol. Results are very much depends on the nature of the feedstock and the source of power used for production process. Similarly, it may be analyzed through a full life-cycle analysis.

The use of ethanol-blended fuels as E-85 (85 per cent ethanol and 15 per cent unleaded gasoline) can reduce the net emissions of GHG by as much as 25 per cent. The reduction is attributable to carbon sequestration during corn farming, which more than offsets GHG emissions during corn farming and ethanol production. Ethanol-blended fuel as E-10 (10 per cent ethanol and 90 per cent gasoline) can reduce GHG up to 3.9 per cent.

Agricultural grain production for ethanol may generate a slight increase in nitrous oxide (N<sub>2</sub>O) emissions resulting from heavy fertilizer use. N<sub>2</sub>O has a high global warming-potential – a measure to enable different GHGs to be compared to each other and expressed in CO<sub>2</sub> equivalents. However, research and advances in agricultural technology in grain production are resulting in a reduction of these emissions, often to levels below other common crops. The net effect of ethanol use still results in an overall decrease in greenhouse gas formation (Licht, 2001).

Particulate emissions of biodiesel are measured as 20% to 39% lower than low sulphur fossil diesel and 10-29 % lower than ULSD (Ultra Low Sulphur Diesel). SO<sub>x</sub> emissions: These from biodiesel are at least 80% lower than low sulphur fossil diesel and are comparable or lower than ULSD due to the negligible sulphur content of biofuels.

NO<sub>x</sub> emissions from biodiesel are slightly higher than those from low sulphur fossil diesel. However, evidence from the European Union shows emissions of NO<sub>x</sub> from ULSD to be marginally worse than low sulphur fossil diesel. Therefore introduction of this fuel will bring to the bio and fossil fuels more in line. Advancing injection timing can significantly reduce emission of NO<sub>x</sub> from biodiesel. Catalytic converters to reduce emissions from fossil diesel also function effectively with biodiesel (Clery, 2001).

In Turkey, benzene is still used in blends as an octane enhancer in gasoline replacing lead. As planned, full replacement of lead in gasoline will be completed as in 2005 (F.Somunkiranoglu, Ankara MoEnvironment, 2001 personal communication).

### **Economical Impacts**

The 1970s was a decade of dramatic changes in the world energy sector. An oil export embargo by Middle Eastern producers shocked the developing countries economy. Per barrel prices of oil rose from roughly USD 3.0 to USD 13.0. As



## Environmental Impacts

The transportation sector has a significant impact on environmental quality. Air pollution, global climate change, oil spillage, and toxic waste generation are all results of petroleum-based transportation fuel use and production. Urban air pollution is likely the most significant environmental impact of transportation fuels. Transportation accounts for most emissions of many air pollutants in the United States. EPA estimates that 67% of CO, 41% of the nitrogen oxides (NO<sub>x</sub>), 51% of the reactive organic gases, 23% of the particulate matter (PM) and 5% of the sulfur dioxide (SO<sub>2</sub>) emitted in the United States are from the direct use of petroleum-based transportation fuels, primarily from cars and trucks. These emissions occur during fuel transfer, storage, and end use (combustion). Reactive organic compounds such as benzene and 1,3-butadiene are the principal air emissions from fuel storage and transfer. Pollutants emitted from combustion include CO, NO<sub>x</sub> reactive organic compounds, and small quantities of PM and SO<sub>2</sub>. In addition to the conventional air pollutants mentioned above, the transportation sector is also responsible for almost 30% the domestic carbon dioxide (CO<sub>2</sub>) emissions; CO<sub>2</sub> and other gases are believed to cause climate change.

Transportation sector has also caused significant adverse impacts to land and water resources with oil spills. An average of more than 9,000 spills occurred each year in the United States from 1970 to 1990; losses of more than \$1 billion were incurred from the 1989 Exxon Valdez spill of more than 37.85 million liters alone.

Pollution from petroleum-based transportation fuels has enormous negative economic, social, and environmental impacts on human health, agricultural productivity, buildings, visibility, and wildlife habitats. For example, the use of gasoline and diesel fuel may cause up to 30,000 premature deaths in the United States annually; the external cost of air pollution in the United States is estimated to range from \$11 billion to \$187 billion annually (Wyman, 1996).

Increasing industrial activity and population growth has resulted in a rising concentration of "green house" (GHG) in the atmosphere that contributes to the "Greenhouse Effect". These gases include carbon dioxide, methane, and nitrous oxide. One international environmental agreement, the Climate Convention, will likely have significant impacts on transportation fuel market in the World. Climate Convention was a voluntary agreement between nations to reduce the risks of global warming by limiting the greenhouse gases (GHG) to 1990 levels by the year 2002. This happened in Kyoto in 1997 at the third climate conference where representatives of more than 160 nations met to negotiate binding limits on GHG for developed countries.

One of the most often used arguments to promote ethanol, as a "green" fuel is that it is renewable. One aspect of ethanol's renewable nature is the carbon cycle. This concept illustrates the fact that by burning bioethanol as transportation fuel the carbon dioxide thus released is absorbed by the plants from which the alternative fuel is produced. Therefore fuel ethanol consumption



# **Biofuels: Environmental and Economical Impact of Using Renewable Energy Sources in Fossil Fuel Importing Countries**

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## **Abstract**

Biofuels are alcohols, ethers, esters, and other chemicals made from cellulosic biomass and a large portion of municipal solid and industrial waste. The biggest producer of ethanol in the world is Brazil followed by USA. On the other hand, the biggest producers of biodiesel are France, Italy, Germany, Austria, and Sweden. Producing and using biofuels for transportation offers alternatives to fossil fuels that can help provide solutions to many environmental problems caused by our dependence on fossil fuels in the transportation sector. Besides environmental benefits, there are many positive economical impact of using biofuels, for example, reducing dependency on foreign oil, preventing oil supply disruptions, encouraging technology development, helping local agriculture growth, and creating domestic jobs in plant construction and plant operation.

## **Introduction**

Biofuels are alcohols, ethers, esters, and other chemicals made from cellulosic biomass such as herbaceous and woody plants, agricultural and forestry residues, and a large portion of municipal solid and industrial waste. Biofuels for transportation include bioethanol, biodiesel, biomethanol, and pyrolysis oil. The two most common types of biofuels that are being developed and used in developed countries are bioethanol and biodiesel. Bioethanol is an alcohol, and most of it is produced by using a process similar to brewing beer where starch crops are initially converted into sugars, then the sugars are fermented into ethanol, and finally the ethanol is distilled into its final form. Biodiesel unlike ethanol is composed of fatty acid alkyl esters. Raw materials for biodiesel are most vegetable oils, animal fats, and recycled greases. (ott.doe.gov/biofuels, 2001) Majority of ethanol in the world is used in transportation sector as either direct blend in gasoline or in Ethyltertiobuthylether (ETBE) as oxygenate. Biodiesel, on the other hand, can be blended in diesel fuel or used straight in place of fossil diesel in transportation vehicles. Oxygenated fuels tend to give a more complete combustion of its carbon-to-carbon dioxide (rather than monoxide) which leads to reduced air pollution from exhaust emissions. Oxygenates were developed in the 1970s as octane enhancers to replace toxic additives like benzene and other aromatic hydrocarbons which are dangerous to health because they are carcinogenic and which are dangerous to the environment because they form highly toxic compounds during combustion. (Licht, 2001).

**Table 2.** Effects of compost and barnyard manure treatments on some properties of the studied soils in tomato plots.

Soil properties	Soil depth(cm)	Treatments*											
		K0			K4			K8			A8		
		1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
Dry bulk density (gr/cm <sup>3</sup> )	0-10	1.39	1.38		1.38	1.37		1.33	1.36		1.24	1.35	
	10-20	1.48	1.49		1.48	1.44		1.45	1.43		1.42	1.41	
Total porosity (%)	0-10	45.58	44.95		45.07	46.97		48.00	48.90		48.04	51.26	
	10-20	45.13	44.14		46.87	47.00		47.16	47.87		47.47	49.79	
Macro porosity (%)	0-10	15.45	11.28		13.75	11.80		15.00	11.62		15.09	15.52	
	10-20	12.72	10.82		13.43	10.82		13.07	9.85		13.68	13.36	
Field capacity (Volumetric %)	0-10	30.13	33.67	29.49	31.32	35.17	30.74	33.00	37.28	31.46	32.95	35.74	31.25
	10-20	32.41	33.32	30.15	33.44	36.18	32.68	34.09	38.02	33.03	33.79	36.43	31.98
Wilting point (Volumetric %)	0-10	17.03	15.75	15.35	16.96	16.17	15.89	17.62	16.32	15.75	17.45	17.40	16.28
	10-20	17.55	16.00	15.47	17.54	17.06	16.38	18.13	17.47	16.50	18.41	17.59	16.42
Available water (Volumetric %)	0-10	13.10	17.92	14.14	14.36	19.00	14.85	15.38	20.96	15.71	15.50	18.34	14.97
	10-20	14.86	17.32	14.68	15.90	19.12	16.30	15.96	20.55	16.53	15.38	18.84	15.56
pH (in water)	0-10	7.62	7.64	7.72	7.60	7.57	7.64	7.54	7.52	7.65	7.61	7.53	7.63
	10-20	7.59	7.59	7.67	7.55	7.44	7.70	7.48	7.36	7.61	7.56	7.46	7.60
Total soluble salts (%)	0-10	0.045	0.052	0.068	0.047	0.053	0.058	0.051	0.060	0.055	0.056	0.063	0.050
	10-20	0.046	0.035	0.045	0.045	0.035	0.059	0.048	0.037	0.056	0.047	0.045	0.052
Organic Matter (%)	0-10	1.09	1.18	0.89	1.31	2.04	1.05	1.76	3.33	1.09	1.54	3.08	1.09
	10-20	1.00	1.13	0.85	1.22	1.52	1.09	1.29	2.27	1.25	1.17	1.51	0.85

\*K0: Control K4: 40 tons compost/ha K8: 80 tons compost/ha A8: 80 tons barnyard manure/ha

**Table 1.** Effects of compost and barnyard manure treatments on some properties of the studied soils in wheat plots

Soil properties	Soil depth(cm)	Treatments*											
		K0			K4			K8			A8		
		1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
Dry bulk density (gr/cm <sup>3</sup> )	0-10	1.38	1.41		1.34	1.40		1.18	1.28		1.30	1.34	
Total porosity (%)	0-10	1.43	1.40		1.43	1.39		1.40	1.33		1.41	1.38	
Macro porosity (%)	0-10	50.45	50.70		51.10	51.44		54.19	53.67		51.16	54.03	
	10-20	46.68	51.26		47.93	51.41		48.16	54.70		46.73	51.29	
	0-10	14.50	10.70		11.49	10.49		15.53	13.14		8.62	13.72	
	10-20	7.08	10.61		6.28	10.57		6.51	14.01		6.35	10.64	
Field capacity (Volumetric %)	0-10	35.95	40.00	38.32	39.61	40.95	39.03	38.66	40.53	39.98	42.54	40.31	40.34
Wilting point (Volumetric %)	10-20	39.60	40.65	39.29	41.51	40.84	39.40	41.65	40.69	39.22	40.38	40.65	39.49
Available water (Volumetric %)	0-10	18.75	26.20	26.59	18.63	26.31	25.47	17.19	26.82	24.82	17.60	25.95	26.25
	10-20	17.84	24.35	25.62	18.27	24.03	25.71	19.72	24.30	25.57	17.67	24.38	25.76
pH (in water)	0-10	17.20	13.80	11.73	20.98	14.64	13.56	21.47	13.71	15.16	24.94	14.36	14.09
	10-20	21.76	16.30	13.67	23.24	16.81	13.69	21.93	16.39	13.65	20.71	16.27	13.73
Total soluble salts (%)	0-10	7.64	7.63	7.76	7.47	7.51	7.61	7.40	7.36	7.57	7.54	7.41	7.48
	10-20	7.65	7.58	7.70	7.60	7.59	7.73	7.60	7.59	7.66	7.60	7.58	7.81
Organic Matter (%)	0-10	0.024	0.052	0.075	0.030	0.055	0.090	0.030	0.067	0.084	0.031	0.083	0.140
	10-20	0.024	0.055	0.077	0.025	0.061	0.082	0.026	0.055	0.075	0.031	0.070	0.095
	0-10	0.95	1.13	1.57	1.29	1.96	1.57	1.24	1.98	1.72	1.12	1.80	2.98
	10-20	0.82	1.05	1.29	1.13	1.29	1.41	0.98	1.10	1.53	0.82	1.49	1.65

\*K0: Control K4: 40 tons compost/ha K8: 80 tons compost/ha A8: 80 tons barnyard manure/ha



Organic matter content of the compost and barnyard manure-treated soils increased highly at the two depths in comparison with the control. However, in the compost plots, soil organic matter content were higher than that of the compost material in 1999. This situation may be resulted from compounds that can be oxidized in the compost. Another reason may be that the compost could not be applied to the soil homogeneously. In all the similar studies, soil organic matter content increased first with the application of various organic materials, but then decreased (Hanay, 1991).

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and 2). The greatest decreases in the bulk density values were observed in the 80 tons/ha compost-applied wheat plots, and also 80 tons/ha barnyard manure-treated tomato plots. The change in dry bulk density was very pronounced in the both layers, compared to the control.

Total porosity values, especially for the 0-10 cm layer, increased with increasing amount of compost and barnyard manure applied in both wheat and tomato plots. The highest amount of compost and barnyard manure applications resulted in a 2-3% net increase in total porosity values. While the application of compost did not affect macroporosity values, the application of barnyard manure increased also macroporosity. This situation might be resulted from the drastic effect of barnyard manure on soil structure.

In comparison with the control, the application of the compost and barnyard manure to the soils increased microporosity (field capacity) values in tomato plots with medium texture (SCL). However, the similar effects were not determined in wheat plots with fine-textured soils. The results obtained from this study are in agreement with the literature data (Nakaya and Motomura, 1984; Pagliai and Guidi, 1985; Hanay, 1991).

In soils with medium texture (tomato plots), wilting point values partly increased with increasing compost amount. But, these increases could not be determined clearly in the soils with heavy texture. A similar trend was also observed in the barnyard manure plots. As reported by Ward and Elliot (1995), the factors affecting changes in field capacity and wilting point may be different.

Available water content increased with increasing amount of compost and barnyard manure in the soils of tomato plot. In some years, the application of 80 tons/ha compost increased available water values by 3% in the tomato plots, compared with the control. However, this effect was not clear in the soils with heavy texture (wheat plots).

In the soils of compost and barnyard manure plots, especially for the 0-10 cm layer, pH values decreased slightly, compared to the control. The decreases in the pH values matched well with the higher amount of compost applications. Similarly, Guidi and Hall (1984) observed that the application of various organic materials decreased pH values since organic and inorganic acids formed when organic matter decomposed in the soil.

Due to higher salt content of the compost used in this research than experimental soils, the compost and barnyard manure treatments increased slightly the total soluble salts content of the soils, except for the 0-10 cm layer of the tomato plot soils in the year 2000. In spite of a slight increase in the soluble salt content of the soils in the three-year-period, the use of the compost during a long period may increase considerably salt content of the soils.



## Materials and Methods

Compost applied to soil was produced from the municipal organic garbage of Antakya (Turkey), bay leaves (*Laurus nobilis*), and barnyard manure mixture in a ratio

of 7.5:1.5: 1.0, respectively. Some properties of compost used in this study were presented, and the quality of compost produced was found applicable to agricultural and horticultural use by Aydın et al. (2000).

Field studies were carried out under Amik plain conditions during 1998-2000. In these experiments, the traditional chemical fertilizers (160 kg N/ha and 105 kg N/ha for wheat and tomato plots, respectively; and 80 kg P<sub>2</sub>O<sub>5</sub>/ha for both crops); 20, 40, 60, 80 tons/ha compost; 80 tons/ha barnyard manure, and control treatments were compared in wheat and tomato plots. The Experimental design was performed as randomized blocks with three replications.

Disturbed and undisturbed soil samples were taken from two different depths (0-10 and 10-20 cm) of the wheat and tomato plots treated with 40 and 80 tons/ha compost, 80 tons/ha barnyard manure and control.

Soil samples were analyzed for texture (Bouyoucos, 1951), dry bulk density (Yeşilsoy and Güzelit, 1966), porosity (Yeşilsoy et al., 1993), available water content (Klute, 1986), total soluble salts, pH (Richards, 1954), lime (Allison and Moode, 1965) and organic matter (Schlichting and Blume, 1966).

## Results and Discussion

### Some properties of the soils

Wheat plot soils had medium-fine (SiCL) and fine (C) texture, slightly alkaline pH, low organic matter and salt content. Dry bulk density, total porosity and CaCO<sub>3</sub> values of these soils were in a range of 1.35-1.41 g/cm<sup>3</sup>, 49.5-51.3% and 18.9-67.7%, respectively.

Tomato plot soils were medium textured (SCL). Soil pH was slightly alkaline. Organic matter and salt contents were low. Dry bulk density, total porosity and CaCO<sub>3</sub> values changed between 1.39-1.48 g/cm<sup>3</sup>, 45.1-45.6%, and 0.5-0.8%, respectively.

### The effects of compost and barnyard manure applications on properties of the soils

The effects of compost and barnyard manure on some physical and chemical properties of soils cropped with wheat and tomato were presented Table 1 and 2.

Dry bulk density values decreased gradually in the upper layers of the soils with the applications of compost in both wheat and tomato plots. Similar trend was also observed in barnyard manure plots, compared to the control (Table 1



# **Effects of Compost Produced from Municipal Solid Wastes on Soil Properties and Crop Yield: Changes in Soil Properties due to the Application of Compost (\*)**

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## **Abstract**

In this study, the effects of compost on some physical and chemical properties of soils cropped with wheat/tomato were investigated.

Compost applied to soil was produced from the municipal organic garbage of Antakya (Turkey), bay leaves, and barnyard manure mixture in a ratio of 7.5:1.5: 1.0, respectively. Field studies were carried out under Amik plain conditions during 1998-2000. In these experiments, the traditional chemical fertilizer applications; 20, 40, 60, 80 tons/ha compost; 80 tons/ha barnyard manure and control treatments were compared in wheat and tomato plots. The Experimental design was performed as randomized blocks with three replications. Disturbed and undisturbed soil samples were taken from two different depths (0-10 and 10-20 cm) of the plots treated with 40 and 80 tons/ha compost, 80 tons/ha barnyard manure, and control.

Our results of the three-year- experiment revealed that porosity, available water, soluble salts, and organic matter content increased with the application of compost, while the dry bulk densities and pH values of the studied soils decreased.

## **Introduction**

Solid waste is a major threat to the sustainable utilization of natural resources and a threat to natural scenery (Basnet, 1993). Composting municipal solid waste is becoming increasingly recognized as a viable and economical method for waste management in both the Europe and the USA. Composting has advantages over landfilling and incineration because of lower operational costs, less environmental pollution, and beneficial use of the end product (He et al., 1992).

Many research (Bazzoffi et al., 1998; Wong et al., 1999; Aggelides and Londra, 2000) showed that the application of compost affected positively the physical and chemical properties of the soils.

The aim of this research was to investigate the effects of compost produced from town solid wastes on physical and chemical properties of soils cropped with wheat/tomato.

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Table.1 Physical and Chemical Characteristics of Industrial Waste

Group	Origin of industrial waste	Mechanical composition (Particles)		pH in H <sub>2</sub> O	Dry residue %	Total sulphur %	CaCO <sub>3</sub> %	Total quantity of trace elements in mg/kg										
								Zn	Cu	Mn	Co	Pb	Ni	Mo	As			
		<.001mm	<.01mm															
1	Tailings and slime from extraction and dressing of ores for the ferrous and non-ferrous metals metallurgy	n	7	7	7	7	7	7	7	7	7	7	7	7	7			
		min	0.1	1.4	0.04	0.52	0.00	65	30	130	0	10	0	0	0			
		max	4.6	7.0	0.99	2.65	20.6	2360	900	12800	400	2250	65	15	60			
2	Ash and cinder from thermoelectric power plants	n	6	6	6	6	6	6	6	6	6	6	6	6	6			
		min	2.9	7.2	0.03	0.16	0.15	20	40	150	0	15	0	0	0			
		max	5.4	9.6	1.12	3.20	4.96	155	120	2400	355	4850	100	15	100			
3	Tailings from chemical plants for the production of paper and cellulose and from thermoelectric power plants	n	5	5	5	5	5	5	5	5	5	5	5	5	5			
		min	2.7	10	0.21	0.25	-	100	48	350	0	0	0	0	0			
		max	5.8	12.5	0.40	0.38	-	690	85	960	10	40	32	4	0			
4	Slime from the production of fertilizers and soda 4.1. phosphogypsum 4.2. soda	n	4	4	4	4	4	4	4	4	4	4	4	4	4			
		min	1.4	1.5	1.5	0	0	205	66	52	20	20	10	-	-			
		max	2.7	3.0	3.1	0.66	0	4050	372	3020	350	5100	50	-	-			
		n	4	4	4	4	4	-	-	-	-	-	-	-	-			
		min	14.4	40.3	7.0	0.15	20.5	-	-	-	-	-	-	-	-			
5	Average content in soils /relative standard/	max	22.0	52.9	0.65	-	30.3	-	100	3000	10	10	10	3	-			
		different content and values			non-soloni	<0.3	different content	50-70	20-	800-	8-	12-	40-	3-5	<5.0			
					zed				30	850	10	14	50					
					<0.15													

## **Conclusions**

1. The studied industrial waste has a heterogeneous physical and chemical composition determining their specific characteristics.
2. Suitability of substrates for biological reclamation
  - 2.1. Physical properties

As a whole /with the exception of materials from soda plants/ they have a very light mechanical composition, low bulk density and high degree of filtration, and by their physical properties they are not entirely suitable for direct biological reclamation.
  - 2.2. Chemical properties

According to their chemical properties, the substrates are divided as follows:

    - 2.2.1. Substrates less suitable for biological reclamation - tailings and ash from thermoelectric power plants and from plants for paper and cellulose production;
    - 2.2.2. Unsuitable industrial waste due to the high contents of water-soluble salts, total sulphur and total quantity of trace elements, which include all materials from the I, II, and IV groups /tailings and slime from mining and dressing of nonferrous metals, ash from thermoelectric power plants and slime from fertilizers and soda production/;
3. Before reclamation, which must take place immediately after closing down production plants, the sites must be characterized according to a wide range of physical and chemical characteristics, and on the grounds of their values and suitability evaluation, a specific project for execution shall be prepared.

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- a) Waste materials from tailings ponds for mining and dressing of ferrous and nonferrous metals and ash from thermoelectric power plants, where there are non-solonized sites and sites with strong solonization with the characteristics of a solonchak;
- b) Waste materials from the production of paper and cellulose with characteristics of slightly to medium solonization; and
- c) Extremely toxic substrates /phosphogypsum and pyrite dross/ where the solonization is the highest.

This subdivision is also applicable regarding the total quantity of sulfur. Solonization is mainly due to the presence of sulphate ions. Of special importance is the necessity to analyze pyrite and organic sulfur in metallurgical industrial sites and in coal mining sites, as well as in fertilizers plants, because they contain  $\text{Fe}_2\text{S}$  minerals which, depending on the conditions for developing oxidation-reduction processes, form acid products which increase the environmental toxicity when growing plants.

Depending on the contents of carbonates, three groups of industrial waste are defined:

- a) Carbonate rich / $\text{CaCO}_3$  contents between 20 and 40%/, which includes some sites from the first group, and the substrates from the production of ammonia ash.
- b) Carbonate free - some tailings ponds from mining and dressing of nonferrous metals and chemical plants for paper and cellulose production.
- c) Third group /ash from thermoelectric power plants/ with carbonate content under 10%.

Judging by the average contents of the total quantity of trace elements in soils, the studied industrial substrates can be characterized as follows:

1. Within each site in the specific groups, a wide range of variation in the values of different trace elements is established.
2. Established is a polymetal pollution in all studied sites in the specific groups.
3. The quantities of Zn, Cu, Mn, Co, Pb in the first group, as well as those in the second group and in the 4.1 subgroup, are several times higher than those in natural soils.
4. Conditions for toxic absorption of heavy metals /pH in water 2.0 - 3.8/ exist in the substrates defined as phosphogypsum and pyrite dross.
5. In some ash deposits /II group waste substrates/ the As quantity is 4 times higher than the normal for the soil.

samples of waste materials have been grouped formally into four groups depending on the character of the respective industrial technology.

The first group of sites includes tailings ponds from mining and dressing of ores of ferrous and nonferrous metals, and metallurgical slime. The second includes the waste substrates of thermoelectric power stations - ash and cinder. The third includes settling tanks and tailings ponds of chemical plants for paper and cellulose, and the fourth - slime ponds of plants for fertilizers and soda / phosphogypsum, pyrite dross and soda/.

The samples collected from 22 sites have been analyzed for their mechanical composition using the N.A.Kachinskiy method /1965/, the total quantity of water soluble salts /dry residue/, the total quantity of sulphur /contents of  $\text{CaCO}_3$ / /E.V.Arinishkina, 1970/, pH measured in the suspension soil:water = 1:2.5. The contents of the total quantity of trace elements was defined using the atomic-absorption method according to the Bulgarian State Standard BDS 17.4.4.02-80 and 17.4.4.01-78.

## Results and Discussions

The data in Table 1 show that the studied substrates differ by their content of silt /particles  $<0.001$  mm/ and residual clay /particles  $<0.01$  mm/. The mechanical composition of the studied groups is relatively uniform, with the exception of the substrates taken from a chemical plant for soda /residual clay from 40.3 to 53.9% and of silt from 16.2 to 22.0%/ which have a low silt content, and are classified as materials of the type loose and connected sand /N.A.Kachinskiy, 1965/. Obviously, the specificity of the industrial technology defines the light mechanic composition which on the one hand leads to worsened water-physical properties, and on the other - represent a danger for pollution of the adjacent territories with heavy metals due to a wind erosion.

Regarding the pH of the environment, the studied industrial waste has almost equal values in the I, II and III group within the range of 6.0÷7.6 - from slightly and medium acid to slightly alkaline reaction, where a large set of substrates are included, and which can be hardly distinguished by this characteristic. In the fourth group two subgroups can be clearly distinguished: one with pH values, valid for very highly acid to extremely acid reaction, which includes the phosphogypsum and the pyrite dross, and the other /waste from a soda plant/ with neutral and very weak alkaline reaction.

Regardless of the varying values of the water-soluble salts and the total sulphur, both in the groups and the contents therein, these indexes are suitable criteria for their classification distribution /in principle/ using the degree of manifestation of the solonization process and suitability for biological reclamation. However, the specificity of the industrial technology divides the studied materials into three degrees of solonization:

## **Characteristics of Industrial Waste and Their Evaluation in View of Reclaiming**

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It is well known that different industrial and construction activities destroy enormous areas of cultivated and uncultivated lands. The most destructive effect is due to the open and underground mining of ores and minerals, the building of processing and dressing plants, and different linear sites /roads, railways, gas pipelines etc./.

According to data of the National Statistical Institute /NSI/ /Environment, 1992/, the damaged lands in Bulgaria amount to 10,000 thousand dca, and 75.5% of them are in the agricultural fund. The group of uncultivated lands also includes areas occupied by quarries, mines, waste banks, ash heaps, tailings ponds, which occupy an area of 400 thousand dca or 0.35% of the territory of Bulgaria. Within these areas not only the land has been physically destroyed, but the built facilities present a serious danger for pollution of the adjacent territories, plants and waters due to the industrial waste of various chemical and physical content.

It is believed /NSI, Environment, 1992/ that about 2.1 million tons of industrial waste has been accumulated in the above mentioned areas, or 235.5 t per capita. Presently it is considered that the average annual increase of industrial waste is about 190 mln t. Of the total quantity of industrial waste, 73.3% are rock and land masses from the mines, 15.3% come from mining and dressing of ores and nonferrous metals, 7.9% are ash and cinder from thermoelectric power plants, 0.9% waste from chemical plants for fertilizers and soda, about 0.02% are the settling tanks of chemical plants for paper and cellulose, and 2.6% other industrial waste.

The main problems resulting from the storage of industrial waste are related to the real danger of environmental pollution due to the specific way of silting /mostly hydraulic/ and the long-term storage of chemical heterogeneous substrates which often contain toxic compounds.

The purpose of this research is to characterize, using modern analytical data, the chemical characteristics of different industrial waste and to state their classification evaluation grade for reclamation fitness.

### **Sites and Methods of Research**

Since on the territory of Bulgaria there exist many real industrial sites with different production, to facilitate the presentation, the collected and studied



**Table 2.** Variance Analysis Results.

	N Doses	P Doses		Mean
		Po	P1	
Number of spikes per plant	No	3,96 b	4,95 a	4,53 ab
	N1	4,16 b	4,03 b	4,09 b
	N2	4,98 a	4,4 ab	4,69 a
	Mean	4,37	4,46	4,41
	LSD (0,05%)	0,59		0,42
Total weight per plant (g)	No	19,13	20,01	19,57
	N1	22,65	18,61	20,62
	N2	22,8	20,94	21,87
	Mean	21,52	19,86	20,69
	LSD (0,05%)	N.S.		N.S.
Total number florets per plant	No	31,94	32,96	32,45 b
	N1	35,93	31,38	33,65 b
	N2	39,78	34,53	37,15 a
	Mean	35,88	32,95	34,42
	LSD (0,05%)			3,46
Diameter of florets (mm)	No	64,66	66,01	65,33 b
	N1	66,19	66,83	65,51 a
	N2	64,47	66,6	65,53 b
	Mean	65,11	66,48	65,79
	LSD (0,05%)	N.S.		0,82
Lenght of florets (mm)	No	47,22 b	46,17 c	46,99 c
	N1	47,28 b	47,73 b	47,5 b
	N2	47,5 b	50,63 a	49,09 a
	Mean	47,33	48,19	47,76
	LSD (0,05%)	0,58		0,41
Lenght of floret stalks (mm)	No	124,49 d	119,5 e	122 c
	N1	127,79 c	131,54b	129,66 b
	N2	133,9 b	155,22a	144,56 a
	Mean	128,73	135,42	132,07
	LSD (0,05%)	3,29		2,33

**Table 1.** Greenhouse soil analysis report.

Salt %	pH	Org. matter%	Na (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)
0.12	6.62	1.6	115	148	490	2000	55	1.7	1.2	4.1	8.3	1.24

## Results

According to the results as it can be seen in Table 2, the largest number of spikes per plant was obtained from the combinations of P1N0 (4.95 per plant) and P0N2 (4.98 per plant), followed by the P1N2 combination, with 4.40 per plant. The lowest value was obtained from the P0N0 combination. Total weight per plant was not affected by the fertiliser combinations but the highest and lowest weights were obtained from the P0N2 and P1N1 combinations respectively. The number of florets per plant was not affected by different combinations of fertilisers, which was the actual subject of our research, although it was noticed that an application of P0N2 resulted in the highest number of 39.78 florets per plant. As can be seen in Table 2, there was no statistically significant difference in the diameter of the florets but the highest value was obtained from the P1N1 combination. The highest values for the length of the florets were found to be 50.63 mm (P1N2) and the lowest value was 46.17 mm (P1N0). The floret stalk, which is one of the most important criteria for the quality of cut flowers, was found to be between 155.22-119.50 mm. The highest and lowest values were obtained from the P1N2 and P1N0 combinations respectively. As a result, it can be said that the number of spikes per plant, number of florets per plant, length of florets and floret stalks increased with the increasing doses of nitrogen.

Especially in fall-winter season freesia production can be advised as a alternative production system for producers in Çanakkale.

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Freesias require soils that retain moisture but are well drained. The pH should be 6.6-7.5 to reduce the risk of leaf scorch and the soils must not contain fluoride. Excessive nutrient levels can result in root burn and stunted growth of the crop. Therefore, base fertilizer dressings are unnecessary unless a soil analysis reveals excessive nutrient deficiency. Double superphosphate should be avoided since this contains fluoride as a contaminant (Hertogh and Le Nard, 1993). Khateeb et. al. (1991), studied the effect of nitrogen and potassium fertilization on growth, flowering and chemical composition of *Freesia hybrida* cv. Aurora in Giza. They planted the corms in 25 cm clay pots filled with clay loam soil. They found that the greatest spike stem length was obtained with 1 g. N (ammonium nitrate) + 2 kg. K (potassium sulphate) per pot. The highest fresh weights of flowering organs were obtained with 2 g. N (ammonium sulphate) + 2 g. K per pot.

Özkahya (1982) recommended using 70-150 kg.da<sup>-1</sup> TSP, 130-350 kg.da<sup>-1</sup> potassium sulphate, 80-240 kg.da<sup>-1</sup> magnesium sulphate and 15-30 kg.da<sup>-1</sup> ammonium nitrate for freesia cultivation. Perry (2001) recommended 100 ppm N every other watering.

In this study we aimed to determine the effects of varying applications of nitrogen and phosphorus on the yield and quality of *Freesia hybrida*.

## Material and Methods

This experiment was carried out between February and June 2001 in the plastic greenhouse belonging to Çanakkale Onsekiz Mart University with the purpose of determining the effect of varying applications of nitrogen and phosphorous on the quality and yield of *freesia hybrida*.

The experiment was set up using random block design with three applications of each plot measuring 2.40 m<sup>2</sup>. Each plot contained 50 plants in 5 rows. Various combinations of fertilisers were used in this study; 3 different doses of nitrogen (0 kg N/da as N0, 20 kgN.da<sup>-1</sup>as N1, 40 kg N.da<sup>-1</sup>as N2) and two of phosphorous (0 kg P<sub>2</sub>O<sub>5</sub>.da<sup>-1</sup>as P0 and 15 kg P<sub>2</sub>O<sub>5</sub>.da<sup>-1</sup>as P1) giving a total of six different applications as P0N0, P0N1, P0N2, P1N0, P1N1 and P1N2 . The sources of fertilisers were ammonium nitrate and TSP and the dose of nitrogen was applied at two different times. Fertilisers were chosen according to the results of greenhouse soil analysis. The soil analysis report from the greenhouse is shown in Table 1. In the experiment, the number of spikes per plant, number of florets per plant, diameter of florets, length of florets and length of flower stalks were examined.



# Effect on Yield and Quality of Varying Applications of Nitrogen and Phosphorus to Greenhouse Cultivation of Freesia Hybrida

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## Abstract

This experiment was carried out between February and June 2001 in the plastic greenhouse belonging to Çanakkale Onsekiz Mart University, with the purpose of determining the effect of varying applications of nitrogen and phosphorus on the yield and quality of freesia hybrida.

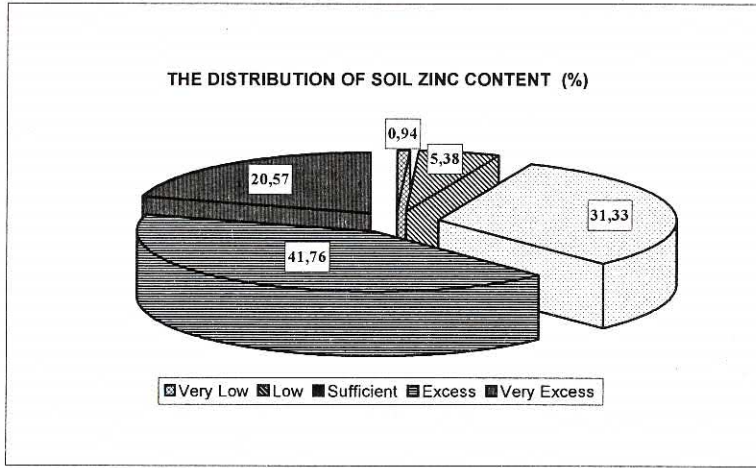
This experiment was set up using a random block design with three replications of each plot measuring 2.40 m<sup>2</sup>. Each plot contained 50 plants in 5 rows. Various combinations of fertiliser were used in the study, 3 different doses of nitrogen (0 kg N/da, 20 kgN.da<sup>-1</sup>, 40 kgN.da<sup>-1</sup>) and two of phosphorus (0 kg P<sub>2</sub>O<sub>5</sub>.da<sup>-1</sup> and 15 kg P<sub>2</sub>O<sub>5</sub>.da<sup>-1</sup>), giving a total of six different applications. The sources of fertilisers were ammonium nitrate and TSP and the dose of nitrogen was applied at two different times.

According to the results, the largest number of spikes per plant was obtained from the combinations P1N0 (4.95 per plant) and P0N2 (4.98 per plant); the number of florets per plant was not affected by differing combinations of fertilisers which was the actual subject of our research, although it was noticed that an application of N2 (40 kgN.da<sup>-1</sup>) resulted in the highest number of 37.15 florets per plant. There was no statistically significant difference in the diameters of florets. The highest values for the length of the florets and floret stalks were found to be 50.63 mm and 155.22 mm respectively, using the P1N2 combinations.

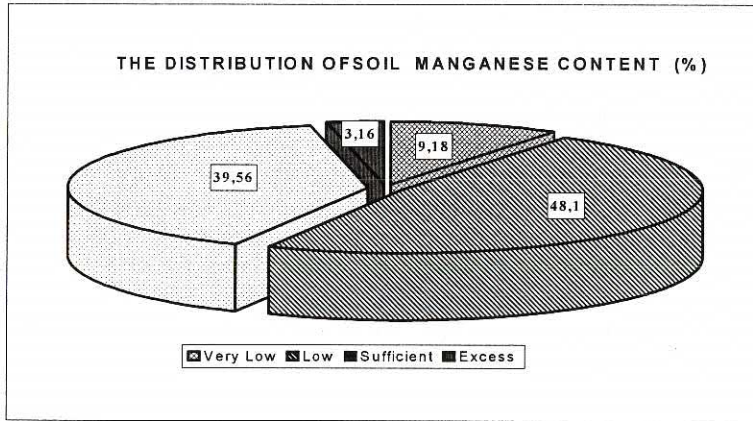
## Introduction

Freesia is a small genus consisting of 11 species, is a monocotyledonea and belongs to the Iridaceae family (Brown, 1934). Freesias are widely used as cut flowers (Smith and Danks, 1985). In recent years, freesia production has increased greatly, especially in Europe.

The best planting time (early March, late March or mid April) of small and large corms for summer season production of cut flowers was determined by DongKwan et. al., (1996), who found that the number of leaves increased with later planting dates. Plants from the late March planting were the tallest. Cut flower quality (flower stem length, number of florets per spike and production of marketable flowers) was best when large corms were planted in late March (8889 bunches of flowers.10 a<sup>-1</sup>).



**Figure 7.** The distribution of Zinc content in green house soils

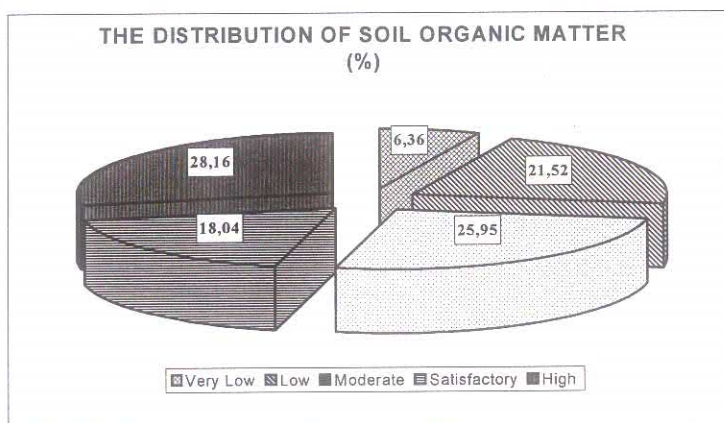


**Figure 8.** The distribution of manganese content in greenhouse soils.

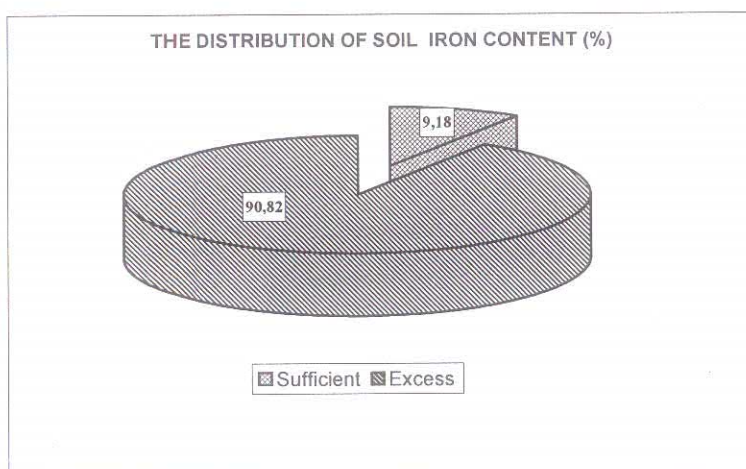
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132.60 ppm and the average manganese value was 16.39 ppm. The detailed manganese content distribution of the soils is presented in fig. 8.



**Figure 5.** The distribution of organic matter in green house soils of the Mediterranean region.

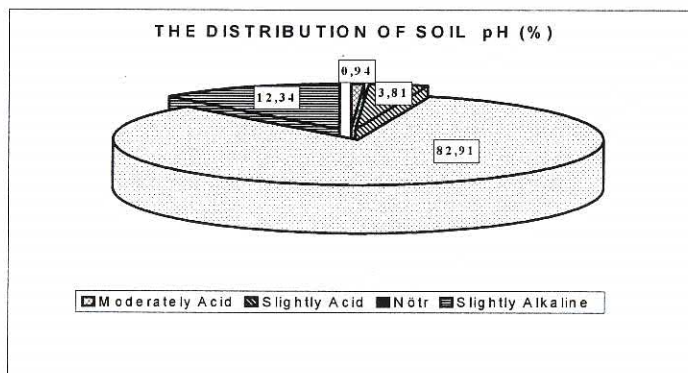


**Figure 6.** The distribution of iron content in greenhouse soils of the Mediterranean region.

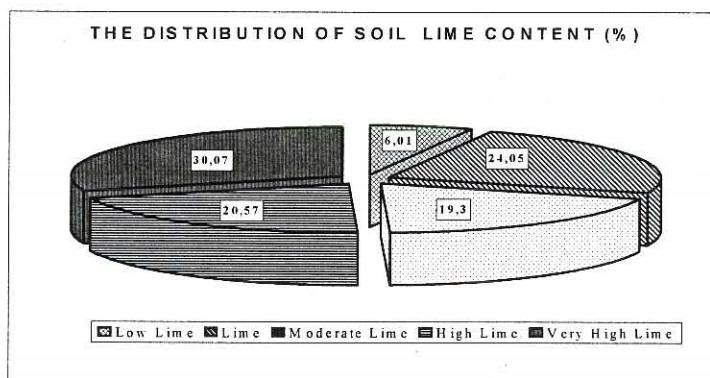
The copper content of the greenhouse soils varied between 0.35 and 52.76 ppm and the average value was 9.22 ppm. All the greenhouse soils are adequate in copper content so copper deficiency will not be a problem in the greenhouses of the area.



average iron content was 9.49 ppm. It seems that there will be no signs of iron deficiency problems but still care must be paid for signs of iron deficiency because of high lime contents. The detailed iron content distribution of the soils is presented in figure 6. The majority of the soils are of high Zinc content. The high Zinc content soils constitute the 41.78 % of the whole greenhouse soils in the region.



**Figure 3.** The distribution of pH in greenhouse soils of the Mediterranean Region.

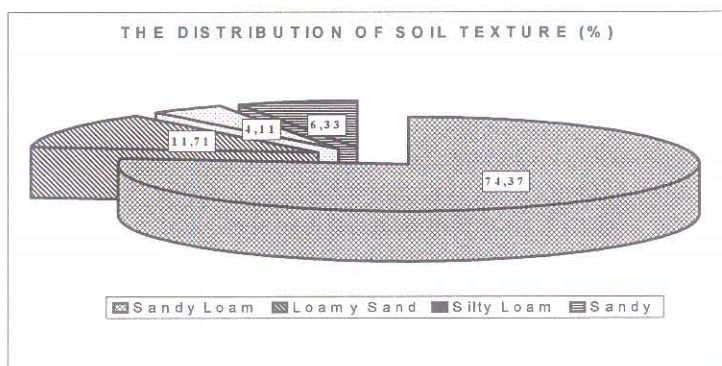


**Figure 4.** The distribution of the lime content of the greenhouse soils.

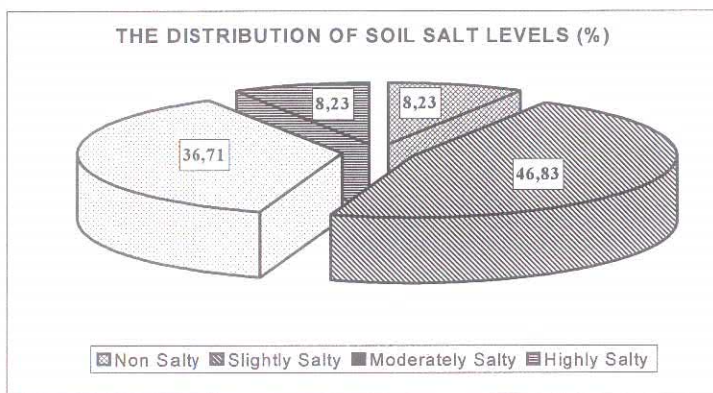
The zinc content of the soils varied between 0.04 and 44.79 ppm and the average zinc value was 6.28 ppm. Although zinc status of the soils seems adequate in most of the soils attention must be paid for zinc deficiency because of the high pH values. The detailed zinc content distribution of the soils is presented in fig. 7.

The majority of the soils are of low manganese content. The low manganese content soils constitute the 48.10 % of the whole greenhouse soils in the region. The manganese values varied between 1.30 and

Care must be paid to trace element nutrition. The detailed lime distribution of the soils is presented in figure 4.



**Figure 1.** The distribution of texture in the surveyed green house soils (%).



**Figure 2.** The distribution of salt level in the surveyed green house soils (%).

The organic matter content of the majority of the soils are of high organic matter content. The high organic matter content soils constitute the 28.16 % of the whole greenhouse soils in the region. The organic matter content of the soils varied between 0.26 and 7.59 % and the average organic matter content was 3.26%. Almost half of the greenhouse soils are not adequate in organic matter content. Attention must be paid for increasing the organic matter content of the green house soils. The detailed organic matter content distribution of the soils is presented in figure 5.

The majority of the green house soils are of high iron content. The high iron content soils constitute the 90.82 % of the whole greenhouse soils in the region. The iron content of the soils varied between 1.58 and 92.54 ppm and the

## Material and Method

316 Soil samples representing different green houses in the region are collected from 0- 25 cm soil depth. The collected soil samples are analysed for texture, pH, lime, organic matter, salt content, and plant available Fe, Cu, Zn and Mn content. The Trace elements are determined by A.A.S following an extraction with DTPA as described by Lindsay and Norwell (1969) . Texture is determined according to Bouyoucos (1951), Organic matter according to Walkley – Black method as described in Chapman and Pratt ( 1961). The lime content was determined according to Scheibler method as described by Tüzüner (1990) and the salt determination was according to Tüzüner (1990) also. Tomatoes, green pepper, cucumber and eggplants were the plants that were grown in the surveyed greenhouses. The analysis values for texture, pH, lime, organic matter and salt content were classified according to Ülgen and Yurtsever (1988), the analysis values for iron, and copper are classified according to the critical values set by Lindsay and Norwell, the analysis values for zinc and manganese are classified according to FAO (1990). The critical values of adequacy for iron, zinc, copper and manganese were 4.5 ppm, 0.7 ppm, 0.2 ppm and 14 ppm respectively.

## Results and Conclusion

The texture of the majority of the greenhouse soils are sandy-loam. The sandy loam soils constitute 73.74% of the soils. The detailed texture distribution of the soils is presented in figure 1. The texture of the soils in general does not create any problem for high yields.

The majority of the greenhouse soils are slightly saline. The slightly saline soils constitute 46.83 % of the whole greenhouse soils. The salt level of the soils varied between % 0.050 and 1.790. The average salt level was % 0.376. The salt level of the green house soils may negatively effect the crop yields in near future. The detailed salt distributions of the soils are presented in figure 2.

The reaction of the majority of the green-house soils are neutral. The neutral reaction soils constitute 82.91 % of the soils in the region. The pH of the greenhouse soils varied between 5.32 and 8.16. The average pH value was 7.17. The pH of the greenhouse soils may become a problem on long term so, special attention must be paid for the use of physiological acidic type of fertilizers. The detailed pH distribution of the all greenhouse soils is presented in figure 3.

The lime content of the majority of the soils are of very high lime content. The very high lime content soils constitute the 30.07 % of the whole greenhouse soils in the region. The lime content of the soils varied between 0.30 and 47.70 % and the average lime content was % 15.79. High lime content of the soils indicate a possible iron and zinc deficiency, and phosphorus fixation problems.



## **Fertility Status of Greenhouse Soils in the Mediterranean Region of Turkey**

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### **Abstract**

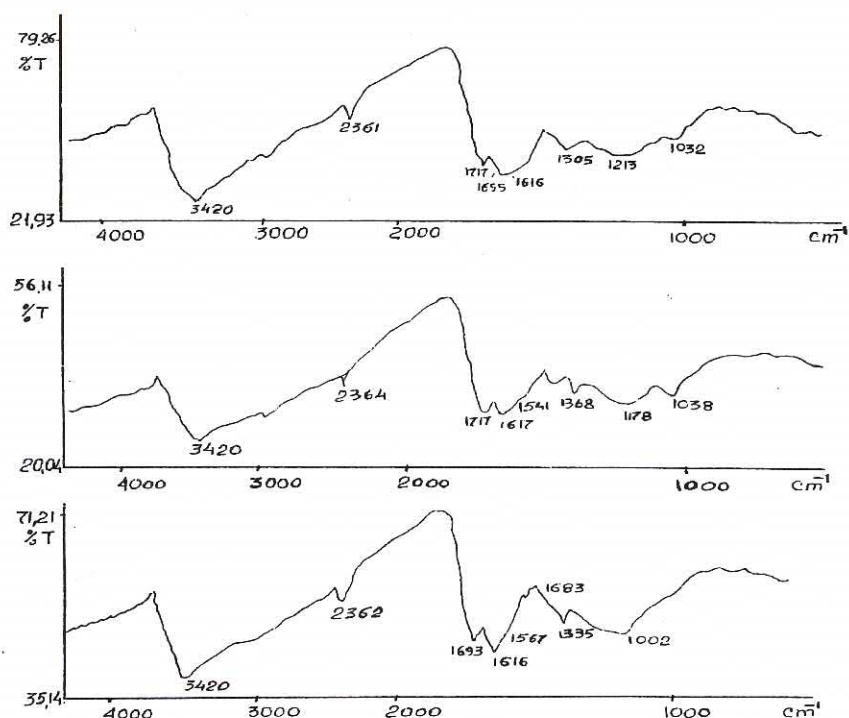
316 soil samples were collected from the greenhouses in the Mediterranean region of Turkey and analysed for texture, pH, total salt, lime, organic matter, iron, zinc, copper and manganese contents. The results of the survey revealed that the greenhouse soils in general are of sandy loam texture, neutral reaction, slightly saline, high organic matter content, and very high lime content, high in iron zinc and copper contents, low in Manganese contents. Tomatoes, green pepper, cucumber and egg plants were the plants that were grown in the surveyed green houses.

### **Introduction**

Soil is the very important part of the agricultural system and it is impossible to achieve high yields without knowing the physical and chemical properties of the soils. If the plant nutrients are not supplied in adequate amounts as fertilisers, they will restrict the yields resulting in economical losses for the farmers and the country. The properties of the soils, the crop type and the conditions of the growth medium will determine the amount of plant nutrient to be applied. Yield is severely affected when a nutrient is deficient and when the deficiency is corrected very rapid plant growth occurs. Soil analysis values are very valuable for successful fertiliser recommendations and management.

Agricultural production under field conditions can not satisfy the market demand of the rapid growing world population. More intensified and controlled systems are looked for achieving higher yields. Green houses are now being continuously used for achieving higher yields under controlled conditions. Day by day green house production is increasing its share in the agricultural system. An important part of the national vegetable production is by means of greenhouses and the share of greenhouse production is continuously increasing. Farmers who transfer from field type production to greenhouse type production are not very familiar with the necessary soil plant nutrient practices. The soils are either polluted by over fertilisation which lead to loss of soil quality or less plant nutrients are applied than the required which lead to reduced yields. The research is conducted in the Mediterranean region, which is one of the most important green house production areas of Turkey in order to monitor the soil qualities for achieving better yields in the future.

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**Figure 2.** IR- spectrum of Humic acids obtained from Beysehir(a), Ilgin(b) and Ermenek(c) lignite.

districts of an infrared spectrum of the three different lignite samples collected from the coal mine sites at the vicinities of Beysehir , Ermenek and Ilgin towns. These findings showed that all of the three lignite samples, taken from Beysehir, Ermenek and Ilgin towns, were rich enough in humic acid substances. Thus it was concluded the lignite samples of Beysehir, Ermenek and Ilgin towns could be suggested and offered to be an important and sufficient resources of raw material in order to obtain organo-mineral fertilizer in a sufficient quality as much as that needed since it has been already indicated in the literature that the vicinities of Beysehir, Ermenek and Ilgin have been known to have large deposits of low grade coals from which the experimental lignite samples were taken (Sensogut, 1999) as it is shown in the Table 1, 2, 3. On the other hand, the addition of the lignite and humic acid materials to the experimental soil at the increasing levels induced and significantly increased the aggregate stability while significantly decreased the modulus of rupture values of the experimental soil (Table 4). Thus, it was concluded that addition of the humic acid substances and lignite materials with increasing level to the experimental soil could be used to reduce the crust formation and soil surface erosion and thus could be used to remediate the physical properties of the soil such as soil aggregation and other related soil properties, as a soil conditioner.

**Table 4.** Results of cumulative effects of additions of the ground lignite samples and the humic acids on some physical properties of the soil (n= 4).

Treatment	Aggregate stability (%)	Modulus of rupture (m.bar)
Control (without treatment)	24.92* a	442.18* a
Beysehir lignite (2 %)	40.51 b	289.89 c
Ermenek lignite (2 %)	35.16 b	301.41 b
Ilgin lignite (2 %)	37.84 b	297.27 b
Humic material (0.25 %)	65.12 d	187.12 f
Beysehir lignite (5 %)	50.61 c	221.42 e
Ermenek lignite (5 %)	45.12 c	241.18 d
Ilgin lignite (5 %)	47.89 c	232.65 e
Humic material (0.5 %)	89.24 e	159.18 g

\*Within a column, mean values followed by the same letter were not statistically different at the 5 % level (Newman –culs test).

### Acknowledgement

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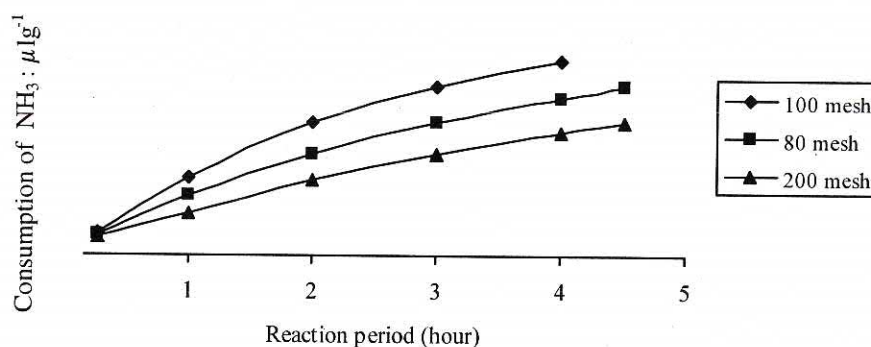


**Table 2.** Results of the fractionation materials for the lignite samples by the extraction method.

Fractionation and resultant materials	The lignite samples		
	Ilgın; 4.0 gr	Beyşehir; 3.2 gr	Ermenek; 5.2 gr
1. Extraction in benzene			
Bitumen; %	2.5	5.0	1.7
Sediment; g	3.9111	3.0484	5.1927
2. Extraction of the sediment I with water			
Pectin material; %	16.04	13.24	5.56
Sediment II; g	3.4441	2.7770	4.9042
3. Extraction of the sediment II with HCl			
Hemicellulose %	1.27	6.55	1.67
Sediment III; g	3.4198	2.6589	4.7542
4. Extraction of the sediment III with NaOH			
Humic acid %	38	42	30
Sediment IV; g	1.8190	0.7896	4.0558

**Table 3.** Results of distribution of humic acid contents of the lignite samples in relation to the soil depth (n=5).

Ilgın lignite	Ash, %	Hig. Humidity, %	Humic acid, %
Top layer	9.65	19.38	32.40
Middle layer	7.48	18.06	30.37
Sub layer	11.00	18.78	24.91



**Figure 1.** The consumption of ammonia of the lignite samples with different size of meshes.

As indicated previously, chemical structures of the humic acid substances were determined by the methods of chemical analysis and IR spectroscopy. (Grosskanisky, 1932; Youngs, 1963; Aitke, 1964). At the end of these determinations, it was found that, there were one or two peaks at 1600-1700 cm<sup>-1</sup> belonging to the aromatic groups. The carboxylic groups appeared at 1600-1700 cm<sup>-1</sup> while the "OH" bands were observed between 3400-3600 cm<sup>-1</sup> in an infrared spectrum. On the other hand, strong peaks were recorded in both

then put into a 300 ml beaker. Twenty ml of 5 % NaOH and 10 ml distilled water were added to the beaker. The mixture was heated on a bright flame and boiled for three minutes. Immediately after the procedure of boiling was completed, the flask containing the boiling mixture was cooled under tap water and then the solution in the flask was centrifuged. The procedure of centrifugation was repeated several times by adding distilled water until the supernatant above the precipitation became clear in colour. The remainders of the solution were collected into another beaker and 50 ml of distilled water was added to the rest of the solution and the pH value was adjusted to pH 3.0 by adding diluted HCl acid. All humic acid materials that were precipitated at the bottom of the flask were filtered, dried and weighed to determine the humic acid contents of the lignite samples.

**Addition of humic acid and lignite samples to the soil:** The soil samples were amended with humic acid substances (at 0.25 %; 5 % levels) and the lignite samples of Beyşehir, Ermenek, Ilgin (at 2 % ; 5 % levels respectively), to remediate the experimental soil.

## Results and Discussion

The percentages of ash, relative humidity and humic acid contents of the three layers of lignite profile belonging to the coal mine site of Ilgin were summarized in Table 3. As it is shown in the table, ash contents varied between 7.48% and 11.0% , whereas hygroscopic humidity values ranged from 18.06% to 19.38% while humic acid contents of the three layers of the Ilgin lignite profile fluctuate between 24.91% (for sublayer) and 32.40% (for toplayer). According to these figures, it was found out that the increases in the humic acid contents were negatively but significantly correlated to the increases in the depth of the Ilgin lignite profile (Table 2,3). On the other hand, the highest humic acid content (average :42%) was found in the Beyşehir lignite sample and it was followed by that of the Ilgin (average : 38%) and the Ermenek (average : 30 %) lignite samples respectively as illustrated in Table 3 and in Figure 1, and also as stated by Sensogut (1999).

On the other hand, it was elucidated that when the lignite was reacted with ammonia, some amount of nitrogen diffused into the coal, and thus this reaction and its rate were directly related to the contents and the formation rates of the humic substance as given in Figure 1.

