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*Full Length Research Paper*

# The effects of land use on properties of soils developed over ophiolites in Turkey[1]

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**Abstract:** The information about effects of land use on soils developed over ophiolites is crucial in terms of the best management practices. The effects of land use types of forest, grassland and arable land on soil properties were investigated. In study area located in Eastern Mediterranean region of Turkey, soils were formed over ophiolites parent materials. The results indicated that soils under arable land had significantly higher clay and available P contents comparing with forest and grassland soils. The grassland soils significantly differed from others in pH, exchangeable K, Na, Ca, and Mg contents. However, soils of three land uses were not different in organic matter contents. Besides, soils of all land use types had low Ca/Mg ratio (0.47-1.07). The low Ca/Mg ratio causes erosion which leads to dispersion of soils. The results also implied that erosion played a key role in variation of soil properties formed over ophiolites parent materials.

**Keywords:** Turkey, land use

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## INTRODUCTION

Change in land use influences physical, chemical and biological properties of soil (Abbasi et al. 1988, Martinez-Fernandez et al. 1995). However, due o the masking effect of parent material and topography, land use impact on soil properties may not be apparent (Breure et al. 2006) particularly in semi arid regions (Jenny, 1980). The soils formed over ophiolites parent material are widespread in the eastern Mediterranean region of Turkey. The native vegetation over ophiolites has been converted from grassland to arable land and forest for 40 to 50 years period.

Ultra mafic rocks named ophiolites generally consists of peridotite, dunite, olivine gabro, piroxenite cover wide area in the study area. Ophiolites are mainly represented by apodunite serpentinites with high content of Mg at low concentrations of Ca (MTA, 1975). Besides, Rabenhorst et al. (1982) stated that soils formed on the ophiolites parent material were usually shallow depth with silt texture and high Ni and Cr concentrations.

In ophiolites, exchangeable Mg content of soils is higher compared with Ca (Yilmaz et al. 2005). Therefore, Ca/Mg ratio is very low especially at subsoils (Walker et al. 1955, Proctor 1971). The low Ca/Mg ratio results in soil erosion, due to the negative effect on soil aggregation. The previous studies reported that high amount of Mg increases the possibility of soil erosion due to surface sealing, decreased infiltration, and increased runoff (Karen 1991).

The fertility of soils formed over ophiolites is limited because of low Ca/Mg ratio (Walker et al. 1955, Proctor 1971), toxicity of Ni and Cr (Soane & Saunder 1959, Halstead 1968), and insufficient plant nutrition contents (Matthews et al. 1960, Spence & Millar 1963). Therefore, such soils have been considered unproductive by farmers. In spite of their low fertilities, the soils located on ophiolites shelter a unique flora which is a home to many endemic plants (Jenny 1980, Callizo 1992).

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Land use effects on soil properties may not be adequately understood if the study area is comprised of different parent materials and the history of land use is not known (Breuer et al. 2006). Therefore, in this study, the impacts of three land-use types (i.e. forest, grassland, and arable land) on soil properties have been investigated in a study area covered by ophiolites parent material.

## Material and Methods

*Study site*

Study area covered ophiolites parent material is located in the north part of Hatay-Maras Graben, which is extend of Rift Valley, in the eastern Mediterranean region of Turkey (Fig. 1). The ophiolites parent material widespreads in Hatay-Maras Graben. Topographically, the study area consists of undulating hill slopes surrounding flat lands (Korkmaz 2001). The region has Mediterranean climate with dry and hot summer and rainy and warm winters. The mean annual temperature is about 16.5 $^{o}$C with the coldest and hottest monthly mean temperatures of 4.1 $^{o}$C in January and 28.0 $^{o}$C in July, respectively. Mean annual precipitation is 714 mm with over 60% occurring in winter and spring season (Kaya 1996).

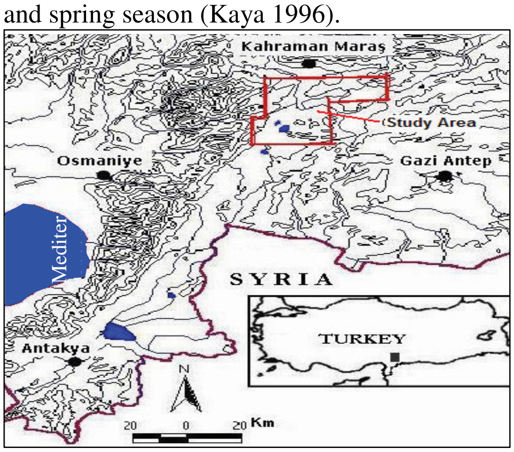


Figure 1. The location of the study area.

