INVESTIGATING CHANGES IN SOME SOIL PROPERTIES DEPENDING ON LAND USE AND DEPTH LAYERS: A CASE STUDY FOR THE GODRAHAV CREEK WATERSHED IN ARTVIN, TURKEY

Esin Erdoğan Yüksel[1]*

[1*]*Artvin Coruh University, Faculty of Forestry, Artvin, Turkey;*

[*]E-mail: eeyuksel@artvin.edu.tr

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ABSTRACT

The Eastern Black Sea Region is characterized by mountainous and steep terrain, limiting agricultural activities. This, in turn, has been causing the natural lands of mostly forests and grasslands in the region to be converted to other uses, mostly agriculture as an alternative income for the local people. However, it is well known that such conversions negatively affect all the natural resources including soil properties. Therefore, in this study, changes in some soil parameters in the forest and the neighboring agriculture (converted from the forest) lands within the watershed of the Godrahav Creek Watershed were investigated with respect to current land use type and soil depth. For this purpose, a total of 36 soil samples based on land use types (forestland, agriculture) and soil depth (0-10 cm and 10-20 cm) were taken to be analyzed for texture, permeability, bulk density, organic matter (OM), pH. Differences and relations among these properties were statistically examined using the analysis of variance analyses (ANOVA). It was determined that the most of the soil characteristics analyzed were significantly different between the lands of forest and agriculture in the study area. For example, as expected, the amount of OM was significantly higher in forestlands with 6.71% than the agricultural land with 5.50% while the pH was increased from 5.51 to 6.88 after conversion. In addition, bulk density was also increased from 1.07 gr/cm^3 in forests to 1.23 gr/cm^3 in agriculture areas whereas better permeability was found for forestlands (302.32 mm/hr) than agricultural lands (110.96 mm/hr).

Key words: Land use types, soil depth, soil properties, Godrahav Watershed, Artvin

INTRODUCTION

Soil is a natural resource which renews itself and makes sustainable use possible only when it is used in a planned way. The main purpose of every type of land use is to obtain the continuous and the highest level of product from the soil by preserving it. This depends on the use of the land in accordance with the capability classes (Hızal, 1991). However, a large number of ecological and economic problems including soil erosion are experienced in our country as a result of failing to comply with land capability classification and improper land use. In Turkey, about 7.1 million people who live in and around the forests and generally have poor economic conditions earn a livelihood by being engaged in grazing and agricultural activities in the forests or lands opened from the forests (Karagül, 2002). As a result of these factors, forest soils become deprived of litter and humus, the soil becomes compacted, so the infiltration and water holding capacity decrease and the surface runoff and erosion increase (Kalay and Karagül, 1992). 26% of the world's lands (1.230 billion hectares.) are destroyed because of improper land use. While

overgrazing is in the first place in the emergence of this problem by 34.5%, deforestation, improper agricultural activities and the improper use of the land have an important share in it as well (Doğan, 2002).
The conversion from forest areas to agricultural areas for reasons such as yield decrease as a result of especially the lack of arable land and erosion is also going on in our day although there has been a significant decrease in recent years. In this study, it was aimed to examine how the said conversion applications that occurred from the past to present in the Godrahav Creek Watershed affected some physical, hydrophysical and chemical properties of the soils in respect to land use type (forest and agriculture) and depth layers.
Material and Method: The research field is in Artvin- Godrahav Creek Watershed (Figure 1) and located between geographical coordinates 41º 12' 35"- 41º 14' 15" North and 41º 51' 27"- 41º 51' 18" East. The highest point is Kesik hill with 2469 m and the lowest point is Aydogan neighborhood with 250 m, and the total area is 5.302 hectares.