**Table 1.** Results of some specific physical and chemical properties of the experimental lignite samples.

Some physico. and Chem. Properties	Ilgin lignite	Ermenek lignite	Beyşehir lignite
Moisture (%)	40-45	15-28	31-41
Ash (%)	6-10	21-42	9-34
Sulphure (%)	3	1.3	1.3

This work was undertaken to extract and to determine the humic acid contents of the lignite samples collected from the coal mine sites at the vicinities of Beysehir, Ermenek and Ilgin towns of Konya Province, Turkiye. In addition, it was aimed to elucidate the influences of the humic acid substances and lignite samples amended at two different on the soil aggregation and the modulus of rupture values of a coarse sandy loam textured soil.

## **Materials and Methods**

**Materials:** The experimental lignite samples as mentioned previously, were taken from the coal mine sites around Beysehir, Ermenek and Ilgin towns belonging the Konya Province coal mine sites, from which the experimental lignite samples were collected, have been known to possess large deposits of low grade coal such as lignite to Konya Province. For example, the natural lignite deposits have been supposed to be around 200 million tons. Beysehir, Ermenek and Ilgin towns belonging to the Konya Province are situated at  $31^{\circ}43'-27^{\circ}41'$ ,  $32^{\circ}53'-36^{\circ}39'$  and  $31^{\circ}55'-38^{\circ}17'$  Eastern latitudes and Northern longitudes respectively.

**The soil sample:** For the study, the soil sample was collected from a surface mined coal site in the vicinity of Ilgin town belonging to the Konya Province in the Central Anatolia of Turkiye. For experiments, freshly collected soil samples were air-dried, sieved to pass 4 mm mesh immediately after they were brought to the laboratory and then they were steam sterilized at  $100^{\circ}\text{C}$  for one hour. The soil of the sampling site was a coarse-sandy loam texture with the following properties; pH 7.10 (1:2.5 soil-water) organic matter 0.28 %, CEC 23.4 me/100 g, exchangeable sodium 0.24 me/100 g and the available phosphorus 5.85 ppm respectively. Water stable aggregate percentages and modulus of rupture values were determined by modifying the methods of Kemper (1965) and Reeve (1965).

## **Methods: Laboratory procedure;**

**Collection of the lignite samples:** The sample were take from the sub, middle and surface layers of the profiles of the coal mine sites in September, 2001. The samples were crushed and then screened to 80, 100 and 200 mesh sizes immediately after they were brought to the laboratory.

**Determinations of ash and higroscopic humidity contents:** The higroscopic humidity (%) and ash (%) percentages of the air-dried lignite samples were determined prior to the fractionation and extraction of the humic acid substances (Kemper, 1965; Reeve, 1965).

**Determination of humic acid contents:** Humic acid contents of the lignite samples were determined by the Method of Kreulen as shown in Figure 1. It can be summarized as follows: One gram of the lignite samples was weighed and



## **A Case Study on the Production of Humic Acid Substances from the Low Grade Lignites and Their Effects upon the Improvement of Some Physical Conditions of a Coarse Sandy Loam Soil**

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### **Abstract**

The oxydized lignite called “leonardite” is a source of readily available humic material. In many respects, this material is identical with soil humus having essentially the same source. The humic acids from both soil and oxydized coal (lignite) are identical in chemical and physical properties. Thus, in many respects, the oxydized lignite can be regarded as natural fertilizers and soil conditioners. Like humus, derived from decaying debris, the substances of humic acid can remediate soil structure by physically interacting with clay and sand particles. The purpose of this work, was to determine the humic acids contents of the low grade lignite samples collected from the sites of Ilgin, Ermenek and Beysehir around Konya. In addition, it was aimed to find out effects of the humic acid substances and the lignite samples on the improvement of soil aggregation and structure thus remediation of a coarse sandy loam textured soil sample collected from the coal mine sites around Ilgin town belonging to Konya Province.

### **Introduction**

It is a general concept that the lignite has been known as “fuel” and source of energy just like the other kinds of coal mine. The lignite has been known to contain hydrogen (H), oxygen (O), nitrogen (N) and sulphur (S) and also inorganic matters such as potassium (K) and phosphorus (P). However the vital importance of the oxydized lignite, called leonardite, is that it is a source of readily available humic material. In various respect, the humic material of the lignite is identical with soil humus having essentially the same sources. The soil humus and lignite humus both represent the residually organic material from the past plant generations (Reeve, 1965; Schnitzer, 1967). The humic acids from the oxidized lignite are known to be identical with in chemical and physical properties. For example, they are polycondensed aromatic substances with a high polymeric structure of molecules. The humic substances are generally characterized as weak acids because they have carboxyl (COOH) and hydroxyl (OH) groups (Mukherjee, 1961; Nikonov, 1964; Chakrabatty, 1966).

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### Effect on some physical quality parameters of fresh fruits

Fruit dimensions were increased with the applied manures, minimum fruit diameter being affected at 5 % level whereas fruit neck length, volume, and ostiole width at 1 % levels. (Table 5).

The amount of application and the ratio of the mixture were effected at 1 and 5 % levels. The fruit length was increased with the applied mixtures and the highest value was obtained with the application of 20 kg per tree of 2:1 mixture. Average fruit weight and the shape (fruit index) were not affected. The physical quality parameters were in general positively effected by the applications (Aksoy et al., 1987b; Anaç et al, 1987a).

### Effect on some chemical quality parameters of fresh fruits

The total soluble solids were increased with the applications (5 % level) however no impact was observed on pH and titratable acidity levels (Table 5) . The values obtained in the researchwork were in accordance with the values cited in the relevant literature (Aksoy, 1981; Aksoy et al., 1987b; Anaç et al, 1987a).

The sugar content was analyzed in dried fruit samples and the effect of the applied manure levels and mixtures were not statistically significant. As could be seen in Table 6, increases compared to the control were found in fructose, the dominant and the sweetest mono saccharide and  $\alpha$  and  $\beta$ -glucose. This aspect is supported by the marked increases in the total soluble solids in which sugars comprise the largest percentage. The levels obtained were similar to the previous findings (Hakerlerler et al., 1998; Hakerlerler et al., 1999).

**Table 6.** Fruit sugar contents as affected by farmyard manure applications.

Variables	Fruc-tose	Galac-tose	Sorbitol	$\alpha$ Gluc-tose	$\beta$ Gluc-tose	Sucrose	Total sugars
	(%)						
Control	30,2	1,1	1,7	9,7	13,8	0,58	57
10kg(1/2*+1/2**)	33,0	1,1	2,0	14,8	15,5	0,74	67
20kg(1/2+1/2)	31,0	0,9	2,1	10,3	14,6	-	59
10kg(2/3+1/3)	33,0	1,0	2,0	11,1	15,9	0,19	63
20kg(2/3+1/3)	31,4	1,1	1,8	10,8	15,1	-	60

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**Table 4.** Leaf (lamina and petiole) and fruit(peduncle and pulp) micronutrients as affected by the tested variables.

Variables	Fe(kgm <sup>-1</sup> )			Zn(kgm <sup>-1</sup> )			Mn(kgm <sup>-1</sup> )			Cu (kgm <sup>-1</sup> )			Na(kgm <sup>-1</sup> )		
	Lam	Leaf	Fruit	La	Leaf	Fruit	La	Leaf	Fruit	La	Leaf	Fruit	La	Leaf	Fruit
Control	216	66	14	42	7,9	3,5	1,4	7,3	159	21	4,8	5,1	4,4	1,2	1,7
10kg(1/2*+1/2**)	171	69	14	71	7,8	3,2	2,0	8,0	144	24	5,5	6,0	3,6	1,0	2,1
20kg(1/2+1/2)	204	53	17	66	8,8	4,3	1,3	10	164	21	5,4	5,4	4,0	1,0	1,8
10kg(2/3+1/3)	210	44	15	47	8,9	2,6	1,5	7,0	155	21	5,8	5,0	4,6	1,0	1,8
20kg(2/3+1/3)	198	38	13	46	9,1	3,1	1,4	7,0	177	20	4,4	4,3	3,8	1,0	1,9
	ns	ns	ns	9,69*	ns	0,62*	ns	ns	ns	ns	ns	ns	ns	ns	ns
						0,50*									

LSD 0.05, Level, Mixture, Level\*Mixture

**Table 5.** Effect of cow and sheep manure on fig fruit quality.

Variables	Sht.	Sht.	#	Min	Max.	Fruit	Fruit	Neck	Ostiole	Fruit	Fruit	Total	Titr.	pH
	L.	W.	nodi	Fruit	Fruit	L	Index	length	width	Weight	vol.	Soluble	acidity	
Control	15	10	9	45,8	49,1	34	1,40	6,59	10,0	52	50	22	0,14	5,3
10kg (1/2*+1/2**)	15	10	9	49,2	49,0	34	1,40	6,34	9,2	60	50	23	0,16	5,2
20kg (1/2+1/2)	16	10	10	47,0	50,0	35	1,51	7,83	8,8	60	58	23	0,16	5,1
10kg (2/3+1/3)	16	11	10	47,0	51,0	35	1,40	7,50	8,7	51	50	24	0,19	5,3
20kg(2/3+1/3)	17	13	10	49,2	53,3	38	1,37	8,03	8,7	57	60	24	0,19	5,3
LSD 0.05														
Level	1,12*	0,58**	0,45**	2,02*	1,48**	0,93**	ns	0,87**	0,68**	ns	5,29**	0,75*	ns	ns
Mixture		0,45**			1,20**	0,77**						0,58*		
Level*Mixture		0,85**				1,33**								

**Table 1.** Physical and chemical properties of soil samples taken at 0-30 cm and 30-60 cm depths.

Depth (cm)	pH	Total salts (%)	CaCO <sub>3</sub> (%)	Sand (%)	Silt (%)	Clay (%)	Text. (%)	O.M (%)	T.N (%)	P kgm <sup>-1</sup>	K kgm <sup>-1</sup>	Ca kgm <sup>-1</sup>	Mg kgm <sup>-1</sup>	Na kgm <sup>-1</sup>	Fe kgm <sup>-1</sup>	Cu kgm <sup>-1</sup>	Zn kgm <sup>-1</sup>	Mn kgm <sup>-1</sup>
0-30	5.75	<.030	0.99	74.87	22	3.12	SL	1.60	0.101	3.86	310	500	144	60	57.5	1.81	0.92	6.8
30-60	5.76	<.030	0.82	78.88	18	3.12	SL	0.73	0.056	3.45	180	500	124	70	52.9	2.90	1.24	4.3

**Table 2.** Properties of cow and sheep manure.

Manure	pH	Tot. salts (%)	Dry M. (%)	Loss on Ignition (%)	Ash (%)	O.M (%)	O.C (%)	Tot. N (%)	C/N	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (%)	Cu kgm <sup>-1</sup>	Zn kgm <sup>-1</sup>	Mn kgm <sup>-1</sup>	B kgm <sup>-1</sup>
Cow	8.7	1.36	46.6	45.01	55	40	23	1.32	18	0.47	1.8	0.68	0.82	0.08	1.79	26.6	126	273	15
Sheep	9.6	5.02	69.9	37.88	62	37	21	1.37	16	0.68	6.2	1.12	1.30	0.23	1.77	40.6	125	414	30

**Table 3.** Leaf (lamina and petiole) and fruit(peduncle and pulp) macronutrients as affected by the tested variables.

Variables	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	La.	Leaf	Pet	La.	Leaf	Pet	La.	Leaf	Pet	La.	Leaf	Pet	La.	Leaf	Pet
Control	1.08	0.5	0.39	0.73	0.10	0.06	0.04	0.10	1.64	0.80	0.86	0.89	3.78	1.69	0.26
10kg(1/2*+1/2**)	1.04	0.5	0.40	0.77	0.10	0.08	0.05	0.10	1.65	0.75	0.82	0.84	3.92	1.86	0.27
20kg(1/2+1/2)	1.11	0.5	0.37	0.77	0.10	0.08	0.05	0.10	1.69	0.80	0.77	0.87	3.85	1.88	0.25
10kg(2/3+1/3)	1.06	0.4	0.39	0.75	0.10	0.08	0.04	0.10	1.65	0.75	0.96	0.90	3.87	1.71	0.23
20kg(2/3+1/3)	1.07	0.5	0.35	0.60	0.11	0.08	0.08	0.10	1.16	0.61	0.91	0.87	3.91	1.96	0.20
***	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Level, Mixture, \*Cow manure, \*\*Sheep manure, \*\*\*non significant. Level\*Mixture, LSD 0,05

## **Results and Discussion**

### **Effects on plant nutrients**

The tested levels of cow and sheep manure mixtures did not have important effects on primary nutrients (N, P, K, Ca and Mg) of the leaf lamina (Table 3). The effects on secondary nutrients were also non-significant. The amount of N, Fe, Zn and Cu were evaluated as low according to the relevant studies (Aksoy et al., 1987 a; Aksoy et al., 1987 b; Anaç et al., 1987a; Anaç et al., 1987b; Eryüce et al., 1987; Aşkın et al., 1998).

The leaf petiole nutrients were not affected by the applied organic manure except Ca and Zn. The petiolar Ca was effected by the tested levels at 5 % level. The Zn content of the petiole was significantly correlated (5 %) by the level of application and ratio of the mixtures. The comparison of petiolar Ca, Fe, Zn and Cu levels with those previously found showed a state of deficiency (Aksoy et al., 1987a; Hakerlerler et al., 1997).

The fruit peduncle and pulp nutritional status was not effected by the applied manure except Fe (Table 4). Higher values of N, P, Fe, Zn and Cu were determined in the pulp than the peduncle. The peduncle tissue had higher Ca and Na levels however K, Mg and Mn levels were similar. Akyüz and Aksoy (1992) state that the Fe and Cu contents were advanced towards the fruit maturation period compared to the other secondary nutrients.

### **Effects on tree vigour**

The shoot growth quantified as shoot length, width and number of nodi per shoot is an important parameter that determines the number of fruits per shoot and thus affecting productivity. As could be seen in Table 5, applied farmyard manure exerted significant effects on shoot length (5 %) and the number of nodi per shoot (1%). The interaction between shoot width and level and ratio of the mixture was important at 1 % level and the thickest shoots were obtained at 20 kg application of 2:1 ratio of cow and sheep manure per tree. This parameter was found to be correlated with the plant nutrients namely N and Ca content of the leaf lamina and petiole (Aksoy et al., 1987b).



Further studies on mineral nutrition of fig trees were carried out in Turkey (Eryüce et al., 1996; İrget et al., 1999; Hakerlerler et al., 1999) however no studies were performed with organic fertilizers till to date. The aim of this study was to analyze the effect of various levels of sheep and cow manure mixtures on yield and fruit quality.

## Material and Methods

The trial was set up in an organic fig orchard located in Birgi-İrmağzı of Ödemiş district. The soil samples taken from two depths revealed that the experimental soil is slightly asidic, sandy loam in texture and poor in humus content (Table 1).

The C/N ratios of the tested cow and sheep manure were 17.6 and 15.5 respectively. The chemical composition of the farmyard manure is displayed in Table 2.

The cow and sheep manure were mixed at two different ratios: 1:1 (v:v) and 2:1 and applied as 10 or 20 kg of air dried mixture per tree. The amounts given were 11 kg fresh cow manure + 17 kg of fresh sheep manure per 10 kg of air dried mixture of 1:1 ratio. For 2:1 mixture ratio, 10 kg of dried fertilizer was equivalent to 14.5 kg of fresh cow manure and 11 kg of sheep manure. The experiment was designed as randomized blocks with 5 replications of 5 variables including the control. Farmyard manure was applied on March 4, 1999.

Soil samples taken at 0-30 cm and 30-60 cm depths were analyzed for physical and chemical properties following the international methodology (Kacar, 1972) (Table 1). The sheep and cow manure were analyzed according to Kacar (1990) (Table 2).

Leaf samples were taken at the onset of fruit ripening period in August 1999 (Kabasakal, 1983) and the fruit samples were picked during the harvest period. The leaf samples were separated as the lamina and petiole and the fruit samples were separated as peduncle and pulp. The total N was analyzed by Kjeldahl method and total phosphorous was analyzed colorimetrically. The samples were wet ashed and K, Ca and Na were determined by flame photometry and Mg, Fe, Cu, Zn and Mn by atomic absorption spectrometry (Kacar, 1972).

The sugar fractions in dried fruit samples were determined by gas chromatography (Neubeller and Buchloch, 1975). The vegetative growth of the trees were assessed by measuring the shoot length, width and number of nodi per shoot in February 2000. Fruit quality parameters were determined, as well. The collected data was analysed by using TARİST program (Açıkgöz et al., 1993).

## Effect of Organic Fertilization on Fig Leaf Nutrients and Fruit Quality

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### Abstract

Organic fig orchards located in Ödemiş-Birgi-İrmağzı (Izmir/Turkey) were fertilized by various mixtures of farmyard manure composed of different levels of cow and sheep manure. The results obtained are summarized as follows:

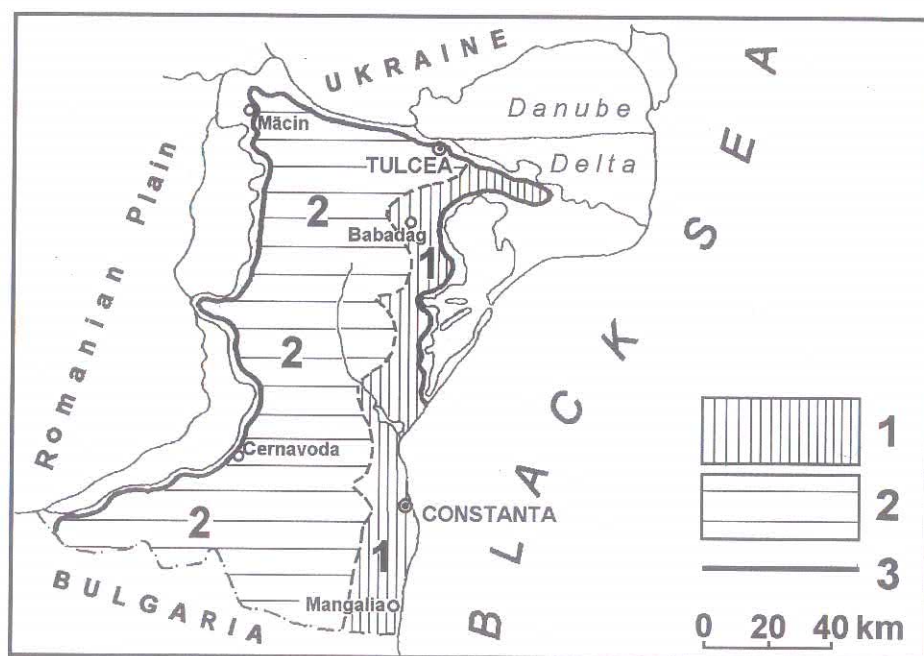
1. The effect of applied mixtures on primary and secondary nutrient contents of the leaf lamina were not significant.
2. The tested variables had marked effects on Ca and Zn contents of the leaf petiole.
3. The farmyard manure applications affected the Fe content of the fruit peduncle and pulp.
4. The organic fertilization enhanced vegetative growth and affected shoot length, width and number of nodi per shoot.
5. The fresh fruit quality parameters as the minimum and maximum fruit diameter, fruit length, neck length, ostiole width and fruit volume were affected by the tested variables.
6. The organic fertilizers created significant effects on dry matter content of the fresh fruit. An increase was observed in the fruit fructose,  $\alpha$  and  $\beta$ -glucose contents however the increase in the sugar content was not statistically significant.

**Key Words:** Fig, Organic fertilization, Quality, Sugar fraction

### Introduction

Organic fig production started in Turkey in 1984-85 and showed an increasing trend parallel to the demand. The acreage of organic fig orchards reached to 3851 hectares in 1999 (Aksoy, 2001). The organic production was 16.1 % of the total and the exportation was 5.8 % in the same year.

In the western part of Turkey, studies on nutrition of the fig tree cultivar Sarılop (=Calimyrna) started with the determination of the seasonal variation of leaf nutrients and then after the research work was concentrated on surveying the nutritional status of orchards in the Big and Small Meander Valleys (Aksoy et al., 1987 a; Aksoy et al., 1987 b; Anaç et al., 1987a; Anaç et al., 1987b; Eryüce et al., 1987; Aşkın et al., 1998).



**Figure 1.** 1, the littoral strip; 2, the central-western strip; 3, the limit of the Dobrogea's Plateau.



In view of the above, a monitoring system of soil erosion control in the littoral area should be put in place to enable both erosion assessment and a detailed territorial outline of erosion control and land reclamation projects.

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more soil particles were entrained, the flow turning into a slimy mass which, reaching the slope foot, formed a 0.35 m-thick mud layer that covered people's courtyards and the streets of Beidaud village. Several wells from Hamangia Floodplain were mud-filled to the brim and no longer usable. The chance to assess right away the quantity of transported material and torrential rain variables made us extend the investigation to a wider area of the Dobrogea Plateau. Similar events associated with slimy mudflows, called "seruri" by the local Turkish-Tatar population, have been signalled to us in the course of time. In the last decade of the 20<sup>th</sup> century, a heavy and very aggressive hailstone-attached rain affected a strip of land stretching out between Valul lui Traian, Constanța and Agigea. The water quantities registered on that occasion (from 4.00 am to 12.00 am) were 100 mm at Valul lui Traian and Constanța, and 110 mm at Agigea. Noteworthy, the rain peak was reached between 7.00 am and 9.00 am, when over 80% of the total water quantity fell, associated with hailstones for over 35 minutes. Damage was done to the southwestern part of Constanța city (down-sagging on loessoid deposits in Bratianu district, affecting over 1,400 residences), the agricultural lands of Cumpăna-Lazu-Agigea area, sinkings of the Danube-Black Sea Canal valleysides, and short fixed valleys forming on slopes and dislodging over 300 tons of soil.

In the conditions of an arid-like climate, particularly in the eastern part of Dobrogea, with annual precipitation means of under 400 mm, torrential rains may fall once in three years, and exceptional events occur once every ten years. Our research looked at soil quantities dislodged or lost in their wake, and at the relationship between this phenomenon and the periodicity of exceptionally heavy rain occurrences in the northern and central Dobrogea. The findings corroborated and completed the data reported by other researchers on the central and southern part of this territory (Bogdan, 1995; Cheval, 1997), revealing significant correspondences between the torrential regime of the June-August interval and the quantities of soil lost through heavy rainfall, especially on the side of the Dobrogea Plateau facing the littoral zone. Two areas, differing in point of soil erosion intensity, were found to be at risk from geomorphic processes (fig.1):

- A. The littoral strip, occupying about 1/3 of Dobrogea's area, stands at high risk from torrential rains causing huge soil erosion (soil loss ca 59 t/ha/year).
- B. The central-western strip, contraining hill-like interfluves and that side of the Dobrogea Plateau facing the Danube, covering 2/3 of the region, is at moderate and low risk from heavy rain-induced processes (soil loss ca 33 t/ha/year).

processes (sheet wash or rilling), and occupy the interfluvies between the Telița and the Carasu valleys, a perimeter representing one of our case-studies. Dobrogea's soils are as a rule quite loose (0-053%), and have a moderate humus and nutrient content. Their vulnerability increases as we approach the littoral zone.

**Human pressure on the environment.** The population registered a progressive increase from the Antiquity until the 10<sup>th</sup> century. When Dobrogea fell under Turkish rule (1417, Mohamed I) and throughout the centuries-long Ottoman occupation, the population decreased, but pressure on the environment did not diminish, on the contrary, the effects of the than massive afforestations are seen to this day. At present, Dobrogea's population numbers over one million inhabitants, the demographic trend indicating a slight decrease from 1,018,000 in 1992 to 1,014,000 in 1996. The rural population lives in 85 communes that englobe 306 villages, but it is unevenly spread in the territory, eg. 28% in Constanța County (southern Dobrogea) and 52% in Tulcea County (central Dobrogea). The average density of 100 inh/km<sup>2</sup> drops in the central part (Casimcea Plateau) and rises on the southern coast where town dwellers are concentrated (Constanța 348,000 inhabitants, Mangalia 44,000 and Năvodari 33,000).

#### **Soil Erosion Processes in Dobrogea Triggered by Heavy Rainfalls**

Geological built-up, together with relief, climate conditions and plant cover and human pressure not the least, are all favouring the development of a wide range of slope and channel geomorphic processes (Cioacă, 1996; Cioacă, Dinu, 1998; Dinu, Cioacă, 1997). Gullying and sheet wash are a frequent occurrence in much of the steppe and sylvosteppe used for hoeing cultures. The intensity of gullying-induced soil erosion in Dobrogea depends on the presence of brittle deposits, steep slope sectors and moreover the torrential regime of the few precipitation falling there. Often enough, thermal convection would generate very intense local continental-type rains, associated with storms, lightning and hail, which in a short time-span pour down quantities several times the average of the respective month (Bogdan, 1995).

One of the many cases of onset and intensification of gullying in the wake of torrential events studied by us illustrates this situation. On July 27, 1977, in a small area (cca 50 ha) belonging to the administrative territory of three communes (Ceamurlia, Stejaru and Beidaud), a five-hour rainfall discharged 108 mm of water, at an intensity of 0.2 mm/min in the first hour and 0.5 mm/min over the next four hours. As a result, nearly 350 tons of soil from the maize-planted interfluvie were washed away, causing a loss of over 7 t/ha. The soil was transported through several ditches and 12 gullies whose drainage basins covered a total of 31 hectares. While the first part of the interval was dominated by high turbidity liquid flow, as the rain became more aggressive,



**The waters.** Deficitary water sheets lie at the basis of shifting deluvial deposits. In the floodplains, where alluvial deposits are thicker and groundwater structures are not very deep, they are closely relating to the other environmental factors (eg. in the Carasu Valley, Basarabeanu, 1973). The situation of deep water sheets occurring in limestone and other carbonate rocks is quite different. The surface net, supplied in proportion of 85% by rain water, has intermittent streams so that runoff from slopes, or sediments moved by floodwaves, are only occasionally evacuated. The eastern basins (Telița with Taița, and Slava with Hamangia, Nuntași, Casimcea and Mangalia) show frequently accumulations of alluvia in the floodplains, largely obturating the stream channel and forming a pile of sediments swiftly carried down by the floods and causing unpredictable changes in floodplain morphology. Therefore monitoring them becomes imperative. In the wake of exceptionally heavy rainfall, the rapid transport of eroded material from cultivated interfluves or from floodplains and terraces used as arable land, affects the tributary basins of the Danube, too (Topolog, Tibrin, Carasu, Rasova, Urluia, and Ceair). Exceptionally high floodwaters, with a great erosive power, carry important quantities of sediment load, the mass of fluid slush, posing a great threat to the human communities living on their banks. As a matter of fact, Dobrogea's rural population has long been aware of this aspect of intermittent watercourses, naming it "seruri" (slimy stream).

**The vegetation.** There are few forest-covered areas. Forest groves are seen only in the northern areas (Măcin Mts, Tulcea Hills) and in the centre of Dobrogea (Babadag and Casimcea plateaus). They represent the mesophyllous belt with Mediterranean, Balkan, and Turanian-Caucasian elements, and the xerothermal belt (lime and oak). In the south-eastern part of the region the mesophyllous belt is represented by ash and hornbeam. In the sylvosteppe (over 100 m alt.), and steppe (under 100 m alt.) there grow couch grass feather grass and wormwood, but there are large expanses of non-agricultural areas, too.

**The soils.** The soil cover belongs to the East-European Region, Danubian-Pontic-Province with excessive continental-temperate shades (Bucur, 1948). The majority of soils are molisols: cambic chernozems in the sylvosteppe; chocolate chernozems, and carbonated chernozems in the steppe, on the marginal glacis and on the low, flat interfluves, respectively; on the western and eastern parts of Dobrogea representative soils are kastanozems. Soils variously affected by podzolisation, more precisely the argillic brown soils, are found at depth of 250 m under the oak forests of the Măcin Mountains, on Niculițel Plateau or Babadag Plateau. Intrazonal soils (erodisols and lithosols) have a local spread (Butnaru, 1962). They are specific to areas affected by torrential

and large plateau sloping down towards the Cernavodă - Constanța axis (under 100 m). The wide, flat southern interfluvies mount up to 100-200 m. Since the relief in general is not very rough, reconstituting the levelled surfaces; ie. the Dobrogea peneplane (Coteț, 1968) interpreted as polygenetic pediplane (Posea, 1974), is not that difficult. Most geographers use to single out four levels: Greci (400 m), Niculitel (300 m), Tulcea (180-200 m), and the Quaternary (80-100 m).

Our study addresses particularly glacis and pediments because these are the sites where torrential events take place, the floodplains being affected by fluvial processes. Reconstructing the terraces along valleysides is a more difficult matter because what has been left are largely fragments, or fossilised traces under colluvial-proluvial deposits. The Casimcea terraces (3 out of 5 of which only two for sure, the 2-5 m and the 10-15 m ones) and the 150-to-over-1,000 m wide floodplains, with 8-20 m-thick alluvial deposits, could be identified more easily.

The structure-controlled relief shows a huge variety of forms: syncline valleys (Luncavița and Slava), anticline valleys (Valea Albă), depressions carved in anticlines (Megina and Boclugea), lithologic contact valleys (Peceneaga and Fântana Mare), tectonic depressions (Nalbant and Cerna-Mircea Vodă). But our attention focused on the petrographic relief, particularly the one developed on loess and loessoid deposits, because in semiarid conditions gullyng is more obvious there.

**The climate.** The main climatic variables designating as Dobrogea semiarid region (Stănescu et al., 1993) are the thermal regime and the atmospheric precipitations conditional upon the radiative and dynamic factors of climate and topography. Since the sun shines for 2,200-2,500 hrs/year, the eastern part of Dobrogea registers the highest annual global solar radiation value in Romania, ie., over  $132.5 \text{ kcal/cm}^2$ . Hence, the radiation balance during June and July is increasing, so that in midday Dobrogea's active surface benefits by over  $0.78 \text{ cal/cm}^2/\text{min}$ , the highest value in this country. The air temperature averages over  $11^\circ\text{C}/\text{year}$  towards the littoral area and the Danube floodplain, and no more than  $10^\circ\text{C}$  and  $11^\circ\text{C}$  in the north and centre. Precipitations have a similar distribution pattern : 375-400 mm/year towards the Danube and the Black Sea, and up to 450 mm/year or even over 500 mm/year in the north. There are 40 tropical days /year, and 220 frost-free days/year on average. Torrential rains (assessed by Hellman's criterion at 2.5-7.5 mm/min are absent in 85% of cases (years), and when they do fall, they cause havoc even on very mild sloping surfaces. Over the 1970-2000 interval, exceptional torrential events were locally recorded in the warm season as follows: July 1977, June, 1985, July 1993 and July 2001, enhancing sheet and linear erosion. As a result, important quantities of material were dislodged and transported from these low-declivity surfaces.



old place names eg. Callatis became Mangalia and Tomis, Kiustenge etc. On October 8/20, 1878 the province of Dobrogea was reunited with Romania.

Although proofs of ancient and continuous inhabitation from the Paleolithic (at Adam and La Izvor), the Neolithic (at Hamangia and Gumelnita) and the Bronze Age (Tracian population) do exist, the population began growing and increasing its pressure on the environment only in the Antiquity, after Milesian and Dorian Greeks settled at Tomis and Callatis, after the Romans conquered Dobrogea turning it into a Roman province (46BC) and especially after the Byzantine occupation that lasted up to the 10<sup>th</sup> century.

The present geographical space between the Danube and the Black Sea is known as the Dobrogea Plateau, a name circulated in the 20th century due mainly to Bratescu's work, *Die Dobrudgea* (1909).

### **The Current State of Dobrogea's Environment**

**Geology.** Much of Dobrogea's territory overlaps the Walachian Platform bordered by the Danube fault in the west, Sfântu Gheorghe fault in the north and a flexion in the east that extends into the Black Sea littoral platform. In the southern part, the province stretches out towards the Balkans (Bulgaria).

The process of its formation was a stagewise event, beginning with the Lower Proterozoic during the Karelian orogenesis, followed by the Baikal orogenesis which shaped an exondated relief developed on granitic gneiss and crystalline schists in the south and green schists in the centre. In the Upper Proterozoic-Lower Paleozoic, the Hercynian domain emerged in the north, revealed by magmatites generating granite masses in Măcin area. There were several synchronous sedimentation cycles in southern Dobrogea: Paleozoic (quartzites and clays); Jurassic-Barremian (carbonite deposits); Cretaceous (micro-conglomerates, sandstones and marl-limestones); Paleogene (numulites limestones); Miocene-Badenian (clays, limestone, marls); Sarmatian (lumashele limestones), and finally Pliocene (marls, sands and Romanian lacustrine limestone). In the northern and central Dobrogea there are only two sedimentation cycles: Jurassic (limestone) and Cretaceous (littoral facies).

That multitude of stages would explain the huge diversity of rocks: crystalline schists, clay-schists, quartzites, limestone, granitic magmatites, limestone marls, and Sarmatian lumaschele limestone. The wide expanses of surface loess and loessoid deposits (Coteț, Cioacă, Anton, 1968) form most of the parental material.

**The relief.** As a result of a long subaerial evolution, the average altitude in Dobrogea is no higher than 125 m. However, in spite of it, altitudinal variation does exist and it reflects just the differences imposed by evolution stages and structural-petrographic conditions. Maximum altitudes occur in the north-west, along the Pricopan Summit (Pietrosu, 426 m, Țuțuiatul, 467 m, Moroianu, 428 m and Sacari, 406 m). Here are also summits and isolated peaks (over 300 m)



## **Torrential Rainfalls in the Semiarid Environment of Dobrogea (Romania)**

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### **Abstract**

In the last century, people became interested in investigating Dobrogea's soil and subsoil resources. As a result, this semiarid area, long deemed hostile to human settlement, started being populated so that more and more localities began cropping up. The increase of population was associated with the need for more terrain, which in turn prompted in-depth studies into the region's environment. The present approach tackles the problem of the relationship between the state of environment and the geomorphic processes peculiar to Dobrogea's semiarid space, with focus on the behaviour of surface formations to the impact of torrential rains. Although the region covers a fairly small area (10,400 km<sup>2</sup>), it nevertheless has a highly varied relief. The diversity of landforms is structure-controlled, petrographic conditions and successions of modelling systems stamping their mark in the course of time. What distinguishes Dobrogea's climate from other regions in Romania is the annual average temperature, somewhere over 110 °C, and the west-east - north-east decrease of precipitation from 450 mm/year to 350 mm/year. Regardless of lower intensities from west (7.5 mm/min) to east (2.5 mm/min), the risk for extreme climate phenomena to set in and affect the relief by torrential rain-induced processes in the valleys is by no means reduced. The final part of this study contains a map of rain-induced soil erosion risk in Dobrogea.

**Key words:** torrential rainfalls, soil erosion risk, Dobrogea.

### **Dobrogea, Brief Historical-Geographical Outline**

Surrounded by the Black Sea (Kara Deniz), in the east and the River Danube in the west and north, Dobrogea is quite a peninsular territory. The River's floodplain is dominated both by the Bărăgan Plain and the Delta's alluvial plain. The region is situated in the south-eastern part of Romania and covers 10,000 km<sup>2</sup>, that is 4.3 % of the country's surface-area.

In Ancient Times, the first to colonise it were the Greeks. Next came the Romans, who conquered and annexed it to the Empire by the name of Scitia Minor. After the Roman Legions left Dacia, the province remained a northern outpost of the Eastern Roman Empire (Byzantine Empire) and fell into decay. Eleventh-century documents speak of it as Paristrion. Between 1186 and the 14<sup>th</sup> century it was part of the Bulgarian Empire. In the 14<sup>th</sup> century, the Empire crumbled and this Principality, led by Dobrotich (from whom its name is derived), was temporarily annexed by the Romanian Principality of Walachia. For five centuries Dobrogea stood under the Ottoman Turks who changed the

**Table 2.** The Armenian Upland Soil mantle Characteristic based on space images deciphering.

№	Basin	Type of morphostructure	Subtype of Morphostructure	Vertical Zones (Landscapes)
1	The Black Sea northern slope aspect	Folded and Blocky-folded (Pontiy mountains)	Marginal mountain chains	Alpine, Subalpine, Mountain Forest
2	The Persian gulf southern slope aspect	Folded and Blocky-folded Armenian (Eastern)Tavr	Marginal mountain chains	Alpine, Subalpine, Mountain Forest Semidesertic
3	The Caspian Sea Eastern sebre aspect	Folded and Blocky-folded Kurdistan (Zagros)	Marginal mountain chains	Subrinal, Alpine, Subalpine, Dry steppe
4	Innercontinental part Persan gulf basin	Folded and Blocky-folded (Antitavr)	Inner ridges	Alpine, Subalpine, Mountain Forest
5	The Caspian Sea Sonthern South western South eastern Slope aspect	Volcanic Massifs	Major Poligenic Volcanoes	Alpine, Subalpine, Steppe Dry steppe, Semidesertic, Desertic
6	The Caspian Sea The Persian Gulf (Innercontinental)	Volcanic Massifs	Volcanic Plateaus	Steppe, Dry steppe,
7	Major lakes basins, major intermountane innercontinental hollows	Intermontane Depressions, Troughs, River Valleys	Low mountain	Semidesertic, Desertic
8	Major lakes basias, major intermountane innercontinental hollows	Intermontane Depressions, Troughs, River Valleys	Medium-mountain	Steppe, Dry steppe
9	The Black and Mediterranean seas	Intermontane Depressions, Troughs, River Valleys	Marine	

vertical zonality of the mountain massif, it's affiliation to a certain sea basin and macroexposition. The phenomena of soil zones interference, inversion and migration often occurs here. Frequently, medium mountains are represented only by one mountainous-forest zone, but the soil mantle composition may be very diverse. The composition is defined both by the climatic conditions and by the intensive anthropological influence, thus promoting soil degradation and the alternation of soil formation type.

Intermountainous valleys and depressions are well detached on space images in the form of stretched isometrical light shade contours.

These morphostructures vary by relative climatic stability and simple orophography; consequently the soil mantle composition depends primarily on the vertical zonality (climatic factor) and on the structure of the original rock.

One can encounter the valleys with the formation of "rain shade" conditions. Depressions at the boundaries of shield volcanic massifs are usually characterized by increased humidity.

Marine alluvial plains are situated along the Black Sea shores. Usually they are close to the lower reaches of the rivers, and their deltas, where the marsh zone soils are developed.

The research shows that in spite of the fact that the Armenian Upland is a single physico-geographical region, it differs by the complexity of landscape structures and soil mantle. The boundary position of the Upland, formed at the junction of the huge Eastern European and Arabian tectonic plates, under the condition of intensive andogenesis, resulted in the diversity of geological, geomorphological and climatic conditions. The difference in soil mantle composition is defined not only by vertical and local slope aspect conditions but the mountain structure as well (morphostructural type, macroexposition, affiliation to a certain marine drainage basin) (table 2).

## **Conclusion**

The degree of soil mantle diversity, deciphered by space images, is greater than the variety of landscapes represented by a number of vertical zones from nival to desertal. This information may serve as a "large-scale" legend to the Armenian Upland Soil mantle spacemap which was compiled according to the results of deciphering using a 1:800000 scale.

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steppe soils); (4) mountain-forest (with brown forest and postforest soils); (5) mountain-steppe (with chernozems and meadow chernozems); (6) dry-steppe (with chestnut soils); (7) semidesert (with brown semidesert and light chestnut soils); and (8) desert (with irrigated brown meadow, boggy soils and solonchaks).

Volcanic morphostructures of the Northern and North-Eastern parts of the Armenian Upland are situated mainly on the territory of the Caspian Sea basin and are influenced by the arid climate. Sets of large volcanoes are also situated in the region near the lakes Van and Urmia.

They are characterized basically by the presence of vertical sequence with more or less broad scales of zones, depending on volcanic massifs height and size. Forests aren't sufficiently developed here.

Another peculiarity of this morphostructural subtype testifies to the fact that almost all volcanic massifs occupy areas with increased moisturizing, where special raised soil water escape occurs. If the escape is rather high then the formation of humid meadows with hydromorphic meadow-marshal, meadow-chernozem soils takes place. At a volcano's foot, marshes are frequently formed, sometimes together with salted saline or saline-alkali soils.

The morphostructures of the volcanic plateaus are usually characterized by sufficiently uniform soil mantle, its composition and structure depending on the geological and climatic conditions.

Arboreal vegetation does not usually occur on the volcano plateaus, landscapes are primarily dry-steppe or steppe. According to the specific photo images it was noticed that Care plateau is the southern boundary of typical steppes with chernozem soils.

### **Folded and Block-Folded Morphostructures**

The peculiarity of folded mountains is defined by the way the watershed basins are formed on their slopes.

We suggested the unique energy model of such basin formation [1,2]. The model proceeds from the assumption that the watershed basin development results from two interrelated processes of mountainous massif destruction and growth of channel fracturing up the slope. In turn, fracturing arises from the relaxing inner stress of the mountain massif and is described by a number of physicommechanical parameters and conditions.

The mountain's soil mantle formation occurs under the conditions of interaction of two biospherical processes - high vertical zones and lithodrainage basins. That's why the slopes of folded and block-folded mountains are subjected to different changes connected with the advanced dynamics of such basins leading to the vertical soil degradation sequence.

The vertical zonality is not so clearly expressed here especially in the boundaries of medium-mountains. The soil mantle composition is defined by the size and

Besides the confined basins of Van and Sevan lakes form special watershed basins. It helps to characterize them as major geosystems with a definite predominante direction of substance displacement and also with climatic peculiarities.

Varions folded and blocky-folded structures compose approximately 60% of the Armenian Upland territory. Volcanic structures are concentrated in the central and eastern parts of the Upland and are represented both by the separate Volcanoes (Ararat, Aragats, Tondurec, Sipan, Velidgean, Nemrut etc.) and volcanic uplands (The Cara (Carskye) plateau and the Aladag Upland).

**Table 1.** Types and subtypes of morphostructures identified in space photographs.

Morphostructures	
Types	Subtypes
Folded and blocky-folded mountain structures	Major marginal mountain chains
Volcanic massifs	Inner mountain ridges
	Separate volcanic structures
Intermontane depressions,	Volcanic plateaus
Troughs, and river valleys	Low- mountain
	Medium- mountain
	Marine alluvial plains

The intermountain depressions are quite equally spread all over the Upland territory in different vertical zones and according to their geologic and, geomorphologic composition, are often characterized by sublatitudinal stretch (Ararat and Mushskaya Valley, Alekshertskaia hollow etc).

Soil mantle deciphering of the major morphostructures were executed within the types and subtypes. The scheme of soil mantle research and mapping on the space images deciphering materials can principally be represented by a set of major positions:

1. Basic macroexposition
2. Morphostructural type
3. Morphostructural subtype
4. Vertical zonality (sequence)
5. Predominant soils

### **Geographical Principles of the Armenian Upland Soil Mantle Formation**

The dissemination of nival alpine and subalpine zones of the Armenian Upland, formed in the zones of free atmospheric circulation, is guided by the principles of vertical sequence, common both to folded and volcanic morphostructural types. There are differences stated by soil mantle deciphering within various morphostructures of lower zones.

The following vertical zones with the related predominant soils are reliable distinguished in the space photographs: (1) subnival; (2) alpine (with mountain meadow, soddy, and soddy peaty soils); (3) subalpine (with mountain meadow

## **Soil Mantle of the Armenian Upland: Mapping by Deciphering of the Space Images**

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### **Abstract**

The vertical natural zones and the soil mantle as a ecosystem component have been characterized by deciphering of the space images. It seems appropriate to consider the soils within different morphostructures (the folded and blocky-folded mountains, volcanic massifs, intermountain depressions, valley, etc.). The soil mantle in folded mountains is developed under the impact of dynamic processes related to the endogenic and exogenic transformation in the river lithodrainage basins. In turn, the location of the specific morphostructure within the definite sea basin determines the bioclimatic and the soil mantle feature at the regional level.

### **Method and Results**

The soil mantle research and spacemapping of the Armenian Upland were made by the extrapolar deciphering of space images with the scale of 1:200000 – 1:20000. The traits of deciphering and the interpreting arid mountain topsoil formation peculiarities, which had been found before on the territory of example regions, were used for this research. The published data and the mapping materials were applied for the expert aspect.

### **Morphostructure as a Mountain Soil Mantle Formation Structure**

The carried research showed that, according to space images, such forms of relief as folded, volcanogeneons and tectogeneons-volcanic are clearly seen (by the image and peculiarities of photoimage borders). For soil mantle deciphering it was suggested to use such characteristics as types of morphostructures as a means of the largest taxon and mapping element, and those satisfactorily deciphered by the images of the least scale ("Meteor" "Kosmos"), were considered as morphostructures.

It is suggested to point out 3 types and 7 subtypes of morphostructures showing geologic – geomorphological peculiarities of the mountaneous country under research. (table I).

The Watersheds of four large basins such as the Black sea, the Caspian Sea, the Mediterranean Sea and the Persian Gulf were represented on the territory of the Armenian Upland.



extending the area of trouble. Optimal nature use was not reached, and main expectations are not realised. What are the reasons of this difference between concepts and real results of reforms?

Political and economical changes in Russia were too abrupt and not provided with correct legislation, particularly in the first half of 1990<sup>th</sup>. Uncontrolled actions were the main factors of rapid soil degradation in the beginning of reforms, and only to the new century land use governed by law is developed. This is the main lesson which we can learn from decade of mountain land use change in Russia.

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oil and oil products from illegal oil refineries. Beech and hornbeam forests are completely destroyed by military actions, and northern slope of Terskiy ridge is destroyed by slides (S. V. Zonn, Moscow, 2001, personal communication).

The combined results of all this factors are the degradation of natural ecosystems and agricultural lands, and the mass migration of population from mountain regions, especially from the North Caucasus. Usually migrants choose central parts of Russia and especially urbanised areas, but many of them, including Georgian migrants, prefer such part of the West Caucasus as Novorossiysk-Sochi coast of the Black Sea. This region is considered now as one of main immigration regions of Russia.

### **Migration of Population as Factor of Land Degradation**

One of the serious impacts of migration process on the land conditions is that many migrants have no practical knowledge and ability to live and work in new environment. Thus the area of troubles is extending. As a case study the agricultural activity of migrants from dry mountains in humid Sochi region was considered. The Sochy district is located on the south-west macroslope of the West Caucasus along east coast of the Black Sea. It is humid subtropical marine region, where mountain slopes along coast are subjected to intensive natural slakensliding, and hazard of soil slides is a highest in Russia. The frequency of landslides and creeps reaches 1000 within narrow 10 km strip along the coast (Azhigirov, 1987). Daily life and activity of local communities are adapted to this phenomena and aimed to reduce slide actions, and it is really life-supporting use of indigenous knowledge. On the end of 1980-th the Armenia-Azerbaijan conflict provoked the waves of migrants from this republics, and later active migration from dry regions of the Northern and East Caucasus took place. New habitants ignore local experience and use their traditional ways of agricultural cultivation and building of houses, such as terracing, excessive irrigation, disturbance of monolithic properties of ground, which are non-adapted to local conditions. This intensifies both shallow and deep slides. So, two different systems of indigenous land use found themselves in contradiction in the mountain region of modern multinational immigration.

### **Conclusion**

More than ten years of transformation of nature use changed the conditions of land and soil resources in forested and agricultural mountain regions in Russia. The combined results of partial regional economical independence, land and forest privatisation led to transformation of ways of mountain land use, and, as a result, degradation of natural ecosystems and agricultural lands. Lack of comfortable agricultural lands and poverty induced the mass migration of population from mountain regions, especially from the North Caucasus, and



stopping grazing during 2-5 years and regrassing are necessary, and grazing licence must be obligate (On the State of Environment in the RNO-A..., 1996; Ilichev & Gracheva, 1998). Present conditions of pastures productivity shows that self-restoration of mountain ecosystems without human efforts is problematical.

The poverty of population and need of food caused the increase of areas of clean-tilled crops in the Caucasus, especially maize, and their expansion to slopes. In the West Georgia even part of tea plantations, including experimental scientific plots, was destroyed and transformed into cropland. As a result, human induced soil erosion on the Caucasus was intensified everywhere except alpine belts (Gracheva & Chernyakhivskiy, 1990; Gigineishvili & Nahutsrishvili, 1998).

In Russian part of the Western Caucasus privatisation of land didn't exceed 17-20%, and the main previous regularities of agricultural land use are preserved. But activity of large part of population is connected with rest service now, and, for example, private individual farms produce only 10-12% of total grapes production of Krasnodar kray (Agricultural activity..., 1999; Agriculture in Russia, 2000). On the whole, condition of lands is more successful in Russian part of the West Caucasus than in the West Georgia where more than 50 % of land was deeply eroded by the end of 1980<sup>th</sup> (Gvazava, 1984; Gracheva & Chernyakhivskiy, 1990). However, impact on the soils and the nature in this region is intensified by increase of population due to immigration (Russian statistical annual, 2000).

The privatization of forestry have led to jump of unemployment, migration and impossibility for mountain communities to take part in forest management. It is particularly characteristic for the West Caucasus, Trans-Caucasus and Altay. Local communities found themselves out of economical activity and forest use management, and non-adapted felling and soil destruction are practically uncontrolled.

3. The indigenous knowledge is often applied for individual survival only and concerns mainly the ways of soil treatment by hand and return to traditional simple food. On the Caucasus this means increasing areas under maize and vegetable, and felling nearest trees for firewood. Unfortunately, hard life conditions and poverty make people to forget their traditional nature protective habits and stop such social public actions as to put roads, soils or streams in order. The indigenous nature use and trades are superseded from present economy of this region. In last years first steps to aboriginal communities, self-government and land use management are undertaken in Altay.

The war conflicts in the Caucasus, ethnic contradictions in South Siberia mountains complicate and multiply all problems of land use in mountain regions. In Chechnya (total area is ~19,000 km<sup>2</sup>) only 200,000 hectares, possibly, are suitable for agriculture now. The vast areas are contaminated by



greatest part of regional budget was expected as financial support from Federal budget (The Concept and the Program..., 1996).

2. Privatization of industry, forestry and agriculture will be a precondition of ecologically adapted nature use. Private-owner psychology was considered as psychology of economy, and it was expected that owners, especially farmers, use the nature protective methods of management on local level.

3. Regeneration of indigenous knowledge of mountain land use will lead to traditional man-nature relationships.

These concepts and expectations were widespread particularly in such populous and multinational mountain regions as the Caucasus and, to a certain extent, Altay and Tuva.

### **Results of Transformation of Nature and Land Use 10 Years Later**

What are the real results of these expectations 10 years later?

1. Collapse of the economical dictation of central authorities turned into independence on nature protection legislation and destruction of nature resources. First of all beech, fir, chestnut (the Caucasus and Trans-Caucasus) and the coniferous (Altay, Sikhote-Alin) forests, including soil- and water-protective ones, were cut, and the afforestation is stopped almost everywhere. According to numerous data more than 30% of forests in the North and West Caucasus, Trans-Caucasus, Sikhote-Alin, Altay are destroyed by felling. Economy of some mountain regions, for example, on the southern part of Far East, is directed to logging only, and predatory forest destroying activated catastrophic soil erosion. In the Caucasus felling was particularly intensive in 1992-1996, and was restricted since 1996-1997. Due to the logging and building of temporary roads the soil erosion and creep intensify catastrophically, especially in the humid parts of Caucasus and Trans-Caucasus. These human induced processes coincided with peak of climate induced activity of slides, mudflows and avalanches. Numerous new landslides appeared in Sochi district (Krasnodar Kray), and the giant catastrophic debris slides took places in Hulo district of Mountain Adzharia (Georgia) during last 10 years.

2. The first steps of privatization began as far back as 1987-1988 in the Caucasus and Transcaucasus as dividing the property of the collective farms and attempts to increase the head of cattle and land areas in the private ownership. This action was unsuccessful because of lack of forage and markets, but its consequences were very significant. The intensive use of the nearest pastures resulted in heavy grazing, depletion of bioproductivity and increase of cattle-plague; distant mountain grazing lands were neglected and rapidly changed to rough, stony areas. Thus, in North Ossetia-Alania the productivity of pastures decreased down to 5-30% from potential one; due to erosion some of pastures lose from 35 to 190 hectares during the year. Now 67% of pastures of Ossetia-Alania are eroded. In order to overcome this state of emergency the

## **Mountain Regions of Russia**

Russia can be called a country of great plains as well as of great mountains, that occupy almost 42% of its total area. All mountains of Russia can be divided into 4 groups depending on density of population and present economic development (Alekseev, 1998; Bol'shakov et al., 1998; Rudskiy, 2000).

1. Mountains of north-east Siberia and Far East, excepting Sikhote-Alin ridge: uninhabited mountains with extremely severe climatic conditions and permafrost. There are isolated mining areas and rare net of temporary settlements of hunters and fishers, and agricultural activity is not characteristic for them. Land use problems of these regions are typical for all marginal cold regions of Russia and are caused by destruction of biota and soil cover by mining.

2. Middle and South Ural, northern foothills of Altay: densely populated multinational industrial regions. Land use problems of these regions are typical for all industrial areas of Russia under reforms, and population does not identify themselves as mountain inhabitants,.

3. Mountains of Middle Siberia, South Siberia (Sayans, Altay, Pribaikalie and Zabaikalie), Sikhote-Alin, Northern and Subpolar Ural which include: a) local relatively densely populated areas, oriented to industry and mining; b) less populated areas of forestry and agriculture; c) vast uninhabited territories. Density of population change from 1–10 to 25 person.km<sup>-2</sup>. The main land use problems are as follows: superseding small aboriginal nations from land management, protection of their environment and nature protection in industrial and mined areas.

4. The North and West Caucasus: strongly dissected mountain region with variability of bioclimatic conditions, multinational dense population, multieconomic development and long history of agriculture. It is unique part of Russia, but all its problems are typical for the Caucasian and Trans-Caucasian new states - Georgia, Armenia and Azerbaidzhan. Problems of agricultural use of land are more characteristic for this region than for other mountains of Russia.

## **Expectations in the Beginning of Reforms**

In the late 1980<sup>th</sup> many ideas and concepts suggesting the new ways of socio-economic development based on the rational nature use were published and discussed very actively in the USSR. The main ideas and expectations concerning optimal nature use can be called as independence, privatisation, and indigenous knowledge, and were as follows.

1. Economical independence from centre (Moscow) and regional self-government will lead to rational nature and land use, adapted to regional specific. This idea was exposed in many regional programs of economical development, for example, in Daghestan Republic, in spite of fact that usually



## **Ten Years of Transformation of Mountain Land Use and Soil Resources in Russia**

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### **Abstract**

The main ideas, concerning the mountain land use, which were widespread in the beginning of political and economic changes of soviet space, were as follows: 1) economical independence of centre and regional self-government will lead to rational nature and land use, adapted to regional specific; 2) privatization will be a precondition of ecologically adapted land use; 3) indigenous knowledge of mountain land use will regenerate traditional man-nature relationships. Real results of these expectations 10 years later are shown: collapse of the economical dictation of central authorities turned into independence on nature protection legislation and destruction of nature resources; privatization results in degradation of natural mountain ecosystems and agricultural lands, unemployment and migration; the indigenous knowledge is often used for individual survival only. Uncontrolled agricultural activity of migrants in the mountain region can be the factor of land degradation.

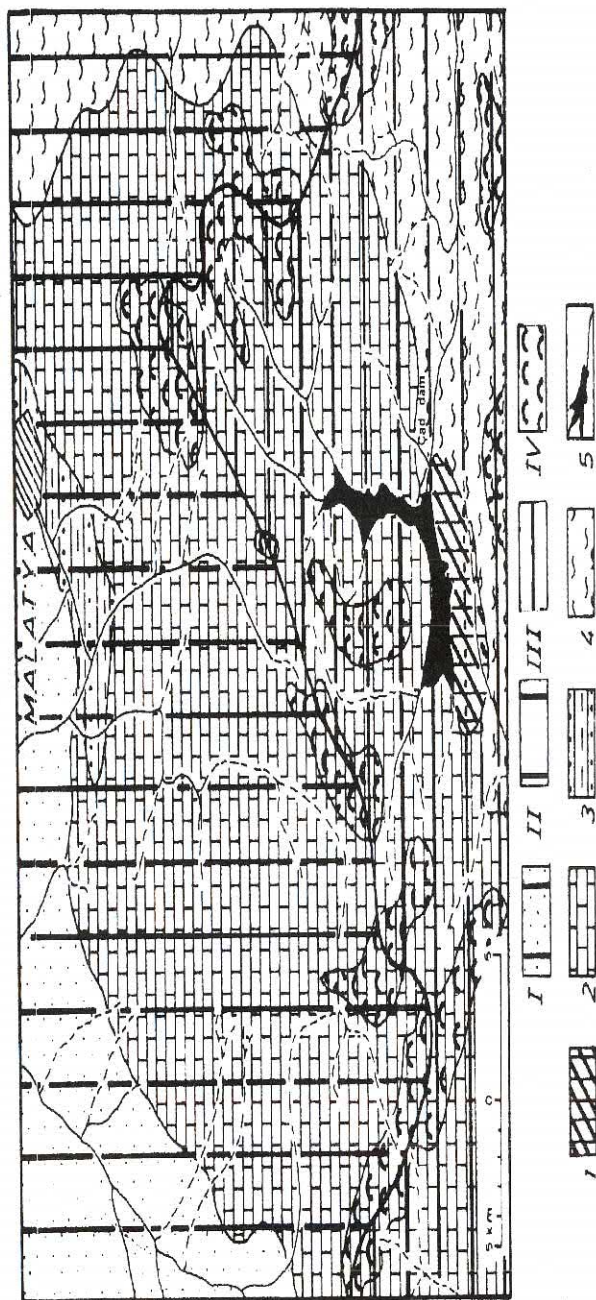
### **Introduction**

Abrupt change of social factors usually leads to the transformation of ways of land use, and as a consequence, to nature and land degradation, and human history gives many examples of that kind of situation. 1991 gave start to the extremely significant political and socio-economic change within all space of former USSR, and after ten years of transformations mountain regions of post-soviet space have as a whole the same social, economic and nature use problems as lowland areas. However, many of these problems, especially nature use ones, in mountains are strengthened up to crises and catastrophes and are reflected not only in present but in future life of mountain community.

One of the main life-supporting factors in mountain regions is existence and conditions of their soils, and first of all the total thickness of soil and fine earth content. Soil degradation and lack of arable lands in agricultural mountain region could be a cause of its economical degradation and depopulation. That is why the understanding the relations in the system "change of social factors - transformation of land use – conditions of soil resources" is very important for working out the policy of sustainable development of mountain regions.

The aim of study was to consider the main results of ten years transformation of mountain land use and reflection of these transformations in conditions of mountain soil resources of Russia. The paper is based on published sources and field researches in 1984-1991 and 2000.





**Figure 2 : Ecosystems of the Malatya Mountains**

**ECOREGIONS:** I. Steppe subregion, II. Dry forest subregion of the Eastern Anatolia, III. Dry forest subregion of the Southeastern Anatolia, IV. Orobiome **GEOBIOMES:** 1. Gneiss, 2. Limestone, 3. Flysch, 4. Serpentine-peridotite, 5. Çat dam

poisonous and spiny weeds should be removed by the natural competition of the herb species in the protected area.