The soils in the region are characterized by shallow with sandy loam texture and highly susceptible to water erosion. They are classified as Xerochrept according to the Soil Taxonomy by Yilmaz et al. (2000). The soils have A, B, and C horizons where the well developed A horizon is dark Brown and B horizon have reddish brown and block structure. There is no or a little clay accumulation in soils.

In the study area, the grassland areas, as native vegetation cover of ophiolites, have been converted into arable and forest land in last 40-50 years (Anonimous 1989). Ozyurt (2007) indicated that ophiolites located in the north part of Hatay-Maras graben covers about 6600 ha in which 39%, 35%, and 20% of the area was classified as forest, grassland, and arable land, respectively (Figure 2).

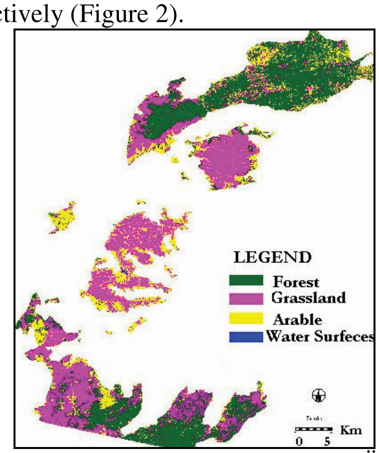


Figure 2. The land use map of the study area (Özyurt, 2007).

*Soil sampling and laboratory analysis*

Soil samples were collected with a soil auger from 0-20 and 20-40 cm depths from each of three adjacent land-use types including forest land, grassland and arable land. Particle-size distribution was determined after the organic matter was removed with 30% $H_2O_2$, by the Bouyoucos hydrometer method (Bouyoucos 1962). Soil pH was measured with a glass electrode, samples having been diluted with water (Peach 1965). Carbonate measured by calcimeter method (Allison and Moodie1965). Soil organic carbon (SOC) was determined using a modified Walkley–Black oxidation method (Nelson and Sommers 1982). The percent Soil Organic Matter (SOM) was calculated by multiplying the percent organic carbon by a factor of 1.724, following the standard practice that organic matter is composed of 58% carbon (Brady & Weil 1999). The available P was measured by the Olsen extraction method (Olsen & Sommers 1982). The exchangeable Na, K, Ca and Mg were extracted with 1 N ammonium acetate, adjusted to pH 7 and was determined Atomic Adsorption Spectrophotometer (Helmke & Sparks 1996).

*Statistical analysis*

Statistical analyses were performed to test the influence of land use on soil properties using one-way ANOVA, and mean comparisons were made using the least significant difference method with $p(0.05)$. The independent variables used in this study were land use types. Significance of both of their interactive effect was identified using Tukey test. All the analyses were conducted through SPSS program.

**Results and Discussion**

The results of the ANOVA variations in soil properties for each of the three land use types and overall averages of the three land use types in the study area were indicated in Table 1. There was a significant differences in percentage of particle size distribution among the three land-use types ($p<0.001$). The soils of arable land had higher clay content than that of other land-use types. It was found that the soils under grassland had the lowest clay content. In contrast, sand content of arable land had significantly lower than that of forest and arable lands ($p<0.001$). The grassland had significantly higher pH than that of both forest and arable lands ($p<0.05$). However, the soils of arable land had significantly higher than the soils of forest and grassland ($p<0.001$). Although there were statistically ($p<0.05$) differences in $Mg^{2+}$ content between arable land and grassland, forest soils were not statistically different from other soils. Besides, there were not statistically differences in carbonate, soil organic mater, available phosphate, exchangeable $Ca^{2+}$ contents and $Ca^{2+}/Mg^{2+}$ ratios among the land-use types. The detailed post-hoc multiple comparisons test is displayed in Tables 2.