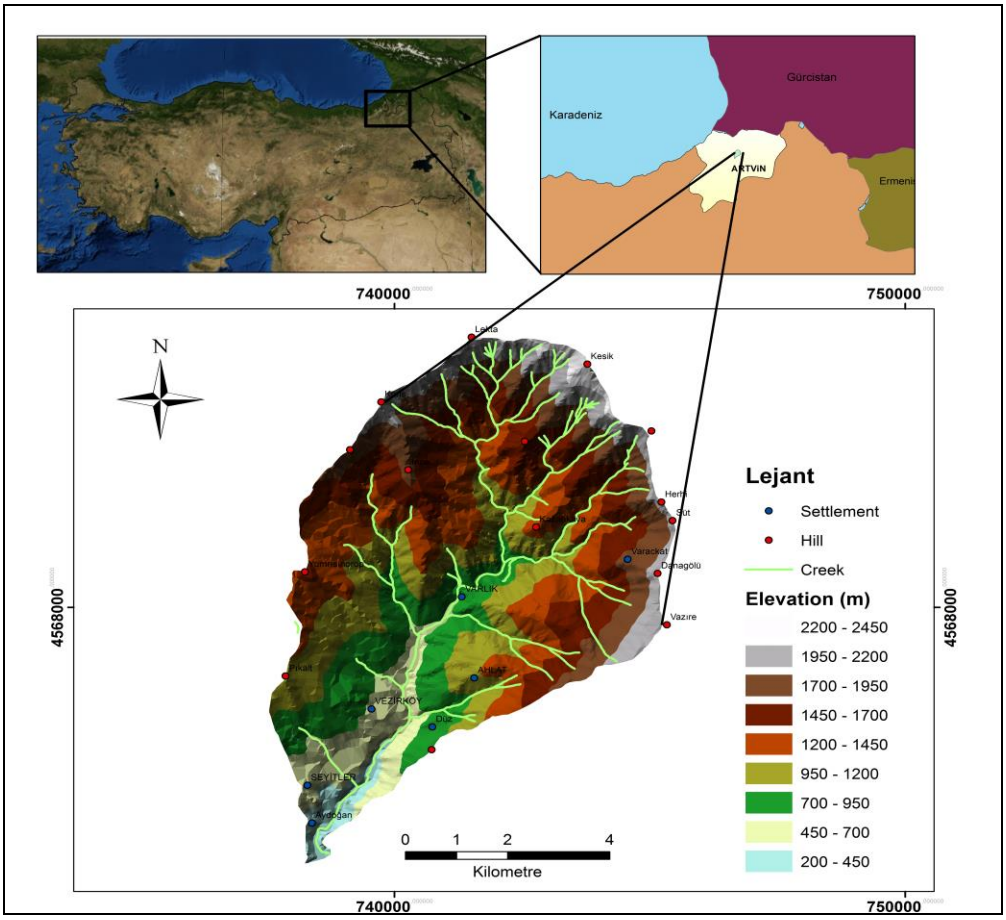

Figure 1. Geographic and Topographic Location of the Research Area

Artvin and its vicinity have the Black Sea coastal (oceanic), Black Sea interior (semi-continental) and Eastern Anatolian (continental) climate belts (Yüksek & Ölmez, 2002). According to the Artvin Meteorology Station' observation data for the last 59 years (1954-2013), the average annual temperature was 12.2 ºC and the average annual precipitation was 698.7 mm (Anonymous, 2014). In terms of vegetation cover and flora, Artvin is a part of the Colchis section of the Euro-Siberian region. Forest vegetation in the region mostly consists of broad-leaved species, and coniferous taxa in some parts, depending on the altitude (Anşin, 1983). Four different types of bedrock groups were identified in the study area: basalt, rhyodacite, granite and limestone. It is seen that basalt bedrock dominates the area, making up 63.3% of the watershed. In terms of the land use, it is seen that the area was composed of forest, agricultural land, meadow and settling areas by 77.88%, 12.25%, 6.11% and 3.75%, respectively. In addition, it was found that as much as 80.72% of the watershed had above 20% slope, and only 19.28% of the area had a slope of less than 20%.