- The cutting of oak branches must be prohibited in order to maintain the natural regeneration and the increase of biomass productivity of the oak forests.

- The eroded areas must be reforested and afforested. In the reforestation activities the oak being climax species of the region plant have to be selected.

The sustainable use of the natural resources, in broad sense including the protection of environment, is dependent on the economic and social development of the rural people. For this reason some measurements, relating to the education, settlement rehabilitation, innovation in the animal husbandry, marketing, economic aids, various extension etc should be taken into consideration.

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Gneiss ecosystem: This rock unit extending as a belt along the southern part of the study area also shows special habitat for erosion and reforestation. As it is known, gneiss produces sandy soil that contains mostly quartzitic particles. These fine particles are being carried away by the runoff on the sloppy area. In these areas deep gullies and rills are widespread. Slope debris are common on the slopes of gullies due to natural equilibrium has been deteriorated. Although CEC is low, these areas produce good habitat for the growth of forest because tree roots develop easily in the well weathered gneiss surfaces. One can see good stand artificial forest composed of cedar and black pine in the vicinity of Çelikhan Town (Fig. 2).

Subalpine ecosystem: This ecosystem appears after the natural timberline extending over at an elevation of 2000-2200 m in the upper part of the Malatya mountains. Subhumid and cold climatic conditions prevail. In this area high mountain soil having acid reaction and rich organic content is common. Indeed, the pH of this soil shows weak acid reaction and its organic content is about 5 % and carbonates have been carried away due to excess precipitation. CEC of this soil varies between 26 and 28 me/100 g soil. This ecosystem is the main meadow areas of sheep and goats. Grass productivity is high on the karstic depressions containing thick soil cover. Most of the climax herbaceous species have been disappeared because of early and heavy-grazing system. For this reason spiny cushion species which are composed of *Acantholimon* and *Astragalus* sp. and bitter species with *Euphorbia* and *Verbascum* which are not eaten by animals are widespread.

## Conclusions

1. Mountainous areas have generally been degenerated and degraded due to misuse of the lands. Karstic lands have been converted into rocky lands as the result of the forest destruction. Soft parent materials composed of flysch and well weathered gneiss have undergone to gully and rill erosion. The sediment yields of these parent materials are very much than that of the other parent materials. For example the sediment yield of 1 square kilometre of Kahta watershed areas connecting the Atatürk Dam is more than 2500 tons.
2. Ecological unites or habitats are determined by the physical and chemical properties parent material in places where natural equilibrium have been deteriorated. In other words, ecological properties of the study area are based on the parent materials.
3. In order to establish the regain of natural equilibrium in the mountainous areas some important measures may be taken as follows:
  - The early and heavy grazing system continuing on the natural pasture areas in the upper part of the mountains must be prevented, the rotational grazing plan should be applied based on herb productivity. In addition to these, the



leads to the widening of fractures, this process is very well expressed in the mesozoic limestones in the Malatya Mountains.

Soils which developed along the fractures, have been transported vertically by a widening of the fractures via chemical dissolution of the limestones. Thus the soil mass may be removed from the near surface to much deeper zones by vertical transportation with time. Such soils, in general are red and completely decalcified. This explains why soils are found in the fillings of caves and of karstic depressions (Atalay 1997b). Soil erosion processes generally do not occur on the surfaces of the karstic lands because of the fact that the run-off is very low and the rock has a high infiltration capacity (Atalay 1995, 1997a, 1997b).

The fractures in the limestones provide suitable conditions for oxidation so that through Fe oxidation soils attain a reddish colour. Soil material in the karstic land is of clay which is the main remaining material after the removal of calcium carbonate. For this reason the soil which is found in the karstic land is of clayey texture (Atalay 1998, 1999). Most of the karstic lands in the Malatya Mountains have been converted into bare land by the destruction of oak forests. In order to maintain the natural equilibrium, potential and the increase of karstic water supply it is necessary reforestation and afforestation activities (Atalay 1999).

Grazing must be arranged according to biomass capacity of the herbaceous plants in the meadows or rangelands which are found on the upper parts of the Malatya Mountains

Serpentine-peridotite ecosystem: These ultrabasic rocky area occurring in the eastern and southern part of the study area is seen as a bare land because natural vegetation has been completely destroyed and so parent material exposed. This area shows special importance in the distribution of plant and erosion control measurement, reforestation and afforestation activities. The nutrients changes in a great extent on the exposed serpentine-peridotite areas regarding to weathering process and degree. Less weathered rocky surfaces contain low plant nutrient. In that areas CEC is lower than 10 me/100 g. For this reason there areas remain as a bare lands. Plant cover is very sparse in the well weathered but not leached areas due to the fact that they contain abundantly clay and bases that form a poison effects for plant. In that ground CEC is over 40 me/100 g. Plant cover is rich and suitable for agricultural purpose in places where bases and carbonates have considerable leached. In that areas CEC changes between 30 and 40 me/100 g. In order to regain natural equilibrium in the deteriorated peridotite-serpentine areas in terms of forestry, these areas should be protected from the grazing and other utilisation. Plant must be planted after deep plough of the flat land for both water conservation and plant roots development.

Mediterranean and Eastern Anatolian continental climatic region. The upper part of the Malatya Mountains belong to the Subalpine orobiome (Atalay 2002). The physical and chemical properties of parent materials determine considerable the ecoregions or ecological units which can be called geobiome due to natural equilibrium has been deteriorated. In other words, parent material is exposed on the sloppy areas due to soil has been in a great extent transported. In order to explain the ecoregion the importance of the parent material effects on the environment can be taken into consideration (Atalay 2000, 2002, and Gerrard 1981).

**Flysch ecosystem:** Eocene and Paleocene flysch formation extends on the northern edges of the Malatya mountains. Clay, marl, sand stone, and thin soft limestone layer extends alternately. This formation is mostly devoted for agricultural land due to easily cultivated. Vineyards are common on these terrains because the roots of the grape vine penetrate easily deeper part and take adequately nutriment from the parent material. Indeed the cation exchange capacity (CEC) is about 35 me/100 g parent material. Deep chestnut soil (mollisol) is found on the flat land which is composed of flysch. In this soil calcium carbonate content increases from the top soil to the subsoil due to leaching, pH is 7,5, and CEC is about 30 me/100 g soil.

The other property of the flysch deposit is that it has been subjected to erosion easily. Because the sandy and silty particles are easily transported by the runoff, so that after the intense rainfall one can see the formation of rill erosion on the sloppy area.

**Karstic ecosystem:** Karstic lands composed of mainly paleozoic limestones and partly eocene limestone cover vast area in the Malatya Mountains. They contain many karstic sources emerging along the valley and in the lower edges of the mountains. Principal karstic sources are Pınarbaşı, Takas (Sürgü), Konak, Ordüzü. The agricultural activities in Malatya plain and its surroundings mainly depend on the water obtaining from the karstic sources. It can be stated that karstic sources have vital importance in the Malatya province. Population more than 600 000 obtain drinking water from the karstic sources (Atalay 1997a). Karstic lands are the main occurrence areas of oak forest. The roots of oaks easily develop along the cracks and bedding surface of limestones.

Soil formation in the karstic lands is mainly determined by the limestone purity, situation of the cracks and the inclination of the beds. The thin bedded limestones produce richer soils than the massive rocks. This is because these types of limestone are good water retainers. For instance, red Mediterranean soils (Terra Rossa or Alfisols) are abundantly found on the thin bedded and fractured limestones. While the soils which are found on/in massive and hard limestones are thinner. The dissolution of limestones along the vertical fractures



As to the southern sector of the Malatya mountains, climatic conditions of this slope are different from the northern slope. The mean annual precipitation is more than 600 mm, this figure attains more than 1000 mm in the upper part of the mountains due to the fact that the fronts coming from the Mediterranean basin are intercepted by the mountain. Frontal occlusion takes place on the southern slopes. This event leads to the increase of precipitation. For this reason humid oak species called *Quercus libani* grows commonly on the southern slopes.

From the point of ecological view, the Malatya Mountains belong to the oak forest and subalpine grass ecosystem. Oak forest begins at elevation of c. 1000 m and continues up to 2000/2200 m.

The economy of the rural people depend, to a great extent, on subsistence agriculture and animal husbandry. Crop production relies on irrigation a system of channels that diverted water from the karstic sources. Animal husbandry activities are based on a system of transhumance, in general. During the summer months, some rural people go to the upland part of the Malatya Mountain in order to graze their animals. They stay three or four months in the tents or primitive houses. During the winter period they return to their own villages. The oak branches containing leaves are cut and dried up in order to obtain fodder and fuel. The leaves of the oak are the main fodder of animals. Over and early grazing, misuse of land and forest destruction are the main responsible factors for the deterioration of natural equilibrium in the study area.

## **Material and Methods**

In order to explain of the natural environment and to illuminate of the Malatya Mountains soil and parent material samples are taken. Texture, pH,  $\text{CaCO}_3$  and CEC of the parent materials and soils are taken into consideration to determine the importance of the parent material in the ecosystem. Stud area is divided into ecosystems according to the climatic, topographic, parent material and soil properties.

## **Results**

### **The Ecosystems of Malatya Mountains**

The ecosystem of the Malatya Mountains can be classified into two main zonobiomes. The northern slopes of the Malatya Mountains area belongs to the Eastern Anatolian Continental Zonobiome or Region (Fig. 2). The Malatya Basin on which semiarid climatic condition prevail is found within the Steppe Subregion. The northern slopes of the Malatya Mountains area belong the Dry Forest Oak Subregion. While the southern part of the Malatya Mountains area is found the Southeastern Anatolian Transitional Region which is located between





# **Sustainable Mountain Management: A Case Study from the Malatya Mountains, Se Taurus**

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## **Abstract**

The mountainous areas of Turkey contain various parent materials or rocks belonging to different geological time. Most of the parent materials are exposed due to the intense erosion. For this reason parent material affects the soil forming process and habitat types in the study area. In other words parent material role is very important for the determining of the natural environment properties. The Malatya Mountains which are composed of limestone, gneiss and micaschist, ultrabasic and ultramafic rocks (peridotite-serpentine-gabro), flysch and limestone form different habitats or ecological units because of the fact that cation exchange capacity or plant nutriment change considerably according to the physical and chemical properties and weathering situation of the parent materials. Cation exchange capacity (CEC) of the gneiss is lower than 15 me/ 100 g, whereas CEC of the limestones changes between 30 and 40 me/100 g. But this figure ranges from 2 to 30 me/100 g on the peridotite and serpentine depending on weathering conditions. There are close relationships between the parent material and land degradation. Each parent material group shows special importance against the degradational effects. For instance deep gully and sheet erosion are common on the gneiss because sandy particles of well weathered gneiss are carried away easily on the steep slopes by the run-off. This area that is found in the Kahta watershed is dissected by deep gullies. The sustainable development and management of the mountainous areas mostly depend on the parent materials where natural equilibrium has been deteriorated. Flysch and well weathered gneiss are suitable for the reforestation and afforestation activities on the semiarid and sub humid parts of the Malatya Mountains. The upper parts of the mountains should be devoted for grazing according to biomass productivity of the grass. Oak seeds should be put within the cracks and holes containing soil in order to provide good germination and generation.

**Key words:** Sustainable management, mountain ecosystem, parent material

## **Introduction**

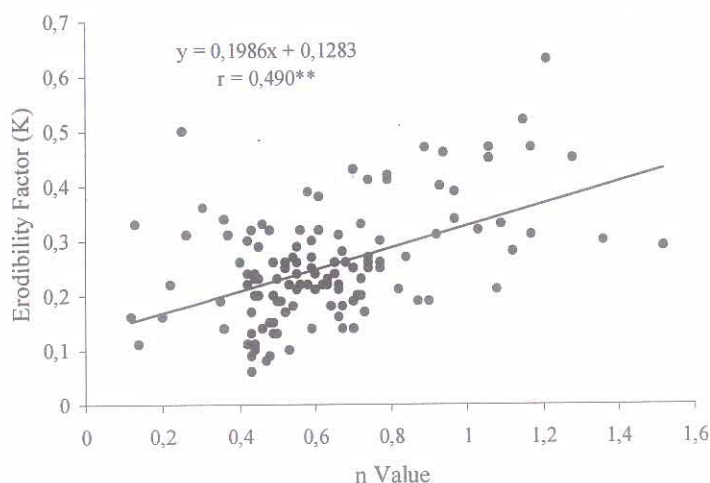
Study area covers the Malatya Mountains which is one of the branch of the Southeastern Taurus Mountains. These mountains extending between the Malatya basin in the north and the Adıyaman plateau in the south begin at an elevation of c. 1000 m in the southern edge of the Malatya basin and rise up to 2500 m (Kelebek T. 2430 m, Türkdagi 2608 m, Bey M. 2591 m, Karabey T. 2424 m and Sillan T. 2545 m). Study area is also located found a transitional region between Eastern Anatolia and the Southeastern Anatolian geographical region (Fig . 1) (Atalay, 2002).

As a result, due to significant relationships between  $n$  value and the other erodibility indices, the  $n$  value may be used as an indicator of soil structural stability especially in soils including finer texture class. Besides particle size distribution, using field moisture and organic matter content in estimation of  $n$  value gives more details about soil structure than DR and SSI. There is not much study about this subject. It will be useful that further studies in field and laboratory conditions should be made along this line.

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**Figure 2.** The relationship between n Value and Erodibility Factor within 129 soil samples.

## Conclusion

The critical n value is accepted as 0.7. In the field by a squeezing a soil sample in the hand, if the soil flows between the fingers with difficulty the n Value is accepted between 0.7 and 1.0. If the soil flows easily between the fingers the n Value is 1.0 or more (Soil Survey Staff, 1998). Therefore, while the n value is getting smaller, soil sample becomes more resist to detachable. In the study on Daphan Plain soils by Akgül (1994), soil texture class of A horizons was mostly clay and the n values of surface soils varied from 0.47 to 0.73. For this study, n values in C texture class varied symmetrically between 0.42 and 0.82 were similar to his results.

n Values in this study usually gave higher correlation with erosion ratio and erodibility factor than the other erodibility indices. It may be explained with that there are some similar parameters used in calculation of highly correlated these indices. For example, field capacity and organic matter content used in estimation of erosion ratio and erodibility factor were only different parameters from the other parameters used in calculation of dispersion ratio and structure stability index. Because, silt plus clay content were only parameters used in estimation of DR and SSI. Organic matter content and field capacity other than particle size distribution were also used in estimation of n value. Therefore, it seems reasonable that n value would probably give higher correlation with ER and K due to having similar parameters in their calculation.

### Relationships Between n Value and Soil Erodibility Indices

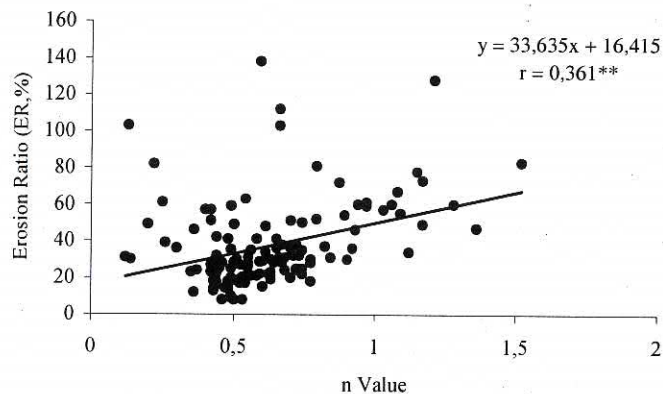
The relationships between the n value and the soil erodibility indices for different texture classes and all soil samples are given in Table 3. When 129 soil samples were evaluated together, the n value gave the statistically significant positive correlations with erosion ratio (0.361\*\* in Figure 1 ) and erodibility factor (0.490\*\* in Figure 2 ) and did not show any relationship statistically with dispersion ratio and structure stability index. If the texture classes are considered individually, the n values in C textural class gave the significant correlations with the most erodibility indices such as, ER, K and SSI. Except SL textural class, n value showed the significant positive relations with almost all ER and K values in the other texture classes too.

On the other hand, significant relationships were obtained among the erodibility indices for 129 soil samples. SSI in only C and CL texture classes were significantly correlated with DR (-0.676\*\*, -0.482\*\*), ER (-0.735\*\*, -0.390\*\*) and K (-0.691, -0.527\*\*) respectively. Also, n values only showed significant negative correlations with SSI (-0.479\*) in C and DR (-0.578\*) in SL texture classes.

**Table 3.** Relationships Between n Value and Erodibility Indices.

Soil Texture Class	DR, %	ER, %	K	SSI, %
C	0.292	0.615 **	0.569 **	-0.479 *
CL	0.278	0.765 **	0.605 **	-0.136
SCL	-0.165	0.463 *	0.218	0.153
L	0.358	0.712 **	0.772 **	0.338
SL	-0.578 *	0.278	0.045	0.422
n=129	0.023	0.361 **	0.490 **	0.022

\*significant at the 0.05 level, \*\* significant at the 0.01 level.



**Figure 1.** The relationship between n Value and Erosion Ratio within 129 soil samples.

138 % with a mean of 37.6 %. While the texture class changed from fine to coarse, mean erosion ratio increased 20.9 % in C to 74.1 % in SL. Erodibility, the vulnerability or susceptibility of the soil erosion, is a function of both the physical characteristic of the soil and the management of the soil (Hudson, 1995). Erodibility factor (K) for all soil samples varied from 0.06 to 0.63 with a mean of 0.25. The lowest mean K (0.16) was obtained in C, the highest mean K (0.37) was determined in L among the texture classes. Structural stability index (SSI) by the sum of the difference between mechanical and aggregate analyses of silt plus clay fractions was introduced as a rapid technique for estimating structural stability of soils by Leo (1963). SSI for 129 soil samples varied from 12 to 74 % with a mean of 44.3 %. While the texture class changed from fine to coarse, mean SSI decreased 56.1 % in C to 26.2 % in SL.

**Table 2.** Descriptive Statistics of n Value, Soil Erodibility Indices such as, Dispersion Ratio (DR), Erosion Ratio (ER), Erodibility Factor (K) and Structural Stability Index (SSI) of The Soils.

Factor	Soil Texture	Min.	Max.	Mean	SD	CV	Skewness	Mean S.E.
n Value	C	0.42	0.82	0.57	0.13	22.8	0.32	0.46
	CL	0.35	1.28	0.63	0.20	31.8	1.38	0.35
	SCL	0.14	1.36	0.58	0.26	44.8	1.28	0.51
	L	0.40	1.21	0.80	0.26	32.5	-0.02	0.49
	SL	0.12	1.52	0.52	0.37	71.2	1.43	0.56
	n=129	0.12	1.52	0.63	0.25	39.7	0.92	0.21
DR (%)	C	10	31	22.9	6.3	27.5	-0.44	0.46
	CL	9	36	23.9	5.9	24.7	-0.37	0.35
	SCL	22	42	29.7	6.4	21.6	0.55	0.51
	L	17	41	31.5	6.0	19.1	-0.81	0.49
	SL	19	50	35.8	8.5	23.7	-0.73	0.56
	n=129	9	50	27.4	7.8	28.5	0.12	0.21
ER (%)	C	8	37	20.9	7.7	36.8	0.24	0.46
	CL	8	60	26.9	10.7	39.8	1.02	0.35
	SCL	20	72	35.6	11.7	32.9	1.60	0.51
	L	30	128	54.0	21.1	39.1	2.03	0.49
	SL	31	138	74.1	28.3	38.2	0.74	0.56
	n=129	8	138	37.6	23.4	62.2	1.81	0.21
K	C	0.06	0.26	0.16	0.058	36.3	0.09	0.46
	CL	0.11	0.45	0.23	0.067	29.1	0.45	0.35
	SCL	0.11	0.40	0.25	0.072	28.8	0.12	0.51
	L	0.20	0.63	0.37	0.108	29.2	0.19	0.49
	SL	0.16	0.50	0.27	0.090	33.3	0.97	0.56
	n=129	0.06	0.63	0.25	0.102	40.8	0.83	0.21
SSI (%)	C	42	74	56.1	7.8	13.9	0.61	0.46
	CL	32	62	47.7	7.4	15.5	-0.08	0.35
	SCL	27	62	42.2	9.7	23.0	0.65	0.51
	L	30	48	38.7	5.2	13.4	-0.27	0.49
	SL	12	36	26.2	7.8	29.8	-0.25	0.56
	n=129	12	74	44.3	11.6	26.2	-0.17	0.21



contents of the soil samples varied from minimum 20, 0 and 0.85 % to maximum 63, 49.81 and 5.47 % with the means of 36.9, 4.82, and 2.15 % respectively. Soil reaction (pH) of the samples was generally alkaline and changed from extremely acid, minimum 4 to strongly alkaline, maximum 8.9 (Soil Survey Staff, 1993).

**Table 1.** Mean (m) and Standard Deviation (SD) of Soil Physical and Chemical Properties.

Soil texture class	Sand, %		Silt, %		Clay, %		Field Capac., %		pH (1:2.5)		CaCO <sub>3</sub> , %		Org. Mat., %	
	m	SD	m	SD	m	SD	m	SD	m	SD	m	SD	m	SD
C	27.1	6.3	27.7	5.2	45.2	4.7	40.7	6.6	7.5	0.8	5.05	5.21	2.24	0.78
CL	35.9	6.5	29.8	6.5	34.3	4.2	38.5	7.3	7.7	0.7	6.62	9.22	2.11	0.94
SCL	44.1	14.8	28.3	11.8	27.6	4.9	33.9	9.6	7.1	1.2	4.30	4.33	1.69	0.52
L	41.6	6.6	36.4	6.4	22.0	3.8	38.2	6.6	7.4	1.2	3.35	4.41	2.19	1.04
SL	63.7	6.5	21.9	4.8	14.4	3.2	28.8	7.9	6.2	1.4	1.96	3.16	2.67	1.22
N=129	39.9	13.4	29.3	8.1	30.8	10.5	36.9	8.3	7.3	1.1	4.82	6.7	2.15	0.94

#### **n Value and Soil Erodibility Indices of The Soil Samples**

Descriptive statistical results for n value and soil erodibility indices; dispersion ratio (DR), erosion ratio (ER), erodibility factor (K) and structural stability index (SSI) in different textural classes are given in Table 2. The n value describes the relationship among the field capacity, clay and humus in soil. Regardless of textural classes, the n values of all soil samples varied from 0.12 to 1.52 with a mean of 0.63 and 39.7 % coefficient of variance (CV). While the texture class changed from fine to coarse, the lowest CV 22.8 observed in C changed to the highest CV, 71.2 obtained in SL. Positive values of the skewness or third central moment suggest tailing to the right, while negative values of the skewness suggest tailing to the left on the horizontal axis of a plot. A symmetrical distribution always has zero for the value of skewness (Isaaks and Sarivastava, 1989). Therefore, the n values in C and L texture classes showed almost a symmetrical distribution due to their skewness values becoming close to zero. The lowest mean n value (0.57) and standard deviation (0.13) were obtained in C among the other textural classes, except the SL textural class. But, the highest skewness, 1.43 and standard deviation, 0.37 for n value were obtained in the SL textural class.

Dispersion ratio was used to evaluate soils erodibility by the amount of silt plus clay in a dispersed state (Bryan, 1969). Dispersion ratio for all soil samples varied from 9 to 50 % with a mean of 27.4 % and 28.5 % coefficient of variance (CV). While the texture class changed from fine to coarse, mean dispersion ratio increased 22.9 % in C to 35.8 % in SL. Erosion ratio is the form of dispersion ratio that is combined with the ratio of "colloidal content / moisture equivalent" (Bryan, 1968). Erosion ratio for all soil samples changed from 8 to

## Material and Methods

129 soil samples used in this study were taken from 0 to 20 cm depth around Samsun. Some soil physical and chemical properties were determined as follows; particle size distribution by the hydrometer method (Demiralay, 1993); lime content by Scheibler Calsimeter (Soil Surv. Staf, 1993); soil reaction, pH in 1:2.5 (w:v) soil-water suspension by pH meter (Black, 1965); organic matter content by Walkley-Black method (Kacar, 1994). Field capacity (FC) was measured at 33 kPa on a ceramic plate after soil samples were passed from 2 mm sieve, saturated for 24 hours and then equilibrated for another 24 hours (Klute, 1986).

The indices such as dispersion ratio (DR), erosion ratio (ER), soil erodibility factor (K), structural stability index (SSI) and n value were estimated by the following standard techniques:

$$DR (\%) = (a/b) * 100$$

where, a is the percentage of silt plus clay in suspension, b is the percentage of silt plus clay dispersed with Calgon agent (Bryan, 1968).

$$ER (\%) = (a/b) * (A/c) * 100$$

where, a is the percentage of silt plus clay in suspension, b is the percentage of silt plus clay dispersed with Calgon agent, A is the field capacity, c is the percentage of clay dispersed with Calgon agent (Akalan, 1967).

$$K = [(2.1 * 10^{-4} (M)^{1.14} (12 - a) + 3.25 (b - 2) + 2.5 (c - 3)) 1.292] / 100$$

where, M is the particle size parameter (% silt + % very fine sand)\*(100 - % clay), a is the percentage of organic matter, b is the soil structure code and c is the profile permeability class (Wischmeier and Smith, 1978).

$$SSI (\%) = \sum b - \sum a$$

where,  $\sum b$  is the percentage silt plus clay dispersed with Calgon agent,  $\sum a$  is the percentage of silt plus clay in suspension (Leo, 1963).

$$n \text{ value} = (A - 0.2 R) / (L + 3 H)$$

where, A is the percent moisture in field capacity, R is the percentage of silt plus sand, L is the percentage of clay and H is the percentage of organic matter (Soil Survey Staff, 1998).

Descriptive statistics of n Value and soil erodibility indices was calculated by using SPSS. The correlations between n value and the other indices, DR, ER, K and SSI were also estimated (Steel and Torrie, 1982).

## Results and Discussions

### Some Physical and Chemical Properties of Soil Samples

Some physical and chemical properties of the soil samples used in this study are given in Table 1. According to soil particle size distribution, 129 soil samples were subdivided into five different textural classes such as, 25 soil samples in clay (C), 46 in clay loam (CL), 20 in sandy clay loam (SCL), 22 in loam (L) and 16 in sandy loam (SL). Field capacity, lime ( $\text{CaCO}_3$ ) and organic matter



## Using n Value as an Indicator of Soil Structural Stability

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### Abstract

The n value characterizes the relationship between the percentage of field moisture capacity and the percentage of clay and humus. In this study, n value was investigated to determine whether it might be used as an indicator of soil structural stability or not. The n values of 129 soil samples gave the significant positive correlations with their soil erodibility factors (K) and erosion ratios (ER). Also, the n values of the soils including clay textural class showed significant negative correlation with soil structural stability index (SSI). It seems that the n value may be used as an indicator of soil structural stability.

**Key Words:** n value, soil erodibility, erosion ratio, structure stability index.

### Introduction

As the world population rate increases, cultivation of agricultural lands becomes increasingly necessary to feed this high population. Therefore, soil management and cultivation practices should be improved to sustain soil fertility and to prevent high erosion vulnerability. It is known that soil properties limit the land use and management or establish the severity of the limitation. An abundance of nutrients in soil does not always indicate high crop production. Soil structure one of the most important soil physical properties is known as an indicator of the productivity of a given soil and also controls the severity of soil erosion.

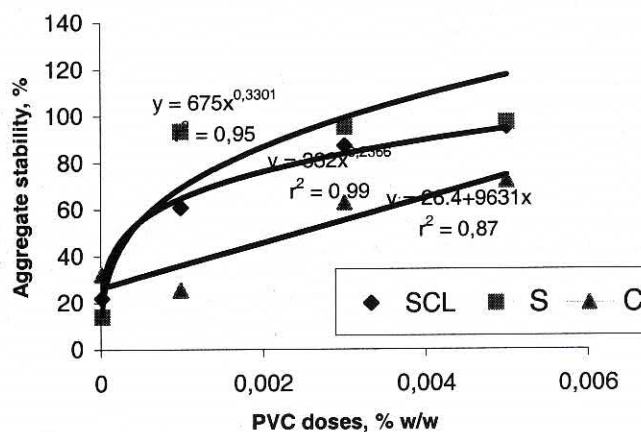
Structure can be improved or destroyed readily through our choice and timing of soil management practices (Hillel, 1982). Soil structure influences some soil erodibility indices such as, dispersion ratio (DR), erosion ratio (ER), erodibility factor (K) and soil structural stability index (SSI). These indices have been developed to determine soil erosion susceptibility and used to assess sustainable soil use and management (Leo, 1963; Bryan, 1968; Karagül, 1999; Özdemir ve Aşkın, 1999).

The n value characterizes the relationship between the percentage of field moisture capacity and the percentage of clay and humus in soil. It is useful to predict whether a soil can be grazed by livestock or can support other loads and to predict what degree of subsidence occurs after drainage (Soil Survey Staff, 1998). It may be used for a rapid and quantitative method to assessing soil structure. The objective of this study was to determine whether n value might be used as an indicator of soil structural stability or not.

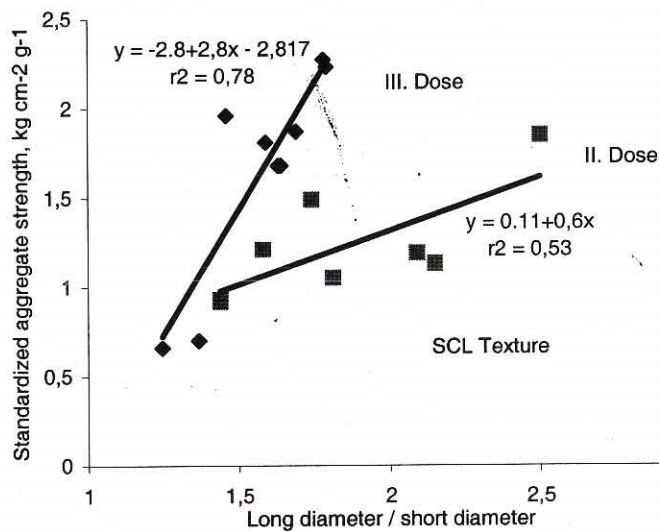


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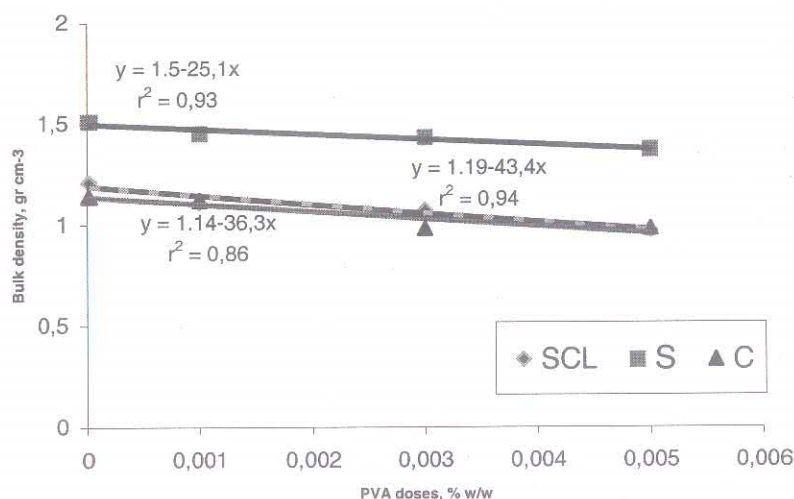


**Figure 2.** Effect of PVA application on wet aggregate stability of soil.



**Figure 3.** Relationship between aggregate diameter rate and aggregate strength.

stress. In clay samples, the aggregate strength values were greater than  $5 \text{ kg cm}^{-2}$ . Aggregate strength increased with increasing application dose, but there was no statistically significant difference between 0.001 and 0.003 doses, but 0.005 dose was significantly different than the others with a highest mean value. The standardized aggregate strength values ( $\text{kg cm}^{-2} \text{ g}^{-1}$ ) increased with increasing rate of long/short diameters in both sandy and sandy clay loam texture samples (Fig.3).



**Figure 1.** Effect of PVA application on soil bulk density.

Data were subjected to analysis of variance (ANOVA) to determine the treatment effect. The ANOVA results indicated that the treatment effects were statistically significant at  $p > 0.001$  significant level considering the bulk density, aggregate stability, mean weight diameter, and aggregate strength as dependent variables. The Duncan's multiple comparison test results also showed that the control sample has completely different means of bulk density, porosity, dispersion rate, wet aggregate stability, mean weight diameter, and aggregate strength than the sample means treated with PVA. Because of the limited page number, ANOVA and the Duncan's multiple comparison test results were not presented in this paper.



Table 2 shows the changes in measured structural parameter values after PVA application. As it was seen bulk density of samples decreased with increasing doses of PVA application. This may due to micro structural development in soils with PVA, which caused in high pore volume in these soils as supported by porosity values. The rates of decrease in bulk density values were 14, 9, and 20 % for SCL, S, and C textured soils, respectively. There was a statistically significant relationship between PVA doses and bulk density values, which was explained by a linear function (Fig.1).

The PVA application to soils caused significant increases in wet aggregate stability. In SCL and S textured soils, aggregate stability increased up to 95 %. However, in a clay soil it was only 72 %. That means may be that all particles in silt and clay fraction in SCL and sandy soils were aggregated by the highest dose of PVA, and most of the aggregates in these soils were water stabile. However, in clay soil the highest dose of PVA may not be sufficient to aggregate all of silt+clay. The effect of PVA doses on wet aggregate stability of soils was given graphically in Fig.2.

**Table 2.** Structural parameter values of samples treated with PVA.

Doses w/w	Bulk density g cm <sup>-3</sup>	Porosity %	Dispersion rate %	Wet aggregate stability %	Mean weight diameter mm	Aggregate strength kg cm <sup>-2</sup>
Soil sample # I						
Control	1.21	49.6	29.5	22.0	2.09	0.94
1	1.11	53.9	9.8	60.9	4.16	2.25
2	1.07	55.6	5.4	87.3	4.23	2.47
3	0.97	57.7	3.6	95.3	4.41	3.58
Soil sample # II						
Control	1.51	41.5	46.6	14.0	0.85	0
1	1.45	41.3	14.5	93.5	1.80	0.26
2	1.43	42.1	8.2	95.3	1.82	0.38
3	1.37	44.5	4.6	97.4	2.51	0.85
Soil sample # III						
Control	1.14	55.1	26.8	32.1	3.71	1.71
1	1.12	56.1	6.5	25.3	5.91	> 5
2	0.98	61.6	0	62.4	5.08	> 5
3	0.98	61.6	0	72.2	7.44	> 5

Mean weight diameter of soils increased at least twice in SCL and S textured samples at the first dose application of PVA. In clay soil the rate of increase was about 60 % at the first dose, and reached up to 100 % at the highest dose.

The most interesting results were obtained in aggregate strength measurements that were determined by crushing individual aggregates between two parallel plates using a modified pocket penetrometer (Oztas et al. 1999a,b). Individual aggregates from the samples treated with PVA needed higher mechanical stresses for breaking down. Higher aggregate strength indicates that bonding mechanisms linking primary particles together in an aggregate are very strong. Even in sandy samples, aggregates resisted against some degree of mechanical

The objective of this study was to determine the effects of polyvinylalcohol (PVA), a hydrophilic polymer, on aggregate stability and other structural properties of soils different in texture.

## Material and Methods

Three soil samples different in texture (clay, sandy clay loam, and sand) were collected and carried to the laboratory. The samples air-dried and passed through a sieve with openings of 2 mm. About 500 g soil samples were put into plastic pots and treated with hydrophilic polyvinylalcohol at three different rates of 0.001, 0.003 and 0.005 w/w. The PVA solutions were prepared at 70 °C and applied to the surface of soil samples with soil moisture content near field capacity, and mixed using a spatula. After 48 h, changes in structural parameters such as bulk density, porosity, dispersion rate, wet aggregate stability, mean weight diameter, and aggregate strength were determined. Soil structural development was evaluated by comparing the structural parameters in soils with or without PVA. The analysis of variance (ANOVA) was performed for determining the treatment effects, and the Duncan's multiple comparison test procedure was used for mean comparisons.

## Results and Discussion

Some physical and chemical properties and structural parameters of the soils studied were given in Table 1. Soils with different textures were chosen for this laboratory experiment in order to determine the effectiveness of PVA application in different soils. Clay soil had higher amount of organic matter content than sandy and sandy clay loam soil. Because of differences in texture and organic matter content, clay soil had the highest wet aggregate stability, mean weight diameter and aggregate strength values, but the lowest dispersion rate, initially.

**Table 1.** Physical and chemical properties and structural parameters of soils studied.

Sample no	Physical properties					Chemical properties			
	Mechanical analysis				Bulk density g cm <sup>-3</sup>	Porosity %	PH 1:2.5	Organic matter %	Cation exchange capacity cmol kg <sup>-1</sup>
I	48	27	25	SCL	1.21	49.6	6.85	1.77	23.8
II	79	10	11	S	1.51	41.5	7.61	1.17	10.2
III	18	34	48	C	1.14	55.1	6.92	2.68	25.2
Structural parameters									
Sample no	Dispersion rate %		Wet aggregate stability, %		Mean weight diameter, mm		Aggregate strength, kg cm <sup>-2</sup>		
I	29		22		2.09		0.94		
II	46		14		0.85		-		
III	26		32		3.71		1.71		

# Structural Developments in Soils Treated with Polyvinylalcohol\*

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## Abstract

Soil structural behavior varies with soil management practices and input of soil amendments. Polysaccharides stabilize soil aggregates because of their contribution as cements and glues. The objective of this study was to determine the effects of polyvinylalcohol (PVA) on aggregate stability and other structural properties. The PVA with the rates of 0.001 and 0.003 and 0.005 w/w were applied on soils with different texture. Changes in structural parameters such as bulk density, porosity, dispersion rate, wet aggregate stability, mean weight diameter, and aggregate strength were determined. Soil structural development was evaluated by comparing the structural parameters in soils with or without PVA. Result of our study indicated that the PVA application to soil had a significant effect on aggregate stability and strength. Increase the rate of application, the higher the aggregate stability and strength of individual aggregates against crushing forces.

## Introduction

Synthetic polymers added to soil as soil conditioners improve soil's physical properties that are important for plant growth and increase soil's resistance against disruptive forces and erosion. The formation of soil structure requires both physical rearrangement of particles and the stabilization of the new arrangement. Aggregate stability, an important soil physical property, affects crop production indirectly through its effects on water, aeration, temperature, mechanical resistance, and soil erosion (Letey, 1985). It influences a soil's ability to transmit or retain water and response to erosive forces. The presence or absence of water-stable aggregates at the soil surface has a direct effect on the potential for sheet erosion, crust formation, and excessive runoff during storms (Shouse *et al.* 1990). Soils with stable surface aggregates resist water and wind erosion better than soils with unstable aggregates (Lehrsch, 1998). Organic polymers have been used quite effectively to stabilize soil structure in recent years. Many researchers have shown that the application of polyacrylamide maintained high infiltration rate during rainfall and reduced soil surface sealing and runoff soil losses (Smith *et al.* 1990; Uysal *et al.* 1995; Ben-Hur and Keren, 1997; Sojka *et al.* 1998; Green *et al.* 2000).

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\* Full paper of this study has been sent for review for publication in Soil Use and Management.



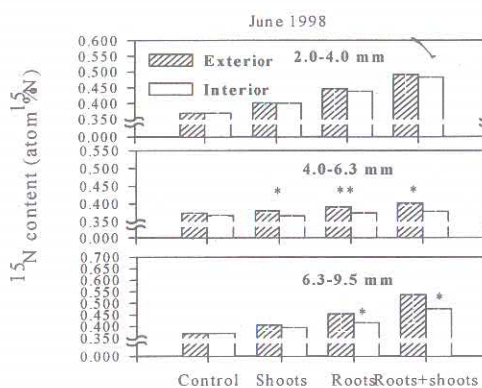


Figure 1. Total  $^{15}\text{N}$  contents of exterior layers and interior regions of 2.0-4.0, 4.0-6.3 and 6.3-9.5 mm aggregates from control, shoot, root and root+shoot treatments of the Kalamazoo loam soil on June 1998.

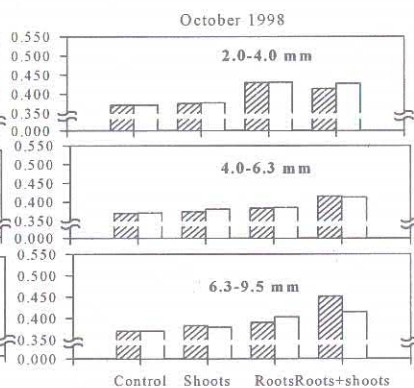


Figure 3. Total  $^{15}\text{N}$  contents of exterior layers and interior regions of 2.0-4.0, 4.0-6.3 and 6.3-9.5 mm aggregates from control, shoot, root and root+shoot treatments of the Kalamazoo loam soil on October 1998.

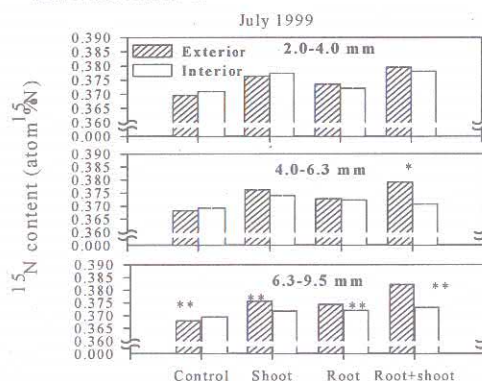


Figure 2. Total  $^{15}\text{N}$  contents of exterior layers and interior regions of 2.0-4.0, 4.0-6.3 and 6.3-9.5 mm aggregates from control, shoot, root and root+shoot treatments of the Kalamazoo loam soil on July 1999.

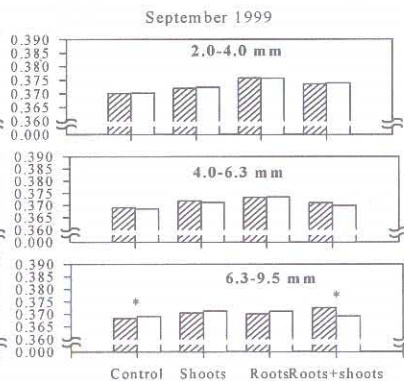


Figure 4. Total  $^{15}\text{N}$  contents of exterior layers and interior regions of 2.0-4.0, 4.0-6.3 and 6.3-9.5 mm aggregates from control, shoot, root and root+shoot treatments of the Kalamazoo loam soil on September 1999.

-Significant differences between exterior layers and interior regions of aggregates within the same treatment at the  $P < 0.05$  (\*) and  $P < 0.005$  (\*\*) probability levels.

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Aggregates greater than 2 mm contain many longer roots and hyphae than microaggregates (Jastrow and Miller, 1998 and Degens et al., 1994). Aggregates greater than 2 mm had 150 times longer hyphal lengths per aggregate than aggregates smaller than 0.5 mm. Aggregates greater than 2 mm also had 7 times longer root lengths within compared to soil aggregates 1.0–2.0 mm across (Degens et al., 1994). Therefore, main stabilizing factors for macroaggregates are roots, root derived materials and hyphae. While rye and corn roots develop between the planes of weakness and along surfaces of aggregates, root derived materials also help to stabilize macroaggregate surfaces. Continuous addition of SOM through dead and leaving roots and uptake of nutrients and waters by roots contributes development and stabilization of soil aggregates.

If we assume the aggregate hierarchy model, proposed by Oades and Waters (1991) is the only model for the soil structure formation of the Kalamazoo loam soil, then macroaggregates should consist of mostly microaggregates and properties of the macroaggregates should be similar all the way across the aggregate. The formation and function of soil macroaggregates are very dynamic processes utilizing many biogeochemical factors. These factors include: continuous additions of C and N compounds by roots (Santos et al, 1998; Kavdir, 2000); additions of N and P by fertilizers (Kinyangi, 2000); weathering of clay minerals by water, microbes and roots (Santos et al., 1997); dessication of aggregates by the uptake of water by plant roots (Sissoko, 1997); nutrient extraction by plant roots and leaching; frequent wetting and drying cycles and countless microbial activities (Guggenberger et al., 1999) all appear to develop concentric layers of various properties into the interior regions of soil aggregates. In a summary, it was found that concentric gradients of rye residue-derived N increased with aggregate size. The location of the N within soil aggregate played an important role on corn N uptake. Rye root and shoot derived N in exterior layers of larger aggregates decreased by time. Therefore these studies suggest increasing soil aggregate size and maintaining active plant root systems are the best strategies for maximizing soil N availability to cash cropping systems and reducing N leaching.

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Dexter, 1983). It was also observed that approximately 20% of the aggregates contained some of the finer roots which had penetrated and passed through soil aggregates. These soil aggregates containing roots were not selected for analyses. Any fine rye root fragment located within aggregates of any size would result in the deposition of mineralized  $^{15}\text{N}$  which could be sequestered within larger aggregates and become unavailable to corn roots unless they penetrated the same larger soil aggregate (Rasse and Smucker, 1999). More rye root-derived N accumulated on exterior layers of soil aggregates 6.3 - 9.5 mm across than rye shoot-derived N (Figure 1). In the first year of experiment soil aggregate samples were taken 17 days after application of labeled rye shoots on the PVC chambers. During the labeling period some  $^{15}\text{N}$  was transferred from rye shoots to roots and was released to soil by rye roots as root exudates. During applications of Round Up and cutting rye shoots, dead roots continued to release N compounds to the soil. Therefore, more rye root-derived N was deposited on the exterior layers of aggregates in 1998 (Figure 1). In the second year of the experiment, first samples were taken 51 days after application of labeled rye shoots. During that time root derived N was already utilized by corn and shoot derived N concentration was greater than root derived N (Figure 2). Separation of external layers of individual aggregates demonstrated the contributions of short-term rye shoot, root and shoot plus root to soil N pools. Nitrogen derived from root ( $\text{N}_{\text{dfr}}$ ) and shoot ( $\text{N}_{\text{dfs}}$ ) located in the exterior layers diminished from planting to harvest. The percentage of total N derived from rye shoot and rhizodeposition from rye roots was calculated using equation [1] (Kavdir, Y. 2000) Exterior layers of aggregates 6.0 - 9.5 mm across retained 1.6% of the  $\text{N}_{\text{dfr}}$  in July 1999, three times more than their interior regions. This was slightly greater than the  $\% \text{N}_{\text{dfs}}$ . One month later, during the corn growing season  $\% \text{N}_{\text{dfr}}$  and  $\% \text{N}_{\text{dfs}}$  were nearly equal in exterior layers and interior regions of soil aggregates, possibly due to diffusion within larger aggregates and uptake by corn. At harvest, there were greater or equal quantities of rye-N located in interior regions compared to exterior layers of aggregates. In the case of N fertilization, diffusion rate of N from exterior layers to interior regions of aggregates and even leaching could be faster limiting availability of N to the plant. Kinyangi (2000), reported that if there is more P in the exterior layers of soil aggregates, 4.0-8.0 mm across, than interior regions at the beginning of corn season, corn roots can easily utilize this P resulting in increased corn yield. Aggregate sizes used in this study covered only 34% of the total soil by weight. Additional research on the best management practices for maintaining more N on surfaces of larger soil aggregates during crop growth as well as sequestering mobile soil N within larger soil aggregates during wet soil periods between cash crops needs to be completed.

aggregates 2.0 - 4.0 mm across decreased with no gradients were observed at harvest (Figure 3). The  $^{15}\text{N}$  gradients developed within larger soil aggregates, 6.3-9.5 mm across, decreased in October 1998, 116 days after rye shoot application (Figure 3). Nitrogen isotope gradients between external layers and internal regions of soil aggregates 4.0 - 6.3mm across developed early in the summer (Figure 1) diminished as the season progressed (Figure 3). Exterior layer of soil aggregates contained similar concentrations of  $^{15}\text{N}$  as interior regions at corn harvest (Figures 3 and 4). In summary, there seemed to be a migration of  $^{15}\text{N}$  materials from rye roots and shoots into soil aggregates at a constant rate. Early in the season, more  $^{15}\text{N}$  migrated to the interior regions of the smallest aggregates, 2 - 4mm across, but was limited to only surfaces and transitional regions of the larger aggregates, 6.3 - 9.3 mm across. At harvest, more of the  $^{15}\text{N}$  located within interior regions of the smallest sized aggregates was withdrawn by corn growth while more  $^{15}\text{N}$  remained within the interior regions of the medium sized aggregates, 4 - 6.3 mm across (Figs. 1-3 and 2-4). Living roots provide large quantities of C compounds to the surfaces of soil aggregates (Santos, 1998) promoting microbial biomass activities and greater N mineralization (Texier and Billes, 1990). Therefore, corn roots appear to be important C sources for stimulating microorganisms in the soil. Their specific locations on soil aggregates of different sized fractions need further investigation. When roots preferentially grow on the surfaces of soil aggregates, as discussed above, these roots should increase N mineralization in the external regions of aggregates. Frequent wetting-drying cycles will diffuse more N into interior regions of soil aggregates of all sizes. Mean-free pathways, however, limit the diffusive distance or depths within aggregates of different size fractions. However, when roots are present or when soil water contents are high, highly mobile mineral N, located on surface layers of larger aggregates and throughout smaller aggregates can either be absorbed or leached from these respective areas of multiple sized soil aggregates with subsequent diffusion from their interior regions towards their exterior regions. The good correlation ( $r^2=0.68$ ) between  $^{15}\text{N}$  ratio of exterior layers to interior regions of soil aggregates and  $^{15}\text{N}$  uptake by corn plant support these conclusions. Similar correlations were found between changes in the ratios of total N of external layers and internal regions of soil aggregates at the beginning and end of the corn growing season and corn biomass in 1999. Increases in the ratios of  $\text{Ne/Ni}$  (in July) -  $\text{Ne/Ni}$  (in September) demonstrate root uptake of N during the corn growing season. As these ratios increased, greater corn biomass was observed. Thus, it is clear that uptake of N is more efficient from the surface of aggregates from a Kalamazoo loam soils larger than 4 mm across. Most of the  $^{15}\text{N}$  presented in the interior regions of soil aggregates greater than 4 mm across was preserved at the time of corn harvest. Especially since many of the roots appear to grow around exterior regions of soil aggregates (Allison, 1973, Whiteley and



dry combustion method (Kirsten, 1983) using a C/N/S analyzer NA 1500 series 2 (Carlo Erba Stumentazione, Milano, Italy) and  $\%^{15}\text{N}$  by using Isotope Ratio Mass Spectrometer Model 2020 (Europa Scientific, Crewe, UK). Total C content of a Kalamazoo loam soil from 0-5 cm depth was assumed to be equal to soil organic carbon as reported by Santos (1998).

$^{15}\text{N}$  signatures in soil aggregate concentric layers were measured and  $\delta^{15}\text{N}$  and atom  $\%^{15}\text{N}$  was calculated as below (Yoneyama, 1996):

$$\%^{15}\text{N} = [({}^{15}\text{N}/{}^{14}\text{N})_{\text{spl}} - ({}^{15}\text{N}/{}^{14}\text{N})_{\text{std}} / ({}^{15}\text{N}/{}^{14}\text{N})_{\text{std}}] \times 100 \quad [1]$$

where;

$^{15}\text{N}$  = Atom  $\%^{15}\text{N}$  which gives the absolute number of atoms of a N-15 isotope in 100 atoms of total N element.

$$\text{Atom } \%^{15}\text{N} = [{}^{15}\text{N} / ({}^{15}\text{N} + {}^{14}\text{N})] \times 100 \quad [2]$$

$${}^{14}\text{N} = \text{Atom } \%^{14}\text{N}$$

$$\text{Atom } \%^{14}\text{N} = [{}^{14}\text{N} / ({}^{15}\text{N} + {}^{14}\text{N})] \times 100 \quad [3]$$

spl = sample std=standard (atmospheric  $\text{N}_2$ )

Treatment effects on measured parameters were estimated by a PROC-GLM procedure using Statistical Analysis System (SAS Institute, 1999). Duncan's multiple range test was used to separate means of measurements. Carbon, nitrogen and  $^{15}\text{N}$  contents of exterior and interior layers of soil aggregates were compared by paired t-test using Statistical Analysis System (SAS). Correlation analysis was used to determine relationship between plant and soil parameters. All significant tests were set at the 0.05 level.

## Results and Discussion

Nitrogen from rye roots and shoots could be detected on the exterior layers of soil aggregates of 4.0 - 6.3 and 6.3 - 9.5 mm as early as 17 days after rye shoot applications to the soil surface in 1998 (Figure 1). Rye root contributions of N were greater than that of rye shoot N, presumably due to the more rapid decomposition and direct contact of rye roots to soil aggregates. Both content and contrasting gradients of  $^{15}\text{N}$ , derived from rye increased with increasing aggregate size (Figure 1). Similar increases of  $^{15}\text{N}$  gradients with aggregate sizes were also observed in July 1999 (Figure 2). These results support that most of roots grow preferentially around surfaces of soil aggregates rather than through aggregates. Although concentrations of  $^{15}\text{N}$  on surface layers and interior regions of aggregates 2 - 4 mm across were the same as the surface layers of larger aggregates, no gradients of  $^{15}\text{N}$  from rye cover crops were observed for aggregates 2 - 4 mm across (Figures 1 - 4). Organic materials derived from rye roots and shoots appeared to be uniformly distributed throughout aggregates 2.0 - 4.0 mm across with minimum  $^{15}\text{N}$  gradients at the beginning of the corn growing season (Figures 1 and 2). Contents of  $^{15}\text{N}$  within



Two open-ended PVC cylinders, 30 cm in diameter and 60 cm in depth, were driven through the Ap horizon and into the center of the Bt<sub>2</sub> horizon in each plot by a front fork loader of a tractor in each year. Approximately 45 rye seeds were planted into each PVC cylinder of the rye treatment plots. In an effort to avoid soil contamination by <sup>15</sup>N, the soil surface in each cylinder was covered with plastic sealed around the walls of the PVC cylinder and each row of rye using nontoxic clay sealant. Pine wood shavings were placed on the plastic to absorb any mist or droplets of the <sup>15</sup>N labeled spray materials preventing them from contacting the soil surface. Rye plants were labeled with <sup>15</sup>N by foliar applications of solutions containing 6.39 g (<sup>15</sup>NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> containing 99 atom% <sup>15</sup>N dissolved in 9 L of distilled water in May. This solution was applied in 3 to 4 separate applications to prevent run off. Following a two-week translocation period, the rye plants were spray-killed with Roundup Ultra without ammonium sulphate that (4.5 L ha<sup>-1</sup>) mixed with 186 L ha<sup>-1</sup> water in early May of 1998 and 1999. Above ground plant parts of rye were manually cut, weighed and subsamples were taken for analyses. Rye shoots were removed or placed on the soil surface inside PVC cylinders with appropriate treatments. Corn seeds (6-8) were hand planted into each PVC cylinder. Following germination PVC <sup>15</sup>N lysimeters were thinned to two corn plants, 2 days after emergence. Thinned corn plants were left on the soil surface of the chambers to retain 100% of <sup>15</sup>N within the PVC lysimeters.

Background soil samples (0-5 and 5-15 cm) were taken from each <sup>15</sup>N lysimeters using a small (2.5 cm in diameter) PVC pipe before <sup>15</sup>N application. Soil samples were air-dried and manually sieved from the 9.5 mm sieve.

Rye root and shoot sub samples were taken before and after the <sup>15</sup>N labeling to determine initial and final <sup>15</sup>N contents of plant shoots and roots. Rye root samples were extracted from the top 15 cm depth of soil surface by pressing PVC cores (117 cm<sup>3</sup>) into the soil to sample rye roots before and after <sup>15</sup>N application. Roots were removed from this sample by developing a slurry of distilled water which was poured through a 53 µm screen and the retained roots were washed under water. Fine and white roots were picked from the sand and residue remaining on the screen by tweezers. Both roots and shoots were oven dried at 70°C for 24 h.

Concentric layers of aggregates were removed from each aggregate by the meso soil aggregate erosion (SAE) chamber technique reported by Smucker et al. (1999). Following the separation of aggregates into 3 equal concentric layers, samples were further processed by grinding in mortar and pestle. Sand was removed by sieving a sample through a 53 µm screen to increase the concentration of the <sup>15</sup>N and N in the small sample size associated with each concentric layer of each aggregate. Resultant clay and silt samples were weighed into small tin capsules, approximately to 10 mg and placed into an autosampler. Total C and N of plant and soil materials were determined by the

plant residues within soil aggregates (Angers et al., 1997). Clay illuviation, preferential movement of water, weathering of clay and preferential growth of roots can change the compositions of aggregate surfaces (Smucker et al., 1997, Whiteley and Dexter, 1983). Living roots may create rapid wetting-drying cycles that enhance SOM degradation (Bottner, 1985). They may induce microbial activity and increase SOM decomposition (Cheng and Coleman, 1990). Roots control the concentrations and fluxes of soil N by absorbing soil water and soluble N compounds (Harper, 1995 and Frensch, 1996). Released N *in situ*, from decomposing plant roots and shoots contribute to stabilizing soil aggregation processes (Oades, 1993). Nitrogen is deposited in the rhizosphere as  $\text{NH}_4$ ,  $\text{NO}_3$ , and root debris. It is assumed that, some of the extracted plant available N forms and mineralized N from rhizodeposits are reabsorbed by the plant. Recent studies showed that soil aggregates develop by adding concentric layers of cations, carbon (Santos et al., 1997, Horn 1990, Smucker et al. 1997) and heavy metals (Wilcke and Amelung, 1996). Short term effects of cropping on soil organic matter and associated rhizodeposition can be determined more quickly when concentric layers are removed from soil aggregates. Six weeks after planting ryegrass in a greenhouse potted study (Santos, 1998) showed exterior layers of soil aggregates contained 20% newly deposited C while interior regions contained only 8% new  $\text{C}_3\text{-C}$ . Therefore, under field cover crop conditions, it is suggested that recently derived rye cover crop shoot and root nitrogen could be deposited at greater concentrations on the surfaces of soil aggregates than interiors. To understand cover crop contributions of N to successive plant uptake and soil aggregation processes, sources and specific locations of N must be identified within soil aggregates. In this study, we determined whether plant-derived organic N, sequestered at different locations in soil aggregates, affected N absorption by subsequent corn crops. The objective of this study was to identify the contributions of rye root and shoot N to different regions within aggregates ranging from 2.0 to 9.5 mm across in the  $\text{A}_p$  horizon of a Kalamazoo loam soil.

## Materials and Methods

A two- year field experiment (1997-1999) was conducted on a Kalamazoo loam soil (coarse-loamy, mixed, mesic Typic Hapludalf) at the KBS/LTER (long term ecological research) site in southwestern Michigan. There were four treatments; 1) Bare soil control 2) Bare soil where rye shoots were applied before corn planting (shoots) 3) Rye where shoots were cut and removed and roots in the soil remained in situ (roots) 4) Rye cover crop roots and shoots (roots+shoots) where rye shoots were cut and placed on soil surface. Each treatment was replicated four times in a randomized complete block design.