Table 1. Soil properties of surface soil ( 0-20 cm) under the three land use types and results of the one-way ANOVA ($p<0.05$ indicates significant differences)

| | Grassland | Forest | Arable | *P value* |
|---|---|---|---|---|
| Clay (g kg$^{-1}$) | 21.8$^{b}$ | 26.9$^{b}$ | 37.3$^{a}$ | 0.000 |
| Silt (g kg$^{-1}$) | 20.8$^{a}$ | 23.4$^{a}$ | 21.4$^{a}$ | 0.242 |
| Sand (g kg$^{-1}$) | 57.4$^{b}$ | 49.7$^{b}$ | 41.4$^{a}$ | 0.00 |
| pH | 6.78$^{b}$ | 6.98$^{a}$ | 7.01$^{a}$ | 0.017 |
| Carbonate (g kg$^{-1}$) | 1.91$^{a}$ | 1.94$^{a}$ | 2.21$^{a}$ | 0.62 |
| SOM (g kg$^{-1}$) | 2.67$^{a}$ | 3.39$^{a}$ | 2.21$^{a}$ | 0.118 |
| P (mg kg $^{-1}$) | 5.41$^{a}$ | 3.38$^{a}$ | 27.46$^{a}$ | 0.052 |
| $K^{1+}$ (mg kg $^{-1}$) | 137.1$^{b}$ | 156.1$^{b}$ | 219.3$^{a}$ | 0.00 |
| $Na^{1+}$ (mg kg $^{-1}$) | 11.92$^{b}$ | 12.39$^{b}$ | 18.90$^{a}$ | 0.017 |
| $Ca^{2+}$ (mg kg $^{-1}$) | 1511.3$^{a}$ | 2259.2$^{a}$ | 1995.0$^{a}$ | 0.100 |
| $Mg^{2+}$ (mg kg $^{-1}$) | 1965.6$^{b}$ | 2294.1$^{ab}$ | 2676.0$^{a}$ | 0.015 |
| $Ca^{2+}/Mg^{2+}$ | 1.07$^{a}$ | 1.12$^{a}$ | 0.92$^{a}$ | 0.703 |

*Particle size*

The result indicated that the soils of study area were generally coarse textures (Table 1). Robenhorst et al. (1982) also stated that soil developed over ophiolites had coarse texture. Clay particles were the highest in the arable land followed by forest and grasslands. However, the sand particle was the lowest in the arable land followed by forest and grasslands.

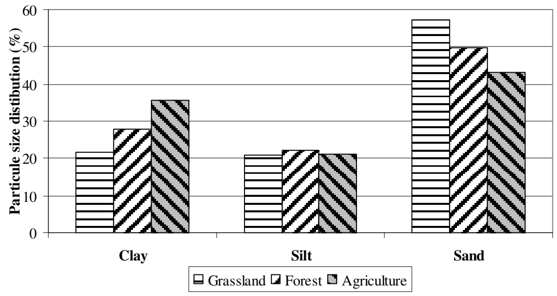


Figure 3. Distribution of the particle sizes for land-use types.

Tukey test revealed that the clay and sand content of the soil for the grassland were different comparing with the soils of other land-use types. The silt content did not considerably vary based on the land use types. The general trend in soil texture of the study area indicate that the grassland has been converted into the forest and arable land, which lead to decreases in the sand content and increases in the clay content (Fig. 3). Zou et al. (2002) also indicated that excessive soil tillage in arable lands accelerate clay content. The coarse soils might be correlated with severe erosion events in grassland with weak vegetation cover.

*Carbonate, pH, soil organic matter and available phosphate*

Since the ophiolites in the region contain some amount of lime (MTA 1975, Çoğulu 1975Ünal 2004), the soils of the study area had very little amount of carbonate. The amount of carbonate content in the arable lands might be greater due to carbonate movements from forest and grasslands at high elevation to arable lands at foot lands. It was found that the soils of grassland contained higher pH than that of forest and grassland due to carbonate loss by runoff. This proved that there is a linear relationship between pH and active carbonate content.