A total of 36 bag (disturbed soil sample) and 36 cylinder (undisturbed soil sample) samples were taken from 36 different points selected from forests and agricultural areas (18 forests, 18 agricultural areas), from two depth layers of 0-10 cm and 10-30 cm. The soil samples taken were crushed after being dried until they became air-dry soil, and they were made ready for the analysis by being filtered through a 2 mm sieve. The Bouyoucos hydrometer method and texture triangle were used to determine the texture of soil samples (Gülçur 1974). The bulk density was calculated as gr/cm^3 by dividing the oven-dry weight of the sample by the cylinder volume on the soil samples the natural structure of which was undisturbed (Blake and Hartge, 1986; Grossman and Reinsch, 2002). Permeability was calculated by being measured under constant hydrostatic pressure on the cylinder samples the natural structure of which was undisturbed (Klute and Dirksen, 1986). Soil reaction (pH) was determined by making measurements from the solution which was composed of 1:2,5 soil - pure water mixture with a digital pH meter (WTW pH 330i/SET) (Gülçür, 1974; Karaöz, 1989a). The organic matter in the soil samples was measured using the "Walkley-Black" wet incineration method (Gülçür, 1974; Karaöz, 1989b; Kacar, 1996). The data obtained from the study were subjected to the analysis of variance to determine whether the difference between the soil properties of forest and agricultural areas was statistically significant.

RESULTS

According to the Land Use Type

According to different land use types of the research area; the average amount of clay was found as 18.25% in the forest and as 24.81% in agriculture, the average amount of sand was found as 56.12% in the forest and as 49.20% in agriculture, and the average amount of silt was found as 25.63% in the forest and as 25.99% in agriculture. In the statistical analysis, while it was found that the difference between the amounts of sand and clay was significant in terms of different land use types, land use types gave similar results in terms of the amount of silt. The highest amount of clay was found in agricultural soils, and the highest amount of sand was found in the forest soils (Table 1). The leaching of the clay in the soil profile was relatively less because the agricultural lands in the research field were located at the altitudes of the watershed, and the average trends were lower compared to forest soils.

According to different land use types of the research area; the average amount of organic matter was found as 6.71% in the forest and as 5.50% in agriculture, and the average pH was found as 5.51% in the forest and as 6.88% in agriculture. It was found that there was a statistically significant difference between land use types in terms of organic matter and pH value (Table 1). The fact that the defoliation and litter accumulation were high for many years despite the human interference in forest areas can be shown as a reason for the high amount of organic matter content in forest soils. Karagül (1994) stated that the organic acids that formed during decomposition of organic matter had a great effect in this event and that the basic elements were leached towards the lower layers in the profile for many years because the forest soils remained in the natural state. The decrease in organic matter by decomposing as a result of the continuous cultivation of the soil, the lack of a quality and continuous vegetation cover that will provide organic matter on soil and the removal of the organic matter spent by agricultural plants during growth and development from the area along with harvesting can be listed as the reasons for the presence of less organic matter in agricultural soils. There are statistically significant differences between land use types in terms of pH values. Organic matter had a great effect on the fact that the pH ratio in forest soils was lower since it has been demonstrated by many researchers that pH decreases as the organic matter increases (Yüksek, 2001; Özalp et al., 2016). Similarly, in this study, although pH was found lower in forest soils as the organic matter was more in them, it was higher in agricultural soils. The subsoil and topsoil are mixed by plowing as a result of the continuous cultivation of agricultural soils, and pH increases in agricultural soils because the basic elements leached in the profile were moved to the top soil again.

According to different land use types of the research area; the average bulk density was found as 1.07 gr/cm^3 in the forest and as 1.23 gr/cm^3 in the agriculture. The highest bulk density values were found in agricultural soils. In the comparisons made, the difference between the bulk density values was found statistically significant according to the land use type (Table 1). The low organic matter value in agricultural soils may be one of the reasons of the result of high bulk density value. In a study in which the relationships between land use types and some soil properties in Çankırı-Eldivan Region were investigated, Göl (2002) measured the lowest bulk density (0.93 gr/cm^3) in natural forest soils with the highest amount of organic matter (7.21%).