## Soil Aggregate Sequestration of Cover Crop Root and Shoot Residue Nitrogen

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### Abstract

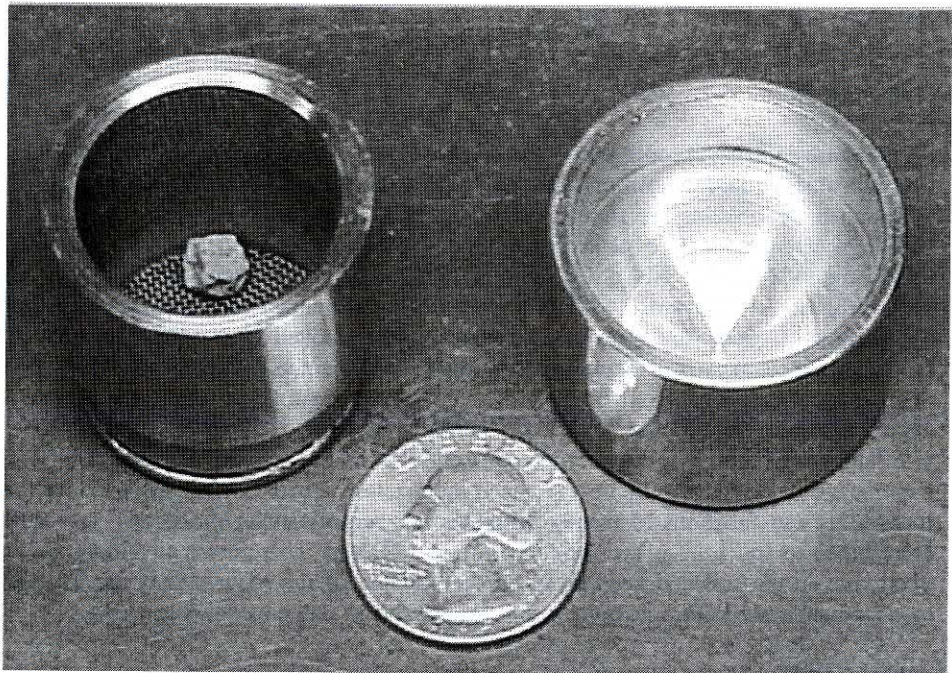
Rye (*Secale cereale* L.) roots and shoots release C and N compounds in situ during their decomposition. Plant deposition of N by rye roots and shoots into soil aggregates was determined by labelling rye shoots with stable N isotope during rye cover cropping of corn agroecosystems. Rye plants were labelled with foliar applications of solutions containing 99% atom ( $^{15}\text{NH}_4$ )<sub>2</sub>SO<sub>4</sub>. Isotopic enrichment of soil aggregates ranging from 2.0 - 4.0, 4.0 - 6.3 and 6.3 - 9.5 mm across was determined following plant residue applications. Concentric layers of aggregates were removed from each aggregate by newly designed meso soil aggregate erosion (SAE) chambers. Significant correlation observed between change in ratios of N in external layer/N in internal regions of aggregates and corn biomass for 6.3-9.5 mm aggregates in 1999 ( $r^2=0.88$  for no cover crop and  $r^2=0.71$  for rye cover crop treatments). Non-uniform distributions of total N and recently derived rye N in soil macroaggregates, across time suggested that the formations and functions of macroaggregates are very dynamics processes. Rye roots contributed as much N as rye shoots to the soil N pool. Therefore maintaining active plant root in the soil and keeping N on the surfaces of macroaggregates are the best management systems for maximizing soil N availability and reducing N leaching.

### Introduction

Cover crops used to reduce leaching of NO<sub>3</sub> (Ditsch et al., 1993) also contribute to the improvement of soil organic matter through the addition of residues in the early spring and throughout the summer. Microbes rapidly deplete decomposing cover crop residues of most sugars, amino sugars, organic acids, starches, and simple proteins (Paul and Clark, 1996). Kladvko (1994) reported that microbial decomposition of fresh organic material produced polysaccharides and other compounds that became the main contributors to the soil aggregate stabilization. Therefore, living rye roots, decomposition and by-products associated with the rye root and shoot residues are effective contributors to soil nutrient cycling and aggregate formation and stabilization. Numerous studies have been reported on the formation, stabilization, and effect of different soil and crop management systems on soil aggregation (Wood et al., 1991, Roberson et al., 1995). However, there is little information on the location of recently decomposed



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**Figure 1.** Soil aggregate erosion (SAE) chambers are constructed of machined stainless steel tubes with a 350 micron sized screen welded on to the base of the erosion chamber (left). Inside walls of the erosion chamber are finely knurled to create an abrasive surface above the screen, retaining the unpeeled portion of the soil aggregate (left). Bases of the SAE (right) are machined from a stainless steel rod, with the bottom drilled into a concave surface that can be easily cleaned.

aggregates forming gradients of N within soil aggregates in the rhizosphere. When ratios (Ne/Ni) of external N (Ne) to internal N (Ni) concentrations within soil aggregates exceeded 1.2, both corn plant biomass and grain yield increased. There were significant correlations ( $r^2=0.88$ ) between Ne/Ni and corn biomass, suggesting root deposits of N on surfaces of soil aggregates became more available to successive corn crops. These results demonstrate, from the plant root's perspective, that the time between N deposition by catch or inter crops and the primary crop are critical and can be better evaluated when soil aggregates are separated into layers and analyzed before the best management practices for controlling plant N can be determined for either high or low input crop production systems of a sustainable agroecosystem.

Image processed information of digitally scanned washed roots (Smucker and Aiken, 1992) enabled the calculations of soluble nitrogen (N) uptake by roots of rye catch crop experiments in the Ap and Bt horizons of a Kalamazoo loam soil (coarse-loamy, mixed, mesic Typic Hapludalf) during a 39-day period in April and May 1998. Measuring  $^{15}\text{N}$  and total nitrate uptake by rye roots, Kavdir (2000) reported 27 ( $\pm 5$ ) mg N were absorbed per  $\text{m}^2$  of rye root surfaces per day in the Ap horizon and 9 ( $\pm 6$ ) mg N were absorbed per  $\text{m}^2$  of rye root surfaces per day in the Bt horizon. These types of data can be used to estimate nitrogen uptake by the root systems of different cover crop species when minirhizotron observations of root demographics are combined with washed roots and frequent soil N evaluations within the soil profile. These combined approaches are most useful for comparing nitrogen uptake efficiencies for different plant species, especially when identifying the best cover crops for the phytoremediation of nitrate, pesticide, or heavy metal contaminations of groundwater beneath high-risk soils.

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More than a century of conventional tillage (CT) of virgin forest soils in Ohio has reduced total porosities of soil aggregates, 2-9.5 mm across, by as much as 17%. Approximately half of this lost porosity was recovered by 40 years of NT. Measurements of the ratios between hydraulic conductivity (Ks) and aggregate porosity for aggregates sampled from these expanding and contracting Wooster silt loam soils demonstrated fewer connected pore networks within CT and NT aggregates than similar sized aggregates from nearby forest soils (Park et al., 2001). These significant interactions among C and N substrates, SMB, and the number of wetting and drying cycles for different management treatments of the same soil type as well as the discontinuous porosities of tilled agricultural soils suggest specific intra-aggregate process-level biogeochemical mechanisms, eg., changes in the internal pore connectivities during frequent W/D cycles of soil aggregates having different microbial populations, SOM levels, ion concentrations, textures, and clay minerals.

## Results and Conclusions

Additions of simulated root exudates to the Kalamazoo loam soils of our 20-year Long Term Ecological Research programs in Michigan, increased the soil microbial biomass (SMB) of soils by 15% and 70% for agricultural and grassland ecosystems. When root exudates were combined with nine wetting and drying cycles, the mean weight diameter indices of aggregate stability increased nearly 4-fold (Sissoko, 1997). Differences among the changes in aggregate stabilities could not be contributed exclusively to changes in C and N substrate and associated SMB. In separate studies, C contents of thin soil layers were 2.4-fold greater on exterior regions of NT than CT aggregates (24 and 10 g C kg<sup>-1</sup>) and 3-fold greater on interior regions of NT than CT aggregates (21 and 7 g C kg<sup>-1</sup>) (Dell et al., 2002). Significantly greater quantities of labile C respired from surface layers of soil aggregates than from soil layers extracted from internal regions of aggregates during the first 88 d of incubation. Therefore, most recently deposited root C appears to be more rapidly respired by microbial communities located on surfaces of soil aggregates than their interiors.

Nearly 75% of the catch crop N was released by the decomposing roots of an irrigated rye cover crop resulting in the absorbance of 40 kg N ha<sup>-1</sup> per year by two successive maize crops (Kavdir, 2000). Decomposing rye roots deposited organic and inorganic N to surface layers of soil



crops for retaining an active microbial biomass as well as additional absorptive surfaces for retaining soluble soil N from leaching beneath the root zone.

Soil aggregates develop and function through a complex biological, chemical and physical interactions with climate, water, ion and many anthropogenic actions upon the soil matrix (Dexter and Horn, 1998). Formation processes include the cementation of adjacent smaller soil aggregates into larger aggregates and/or the accumulation, sorption, and cementation of soil minerals, ions, and particulate organic matter (POM) (Dexter and Horn, 1998; Smucker, et al., 1998). Repeated wetting and drying cycles develop stronger soil aggregates than surrounding bulk soil and create smaller internal pores than the surrounding macropores of bulk soil. Root growth, exudation, fungal associations and death contribute substantial quantities of C into soil aggregates (Jastrow, et al., 1996). Continuous rhizodeposition of C into soil aggregates can be considered one of the major contributions of crop management to soil structure formation and stability. There seems to be very little information on biogeochemical mechanisms associated with the improvement of C fixed by plants and retained for prolonged periods of time. Many of the mechanisms controlling soil aggregation processes remain unknown. These and other dynamic feed-forward and feed-back root and soil activities are being investigated. Some are reported in this paper.

## Approach

Measurement of most soil properties has been limited to evaluations of composite samples of bulk soils or individual aggregate fractions. Although this approach has led to the discovery of many soil properties, the bulk soil approach provides little information on the microsite sequestration or protection of soil carbon (C), nitrogen (N) and other ions that influence the root soil interface and microbial communities. We mechanically removed concentric layers from soil aggregates by rotating individual aggregates in soil aggregate erosion (SAE) chambers, Fig. 1, until pre-designated quantities of soil material are removed by erosion. Using more than 130 SAE chambers enables one individual to remove multiple soil layers from literally 100s of aggregates daily. Most frequent rotational speeds range from 250 to 450 revolutions per minute (rpm) and are dependent upon the tensile strength and erosion resistances of layers within each aggregate. Nondestructive CMT characterization of pore networks, within aggregates, is essential to our understanding of the intra-aggregate porosity. Knowledge of pore connectivities will greatly assist our knowledge of fluid transport and residence times of soil solutions among connected pores within aggregates.

## **Biophysical Infrastructures That Promote Carbon Sequestration within Soil Aggregates**

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### **Abstract**

Increasing soil carbon (C) generally increases the stability of soil aggregates. Physical and chemical analyses of extracted soil organic matter (SOM) have produced considerable quantities of information. Yet, little is known of the *in situ* biophysical locations and interactions between the SOM and the microbial biomass within soil aggregates. Using small soil aggregate erosion (SAE) chambers for separating individual soil aggregates into concentric layers, we have been able to identify gradients of carbon, nitrogen (N), several ions, clay minerals, and microbial communities within soil aggregates. Recent developments of computer microtomography (CMT) evaluations of whole aggregates also provide opportunities to view internal porosities of 3D images of these small aggregates. Soil aggregates extracted from no-till (NT) soil management of continuous maize production for nearly 40 years, contained nearly twice the total C concentration of Wooster silt loam aggregates sampled at 0-5 cm depths. Short-term cover crop management systems have demonstrated clear accumulations of both C and N within concentric layers of soil aggregates.

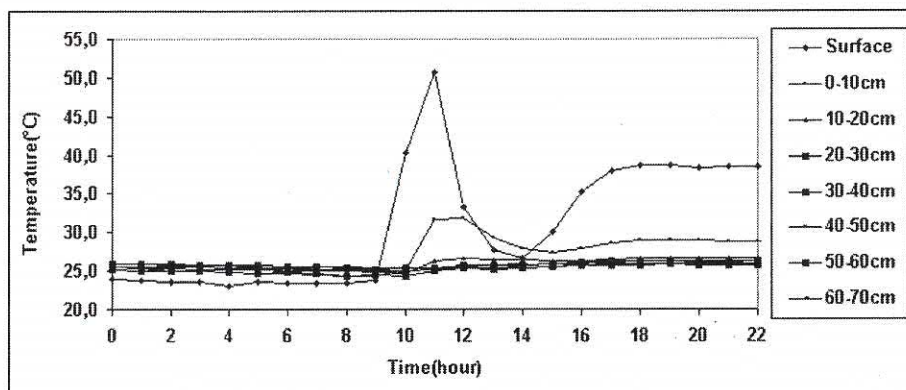
### **Introduction**

Soil structure includes a vast array of heterogeneous and separable individual soil aggregates that are repositories of C, water, microbial communities, plant nutrients, and pollutants within the soil profile. These biophysical polymorph structures control the absorption, storage and losses of most soil constituents. Nitrogen is highly mobile, especially in soils containing low levels of soil organic matter. Increasing concentrations of soil nitrate (NO<sub>3</sub>) in fertilized agroecosystems are leaching into groundwaters creating potential health risks. Timing of N fertilizers combined with proper tillage and cover cropping are excellent management approaches for minimizing the leaching of soil nitrates. Living biomass is the best possible approach for reducing N leaching through coarse and medium textured soils. Microbes in the rhizospheres of plants develop into large reservoirs of N metabolites retained by the living microbial biomass. Therefore, it is essential that living plants and associated rhizospheres remain active for the duration of each year. Cover crops are excellent bridge

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**Figure 5.** Temperature distribution in 30.05.2001 at wet conditions (500W projector heat source) between 10:00-11:30 and at 15:00 (100W lamb were used as heat source).

## Results and Discussion

2 different methods were utilised for the determination of temperature values in soil columns. In the first method, values were obtained using the Analog-Digital (AD/DA-14 byte) card, connected to 16 different sensors. The card converter sensed temperatures to digital data in relation to time and depth.

In the second, the advanced step of the study, the simulated soil temperature related to time and depth were also measured using the mathematical model developed in this work. Basic physical laws, soil temperature capacity and flux values along with initial soil moisture were the main components of the model.

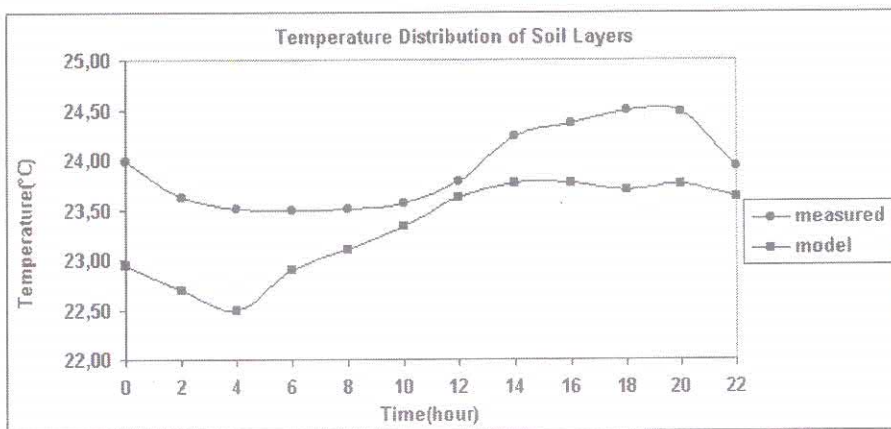
Methods used in this study both yielded satisfactory results. However, there are negligible differences between measurement and model values. These differences have occurred due to the continuous evaporation of the soil moisture from the surface of the soil, which is effective on soil temperature. Also, balancing the parameters according to the constant moisture content in the model has been the main factor causing the difference. Mean difference in other layers is relatively low and well correlated.

Thus, in similar soil temperature studies the use of suggested method will yield satisfactory results.

Results revealed that AD/DA converter card and sensors are determined to be sensitive for measuring the effect of external heat sources. Thus, AD/DA converter card and sensors can be successfully used for measuring other physical and chemical properties of soils when they are effectively calibrated.

$$\lambda = \frac{c_s \cdot \frac{T_1^s - T_1^i}{\Delta t}}{\frac{T_1 - T_2}{\Delta x^2}} \quad [\text{Eq. 6}]$$

in the equation  $T_1^s, T_1^i$  are same layer,  $(\Delta t)$  initial and final temperature in certain period,  $T_1$  and  $T_2$  represents adjoining layer temperatures and  $\Delta x$  is the thickness of the layer. The heat conductivity were calculated by taking into account moisture ( $\theta = 33.5\%$ ) and low moisture ( $\theta = 15\%$ ) conditions along with measured values. The heat conductivity value for the moisture conditions were higher than low moisture contents of the soil,



**Figure 3.** Measured and mathematical model values of temperature at 30-40 cm depth.

**Table 4.** The heat conductivity value for the moisture and low moisture conditions of the soil. (hour:11:00-12:00)

Date	Low Moisture $\lambda$	Moisture $\lambda$	Difference $\lambda$
19.05.2001	0.010	0.158	-0.148
29.05.2001	0.010	0.007	0.003
09.06.2001	0.037	0.007	0.030

Temperature changes due to external heat resource application are given in figure 5 at moisture condition.

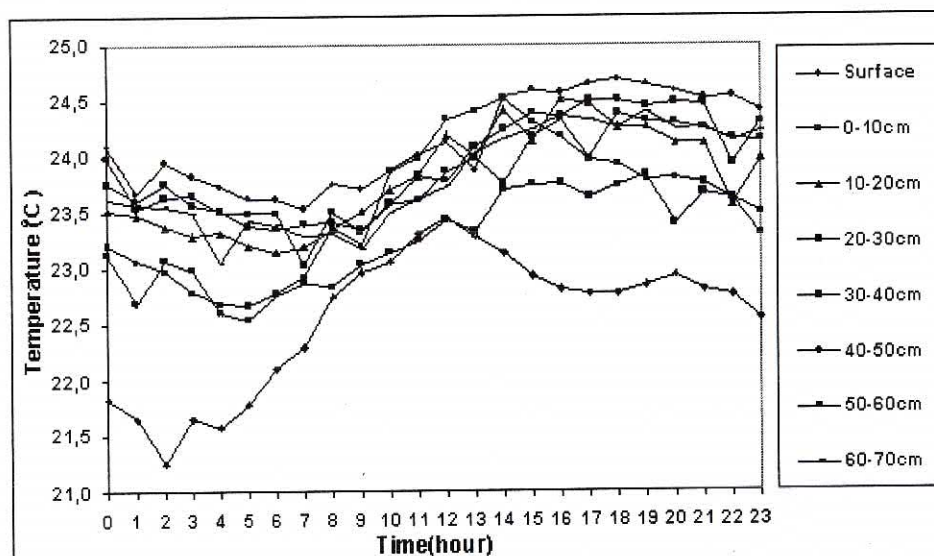
## Results

Physical and Chemical Properties of Soils are given in Table.1.

**Table 1.** Some chemical and physical properties Soils.

Depth (cm)	pH	Salinity %	CaCO <sub>3</sub> (%)	Org. Matter (%)	Bulk density (g cm <sup>-3</sup> )	Hydraulic cond. (cm h <sup>-1</sup> )	Sand %	Silt %	Clay %
0-10	7.52	0.053	26.89	1.34	1.16	0.39	28.2	34.8	37.0
10-30	7.61	0.048	27.76	1.97	1.43	0.76	30.4	31.6	38.0
30-60	7.56	0.046	28.77	1.33	1.55	0.36	33.9	31.0	35.1
60-90	7.76	0.020	33.18	0.74	-	-	46.8	26.9	26.3

Measurement values and results obtained from the model are given in Figure 2,3.



**Figure 2.** Soil layer temperatures changes.

In equation (1), the thermal conductivity and the heat capacity can be measured by using finite differences method and  $c_s = 0.20 \rho_b + \theta$  (Hanks and Ashcroft, 1985) equation respectively as in the following formula:



Çukurova were determined according to the following methods. Texture Bouyoucos (1951), Bulk density on undisturbed soil samples collected by 100 cc cylinders (Blake&Hartge1986), Hydraulic conductivity (Klute&Dirksen,1986), Salinity (U.S. Salinity Laboratory Staff, 1954), pH and %CaCO<sub>3</sub> equivalent (Schlichting and Blume, 1966) (Table 1).

Methods employed are; Properties heat of Analog / Digital (A/D) converters used for measuring. Data collectors' capability of data storage and capacity let the use of varying methods. With the aid of the software, data-collecting system collects data via suitable modules or sensors. For heat measurements, Super (output impedance 2K ohm) 14 byte AD/DA card is used in computer, capable of converting data to digital data, which were attained 16 different points. Analog data can be calculated less than 2 ms by sensors.

### Measurement and Experiment Set

The experiment set consists 2 soil columns, and each column 8 sensors were placed in. Temperature changes were observed in one column by using varying moistures. Also, for determining the sensitivity of the sensors 500W and 100W heat sources were utilized.

Soils were placed in plastic columns (R=11 cm) and kept in field conditions. Holes are opened at 10 cm intervals in columns and heat sensors were placed in to the holes. Changes in temperature and periodic measurements were transferred to computer. Software was developed for the use and calibration of A/D card.

Temperature values were calibrated and analysed in MS Excel software. The valid equation, trend and validity values were observed for each channel. These trends were also used for temperature the measurement program.

The height of PVC column is 1 m with a radius of 5.25 cm, having 10 layers with 10 cm thickness with soil of known bulk density (Figure 1).

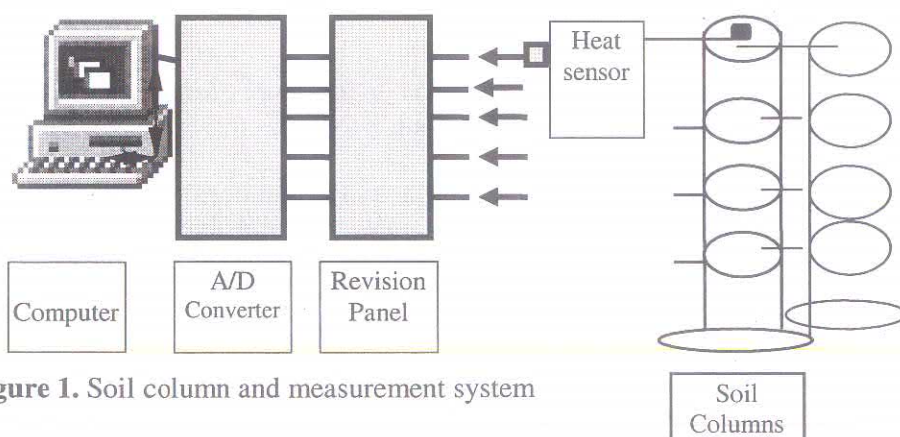


Figure 1. Soil column and measurement system

$$C_s(\theta) \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} (\lambda_s(\theta) \frac{\partial T}{\partial x}) \quad [\text{Eq. 1}]$$

Higher and lower limits can be respectively expressed as follows;

Higher limit condition:

$$T|_{x=0} = T_a + (3 * (1 + 1.16 * \sin((2 * \pi * t_k / 24) - 2.09)) + 0.56 * \sin((2 * \pi * t_k / 24) - 0.785) * \ln(\varphi)) * \cos(0.0464 * n) - (0.85 * \ln(u + 1)); \quad [\text{Eq. 2}]$$

Lower limit condition:

$$T(N) = \text{Const.} \quad [\text{Eq. 3}]$$

Initial condition:

$$T_{i(x)} = f(x)$$

In Eq. (1),  $C_s(\theta)$  ( $\text{calcm}^{-3} * ^\circ\text{C}$ ); is the volume heat capacity related to soil moisture content,  $\lambda_s(\theta)$  ( $\text{calcm}^{-1} * ^\circ\text{C}^{-1} * \text{h}^{-1}$ ); soil heat conductivity,  $T$  ( $^\circ\text{C}$ ); soil temperature,  $t$  (hour); time,  $x$  (cm); thickness of the soil layer,  $N$ - soil depth. Other parameters are,  $T_a$ , air temperature,  $n$ : cloud cover,  $u$ : wind speed,  $\varphi$ : relative air moisture.

Equation expressed above is defined below (Sarıyev et al, 1998):

$$T_i(t_{k+1}) = T_i(t_k) + A_t (T_{i-1}(t_k) - 2 T_i(t_k) + T_{i+1}(t_k)) \quad [\text{Eq.4}]$$

For simplifying this expression, determination of temperature in homogenous soil can be expected as follows;

$$T_j = \frac{NR - J}{NR} \cdot T_0 + \frac{J}{NR} \cdot T_{NR} \quad [\text{Eq. 5}]$$

As seen in this equation, for any  $J$  layer temperature surface and sub layer temperature and layer position are in relation to each other, whereas  $NR$  is the number of layers.

For testing the approaches (steady and unsteady conditions) in both condition experiment were undertaken in soil columns, and probable similarities were investigated. Data were stored in computers by utilising AD/DA converter card and sensors.

## Materials and Methods

The physical and chemical properties of disturbed and undisturbed soil samples collected from the Experimental Farm of Field Crops Department, University of

# **The Measurement of the Soil Temperature in Soil Columns with AD/DA Converter Card-Sensors and its Simulation along with the Determination of the Thermal Conductivity**

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## **Abstract**

Soil temperature was studied in soil columns at steady and unsteady flow conditions at 4 different moisture content rates. Changes in temperature in soil columns were determined both with sensors and mathematical models. AD/DA converter cards and sensors were determined to be sensitive for measuring external heat sources. Thus, AD/DA converter cards and sensors are suitable for utilising in soil temperature studies. Moreover, mathematical models are also determined to be in accordance with measured results.

## **Introduction**

Soil temperature significantly effects plant growth, at 0–5 °C, germination and root development can not be healthy, moreover, below freezing point, biological activity stops. Each plant requires specific heat levels for growing, since chemical reactions, micro organism activity, aeration, water holding and movement are all heat dependant parameters. Soil colour, specific heat, water content, soil surface relief, type and intensity of vegetation cover are effectiveness soil heat (Yeşilsoy, 1975).

Recent, studies plant growth revealed models are that successfully used and applied in agricultural sciences. Plant growth models, based on blocks principle, all parameters should be individually outlined and correlated with suitable software. Soil head is an important parameter in block based modelling of Energy-Mass and plant growth of currently developing Agro ecosystem studies (Poluektov, 1991).

## **Theory**

Mathematical modelling and digital analyses of soil temperature is an important approach. When mathematical modelling of soil temperature is evaluated at 2 conditions, for unsteady flow limit and initial condition can be expressed as flow (Poluektov, 1991).



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Weiler et al., (1998) reported that GPR, which employs an unguided EM wave, shows great promise in the future for nondestructive soil water sensing. They claimed some advantages of GPR over TDR are that it can measure larger volumes of soil than the TDR and can be utilized without disturbing the soil. Disadvantages include that automatic measurements are not possible because every instrument might have to be calibrated first and that it is prone to failure in soils with high clay contents and high salinity contents.

In another study, digital GPR for soil moisture determination and mapping of soil water content were evaluated by Chanzy et al. (1996). In this research two modes of operation were considered: the ground mode and the airborne. A strong correlation between the GPR data and the soil water content was observed in both the ground and airborne modes of operation. In the ground mode, soil moisture error after calibration was found lower than  $0.03 \text{ m}^3/\text{m}^3$ . However in the airborne mode, soil moisture estimation was less accurate ( $0.046 \text{ m}^3/\text{m}^3$ ). Additionally, it was asserted that this method has a great potential for mapping soil moisture and is efficient on most natural surface as vegetation and surface microtopography have only a small effect on the reflection of low-frequency pulses.

Huisman et al., (2001) evaluated GPR performance, TDR and gravimetric soil water content measurements. The results showed that the calibration equations between GPR and aggregated gravimetric soil water content were similar to those obtained for TDR, suggesting that available TDR calibrations (e.g. Topp's equation) can be used for GPR.

## **Conclusion**

The restrictive use of neutron probe, the rapid advancement and the decreasing cost of the non-nuclear methods in recent years, brought about to compare these methodologies. This also defines decision-making process for assessing the characteristics of technology in relation to project objectives. Soil water measurements encounter particular problems related to the physics of the method used. Great effort has been devoted in the last decades to the development of new soil water-content sensors based on the capacitance technique or working with TDR or FDR.

Each soil water sensing method has strengths and weakness. A strength in one application may be a weakness in another. All of the methods have their own specific field of application. However they complement each other in some aspects such as sensitivity at low water content. To select the right method, the user must have a good understanding of how its qualities fit the requirements of the project. Finally we conclude whichever sensor one chooses, time must be invested to become proficient with them, and to be cautioned to find out their site-specific behaviour and plant compatibility.



For the CP electrodes, the surface area of electrodes is well known but the degree to which the torus of electric force line permeates the soil is not. Thus, it seems that any term equivalent to  $d$  (Eq. 1) is particularly poorly defined in this soil-access tube since soil, with all its variability in bulk density and water content, becomes the dielectric in the capacitive system and the shape of the field may be influenced by soil heterogeneity including any gaps between the soil and tube wall induced by tube installation. Installation and calibration for this type capacitance probe gain an importance as described by Bell et al. (1987).

The capacitance probe is an attractive device for monitoring soil moisture automatically. However, its sphere of influence is rather small (a few cubic centimeters only) (Chanzy et al., 1998). Their results showed that the calibrations differ significantly from one probe to another. Once calibrated, the capacitance probe provided accurate soil water measurements, but it is advisable to have at least two replicate probes.

On the other hand, Evett and Steiner (1995) found poor results with CP gauges and attributed these results to non uniformity of their soils studied and considerable small measurement volume. They concluded that the CP gauge has limited precision and is unacceptable for routine soil water content measurements under their conditions and, however, NP provided acceptable precision.

Tomer and Anderson (1995) compared the results of soil water contents with CP and NP and data obtained by TDR. They found that the CP gave greater soil water estimates than the NP when the data grouped according to date. However, when data grouped according to depth, between probe differences changed with measurement. CP measurements were greater than NP measurements at shallow depths. They concluded that CP has several advantages in soil water measurement. Measurement time of the CP is less than for the NP, hazards and expenses incurred with radiation are eliminated, and has good depth resolution. On the other hand CP has several disadvantages that are related to the small soil volume and the nature of the dielectric response that is measured. Therefore, users of CP should investigate the effects of salts, bulk density, and texture. For dry and coarse textured soils changes in water content are difficult to detect with the CP (i.e., less than 10 to 12 percent).

More recently, GPR has been employed to follow the wetting front movement beside to monitor changes in soil moisture content (Vellidis et al., 1990). GPR is also suitable method for monitoring moisture content changes in the vadose zone and permit relatively large measurement scales, appropriate for hydrological models of unsaturated processes (Binley et al., 2001). GPR is a near-surface geophysical technique that can provide high resolution images of the dielectric properties of the top few tens of meters of the earth (Knight, 2001; van Dam and Schlager, 2000).

A recently commercialized device with several advantages is called a FDR. Dirksen and Hilhorst (1995) revealed that the greater complexity of processes occurring at the lower FD frequency results in greater sensitivity for FD than for TDR, but the larger differences between soils also present a greater need for soil specific calibrations. They also noted that when calibrated, the new type FD sensor appears capable of measuring  $\theta$  with at least equal accuracy as TDR, while offering operational simplicity and financial advantages. Surface area, surface charge density, composition of counterions decrease the permittivity at high frequencies but increase it at the 20 MHz frequency of FD sensor. At low frequencies, the soil particles behave as conducting particles without surface effects, whereas at high frequencies the soil particles behave as dielectric inclusions without surface effects.

Hilhorst and Dirksen (1995) reported that ionic conductivity can be measured more easily and more accurately with the FD sensor and than with existing time domain sensors. TDR is suited mostly on the studies on stratification detection, whereas FD sensor has superior features from an operational point of view, additionally it has low cost, and is robust and reliable.

FDR has several advantages over TDR: interpretation of data is direct; it has low power consumption, it is inexpensive for multiple site measurements; there is no need of an expensive cable tester; its probes can be buried for a long time, because they are designed to withstand harsh environmental conditions, bound water sensibility is as for free water (for TDR this is less than for free water), and its operation is simple. There are, however, also disadvantages of FDR: accuracy and resolution decreases with decreasing water content, stratification detection is average and it has not been widely used yet.

On the other hand all TDR and FDR require special calibration for high clay and organic matter content soils. The propagation of electromagnetic waves is also affected by electrical conductivity and temperature. High clay content has a similar effect on calibration, but the magnitude is dependent on the clay type. The temperature dependence of the FDR sensor varies with water content and can be easily corrected for (Campbell Scientific, 1998).

Since its low cost and easy-to-use, FDR technique are promising for practical use. Because of these properties FDR is being applied on irrigation scheduling. Laboski et al. (2001) and Kukangu et al. (1999) successfully used this technique for irrigation practices.

Capacitance sensors are another means of characterizing the soil dielectric constant. Their design depends on their expected applications. In particular, the electrode geometry has a critical influence on the extension of the probed region. Moreover, the soil may not always be viewed as a medium of statistically uniform dielectric constant (de Rosny et al., 2001). Mead et al. (1998) showed that the device is likely also affected by temperature.



GPR emits electromagnetic (EM) microwaves, and measures dielectric constant. GPR uses a free wave that propagates and spreads in the soil, where it will reflect off interfaces with different dielectric constants.  $\epsilon$  can be found from

$$\epsilon = (C/v)^2 \quad \text{Eq. 2}$$

Where  $C$  is the speed of light and  $v$  is the velocity of the EM wave that can be calculated for GPR, the EM wave speed can be determined with the common midpoint method or from the travel time to a layer of known depth with a distinct  $\epsilon$ .

### Comparison of New Techniques

Both old and new soil moisture measurement techniques have some advantages over the other techniques for certain conditions. The TDR method for soil water content measurement is widely applicable and is used for automated data collection. However, obtaining precision and accuracy is very much dependent on wave form interpretation methods used in software (Evetts, 2000). Most of them are based on the relationship between volumetric soil water content and dielectric constant (permittivity) of soils ( Topp-Davis-Annan Equation or Universal Equation). But this equation is not adequate for all soils. Dirksen and Dasberg (1993) reported that this equation can be valid for the soils with low clay contents (specific surface) and typical bulk densities (  $\rho_b = 1.35-1.5 \text{ g cm}^{-3}$  ). Zegelin et al. (1992) revealed that the use of universal equation gives water balance to within  $\pm 10 \%$  of soil water content. However the Maxwell- De Loor's mixing model for the four components (solid phase, tightly bound water, free water and air ) can account for both factors with average values of the volume fraction and dielectric constant of the tightly bound water.

When using the TDR, it is often of great importance to obtain high depth resolution with minimal disturbance of the soil and to be able to measure close to the soil surface. Shorting the probe size increases the accuracy of TDR in measuring the small measured volume of soil (Nissen et al. 1998; Amato and Ritchie, 1995).

Superior accuracy using the right calibration equation (within 1 or 2% of volumetric water content) (Roth et al., 1990), excellent spatial and temporal resolution and simple to obtain continuous soil water measurement through automation and multiplexing (Baker and Almaras, 1990) are strengths of the TDR. On the other hand limitation of the TDR method include relatively high equipment expense, limited applicability in soils high in swelling clays and organic matter (Zegelin et al., 1992), and under highly saline condition due to signal attenuation ( Roth et al., 1992). Moreover some clays having high surface area and surface charges and high soil moisture content (Zegelin et al., 1992) weakens the TDR signal and limits usefulness of the method.



to the volumetric moisture content of soil by various models (Topp et al., 1980, Dalton et al., 1984, Dalton and van Genuchten, 1986).

The permittivity,  $\epsilon$ ; is a complex quantity, but for soil water content measurements the imaginary part can generally be neglected. This part of complex permittivity represents energy absorption by the soil as a result of dielectric losses and ionic conduction. The permittivity is then equal to the real part and magnitude. Thus for vacuum and air  $\epsilon=1$ , for water  $\epsilon \approx 81$ , while for most mineral soil components  $\epsilon \approx 3$  to 7 (Zegelin et al., 1992). As a result, the permittivity of moist soil varies strongly with water content and can be used to determine soil water content.

FDR sensor was also developed for continuous measurement of soil water content. This system uses the dielectric properties of water but in a different approach than TDR (Bilskie, 1997). As TDR measures the apparent dielectric permittivity of soil, changes in the permittivity can be attributed to changes in soil water content. The FDR sensor, on the other hand, sends an electromagnetic wave along its probes and measures the frequency of the reflected wave, which varies with water content. Each FDR sensor contains an Application Specific Integrated Circuit (ASIC) which measures real and imaginary part of the complex dielectric permittivity simultaneously by the sensor rods and the soil at the single frequency of 20 MHz. The ASIC increases the accuracy of the measurements and eliminates influences of lengths of cables, quality of cables, connectors, and switches, making multiplexing easier and cheaper (Dirksen and Hilhorst, 1995).

A capacitance probe (CP) consists of an electron pair separated by a plastic dielectric. The upper and lower electrodes and the plastic separator are in the shape of a cylinder that fits closely inside a plastic access tube. A resonant LC (L: inductance, C: capacitance) circuit in the probe includes the ensemble of the soil outside the access tube itself, plus the air space between the probe and access tube, as one of the capacitive elements. Changes in the resonant frequency of the circuit depend on changes in the capacitances of the soil-access tube system. Capacitance of a simple two electrode plate capacitor, C,:

$$C = \epsilon_0 K_a a / d \quad \text{Eq. 1}$$

Where  $\epsilon_0$  is the permittivity of free space ( $8.9 \times 10^{-12}$  F/m),  $K_a$  is the system apparent dielectric constant,  $a$  is the overlapping area ( $\text{m}^2$ ) of the plates, and  $d$  is the thickness (m) of the dielectric separate the plates.

GPR offers a fast and nondestructive way for estimating the soil dielectric constant. Ground-penetrating radar measurements are based on transmission or reflection of an electromagnetic wave in the studied medium. Wave propagation velocity depends on the dielectric constant of the medium and its spatial variations; wave velocity varies from 30 cm/ns in air to 6 to 15 cm/ns in soils.

water content. The two major techniques that make use of this property are the capacitance probes (CP) and time domain reflectometry (TDR). Other promising technologies being used or developing are frequency domain reflectometry (FDR) and ground penetrating radar (GPR).

The objective of this paper was to give information about new water measurement techniques, to bring up the advantages and disadvantages of these techniques and to guide to those choosing a water measurement technology with a point by point comparison between the technologies presented here.

### **Classical Methods for Soil Water Content Measurement**

Thermogravimetry, electrical resistance and the neutron scattering methods have been extensively used on soil water content determination in the past. However, all these techniques did not meet to the increasing demand of our present needs any more. Thermogravimetric method is labor and time intensive, time delay required for drying, destructive although it gives precision measurements, direct and inexpensive (Or and Wraith, 2000). The electric resistance method measures the electric resistivity of soils with changes in water content (Gardner, 1986).

To monitor the soil water changes in soil, neutron probe (NP) has been extensively used for a long time. The instrument known as a neutron moisture meter consists of a probe and a scaler to monitor the flux of slow neutrons. When the probe lowered into an access tube, fast neutrons are emitted radially into soil where they collide with H nuclei, which have similar mass to neutrons, cause a significant loss of kinetic energy and slow down the fast neutrons. As a result of repeated collision, the speed of fast neutrons diminishes, they are called thermalized or slow neutrons. The flux of slow neutrons is measured by detector. The average loss of neutrons kinetic energy is proportional to the amount of H nuclei in the surrounding soil. Advantages of this method include the ability to repeatedly measure volumetric water content at the same locations, averaging of the measured water content over a substantial soil volume, and ability to measure soil water content at multiple depths and locations using the same equipment. Limitations or disadvantages include radiation hazard and attendant licensing requirements, relatively poor spatial resolution, unsuitability for near-surface measurements, and the soil specific calibration requirement (Or and Wraith, 2000).

### **Working Principles of New Techniques**

TDR is an indirect method of determining soil water content. It makes use of the fact that the dielectric constant or permittivity of water is much higher than that of the other soil constituents. The method involves measuring the propagation velocity of an electromagnetic pulse traveling along a parallel metallic probes (rods) embedded in the soil. This measurement later converted



## **Evaluation of Recent Technologies on the Measurement of Soil Water Content**

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### **Abstract**

The development and continuing refinement of new techniques have enhanced our ability to measure and monitor the storage and movement of soil water in-situ. However there is no single approach that has the best overall performance for a range of soil, crop and landscape conditions. Time domain reflectometry (TDR), frequency domain reflectometry (FDR) and Capacitance probe (CP), which based on dielectric properties of soil and provide point measurement, are suitable for automatic, precise, rapid, and reliable measurement of soil water. Ground-penetrating radar (GPR), on the other hand, offers a fast and non-destructive way for estimating dielectric constant and suitable for mapping of large areas. It is the aim of this paper to define decision making processes for assessing the characteristics of technology in relation to project objectives, the properties of the soil(s) of interest, and to compare advantages and disadvantages in these soil water measuring techniques.

### **Introduction**

Soil water is essential for plant growth and is the vehicle for solute transport, including nutrients and soil contaminants. Accurate measurement of soil water is crucial for the better management of irrigation water and rainfall capture. Crop yields are generally more closely related to soil water availability than to any other soil and meteorological variable. Therefore the effective use of soil water requires frequent and accurate measurements and the technique should be rapid, reliable, simple, cost effective and non-destructive.

On the other hand, soil water is a highly dynamic entity, exhibiting substantial variation in both time and space. This is particularly true near the soil surface, and in the presence of active plant roots (Or and Wraith, 2000). Continuous monitoring of soil water content can be a valuable part of agricultural, environmental and ecological research. Since most of the research project are conducted on multiple sites, the accessibility of sites (including limitation of labor and electric power supply) is the most important consideration when selecting an automated system for measuring soil water content (Veldkamp and O'Brien, 2000).

Several new sensors and measurement methods are based on combinations of capacitive, reflective and frequency-shift principles, all of which are governed by the soil dielectric properties. In past years, a plenty of researchers have studied on the dielectric constant property of soil as the basis to estimate the soil



contents of the soils, except the soil that had the highest amount of organic matter content. In general, soils with high amounts of sand had the highest maximum dry density and the lowest optimum moisture content, but soils with finer textures had the highest optimum moisture and lowest dry density values. The LSD mean comparison test results indicated that soils with fine texture and having higher amounts of organic matter had the highest mean porosity values. The effect of the number of hammer blows on soil porosity was very clear. While the mean porosity value was 54.43 at 5 hammer blows, it went low to 50.62 and 49.02 at 15 and 25 blows, respectively.

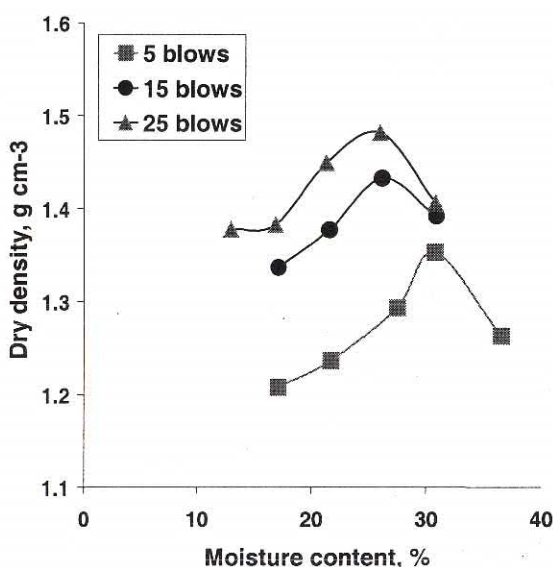
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## Results and Conclusions

The soils used in this study had different texture and organic matter content. Clay content of soils varied from 19 to 34 %, and organic matter content between 2.54 and 7.36 %.

Our results indicated that the dry density of soils increased with increasing in compaction level for all soils, and the 25 hammer blows produced the highest density values. However, the optimum moisture content, which is the moisture content where the maximum dry density was reached, decreased with the number of hammer blows increased.



**Figure 1.** Moisture content vs. dry density at different blows.

Figure 1 shows the relationship between moisture content and dry bulk density for one of the soils studied. As it was seen the dry density increased with increasing in moisture contents until the maximum dry density was reached and decreased after that point.

The results of the analysis of variance showed that the effects of soil type, and the number of blows on maximum dry density, porosity, and cone resistance were statistically significant at  $p < 0.001$  level. Soil with highest organic matter content had the lowest mean of maximum dry density. This may indicate that organic matter makes soil more resistant to compaction as stated by Arridsson (1998). There were small differences in the mean of the optimal moisture

## **Compactibility of Soils at Different Moisture Contents**

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### **Abstract**

The objective of this study was to determine the compactibility of two soil aggregate fractions at different moisture contents, and to evaluate their effects on soil properties. Six soil samples different in organic matter content and soil texture were used. Two sets of aggregate size fractions ( $<4.76$  mm and  $<2.0$  mm) were prepared, and drinking water was added to samples until they reach the levels of different moisture tensions. Standard Proctor test was used for defining compactibility at three different compaction levels (5, 15 and 25 blows). Maximum bulk density, optimal moisture content, porosity, pore volume, and penetration resistance were evaluated. Results indicated that soil type, the levels of compaction and moisture content had significant effects on measured soil properties. Maximum dry density increased with increasing number of hammer blows for all soils studied.

### **Introduction**

In many studies it was reported that soil compaction caused an increase in soil bulk density and soil strength, therefore, resulted in poor hydraulic and physical soil properties (Carter, 1990; Smith, 1997; Arridsson, 1998). Soil compaction, which refers to an increase in soil bulk density or decrease in soil porosity, also reduces crop yield.

The objective of this study was to evaluate the effects of different compactive loads at different moisture contents on the maximum dry density, porosity, and penetration of soils with different texture and organic matter content.

### **Material and Methods**

Two sets of aggregate size fractions ( $<4.76$  mm and  $<2.0$  mm) from six soil samples different in organic matter content and soil texture were subjected to different levels of compaction (5, 15 and 25 blows) using a Proctor hammer at 5 different moisture levels (pF4.5, pF4.2, pF3.3, pF2.7, pF1.8, and pF1.0) in the laboratory. The dry densities, optimal moisture contents, porosities, and penetration values of soils were determined.



rupture. Having high modulus of rupture, the soils have usually lower aggregate stability in water. In this research, changing doses of portland cement were added to the soil having a problem as above. Portland cement was increased to increase aggregate stability in water and decreased modulus of rupture of the soil. Similar results were observed for Ahuja and Swartzendruber (1972) and Stivers et al. (1977).

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(w/w) couldn't measured because of too weak of top soil (10 mm). Thus, penetration resistances of these plots were accepted zero kPa.

**Table 2.** Effects of portland cement on modulus of rupture after 25-50-75 and 100 days of incubation\*.

Soil amendment	Doze (% wt/wt)	Modulus of rupture (kPa)			
		25	50	75	100
	0	334 a	288 a	670 a	726 a
	2	75 b	60 b	136 b	300 b
Portland cement	4	ND	ND	36 g	65 c
	6	ND	ND	ND	ND

\*: Values with same letter in columns are not significantly differences at  $p < 0.01$  according to LSD test. ND: not determined because prepared briquettes were too weak.

**Table 3.** Effects of portland cement on aggregate stability after 25-50-75 and 100 days of incubation\*.

Soil Amendm ent	Doze (% wt/wt)	Aggregate stability (%)			
		25	50	75	100
	0	8.19 d	9.36 d	7.33 d	5.16 d
	2	16.08 c	20.23 c	16.83 c	12.75 c
Portland cement	4	37.64 b	43.40 b	40.13 b	34.19 b
	6	55.94 a	69.29 a	61.80 a	55.02 a

\*: Values with same letter in columns are not significantly differences at  $p < 0.01$  according to LSD test.

**Table 4.** Effects of portland cement on seedling emergence of wheat, penetration resistance and aggregate stability of the surface soil in microplot experiment\*.

Doze (% wt/wt)	Portland cement			
	0	2	4	6
Number of seedling emergence in each microplot	26 b	75 a	80 a	72 a
Seedling emergence (%)	29	83	89	80
Penetration resistance (kPa)	481 a	79 b	ND	ND

\*: Values with same letter in rows are not significantly differences at  $p < 0.01$  according to LSD test. ND: not determined.

Modulus of rupture of control soils and added portland cement decreased at 50 days of incubation, but increased at 75 and 100 days of incubation (Table 1). Water stable aggregate of control soils and added portland cement increased at 50 days of incubation, but decreased at 75 and 100 days of incubation (Table 2). Chancing of water stable aggregate values were opposite of modulus of rupture values. Increasing of water stable aggregate values of a soil brings down modulus of rupture value of the soil. Increasing of dispersions of soil aggregates in water cause to break down of soil aggregates and increasing of modulus of



$p < 0.01$  test when ANOVA indicated a significant F-value (Snedecor and Cochran, 1980).

## Result and Discussion

The effects of portland cement on modulus of rupture in pot incubation experiment are given in Table 2. Portland cement reduced modulus of rupture compared to the control soil at 25, 50, 75 and 100 days of incubation. This reducing of modulus of rupture was significant by statistical ( $p < 0.01$ ). Modulus of rupture of control soils at 25, 50, 75 and 100 days of incubation were 334, 288, 670 and 726 kPa, respectively. Modulus of rupture of soil samples added portland cement at rate of 2 % (w/w) at 25, 50, 75 and 100 days of incubation were 75, 60, 136 and 300 kPa, respectively. Modulus of rupture of soil samples added portland cement at rate of 4 % (w/w) at 25, 50, 75 and 100 days of incubation were 0, 0, 36 and 65 kPa, respectively. Modulus of rupture of soil samples added portland cement at rate of 6 % (w/w) at 25, 50, 75 and 100 days of incubation were not measured because of prepared briquettes were too weak. The effects of portland cement on water stable aggregate in pot incubation experiment are given in Table 3. Between water stable aggregates of control samples and treated with portland cement were different by statistically ( $p < 0.01$ ). Water stable aggregate of control soils at 25, 50, 75 and 100 days of incubation were 8.19, 9.36, 7.33 and 5.16 %, respectively. Water stable aggregate of soil samples added portland cement at rate of 2 % (w/w) at 25, 50, 75 and 100 days of incubation were 16.08, 20.23, 16.83 and 12.75 %, respectively. Water stable aggregate of soil samples added portland cement at rate of 4 % (w/w) at 25, 50, 75 and 100 days of incubation were 37.94, 43.40, 40.13 and 34.19 %, respectively. Water stable aggregate of soil samples added portland cement at rate of 6 % (w/w) at 25, 50, 75 and 100 days of incubation were 55.94, 69.29, 61.80 and 55.03 %, respectively.

The effects of portland cement on seedling emergence of wheat in micro-plot experiment are given table 4. These effects were significant by statistical ( $p < 0.01$ ). In the control plot were observed 26 seedling emergence from 90 planted seeds. Seedling emergence were 75, 80 and 72 count from 90 planted seeds in plots added portland cement at rates of 2, 4 and 6 % (w/w), respectively. Percentage of seedling emergence in control plot was 29 % of 90 planted wheat seeds. Percentage of seedling emergence in plots added portland cement at rates of 2, 4 and 6 % (w/w) were 83, 89 and 80 % of 90 planted wheat seeds, respectively (Table 4).

Penetration resistances measured in plots were different by statistical at 0.01 level. Penetration resistances in plots of control and added portland cement at rates of 2, 4 and 6 % (w/w) plot were 481, 79, 0 and 0 kPa, respectively (Table 4). Penetration resistances in plots added portland cement at rates of 4 and 6 %



for 5 min. Air-dry soil aggregates (about 5 g) between 1-2 mm size were dispersed on the screen (0.25 mm). Weight of aggregates >0.25 mm retained on the screens was determined by after drying them at 105 °C in the oven. Weight of sand >0.25 mm in the aggregates was determined by dispersion of duplicate samples with a mechanical stirrer and a dispersing agent (5 ml of 2.5 M NaOH), and washing the material through the sieve (0.25 mm screen holes). Weights of stable aggregates were then determined by subtracting the weight of oven-dried sand from the weight of the aggregates retained on the screen (Kemper, 1965). Sand, silt and clay distributions were determined by hydrometer method (Day, 1965). Soil pH (Peech, 1965) and electrolytic conductivity (EC) (Bower and Wilcox, 1965) were measured in 1:2.5 soil: water suspension. Organic matter concentration was determined by a Smith-Weldon method (Allison, 1965). The CaCO<sub>3</sub> equivalent of the soil was determined with a calcimeter (Allison and Moodie, 1965). Water contents as a percentage of dry weight representing field capacity was measured according to Peters (1965). Cation exchange capacities were evaluated as US. Salinity Lab. Staff (1954).

### **Micro-Plot Experiment**

A seedling emergence experiment was conducted in micro-plots under unheated greenhouse conditions. Portland cement was used for improving of seedling emergence of wheat and decreasing of penetration resistance at the soil. The surface soil sample (0-15 cm) was air-dried, and ground to pass a 2-mm sieve was filled a deep of a 10 cm, in 21 wooden boxes (40 cm long, 40 cm wide and 15 cm deep). The soils mixed with portland cement at rates of 2, 4 and 6 % (w/w) were spread on the surface of the soils in the boxes at depths of 5 cm, three replications. Three boxes were selected as control plots (no amendments) and filled the soil at depths of 5 cm. Eighty grains of wheat seeds (*Triticum durum* Desf.) were seeded in each wooden box, in six rows, at depths of 3 cm and 2.5 cm the length, after mixed with portland cement.

The soils in the plots were watered with distilled water applied through a finely drilled spray nozzle approximately at depth of 10 cm of the soil surface in the plots. Maximum and minimum values of temperature and humidity in greenhouse at the experiment periods (14 days) were +1 and +33 °C, 35 and 92 %, respectively. Seedling emergency of wheat were counted at 14 days after seedling. After, a flat-tipped pocket penetrometer to 10 mm soil depth from soil surface was used for nine penetrometer measurements in each plot after 20 days of seedling.

### **Statistical Analysis**

The analysis of variance procedure (Minitab, 1995) was carried out to compare the effects of the portland cement on the measured soil physical properties. Mean separations were conducted using least significant differences (LSD) at

improving of water stable aggregate. The soil samples was passed through a 2-mm sieve and mixed homogeneously, before using. The pot experiment was conducted in pots of 18 cm dept and 18 cm in diameter, containing 3 kg soil (oven-dry weight basin, 105 °C). Soil samples in the pots were watered to the field capacity with distilled water. The pots were weighed after one weak, and water was added to compensate the evaporation. The contents of pots were mixed with a small shove to represent repeated cultivation and to even the microbial activity throughout each pot. Subsoil samples of 250 g were taken from each pot on 25 days intervals for four times. These sub samples were used to determine modulus of rupture (three replication in each pot) and water stable aggregate (two replication each pot).

**Table 1.** Some physical and chemical properties of the soil used in the study <sup>x</sup>

Classification (Soil type)	Texture	Particle size distribution			pH <sup>y</sup>	EC <sup>y</sup>
		Sand, mm 2-0.05	Silt, µm 50-2	Clay, µm <2		
Aquic <sup>z</sup>	Silty loam					dS m <sup>-1</sup>
Haplocalcides		16	64	20	8.14	1.45
OM	CaCO <sub>3</sub>	CEC	FC	AS	MR	
	g kg <sup>-1</sup>	cmol (+)kg <sup>-1</sup>	gH <sub>2</sub> O kg <sup>-1</sup>	%	kPa	
18.9	600	24	310	14	535	

<sup>x</sup> All values in the table were conducted on a composite sample of three replication

<sup>y</sup> pH and EC<sub>e</sub> were determined on a 1:2.5 soil : distilled water mixture

<sup>z</sup> Soil Conservation Service (1994)

EC: electrical conductivity; OM: organic matter content; CEC: cation exchange capacity;

FC: field capacity; AS: aggregate stability in water; MR: modulus of rupture

Modulus of rupture was determined by the procedure of Richards (1953) using briquettes prepared in modulus made from mild steel of rectangular cross-section with inside dimensions 70x35x10 mm. Briquettes were prepared using sieved subsoil sample (<2 mm), taken from each pot. Moulds on screen-bottom try in the soaking tank were filled the subsoil samples, and added distilled water to the soaking tank until the upper surface at the mould, and allowed samples to stand for one hour, and dried oven at 50 °C. Briquettes were broken by downward motion of a bar of triangular cross-section, constrained by a force was attached by water accumulations in a vessel was used for calculation of the modulus of rupture, and expressed as a convenient unit (kPa).

$$MR = 3 F L / 2 b d^2$$

where, MR is modulus of rupture in dynes cm<sup>-2</sup>, F is breaking force in gram water x 980, L is distance between the lower supports in cm, b is width of the briquette in cm, and d is thickness of the briquette cm.

Aggregate stability wetted by foregoing two procedures were then determined by immersion the sieves, containing aggregate samples, in distilled water an oscillating the screens up and down through a 55mm depth at 30 strokes min<sup>-1</sup>



Soil crusts are known: to reduce infiltration, increase runoff (Morin et al., 1981), slow down the soil-atmosphere gas exchange (Cowans et al., 1965). Surface crusts show different thickness ranging from 2-3 mm to 4-5 cm. They are characterized by greater density, fine pores, and lower saturated hydraulic conductivity comparing with the underlying soil (Shainberg, 1985; Bengough & Young, 1993). The presence of a crusted soil surface due to rain fall is a common feature of many soils, particularly in the arid and semi-arid regions.

Soil texture also plays a significant role in the development and stability of soil structure and can be expected to influence the susceptibility of soils to crusting. Lutz (1952) reported that crusts can form on soil of almost any texture except coarse sand with extremely low silt and clay contents. Generally, high contents of fine sand and/or silt are considered the textural characteristics most likely to lead to the development of strong crusts (Lutz & Haque, 1975). Furthermore, low organic matter contents of soils and high dispersion of soil aggregates were lead to in hard crusts preventing seedling emergence (Hussain et al., 1985; Arshad & Mermut; 1988).

The objective of this study were to investigate effect of portland cement on modulus of rupture, water stable aggregate, seedling emergence of wheat (*Triticum durum Desf.*) and penetration resistance in a silty-loam soil.

## Materials and Methods

The study was conducted in two phases: (1) pot incubation experiment in laboratory; (2) micro-plot experiment under unheated greenhouse conditions.

Both pot experiment and micro-plot experiment were conducted on the soil, taken from the Konya plain (0-15 cm soil depth), located in central Anatolia (latitude 36° 51'-39° 29' N, longitude 31° 36'-34° 52' E, 1025 m altitude). The climate is arid to semi-arid climate, with an annual precipitation of 324 mm, annual mean temperature of 11.5 °C, and annual mean evaporation of 1173 mm. First the surface soil sample (0-15 cm) was collected from cultivated fields, and were air-dried. Then it was ground to pass a 2-mm sieve, and mixed homogeneously. Some physical and chemical properties of the soil are given Table 1. The soil (Aquic Haplocalcids) was characterised by silty-loam texture and quite high soil pH value (8.14). Organic matter and CaCO<sub>3</sub> content of the soil were 18.9 and 600 g kg<sup>-1</sup>, respectively. The soil has a high modulus of rupture (535 kPa) and a weak water stable aggregate (14 %) in water (Table 1). The portland cement used was furnished gratis by Konya Portland Cement Company. Company-supplied specifications were contents of 56.0 % CaO; 25.5 % SiO<sub>2</sub>; 6.6 % Al<sub>2</sub>O<sub>3</sub>; 3.0 % Fe<sub>2</sub>O<sub>3</sub>; 2.7 % SO<sub>3</sub> and 1.3 % MgO.