Table 2. Results of the post-hoc multiply comparison test[a] of soils properties for the three land use

| Soil properties | Significant contrasts | *P value* |
|---|---|---|
| Clay | Grassland and arable land | 0.000 |
| | Forest and arable land | 0.000 |
| Sand | Grassland and arable land | 0.000 |
| | Forest and arable land | 0.025 |
| | Grassland and forest | 0.003 |
| pH | Grassland and forest | 0.042 |
| | Grassland and arable land | 0.022 |
| K | Grassland and arable land | 0.001 |
| | Forest and arable land | 0.003 |
| Na | Grassland and arable land | 0.042 |
| | Forest and arable land | 0.031 |
| Mg | Grassland and arable land | 0.012 |

[a] Only comparisons where differences are statistically significant are given.

Even though there was no significant relation between soil organic matter and land-use types in the study area, forest soils contained high amount of soil organic matter as reported by many of the previous studies (Fu et al. 2000, Caravaca et al. 2002, Bettina et al. 2005, Wang et al. 2006).The results indicated that the organic matter content of the soils in forest land were 53% and 27% more than that of arable land and grassland, respectively. It was found that the conversion from grassland to arable land reduced soil organic matter content of soils in the study area while conversion from grassland to forest land increased soil organic matter content. Wang et al. (2006) also found that organic matter content decreases from forest land and grass land to arable land.

The results in Table 1 indicates that available phosphate value in arable lands were about 27.46 mg $kg^{-1}$, which is five and eight times grater than the available phosphate in the grassland (5.41 mg $kg^{-1}$) and forest land (3.38 mg $kg^{-1}$). The previous studies reported that available phosphate in arable lands might be significantly greater than that of other land-use types (Wang et al. 2003).

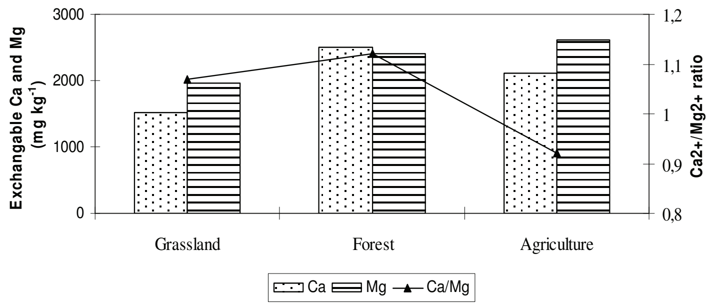


Figure 4. Exchangeable $Ca^{2+}$ and $Mg^{2+}$ and $Ca^{2+}/Mg^{2+}$ ratios

*Exchangeable cations and Ca2+/Mg2+ ratios*

The content of K, NA, and Mg were generally higher in the soils of study area due to chemical characteristics of the ophiolites parent material (Birkeland 1984). Arable lands contains greater amount K and Na, which might be related with higher clay content and usage of fertilizer in arable lands, respectively. The arable lands also contain higher amount of Mg since runoff water removes Mg from the soils in forest land and grassland. Exchangeable Ca was found to be less than the exchangeable Mg in soils of the study area (Figure 4).

Baillie et al. (2000) reported that exchangeable Mg is dominant cation in the soils developed over ophiolites. Due to lower Ca and higher Mg, $Ca^{2+}/Mg^{2+}$ ratio was very low (i.e. 0.92-1.12) in soils of all land-use types in the study area. In a similar study conducted by Alexander (1988), average $Ca^{2+}/Mg^{2+}$ ratio was found to be about 0.4 for Xerocrept soils in California. Yilmaz et al. (2005) indicated that the soils developed over ophiolites are sensitive to erosion due to very low $Ca^{2+}/Mg^{2+}$ ratio. Karen (1991) reported that high amount of Mg deteriorate soil structure through surface sealing, decreased infiltration, and increased runoff.

**Conclusion**

In this study, the effect of land use change within 40-50 years period on the properties of soils developed over ophiolites parent material in the eastern Mediterranean region of Turkey was investigated. The results revealed that the most of soil properties, determined for different land-use types, were higher in the arable land and forest converted from grassland with few exceptions. In the contrary, the sand fractions and soil organic matter contents declined due to erosion and cultivation of arable land. However, soil organic matter contents increased in the forest soils after being converted from grassland due to the abundant of permanent plant cover. It can be concluded that the properties of soils developed over ophiolites parent material with very low $Ca^{2+}/Mg^{2+}$ ratio can be easily effected by land-use and land-use changes.

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