### Pot Incubation Experiment

At the pot experiment; portland cement was used for preventing of soil crusting or decreasing of crust strength which measured by modulus of rupture, and



# Effect of Portland Cement on Soil Mechanical Properties and Seedling Emergence of Wheat (*Triticum Durum Desf.*) in a Silty Loam Soil

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## Abstract

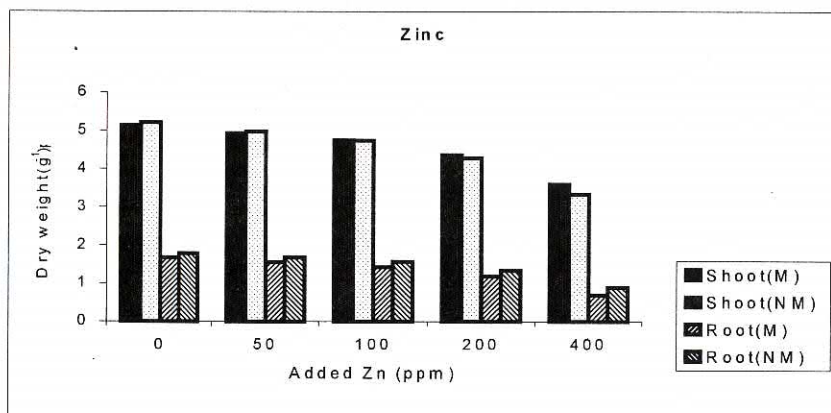
The effects of portland cement on modulus of rupture and water stable aggregates were measured in a pot experiment in the laboratory. Seedling emergence of wheat (*Triticum durum Desf.*) and penetration resistance were investigated in a micro-plot experiment in the greenhouse. Portland cement was added to the soil samples at rates of 0, 2, 4 and 6 % (w/w). Control and with portland cement, soil samples were incubated at about field capacity water content for a hundred days in the laboratory. Modulus of rupture and water stable aggregates were measured after 25, 50, 75 and 100 days of incubations. Modulus of rupture of the control soil samples and mixed with portland cement at rates of 2, 4 and 6 % (w/w) after 100 days of incubation were 726, 300, 65 and 0 kPa, respectively. Water stable aggregates of the control soil samples and mixed with portland cement at rates of 2, 4 and 6 % (w/w) after 100 days of incubation were 5.16, 12.75, 34.19 and 55.02 %, respectively. Penetration resistance of the control plot and mixed with portland cement at rates of 2, 4 and 6 % (w/w) in the micro-plots were 481, 79, 0 and 0 kPa, respectively. Seedling emergence (%) of wheat of the control plot and mixed with portland cement at rates of 2, 4 and 6 % (w/w) in the micro-plots were 29, 83, 89 and 80 %, respectively.

## Introduction

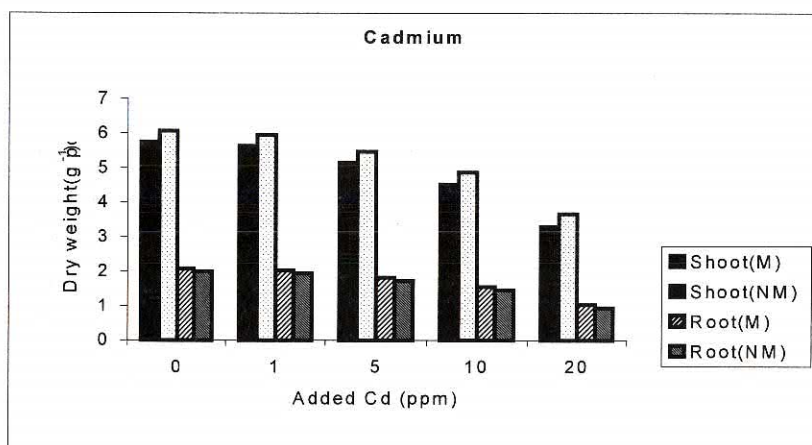
Portland cement acts as a binding agent when it hydrates and hardens. Hence, it could be expected to bind small soil particles into larger ones when favorable ratios of cement, water and soil are mixed and allowed to react under desirable curing conditions (Ahuja and Swartzendruber, 1972). There is little reported research on its possible use on soils for crop production. Ahuja and Swartzendruber (1972) and Stivers et al. (1977) found increases in water-stable soil aggregation and hydraulic conductivity for soil tilled with cement at rate up to 1.90% by weight.

Crust formation in soils exposed to the beating action of water dropping is due to two mechanisms: (i) Breakdown of the soil aggregates caused by the impact action of the rain drops over the soil surface. As a result the destruction of the aggregates reduces the average size of the pores of the surface layer (Morin et al., 1981). (ii) A physicochemical dispersion of the soil clays which can then migrate into the soil with the infiltrating water, and clog the pores immediately beneath the surface (Kazman, et al., 1983).

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**Figure 5.** Dry weight (Zn application)



**Figure 6.** Dry weight (Cd application)

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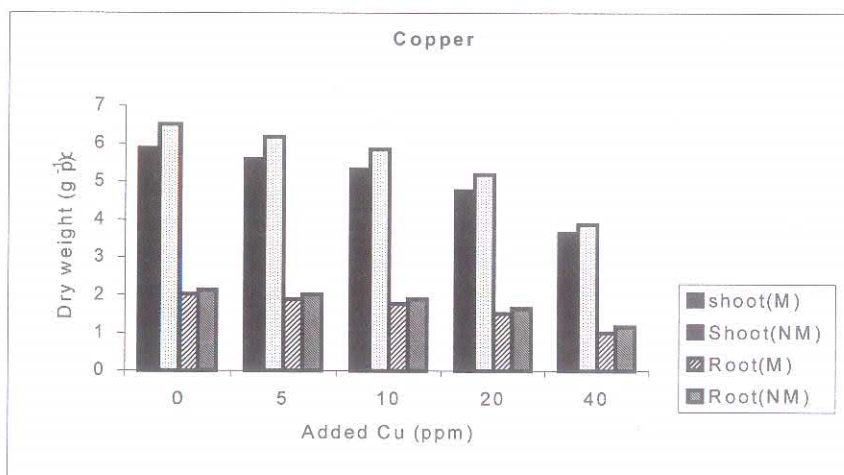
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the increasing the root and plant dry weight and increased heavy metal doses enhanced the soil heavy metal content.

### The effect of heavy metals on root and plant dry weight

No difference was observed between the root dry weight of infected and non-infected plants, both of which received Cu, Zn and Cd applications. Increased doses of heavy metals brought about decrease in both infected and non-infected plants (Fig.4, Fig.5, and Fig.6). Smilde (1981), examined the effect of increased Cu, Zn and Cd application on the growth of oat and maize and found less oat weight in response to the increased Cu and Cd doses and no toxicity in the plant. When Cd was added to the soil, dry weight and grain yield decreased (Allinson and Dzialo 1981). Considerable decrease occurred in dry weight, when high doses of zinc were added (Gildon and Tinker 1983 b). Researches of similar nature conducted show that mycorrhizal symbiosis has no notable effect on plant dry weight.



**Figure.4.** Dry weight (Cu application).

It can be expressed that VAM infection enables the most of Cu, Zn and Cd to be retained by roots, allowing less heavy metal translocation to leaves. The filtering property of mycorrhiza may contribute to the efforts to mitigate high levels of heavy metals in soils which is direct linkage with the food chain.

Cu uptake by mycorrhizal infected roots (24.80 ppm) was higher than that of mycorrhiza-free roots (14.10 ppm). Heavy metal contents of the soil increased depending on the applications of heavy metals. Cu content of mycorrhizal infected roots was observed higher than that of non-infected roots. Increased doses of Cu caused Cu uptake by both applications to increase (Fig.1). Infected roots absorbed much less Zn in comparison with the control application. As Cu doses increased in both application so did Zn concentration in roots. However, Zn content in mycorrhizal application was recorded lower than that in non-mycorrhizal application. Due to the high level of available phosphorus in the soil ( $5.0 \text{ kg da}^{-1} \text{ P}_2\text{O}_5$ ) and its negative effect on Zn, less Zn uptake occurred in mycorrhizal applications (Fig.2). Dueck et al (1986), expressed that although VAM had no complete hindrance effect on Zn uptake, VAM colonization mitigated Zn effect on the growth of meadow grass.

Cd content in infected roots was found less than that in control application. With the increased Cd doses, Cd content of the mycorrhiza free samples increased as well. The highest Cd value was recorded in the application of Cd<sub>20</sub> (M: 13.43 ppm, NM: 24.28ppm). This revealed the positive effect of the mycorrhizal infection and the less Cd uptake by roots through hyphae of VAM hindering the translocation of the elements (Fig.3).

The comparison between mycorrhizal (M) and non-mycorrhizal (NM) application showed that high level of Cu in the root of the infected plants was held by mycorrhiza, thereby the translocation of the elements to leaves was hindered resulting in less Cu movement to the leaves. The highest Zn accumulation was found in root system and Zn content in non-infected plants was higher than that recorded in infected plants. Due to the retention by hyphae depending on the uptake by the plant, Zn content in the infected plants was found less than that in non-infected plants. Zn translocation to the leaves in infected plants was not completely hampered. Much less Cd uptake took place in mycorrhizal infected plants in comparison with the non-infected plants. Cd application affected mycorrhizal infection negatively; however, Cd uptaken by infected plants was low and was retained in root systems allowing not a complete translocation to leaves.

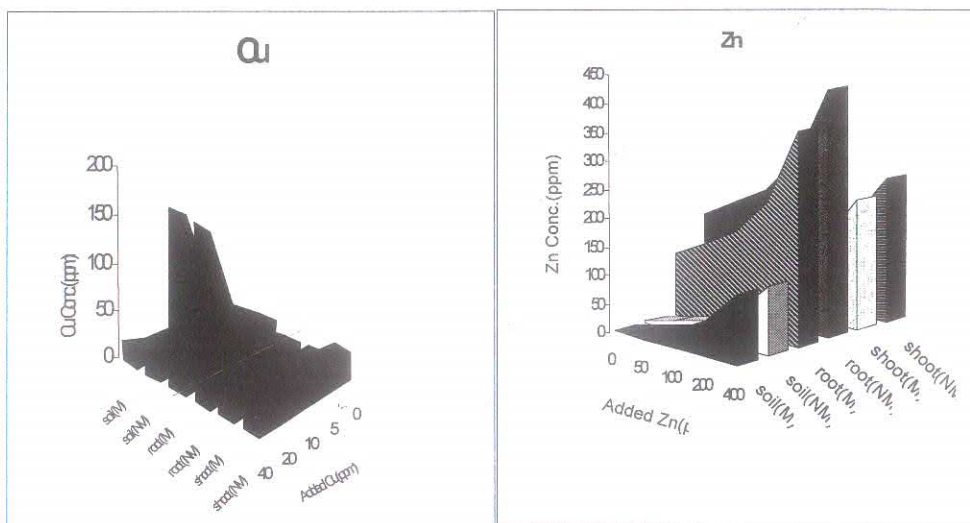
Gildon and Tinker (1983b), conducted a research by applying Cu, Zn, Ni and Cd to trifolium and found no significant effect on plant dry weight in VAM infected plants. In addition, they expressed that the addition of high level of Zn and Ni caused decrease in plant dry weight.

### **Conclusion**

Infection rate was found 36 % in VAM infected oat roots. As a result of increased heavy metal application (Cu, Zn and Cd) VAM infection rate lessened [ Cu (36-21%), Zn (36-15%) and Cd (36-4%) ]. As heavy metal doses increased oat root dry weight and leaf dry weight decreased. VAM had nothing to do with

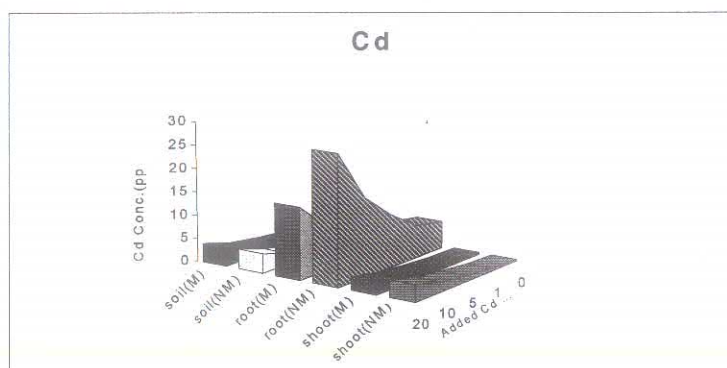
and mycorrhizal infected oat roots in Zn application ( $Y = -0.0403x + 28.358$   $r = -0.78^{**}$ ,  $P < 0.01$ ). As Zn doses increased, mycorrhizal infection decreased. As to the effect of Cd, a negative correlation was observed between mycorrhizal infected plants and Cd doses. Increased Cd doses caused mycorrhizal infection to decrease ( $Y = -1.424x + 28.255$ ,  $r = -0.88^{**}$ ,  $P < 0.01$ ). Similarly, increased doses of heavy metals (Cu, Zn and Cd) brought about decrease in mycorrhizal infection rate.

### Heavy metals concentrations in soil, root and shoot



**Figure.1.** Copper concentration in soil, root and shoot (ppm).

**Figure.2.** Zinc concentration in soil, root and shoot (ppm) (M: Mycorrhizal, NM: Non-Mycorrhizal).



**Figure.3.** Cadmium concentration in soil, root and shoot (ppm).



DTPA (pH:7.3). Zn, Cu concentration were measured by flame AAS (Perkin-Elmer 2100) and Cd concentration was measured by flame AAS(Perkin-Elmer AS 800). Statistical tests (Analysis of variance, regression , Pearson correlation) were made by the statistical Package for the social Sciences(SPSS).

## Results and Discussion

### VA mycorrhizae infection

Infection rate of 36% was determined in infected oat roots (Table 1). Infection rate decreased in parallel with the increased doses of heavy metals (Cu, Zn and Cd). The fact that an infection rate of 36% took place in infected plants alone may be due to the available phosphorus content of 5 kg da<sup>-1</sup> of the soil samples and the slightly increase in the available phosphorus content after sterilisation. Generally, soil nutrients are released through the decomposition of organic components by sterilisation and died organisms( Walker 1985, Stribley 1987). A known fact is that heavy metal uptake by plant and the plant tolerance to heavy metals may contribute to the changes in infection rate (Olsen 1972, Baker 1978).

**Table 1.** VA Mycorrhizal infection(%).

Cu added (ppm)		0	5	10	20	40
Root infected (%)	M	36	30	24	23.5	21
	NM	0	0	0	0	0
Zn added (ppm)		0	50	100	200	400
Root infected (%)	M	36	22	21.5	18	15
	NM	0	0	0	0	0
Cd added (ppm)		0	1	5	10	20
Root infected (%)	M	36	23	21	6	4
	NM	0	0	0	0	0

M: Mycorrhizal, NM:Non-mycorrhizal

### The effect of VAM on plant and root dry weight

Plant dry weight of 6.605 g pot<sup>-1</sup> in control and 5.970 g pot<sup>-1</sup> in mycorrhizal infected plants were recorded. Mycorrhizal infection did not contribute to plant dry weight. As mycorrhizal infection ratio decreased so did the plant dry weight. A positive correlation was found among mycorrhizae, plant and root dry weight in each three heavy metal treatments. Graham and Fardelman (1986) conducted a research of similar nature and found no correlation between root infection and mycorrhizae effectiveness.

### Heavy metal tolerance of VAM infection

A negative correlation was found between Cu doses and mycorrhizal infected roots

( $Y = -0.318x + 31.662$ ,  $r = -0.82^{**}$ ,  $P < 0.01$ ). As Cu doses increased, mycorrhizal infection decreased. A negative correlation was also found between Zn doses

Several authors reported that shoot concentrations of Zn, Cu, Pb and Cd decreased compared with AM colonization at high levels of available metals, whereas at lower levels metal uptake increased compared with non-mycorrhizal plants (Weissenhorn et al., 1995). High concentrations of heavy metals in soil have an adverse effect on micro-organisms and microbial processes. Among soil microorganisms, mycorrhizal fungi are the only ones providing a direct link between soil and roots, and can therefore be of great importance in heavy metal availability and toxicity to plants (Leyval et al., 1997).

The objective of the study is to investigate the possibilities of utilisation of VAM in mitigating pollution in soil. In this context, the uptake of heavy metals by plants, the effects of mycorrhiza on heavy metal absorbed by plants and mycorrhizal tolerance to heavy metals were tried to explain.

### Material and Methods

Soil samples used in the research were taken from (Lodumlu) Research Institute at the depth of 0-20 cm. The soil was sieved (4mm) and mixed with sand (3:1)(w/w) ratio. The mixture was sterilised (120° C for 2 h on three consecutive days) to eliminate native AM propagules. Four species of AM fungi were used as mycorrhizal inoculum: *Glomus mossea*, *G.fasciculatum*, *G.etunicatum*, *Gigaspora margarita*. The host plants was onion (*Allium cepa*); the test plants was oat (*Avena sativa* L.) (native variety : Yeşilköy-Y 1779).

The different metal contents in the soil were obtained by adding aqueous solutions of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ , at the rates of 0-50-100-200-400 mg Zn kg<sup>-1</sup> soil,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  (0-5-10-20-40 mg Cu kg<sup>-1</sup> soil and  $3\text{Cd}(\text{SO}_4) \cdot 8\text{H}_2\text{O}$  at the rates of 0-1-5-10-20 mg Cd kg<sup>-1</sup> soil. After carefully mixing the metal solutions with the soil, this was allowed to stabilise for 15 days before using. All treatments were applied with and without mycorrhizal inoculum and there were four replicates. In order for infection material to be reproduced, AM fungus-infected onion was used for the infection process of oat roots. One g of inoculum consisting of soil with spores, infected roots and hyphae was added to each pot at 3 cm deep and mixed with the soil. PVC pots of 8 kg were used in the experiment. Oat seeds were sterilised with hydrogen peroxide (10 vol) for 30 minutes, washed with sterile water. The seeds were sown into pots (30 in each) and thinned to 20 per pot after germination. After a growth period of 8 weeks in the greenhouse all plants were harvested. Inoculated root samples (1 in each) were stained with lactoglycerine-Trypan blue (by Philips and Hayman 1970) to determine the extent of mycorrhizal infection. Percentage infection was calculated as the light microscope fields per 100 containing any mycorrhizal fungus structure. The plants were separated into root and shoot dried to constant weight at 65° C. Dry plant material was digested in  $\text{HNO}_3$ :  $\text{HClO}_4$  (3:1). Soil samples extracted with

## Effects of Vesicular- Arbuscular Mycorrhizae on The Growth and Uptake of Some Heavy Metals by Oat(*Avena Sativa L.*)

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### Abstract

In this study, the effects of VA mycorrhizae on the growth of oat and the uptake of some heavy metals by the plant were studied. Within this context, oat roots were inoculated with VAM fungus and the rate of infection on the roots was determined. Heavy metal contents increased in soil, root, stem and leaves, depending on the increased doses of Cu, Zn and Cd being applied to both inoculated and non-inoculated treatments. A decrease was observed in the rate of mycorrhizal infection associated with the increased doses of heavy metals.

Increased doses of Cu, Zn and Cd resulted in more accumulation in oat root, stem and leaf systems in the non-infected treatments. However , a large part of the metals were retained by roots and thereby less translocation to stems and leaves occurred in the infected treatments. Consequently, VA mycorrhiza hindered metal movements to stem and leaves.

### Introduction

With the advent of environmental problems originating from pollutants having been transmitted up to the consumer through food chain, the concept of ecological pollution has been the focal issue. Today, agriculture practices being full filled by taking environmental concerns into account are of great importance. This phenomena has urged consistent cultivation and production systems to be developed and implemented. The purpose of the agrieocosystem is to ensure alternatives with the concern that population of natural species is to be sustained and the likelihood hazardous effects is to be minimized. One of these alternatives proposed is that soil microorganisms might be used in agriculture, thereby a natural protection management might be promoted. As known, mycorrhizal fungus gives the plants an ability to resist heavy metal stress and enviromentally pollution agents.

Interest in Cd as an enviromental pollutant has arisen because of its potentially harmful effects on human health. There is concern that , as a result of additions to soil in sewage sludge and in other ways, increasing amounts of Cd are entering the food chain through uptake by plants ( Hatch at all,1988).



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High P is known to depress mycorrhiza formation (Amijee et al. 1989; Ortaş et al., 1996) consequently the plant gets less P, but in the present study such an effect was not uniform among mycorrhizae species for both soils. Therefore, mycorrhiza formation, response to added P, host nutrient requirement, and mycorrhiza responsiveness are all interrelated. Janos (1996) stated that host independence of AM is a consequence of low nutrient requirement or the ability of roots alone to take up all required mineral nutrients. In the present experiment mycorrhizal inoculation regarding P addition significantly increased the P uptake even in Konya soil.

The results obtained indicate that peppers, maize and beans are mycorrhizal-dependent plant with under low P and Zn supply, and therefore inoculation of mycorrhizae in soil with P and Zn deficiency is a critical factor in crop production as well as in P and Zn uptake of plants. Phosphorus treatments generally reduced mycorrhizal dependence. But Zn application did not lead to any differences. In general, *G. etunicatum* inoculated plant had high mycorrhizal dependence compared to the *G. mossea* inoculation. In the present experiment although mycorrhizal inoculation increased plant Zn uptake, yet the plant was found to be much more mycorrhizal dependent on P nutrition.

It seems that mycorrhizal dependence is an inherent characteristic for which plant nutrient requirement and uptake efficiency are important parameters, especially for P requirement. Considering the importance of mycorrhiza dependence for plant survival, it is of great interest to categorize species according to this characteristic.

### Conclusions

Under field condition plant depend on mycorrhizal inoculation but also depend on P supply and year differences. With high P application, mycorrhizal dependence significantly reduces.

Under green house conditions, irrespective of P and Zn treatments, mycorrhizal inoculation increases shoot, and increasing P and Zn supply also significantly response to plant growth. Although plant growth is strongly affected by the P and Zn supply, mycorrhizal inoculation increases P and Zn uptake, but this is strongly dependent on the P supply rather than the Zn supply. Results obtained support the hypothesis that pepper, maize and bean are mycorrhizal dependent, nevertheless with increasing P and Zn this is gradually reduced. But mycorrhizal dependence (MD) decreases more pronouncedly for the P requirement rather than the Zn requirement.

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seedling of 17 species of vegetable crops were investigated and it was reported that growth was noticeably enhanced by AMF inoculation (Matsubara et al., 1994).

In greenhouse experiments, mycorrhizal inoculation of *G. etunicatum* and *G. mosseae* significantly increased plant growth in Sultanönü soil but did not so in Konya soil. Mycorrhizal species were different in their effect on plant growth; in Sultanönü soil, *G. mossea* was much more effective than *G. etunicatum*, but in Konya soil *G. etunicatum* was more effective than *G. mossea*. Since beans are sensitive to salt effect in Konya soil, the plant did not grow in a proper way. Consequently bean plant is less mycorrhizal dependent (Table 2). Sultanönü and Konya soils had different responses to the P and Zn application. In Sulatanönü soil, mycorrhizae inoculation without P addition, both mycorrhiza species increased plant growth. Addition of Zn application increased plant growth as well. But in the Konya soil, there was less effect.

**Table 2.** Effect of mycorrhizal species and P and Zn interaction on mycorrhizal dependence for maize, pepper and bean plants.

Mycorrhizae Species	P and Zn Supply mg kg <sup>-1</sup> soil		Mycorrhizal Dependence (%)					
			Sultanönü Soil			Konya Soil		
			Maize	Pepper	Bean	Maize	Pepper	Bean
<i>G. etunicatum</i>	P0		83	74	49	60	70	37
	P1	Zn0	66	41	21	51	70	24
	P2		39	29	17	29	27	17
	P0		72	87	45	40	54	17
	P1	Zn1	50	9	16	39	7	25
	P2		34	6	16	45	4	16
<i>G. mosseae</i>	P0		83	82	43	60	76	14
	P1	Zn0	64	42	16	54	73	4
	P2		31	34	28	58	47	24
	P0		64	92	33	57	48	20
	P1	Zn1	49	15	20	51	15	28
	P2		19	18	17	47	17	26

Without mycorrhizal inoculation, shoot and root dry matter productions were affected by P and Zn deficiency, and increases in supply of adequate amounts of P and Zn significantly enhanced plant growth, especially for Sultanönü soil. When the soil was inoculated with mycorrhizal species, P and Zn fertilization could only slightly increase plant growth. Mycorrhizal species were different in their effect on nutrient uptake; *G. mossea* was little higher than *G. etunicatum*. There were small differences in plant growth between the doses of P fertilization. By contrast, Zn addition significantly increased plant growth, irrespective of P addition. Compared to P supply, the effect of Zn on plant growth was much greater, especially at higher P rates in Sultanönü soil. But Konya soil because of high B concentration, mycorrhizal inoculation and nutrient supply did not make a significant contribution. In this case mycorrhizal inoculation had a slightly higher effect than the nutrient supply.



**Table 1.** The effect of mycorrhizal inoculation and P addition on green paper, tomato and egg plant yield and mycorrhizal dependence under metil bromide treated and not treated field condition.

+Sterile (Metil Bromide)		Yield kg/1000 m <sup>2</sup>					Mycorrhizal dependence(%)		
		1997		1998		1999	1997	1998	1999
PEPER									
P0-M	2924	±483	1022	±308	1004	±258			
P0+M	3965	±658	1045	±9	2148	±263	26.3	2.2	53.2
P1-M	3255	±28	1141	±349	2246	±628			
P1+M	3923	±583	1239	±70	2448	±125	17.0	7.9	8.2
-Sterile (Metil bromides)									
P0-M	2978	±120	691	±15	1689	±144			
P0+M	3785	±488	762	±48	2116	±237	21.3	9.2	20.2
P1-M	2918	±131	715	±112	1399	±58			
P1+M	3525	±417	716	±94	2046	±441	17.2	0.2	31.7
+Sterile (Metil Bromide)									
TOMATO									
P0-M	4635	±987	2861	±301	4271	±223			
P0+M	6219	±339	3216	±765	5198	±1850	25.5	11.1	17.8
P1-M	4860	±50	2514	±129	4150	±1738			
P1+M	6792	±265	3165	±100	5476	±1508	28.4	20.6	24.2
-Sterile (Metil bromides)									
P0-M	7906	±15	2831	±165	2161	±161			
P0+M	9485	±551	2851	±228	2226	±412	16.6	0.7	2.9
P1-M	7646	±147	3820	±479	2206	±1089			
P1+M	10018	±147	3336	±644	3557	±21	23.5	-14.5	38.0
+Sterile (Metil Bromide)									
EGGPLANT									
P0-M	6499	±823	6938	±835	3736	±1312			
P0+M	11153	±4117	7704	±123	4725	±1445	41.7	9.9	20.9
P1-M	12202	±4413	7065	±3464	4490	±497			
P1+M	15404	±1432	8983	±594	5233	±2661	20.8	21.4	14.2
-Sterile (Metil bromides)									
P0-M	6809	±191	7812	±209	6020	±374			
P0+M	12909	±4217	8598	±427	6215	±424	47.3	9.1	3.1
P1-M	10566	±3452	7881	±1277	6288	±449			
P1+M	11011	±1583	8724	±91	6043	±160	4.0	9.7	-4.1

Mean (three replicates) Bracket is SE (Standard error).

Mycorrhizal dependence was calculated. It was found that in 1997 all three plants give high MD especially green peppers and eggplants. Mycorrhizal dependence was higher in P0 than P 1 treatment. In 1998 mycorrhizal dependence was lower in general but in 1999 again microbial response was high. The reason is not known why some year it is non-responding to the mycorrhizal inoculation. Even in 1998 there was a negative response to mycorrhizal inoculation (Table 1).

Under field conditions, mycorrhizal inoculation increased eggplant, tomato and pepper plants fruit yields, especially under the low P supply conditions. Although during the vegetative growth mycorrhizae inoculated eggplants were larger and grew earlier, but this was not been reflected in the yield increase. Al-Raddad (1987), also used eggplant, tomato and pepper plants with inoculation of *G. fasciculatum*, *G. monosporum* and *G. mossea* under greenhouse conditions and found that eggplant dry weight increased significantly. In Japan under greenhouse conditions, the effect of mycorrhizal fungus inoculation on

### Pot experiment

Two widely distributed Zn and P-deficient calcareous soils from the Central Anatolia were used in the experiment. Concentration of  $\text{NaHCO}_3$  extractable P and DTPA-extractable Zn were very low, and below the critical deficiency level (i.e.,  $32 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  and  $0.15 \text{ mg Zn kg}^{-1} \text{ soil}$ ).

Maize, green pepper and bean were grown in two soils low in phosphorus (P) and Zinc (Zn) and fertilized with 3 levels of P ( $\text{P}_0=0$ ,  $\text{P}_1=25$ ,  $\text{P}_2=125 \text{ mg P kg}^{-1} \text{ soil}$ ) and 2 level of Zn ( $\text{Zn}_0=0$  and  $\text{Zn}_1=5 \text{ mg Zn kg}^{-1} \text{ soil}$ ) in 2 kg soil. Plants were inoculated with *G. mossea* and *G. etunicatum* (1000-spore per plant, 3 cm below seeds). Non-inoculated pots received the same amount of non-mycorrhizal spore inoculums.

*G. mossea* (Nicolson and Gerdemann) Rothamstedt Isolate, UK) and *G. etunicatum* (Becker and Gerdemann) Nutri-Link Isolate, USA) were used as mycorrhizal inoculum. Mycorrhizal Dependence was calculated according to the following formula

$$\text{MD} = \frac{\text{DW Mycorrhizal Plant} - \text{DW Non Mycorrhizal}}{\text{DW Mycorrhizal plant}} \times 100$$

### Mycorrhizal infection

Before plant flowering, two plants per plot were killed off, and plant root were collected from the soil. The Roots of the plants were washed carefully for mycorrhizal infection. The root clearing and staining procedure followed the method described by Koske and Gemma, (1989). The percentage of AM infection was calculated as a number of 10 mm long root segments out of 100 identified as infected under a stereo microscope at a magnification of X 20 (Giovannetti and Mosse, 1980). All statistical analyses were performed using the Statistical Analysis System (SAS).

### Results and Discussion

Under the field conditions, tomato, eggplant and green pepper plants were grown and plants responses to mycorrhizae were investigated. Fruits were harvested several times (weekly) and finally total yield was recorded. It has been observed that mycorrhizal inoculation increased fruit yield of three vegetable plants significantly compared to non-inoculated ones. The effect of mycorrhizal inoculation on plants in control plots (0 P) yield was higher than yield increase with additional P application. When zero P was applied, mycorrhizal inoculation increased tomato yield up to 52%, eggplants up to 28% and pepper up to 36 %, but with P addition, mycorrhizal inoculation increased yield up to 28 %, 14 % and 21 % respectively, compared to non inoculated ones (Table 1).

suggested that the relative mycorrhizal dependence should be subscribed with the level of available phosphorus.

Sylvia (1986) tested mycorrhizal dependence by using two arbuscular mycorrhizal fungi, identified as *Glomus intraradices* and *G. etunicatum*, at three different levels of available phosphorous and mycorrhizal inoculation increased flowering dogwood seedling survival, root length, root fresh mass, shoot dry mass, shoot height and the proportion of roots colonized. Azcon and Barea (1997) suggested that mycorrhizal dependence for a representative plant species in Mediterranean shrublands (*Lavandula spica* L.) as a key factor to its use for re-vegetation strategies in desertification-threatened areas. The degree of plant dependence is of great practical and ecological interest for plant nutrition.

In the present study we attempted to study the mycorrhizal dependence of several plants grown under field and green house condition.

## **Materials and Methods**

### **Field Experiment**

#### **Soils**

The experiment was carried out on Menzilat soil series (*Entic Chromoxerert*), which is located in Research Farm of the University of Çukurova, Turkey. The soil chemical and physical properties are given on Table 1.

#### **Soil Fumigation**

Methyl bromide (60 g/m<sup>2</sup>) exploited under the plastic polyethylene sheet. One week after the application, the plastic sheet was removed from the surface. Following this, soil was aerated for a five-day period before sowing.

#### **Experimental Design**

The experiment was conducted in two blocks with and without soil fumigation. In each block, main treatments P0 (0 kg P<sub>2</sub>O<sub>5</sub> ) and P1 (100 kg P<sub>2</sub>O<sub>5</sub> /ha) were applied with and without mycorrhizae inoculation. The plots were 3 x 5 m wide equal to 15 m<sup>2</sup>. For eggplants and tomatoes there were four rows, with each row 60 cm away from the next. For peppers, there were six rows with 50 cm interrows. Inoculum of *Glomus mosseae* ((Nicolson and Gerdemann) isolated from Rothamsted, UK) 1000 spores/plant mix of source (soil, sand and organic matter mix), chopped roots and mycorrhiza spores were placed 30 mm below the seedlings. The non-mycorrhizal plants received the same amount of mycorrhiza free-inoculum (containing the same microbes).

#### **Seedling production**

For Eggplants (Pala), Tomatos (SC2121) and Peppers, Local variety (Kahramanmaras) seeds were sown on a mix of sand: soil: organic matter (7:2:1 v/v) growth medium. Seeds were treated with and without mycorrhizal inoculation. Water was added daily to maintain moisture near field capacity. The seedlings were grown in a greenhouse for 32 days before being transferred to main field plots.



infection results in an increase in the uptake of other macro and micronutrient (George et al., 1995).

Based on plant ability to grow with or without mycorrhizae at different levels of nutrients, plants can be separated into two major groups: non-mycotrophic and mycotrophic. Mycotrophic plants are also classified according to their degree of dependence on the mycorrhizae from obligatory to facultative. Plants get benefits from mycorrhiza by enhancing nutrient and water uptake and other benefits such as resistance to stress factors.

Considering the plant-fungus interaction, it is to be expected that the extent of mycorrhizal colonization of the root system and related plant responses will vary in different plant-fungus combinations (Smith and Read, 1997). Nevertheless, study of host response to inoculation with a single fungus isolate can provide useful information. This is particularly true where the inoculating fungus exhibits a broad host range, as is the case for the *G. mossea* and *G. etunicatum* isolate used in this study. Mycorrhizae species to be different in root colonization and dependence ratio in a low-fertility soil with increased P and Zn application (Ortaş et al., 2001). This may be the effect of soil ecological parameters on root infection. Very high and very low phosphorus levels may reduce mycorrhizal infection/colonization (Koide, 1991). It is well established that infection by mycorrhizal fungi is significantly reduced at high soil phosphorus levels (Amijee et al., 1989; Koide and Li, 1990). The level of phosphorus in the plant has also been shown to influence the establishment of a mycorrhizae with high levels inhibiting colonization by mycorrhizae (Menge, et al. 1978; Graham et al., 1981; de Miranda et al., 1989; Asimi et al., 1989). However no information related to the mycorrhizal dependence about excess Zn application on root infection was obtained.

It has been hypothesized that mycorrhizal dependence is largely controlled by root architecture system (Baylis, 1975) and nutrient requirement (Ortaş et al., 2001). Plants with coarsely branched roots and with few or no root hairs are expected to be more dependent on mycorrhiza than are plants with finely branched root systems (Smith and Read, 1997). Menge et al. (1978) defined mycorrhizal dependence as the degree to which a plant species is dependent on the mycorrhizal condition to produce its maximum growth at a given soil fertility. This definition mostly pronounced for P requirement but not for other nutrients such as Zn (Ortaş et al., 2001). Plenchette et al. (1983) suggested a new definition of mycorrhiza dependence by expressing the dry mass of a mycorrhizal plant as the dry mass of a non-mycorrhizal plant at a given level of soil fertility. An earlier definition of mycorrhiza dependence (Menge et al. 1978) is expanded and modified to give a percentage increase of yield relative to that of mycorrhizal plants. In this definition the range is between zero and 100% rather than an unlimited percentage increase. The result is likely to vary depending on the nutrient status of the soil, so it is

## **Do Plants Depend on Mycorrhizae In Terms of Nutrient Requirement?**

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### **Abstract**

Nutrient deficiency is a common nutritional problem in crop production in Turkey. This problem results in the application of increasing amounts of P, N, Zn and other fertilizers. Mycorrhizal inoculation or indigenous potential of mycorrhizae in soil is a critical factor in crop production under low supply of P and Zn. Under semiarid conditions mycorrhizae contributes to overcoming mineral nutrient deficiencies.

Under field conditions mycorrhizal dependence of several plants and effect of indigenous mycorrhiza on plant growth and root infection has been tested with and without methyl bromide application for three years. Between 1997- 1999, under field conditions several plants were treated with and without methyl bromide, mycorrhizal inoculation and phosphorus application. Three years of experiments revealed that under field conditions mycorrhiza spores effectively infected pepper, eggplant and tomato plants. So far results showed that indigenous mycorrhiza successfully infected plant roots resulting in better plant growth. The effect of mycorrhizal inoculation on plant growth is changed by effectiveness of inoculum and time. Compared to non-inoculated control plants, mycorrhizal inoculation increased yield but some years did not. In general horticultural plants such as green peppers and eggplants are more mycorrhizal dependent plants. After three years of field experiments it has been concluded that for field crops, soil and plant management systems, but for horticultural plants mycorrhizal inoculation is more practical and advised to be used.

In another experiment under greenhouse condition mycorrhizal dependence was searched in term of Zinc (Zn) and phosphorus (P) requirements. In the study the role of mycorrhizal inoculation on growth of maize, bean, and pepper in two calcareous soils with both Zn and P deficiency were searched. The results revealed that plants are strongly dependent on mycorrhizal infection. Although addition of Zn increased plant growth, but mycorrhizal dependence is much more depend on P nutrition.

### **Introduction**

Nearly 90% of plant communities are mycorrhizal (Smith and Read, 1997). The majority of plant species are naturally arbuscular mycorrhizae (AM). Plants neither benefit from this symbiosis nor the factors responsible for different degrees of mycorrhiza formation and host dependence are well-defined and understood. One of the most dramatic effects of mycorrhizal infection on the host plant is the increase in phosphorus (P) uptake (Koide, 1991, Ortaş et al., 1996) and Zn (Lambert et al., 1979; Kothari et al., 1991; Ortaş et al., 2001), mainly due to the capacity of the mycorrhizal fungi to absorb phosphate from soil and transfer it to the host roots (Asimi, et al. 1980). In addition, mycorrhizal



of herbaceous plants as a host and organic wastes in association with the microbial inoculation of VAM fungi and the organic waste-decomposing bacteria prior to any practical application in a large scale to the field.

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Under the minesoil conditions in this, *Glomus mosseae* (VAM) formed an especially effective mycorrhizal association with the experimental plants typically producing great quantities of both internal and external hyphae. Histochemical techniques have demonstrated the presence of chitosan, polymer composed of aminosugar unit (17) in the hyphal wall of a closely related species in the genus, and it is reasonable to assume that there is a comparable morphogenetic pattern in *Glomus mosseae*. Because of the proximity of the mycorrhizal association, it is likely that the phenolic compounds released during lignin degradation in the plant tissues react with the glucoamine units in the cell wall of the VAM fungus, i.e.; *Glomus mosseae*. These conjugated sites are proposed as the effective centers in the organization and subsequent stabilization of granular type aggregates in the sandy loam (Clough, 1978; Allen, 1980).

Lignin represent an important source of aromatic compounds "for humus formation" (10) and as suggested by Kirk, the structural differences of lignin in different plants may, to a great extent, influence their degradation potential. While the slow degradation rate of the experimental plants may be an undesirable agronomic feature, the longterm availability of substances important in soil structure development and the effectiveness of these legume plants as a mycorrhiza host appear to be contributing factors in its success in revegetation surface mines and controlling minesoil (Trappe, 1981; Fresques, 1982).

## Conclusions

The results can be elucidated as follows:

- 1) The external mycelium of the VAM fungus and also the polysaccharides were secreted by both fungus and bacteria on the surfaces of coarse sand particles in contact with the fungal hyphae and bacterial cells.
- 2) The fungal and bacterial inoculations both increased significantly ( $P < 0.01$ ) the aggregate stability while decreased the modulus of rupture values of the mine soil samples.
- 3) It was found that aggregate stability values of the soil samples were positively and significantly correlated to the VA. Mycorrhizal, azobacterial and rhizobial infection levels.
- 4) Negative relationships ( $P < 0.01$ ) were found between the water-stable aggregate percentages and the modulus of rupture values of the soil samples.
- 5) It was concluded that, VAM fungal and bacterial inoculation amended with various organic wastes could help to remediate the mine soil to some extent and thus to reduce the crust formation on the soil surface, the probable water runoff and surface erosion by binding of the soil particles into stable aggregates. However, it would be much better and necessary to do a number experiments under the greenhouse conditions by using different types

It was found that, additions of the organic wastes have significantly increased the percentage of the water stable aggregate while decreased the modulus of rupture values of the mine soil samples. Among the organic wastes added, the treatment with the mixture of “saw dust and straw” at 0.50 % level was found to be the most effective addition and then it was followed by the treatments of “0.25 % saw dust + 0.25 % straw”, “0.50 % ground straw”, “0.50 % saw dust”, “0.25 % ground straw, 0.25 % saw dust” respectively (Table 2).

**Table 3.** Cumulative effects of the experimental plants on the average values of aggregate stability and the modulus of rupture of the experimental mine soil (n=168).

Plant variety (P)	Aggregate stability (%)	Modulus of rupture (m.bar)
Control (without plant): P <sub>0</sub>	31.42 a*	348.26 a*
<i>Trifolium repense</i> (clover): P <sub>1</sub>	64.46 c	191.63 c
<i>Agropyron eristatum</i> : P <sub>2</sub>	54.65 b	220.18 b
<i>Festuca ovina</i> : P <sub>3</sub>	60.47 bc	197.12 bc
<i>T.repense</i> + <i>A. Eristatum</i> : P <sub>4</sub>	78.12 d	159.18 d
<i>T. repense</i> + <i>F. Ovina</i> : P <sub>5</sub>	76.48 d	161.65 d
<i>A. cristatum</i> + <i>F. Ovina</i> : P <sub>6</sub>	70.92 d	174.41 d
<i>T. repense</i> + <i>A. Cristatum</i> + <i>F. ovina</i> : P <sub>7</sub>	85.01 e	148.91 e

\* Within a column, mean values followed by the same letter were not statistically different at the 5 % level (Newman –culs test).

When the plant varieties were compared to each other, in terms of increasing the percentage of water stable aggregate and decreasing the modulus of rupture values of the mine soil sample, the mixture of “P<sub>7</sub>: *T. repense* + *A. cristatum* + *F. ovina*” was found to be the most effective treatment and then it was followed by the treatments of P<sub>4</sub>, P<sub>5</sub>, P<sub>6</sub>, P<sub>3</sub>, P<sub>2</sub> respectively with compare to the control (without plant) treatment (Table 3).

It has been suggested that while polysaccharides are effective in the organization of small aggregates, they are generally less significant as primary binding agents as soil level of humic materials increased (6,22). Humic materials effective in stabilizing aggregates are thought to function primarily in the organization and strengthening of bonds between quartz and clay particles, though the reaction sites of humus also may bind sand particles directly (5,10). While the stabilizing mechanism has yet to be determined for the granular aggregates in this work, and the bonding sites of the clay fraction is undoubtedly involved to some extent, thus it was suggested that the abundant fibrous roots and fungal hyphae were significant factors contributing to minesoil stabilization as a result of humic substances formed in the interaction between the experimental plants and the VAM fungal inoculum (Clough, 1978; Fresque, 1982).

determine the percent maycorhizas with these structures. Root samles were treated as noted previously (Kemper, 1965; Reeve, 1965; Clough, 1978; Gur, 1987).

## Results and Discussion

**Table 1.** Comparison of cumulative effects of the microbial inoculums used in the experiment on the average values of aggregate stability and the modulus of rupture of the mine soil (n=168).

Inoculum (I)	Aggregate stability (%)	Modulus of rupture (m.bar)
Control uninoculated (I <sub>0</sub> )	23.86 a*	438.03 a*
<i>Glomus mosseae</i> (VAM): I <sub>1</sub>	41.28 c	298.18 b
<i>Rhizobium trifolii</i> : I <sub>2</sub>	38.15 b	300.91 b
<i>Azotobacter indicum</i> : I <sub>3</sub>	34.83 b	312.04 b
VAM + <i>R.trifolii</i> : I <sub>4</sub>	56.68 d	218.14 cd
VAM + <i>A. indicum</i> : I <sub>5</sub>	50.98 d	224.24 c
<i>R. trifolii</i> + <i>A. Indicum</i> : I <sub>6</sub>	53.89 d	223.47 c
VAM + <i>R. trifolii</i> + <i>A. indicum</i> : I <sub>7</sub>	68.12 e	189.01 d

- Within a column, mean values followed by the same letter were not statistically different at the 5 % level (Newman –culs test).

As it is shown in Table 1, the microbial inoculums have significantly increased the percentage of water stable aggregates whereas decreased the modulus of rupture values of the mine soil samples, where the mixed inocula of “VAM + *R. trifolii* + *A. indicum*” was found to be the most effective treatment and it was followed by “VAM + *R. trifolii*”, “VAM + *A. indicum*”, “*R.trifolii* + *A. indicum*”, “VAM”, “*Rhizobium trifolii*” and “*Azotobacter indicum*” inoculum respectively, in comparison to the control (non-inoculated) treatment (Table 1).

**Table 2.** Cumulative effects of the organic wastes used in the experiment upon the average values of aggregate stability and the modulus of rupture of the mine soil (n=192).

Organic wastes (ow)	Aggregate stability (%)	Modulus of rupture (m.bar)
Ccontrol (without organic waste): ow <sub>0</sub>	29.89 a*	384.08 a*
0.25 % saw dust: ow <sub>1</sub>	48.41 b	271.17 b
0.50 % saw dust: ow <sub>2</sub>	54.18 c	224.42 c
0.25 % ground straw: ow <sub>3</sub>	49.12 b	262.56 b
0.50 % ground straw: ow <sub>4</sub>	66.84 d	197.17 d
0.25 % saw dust + 0.25 % straw	68.72 d	230.42 c
0.50 % saw dust + 0.50 % straw	78.59 e	161.81 e

- \* Within a column, mean values followed by the same letter were not statistically different at the 5 % level (Newman –culs test).



**VAM fungal inoculum:** The indigenous strain of (*Glomus mosseae* L<sub>4</sub>) with predominantly coarse hyphae was isolated and maintained on onion roots was used for the VAM fungal inoculation. The endophyte originally was isolated and identified from the agricultural soils of Konya Province, prior to the preparation of the VAM fungal culture. The mycorrhizal inoculum was a mixture of spores and infected root segments of onion plants and the mixed culture of the VAM fungus were diluted in the sterile water prior to the inoculation. At harvest, the roots of the experimental plants were washed free of soil particles, cleaned and stained then the level of VAM fungal infection was determined using the grid intersect method (Phillips, 1970; Gur, 1974; Gur, 1976; Clough, 1978).

**Organic waste amendment:** Saw dust (C:N=187:1) and ground straw (C:N=98:1) materials were used as organic wastes at the application rates of 0.0; 0.25 % and 0.50 % (w/w). They were mixed thoroughly with the experimental soil samples prior to the seeding.

**Plant culture and experimental design:** Experimental plants were grown in a 16 cm pots lined with plastic bags which contained 3 kg soil. Pots were watered to field capacity and left for two weeks at 25 °C (in root cooking tanks) prior to planting. Each pot received NPK fertilizer and was seeded with *Trifolium repense*, *Agropyron cristatum* and *Festuca ovina* representing leguminosae and graminaceae families respectively. The seeds were germinated (one day) prior to planting and inoculated with one ml of dense suspension of the *Rhizobium* and *Azobacter* species of planting.

This work was planned as a pot experiment under the glass house conditions with an (plant x inoculation x organic waste x replicate : 8 x 8 x 7 x 3) randomized experimental design with three replications.

The soil sample was coarse sandy loam with 0.28 percent organic matter and average pH of 7.2 (1:2 soil water mix). Each pot received NPK fertilizer and was seeded with three plant species such as, *Trifolium repense*, *Agropyron cristatum* and *Festuca ovina*.

Every two months during the second and third growing seasons roots of the experimental plants with rhizosphere soil intact were sampled from the experimental pots. Root samples were immersed in water overnight and carefully washed free of adhering soil with a fine spray rinse. Young growth portions of the root system were cut into segments approximately 2.5 cm and stained with lactophenol-aniline blue to detect the presence of VAM fungi. Polysaccharide materials on the fungal hyphae and internal surfaces of sand grains making up the aggregates were determined by the periodic acid schiff reagent staining procedure of Clough and Sutton. Additional rhizosphere samples for sericea lespedeza were collected near the end of the fifth and sixth growing season (2000). The soil was air-dried until friable, separated from the root material by gentle shaking and sieved manually to recover the 4 mm aggregate fraction. Typical granular type aggregates selected from the sieved fraction were dispersed carefully in a staining solution and observed microscopically to

has been supposed that VAM fungi and some N<sub>2</sub>-fixing bacteria (*Azotobacter* spp. and *Rhizobium* spp.) could play several important roles including the binding of the soil particles into stable aggregates (Gur, 1974; Gur, 1976; Allen, 1980; Fresques, 1982). Limited information is available, however, in the literature, on the possible roles of VAM fungal and the bacterial inocula in mine soil (Allen, 1980; Trappe, 1981; Fresques, 1982).

It is generally known that, there are several factors that influence the formation of water stable aggregates as well as the crust formation and thus the modulus of rupture values, of soils. Again, as stated by several workers in the literature, there have been negative correlations between the percentage of water stable aggregate and the modulus of rupture values representing the degree of the surface soil crust formation avoiding the germinating the plant seeds to emerge on the surface of the agricultural lands (Kemper, 1965; Reeve, 1965; Gur, 1987 ).

The purpose of this study was to investigate the effects of the Vesicular-Arbuscular Mycorrhizal (VAM) fungus (*i.e. Glomus mosseae* L<sub>2</sub>) and two N<sub>2</sub>-fixing bacteria *R. Trifolii* and *A. indicum*) with applications of different levels some organic wastes (*i.e.* sawdust and ground straw) on the aggregate stability and modulus of rupture values of a mine soil with a coarse sandy loam textured collected from the vicinity of Ilgın town.

## **Materials and Methods**

**The soil sample:** For the study, the soil sample was collected from a surface mined coal site in the vicinity of Ilgın town belonging to the Konya Province in the Central Anatolia of Türkiye. For experiments, freshly collected soil samples were air-dried, sieved to pass 4 mm mesh immediately after they were brought to the laboratory and then they were steam sterilized at 100 °C for one hour. The soil of the sampling site was a coarse-sandy loam texture with the following properties; pH 7.10 (1:2.5 soil-water) organic matter 0.28 %, CEC 23.4 me/100 g, exchangeable sodium 0.24 me/100 g and the available phosphorus 5.85 ppm respectively. Water stable aggregate percentages and modulus of rupture values were determined by modifying the methods of Kamper (10) and Reeve (12).

**The microbial cultures:** For the microbiological inoculation, the cultures of *Rhizobium trifolii* (symbiotic, N<sub>2</sub>-fixing bacteria) and *Azotobacter indicum* (non-symbiotic, N<sub>2</sub>-fixing bacteria) giving about 10<sup>6</sup> and 10<sup>8</sup> organisms per plant seed respectively when applied by the peat inoculum techniques, were used in all experiments. The number and size of rhizobial nodules on the experimental legume plant (clover) roots were also assessed and recorded, at harvest. In addition, the number of *Azotobacter indicum* in the experimental soils were also determined by the dilution and plate count techniques (using the most probable number assesment method, at the end of the experiment (Gur, 1976; Gur, 1984; Gur, 1987; Gur, 1993).



# **Remediation of a Mine-Soil Supplied with Some Organic Wastes and Inoculated with (VA) Mycorrhizal Fungus and Two N<sub>2</sub>-Fixing Bacteria**

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## **Abstract**

The present work was undertaken to evaluate functions of a VAM fungus species (*Glomus mossoae*) and two N<sub>2</sub>-fixing bacteria (*Rhizobium trifolii* and *Azotobacter indicum*) in a coarse sandy loam mine soil and to assess their possible aggregating potentials of the soil particles in a predominantly herbaceous legume and gramineae ground covers supplied with some organic wastes.

The results can be summarized as follows;

1) The external mycelium of the VAM fungus and also the polysaccharides were secreted by both fungus and bacteria on the surfaces of coarse sand particles in contact with the fungal hyphae and bacterial cell for a sufficient aggregation of the mine soil.

2) The fungal and bacterial inoculations both increased significantly ( $P < 0.01$ ) the aggregate stability while decreased the modulus of rupture values of the mine soil samples.

3) It was found that aggregate stability values of the soil samples were positively and significantly correlated to the VA. Mycorrhizal, azobacterial and rhizobial infection levels.

4) Negative and significant relations ( $P < 0.01$ ) were found between the water-stable aggregate percentages and the modulus of rupture values of the soil samples.

5) It was concluded that, VAM fungal and bacterial inoculation amended with various kind of organic wastes could help to remediate the mine soil to some extent and thus to reduce the crust formation on the soil surface, the probable water runoff and surface erosion by binding of the soil particles into stable aggregates.

## **Introduction**

Vegetation types are recognized factors in mine soil aggregation (Allen, 1980). Since Vesicular-arbuscular Mycorrhizal (VAM) fungi derive most of their energy directly from the plant roots, the host plant may greatly influence the physiological response of the fungal associate in mycorrhiza-soil interactions on surface-mine sites. The (VAM) fungi are involved in many well-known beneficial soil reactions (Allen, 1980; Fresques, 1982) including the binding of soil particles into stable aggregates. Little information is available, however, on their possible role in mine soil aggregation. The main aim of this work was to assess the aggregating potential in a predominantly herbaceous legume and gramineae ground cover (Allen, 1980; Fresques, 1982).

VAM fungi have been known to be ubiquitous, stimulate growth of several plant species including leguminous and graminous plants. On the other hand, it



4. Basic problems of the rural areas, like education and health should be solved to reduce or stop the migration in the GAP Region.

5. All the main private and public sector representatives including universities, should be arranged under an organization and taking their opinions about the solutions before it is applied.

6. Crop pattern designed for the Region before must be applied.

7. Land consolidation must be applied before starting the irrigation due to the fragmentation and unsuitable shape for irrigation (Kızılgöz, 1997; Kızılgöz, 1998a; Kızılgöz, 1998b; Kızılgöz, 1999).

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- Decrease in storial capacity and its volume of water, such as lake, dam, sea or recreation areas
  - Restriction of soil microorganism and enyzme activities
  - Increase in the amount of unplesant smells on soil
  - Restriction of arable land
  - Decrease of oxygen content in the atmosphere because of burning all kinds of disposal materials
  - Start of acid rain resulted from air pollution and moisture
  - Increase in radiation on soil
  - Increase in physiological problems on mainly human bodies
2. The problems in the structure of community and its balance due to the soil pollution in the GAP region
- Financial decrease in land value
  - Increase in work accident
  - Increase in energy requirements
  - Decrease in amount of picnic area
  - Increase in loses of time and income
  - Increase in unemployment
  - Increase in inside or/and outside migration
  - Other financial loses and disrupts of infrastructure because of road construction, phone or electric supply

## Result and Suggestions

In the near future, soil pollution problems could be increased significantly in the GAP Region soils because of over population in some cities mainly inward migration, low education, and other factors. The below are some suggestions to solve or reduce the effects of soil pollution problems in the GAP region.

1. Education services should be attained for whole population especially to increase their literacy rate in the region (about 40 %).

2. Around 70 % of the soils are exposed to intensity or the most intensity erosion. Soils have generally 10-20 % forest in the Region while 0.42 % in Şanlıurfa (Çağlar, 1995). Furthermore, almost there are no real meadow areas in the region, especially in Şanlıurfa. To solve this problem, which are indicated above meadow, forest, and fruit production areas should be established in the region.

3. Increase in population rate is above in the region (about 3 % each year) is more than the increase rate of Turkey. For this reason, construction will be increased significantly due to the increase in wealth of people for the new and colossal city or industry foundation necessary laws and governing statu such as Environmental Impact Assessment (1993) or Improper Use of Arable Land (1998) must be applied to limit the soil pollution.

It is clear from the Table 2 that, the amount of land area per person in the GAP Region is better than the indicated countries.

### **Present and Possible Soil Pollution Problems of the Gap Region**

Today, we can consider the air, water and soil pollutions of the GAP region as environmental problems among there water and the soil pollutions are the most important.

Due to the increasing irrigation investments, some major and big scale soil pollution problems may be emerged or increased in the region. These are given below;

- Using drainage waters for agricultural treatments
- Salinization, because of over irrigation
- Extinguish of harvest disposals
- Storage areas of solid disposals (rubbish)
- Improper land use
- Cultivation of unsuitable areas
- Use of chemical fertilizers
- Fragmentations of land
- Soil erosion

### **Possible Negative Effects of Soil Pollution on GAP Region Sources**

There can be negative effects of soil pollution on GAP region's sources. These effects may be arranged under 2 main topics.

#### **1. Effects on environmental and health in GAP region**

- Increase in especially inorganic colloids in soil and/or water sources
- Increase in microbial disease concerning body resistance
- Increase in health problems due to heavy metals
- Increase in fire and explosions depending on metan ( $\text{CH}_4$ ) or similar gases
- Covering of topsoils with sediments resulted from especially water erosion
- Destruction of environmental appearance depending on the degree of soil pollution
- Decrease in the forest and meadow area
- Increase in poisonous gases such as  $\text{NH}_3$  and  $\text{CH}_4$
- Decrease of water holding capacity of soils
- Decrease in quality and quantities of plant production
- Dcrease in biological diversity and theirs activities
- Increase in soil loses (erosion)
- Decrease of plant nutrients in the soil



Indeed, this types of soil erosion can be seen with naked eyes. Nowadays, main soil loses are because of human activities in the worldwide.

Soil pollution occurred by human activities are expressed with the effects of; 1. air pollution 2. water pollution 3. heavy metals 4. solid disposals (rubbish) 5. erosion 6. energy production 7. agricultural activities 8. other human activities, such as expending of harvest disposal, war or improper land use misuse of soils (Kaptan and Kızılgöz, 1998).

### Status of Soil Resources in the Gap Region

Southeastern Anatolia Project (GAP) region has 8 different cities which are Diyarbakır, Şanlıurfa, Kilis, Mardin, Şırnak, Gaziantep, Siirt and Batman with the total area of 73863 km<sup>2</sup> (10 % of Turkey's total area). The population of the region is around 7.2 million. According to the projections, total of 32 billion USD will be spend for the GAP. Till now, around 13 bilion USD was used for the project.

The soils in GAP region can be classified into 8 different land qualities. The quality classifications of the soils in the region is given in Table 1.

**Table 1.** Quality classifications of GAP region soils.

City	Quality classifications and areas of GAP region soils (ha)								Total
	I	II	III	IV	V	VI	VII	VIII	
Adıyaman	21928	58258	64432	56733	1456	88383	430493	36616	758299
Diyarbakır	150765	225104	180031	140468	-	260965	520185	52728	1530246
Gaziantep	80753	122939	76224	86572	218	90564	298935	6910	763115
Mardin	181598	137788	120367	95518	-	189277	451213	55169	1230930
Siirt	22489	39698	41939	37702	-	94243	776015	84163	1096249
Şanlıurfa	454219	234903	249572	239998	39	134005	654693	19204	1986633
GAP Region	911752	818690	732565	656991	1713	857437	3131534	254790	7365472

According to Table 1, it is clear that, 33.4 % of soils in GAP region is suitable (I-III class soil), 8.9 % is limited suitable (IV class) and 54.2 % is unsuitable (V-VIII class) for cultivation. Considering the total arable land area (26500000 ha) (Ocaklı, 1991), we can express that 15.0 % of the total arable land of Turkey is present in the GAP region.

Turkey has total of 19.0 million ha suitable for cultivation. According to this figure GAP region contains 12.9 % of the total cultivatable soils of Turkey.

Geographically, GAP region is spread a wide area. The comparisons of the regions area with some countries in the world, are given in Table 2.

**Table 2.** Land area and the populations of some countries and GAP Region.

Country	Holland	Belgium	Greece	Israel	England	GAP region
Square, km <sup>2</sup>	34174	30507	132562	20850	131760	73863
Population, million	15.0	10.0	10.5	4.8	50.0	7.2
Area per person, da	2.28	3.05	12.60	4.34	2.63	10.27

## **Present and Possible Soil Pollution Problems of Gap Region and Some Propositions for Solution**

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ŞANLIURFA

### **Abstract**

In the future, with the prevalence of irrigation and effects of other factors; problems such as using drainage waters for agricultural treatments, salinization (because of over irrigation), extinguish of harvest disposal, storage areas of solid disposals, unproposal land using, cultivation of unsuitable areas, use of chemical fertilizers, fragmentation of land additionally, soil erosion will be emerged or increased in the GAP Region.

There can be negative effects of soil pollution on GAP region's sources. These effects may be arranged under 2 main topics. One of them is effects on environmental and health the other one is the problems in the structure of community and its balance due to the soil pollution in the GAP region.

For solutions of present or possible soil pollution problems in GAP Region, main factors like legal precautions and educational support; besides, secondary factors like biodiversity (growing new plant types), meadow and forestry studies should be done.

### **Introduction**

Plants are must be present for the existence of ecosystems. Humans and animals can live only using of plants for their life.

Soil is not only a source of nutrition but also a place for the plants to stand. Nitrification and amonification reactions occurred in soil have important roles for the plants, since plants can only use the nitrogen converted to nitrate resulted from these reactions.

The term soil means that it is a natural habitat which has three dimensions including air, water, organic and inorganic matters and the biological living organisms (Brady, 1990). It is indicated at least 1000 years required for the creation of only 5 cm of otockton soils (Akalan, 1989). It is clear that it will take hundreds of years to regenerate the lost soil from the ground surface.

Soils can be renewed for a long time, but they might be affected less from the pollution compared to water or air. This condition is due to the bumper structure of soils. But, cleaning of polluted soils is more difficult and complex than water and air (Haktanır, 1987).

Soils can move to other areas as a result of natural or artificial occurrences. The little soil movements are called natural erosion. This kind of erosion occurred without human effects. But, there can be significant soil movement with artificial erosion. Human effects are dominant at this kind of soil erosion.

characteristic of linuron is in demand like all pesticides to prevent environmental pollution.

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increased with removal of organic matter fractions. Grover (1975), pointed out in his study with urea herbicides, that comparing K coefficients of soils is valid when  $C_e=1$  and this relationship could be different for other concentrations. This finding of Grover is consistent with our findings. For instance, expected results would be obtained using  $15 \mu\text{g ml}^{-1}$  linuron concentration, the application rate in practice.

**Table 4.** Adsorption Coefficients for Linuron

Soil samples	K	1/n	R <sup>2</sup>
Beyazbayır- Natural soil	1.013	0.654	0.953
Beyazbayır- HCl treated fraction	1.613	0.375	0.987
Beyazbayır- Alkali extracted fraction	1.106	0.580	0.988
Beyazbayır- H <sub>2</sub> O <sub>2</sub> oxidized fraction	1.270	0.258	0.979
Kepir- Natural Soil	1.057	0.731	0.984
Kepir- HCl treated fraction	1.276	0.711	0.980
Kepir- Alkali extracted fraction	1.169	0.624	0.988
Kepir- H <sub>2</sub> O <sub>2</sub> oxidized fraction	1.222	0.502	0.961

Slope values (1/n constants) that were determined from linear form of Freundlich equation ranged from 0.258 to 0.731. Osgerby (1970) stated that low 1/n constants were related with high organic matter contents. But similar relationship was not observed by Singh et al. (1980) for linuron. In this study no relationship was found between low 1/n constants and high organic matter contents.

Since all 1/n constants are smaller than 1, the L-type of adsorption isotherms was observed. Similar results were obtained by Grover (1975) for urea herbicides. The type L shape is indicative of gradual decrease in sites available for sorption as the concentration of solute in solution increases; that is, the sorption of new molecules would occur with greater difficulty possibly involving some kind of bond or a specific type of binding mechanism to the humic material.

## Conclusion

The results of the study showed that either organic matter or mineral part of soil is involved in adsorption of linuron. Increase in organic matter content of the soil caused an increase in adsorption of linuron. On the other hand it is thought that adsorption of linuron is related with rates of clay type rather than clay content. Therefore organic matter content, clay type and contents of the soils should be considered when linuron is applied in practice. Adsorbed linuron by organic matter may desorb afterwards and has a phytotoxic effect on crops. On the other hand adsorption of linuron by organic matter can prevent it from leaching thorough soil profile and accumulating in groundwater. And this

**Table 2.** Organic Matter Content of the Fractions

Soil Samples	Organic Matter, %
Beyazbayır- Natural soil	1.68
Beyazbayır- HCl treated fraction	2.21
Beyazbayır- Alkali extracted fraction	1.21
Beyazbayır- H <sub>2</sub> O <sub>2</sub> oxidized fraction	0
Kepir-Natural soil	3.02
Kepir-HCl treated fraction	3.48
Kepir-Alkali extracted fraction	1.68
Kepir-H <sub>2</sub> O <sub>2</sub> oxidized fraction	0

**Table 3.** Adsorption of Linuron on Natural and Treated Soils (Percent of total linuron adsorbed at 15 µg ml<sup>-1</sup> concentration)

Treatment	Adsorption of Linuron, %	
	Inceptisol (Beyazbayır)	Entisol (Kepir)
Natural soil	23.43	34.37
HCl treated (CaCO <sub>3</sub> removed ) fraction	30.35	39.56
Alkali extracted (humin+mineral) fraction	22.16	28.63
H <sub>2</sub> O <sub>2</sub> oxidized ( mineral) fraction	9.93	23.32

Adsorption of linuron by HCl treated (calcium carbonate removed) fractions of Beyazbayır and Kepir was higher when compared with natural soil samples, alkali extracted and H<sub>2</sub>O<sub>2</sub> oxidized fractions. Removing calcium carbonate caused an increase in organic matter per unit soil sample since adsorption of linuron increased relatively. Adsorption isotherms indicated that besides organic matter, mineral part of soils was also involved in adsorption of linuron. Table 3 showed that mineral fraction of Beyazbayır soil adsorbed 9.93 % of initial linuron, and mineral fraction of Kepir soil adsorbed 23.32 % of initial linuron. It is thought that adsorption of linuron by mineral fractions of clay textured soil is related with clay contents of soils. Stevenson (1976) pointed out that the amount of organic matter required to coat the clay will depend on the soil type, the kind and amount of clay that is present.

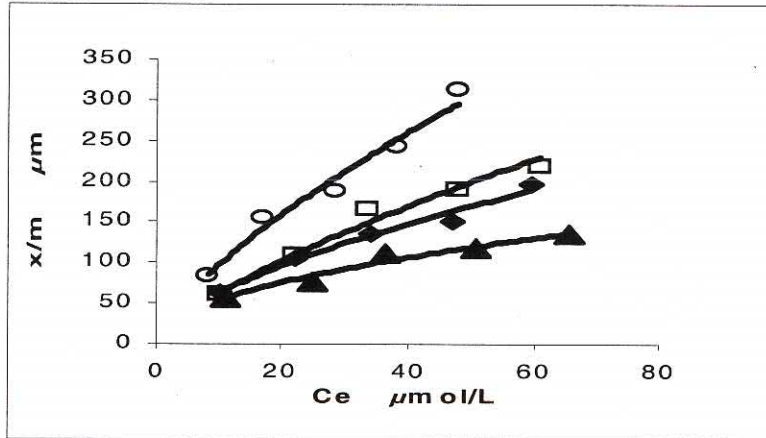
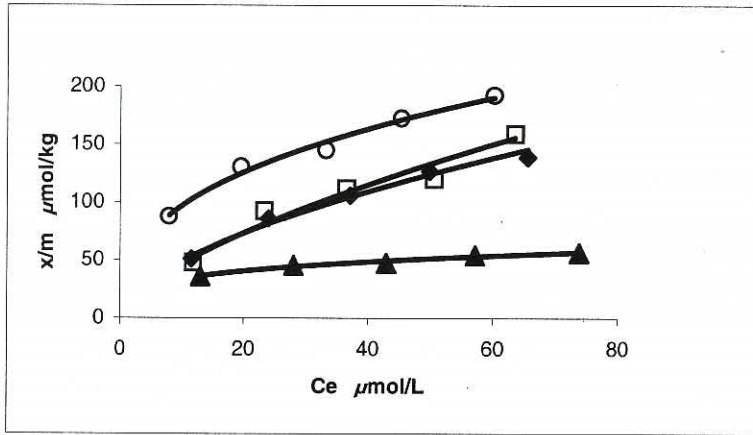
Although both soils have similar clay mineral types adsorption of linuron values were differed each other, due to different organic matter and, HA, FA and humin contents. Entisol Kepir contains more organic matter than Beyazbayır, as can be seen in Table 3 that the adsorption of linuron on Kepir was higher than Beyazbayır. Many scientists found that the herbicidal activity of phenylureas is related to the organic matter content of the soils. (Weber *et al.*, 1974, Carringer *et al.*, 1975, Grover 1975).

K and 1/n constants belonging to Beyazbayır and Kepir soil samples were calculated from logarithmic form of Freundlich equations and are presented in Table 4. In the study Freundlich coefficients (K) ranged from 1.013 (Beyazbayır- Natural soil) to 1.613 (Beyazbayır-CaCO<sub>3</sub> removed fraction).

It is expected that adsorption coefficients (K) decrease with removal of organic matter fractions. But in this study conversely, adsorption coefficients (K)

values indicated that 56.63 % of organic matter is consisted of humin fraction and 44.37 % of organic matter is consisted of HA and FA.

Due to comparison of linuron adsorption of soil samples, concentration of  $15 \mu\text{g ml}^{-1}$  for applying rate in practice was selected. The calculated values are given in table 3. For Beyazbayır, after removing humin with  $\text{H}_2\text{O}_2$  oxidization, decrease of adsorption was the highest. Difference of adsorption ratios between natural soil and alkali extracted fraction indicated that adsorption by HA and FA fractions was very low for Beyazbayır. For Kepir adsorption ratios provided by HA, FA and provided by humin are too close to each other. This may be attributed to their similar organic matter contents.



□ : natural soil ○ : HCl treated fraction ♦ : alkali extracted fraction ▲ : H<sub>2</sub>O<sub>2</sub> oxidized fraction

**Figure 1.** Adsorption isotherms for linuron

**Figure 2.** Adsorption isotherms for linuron on Inceptisol (Beyazbayır) soil and its fractions Entisol (Kepir) soil and its fractions



different concentrations (0, 5, 10, 15, 20, 25  $\mu\text{g ml}^{-1}$ ). After equilibrium, the concentration of the unadsorbed linuron was determined spectrophotometrically by measuring the adsorbance at 248 nm (Khan and Mazurkewich, 1974). All treatments carried out in triplicate. The analytical data obtained from the adsorption experiments was revealed by using the logarithmic form of Freundlich adsorption equation.

Logarithmic form of the Freundlich equation is:

$$\log x/m = \log K + 1/n \log C_e$$

Where  $x/m$  is the amount of the adsorbate taken up by unit mass of the adsorbent,  $C_e$  is the equilibrium concentration in solution  $1/n$  and  $K$  are constants representing the slope and the intercept of the isotherm respectively.

## Results

Adsorption of linuron by two soils and their fractions is presented as Freundlich adsorption isotherms in Fig 1 and 2. When concentration of adding linuron increased, adsorption of linuron by all of the samples also increased. This increase is clearer for natural soil samples and HCl treated fractions than the  $\text{H}_2\text{O}_2$  oxidized fractions. Adsorption isotherms indicate that adsorption of linuron by both soils decreased when the organic matter fractions were removed.

Adsorption of linuron by natural soil samples and alkali extracted fractions for both soils were similar to each other at low concentrations but at high concentrations, natural soil sample adsorbed more linuron than alkali-extracted fraction. It means that after removal of HA and FA, linuron adsorption was decreased. In addition, with the removal of humin, adsorption of linuron drastically decreased. Hance (1974) indicated that removing organic matter fraction that is soluble in alkali, decreased adsorption of linuron and also peroxidation of soil constituted a material that has very small adsorption capacity. Kozak *et al.* (1983) obtained similar results for prometryn and metolachlor.

After removing organic matter fractions, decrease in adsorption capacity of soil samples can be explained by decrease in soil organic matter contents (Table 2). Only organic matter contents of HCl treated fractions were higher than natural soils, as removal of  $\text{CaCO}_3$  caused an increase in organic matter content of soils. After removal of HA and FA (alkali extraction) organic matter content of natural Beyazbayır decreased from 1.68 % to 1.21 %. After removing humin ( $\text{H}_2\text{O}_2$  oxidation), organic matter could not have been determined in soil samples (Table 2). The values indicated that 72.02 % of organic matter was consisted of humin fraction and 27.98 % of organic matter was consisted of HA and FA. Organic matter content of the natural soil sample of Kepir decreased from 3.02 % to 1.68 % after extraction of HA and FA. Finally after removal of humin, organic matter could not have been determined in the samples (Table 2). These

## Materials and Methods

### Soils

Two surface soil samples of Beyazbayır and Kepir soil series having similar properties except organic matter contents were used as research materials. Some properties of the soils are given in Table 1.

**Table 1.** Soil Characteristics

Soil series	Taxonomic Name	Clay %	Silt %	Sand %	Organic Matter %	CaCO <sub>3</sub> %	pH (1:2.5 w/v)	EC (1:2.5 w/v) ds m <sup>-1</sup>	CEC mmo l kg <sup>-1</sup>	Primary Clay Mineral*
Beyazbayır	Inceptisol Ochreptler Xerochreptler Clay Entisol Fluvent	46.1	29.2	24.7	1.68	26.5	7.80	0.184	261	S,P,K
Kepir	Xerofluvent t Clay	42.1	31.5	26.4	3.02	22.6	7.68	0.224	322	S,P,K

\* S: Smectite, P: Paligorskit, K: Kaolinite.

### Fractionation of soil samples

Soil samples were treated as described by Kozak *et al.*, (1983).

a) Natural soil sample: Soil samples were passed through a 1 mm sieve, washed with hot distilled water and then dried at 60°C.

b) HCl treatment (CaCO<sub>3</sub> removed soil): After washing with hot distilled water, soils were treated with 0.1 M HCl to remove calcium carbonate. When the reaction was completed, residues were washed with distilled water and dried at 60°C.

c) Alkali extraction (humin+mineral fraction): Soils were treated with alkali to remove humic acid (HA) and fulvic acid (FA). For the purpose, after washing with hot distilled water, soil samples were shaken overnight with 0.1 M Na-pyrophosphate (1:2 w/v). The supernatant was decanted and soil residues were shaken with 0.5 M NaOH overnight (1:2 w/v). Again supernatant was thoroughly decanted and residues were washed with distilled water and then dried at 60°C.

d) H<sub>2</sub>O<sub>2</sub> oxidization (mineral fraction): Soils after removing HA and FA by alkali extraction, were oxidized by three additions of 30 % H<sub>2</sub>O<sub>2</sub> to remove humin. After oxidation, residues were washed with distilled water and then dried at 60°C.

### Adsorption Isotherms

Adsorption isotherms were obtained using batch equilibrium technique. The adsorptive properties of the materials were determined by shaking a series of 1 g samples for 24 h with 10 ml of aqueous linuron (analytical grade) solutions of

## Adsorption of Linuron Herbicide by Sub-sequentially Removed Soil Organic Matter Fractions

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### Abstract

The adsorption of linuron was studied on clay textured soils which varied in their organic matter content, belonging to the Inceptisol (Beyazbayır) and the Entisol (Kepir) ordos, collected from Polatlı, Ankara. The adsorption of linuron on the soils after removal of organic matter fractions and calcium carbonate was compared.

The adsorption of linuron by natural soil samples, alkali extracted fractions,  $H_2O_2$  oxidized fractions and HCl treated fractions was determined through the batch-equilibrium technique using analytical grade linuron. The Freundlich equation was used to characterize the adsorption isotherms and Freundlich coefficients ( $K$  and  $1/n$ ) were obtained. Adsorption isotherms for soil-Beyazbayır indicated that adsorption of linuron by natural soil samples was higher as compared to the alkali extracted fraction and  $H_2O_2$  oxidized fraction. Also, similar results were obtained for soil-Kepir. Adsorptions for both soil-Beyazbayır and soil-Kepir free from calcium carbonate, were the highest.

According to  $1/n$  values, for all soil samples belonging to soil-Beyazbayır and soil-Kepir, L-type adsorption isotherms were obtained.

**Key words:** linuron, adsorption isotherms, soil organic matter, humic acid, fulvic acid, humin, calcium carbonate, clay.

### Introduction

The behavior of herbicides in the soil depends on factors such as the physicochemical characteristics of the herbicide, the active surface of the soil mineral and organic components, and the amount of the herbicide applied (Govi *et al.*, 1996).

Adsorption of pesticides by soils has frequently been found to be correlated with organic matter and clay contents. It is generally accepted that this effect is due to the high adsorptive capacity of these soil constituents for herbicides. Adsorption of herbicides, therefore, is basic to understanding the behavior of herbicides in soil. Most studies on the adsorption of pesticides by soil organic matter were based on extracted soil organic matter fractions which behave differently with regard to herbicide sorption. But extraction of these fractions is time consuming and tedious. Therefore, instead of extraction of these fractions, sub-sequential removal of fractions may be the easiest way for organic matter studies. The objective of this study was to determine the role of organic matter fractions in the adsorption of linuron.



**Table 2.**Chemical characteristics of strongly leached to slightly podzolized cinnamon forest soil  
Village orlov dol, yambol province

Profile №	Depth in cm	pH in H <sub>2</sub> O	Total quantity water soluble salts (dry residue) %	SO <sub>4</sub> <sup>2-</sup> mg equiv/ 100 g	Quantity Trace Elements mg/kg							
					Pb	Cu	Zn	Mn	Co	Ni	Mo	As
A. Naturally (non polluted) soil – background												
9	0-20	5.4	0.05	0.264	26	14	60	1250	16	25	0.2	0.1
	20-40	6.6	0.04	0.264	23	18	86	440	18	22	0.0	0.0
	40-60	6.3	0.02	0.401	19	22	86	320	8	18	0.2	0.2
	60-80	6.4	0.04	0.462	21	16	66	520	9	15	0.3	0.0
	80-100	6.5	0.04	0.368	27	20	56	480	7	20	0.5	0.0
B. Polluted soil												
10	0-20	3.0	0.25	4.122	27	26	86	780	15	20	* 0.3	1.0
	20-40	3.3	0.87	11.992	24	28	88	340	24	18	0.5	0.9
	40-60	5.9	0.11	1.821	19	29	92	440	10	22	0.7	0.3
	60-80	6.4	0.08	0.668	17	22	88	365	15	25	0.4	0.0
	80-100	6.4	0.03	0.616	23	18	62	490	8	20	0.3	0.1
7	0-20	3.5	0.06	0.707	31	29	52	480	12	28	0.2	0.7
	20-40	3.4	0.60	8.119	26	34	90	580	10	25	0.5	0.3
	40-60	3.9	0.41	5.205	24	32	94	720	18	20	0.4	0.0
	60-80	4.9	0.42	6.953	19	26	76	650	16	15	0.7	0.4
	80-100	5.3	0.12	1.915	22	22	65	560	15	18	0.3	0.2

**Table 1.** Cation exchange capacity of strongly leached to slightly podzolized cinnamon forest soil village orlov dol, yambol province

Profile №	Depth in cm	pH in H <sub>2</sub> O	CHANGEABLE CATIONS					T <sub>8.2</sub> mg equiv/ 100 g	Degree Of saturation with basis %			
			Ca <sup>2+</sup>	Mg <sup>2+</sup>	Al <sup>3+</sup>	H <sub>8.2</sub> Total acidity	H <sub>8.2</sub>					
										Ca <sup>2+</sup>	Mg <sup>2+</sup>	Al <sup>3+</sup>
mg equiv/ 100 g												
9	A. Naturally (non polluted) soil – background											
	0-20	5.4	5.40	2.92	0.65	4.65	41.6	22.5	5.00	12.97	64.2	
	20-40	6.6	19.24	8.24	0.16	3.84	61.4	26.3	0.51	31.32	87.7	
	40-60	6.3	19.36	8.24	0.16	4.08	61.1	26.0	0.51	31.68	87.1	
	60-80	6.4	18.84	8.24	0.16	3.08	62.4	27.3	0.53	30.18	89.7	
80-100	6.5	18.44	8.04	0.16	3.04	62.5	27.2	0.54	29.52	89.7		
10	B. Polluted soil											
	0-20	3.0	3.92	1.56	5.77	12.41	22.8	9.08	33.6	17.18	33.6	
	20-40	3.3	16.92	6.64	16.56	23.94	36.0	14.1	35.2	47.00	50.1	
	40-60	5.9	17.00	7.60	0.16	2.79	62.1	27.8	0.58	27.36	89.9	
	60-80	6.4	15.12	5.56	0.04	1.64	67.7	24.9	0.18	22.32	92.6	
80-100	6.4	16.16	6.08	0.16	1.80	67.2	25.7	0.65	24.46	92.5		
7												
	0-20	3.5	2.08	1.12	6.16	9.88	15.9	8.60	47.1	13.08	24.5	
	20-40	3.4	14.32	4.88	12.80	18.24	38.2	13.0	34.2	37.44	51.2	
	40-60	3.9	15.80	12.40	4.62	7.82	43.9	34.4	12.8	36.02	78.3	
	60-80	4.9	14.48	13.60	0.80	2.48	47.4	44.5	2.62	30.56	91.9	
80-100	5.3	12.28	6.76	0.32	3.04	55.6	30.6	1.45	22.08	86.2		

## Conclusion

This study leads to the following conclusions and recommendations:

1. The studied strongly leached to slightly podzolized cinnamon forest soil in the zone of uranium mining is anthropogenically polluted to the depth of 40-60cm /80cm/ with sulphuric acid solutions leading to:
  - 1.1. Sulphate solonization - dry residue up to 0.87% ;
  - 1.2. Acidification of the environment - pH in H<sub>2</sub>O in the range of 3.9 - 3.0;
  - 1.3. Destruction of the alumo-silicate mineral mass - exchange aluminum up to 16.56 mg equiv./100 gr, occupying up to 49.9% of T<sub>8.2</sub> ;
  - 1.4. Ca<sup>2+</sup> and Mg<sup>2+</sup> leaching;
  - 1.5. Soil non-saturation with bases - V% under 53.5% up to 24.5% in the agricultural layer;
  - 1.6. Formation of ion-adsorption forms of heavy metals at pH4.0.
2. The soil-genetic changes require a reevaluation of the diagnostics, nomenclature and classification of the anthropogenically acidified soils, as well as a new approach to their quality evaluation.
3. By applying the methodical approach of liming following the so called "balance method", a neutralization of the hazardous soil acidity can be achieved.

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Ganev, St., Arsova, A. /1980/ - Soil science and agrochemistry, Sofia.



sulphuric-acid solutions. The processes of solonization and acidification in some cases /Profile 10/ have seriously affected the soil at a depth of 40 cm, while with Profile № 7 this process has changed it to a considerable degree, at a depth of 40-60 cm, even up to 80 cm.

The processes of strong destruction of the alumo-silicate mineral mass are clearly demonstrated by the established high readings for the total and exchange acidity /Table 1, Profiles 10 and 7/.

The presence of too high values of  $\text{Al}^{3+}$  (35-47% of  $T_{8.2}$ ) at the studied depths with a differentiated character of distribution changes the soil-absorption complex to an extent of alkaline saturation /V%/ in the range 24.5-32.0% for the layer 0-20, and 51.3-54.5% for the layer 20-40. Observed are also processes of leaching of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  in the depth of the profile with an eluvial-illuvial character of distribution and migration outside the boundaries of the profile /Profile 7/.

Although the implemented technology does not represent a direct danger of importing heavy metals in the soil, however the change in the pH of the environment increases their "mobility". The data in Table 2 show that in polluted soil /Profiles 10 and 7/ the total quantity of trace elements is within the limits of their natural content, not only for the soils in Bulgaria but also for the soils in a non-polluted, strongly leached to slightly podzolized cinnamon forest soil /Table 2, Profile 9/. The change in the environmental pH under 4.0 increases the possibility for transferring into the soil solution of different ion-absorption forms of some heavy metals, causing vegetable toxicity. This is especially valid for Pb, Cu and Zn, which at pH 3.5 in  $\text{H}_2\text{O}$  have values of admissible content in the soil respectively <20, <15 and <20 mg/kg.

Although we do not give any morphological characteristics and other analytical data, the physicochemical situation shows the need for a reevaluation of the structure of the profile of this type of damaged soil /damaged were the organic-mineral complex, its structure, etc./ from the point of view not only of a genetic classification, but also from a manufacturing point of view. This raises the issue of its fertility but also of its quality evaluation.

The whole negative complex of anthropogenic changes in the studied soil requires the neutralization of the soil acidity.

This approach for neutralizing the hazardous soil acidity under these damages, has been used in the last 3-4 years, and the standards of liming are determined according to the so called "balance method" /Manual for liming soils with a hazardous acidity, 1978/ where the standard quantities of CaO aims not only at neutralizing the "mobile" Al, Mn, Fe, but also at compensating the losses of crops, the leaching of lime materials and the neutralization of acid fertilizers etc.

elements by the atom-absorption method, according to BDS 17.4.402-80 and 17.4.4.01-78.

### Results and Discussion

The natural /non-polluted/ strongly leached to slightly podzolized cinnamon forest soil is texture-differentiated, i.e. has a two-element profile - a surface eluvial  $A_1A_2$  horizon, and illuvial  $B_t$  horizon. The thickness of the eluvial horizon is approximately 22 cm with clay content /particles < 0.01 mm/ - 31.5%. Beneath lies a clearly defined  $B_t$ -horizon with thickness from 40 to 60-65 cm, where is the zone of maximum accumulation of finely dispersed mineral mass /content of clay - 57.1%/. This differentiation /in this case the texture differentiation is 1.8/ and should be considered a result of natural processes of leaching and intrasoil clay-formation. The soil is poor in humus since it contains only 1.19% organic matter in its eluvial horizon. The eluvial horizon pH /Table 1 and 2, Profile 9/ shows values for a medium acid reaction and non-solonized /dry residue < 0.15%/. The next thickness levels are characterized with almost equal pH values, valid for a slightly acid reaction.

The sorption capacity -  $T_{8.2}$  /Table 1, Profile 9/ as the differentiation by mechanical composition, has lower values in the layer 0-20 cm, characteristic of the medium values of  $T_{8.2}$  and maximum in the zone 40-60 cm /a big sorption capacity/. Similarly distributed in the profile are also the exchange bases with the  $Ca^{2+}$  prevailing over  $Mg^{2+}$ . In the eluvial horizon /0 - 20 cm/, V% is under the recognized qualification limit for saturation with bases.

The total content of trace elements /Table 2, Profile 9/ has the average values for Bulgarian soils, and with the specific pH of the environment it does not pose a problem to the growth and development of a large number of agricultural crops.

On the above mentioned background, the polluted soils /Tables 1 and 2, Profiles 10 and 7/ regarding the studied characteristics show considerable differences. They are mostly expressed in the sharp change of the environment pH not only in the layer 0 - 20 cm but also at greater depth and with Profile №10 - up to 40 cm, and with Profile №7 - 40-60 cm, and even up to 80 cm. The changes in soil acidity in the studied depths from medium acid to strongly acid /pH < 4.0/ should be considered as a result of a strong anthropogenic influence and not as changes caused by natural soil-formation processes. This is shown by the data for the content of water-soluble salts /Table 2/, which reach their maximum in the layer 20 - 40 cm - 0.87% for Profile №10, and 0.60% for Profile №7. These values identify the studied soils as strongly solonized as a result of the established high quantities of sulphate ions. Corresponding to the high values of dry residue, respectively sulphates is the low pH. Definitely such changes, on the background of the natural readings of these indexes /Table 2, Profile 9/ have an anthropogenic character resulting from uranium mining by pollution with



## **Content of Trace Elements in Strongly Leached to Slightly Podzolized Cinnamon Forest Soil, Damaged by Uranium Mining**

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In the last 10 years, the new different researches in soil science had to face new problems related to the liquidation of the consequences of uranium mining. It is of utmost importance to identify the type, extent, intensity and area of the anthropogenic changes resulting from such activities, as well as the elaboration of scientific approaches to liquidating the damages.

According to data of the Ministry of Agriculture and Forests and the Ministry of Environment and Waters, it was established that the lands damaged by uranium mining were about 17-18,000 dca. Although these figures cannot be accepted as completely true /the damaged area is probably much larger/, the changes in the environment are of a complex nature due to the different mining methods - from the physical destruction of the natural soil during open and underground ore mining, to the chemical and radioactive pollution of soils, plants, surfaces and underground waters. This situation creates a health risk to the population.

The most widely used was the so called geotechnological approach - a drilling method for uranium mining, where, as a result of which technological omissions, the soil surface was polluted with sulphuric acid solutions. According to our data, the changes in the soils are happening not only horizontally, but also vertically, and are influenced mainly by the chemical and, to a lesser extent, by the radionuclide pollution.

The problems to solve have many aspects, and it is impossible to present them in just one publication. This article presents partial results from scientific research for evaluation of some changes in the soils under the influence of anthropogenic activities /surface spills of sulphuric acid solutions/ from uranium mining.

### **Objects and Methods of Study**

The object of study are soil samples from strongly leached to slightly podzolized cinnamon forest soil within the range of an uranium field and outside the field /background/ in order to established the changes occurred as a result of the pollution. These soils can be regarded as a soil variety of a large group of Mediterranean red colored soils.

The sample collection has been carried out at any 20 cm of depth to a depth of 1 m in order to achieve an equal presentation since damaged soils have extremely damaged diagnostic horizons.

The samples were analyzed for their sorption capacity and exchange ions /Ganev St., Arsova A., 1980/, and sulphate ions /E.V.Arinishkina, 1970/, pH in water measured in water suspension soil:water = 1:25, and total content of trace



**Table 7.** The relation ( r ) between soil Boron content and other soil properties.

Depth cm	Sample	Texture	Total salt	pH	Lime	P	K	Organic M.
0-25	278	0.074	0.090	0.083	0.045	0.235 <sup>xx</sup>	0.225 <sup>xx</sup>	0.240 <sup>xx</sup>
25-50	278	- 0.010	0.254 <sup>xx</sup>	0.133 <sup>*</sup>	0.059	0.092	0.274 <sup>xx</sup>	0.175 <sup>xx</sup>
50-75	274	- 0.001	0.325 <sup>xx</sup>	0.169 <sup>xx</sup>	0.048	0.142 <sup>*</sup>	0.251 <sup>xx</sup>	0.200 <sup>xx</sup>
Total	830	0.018	0.257 <sup>xx</sup>	0.134 <sup>xx</sup>	0.053	0.330 <sup>xx</sup>	0.239 <sup>xx</sup>	0.184 <sup>xx</sup>

<sup>xx</sup> p<0.01, <sup>\*</sup> p<0.05**References**

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**Table 3.** Distribution of soil boron contents in the Central Anatolian region according to different soil pH groups (%).

Soil pH	#	Av.B ppm	Min. B ppm	Max. B ppm	Distribution of Boron contents (%)					
					<0.5 ppm B	0.5-1.0 ppm B	1.0-1.5 ppm B	1.5-2.0 ppm B	2.0-2.5 ppm B	>2.5 ppm B
<6	4	0.86	0.39	1.64	25.0	50.0	25.0	0.0	0.0	0.0
6.0-7.0	8	0.71	0.22	2.19	50.0	37.50	0.0	0.0	12.50	0.0
7.0-7.50	50	0.41	0.01	1.68	66.0	28.0	4.0	2.0	0.0	0.0
7.50-8.0	188	0.59	0.01	4.81	63.8 3	18.62	11.17	3.72	0.54	2.12
>8.0	28	1.19	0.05	11.1	57.1 4	14.28	10.71	7.16	0.0	10.7 1

**Table 4.** Distribution of soil boron contents in the Central Anatolian region according to different soil lime levels (%).

Soil lime levels (%)	#	Av.B ppm	Min. B ppm	Max. B ppm	Distribution of Boron contents (%)					
					<0.5 ppm B	0.5-1.0 ppm B	1.0-1.5 ppm B	1.5-2.0 ppm B	2.0-2.5 ppm B	>2.5 ppm B
< 1.0	34	0.85	0.07	3.86	61.76	26.47	5.88	2.94	0.0	2.94
1. - 5	38	0.38	0.02	1.05	73.68	23.68	2.64	0.0	0.0	0.0
5 – 15	71	0.72	0.01	4.57	57.75	18.31	15.49	2.82	0.0	5.63
15 – 25	57	0.68	0.02	4.81	61.40	12.28	14.04	8.77	1.75	1.76
> 25	78	0.63	0.01	11.1	62.82	25.64	5.13	3.85	1.28	1.28

**Table 5.** Distribution of soil boron contents in the Central Anatolian region according to different soil organic matter levels (%).

Soil Org. M (%)	#	Av.B ppm	Min. B ppm	Max. B ppm	Distribution of Boron contents (%)					
					<0.5 ppm B	0.5-1.0 ppm B	1.0-1.5 ppm B	1.5-2.0 ppm B	2.0-2.5 ppm B	>2.5 ppm B
< 1	46	0.43	0.03	1.67	71.73	19.57	6.52	2.18	0.0	0.0
1-2	153	0.54	0.01	4.81	66.67	18.30	9.15	3.92	0.65	1.31
2 – 3	63	0.79	0.04	4.20	50.79	25.40	12.70	1.59	0.0	9.52
3 – 4	9	0.77	0.02	23.38	44.44	33.33	0.0	11.11	11.12	0.0
> 4	7	2.11	0.14	11.1	42.86	28.57	14.28	0.0	0.0	14.29

**Table 6.** Distribution of soil boron contents in the Central Anatolian region according to different soil total salt levels (%).

Soil total salt levels (%)	#	Av. B ppm	Min. B ppm	Max. B ppm	Distribution of Boron contents (%)					
					<0.5 ppm B	0.5-1.0 ppm B	1.0-1.5 ppm B	1.5-2.0 ppm B	2.0-2.5 ppm B	>2.5 ppm B
Eseri	25	0.56	0.02	4.81	72.0	16.0	8.0	0.0	0.0	4.0
Eseri-0.150	250	0.63	0.01	11.1	61.6	21.20	9.6	4.4	0.8	2.4
>0.150	3	0.33	0.02	0.77	66.7	33.33	0.0	0.0	0.0	0.0

**Table 1.** Boron distribution of soils at 0-25 cm depth of different provinces in Central Anatolia region.

Provinces	Number of samples	Average boron content (ppm)	Min. Boron value (ppm)	Max. Boron value (ppm)	Distribution of Boron contents (%)						
					<0.5 ppm B	0.5-1.0 ppm B	1.0-1.5 ppm B	1.5-2.0 ppm B	2.0-2.5 ppm B	>2.5 ppm B	
AKSARAY	23	1.19	0.08	11.08	43.48	34.78	8.70	0.0	4.34	8.70	
ANKARA	15	0.41	0.06	1.50	73.33	20.00	6.67	0.00	0.00	0.00	
ESKİŞEHİR	16	0.70	0.05	2.64	68.75	12.50	0.0	0.0	6.25	12.50	
KARAMAN	25	0.19	0.05	0.56	92.00	4.00	4.00	0.00	0.00	0.00	
KAYSERİ	25	0.28	0.02	0.78	84.00	16.00	0.00	0.00	0.00	0.00	
KIRIKKALE	25	1.01	0.10	4.57	64.00	12.00	4.00	4.00	0.00	16.00	
KIRŞEHİR	25	0.72	0.02	4.81	50.00	30.78	11.54	3.84	0.00	3.84	
KONYA	50	0.39	0.01	1.72	72.00	20.00	4.00	4.00	0.00	0.00	
NEVŞEHİR	25	0.57	0.36	1.67	52.00	44.00	0.00	4.00	0.00	0.00	
•NİĞDE	24	0.51	0.02	1.64	62.50	29.16	4.17	4.17	0.00	0.00	
YOZGAT	25	1.16	0.05	1.68	16.00	4.00	64.00	16.00	0.00	0.00	
WHOLE REGION	278	0.62	0.01	11.0	62.59	20.86	9.35	3.96	0.72	5.12	

**Table 2.** Distribution of soil boron contents in the Central Anatolian region according to different soil texture groups (%).

Soil Texture	Number of samples	Average Boron content (ppm)	Min. Boron value (ppm)	Max. Boron value (ppm)	Distribution of Boron contents (%)							
					<0.5 ppm B	0.5-1.0 ppm B	1.0-1.5 ppm B	1.5-2.0 ppm B	2.0-2.5 ppm B	>2.5 ppm B		
Sandy	15	0.35	0.02	1.13	73.33	20.0	6.67	0.0	0.0	0.0		
Loamy	145	0.60	0.02	4.81	62.07	23.44	8.28	2.75	0.0	3.46		
Clay loam	113	0.69	00.1	11.08	61.96	17.69	10.62	6.19	1.77	1.77		
Clay	5	1.00	0.02	1.15	60.0	20.0	20.0	0.0	0.0	0.0		



where organic matter content was higher than 4% (Table 5). Similar relations between soil organic matter and boron content was reported by Elrashidi and O'Conner (1982) and Gupta (1968). The mineralisation of organic matter releases boron, resulting an increase in the boron content of the soil.

Although the relation between the soil salt level and boron content was not significantly important (Table 7), the average boron content was lowest (0.33 ppm) in soils whose salt level was higher than 0.15% (Table 6).

An area with clear indications of boron toxicity was observed during the survey. This area was sampled with extra 50 samples, to find out the soil conditions that create boron toxicity. The average soil boron content of these soils were 2.69 ppm, the pH was 7.82 and the average organic matter content was 3.07%, average lime content was 27.9%. Thus a special attention must be paid to high organic matter soils when they are coupled with high pH and lime content for possible boron toxicity.

According to the results of the survey, boron deficiency seems a greater problem than the boron toxicity in the rainfed cereal growing areas of Central Anatolia, although deficiency symptoms were not clearly observed in cereals due to the reason that monocots require less boron than dicots. It is highly probable that the symptoms of deficiency will be more clear on legume crops, papaver, sugar beet and fruit trees grown in the area.

A special attention must be paid to boron fertilisation in the region. Research and application studies must be initiated in the area.

daily). The colour was allowed to develop for one hour. Intensity was measured spectrophotometrically at 420 nm and compared to standards varying from 0-2 ppm

## Results and Conclusion

The average Boron content of the rainfed cereal grown areas of Central Anatolian region is determined as 0.62 ppm. The Boron content of the 278 soil samples that represent the 0-25 cm depth of the region varied between 0.01 ppm and 11.0 ppm.. 62.59 % of the samples have values less than 0.5 ppm which may be stated as the critical value for soil Boron deficiency. The percentage of soils that has boron content less than 0.5 ppm is highest in Karaman, while the percentage of soils that has boron content less than 0.5 ppm is lowest in Yozgat . 2.52% of the samples have values higher than 2.5 ppm which may be stated as the critical value for soil Boron toxicity (Table 1). Boron deficiency seems as a more critical problem than the Boron toxicity in the region. The average Boron content of 0-25, 25-50, 50-75 cm depth soils were 0.62, 0.62 and 0.69 ppm respectively. The boron content of the soils did not vary significantly by depth.

Although the relation between the soil texture and boron content was not significantly important (Table 7), the average boron content was lowest in sandy soils (0.35 ppm), highest in clay soils (1.00 ppm) and steadily increased from sandy to clay soils. The percentage of potential boron deficient areas was highest in sandy soils (73.33%) (Table 2). Sandy soils can be taken as an indicator of Boron deficiency. Higher probability of Boron deficiency in sandy soils was reported by Gupta (1968) and Fleming (1980).

Although the relation between the soil pH and boron content was not significantly important (Table 7), average Boron content of the soils were highest (1.19 ppm) when the soil pH was higher than 8.0 and lowest (0.41 ppm) when the soil pH varied between 7.0-7.5. The percentage of potential Boron deficient areas were lowest (25%) in acid reaction soils whose pH were lower than 6.0 and highest (63.83%) in 7.0-7.5 pH soils (Table 3). High pH seems as an indicator for boron toxicity. Similar results were presented by Berger and Troug (1945)

Although the relation between the soil lime level and boron content was not significantly important (Table 7), the average boron content was lowest in soils whose lime content vary between 1-5 % (0.38 ppm) and highest (0.85 ppm) in soils whose lime content less than 1.0 ppm.

The relation between the soil organic matter content and boron content was found significantly important (Table 7). The average boron value was lowest (0.43 ppm) in soils whose organic matter level was less than 1% and highest (2.11) in soils whose organic matter level was higher than 4%. Similarly the percentage of potential Boron deficient areas were highest (71.73%) in soils whose organic matter content was less than 1 % and lowest (42.86%) in soils

treatment is also required when acid soils are limed, as excess amounts of lime can induce Boron deficiency (Walsh and Goulden, 1952). Boron availability decreases with increasing soil pH, Inadequate Boron availability has thus frequently on calcareous soils. High clay contents also impair Boron availability, probably due to borate adsorption (Welte 1955).

Crop differs in their sensitivity to B deficiency. The most sensitive crops are sugar beets, mangolds and celery. Various Brassica crops such as turnips, cauliflower, cabbage, brussels sprouts also have a high Boron requirement. Of the fruit trees apples and pears are known to be particularly sensitive to Boron deficiency (Bradford 1966). (Gartel 1974) claims that Boron deficiency is one of the most severe non-parasitic diseases in wine growing and yield depression may be up to 80%. In general dicots have higher Boron requirement than monocots. For this reason Boron deficiency in cereals is less common (Shive 1941).

A series of various studies revealed that both the deficiency and toxicity of Boron exists in Turkey. Hakerler (1986), Çengel and Özkara (1989), Güneş et al (1997), Taban et al (1997) has reported Boron adequacy or toxicity as the major finding of their studies. But on the other hand Düzbastılar and Güleç (1995), Dikmelik (1995) reported wide distribution of Boron deficiency, Shorrocks (1997) also reported a significant yield increase of sugar beet and olive due to Boron applications in Turkey. Sillanpaa (1982; 1990) reported both severe toxicity and deficiency in his studies held in Turkey and attracted a special attention to Boron management. Bayraklı and Er (1988), Kacar and Fox (1967), Kacar et al (1979) also reported significant amounts of Boron deficiencies in Turkey as the results of their studies.

## **Material and Methods**

Totally 830 soil samples representing rainfed cereal grown areas of Central Anatolia are collected from 0-25, 25-50, 50-75 cm soils depths. Each soil depth is represented about 278 soil samples. Soil samples are air dried and passed through 2-mm sieves and prepared for further analyses. The soil samples are analysed for texture, pH, total salt level, organic matter and lime contents in order to identify the relationship of these factors with plant available boron status of the surveyed soils.

Boron status of the soils are determined by hot water extraction method. Hot water soluble soil Boron content was determined by a modified Berger and Trog (1944) method. 20 g. of air-dried soil and 40 ml of 0.01 M  $\text{CaCl}_2$  and about 0.5 g of activated charcoal was boiled for 5 minutes in a quartz flask and filtered immediately. 2 ml of this extract and 4 ml of buffer masking agent ( 250 g  $\text{CH}_3\text{COONH}_4$  and 15 g  $\text{Na}_2\text{EDTA}$  dissolved in 400 ml of water and 125 ml of 100%  $\text{CH}_3\text{COOH}$  added) were mixed and 4 ml of azomethine reagent (0.9 g azomethine-H and 2 g ascorbic acid dissolved in 200 ml water, prepared



## **Boron Status of Central Anatolian Soils**

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### **Abstract**

A soil survey study is conducted on rainfed cereal growing areas of Central Anatolian Plateau (CAP) in order to determine the Boron status of soils. Soil samples are collected at 278 locations from 0-25, 25-50 and 50-75 cm. Totally 830 soil samples are collected from three depths. The soils are extracted with hot water according to modified Berger and Troug (1944) as described by Sillanpaa (1990). Hot water extractable boron content of 0-25 cm depth soils varied between 0.01-11.0 ppm and the average value was 0.62 ppm. If 0.3 ppm is taken as the critical value for deficiency then the potential Boron deficient areas occupy 44.24 %, if the critical value is accepted as 0.5 ppm for deficiency then the potential Boron deficient areas occupy 62.59 % of the soils in the CAP area. If 2.5 ppm is accepted as the possible critical level for boron toxicity then 2.52 % of the soils in the CAP is potentially toxic for Boron.

The average boron levels of the soils did not significantly differ along the soil depth. The average boron values were 0.62, 0.62 and 0.69 ppm in the soil depths of 0-25, 25-50 and 50-75 cm respectively.

Boron toxicity was observed in the soils where the soil boron content varied between 0.86 – 4.86 ppm, and the average Boron values were 2.69 ppm. It is highly probable that Boron toxicity will be observed in the areas where average Boron values are around 2.69 ppm. Soil pH was determined as the most determining factor in assessing Boron toxicity. The average pH value of Boron toxic areas was 7.82.

According to the results of the survey, Boron deficiency seems a greater problem than the boron toxicity in the rainfed cereal growing areas of the CAP, although deficiency symptoms were not clearly observed.

### **Introduction**

Boron is an essential element for the plant growth and taken into the plant as boric acid. Boron is one of the trace elements that cause a major problem in soil management. Only a small amount is necessary for optimal plant growth, while values slightly above this optimal amount affect the plant growth negatively and reduce plant growth. Toxic and deficiency values are very close to each other. Boron is of interest in crop production both from the viewpoint of its effects in deficiency and excess. According to Reisenauer et al (1973) deficiencies of Boron occur in a wider range of crops and climatic conditions than deficiencies of any other trace element. Boron is also probably more important than any other micronutrient in obtaining high quality crop yields.

The soils on which Boron deficiency occurs include those which are inherently low in B such as soils derived acid igneous rocks and podsolized soils. Sandy acid soils in particular need regular treatment of Boron fertilizers. The same

paths, courtyards, lawns, and spaces surrounding tenant gardens and community facilities constitute a coherent play scope, which no longer requires any need for specially designed play grounds. In contrast to conventional settlement projects which are often marked by an unnecessary high degree of sealed surfaces and “manicured” green spaces, which hardly enhance children to play. On the other hand ecological settlement projects have play areas, which are usually characterized by minimum paving, plenty of vegetation, and porous surfaces, e.g. gravel areas with spontaneous vegetation rather than by “manicured” landscaping.

### **Recommendations**

Urban environments can and should become more fundamentally green and natural. The examined European cities provide a tremendous variety of creative and inspirational ideas for greening the urban landscape. These ideas range from strategic tree planting, ecological roofs, and desealing of urban pavement, to the incorporation of a range of ecological features into new development projects and renovated urban districts. Virtually all of these ideas have potential application in Turkish cities. In given examples, the emphasis, especially in the Netherlands, on developing ecological networks \_an integrated coherent strategy for protecting and restoring natural landscapes\_ is one of the most important lessons to be learned. A Nature Policy Plan needs to be prepared and a National Ecological Network should be elaborated for Turkey. In addition to these a climate zone plan should be prepared and wind circulation patterns should be map. In new housing development areas should be designed according to data gained by these studies.

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greening courtyards and other urban green strategies necessary compensation for the loss of green space brought about through urban buildings development.

Efforts have also been made in many of these cities to avoid large areas of paving or hard surface without trees and vegetation. Very often permeable brick or paving material is also emphasized. Green roofs, or eco-roofs as they are sometimes called, have become increasingly common in Europe, especially in Germany and the Netherlands, and provide many benefits over conventional roofs. Among their key advantages are the protection they provide from UV rays and the ability to extend the life of a roof, the ability to cool the urban environment (addressing the urban heat island effect), carbon dioxide sequestration, the control of storm water run off, and the provision significant habitat, especially for plants, invertebrates, and birds. Traditionally two styles or types of green roofs are distinguished –intensive or traditional roof gardens, and extensive or ecological rooftops. The former –typically referred to as roof gardens\_ includes structures that can accommodate deep soils, trees, and shrubs, and deeper rooted vegetation. Because of the depth of the soil cover required for intensive roof gardens, additional structural reinforcement is typically needed, as well as more active and intensive management. Extensive rooftop systems or ecological roofs\_ typically involve coverage of the entire rooftop with a relatively thin covering of soil and vegetation. Green roofs have the potential to make a tremendous difference in the visual landscape and qualities of cities. The use of extensive green roofs has become increasingly common in the Netherlands, and a number of creative applications there can be cited such as the terminal building at Schipol Airport, technical University in Delft, and the GWL-terrein housing project in Amsterdam.

European cities and towns offer many other examples of creative urban greening. Green walls are especially common in German cities, and green walls provide many of the same benefits as green roofs. Wall vegetation shields against UV rays, provides shading and cooling during summer months and insulation during winter months (as much as 30 percent, according to Johnston and Newton 1997) and provides protection against chemical weathering. Health benefits of green walls include the filtering of air pollutants, the minimizing of noise and positive humidifying effects.

Many of the ecological housing projects or ecological renewal projects demonstrate a remarkable ability to create green-space. Kennedy and Kennedy 1997, in their study of European ecological settlements, observe the positive qualities of many of these projects for children and the provision of impressive natural play spaces: Ecological settlements with diverse automobile free open areas offer an ideal opportunity to develop this kind of play environment around the residences\_alleys,



Especially impressive in these European Cities is the attention paid to streetscapes and public space. In addition to pedestrian only streets there are numerous examples of street enhancement efforts. Many of these cities have taken a host of actions including tree planting, increased places to sit, and public sculptures and other forms of art, to make streets and public spaces more desirable places to be. These streets include, for example, Mariahilfstrasse in Vienna, Damrak in Amsterdam and Copenhagen city center. These urban centers represent the best conditions and qualities of an ecological design as definition, human scale, visual complexity, complex and detailed facades, diversity of uses, focal points, and significant destinations, and places to sit and stand among others (Beatley 2000).

Beginning in the 1960s, and continuing today, many European cities have been gradually pedestrianizing parts of their centers taking space away from cars and parking and returning it to the pedestrian. This has had the effect of not only helping to control the automobiles, but also creating city centers and downtown areas that are much more inviting places to visit and shop. Copenhagen is the best examples of a successful and continual effort to pedestrianize a city center.

A variety of specific traffic calming strategies and technologies exist. These strategies include speed humps, curb and sidewalk extensions, raised brickwork, bollards and physical barriers of all types and creative use of trees (placement of trees in streets and parking lots).

### **Strategies for Greening the Urban Environment**

A number of strategies for protecting and promoting green have been pursued by the European cities. One approach has been to mandate a high degree of green and nature enhancing features as part of new development or redevelopment schemes. Many examples can be cited of new development projects that will incorporate or have incorporated (such as the Vienna Woods) extensive natural areas in close proximity to residents. While at the same time accommodating a relatively high density of people and development. Many of these European cities have a long history of protecting extensive systems of open space, woodlands, and natural areas in close proximity to urban areas. Many are structured around the notion of open space fingers, or wedges, that penetrate urban centers. Another important point is that largely as a result of the density, compactness, and design of European cities, residents have phenomenal access to large areas of open space and nature.

Many European cities are attempting to bring nature into the city center and to develop physical and ecological connections between built up areas of the city and surrounding natural areas and green spaces. European cities offer many positive examples of efforts to incorporate green features and nature into the design of the built environment. One of the key notions behind rooftop gardens, green roofs,

problem areas identified. Policies flow directly from these conditions, including mandating that certain areas of the city must convert to the city's district heating network by a certain date, as well as the preparation of a new landscape plan that will better protect green space in and around the city (Beatley 2000).

### **Vitality of City Centers and Mixed use**

The common problem faced in most European cities the rundown or urban decline inner city areas". As a result of numerous efforts, the quality and attractiveness of the city centers were maintained and enhanced. In most of the study cities, the center area has remained a mixed-use zone, with a significant residential population. A common pattern is the location of residential units above retail shops and offices (as in most Dutch cities and towns, for example). An extensive system of pedestrian streets and the presence of many amenities have made the center an attractive place to live near. Many European cities are investing major resources in supporting new development in city center locations. Examples of such projects on quite a massive scale can be seen in Berlin and Den Haag. In Berlin the largest new development site is the Potsdamer Platz, where 1.1 million square meters of office and residential space are under construction. This new area will be served by major new transit investments with a planned model split of 20 percent private car and 80 percent public transit and will be served with central heating and cooling. For example in Groningen "cohesive set of measures to improve the center are: the creation of new pedestrian only shopping areas, the installation of yellow brick surfaces in walking areas, the installation of new street furniture and the adaptation a new public transit concept includes making the center car free, providing free peripheral parking and direct bus service to the center, replacing street parking with a series of underground car parks on the edge of the city center, and increasing the number of cycling paths (Groningen Gemeente 1993;1996; Beatley 2000). Together these measures are designed to improve the access to and attractiveness of the center.

The relatively high density and compact urban structure of European cities are critical features in determining their sustainability on other measures. These features make possible or at least much easier, many of the other qualities that have been discussed above, including the high use of public transit, high walkability, vital and vibrant civic spaces, the use of extremely efficient district heating systems, and the protection of large systems of extremely accessible green spaces. There are many lessons to be learned from these European Cities in terms of both design and building of new residential districts and the broader scales of community and regional planning.



## Results

Cities play an increasingly important role in addressing various environmental problems. The attributes and specific designs featured in the presented projects vary, but they tend to have in common emphasis on minimizing the ecological footprint of their residents, and they tend to include high energy conservation standards, low water usage, the use of sustainable building materials, an emphasis on recycling and material reuse, and the incorporation of solar energy in the form of solar panels among other features. These projects also emphasize minimizing the role of, or doing without, the automobile. Most are sited in close proximity to public transit, emphasize walking and bicycling as mobility options, and typically restrict the number of spaces provided for automobiles.

### Land Use

Compact urban form is one of the important components of an ecological design. Despite some degree of urban spread, European cities have been largely able to maintain their compactness and density. Because of the value attached to rural and undeveloped lands compact urban form is considered necessary in many European countries. In Europe rural and agricultural lands are not seen as transient or residual activities but as important primary societal uses. The green paper on the Urban Environment for example strongly endorses the avoidance of sprawl and instead recommends that new development be guided into existing areas and abandoned lands in need of redevelopment (Commission of The European Communities 1990). There is a consensus among planners and policy makers that this is the appropriate direction for European cities. There are several advantages of this tight urban structure such as the extensive amount of open space and natural lands often owned by cities and good public transit, means that European urban residents have relatively quick access to natural areas.

The European Cities demonstrate that it is possible to achieve compact urban form at the same time that green spaces in and around cities are protected. In Helsinki and Copenhagen, large wedges of green space and nature extend into the very center. In many respects, it is the very compactness that allows these networks of green space to exist in such proximity to large populations. Good public transit system that make outlying green spaces easy to reach even from the very core of the city, is another important gradient.

A detailed climate study serves as a major environmental basis for the land use plan for Graz. This city has pollution problems that are the result of a combination of topographic conditions, and inversions that occur in certain months of the year. Climatopes and wind circulation patterns have been extensively mapped, and



Ecological design begins with the particularities of place, the climate, topography, soils, water, plants and animals, flows of energy and materials and other factors. The task is to integrate the design with these conditions in a way that respects the health of the place.

### **Material and Method**

The aim of this research is to define the concept of ecological design as well as to clarify its main application areas and devices through the examples in European countries. The recommendations developed for the design of urban areas and mentioned within this declaration are divided into two categories; one of which is related with the planning decision and the strategies whereas the other is directly related with urban design applications. Even this situation itself expresses that the ecological design in urban areas is such a detailed and wide ranged matter which initiates by planning decision and strategies and leads to one to one designs that has a strong link with each other. The research has been based upon a detailed literature survey not only to define the various dimensions of ecological design but also exemplify the different designs in urban areas.

The examination of this research covers the European cities that represent the best practices of ecological urban design. This subject selection among the European cities has been made through the Beatley 2000, City and Environment 1994, Best Practice (Ministry of Housing special planing and the environment Netherlands), Mixes uses in Buildings, Blocks and Quarters 1993 , Green Paper on the Urban Environment 1990.

Related with this literature survey the cities such as Berlin, Copenhagen, Den Haag, Utrecht, Rotterdam and Vienna are selected to be examined from the point of their ecological designs since these cities have built a pattern for future designs in urban areas. The research materials of all sorts of printed documents including books and journals, city development plans and slides taken at site visits are collected from the selected European cities.

These below mentioned four steps can summarize the method conducted to actualize this study. First step is the examination of related literature to form the concept of ecological urban design. Secondly the matter is the clarification of solutions and precautions to the problems that effect environment and living quality in urban areas. Third step is the presentation of the mentioned precautions and recommendations applied within the selected European cities, based upon the research and the observations. Finally, analyzing the further developments in this matter based upon the examples of European cities which has already passed the industrialization period.

## **Ecological Design in Urban Areas: Case Studies from European Countries**

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### **Abstract**

The world is in the midst of a disturbing period of growing consumption, population, and environmental degradation. From global warming to biodiversity loss to patterns of sprawling land consumption, the environmental trends are increasingly dire. Cities will by necessity play an increasingly important role in addressing these problems. We can define ecological design as any form of design that minimizes environmentally destructive impacts by integrating itself with living processes. This integration implies that the design respects species diversity, minimizes resource depletion, preserves nutrient and water cycles, maintains habitat quality and attends to all the other preconditions of human and ecosystem health (Van der Ryne and Cowan 1996). Ecological design in Urban Areas brings about many recommendations and precautions for land use, city centers, pedestrianized centers, and strategies for greening the urban environment. This paper examines the ecological design implementations in some European cities and puts forward various recommendations for use. Research shows all of these ideas have potential applications in Turkish cities.

### **Introduction**

Ecological design is simply the effective adaptation to and integration with nature's processes. Its scope is rich enough to embrace the work of architects rethinking their choices of building materials, the civil engineers reformulating the flood control strategy, and industrial designers curtailing their use of toxic compounds. Ecological design provides a coherent framework for redesigning our landscapes, buildings, cities and systems of energy, water, food, manufacturing and waste. We define ecological design as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes". The integration implies that the design respects species diversity, minimizes resource depletion, preserves nutrient and water cycles, maintains habitat quality and attends to all the other preconditions of human and ecosystem health (Van der Ryne and Cowan 1996). The first generation of ecological design was based on small-scale experiments with living lightly in place. Many of the technologies and ideas of this generation, such as alternative building materials, renewable energy, organic foods, conservation and recycling have been widely adopted separately.

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arising from its proximity to Ankara Metropolitan area and have become a deformed extension of the urban structure. This region, which presents an overstressed multi functional structure today, could strengthen its local and specific structure and develop the ecological and socio-cultural assets it owns. In this context :

- It is observed that Gölbaşı SPA has been undergoing a rapid change process from the past to the present day. Therefore, the change itself as well as its reasons and results and the change process should be analysed to guide and harmonise the change.
- The Gölbaşı SPA and its immediate vicinity should be evaluated as an entire ecosystem and this relationship should be established in the management process.
- In managing the Gölbaşı SPA, which has undergone an ecological and socio-economic change process, the system should be addressed as a whole, paying attention to mutual and continuous interaction of the social and economic systems.
- One of the major factors that must be considered in the landscape management process for Gölbaşı SPA is that the dominance of the young population. This population should be considered as the target group to guide the life style and production - consumption patterns of the community in the context of sustainability. In addition, the local people should be urged to play an active role in the formulation of regional planning, policies and priorities. To this end, community awareness of landscape values should be encouraged.
- The Landscape management studies should be integrated to all planning scales and decisions, taking the national planning hierarchy into consideration.
- To guide the change in landscape within the framework of landscape management, a socially, economically and culturally acceptable support system should be established in the region.

Taking into consideration the specific situation of the Gölbaşı SPA and the national conditions, in addition to the complexity of Landscape Management process, the Landscape Management studies for Gölbaşı SPA and its environs could not be implemented in the short term. Besides it is the fact that Turkey is in the process of becoming of a member of European Union and is party to many bilateral and multilateral agreements (e.g. the European Landscape Convention) with many countries, some of which are EU members. The discharge of responsibilities under these agreements entails legal and administrative changes.

In this context, in the framework of the basic principles mentioned above and perhaps the most significant aspect of landscape management is to realize the need to change the traditional concepts and approaches

population of more than 30.000 people today. In parallel to this quantitative change, the population of Gölbaşı has also changed qualitatively, from rural character in the past to urban character today.

The urban pattern of Gölbaşı has a representative character of its social and cultural structure. Three basic social groups namely; lower medium, medium, and upper medium income groups live in the city. Additionally, in recent years, recreational needs of the Ankara citizens resulted with secondary housing areas. Thus, a different socio-cultural structure imported to Gölbaşı SPA. This group, however, has no relationship with the other three groups (Anonymous 1999). Besides, the lakes in Gölbaşı SPA are being intensively used by the citizens of Ankara for recreational purposes on daily basis especially at weekends.

On the other hand, Gölbaşı settlement is subject to an intensive uncontrolled and illegal development. Despite the increased density arising due to continuing squatter settlement (*gecekondü*) development and illegal storey construction in spite of the current planning decisions and laws, social utility areas have remained the same. Therefore the social utilities (education, health, open - green areas etc.) have become insufficient in the course of time. In addition to this, in areas for which the existing plans maintain lower densities, development occurs horizontally, which influences the valuable agricultural areas in the surroundings (Anonymous 1999)

#### **\* Economic Structure and Change**

The Interaction with the metropolitan area of Ankara impacts upon the forming and economy of Gölbaşı. As a result of this interaction, land use pattern has begun to change. Local people began to leave agricultural uses, and expectations of the agricultural population from the soil have differed. (Anonymous 1999)

The sectoral distribution of the active population in Gölbaşı had an agriculture-based pattern in the past. Today, industry and trade are the main sectors today, having 26% and 20% shares respectively. In the manufacturing sector, which has a share of 21.9% mining (quarries and etc.) takes the first place with its share of 18,7%. On the other hand, the agriculture sector has only a share of 3%.

#### **Conclusion**

Due to the complex natural and socio-cultural structure of landscape and the complexity involved in the management of them, it is not possible to recommend a management schema that could be valid for different types of landscapes. For this reason, this paper referred to the example of Gölbaşı SPA to discuss general principles and approaches of the Landscape Management. Gölbaşı SPA and its environs could not have made use of the advantages



Yurtbeyli are also located in the area. Lake Mogan (5,6 sq.km) and Lake Eymir (1,08 sq.km) are located in the northeast of Gölbaşı SPA. These lakes are important both as natural and recreational resources for Ankara which is the capital of Turkey.

#### **\* Ecological Structure and Change**

In Gölbaşı SPA, which includes Lake Mogan and Eymir as an important component of the Central Anatolian Wetland system, different varieties of vegetation are observed due to various elevation, temperature and moisture conditions. In general, the steppe variety of vegetation dominates.

Due to its location, Gölbaşı SPA has a specific hydrological structure. This structure consists of four basic formations. These are:

- a) The valley that connects Lake Mogan, Lake Eymir and İncesu Brook,
- b) Tributary rivulets and streamlets that supply this valley,
- c) Wetlands taking place in the beginning of and along the valley and all underground waters that supply them and
- d) The underground water supply basins (Anonymous 1999).

These four basic formations influence all other features of Gölbaşı SPA directly (flora and fauna) and/or indirectly (productivity).

Shallows and shores of Lake Mogan and its surroundings where the ground water level is high, are densely covered with reeds. As a wetland, the entire area is very important for sheltering and breeding of waterfowl. 160 bird species nest and shelter in the region (Anonymous 2001). Gölbaşı SPA is also a specific area where globally threatened species can regularly be observed.

Despite its ecological value mentioned above, the water regime of Gölbaşı SPA has deteriorated due to misuse of land and resources, which has in turn influenced supply and discharge equilibrium of the lake adversely. The allocation of agricultural areas to different uses has increased the perceptibility of change in landscape. In addition, the soil, water and air pollution and erosion caused by different land uses have emerged as a significant indication of adverse changes in the landscape structure and function.

#### **\* Socio-cultural Structure and Change**

The data for the year 1997 shows that Gölbaşı SPA has a total population of 35.069. The assessment of the structure and distribution of the urban population by age groups indicates to a quite young population. The half of the count is of individuals below the age of 25 while only 4% of the count is above the age of 65. This shows the important presence of young generations in the demographic structure of the area. The active population between 15 - 64 years of age is 67% of the total population. (Anonymous 1999)

A small town of 3000 people in 1950's, Gölbaşı accommodates an urban



"alteration in the structure and function of the ecological mosaic over time" (Anko 1999) Being an open system, spatial and temporal change is essential in landscapes. "Landscape management" should consider the changes in landscape structure and function.

- **INDICATORS:** Indicators can provide crucial guidance for decision-making in a variety of ways. They can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process. They can help to measure and calibrate progress towards sustainable development goals. They can provide an early warning, sounding the alarm in time to prevent economic, social damage (United Nations 2001). Indicators are important tools especially in identifying landscape change trend and for purposes of guiding future actions and policies in the "Landscape Management" process.

Landscape changes depending on natural processes and human activities, and this change can be either continuous (continuously increasing) or discontinuous (in depth). Functional loss and failure are two basic results of landscape change (Wood and Handley 2001).

In the context of the information given above, Gölbaşı Specially Protected Area (SPA), has been selected as the research area because of major changes in its function & structure, for evaluation in the framework of Landscape Management.

## **Material and Method**

Gölbaşı (SPA) constitutes the main material for the research. To carry out the research, related literature including remote sensed data, photographs and slide films, video camera images, and data obtained during field survey were used as additional material.

In order to identify changes in the structure and function of the research area in the framework of landscape management, comparative evaluations were performed. In this context, Anko (1999), Slocombe (1998) and Haeuber (1998) approaches were evaluated and an analytical approach, the ecological, economic and socio-cultural structure was studied, interpreted and related to landscape components to diagnose problems and develop proposals.

## **Results**

The Council of Ministers' Decree 90/1117 of 22.10.1990 establishes and proclaims Gölbaşı and its surroundings as a SPA. Gölbaşı SPA covers an area of 245 sq.km including the District of Gölbaşı and is 17 kms from the City of Ankara (Anonymous 2001). The villages of Ballıkpınar, Gökçehöyük, Hacıhasan, Hacılar, Karaoğlan, Oğulbey, Örencik, Yağlıpınar, Yavrucak and

with the following goals:

- \* Protecting and supporting natural productivity,
- \* Reducing risks,
- \* Maintaining landscape quality and potential,
- \* Ensuring economic vitality, and
- \* Ensuring socially acceptability (Anko 1999).

Depending on these goals, the Landscape Management components are listed below.

- **HOLISTIC APPROACH:** Landscapes are concrete, mixed natural and cultural systems of our total human ecosystem that integrates humans and their total environment (Naveh 2000). Holistic approach is essential in analyzing this complex and diverse structure and identifying the interactions and results within the system.
- **TRANSDISCIPLINARY APPROACH:** In landscape management, transdisciplinary notion of landscapes, emerging from the Holistic systems view (Naveh 2000), is necessary to integrate different kinds of knowledge about different parts of the ecosystem (Slocombe 1998).
- **SUSTAINABILITY:** For landscape management, it is a prerequisite to meet social and economic needs of the population living in a landscape, in other words, guide the landscape so as to enhance quality of life and, at the same time, safeguard the integrity and health of the ecosystem are primary requirements.
- **SYSTEM PERSPECTIVE:** Landscape is a whole that incorporates ecological and social systems. These systems present a dynamic and complex structure in which they are in a continuous interaction with each other. They also determine the structure, function and change trend of the landscape. The functioning of this dynamic and complex structure must be considered in landscape management process.
- **ECOSYSTEM BASED:** Management at the landscape level requires accepting landscape as a whole of different ecosystems. As a consequence, landscape management should be based on ecological principles (Slocombe 1998)
- **HUMAN DIMENSION:** Human is the dominant organism specifically for the cultural landscape. The human's way of life, production and consumption patterns are important factors in landscape change. Establishing a balance between natural resources and human needs is a guaranty for the sustainability of ecosystem as well as the survival of human being. It should be remembered that, in determining the management goals and predicting the structural and functional change trends of landscape, the human dimension is a complementary part of the "Landscape Management".
- **SPATIAL AND TEMPORAL CHANGE:** Change of landscape is the



# **The Evaluation of Gölbaşı Specially Protected Area in the Framework of Landscape Management**

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## **Abstract**

Landscape is a spatial and temporal result of interacting ecosystems and socio- cultural environment and has a certain structure, function and change trend. Guidance and harmonization of landscape changes in the perspective of sustainable development could only be possible with "Landscape Management". Having specific ecological values and an overstressed and multi functional structure, Gölbaşı Specially Protected Area has been selected as the research area for evaluation in terms of "Landscape Management". This paper handles the example of Gölbaşı Specially Protected Area and discusses the general principles and approaches of Landscape Management. In addition, it emphasizes the necessity of legal, administrative and conceptual changes to implement "Landscape Management studies in Turkey, also taking into consideration the international conventions to which Turkey is a part.

## **Introduction**

Partial approaches to the conservation, use and evaluation of natural and cultural resources accelerate the loss of these resources and cause significant changes in landscape. Being defined as "an area, as perceived by people whose character is the result of the action and interaction of natural and/or human factors" in the European Landscape Convention (European Commission 2000), landscape has been losing its biological, ecological and cultural richness. And depending on this, economic and social change and losses are inevitable. Landscape is a dynamic system and it inherently contains "change". However, the acceleration and change of direction of such change by the human influence cause certain negative impacts upon the landscape components and the entire landscape itself.

Conservation and improvement of landscape and evaluation of its resources in the context of sustainability could only be possible by defining and analyzing the structural and functional landscape changes.

In the perspective of sustainable development, "Landscape Management" is expressed as a guidance and harmonization and regular upkeep of landscape changes caused by social, economic and environmental processes. For the integration of socio- economical principles with the environment, landscape management aims at the combination of technologies, policies and activities



**Table 6.** Correlation coefficient between farm sizes and LUTs

LUT	Mono-active	Multi-active
Cereals	0.69	0.96
Cotton	-0.81	-0.85
Corn	0.84	0.83
Legumes	-0.88	-0.67
Watermelon	-0.78	-0.36
Vegetables	-0.90	-0.83
Citrus	-0.90	-0.93
Wheat/corn	0.78	-0.51

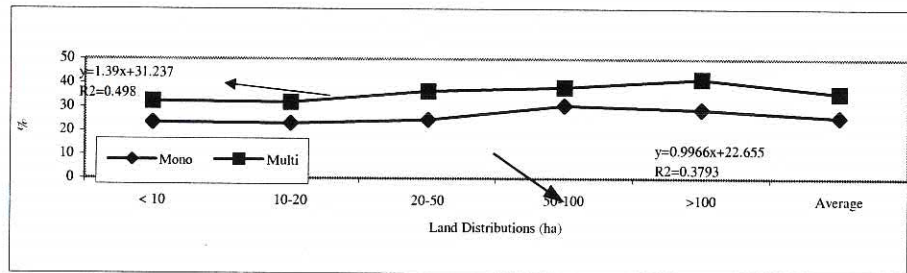
## Conclusions

The following results can be concluded from this study:

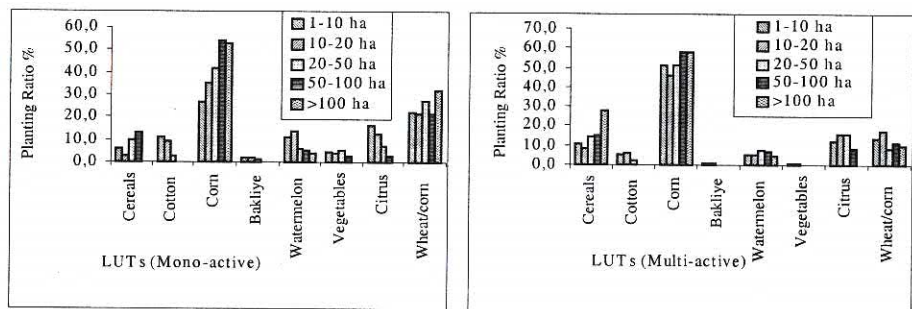
- An average labour usage for all farm sizes was about 25% in mono-active farm and 36% in multi-active farm
- Labour usage efficiency (labour usage per ha) increased with decreasing farm size.
- Cross production value per ha was the highest in the farm size group less than 10 ha.
- Mono-active farms used the land most efficiently.
- The relationship between farm sizes and crop plantation ratio were positive for cereals, corn, wheat/corn alternation and negative for cotton, legume, watermelon, vegetables and citrus for both mono and multi active farms (except wheat/corn alternation in the multi-active farm).

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**Figure 4.** Labour usage efficiency



**Figure 5.** LUTs in mono and multi-active farms

### Statistical analysis

The change in variances of LUTs of mono and multi-active farms were tested. Test results showed that the changes in variances of all farm sized groups were significant at the 5% level (Table 4). Analysis of correlation was performed between farm sizes and labour usage, and between farm sizes and LUTs (Table 5 and 6). The relationship between crop plantation ratio and farm sizes were found varying as regards LUTs in mono and multi active farms. The relationship in cereals was 0.69 in mono and 0.96 in multi active farm and showed that cereal plantation significantly increased with farm size in multi-active farms. Citrus, vegetables, legume, cotton and watermelon were found taking negative and statistically significant at the level of 5%.

**Table 4.** F test for crop pattern of mono and multi-active farms

	Farm sizes (ha)				
	0-10	10-20	20-50	50-100	100- +
Fcalculated ( $\alpha=0.05$ )	0.293	0.575	0.730 Rejected	0.918 Rejected	0.896
	Rejected	Rejected			Rejected
F critic	0.264	0.264	0.264	0.264	0.264

**Table 5.** Correlation coefficient between farm sizes and labour usage

Mono-active farm		Multi-active farm	
In-farm	In-farm	Off-farm	Total
0.57	0.65	-0.31	0.93





## Results and Discussions

### The soils

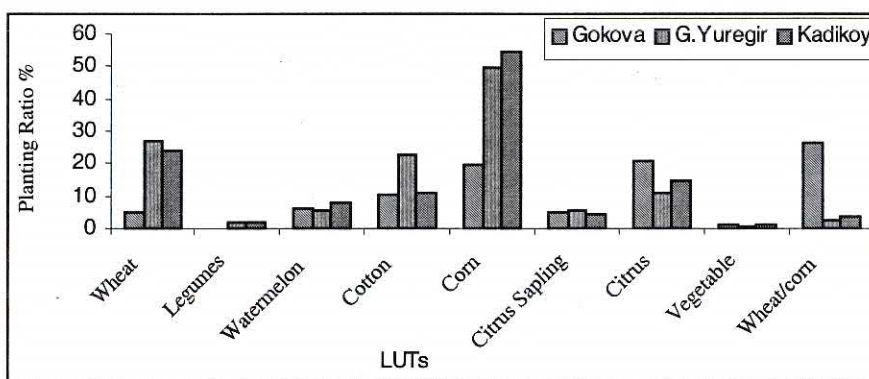
The soils in the study area consist of mainly three physiographic units (Dinç et al., 1990). These are bottomland soils (Arikli-Entic Chromoxererts; Arpacı-Aquic Xerofluvent and Mursel-Fluventic Xerochept series), river terrace soils (Canakci and Oymakli series-Typic Xerofluvent) and delta soils (Gemisure series-typic Chromoxerert). Arikli, Arpacı and Gemisure series have heavy clay texture with massive structure and show large variability in terms of permeability depending on the high clay content. Mursel series has a medium, Canakci and Oymakli series have light to medium texture with high permeability. The mediterranean climate prevails within annual precipitation of 772 mm/year. From a topographic perspective the area is flat with 0.5-2.0% slope.

### Water User Associations

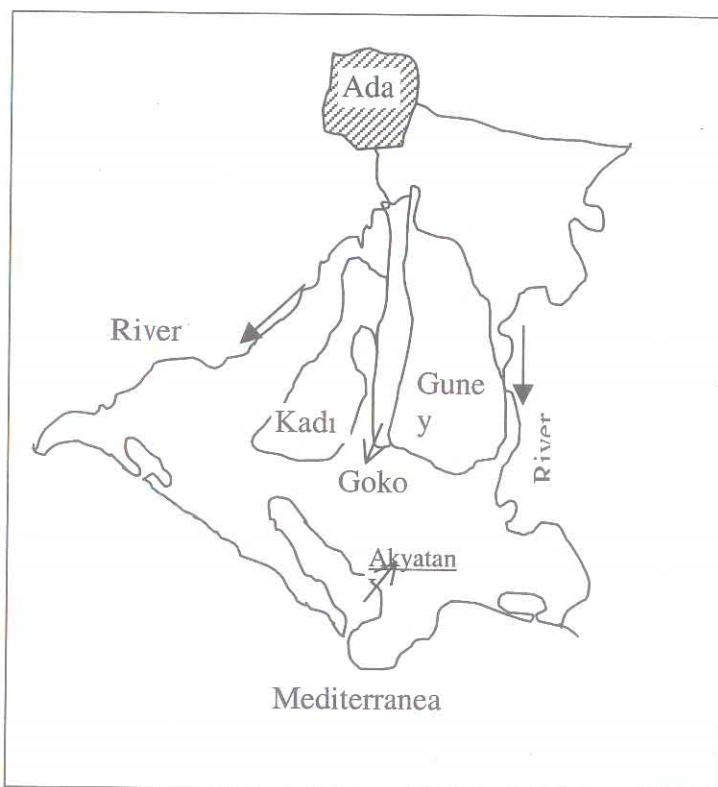
The area formed from three WUA named Güney Yüreğir, Gökova and Kadıköy in the Yüreğir Plain within Lower seyhan Plain. These WUA were constructed in 1994-1995. The irrigation area of WUA are 16890 ha, 4289 ha and 9808 ha, respectively. Total investigation area is 30987 ha. Table 2 shows some of data and Figure 3 illustrates LUTs of WUA in the year of 2000.

**Table 2.** Some data of WUAs in the year of 2000.

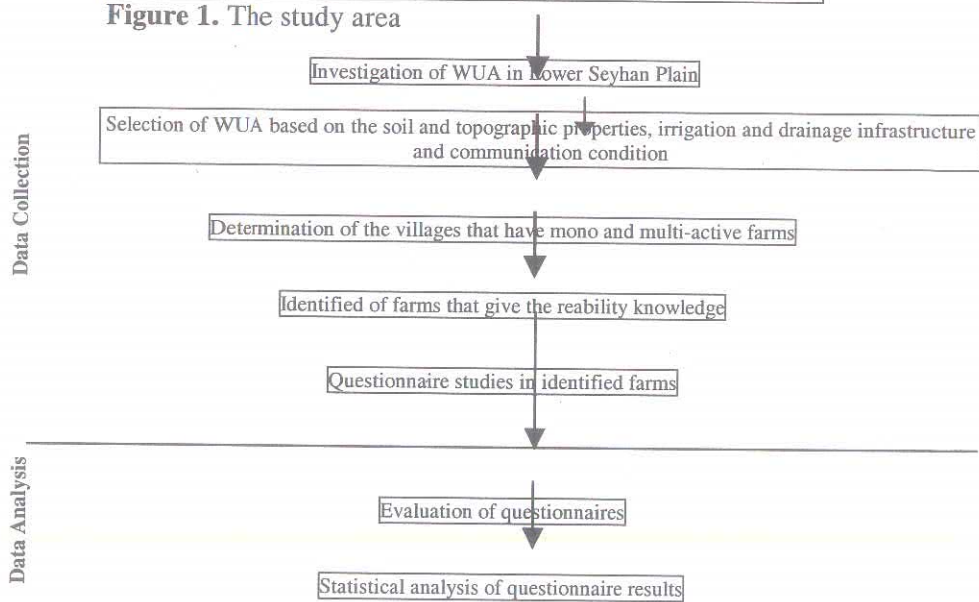
Name	Area (ha)	Mean parcel area (ha)	Total parcel	Number of farmer	Planted area (ha)		
					First crop	Second crop	Total
G. Yuregir	16890	1.6	10556	2013	166198	4657	170855
Kadıköy	9808	5.3	1851	932	94059	4119	98178
Gokova	4289	4.5	953	403	27450	12839	40289



**Figure 3.** Planting ratio of LUTs of WUAs in the year of 2000



**Figure 1.** The study area



**Figure 2.** Flow chart.

should work outside of the farm. It is evidently that a farm has mono-active or multi-active affects on cropping patterns, usage of agricultural inputs, farm area and labour productivity. The history of multi-active farming had extended to 1950 (CIHEAM, 1991). Yurdakul and Akdemir (1989) searched the affection of multi-activate on farming systems which selected from Cukurova Region. Erkan (1987) reported that a small sized farm used the land most efficiently. In the study, the labour usage of the rural area of farm and/or off-farm, farm size, number of the plots and their effects on land use types (LUT) are determined for the mono and multi-active farms in the three water user associations (WUA) in the Yuregir plain irrigation area within Cukurova Region.

### Material and Methods

This study was carried out in the selected three WUA area named Guney Yuregir, Kadikoy and Gokova which have the same soil and topographic properties, irrigation and drainage infrastructure and communication conditions, in Yuregir plain within Cukurova Region (Figure 1). The area has two towns, 42 villages and 4 sub-districts. The average farm size distribution of Karatas and Yuregir towns on the census of 1990 was given in Table 1.

**Table 1.** Farm size distribution of Karatas and Yuregir (Anomys, 1991)

Town	Number of village	Number of farmer	Farm size distribution (%)					Total
			0.1-5 (ha)	5-10 (ha)	10-20 (ha)	20-50 (ha)	50-+ (ha)	
Karatas	47	2504	36.4	27.9	19.3	11.4	5.0	100.0
Yuregir	84	13950	45.6	23.8	17.3	8.3	5.0	100.0

The farming systems of mono and multi-active farms, farm sizes and present LUTs of three WUA in the year of 2000 were used as a basic materials.

The study was carried out in two stages (Figure 2). Sample farms were identified by consulting the teacher, engineers and headmen of the villages. It was sampled aimly; so the homogenous data collection was done as it was described by Bowen and Starr, (1987). Total 120 questionnaire studies were performed for mono and multi-active farms in 30 villages out of 120 villages in the area. Farms were divided into two groups: mono-active farms which use all available labour in agriculture and multi-active farms which use some part of family labour in agriculture and some other part in non-agricultural fields. The labour usage in off-farm must be permanent therefore seasonal and temporary works have not been considered. Questionnaire results were evaluated in excell program. The F-test was used to test hypothesis which states that two samples were drawn from the populations having an equal variances, through following Davis (1986). Data were subjected to correlation and regression analyses by using SPSS software (SPSS, 1988).



## **The Relationship among Farm Size, Labor Usage and Land Use Types**

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### **Abstract**

The labour usage of the rural area in farm and/or off-farm, farm size and their effects on land use types (LUT) were determined for the mono and multi-active farms in the three water user associations (WUA) in the Yüreğir plain irrigation area within Lower Seyhan Plain. Results showed that labour usage was about 25% in mono-active farm and no remarkable changes was observed with farm sizes, but increased from 32% to 41% in multi-active farms with farm sizes. Labour usage per ha was the highest in the area less than 10 ha for all mono and multi-active farms. Cross production value per ha was the highest in the area less than 10 ha in mono-active farm and it can be clearly said that the mono-active farm uses the land more efficiently if the farm size is small.

LUTs and plantation ratio varied with farm sizes and significant relation was found at the 95% probability level between crop plantation ratio and farm sizes. The variance test showed that the changes in variances of LUTs of mono and multi-active farms significant at the level of 5%.

### **Introduction**

A remarkable increase in agricultural productivity can be supported by using natural resources suitable on their potential. The main factors that care for increasing yield in agriculture, are to improve soil and water resources. There is no possibility to increase the agricultural area in Turkey due to population pressure. According to DIE (1996), the agricultural area was 27662000 ha in 1975 and 26986000 ha in 1996, the population was 40347719 in 1975 and 65311000 in 2000. Further more; agricultural sectors have not been develop in considered level, the reverse development occurred owing to misuse (Özcan, 1998). The structural problems in agricultural sector prevents desired developments. Farm sizes and number of plots are main structural problems in Turkey. The ratio of active member of family in agricultural to total member of family from 1980 to 1991 decreased 91% to 86%, respectively. Average farm size was 7.7 ha in 1950, 5.91 ha in 1991 and 62% of farms have less than sizes of 5 ha, 80% of farms have sizes of less than 10 ha area (Demirer, 1997). Increased population makes pressure to decrease farm sizes and to increase plots. Income obtained from small farms can not be sufficient to afford the needs of the farm family member and some of the members of the family

**Table 7. Rating of Soils for Human Waste Disposal in Septic Tank Seepage Fields.**

Soil No	Soil rating	Important properties
1	Well suited (Ws)	There is no problem.
2	Poorly suited (Ps)	There are slow permeability horizons.
3	Poorly suited (Ps)	There are slow permeability horizons and gleying horizons under the 2Cg horizon (75 cm+).
4	Poorly suited (Ps)	There are slow permeability horizons and gleying horizons under the 2Cg1 horizon (126 cm+).
5	Moderately well suited (Mws)	There are moderate permeability horizons, in addition some zones have C (%6-12) and D (%12-20) slope groups. These area belong to poorly suited class.
6	Well- Moderately well suited (Ws-Mws)	The horizons that placed in 60 cm depth have lower and of moderate permeability class and subsurface horizons have no limitations.
7	Well suited (ws)	There is no problem. However some zones have C (%6-12) slope group. These area belong to moderately well suited class.
8	Poorly suited (Ps)	There are slow permeability horizons and gleying horizons under the Cg horizon (86 cm+).
9	Well suited (Ws)	There is no problem.
10	Well suited (Ws)	There is no problem. However some zones have C (%6-12) slope group. These area belong to moderately well suited class.
11	Moderately well suited (Mws)	There are gleying horizons under the Cg horizon (111 cm+) and some zones have C (%6-12) slope group.
12	Poorly suited (Ps)	The profile has heavy textural classes and slow permeability class.
13	Poorly suited (Ps)	The profile has heavy textural classes and slow permeability class.
14	Poorly suited (Ps)	The profile has heavy textural classes and slow permeability class.
15	Moderately well suited (Mws)	The profile has lower end of moderate permeability class.
16	Poorly suited (Ps)	The profile has heavy textural classes.
17	Poorly suited (Ps)	The profile has heavy textural classes and slow permeability class. Some zones have C (%6-12) slope groups.
18	Poorly suited (Ps)	The profile has heavy textural classes and slow permeability class. Some zones have C (%6-12) slope groups.

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**Table 6.** Engineering Uses for Researched Soils.

Soil No	Horizon	Foundations*		Erosion		AASHO	Hydraulic Conductivity(cm/h)	Suitable moisture for Cultivation (%)
		Seepage	Important	Seepage	not Important	K Factor	T Factor	WEG <sup>a</sup>
1	Profile	4		8		0,14	3	5
2	Profile	3		7		0,18	2	2
3	Epipedon	3		7		0,20	3	3
	Subsurface (2A)	9 <sup>a</sup>		13 <sup>a</sup>		0,11		
4	Epipedon	4		8		0,21	4	5
	Subsurface(2A)	5		10		0,16		
5	Epipedon	4		8		0,11	4	5
	Subsurface(Bt)	9 <sup>a</sup>		13 <sup>a</sup>		0,13		
6	Epipedon	4		8		0,23	4	3
	Subsurface(Bt1)	5		9		0,19		
7	Epipedon	4		8		0,19	3	5
	Subsurface(Bw1)	5		9		0,15		
8	Epipedon	4		8		0,17	3	5
	Subsurface(Bt)	6		10		0,06		
9	Epipedon	3		7		0,18	4	3
	Subsurface(Bt1)	4		8		0,14		
10	Epipedon	3		7		0,21	4	3
	Subsurface(Btd)	4		8		0,19		
11	Epipedon	4		8		0,27	4	3
	Subsurface(Bt1)	10 <sup>a</sup>		14 <sup>a</sup>		0,13		
12	Epipedon	4		8		0,21	5	5
	Subsurface(2A)	11 <sup>a</sup>		14 <sup>a</sup>		0,14		
13	Epipedon	4		8		0,17	5	5
	Subsurface(2A)	10 <sup>a</sup>		13 <sup>a</sup>		0,14		
14	Epipedon	4		8		0,13	4	5
	Subsurface(2A)	5		10		0,11		
15	Profile	5		9		0,27	5	5
16	Profile	6		11		0,12	4	4
17	Profile	6		11		0,10	3	4
18	Profile	7		12		0,13	4	4

\*In ranked order: 1-best; 14- poorest. a) Volume change critical.



**Table 5. Engineering Uses for Researched Soils.**

Soil No	Horizon	When saturated	Shearing Strength	Compressibility	Permeability when compacted	Workability as a constructional material	Relative Desirability			for various		Uses*
							Homogenous embankment	Rolled Earth	Core	Shell	Erosion resistance	Canal sections
1	Profile	Good		Low	Impervious	Good	3	2	2	-	5	2
2	Profile	Good		Low	Semipervious	Fair	4	5	5	-	7	5 (erosion critical)
3	Epipedon	Good		Low	Semipervious	Fair	4	5	5	-	7	5 (erosion critical)
	Subsurface(2A)	Poor		High	Impervious	Poor	7 <sup>a</sup>	7	7	-	10	8 <sup>a</sup>
4	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(2A)	Fair		Moderate	Impervious	Fair	5	3	3	-	9	3
5	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(Bt)	Poor		High	Impervious	Poor	7 <sup>a</sup>	7	7	-	10	8 <sup>a</sup>
6	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(Bt1)	Fair		Low	Impervious	Good	4	3	3	-	5	3
7	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(Bw1)	Fair		Low	Impervious	Good	4	3	3	-	5	3
8	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(Bt)	Fair		Low	Impervious	Good	5	4	4	-	6	4
9	Epipedon	Good		Low	Semipervious	Fair	4	5	5	-	7	5 (erosion critical)
	Subsurface(Bt1)	Good		Low	Impervious	Good	3	2	2	-	5	2
10	Epipedon	Good		Low	Semipervious	Fair	4	5	5	-	7	5 (erosion critical)
	Subsurface(Btd)	Good		Low	Impervious	Good	3	2	2	-	5	2
11	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(Bt1)	Poor		High	Impervious	Poor	8 <sup>a</sup>	8	8	-	11	9 <sup>a</sup>
12	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(2A)	Poor		High	Impervious	Poor	8 <sup>a</sup>	8	8	-	11	9 <sup>a</sup>
13	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(2A)	Poor		High	Impervious	Poor	7 <sup>a</sup>	7	7	-	10	8 <sup>a</sup>
14	Epipedon	Good		Low	Impervious	Good	3	2	2	-	5	2
	Subsurface(2A)	Fair		Moderate	Impervious	Good	5	3	3	-	9	3
15	Profile	Good		Low	Impervious	Good	4	3	3	-	6	2
16	Profile	Fair		Moderate	Impervious	Fair	6	3	3	-	9	4
17	Profile	Fair		Moderate	Impervious	Fair	6	3	3	-	9	4
18	Profile	Fair		Moderate	Impervious	Fair	7	5	5	-	11	5

\*In ranked order: 1-Best; 14- Poorest. a) Volume change critical.

12	Poorly suited (Ps)	Unified soil group for sub-grade is CH under the 2A horizon (34 cm+). High shrink- swell potential.
13	Poorly suited (Ps)	Unified soil group for sub-grade is CH under the 2A horizon (38 cm+). High shrink- swell potential.
14	Poorly suited (Ps)	Unified soil group for sub-grade is CL with plasticity index value 23,2. High shrink- swell potential.
15	Poorly suited (Ps)	Unified soil group for sub-grade is CL with plasticity index value 23,7. High shrink- swell potential.
16	Poorly suited (Ps)	Unified soil group for sub-grade is CL with plasticity index value 28,5. High shrink- swell potential.
17	Poorly suited (Ps)	Unified soil group for sub-grade is CL with plasticity index value 22,7. High shrink- swell potential. Some zones have high grade slope (%8-15).
18	Poorly suited (Ps)	Unified soil group for sub-grade is CL with plasticity index value 29. High shrink- swell potential. Some zones have high grade slope (%8-15).

**Table 4. Rating of Researched Soils for Buildings.**

Soil No	Soil rating	Important properties
1	Well suited (Ws)	It's beginning sandy horizon below the 4C horizon (170 cm+). Also these soils are suitable for without basements building.
2	Well suited (Ws)	It's beginning sandy horizon below the 2CA horizon (160 cm+). Also these soils are suitable for without basements building.
3	Moderately well suited (Mws)	It's beginning sandy horizon below the 2C horizon (73 cm+). Also these soils are more suitable for without basements building.
4	Moderately well suited (Mws)	Unified soil group in the subsurface horizons is CL with plastic index 24,7. It's beginning gleying horizon below the 2Cg1 horizon (126 cm+).
5	Poorly suited (Ps)	Unified soil group in the subsurface horizons is CH.
6	Well suited (Ws)	There is no problem.
7	Moderately well suited (Mws)	It's beginning gleying horizon below the 2C horizon (140 cm+).
8	Moderately well suited (Mws)	It's beginning gleying horizon below the CB horizon (86 cm+). Also these soils are more suitable for without basements building.
9	Well suited (Ws)	There is no problem.
10	Moderately well suited (Mws)	It's beginning gleying horizon below the C horizon (110 cm+).
11	Poorly suited (Ps)	Unified soil group in the subsurface horizons is CH.
12	Poorly suited (Ps)	It's beginning gleying horizon below the C horizon (110 cm+). Unified soil group in the subsurface horizons is CH. The profile has high shrink- swell potential and very poorly drainage class.
13	Poorly suited (Ps)	Unified soil group in the subsurface horizons is CH. The profile has high shrink- swell potential and very poorly drainage class.
14	Poorly suited (Ps)	Unified soil group in the subsurface horizons is CL with plastic index 23,18. The profile has high shrink- swell potential and poorly drainage class.
15	Poorly suited (Ps)	Unified soil group is CL with plastic index 23,68. The profile has high shrink- swell potential and poorly drainage class.
16	Poorly suited (Ps)	Unified soil group is CL with plastic index 28,46. The profile has high shrink- swell potential and poorly drainage class.
17	Poorly suited (Ps)	Unified soil group is CL with plastic index 22,73. The profile has high shrink- swell potential and poorly drainage class.
18	Poorly suited (Ps)	Unified soil group is CL with plastic index 29. The profile has high shrink- swell potential and very poorly drainage class.

Table 2	continued	
6	SCL on SL, superactive, acid, mesic, Haplic Palixeralf	Poorly suited (Ps)
7	SCL, superactive, acid, mesic, Inceptic Haploxeralf	Poorly suited (Ps)
8	SC on SCL, superactive, acid, mesic, Inceptic Haploxeralf	Poorly suited (Ps)
9	SC on CL, superactive, acid, mesic, Ultic Haploxeralf	Epipedon-Moderately well suited (Mws) Subsurface horizons-Poorly suited (Ps)
10	SCL on SL, superactive, acid, mesic, Typic Haploxeralf	Epipedon- Moderately well suited (Mws) Subsurface horizons- Poorly suited (Ps)
11	SC on SL, superactive, acid, mesic, Typic Haploxeralf	Epipedon- Poorly suited (Ps) Subsurface horizons- Unsuited (Us)
12	fC on SCL, smectitik, superactive, nonacid, mesic, Entic Haploxerert	Epipedon- Poorly suited (Ps) Subsurface horizons- Unsuited (Us)
13	C on SCL, smectitik, superactive, nonacid, mesic, Entic Haploxerert	Epipedon- Poorly suited (Ps) Subsurface horizons- Unsuited (Us)
14	SC on SCL, smectitik, superactive, nonacid, mesic, Entic Haploxerert	Epipedon- Poorly suited (Ps) Subsurface horizons- Unsuited (Us)
15	C on SC, smectitik, superactive, nonacid, mesic, Udic Haploxerert	Unsuited (Us)
16	C on CL, smectitik, superactive, nonacid, Calcareous in subhorizons, mesic, Udic Haploxerert	Unsuited (Us)
17	C, smectitik, superactive, nonacid, mesic, Typic Haploxerert	Unsuited (Us)
18	C, smectitik, superactive, calcareous, mesic, Typic Calcierert	Unsuited (Us)

\*Moderately well suited- Probable source. Poorly suited and Unsuited- Improbable source

**Table 3. Ratings of Researched Soils for Secondary Roads.**

Soil No	Soil rating	Important properties
1	Moderately well suited (Mws)	Downgrade soil rating to moderate causes content of fines is more than about 30% between 35-90 cm.
2	Well suited (Ws)	There isn't any limitation factor..
3	Poorly suited (Ps)	Unified soil group for sub-grade is CH under the 2A horizon (28 cm +).
4	Poorly suited (Ps)	Poorly drained in epipedon and unified soil group for sub- grade is CL with plasticity index value 23,7.
5	Poorly suited (Ps)	Unified soil group for sub-grade is CH under the Bt horizon (28-46 cm). Some zones have high grade slope (%8-65).
6	Moderately well suited (Mws)	Downgrade soil rating to moderate causes content of fines is more than about 30% between 23-80 cm.
7	Poorly suited (Ps)	Unified soil group for sub-grade is CL with plasticity index valu 28. Some zones have high grade slope(%8-15).
8	Moderately well suited (Mws)	Downgrade soil rating to moderate causes content of fines is more than about 30% under the Bt horizon (31 cm +).Some zones have high grade slope (%8-15).
9	Moderately well suited (Mws)	Downgrade soil rating to moderate causes content of fines is mor than about 30% under the Bt1 horizon(44cm+).
10	Moderately well suited (Mws)	Downgrade soil rating to moderate causes content of fines is more than about 30% under the Btd horizon (12 cm +).Some zones have high grade slope (%8-15).
11	Moderately well suited (Mws)	Unified soil group for sub-grade is CH under the Bt1 horizon (28cm+). Some zones have high grade slope (%8-15).
Table 3	continued	



**Table 1.** The Results of Atterberg Limits and Some Important Engineering Properties.

Soil No Horizon	Plasticity Index	Liquid limit	Plastic limit	Clay (%)	Silt (%)	Texture	Clay ctivity	Optimum moisture (max density %)	USC
2/ A	2,70	9,82	7,12	8,16	10,05	LS	0,33	-	SM
2/Ax	3,23	14,12	10,89	10,17	16,08	SL	0,32	8,96	SM
9/A	3,27	13,78	10,51	11,09	11,83	SL	0,29	9,11	SM
10/A	5,51	15,37	9,86	12,76	12,19	SL	0,43	8,83	SM
3/A	6,03	18,03	12,00	16,96	12,30	SL	0,36	10,55	SM
12/A	6,88	19,41	12,53	20,07	14,22	SCL	0,34	10,11	SC
11/A	6,89	19,24	12,35	16,86	16,18	SL	0,41	10,13	SC
1/A	7,31	20,16	12,85	20,77	12,17	SCL	0,35	11,64	SC
6/A	9,11	24,74	15,63	14,55	22,36	SL	0,63	12,66	SC
13/A	9,15	21,82	12,67	26,78	14,16	SCL	0,34	11,50	SC
8/A (phase)	10,58	2,54	11,96	15,57	14,27	SL	0,67	11,00	SC
4/A	11,63	25,14	13,51	27,10	12,28	SCL	0,43	11,76	SC
8/A	13,98	26,48	12,50	21,54	10,69	SCL	0,65	11,78	SC
14/A	15,16	28,20	13,04	27,23	16,63	SCL	0,56	12,29	SC
7/A	15,19	30,14	14,95	28,26	12,42	SCL	0,53	13,21	SC
9/Bt1	16,05	33,44	17,39	34,65	8,04	SCL	0,46	14,26	SC
5/A	18,33	31,91	13,58	32,64	14,36	SCL	0,55	13,40	SC
10/Btd	21,18	35,23	14,05	34,38	8,44	SCL	0,62	13,80	SC
7/Bw1	21,41	36,61	15,20	32,11	11,37	SCL	0,67	14,33	SC
6/Bt1	21,68	38,11	16,43	33,52	12,45	SCL	0,65	15,60	SC
8/Bt	21,96	36,18	14,22	44,28	6,01	SC	0,50	14,51	SC
17/A	22,73	39,50	16,77	41,50	15,07	C	0,55	14,96	CL
14/2A	23,18	42,56	19,38	43,56	8,21	SC	0,53	16,61	CL
15/A	23,68	38,34	14,66	39,83	16,84	SC	0,59	15,72	CL
4/2A	24,69	41,13	16,44	42,19	9,09	SC	0,59	16,04	CL
16/A(Variant)	27,88	45,04	17,16	39,52	16,84	CL	0,71	16,22	CL
16/A	28,46	43,64	15,18	38,94	16,89	CL	0,73	16,00	CL
18/A	28,67	45,52	16,85	47,97	11,75	C	0,60	15,90	CL
18/Ass	29,92	48,74	18,82	60,43	10,22	C	0,50	17,27	CL
11/Bt1	33,51	55,19	21,68	44,92	6,32	SC	0,75	18,87	CH
3/2A	34,61	53,75	19,14	49,44	12,61	C	0,70	18,22	CH
5/Bt	34,86	54,92	20,06	52,09	8,75	C	0,67	18,41	CH
13/2A	36,50	50,32	13,82	46,45	14,25	C	0,79	17,44	CH
12/2A	40,22	58,25	17,73	55,31	6,41	C	0,73	19,25	CH

**Table 2.** Rating of Soils as Sources of Aggregate Material for Construction Purposes.

Soil No	Soil Family	Properties*
1	SC on SCL, superactive, acid, mesic, Haplic Xerarent	Poorly suited (Ps)
2	SL on LS, active, nonacid, mesic Typic Xerofluvent	Moderately well suited (Mws)
3	C on SL, superactive, acid, mesic, Typic Xerorthent	Epipedon- Moderately well suited (Mws) Subsurface horizons- Unsuited (Us)
4	SC on SCL, active, nonacid, mesic Fluventic Haploxerept	Epipedon- Poorly suited (Ps) Subsurface horizons- Unsuited (Us)
5	C on SCL, active, acid, mesic, Calcic Palaxeralf	Epipedon- Poorly suited (Ps) Subsurface horizons- Unsuited (Us)

## **Interpretation for Engineering Purposes on the Projects of Land Use Planning and Soil Management**

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The agricultural and pasture land alone cannot guarantee safe environment, as long as other land uses exist in a region. Agricultural production policies must constitute on land use planning projects. Sustainable agriculture is only possible, if all the other land uses are sustainable as well. In this definition, sustainability can be determined by ecological as well as by socio- economic and cultural factors. One of the strategical goal in relation to sustainable agriculture are considered that the growth or new settlement of urban and periurban or town areas in regard to land use planning; sustainable soil management and environmental protection. A child born in future has less change of getting adequate food to eat, space to live and pure air to breathe if compare a child born today. The first rule of the conservation and management of the soils secure to continued satisfaction of human needs for present and future generations. In this way, for these reasons the soils evaluate for engineering purposes for the sustainable agriculture and land use planning. Soils of the Karamehmet village (Tekirdağ- Thrace) were evaluated for different engineering purposes in order to determine the most suitable land use or land use system and ratings of soils for non-agricultural uses like secondary road in soils, aggregate soil materials, building foundations in soils, human waste disposal in soils, dam and embankment of soil materials. This kind of studied should be useful to the members of agricultural sector; also to teams of the other engineering branches, architects, regional (rural and city) planners, inspectors, Project manager, superintendents, manufacturers, specification writers.

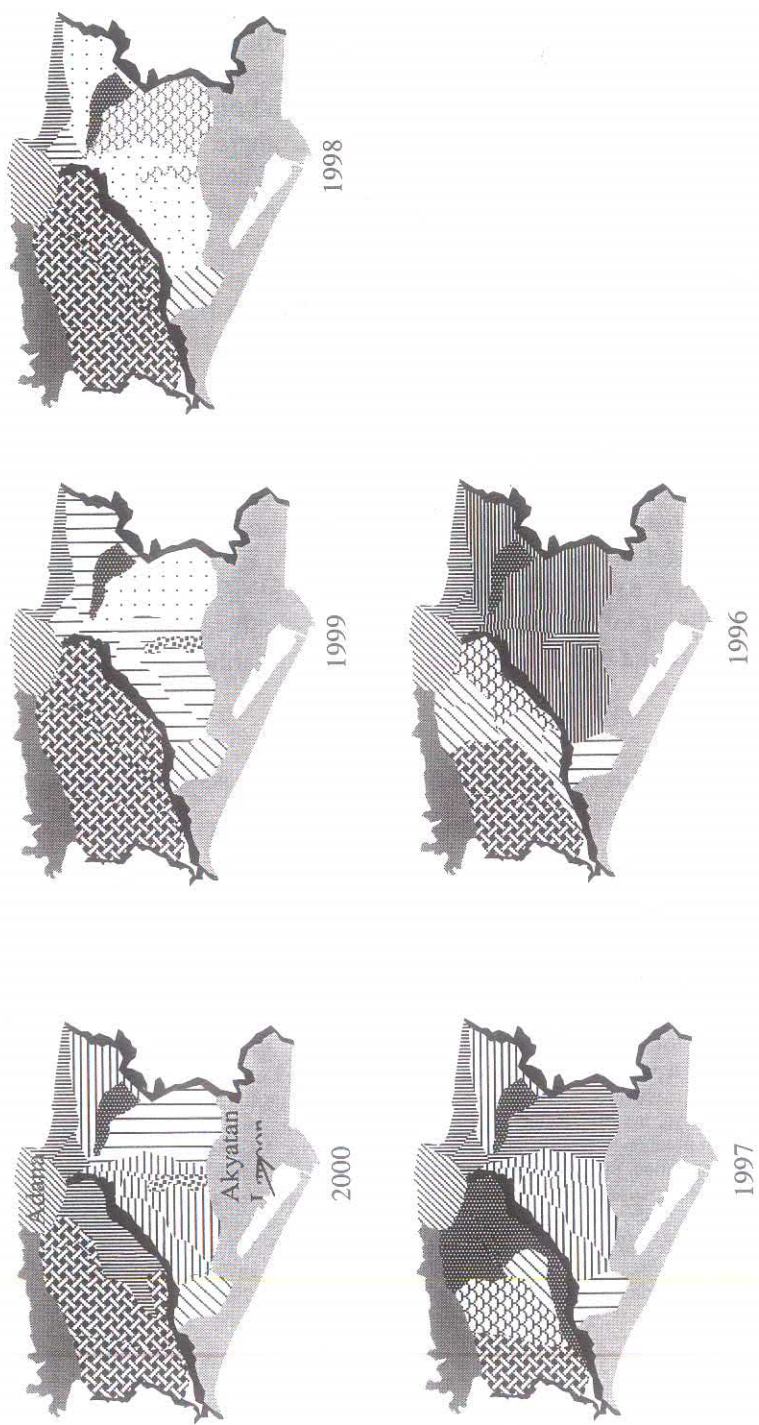


Figure 2. Spatial and temporal changes of groups from 1996 to 2000.



Coefficients of determination of regression equations between parcel size and plot; plot and LUE; parcel size and LUE for both YP and TP were -0.62, -0.02, 0.54; -0.07, -0.44 and 0.35, respectively. Plantation percentage of 10 LUTs of 18 WUAs were grouped by clustering from 5 to 10 and the best result was obtained from the clustering system containing eight groups. As seen in Figure 2, groups were changed over the study area in both space and time. The WUAs named Toroslar, Cotlu and Ata were differentiated from others. The soil and topographic properties of Toroslar and Cotlu WUAs are different from others and Toroslar has opportunity to get irrigation water from irrigation canals during the year. Ata has no full irrigation infrastructure, but it has opportunity to be irrigated from Seyhan river and well. The other WUAs both YP and TP mainly show similar behaviour in their plain. This situation can be attributable to the farmer's habit and neighbour effect.

## Conclusions

In the study area, average parcel size, plot and total parcel values appear to be different in two plains. However, this situation could not be justified by statistical test at 95% probability level but clustered results and produced maps showed that groups changed in space and time. Therefore, it is considered that the following consequence can be attributable on these changes. The main factors affect on determining of LUTs mainly topographic and soil properties, possible irrigation for all the year, neighbour effect and farmer behaviour, respectively.

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maps. The F-test was utilised for parcel size, number of parcel and land use efficiency (LUE); Student t test was performed for the LUTs; correlation coefficient was performed to understand the relationships between number of plot and parcel size, between number of plot and LUE, between parcel size and LUE of the WUAs within Yüreğir and Tarsus Plain (Davis, 1986).

## Results

### Water User Associations in The Study Area

The State Hydroulic Works were handing over the management and operation of irrigation schemes to WUAs between 1994 and 1995 in a study area. Some data belong to WUAs are presented in Table 1.

**Table 1.** Some data belongs to WUAs.

WUAs	Area (ha)	Average parcel size (ha)	Total parcel	Number of farm family	Number of plot
Cumhuriyet	2655	1.5	1770	637	2.8
K.Yüreğir	4860	2.86	1699	1362	1.3
Akarsu	8943	3.37	2654	2095	2.7
Çotlu	2425	3.5	693	849	2.0
G.Yüreğir	16890	1.6	10556	3330	5.2
Gökova	4289	4.5	953	605	2.4
Gazi	6394	7.1	901	967	1.6
Kadıköy	9808	5.3	1851	1715	2.0
Yenigök	1864	5.8	321	277	1.6
Ata	600				
<b>Average</b>	<b>5873</b>	<b>3.95</b>	<b>2377</b>	<b>817</b>	<b>2.41</b>
Toroslar	13700	1.6	8563	7970	1.6
Yeşilova	3740	3.1	1206	790	3.3
Çukurova	6847	1.8	3804	3113	2.2
Y.Seyhan	4895	2.4	2040	1554	2.8
Seyhan	3610	2.9	1245	1094	1.9
Altınova	6150	4.4	1398	1147	2.0
Pamukova	12037	2.1	5732	4862	2.8
T.Onköy	11983	1.6	7489	5180	3.1
<b>Average</b>	<b>7870</b>	<b>3935</b>	<b>1762</b>		<b>2.47</b>

### Statistical Analysis

Changes in variances of two groups of WUAs for five years were tested. The results showed that the changes in variances of most variates, except for parcel size, were not significant at the level of 95% (Table 2).

**Table 2.** Test results for equality of variances and mean.

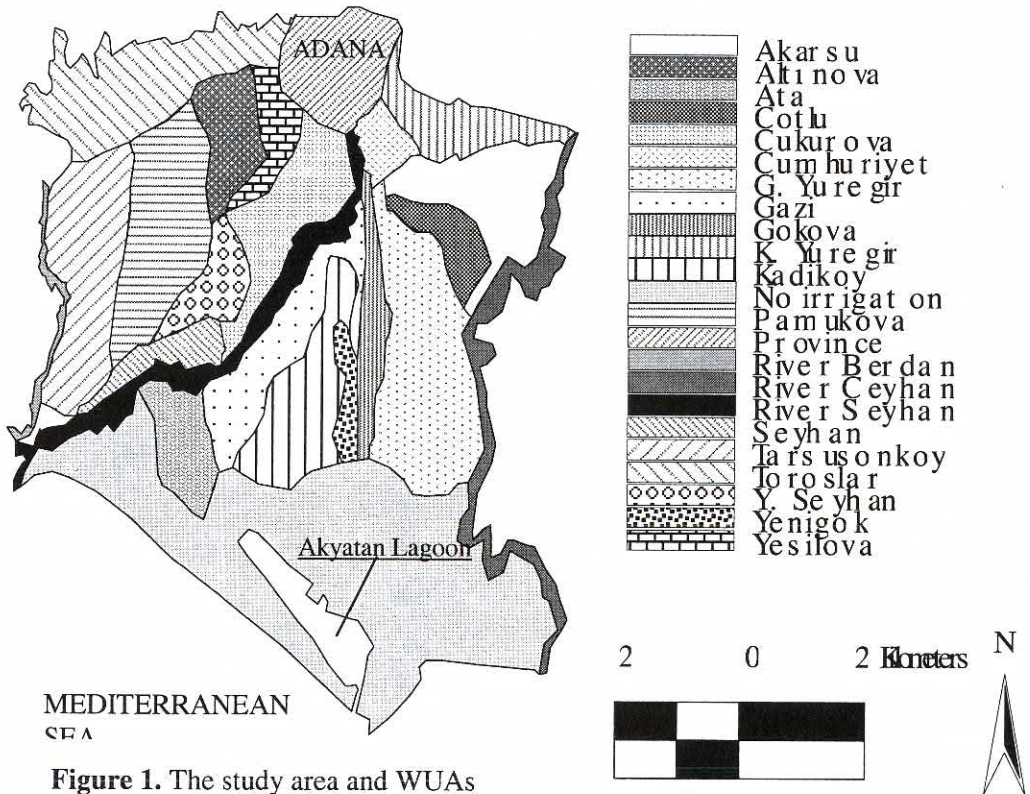
Statistics	Number of Parcel		Parcel size		LUE		Plantation ratio of	
	YP	TP	YP	TP	YP	TP	LUT	YP TP
F test for equality of variances								
S	2378	3935	39.48	24.88	84.30	78.93	13.098	9.759
df (v=n-1)	8	7	8	7	9	7	9	9
F calculated	1.12	Accepted	3.92	Rejected	1.7	Accepted	1.68	Accepted
F critical ( $\alpha=0.05$ )	3.73		3.73		3.68		3.18	
Student t test for equality of mean								
x							13.098	9.759
df (v=n+m-2)							9	
t calculated							1.99	Accepted
t critical ( $\alpha=0.05$ )							2.26	



The archive data of 18 WUAs from 1996 to 2000, topographic maps scaled 1/25000 and irrigation schemes of WUAs were used in the study as a basic material.

### Data collection

The LUTs of each WUAs for consecutive 5 years, from 1996 to 2000, were taken from archive data of 18 WUAs.



**Figure 1.** The study area and WUAs

### Data analysis

A map showing WUAs was overlaying on the topographic maps and was recorded in the digital form by scanning. This scanned map was digitised by screen digitisation to form a digital data based analysis, which will serve LUTs change analysis. Investigation of 5 years Archive data, 23 different LUTs were distinguished and 10 of them which have largely planted and more economical priority were used to cluster in the monitoring and evaluation of LUTs change. These data were grouped by clustering from 5 to 10 by using SPSS software (SPSS, 1988). Clustering was based on the plantation percentage of selected 10 LUTs of WUAs. The clustering results were exported to geographical information systems (GIS) used for output on monitoring of the change of LUTs. The Arc View 3.0 GIS (ESRI, 1996) was employed to developed the



Differences in soils and their ability to produce crops have been recognized world over since ancient times. The capability of a land to grow plants and to produce crops depends both on physical factors (climate, soil, physiography,...etc.) and on the socio-economic context (availability and skill of manpower, technology, management, land tenure, market conditions, etc.) (Bennett, 1976; Alig, 1986; Fortmann and Kusel, 1990; Turner et al., 1991; Sys et al., 1991). Physical, cultural and socio-economical factors and environmental characteristics generally determine the type of farming done. Özcan and Gümüş (2000) investigated the some socio-cultural factors affect on determinig land use type. They stated that soil, topography, market conditions, distance to big settlement were more effective than socio-cultural factors in the Tarsus Plain, Turkey. Concurrently, in many cases, the type of farming systems determined by the variety of socio-economic situations is also very variable. So, insufficient and non-detailed knowledge of natural resources, we can easily misuse natural resources. This situation is one of the most important reason for land degradation and inappropriate land use. Statistics, data bases, geographic information processing are well known computer applications in land evaluation and testing land use efficiency.

The objectives of this paper are; first to examine and monitor the land use type (LUT) changes which occured during the period from 1996 to 2000 based on the area of eighteen Water User Associations (WUA) in the Lower Seyhan Irrigation Project Area within Çukurova Region, Turkey and second to determine factors which affect this change

## **Material and Methods**

This study was carried out in Lower Seyhan Irrigation Project Area within Çukurova Region in Turkey. The area of Çukurova was chosen as a suitable pilot area for the development of such a monitoring system and land use change analysis. The geology, soils and water resources of the area have been studied during the last five decades. The social and economic structure, and the land use history are also known from previous studies and archive data. The land use change in the area is so dynamic, that was expected that there would be sufficient changes within five years.

Area description: The study area lies between 36°30' and 37°00' northern latitude and covers 120 000 ha irrigation area. River of Seyhan divides the area in two plains which are Yuregir (YP) in left side has 10 WUAs and Tarsus (TP) in right side has 8 WUAs that founded between 1994 and 1995 (Figure 1). The area has a typical mediterranean climate and the soils can be grouped into five geomorphic units (Dinc et al., 1990).

## Water User Association and Land Use

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### Abstract

The purpose of this study was; firstly to examine the land use type changes which occurred during the period from 1996 to 2000 based on the area of Water User Associations (WUA) and secondly to determine factors which affect this change.

This study was carried out in seventeen WUAs in Lower Seyhan Plain Irrigation Project Area, Turkey. The archive data of land use types (LUT) and their plantation ratio of seventeen WUAs between 1996 and 2000 were used.

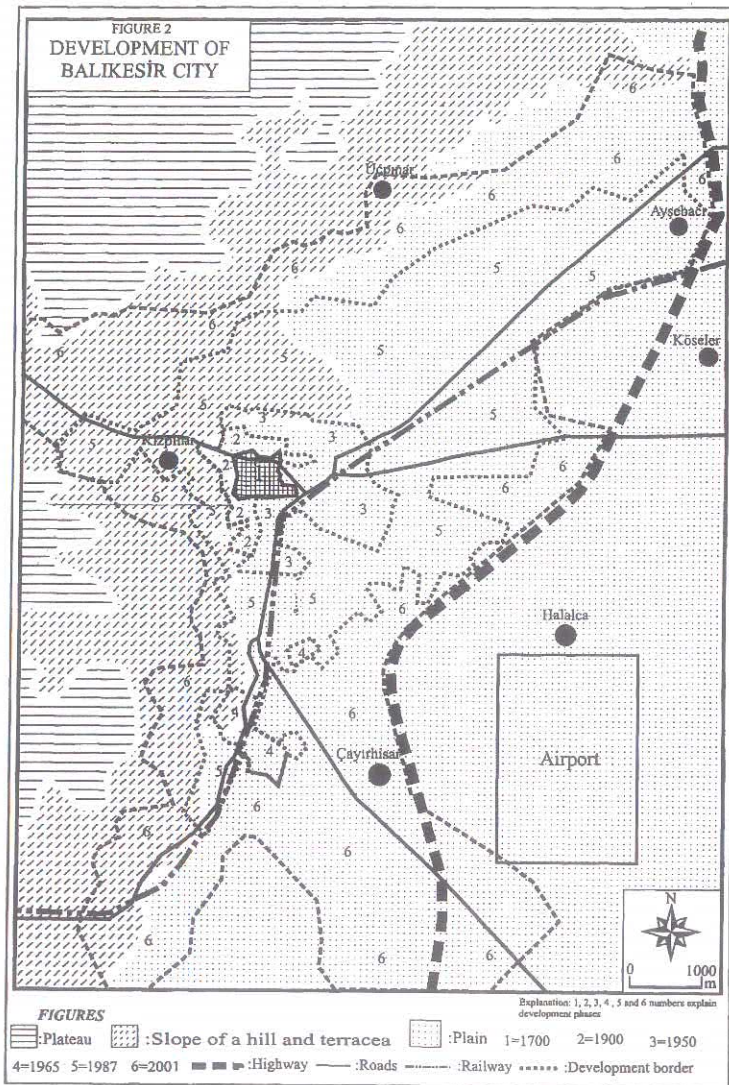
The data for consecutive five years of WUA were grouped by clustering from 5 to 10 and the best result was obtained from the clustering system containing eight groups. The clustering results were transferred to a Geographical Information System (GIS-Arc View 3.0) for output on group and group changes.

Two WUAs namely Toroslar and Çotlu showed an independence behaviour for all years due to different soil and specially topographical properties. Grouping results obtained from Tarsus plain were different from those of Yüreğir plain. This could be attributed on farmer behaviour such as habititiy and neighbourship. The grouping results showed that the main effect interms of the factors affecting on the change of LUTs was soil and topographic properties, and was followed by habits and neighbour's behaviour. The last factors were the parcel sizes, number of plot, the distance from water resources, main road and urban area.

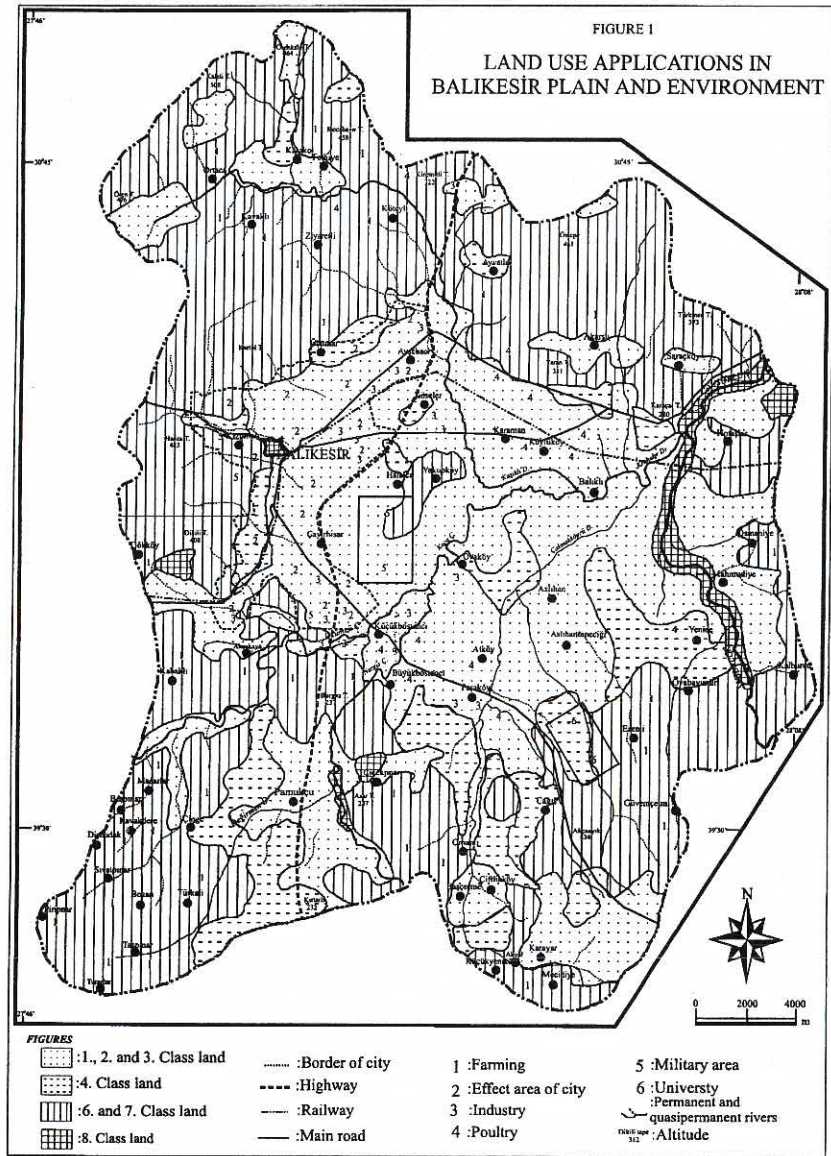
### Introduction

There is a growing awareness that water will be one of the most critical natural resources in the next century. In many parts of the world it became apparent that bureaucracies, with staff trained as administrators, were not best suited for management tasks. Various approaches have been made to hand over the management of irrigation projects and even of larger water resources development entities to organisations of the users or closer to the users (Tekinel and Doorenbos, 1997). Water for irrigation carries a high value and has an appreciable cost. Therefore, the irrigation project has begun to transfer users. To establish of Water User Associations (WUA) were accelerated over the last ten years in Turkey. Besides irrigation scheme and transfer, improvement of the agricultural product is related to use of agricultural area in a well design land use planning or managing system. Water and soil are essential for land use. Knowledge of soil and water conditions is indispensable for the understanding of past and present land use as well as for prediction of future uses.









agricultural lands ( I., II., III.,and IV. class lands). The continuation of this enlargement will cause Balıkesir Plain to be used completely for non-agricultural purposes. The urbanization of Balıkesir town settlement being in this direction will be wrong with the respects of Turkish agriculture and economy. Therefore, the decisions made for the urbanization of Balıkesir should be reviewed. The most suitable direction of enlargement of Balıkesir town settlement is the hillsides and plateau surfaces to the west of the town. These areas are non-agricultural lands (Figure 1). In addition to its preventing wrong land use, the westward enlargement will be the solution to the problems of air pollution and sewage system.

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lands. The small industrial site which was founded near Ayşebacı village caused the urbanization to direct to this part (Figure 2). In the last period the urbanization directed mostly to the north and the south (Figure 2). The town reached the area of 5 690 ha with an enlargement of 134%. In this period, the urbanization towards the north and the west show the correct use of land. However, the urbanization around Ayşebacı village and in the south is totally wrong use of land. Settlement, transport and industrial plants on agricultural lands point out applications of wrong land use (Figure 2). The town enlarged to İstanbul-İzmir highway from the east. And the highway blocked the eastward urbanization. Enlargement of Balıkesir town settlement is expected to take place towards Ayşebacı village in the north and the university campus in the south-east. The enlargement towards the university is thought to happen after the side of İstanbul-İzmir highway has been completely filled (Figure 1). In the meanwhile, it is also noticed that there are tendencies to cross the highway towards the east. The urbanization areas mentioned above will lead to an increase in the wrong land use. Urbanization has already started from Kızıpınar, Adnan Menderes settlements onwards. Enlargement towards the west will be the correct choice in regard to the land use capability classification. The industrial site and the new suburban settlements by the motorway of Balıkesir-Edremit are the samples of correct area selection in respect to the land use capability classification. No urbanization towards this area, however, is expected.

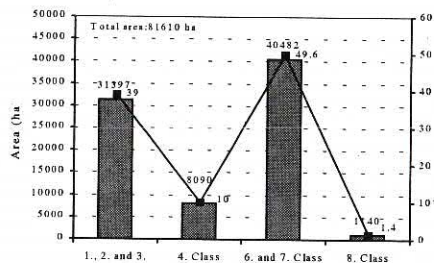


Figure 3. Land Use Capability Class and total area of Balıkesir Plain and its environment

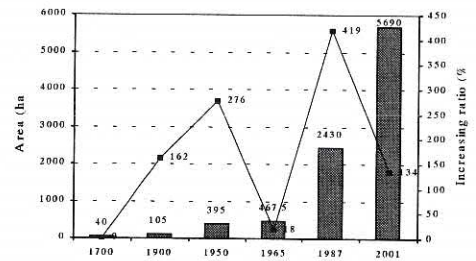


Figure 4. Widen ratio according to preceding period and total area of Balıkesir city

## Conclusion

The first foundation area of Balıkesir settlement is the sample of correct area selection in respect to the land use capability classification. Nevertheless, in the later periods correct area selection did not continue. It has rapidly enlarged to



activities . Scientific studies (Akalan 1974, Güzel et al., 1999, Kocataş 1997), missionary works (Commission 1992) and the regulations (1989, 1998) specify the use of the first four classes of lands in detail. These lands must only be used for agricultural purposes.

V. class of land has not been found in Balıkesir Plain (Figure 1, 3). VI. and VII. classes of land cover 49.6% (40 482 ha) and VIII. class of land covers 1.4% (1 140 ha) of the research area (Figure 1, 3). In other words, the areas suitable for non-agricultural use forms 51% (41 622 ha) (Figure 1, 3). In the research area, the ratio of agriculturally suitable lands is higher than the ratio of Turkey (34%) and of Balıkesir (23.5%). The agricultural lands in Balıkesir Plain and its environment are important land sources of Turkey. Land use activities in Balıkesir Plain are given under the four headings of agriculture, settlement, transportation and industry (Figure 1). The general use of land in the area is observed to be based on Balıkesir settlement (Figure 1). It has been found out that wrong land use is common in Balıkesir Plain and its environment (Koç 2001b). It can be noticed that there is a decrease in wrong land use towards the east of the town of Balıkesir which is located in the west of Balıkesir Plain. This fact indicates that urbanization is a determining factor in the land use in Balıkesir Plain.

The first settlement of the town is on the east skirts of Harita Hill. The old town which covered approximately 40 ha in 1700's is placed in VI. and VII. class lands (Figure 1, 2, 4). The selection of the first settlement place is quite right from the view of land use capability classification. The enlargement between 1700 and 1900 took place towards north-western and western directions, towards the VI. and VII. class lands (Figure 2). During the two century-period the town enlarged at 162% to cover 105 ha (Figure 4). In this period Balıkesir was still a small town. The third period was nearly at the same time as the foundation of the Turkish Republic (1900-1950). During this period the town enlarged its area at 276% to reach 395 ha (Figure 2, 4). But the enlargement between the years 1900 and 1950 took place towards the east where productive agricultural lands were available. The town which had not passed across the railway in the east before now began to extend towards the productive plain. In the period between 1950 and 1965 the urbanization speed slowed down considerably (Figure 2, 4). In this period the new settlements of Gaziosmanpaşa and Plevne were founded to the south of the town. These new settlements are located on the productive agricultural lands (Figure 2).

The period of 1965-1987 is the period when urbanization was at its highest level. In this period the town enlarged its area 419% bigger than it was in the previous period and reached 2430 ha (Figure 2, 4). As a result of the rapid enlargement of the town, Kızpınar and Ayşebacı villages are included in the town area. The most apparent feature of this period of 1965-1987 is that the rapid enlargement of the town was directed onto the productive agricultural

show that non-agricultural land use has become an important problem in Turkey.

One of the counties of Turkey where non-agricultural land use is common is Balıkesir. The county of Balıkesir is located in the middle of three big cities, Istanbul, Bursa and Izmir. And the plain where the town of Balıkesir is located is a tectonic-formed Neogene sunken plain. Balıkesir Plain is surrounded by plateau levels ranging between 300 and 400 m. The town which has a population of 200 000 is located in the west of Balıkesir Plain. The most important problem is that the town is developing into the productive areas. There is a relationship between this problem and the urbanization. In this research, the relationship between urbanization and wrong land use in Balıkesir Plain and its environment is studied.

### **Material and Methods**

The area of the research is consisted of Balıkesir Plain and Pamukçu Plain which is connected to it through a gorge from the south-west. These two plains are defined as Balıkesir Plain in this research. The border line around Balıkesir Plain is formed by the watershed of the short-period streams that flow into the plain basin (Figure 1).

First of all, the reference books about the physical properties of Balıkesir Plain and its environment were obtained (Özoğul 1987, Koç 2001a). Then, the works which mention about the social conditions of the area were examined (Ayyıldız 1988, Tolun 1970). Apart from these, the researches made by Aktimur et al. (1994), Eren (1995) and Koç (1997) about the environmental problems around Balıkesir were also reviewed.

The maps (1/100 000) and the report of Land Use Capability Classifications prepared by Güzel et al. (1999) were used as the main source of data on the relationship between urbanization and land use in Balıkesir Plain. Topography, land and urbanization maps were scaled to 1/50 000 and the relationship was searched. In each period of urbanization (between the years 1700 and 2001) the urbanization area was calculated and examined for wrong land use. The years to be examined during the research were specifically determined according to the availability of the urbanization plans. The results of the studies are submitted in two maps (Figure 1, 2).

### **Results**

The research area is consisted of the central plain, the surrounding plateau and the slopes between these areas (Figure 1). As the plain covers a large area, it provides a large agricultural land. The lands suitable for agricultural farming (I., II., III. and IV. class lands) covers 49% of the research area (39 487 ha) (Figure 1, 3). These are the lands in which the priority must be given to agricultural



## Urbanization and Land Use in Balıkesir Plain

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### Abstract

Balıkesir Plain is located in Marmara District, Karesi Environs of South Marmara Region. Land use capability classifications have been determined for sustainable use. Farming areas are very wide in Balıkesir Plain and its environment. In this research, it has been studied how carefully land use capability classification is taken into consideration when the land is used in Balıkesir Plain and its environment.

An agricultural area in which planted farming must be done covers only 49% of Balıkesir Plain and its environment. In addition to this, it has been found out that very big parts of the productive areas are not used for agricultural purposes. The causes of wrong land use in Balıkesir Plain and its environment are urbanization, and the use of productive areas for communication, industry and military purposes. Wrong land use is increasing in Balıkesir Plain and its environment. If it is not prevented, concrete will cover all of the agricultural areas in Balıkesir Plain. In order to prevent the wrong land use, development of the city of Balıkesir, construction works in the industrial area and the communication lines must be taken under control.

**Key words:** Land use, wrong land use and urbanization.

### Introduction

The rapid increase in population and consequently, in consumption has a growing pressure on natural resources. One of the irreplaceable resources is the soil. The soil whose formation could take hundreds of years can vanish in a very short time. 34% of the Turkish territories is consisted of the land (I., II., III., and IV. class areas) which must be used for agricultural purposes only (Cangir et al., 1996). The average height in the Turkish territories being 1132 m and 82.17% of its lands being too steep are the main cause that leads to the limited amount of agricultural areas (Atalay 2000). These facts point out that utmost care must be shown to protect the agricultural areas in Turkey.

One of the most important problems related to soil is the use of the agricultural lands for non-agricultural purposes. According to the data of 1996, 18% of the potential agricultural lands of Turkey (4 787 451 ha) is being used wrongly and for non-agricultural purposes (Cangir et al., 1996). While the loss of agricultural lands due to wrong and non-agriculturally use was 171 992 ha in 1978, it reached 573 239 ha in 1996 (Cangir et al., 1996). And the use of land for non-agricultural purposes is increasing. The increase between the years 1978 and 1996 has been found as 333.3% (Cangir et al., 1996). The reference researches



Table 3. Land slope groups and usage distribution in Çanakkale

Slope	General total (ha)	%
Flat (%0-2)	76,170	7.91
Slight slope (%2-6)	97.825	10.15
Total	<b>173.995</b>	<b>18.06</b>
Medium (%6-12)	134.852	14,00
Steep + (>%12)	<b>654.633</b>	<b>67.94</b>
Total	789.485	81.94
General total	963,480	100.00

Table 4. Distributions of lands according to soil depths in Canakkale

Soil depth (cm)	Area (ha)	%	%	
Very shallow ( 0 - 20 )	298,060	30,63	82,77	Agricultural lands, pastures, forests and scrubs
Shallow ( 20 - 50 )	499,485	51,84		
Moderately deep( 50 - 90 )	52,306	5,43	15,58	
Deep ( 90+ )	97,798	10,15		
Total	947,649			
Very shallow ( 0 - 20 )	2512,000	1,65		Other lands (Sand dunes, river beds, rocks and rubbles)
Shallow ( 20 - 50 )	7735,000			
Moderately deep( 50 - 90 )	2516,000			
Deep ( 90+ )	3139,000			
Total	15,902	100,00		
General total	963,551			

Table 5. Effects of water erosion on lands which are suitable and unsuitable to arable agriculture in Canakkale

Erosion severity	Lands suitable for arable agriculture (ha)*	%		Lands unsuitable for arable agriculture (ha)	Total of province (ha)	%	
No or slightly eroded	96.513	26.85	53.49	4.374	100.887	10.47	89.53
Moderately eroded	125.914	35.02		22.229	148.143	15.38	
Severely eroded	66.406	18.47		612.492	678.898	70.46	
Extremely eroded	-			35.623	35.623	3.69	
Total	288.833			674.718	963.551	100,00	

\* Except I. Class lands

Total agricultural lands are 359,551 ha in Canakkale province.

Tablo 2. Distributions of land capability classes within great groups in Canakkale

Great soil groups	Land use capability classes (ha)							Total	VIII	VII	VI	V	IV	III	II	I	Total (ha)	%	% of province	General total	%
	I	II	III	IV	V	VI	VII	VIII													
Alluvial soils	33505	21112	6449	2158		1163					1163						63224	21.89	0.12	64387	6.63
Hidromorphic alluvial.							178												0.10	996	0.10
Alluvial coastal marshes							2095												0.22	2095	0.22
Saline-alkaline						120													0.01	120	0.01
Colluvial soils	4437	14284	3055	95		511											21871	7.57	0.05	22382	2.30
Brown forest soils.	579	21659	19842	35208		56366	76843										77288	26.76	13.71	210497	21.66
Non-calcerous brown forest soils		17003	18062	26247		118717	374060										61312	21.23	50.72	554089	57.03
Red mediterranean soils		87				87	2402											0.03	0.25	2489	0.26
Red-brown mediterranean soils	643	12404	3664	6521		23232	20087										23232	8.04	2.45	47021	4.83
Non-calcerous brown soils		70	954	1049		2073	5928										2073	0.72	0.93	11061	1.14
Rendzina soils		3699	4974	6615		15288	274										15288	5.29	0.72	22241	2.29
Vertisols		16688	6976	794		24458											24458	8.47		24458	2.52
Regosol soils							1715												0.18	1715	0.18
River flood beds								2238													
Rocks and rubbles								3291													
Marshes								8											0.83	8073	0.83
Sand dunes								1549													
Extensive settlement								987													
TOTAL	39164	107006	63976	78687		190318	483582	8073									288833	100	70.27	971624	100

and quality. Some producers use excess inorganic fertilizers. For instance soils, which sampled from a peach orchard in alluvial land around Umurbey , had 9,62 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> and very high K<sub>2</sub>O contents. Irrigatable land sizes must be extended as much as possible. Therefore groundwaters and ponds used for irrigation should be analyzed to reduce salinity risk of soils. Studies on land use planning in the region, considering previously intensive agricultural areas, should be started.

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Since forests and scrubs cover 54 % of Çanakkale, erosion risk is also partly reduced. However there is a need to use new soil tillage techniques plus use of lands according to their capabilities. Besides, 34,343 m<sup>3</sup> of trees were destroyed due to forest fire, which affected 4428 ha area, in 1994 in Gelibolu. In December 2001, due to heavy rains and resulting erosion, costs of Çanakkale strait turns into mud and changed its color to brown.

#### **.6) Stony – rocky lands / Drainage, Saline-alkaline lands**

Only 675,723 ha areas of Çanakkale have not stone and rock problems. However 24,265 ha (% 2,52) of the lands have stone problem and 263,563 ha (% 27,35) ha lands have rock problem.

28,728 ha of arable lands (% 9,95) have inadequate drainage and aridity (saline + alkaline) problems. Lands with both problem covers 33,102 ha (%3,43) of Çanakkale lands (Table 6). Both stony -rocky and drainage aridity of lands cause problem for arable lands.

**Table 6. Distributions of lands with a drainage problem in Canakkale (ha)**

Problem	II +III. Class Lands	Suitable for limited arable agriculture	Arable agriculture %	Non-suitable for arable agriculture	Total ha	%
Wetness	21,313	-	7,38	-	21,313	2,21
Saline and alkaline	5257	2,158	2,57	4374	11,789	1,22
Total	28,728		9,95		33,102	3,43

#### **Conclusions**

Size of the lands that have moderate and steep slope in Çanakkale province is 789, 485 ha (81,94 %). Therefore, shallow-very shallow soils with a coverage area of 797,545 ha (82,77 %) bring up the susceptibility of these soils to water erosion. Meanwhile, in overall the province, 862,664 ha land (89,53 %) is subjected to moderate, severe and very severe erosion damage. Therefore, more than half (54 %) of the forests in the province must inevitably be protected against fires, excessive grazing and land openings. Pastures must be amended and controlled grazing must be applied. Lands should be cultivated with appropriate farming techniques after taking protective and yield improving precautions based on the capability and quality of the land at hand.

Green fertilizer and manure, even in small amounts, must be applied to the lands with heavy clay soils; and hardpan must be broken. Legume cover crops must be included into crop rotation and inorganic fertilization should be checked for amount

## **2) Great Groups and Land Capability Classes**

Soils in the Çanakkale province were classified by Soil and Water Institution based on the system developed by Thorp and Smith (1949) (Anonymous 1979 and 1980). Later on these studies were revised by General Management of Rural Affairs (Anonymous 1999). Classification of the soils in the Çanakkale province using modern classification methods has been started through various studies that are still going on. Great soil groups and land capability classes one given in Table 2. As it can be seen from the Table 2, non-calcerous brown soils exist in the largest section of the region with 554,089 ha (57.03 %) while saline alkaline soils (0,01 %) and hydromorphic alluvial cover a land size of 996 ha (0,10 %). Based on the modern soil classification system, soils exist in Çanakkale are ordos of Entisol, Alfisol, Inceptisol, Vertisol and Mollisol. Arable lands (class I, II, III and IV.) in the province are around 288,833 ha with a ratio of 29,66 %. Size of the first class lands is 39,164 ha with a ratio of 4,02 %. V.class lands cover 818 ha which are Hydromorphic alluvial soils. The town that has the largest arable land (59,126 ha) mentioned above is Biga in Çanakkale region. The town that has the least arable land (1,798 ha), on the other hand, is Bozcaada. However, these ratios can change when the land sizes of the towns themselves one considered, for instance, town Eceabat with a 42,35 ha overall land size is leading among the towns with the total arable land size of 24,533 ha (57,93 %) on the other hand, VII. class lands have the largest coverage (483,582 ha) among the lands that are not suitable for farming; i.e., 50% of Çanakkale region consist of VII. Class land.

## **3) Slope**

As it is seen from the Table 3 that flat and slightly sloping lands cover 173,995 ha and 18,06% proportion of Çanakkale lands. Medium and steep lands exist in a land size of total 789,485 ha (81,94 %). Average 654,633 ha (%67,94) of this area has a slope, which is more than 12 % and classified as a steep lands. Because of that, Çanakkale lands are faced to serious soil erosion problem.

## **4) Soil Depth**

One of the most important problems of Çanakkale lands is excessive sloping land and consequently shallow and very shallow areas cover 797,545 ha area (82,77 %) (Table 4). Medium deep and deep soils have mostly agricultural lands, pastures, forests and shrubs.

## **5) Erosion**

Average 862,664 ha lands (%89,53) are subjected to medium, severe and extreme water erosion (Table 5). Some of this area is arable agricultural lands and a land size of and these area covers 2/3 of the total 192,32 ha arable agricultural lands.

In Çanakkale, which has a Mediterranean climate in general annual average rainfall is 629,1 mm and average temperature is 14.9 °C. Flora in the region is forest and scrubs. Forests start in sea level and their density increase after 300 m altitude. Bushes and scrubs seen on the shores between Lapseki and Biga can spread 30-40 m inward the land and up to 600 m altitude (Anonymous, 1999). In this research, mainly maps and reports prepared by various government institutions were used. Representative soil samples were also taken from the common great soil types of Çanakkale area.

### 1) Types of Land Use in Çanakkale

Land use types and their proportional distributions in Çanakkale are presented in Table 1. As it is seen from the Table 1, approximately 359,514 ha (36,92 %) of lands are being used for agricultural purposes. Some of these agricultural lands are used as a dry agriculture (258,310 ha; 26,52 %) and irrigated agriculture (54,801 ha; 5,63 %). Rests of these lands are used for vine yard-orchard (46,403 ha; 4,77 %) and some special crops. Forests and Shrubs cover 53,93 % of the Çanakkale lands (525,124 ha). Forests have 413,192 ha. (42,44 %) and Shrubs have 111,932 ha (11,50 %) of this area. Pastures cover 63,011 ha (6,47 %) of the Çanakkale lands.

Table 1. Distribution and ratio of land use types in Çanakkale

Land use types				Area (ha)	Province total (%)	Area (ha)	Province total (%)	Total Area (ha)	Total (%)
Agricultural Lands	Dry agriculture			32,15	258,310	26,52	359,514	36,92	
	Irrigated Agr.				54,801	5,63			
	Vineyard-orchard	Vineyard	3,444	0,35	16,152	1,66			
		Orchard	12,708	1,31					
	Special crop	Olive	29,087	2,99	30,251	3,11			
		Chesnut	1,164	0,12					
Forests and shrubs		Forest	413,192	42,44			525,124	53,93	
		Shrubs	111,932	11,50					
Pastures							63,01	6,47	
Non-agricultural							16,889	1,74	
Other lands (Rocky, sand dune, river bed etc.)							7,09	0,73	
Water surfaces (lake and rivers)							2,07	0,21	
General total							973,690	100,00	



## **Evaluation of Çanakkale Region Land Resources in Terms of Sustainable Agriculture**

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### **Abstract**

Total area of Çanakkale is 973,690 ha. A major part of this area is made of steep lands due to breaking of mountainous and hilly lands into valleys. Lands with medium and straight slope level formed approximately 82% of the city. Because of that, total 827,041 ha (85.83%) area is subjected to medium to strong erosion risk. However, 54% (525,124 ha) of lands have forests and shrubs, which partially reduces this erosion risk in Çanakkale. Total cultivatable agricultural land quantities in Çanakkale are 288,833 ha (29.66%). Beside slope and soil erosion, another important problem for agricultural soils of Çanakkale is an inadequate soil depth (82.77% is shallow or very shallow).

In addition, problems such as excessive grazing, excessive usage of fertilizers, opening of forestlands into farming, destroying forests by fire, limited amount of lands that can be irrigated and salinity caused by poor water quality in watering lakes, and underground water reservoirs are the primary reasons. Studies of land evaluations and planning of land usage based on detailed soil survey must be started.

### **Introduction**

Çanakkale City is one of the most important settling regions in Turkey due to reasons such as its closeness to ancient cities of Troy and Assos, its location on the shore of Çanakkale strait (Dardanelles), which is one of the most strategically important spots in the world. Moreover, Çanakkale is a leading city in Turkey agriculture, in terms of production of fruits and vegetables and also of animal products.

Total land size in the province of Çanakkale is 973,690 ha. Majority of these lands are in South Marmara. However, 123,899 ha. (12.72 %) land is in Thrace region. Geography of the provincial region is rough due to breaking of mountainous and hilly lands into valleys. Ratio of lands that can be attributed as valley is around 15 % (A anonymous 1978, 1999). Geological structures consist of gneiss, crystalline schist, and limestone formed in paleozoological time; claystone and schist formed in mesozoic time; conglomerate, sandstone, limestone and marl formed in tertiary; alluvial and volcanic masses formed in quaternary (Anonymous, 1987).

**Table 2. Water Quality and Quantity Measurements Carried Out by State Hydrolic Works (DSİ,1998) in Çanakkale.**

Date	Location	Discharge	pH	Cations (me/l)					Anions (me/l)					Hardness (French)					N-as NH <sub>3</sub> mg/l	N-as-NO <sub>2</sub> mg/l	O Mr mg/l	B mg/l	Cl Water
				Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	% Sodium	SAR										
20.4	Anbardere	-	8.1	1055	2.93	.06	4.3	5.73	13	.51	6.99	3.30	2.08	13	23	1.3	50	-	-	-	.33	C <sub>3</sub> S <sub>1</sub>	
98	B. Anafartalar	-	8.1	803	1.89	.05	4.3	3.47	9.7	.51	6.84	1.40	1.24	10	20	1.0	39	-	-	-	.24	C <sub>3</sub> S <sub>1</sub>	
"	Zübütüdere	-	7.6	1022	1.74	.04	4.7	6.26	13	0	8.88	1.92	1.67	13	14	0.7	55	-	-	-	.40	C <sub>3</sub> S <sub>1</sub>	
"	İlgardere	-	7.6	988	2.17	.03	5.6	3.31	11	0	6.33	3.83	1.29	11	20	1.0	44	-	-	-	.15	C <sub>3</sub> S <sub>1</sub>	
"	Kireç Ocağı	-	8.2	1523	5.30	.06	5.3	7.53	18	.51	8.11	4.21	3.44	16	29	2.1	64	-	-	-	.33	C <sub>3</sub> S <sub>1</sub>	
"	Creek-Beşyol	-	7.9	993	1.85	.04	5.3	3.75	11	0	6.94	3.11	1.22	11	17	0.9	45	-	-	-	.26	C <sub>3</sub> S <sub>1</sub>	
"	Cumalı	-	7.4	615	0.57	.04	4.7	1.87	7.2	0	6.11	0.53	0.79	7	7.9	0.3	33	-	-	-	.38	C <sub>3</sub> S <sub>1</sub>	
23.9	Çınarköy-Yenice	.23	7.4	498	1.37	.10	3.1	0.83	5.4	0	1.36	0.80	2.92	5	25	1.0	20	-	-	-	.57	C <sub>3</sub> S <sub>1</sub>	
97	Spring	.002	7.4	325	0.85	.06	2.1	0.83	3.8	0	3.08	0.61	0.28	4	22	0.7	15	-	-	-	.68	C <sub>3</sub> S <sub>1</sub>	
"	Kocadere-Kurtlar	.005	7.3	424	0.69	.08	2.2	1.30	4.3	0	1.89	0.69	1.85	4	16	0.5	18	0	0	.25	.09	C <sub>3</sub> S <sub>1</sub>	
23.1	Hamdibey	-	7.9	790	1.03	.08	4.7	2.50	8.3	0	1.68	0.92	5.46	8	12	0.5	36	0	0	.33	.18	C <sub>3</sub> S <sub>1</sub>	
2.96	Ç.kale Tap	.178	7.4	538	0.40	.03	3.6	1.70	5.7	0	4.96	0.40	0.37	6	7.0	0.2	27	0	.004	.49	.26	C <sub>3</sub> S <sub>1</sub>	
"	Sarıçay	.159	7.4	298	0.55	.03	1.9	0.90	3.4	0	2.40	0.46	0.17	3	16	0.5	14	0	.003	.25	.14	C <sub>3</sub> S <sub>1</sub>	
"	Nişankaya	.124	7.9																				
"	Viranlı Creek,																						
"	Bayramiç																						
"	Eşref Creek																						
"	Bayramiç																						

**Table 1. Water Quality Measurements of Çanakkale, Ezine and Lapseki Provinces (Continued).**

No	Location, water sampled	Date	T °C	pH	E.C. mmhos/ cm	NO <sub>3</sub> ppm	NO <sub>2</sub> ppm	SO <sub>4</sub> ppm	Cl <sup>-</sup> ppm	CO <sub>3</sub> <sup>-</sup> me/l	HCO <sub>3</sub> <sup>-</sup> me/l	(Ca+ Mg) me/l	RSC me/l	K me/l	Na me/l	SAR	Class of Water
13	Kösedere Dam	27.06.00	25	7,9	831	0,02	0,03	370	0,05	0,3	2,4	10,0	-	0,15	0,83	0,37	C <sub>3</sub> S <sub>1</sub>
14	Bahçeli Creek	27.06.00 Dried Out	23	7,9	528	0,15	0,02	61	0,01	0,3	3,1	6,2	-	0,12	0,78	0,44	C <sub>2</sub> S <sub>1</sub>
15	Uluköy Dam	27.06.00	25	7,6	518	0,52	0,23	33	0,07	-	2,8	4,4	-	0,15	0,79	0,53	C <sub>2</sub> S <sub>1</sub>
16	Bayramdere Creek	28.06.00	21	8,0	475	15,0	0,03	15	0,00	-	4,1	5,5	-	0,05	0,57	0,34	C <sub>3</sub> S <sub>1</sub>
17	Umurbey Dam	28.06.00	24	7,6	576	0,09	0,02	170	0,02	-	3,2	6,7	-	0,12	0,87	0,48	C <sub>3</sub> S <sub>1</sub>
18	Atikhisar Dam	28.06.00	25	7,6	465	0,04	0,05	160	0,01	-	2,0	4,7	-	0,09	0,61	0,40	C <sub>2</sub> S <sub>1</sub>
19	Dümrek Dam	24.07.00	21	7,9	418	0,06	0,01	10	0,04	1,0	2,0	3,5	-	0,04	0,7	0,53	C <sub>2</sub> S <sub>1</sub>
20	Sarnısakçı Creek	24.07.00	18	7,4	618	0,35	0,06	26	0,00	1,0	2,5	4,0	-	0,07	2,02	1,42	C <sub>2</sub> S <sub>1</sub>
21	Alpagut Dam	25.07.00	15	7,5	489	0,02	0,02	39	0,21	0,4	1,9	3,2	-	0,07	1,58	1,25	C <sub>3</sub> S <sub>1</sub>
22	Adatepe Well Water	25.07.00	18	7,2	448	-	0,00	39	0,00	0,6	1,9	3,7	-	0,04	0,74	0,54	C <sub>3</sub> S <sub>1</sub>



**Table 1. Water Quality Measurements of Çanakkale, Ezine and Lapseki Provinces.**

No	Location, water sampled	Date	T °C	pH	E.C. mmhos/ cm	NO <sub>3</sub> <sup>-</sup> ppm	NO <sub>2</sub> ppm	SO <sub>4</sub> ppm	Cl <sup>-</sup> ppm	CO <sub>3</sub> <sup>-</sup> me/l	HCO <sub>3</sub> <sup>-</sup> me/l	(Ca+ Mg) me/l	RSC me/l	K me/l	Na me/l	SAR	Class of Water
1	Sarıçay Creek	28.06.00	23	7,5	2080	0,56	0,02	340	0,04	-	3,9	17,8	-	0,72	10,7	3,59	C <sub>3</sub> S <sub>1</sub>
		25.07.00	23	7,3	2380	-	0,02	240	0,00	0,6	3,1	9,3	-	4,4	15,64	7,25	C <sub>4</sub> S <sub>2</sub>
2	Kepez Irrigation Canal	27.06.00	17	7,8	435	0,26	0,03	160	0,08	-	1,8	4,7	-	0,08	0,57	0,37	C <sub>3</sub> S <sub>1</sub>
		24.07.00	18	7,5	454	-	0,00	210	0,01	0,4	1,3	3,7	-	0,07	0,8	0,59	C <sub>2</sub> S <sub>1</sub>
3	Haliteli Well Water	27.06.00	16	7,7	1462	34,8	0,04	200	0,00	-	11,5	23,7	-	0,12	1,92	0,56	C <sub>3</sub> S <sub>1</sub>
		24.07.00	16	7,2	1446	703	0,19	260	0,00	1,6	9,1	18,5	-	0,08	4,8	1,57	C <sub>3</sub> S <sub>1</sub>
4	Yeni Mahalle Well Water	27.06.00	17	7,8	1916	15,0	0,03	280	0,00	-	11,5	23,7	-	0,12	1,92	0,56	C <sub>3</sub> S <sub>1</sub>
		24.07.00	17	7,2	1886	45,5	0,26	360	0,02	1,6	9,1	18,5	-	0,08	4,8	1,57	C <sub>3</sub> S <sub>1</sub>
5	Dümbek Dam	27.06.00	21	7,8	472	0,06	0,04	9	0,01	0,4	3,8	5,3	-	0,05	0,48	0,29	C <sub>2</sub> S <sub>1</sub>
6	Kumkale Diversion	27.06.00	25	7,6	651	0,25	0,03	25	0,01	-	3,8	5,4	-	0,14	1,91	1,18	C <sub>2</sub> S <sub>1</sub>
		24.07.00	25	7,7	543	-	0,01	25	0,00	0,8	2,2	3,5	-	0,07	1,78	1,35	C <sub>2</sub> S <sub>1</sub>
7	Pınarbaşı Well Water	27.06.00	17	7,8	610	1,20	0,06	26	0,01	-	5,1	7,2	-	0,07	0,80	0,42	C <sub>2</sub> S <sub>1</sub>
		24.07.00	18	7,5	614	2,26	0,02	32	0,01	1,2	3,2	5,5	-	0,05	1,04	0,63	C <sub>2</sub> S <sub>1</sub>
8	Üvecik Well Water	27.06.00	18	7,5	1045	9,21	0,01	29	0,00	-	5,3	8,4	-	0,12	4,35	2,14	C <sub>3</sub> S <sub>1</sub>
		24.07.00	18	7,3	1001	18,5	0,05	28	0,01	1,0	3,7	6,1	-	0,07	4,27	2,44	C <sub>3</sub> S <sub>1</sub>
9	Umurbey Creek	28.06.00	25	7,3	934	0,56	0,01	180	0,03	-	5,5	10,0	-	0,12	1,87	0,83	C <sub>3</sub> S <sub>1</sub>
		25.07.00	25	7,6	1261	-	0,00	210	0,00	1,2	2,8	9,0	-	0,16	3,08	1,45	C <sub>3</sub> S <sub>1</sub>
10	Umurbey Well Water	28.06.00	15	7,3	1253	0,84	0,08	150	0,04	-	9,1	15,5	-	0,17	1,91	0,69	C <sub>3</sub> S <sub>1</sub>
		25.07.00	17	7,4	1362	53,3	0,48	230	0,00	1,2	7,0	11,7	-	0,12	2,53	1,04	C <sub>3</sub> S <sub>1</sub>
11	Alpagut Well Water	28.06.00	13	7,7	481	0,72	0,13	28	0,06	-	3,0	4,7	-	0,10	1,04	0,68	C <sub>2</sub> S <sub>1</sub>
12	Adatepe Well Water	Dried out															
		28.06.00	13	7,5	557	0,47	0,01	81	0,01	-	3,1	6,2	-	0,06	0,70	0,40	C <sub>2</sub> S <sub>1</sub>
		Dried Out															

Water analysis results showed that; Irrigation water samples collected from the locations (numbered; 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22) were suitable for irrigation when compared with standard parameters mentioned above. But on the other hand well waters from Halileli Village (numbered 3 and 4), and Umurbey area (numbered 10) showed high  $\text{NO}_3$  and  $\text{NO}_2$  contents especially in the water samples collected in July. Almost two to three times more  $\text{NO}_3$  and  $\text{NO}_2$  levels at the end of irrigation season showed that overuse of well waters during the summer period caused to lower water levels in the wells and as a result of seepage from the sewers and other organic pollutants nearby increased the  $\text{NO}_3$  and  $\text{NO}_2$  contents of the well waters. These kinds of waters should not be used continuously for irrigation.

pH values from 6,5 to 8,4 are considered permissible range for irrigation waters and pH values of the waters sampled varied from 7,2 to 8,0 which is suitable for the most crops (Tok, 1997; Hoffman at all 1992).

Temperature of irrigation waters is an important factor for germination of the seeds and for the plant development. Irrigation water temperatures lower than  $10^\circ\text{C}$  and over than  $30^\circ\text{C}$  may retard growing and cause some hazardous developments in most crops (Ayyıldız, 1983). Temperature values of the waters sampled, varied from  $13^\circ\text{C}$  to  $18^\circ\text{C}$  in the well waters and  $21^\circ\text{C}$  to  $25^\circ\text{C}$  in the surface waters (table 1).

Evaluation of the water quality measurements at table 1 and table 2; show that surface waters are mostly have low salt and toxic material content and suitable for irrigation in Çanakkale Region. But some of the ground waters are contaminated with organic pollutants and should not be used continuously for a sustainable irrigation.

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Since the irrigated area has been increasing every year in the region, utilization of the lower quality surface and ground water is also increasing. But this situation creates salinity and toxicity hazards for agricultural crops and soils (Ayyıldız, 1976). The aim of this research was to determine the quality and suitability of surface and ground waters used in irrigation in Çanakkale region and then if there were salinity or toxicity problems to inform the farmers and extension service people, to take necessary precautions.

## Materials and Methods

This research was carried out on the samples collected from dams, creeks and farmers' well waters used for irrigation in Çanakkale, Ezine and Lapseki provinces. Two monthly samples were collected during irrigation period (June-July) from 22 locations in 2000. Samples from wells were collected after the pump had been running for at least twenty four hours and samples from streams was taken from running water. At the time of collection, a label bearing a short identifying description was attached to the bottle. Name of the farmer, location, irrigated crops, temperature of the water, farmers observation on the source of the irrigation water (possible contamination reasons) were also recorded (US Salinity Lab. 1954).

$K^+$ ,  $Na^+$ , ( $Ca^{++} + Mg^{++}$ ),  $CO_3^{--}$ ,  $HCO_3^-$  and pH according to Tüzüner (1990) and other parameters (EC,  $Cl^-$ , Nitrite, Nitrate, Sulfate) were determined with La Motte Smart Colorimeter.

The data collected from water analysis compared with standard water quality parameters.

## Results and Discussion

Irrigation water analysis results given at table 1 compared and evaluated according to standard irrigation water quality criteria (Anonim,1991 and US Salinity Lab. 1954). Also chemical composition of some irrigation water in Çanakkale Region analysed by State Hydraulic Works Laboratory are given at table 2 for comparison. Some well waters of the farmers evaluated according to drinking water standards (Anonim, 1991).

Evaluation of the research results is the following; Sarıçay Creek water salt content was rather high at the down stream and classified as  $C_4S_1$ .  $SO_4^{--}$  content varied from 240 to 340 ppm and considered 3<sup>rd</sup> class irrigation water (Şener,1983) (sample no:1). But at the upstream of the same stream conductivity is very low (465 micromhos / cm) and classified as  $C_2S_1$  (numbered, 18). The main pollutants for the downstream of Sarıçay creek might be industrial waste waters and discharge waters from settlements.



# **A Research on Irrigation Water Quality of Çanakkale, Ezine and Lapseki Provinces**

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## **Abstract**

This research was carried out to determine the irrigation water quality of Çanakkale, Ezine and Lapseki provinces. Irrigation water samples were collected from surface waters, reservoirs and well waters in the research area, during the Irrigation period. EC, pH, temperature,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$ ,  $\text{K}^+$ ,  $\text{Na}^+$ ,  $(\text{Ca}+\text{Mg})$ , RSC and SAR measurements were carried out at all samples.

The data obtained from the research results showed that all samples collected from surface waters, reservoirs and well waters were suitable for irrigation purpose, except, three samples from Halileli Village, Yeni Mahalle and Umurbey well waters contained high levels of  $\text{NO}_3^-$ , which is not suitable for a sustainable irrigation. Even though the results of the measurements indicate that surface water is better than ground water in terms of chemical quality, surface water is more likely to be contaminated with domestic and industrial disposals especially when big settlements are close to the stream.

**Key Word:** Irrigation Water, Water Quality, Çanakkale Region

## **Introduction**

Total agricultural farm lands are 333 573 hectares in Çanakkale Region. 120 000 hectares of this land is suitable for irrigation but only 60 000 hectares are under irrigation today. This research was carried out Çanakkale, Ezine and Lapseki provinces which covers 79 050 hectares of agricultural land which is approximately 24 percent of the total agricultural area of the Çanakkale Region. Generally mesothermal climate prevails in the region, which is relatively dry and hot in the summer, cool and rainy in winter. Relative humidity is about 64 percent in summer month and 78 percent in January, yearly average is 71 percent. The annual average temperature is 14.8°C. The average monthly maximum and minimum temperatures are 24.6°C in August and 6.2°C in January. The average annual rainfall is 610 mm in Çanakkale province (Anonymous,2001).

I would like to conclude my speech with thanks to all of you for attending the Conference. Please enjoy your staying and delights of Canakkale as well as exploiting invaluable scientific and experiences that Conference is going to offer to you.

Prof. Dr. Nuri MUNSUZ  
Honorary President of SSST

Dear Governor, Mayor of City, President of the University, Distinguished Scientists and the Member of the Media,

As Honorary President of Soil Science Society of Turkey, I am very delighted to welcome all of you to Canakkale for the International Conference on Sustainable Land Use and Management, and I herewith wish you a good conference in Canakkale.

In my speech, I'd like to touch shortly on our role in sustaining land and conserving environment.

Figures and facts prove that there are already, and certainly there will be, too many people in the world. Population explosion is the source of a complete series of environmental degradation, which in time can have disastrous consequences. Because, at any price, the population-food imbalance necessitates a growth of agricultural production, methods often harmful to the environment are used without judgment. Examples are abundant, and the result will obviously be a decrease in the fertility of the lands.

Fertilizers, synthetic pesticides, and DDT can be devastating, transforming complex ecosystems, which are necessary for the conservation of the environment, into simple ecosystems. Monocultures are a case of such mutation.

Certain situations are perceived as dangerous only when they become critical enough to cause serious damages. The change of any equilibrium is always extremely difficult, however, after the change, it is sometimes too late to bring things back to the way they were before.

Undeniably, these facts suggest that sustainable land use and management is immediate to reach a new equilibrium between human factors, socio-economic conditions, and environmental factors.

In this context, it is our mission and dedication as soil and environmental scientist to harness the planners and policy-makers and make them responsible, or at least part of the challenge for the conservation of natural resources for future use and generations.

Admittedly, as for the future, our task is not to be teller of disasters but to be unnamed masters of nature. We have learned much from the past, there is nothing we can do except providing means to sustain earth.

After having served the Soil Science Society of Turkey, first as a member and eventually president for 35 years, it is very clear to me that this International Conference on Sustainable Land Use and Management will help you learn some ways of dealing with the situation and managing problems.



together with the soils makes possible to grow a special kind of grape for the wine and cognac production.

I sincerely believe that this International Conference would have a great importance and influence over the development of our University and eventually over our city. Finally, within the frame of the recent changes and renovations that have been happening in Turkey, Çanakkale will take its part in the success of Nation.

I would again like to thank all of you for attending the Conference hosted by Çanakkale.

Süleyman KAMÇI  
Governor of Çanakkale

Dear Mayor of the City, President of the University, Distinguished Scientists, and the Members of the Media,

As governor of Çanakkale it is a very great honor to thank all of you for participating in the Biennial Conference of Soil Science Society of Turkey organized in cooperation with Agricultural Faculty of “Çanakkale Onsekiz Mart University”, and it is my pleasure to welcome all of you to Çanakkale.

In my opening speech, I would like to give you some information about historical and cultural background of Çanakkale and about its agricultural potential. The city is one of the most strategic territory of the world since it is located on both sides of strait, which separates Europe from Asia. It is the one of the core places of the 1<sup>st</sup> World War where Turkish and Allies troops in thousands died, therefore, Memorials, Martyries, and Cemeteries in the Historical and National Park of the Gallipoli Peninsula have been visited by an increasing number of people each year, particularly between 18<sup>th</sup> March and 25<sup>th</sup> April. Historically, the city takes its name from the Fortresses constructed by Sultan Mehmet the Second, Conqueror of Istanbul, at the narrowest part of the strait on both European and Anatolian sides; namely Kilitbahir and Kalei-Sultaniye castles for controlling the strait, respectively.

On the other hand, the city is one of the centers of Turkey for culture, art, science and tourism, and it has been cradle for many civilizations like Troy, Alexandria and Assos since early Bronze Age. Its geographical position provided its inhabitants economical and military advantages, which later brought them into advancement more than the contemporary societies. Forming a bridge between Asia and Europe and blending of various civilizations, the province offers a colorful cultural mosaic. Of the oldest handicrafts of civilization, ceramics and carpet-making have maintained their significance for industry and trade in Çanakkale.

The percentage of agricultural land is 55 percent, and grains, sunflower, olive, fruit and vegetables as well as animal husbandry and fisheries are essential income sources in the city. Olive trees form a continuous line extending from Aegean Region to the Çanakkale Province. The major fruits grown are peaches, cherries and apples. Additionally, the climate, which is mixture of the Mediterranean and the Black Sea Climates,

International Conference, which will bring a unique experience for the future of our city and country.

On behalf of Çanakkale, I wish you a great success in the conference extending my sincere regards and thanks to appreciable contributions of scientists.

İsmail ÖZAY

Mayor of Çanakkale.



Dear Governor, President of the University, Distinguished Scientists, and the Member of the Press,

I am very happy to express my gratitude to Soil Science Society of Turkey and Çanakkale Onsekiz Mart University for being so cooperative to organize this International Conference on Sustainable Land Use and Management in Çanakkale.

We are about to make this joint activity real in Çanakkale, whose land is known to witness some of the most violent battles of the human history like Trojan and Gallipoli Battles. Indeed, sons of this land were not as warrior as they were thought, instead, they were the people who assimilated the value of peace and believed in defending their lands against outsiders. Trojan epics and stories tell us how gullible Trojan were as they were easily cheated by a wooden horse full of the hidden soldiers inside as a war trick and killed by Greeks. Also, Great Leader Atatürk told that sons of this land would continue to respectfully remember their enemies who died in the Gallipoli Battles and to believe in peace. Therefore, Çanakkale is the place where peace and affection have been seed-bedded for centuries although known as battle-field at first sight.

Nowadays, it seems no threat of a war in Çanakkale, but there is a impending danger hung over this land resulting from misuse and mismanagement like unplanned urban development, misuse of chemicals and fertilizers and herbicides, erosion and deforestation. In reality, these have recently threatened not only Çanakkale but also Turkey. Undoubtfully, today's conference is a look-in for protecting our land for sustainable environment, which necessary for a peaceful future. As partially responsible for managing land and making policies, we are going to learn a lot from your invaluable studies, and come across to have chances to correct our mistakes made consciously or not.

Municipal Government of Çanakkale hosted the Symposium on Urbanization and Environmental Problems in Çanakkale in the leadership of University of Dokuz Eylül in 1996, and we supported the symposium by publishing its outcomes, from which we later benefited greatly for Çanakkale. Now, our own university is sharing the leadership of this

I am very happy to host this International Conference, which coincided with the tenth anniversary of the foundation of our university. Nationally and internationally, I genuinely consider that the conference will make important contributions to widely using modern agricultural techniques to sustain soil and water resources.

In conclusion, I would like to thank all who laboriously contributed to the preparation of the conference and wisely made this happen. I wish you a successful conference here in Çanakkale.

Prof. Dr. Ramazan AYDIN  
President, Çanakkale Onsekiz Mart University

Ladies and Gentlemen

I would like to thank all of you for honoring us by attending the International Conference on Sustainable Land Use and Management cooperatively organized by Agricultural Faculty of “Çanakkale Onsekiz Mart University” and Soil Science Society of Turkey.

Since revolutions in the agriculture and industry, the world has been going through the era of information, in which changes have been so rapidly occurring in all fields of technology that it is very competitive to keep abreast of the new developments. Globalization, I believe, leads these changes in last decade, and the globalist policies on; the world has become a market that nourishes people who have identical preferences and pleasures. In this global market, only the best can stand out, and this is valid not only for nations but also for individuals.

More significantly, conservation of whole world and accordingly its ecosystems draws critical attention, and it is very crucial to sustain the Earth as natural resources have increasingly been degraded especially since last half of the 20<sup>th</sup> century parallel to the industrializations. In this connection, sustaining the ecosystems of soil, water, and air as fundamental resources of our lives is unavoidable. Expectantly, findings and propositions of the scientific studies will enlighten us to minimize or possibly, to completely remove the negative effects of the global increase in surface temperature and the climate change on the ecosystem sustainability. Likewise, the relentless efforts of the scientists have also a very significant role in environmentally solving problems of the modern agriculture and the related industries.

Çanakkale attracts interests not only for its rich historical and cultural background and its civilizations but also its natural beauties and fertile arable lands. In spite of potential fertility and availability of soils to the modern agriculture, undeniably, Çanakkale province much less benefits from the regional economical development plans than other western provinces of Turkey. In order to fill this gap and keep up with others, Çanakkale Onsekiz Mart University and Research Centers take a great responsibility for introducing information technology and innovative developments in agriculture to the farmers. We are appreciatively observing these kinds activities of our Agricultural faculty in the field.



I am particularly grateful to the Soil Science Society of Turkey for cooperating with Agricultural Faculty of “Çanakkale Onsekiz Mart University” to organize this conference, and my thanks go to the Governorship and Municipal Government of Çanakkale for their kind support to bring the conference into the reality.

With my best regards,

Prof. Dr. Kenan KAYNAŞ  
Dean, Faculty of Agriculture  
Çanakkale Onsekiz Mart University

Dear Governor, Mayor of the City, President of the University, Distinguished Scientists, and the Member of Media,

I first want to thank all of you for coming to the International Conference on Sustainable Land Use and Management, which is the first time that Agricultural Faculty of “Çanakkale Onsekiz Mart University” has organized in collaboration with Soil Science Society of Turkey.

Approaches to planning and managing land have been changing in our country and in the world as population and physical pressure on the land by human are rapidly increasing since 1950s. Therefore, the need for optimum use of land has never been greater than at present because of increases in land degradation and misuse and mismanagement of the land. As a result, new methods and strategies have been developed to satisfy the increasing demand for existing land by a wide range of disciplines in order to correctly select optimum use of natural resources, considering both physical and socio-economic aspects and conservation of the environment.

Unavoidably, the sustainable management of agriculture imposes techniques for optimal use of land with respect to its potential suitability. In fact, environmental health and stability, profitability and suitability to socio-economic conditions are three main objectives considered in defining needs of sustainable agriculture. The respective third objective further necessitates a land use planning that involves a complete surveying of current natural resources and study of human requirements. Eventually, more profitable and optimal use of the resources is expected from the strategies for sustainable land use and management.

Together with policy-makers and government experts, scientists have a crucial role in planning land use and management and in sustaining nature. In this connection, soil is one of the natural resources, which is irreplaceable after lost, and it is therefore our responsibility to protect our soils from erosion, degradation, and pollution.

I have no doubt that this conference would bring us one-step closer to our final objective of achieving a new equilibrium between human factors, socio-economic conditions and the factors of the physical environment.

systems, and pesticide residues in soil, water and food and also the cause of degradation of the soil or rise of the erosion rate due to plowing without conservation techniques.

The issues relating to environment and the agriculture are very complex. Although there exists a large scale of scientific knowledge in this field, the public debate does not always reflect these insights. Of all human activities, agricultural production has had the greatest impact on soil degradation. In recent decades, human management of agro-ecosystems has been steadily intensified through irrigation and drainage, heavy inputs of energy and abundant chemicals, and improved crop varieties increasingly grown as monocultures. These processes have made agro-ecosystems more and more artificial and often unstable to rapid degradation.

Human activities have mostly un-restorable reshaped the world's natural land cover. Improper management of agricultural land has resulted in the degradation of extensive land areas. The human being needs to well-understand to choose a new life style and the management of the world resources.

I hope all we can do is some contribution to solving these kinds of agricultural problems and negative human impacts on the ecosystem with new scientific and philosophical approaches in the conference.

On this occasion, on the behalf of Soil Science Society of Turkey, I would like to express my heart-felt thanks to the organizing and scientific committee to develop this important scientific event. Also I would like to express my sincere thanks to dear Governor and the Mayor of the City, and President of the University for hosting the Conference and to the immense facilities they have.

I am sure the information that shall be given during the running of the Conference, the discussion that will take place and the recommendations proposed will be of great help in setting and up-dating program to cope with our future opinions (or plans).

It is my pleasure to extend a very hearty welcome to all scientists and experts for their valuable contributions.

On the behalf of the Organizing Committee

Prof. Dr. Koray Haktanır

President of the SSST



Yrd. Doç. Dr.  
**Rıdvan KIZILKAYA**

## **WELCOME ADDRESS**

Mr. Governor, Mayor of the City, President of the University, Distinguished Participants, and the Member of the Press;

As a chairman of the Organizing Committee I have honor and the great pleasure to hearty welcome to all participants of the International Conference on Sustainable Land Use and Management, organized under the patronage of the Soil Science Society of Turkey.

We are very much satisfied that over 90 participants from 10 Countries decided to join our conference. And we are greatly honored by the presence of our distinguished guest Professor Nuri Munsuz-Honorary President of the Soil Science Society of Turkey, and also we have special thanks to the president of the Soil Science Society of America, Professor John Doran who kindly accepted to attend our conference.

A better and broad understanding to advance the soil science by sharing information about soils and water in relation to sustainable ecosystem and environmental quality, agricultural crop production, mitigation techniques for problem soils, bioremediation and waste management techniques, ideal land use planning and management are the major objectives of this conference.

The International Conference on Sustainable Land Use and Management will highlight the major role of the soil, water, land and biological resources, and it will provide a discussion for presenting information and effectively transferring current research, new technologies, new progresses and practical applications in sustaining natural resources, adequate feature agriculture productivity and environment stability.

The Soil Science Society of Turkey (SSST) was founded by the leadership of the late Prof. Dr. Kerim Ömer Çağlar in 1964. He devoted most of his efforts for the development of Turkish Soil Science, and conservation and improvement of soils and water resources.

The SSST reached over 600 members and made 16 scientific meeting, national and international level biennially. As the member of ISSS, our society expressed valuable interest to organize scientific meeting at the international levels, particularly during the last decade.

There are good reasons to be concerned about the environment on our fragile planet. During the last centuries the extraordinary growth in the world population and ascending consumption of the foods per capita are putting a great pressures on resources and the environment.

Intensive and high input-agricultural practice is seen as a major contributor to some of the present environmental disorders. In many countries, agriculture is considered to be prime source of pollution-eutrophication of fresh and marine



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