Table 1. Statistical comparison of the changes in some properties of forest and agricultural soils of the research field according to land use types and depth layers

Soil Properties	N	Land Use Type	X	F Value	Depth Layers(cm)	X	F Value
Clay	18	Forest	18,25	13,53**	0-10	19,07	7,02*
	18	Agricultural	24,81		10-30	23,99	
Sand	18	Forest	56,12	7,95**	0-10	55,96	7,16**
	18	Agricultural	49,20		10-30	49,36	
Silt	18	Forest	25,63	0,09^{NS}	0-10	24,97	1,88^{NS}
	18	Agricultural	25,99		10-30	26,66	
pH	18	Forest	5,51	76,33**	0-10	6,07	1,20^{NS}
	18	Agricultural	6,88		10-30	6,31	
Organic matter (%)	18	Forest	6,71	4,97*	0-10	7,09	14,73**
	18	Agricultural	5,50		10-30	5,13	
Bulk density (gr/cm3)	18	Forest	1,07	10,62**	0-10	1,04	26,14**
	18	Agricultural	1,23		10-30	1,27	
Permeability (mm/hr)	18	Forest	302,32	13,30**	0-10	282,64	7,84**
	18	Agricultural	110,96		10-30	130,67	

N: Number of Sample; X: Arithmetic Mean; *: Significant with 0.05 Error; **: Significant with 0.01 Error; N.S: Insignificant with 0.05 Error.

According to different land use types of the research area; the average permeability was found as 302.32 mm/hour in the forest and as 110.96 mm/hour in the agriculture, and the difference was found to be statistically significant (Table 1). It is generally known that the permeability amount decreases as moving from forest soils towards agricultural soils. The fact that the permeability is significantly more in forest soils compared to agricultural soils can be explained by the microorganism activities occurring in forest soils for many years, the decay of dead roots, and also by the formation of a channel system with the action of water and the rapid transition of rainfall to the lower soil layers for these reasons. Furthermore, the excessive amount of organic matter with the feature of improving the structure of the soils increases the amount of permeability.

According to Depth Layers

When the research area soils were analyzed according to depth layers, the amount of sand was more in the depth layer of 0-10 cm, and the amount of clay was more in the depth layer of 10-30 cm, and the differences were significant. In the amount of silt, although an increase was observed as moving towards subsoils, no significant change was found according to depth layers (Table 1). In his study, Özyuvacı (1978) investigated the erosion trends of Kocaeli peninsula's soils and stated that the parent material was the most important factor involved in the development of different properties of soils located in the research area. In the same study, it was determined that the amount of sand content decreased depending on the soil depth, and the amounts of silt and clay increased depending on the depth. In the study in which Kalay and Yüksek (2001) investigated some physical, hydrophysical and erosion trends of the soils under different land use types in the Artvin Kafkasör watershed, they found, in terms of soil fractions, that the sand and silt ratio changed inversely proportional to the sampling depth, and the clay ratio changed directly proportional to the sampling depth.

In the research area soils, the amount of organic matter decreased and pH increased depending on the depth layer (Table 1). The difference according to depth layers was found as statistically significant in terms of the amount of

organic matter and as statistically insignificant in terms of pH value. The activities of living creatures above the soil, amount of root and defoliation are the most important causes of the excessive organic matter on the topsoil. Özyuvacı (1976) found that organic matter values decreased depending on the soil depth, and clay content, bulk density and pH values increased depending on the sampling depth.

The bulk density increased depending on the depth, and the difference was found to be statistically significant (Table 1). The increase in the amount of clay affects the soil's bulk density in an increasing way, and the organic matter affects it in a decreasing way. The bulk density was low in topsoils that were rich in organic matter, and various living creature activities and plant roots decreased the bulk density by increasing the pore space. Mc Conkey (1997) stated that the bulk density was increased from 1.4 gr/cm^3 to 1.7 gr/cm^3 when the soil depth reached from 0-10 cm to 20-30 cm. Wall and Heiskanen (1998) analyzed 84 soil samples at various depth layers in agricultural areas and found that the amount of organic matter decreased by 54% according to the soil depth and that the bulk density increased by 37%. There was a decrease in the average amount of permeability as the depth increased, and the statistical difference was found to be very significant (Table 1). Soils become more impermeable as the depth increases, and the pore volume of the water decreases. This also decreases the permeability by making the movement of water in soil difficult.

CONCLUSION

The changes of a total of 7 soil properties including physical, hydrophysical and chemical properties on soil samples taken from the research area according to different land use types and different depth layers and the relations with each other were examined. According to the results obtained from the studies carried out, the land use type significantly affected the soil properties of the research area, and 6 properties (clay, sand, organic matter, pH, bulk density, permeability) of the 7 soil properties which were studied for the research area were statistically significantly changed depending on the land use type. According to depth layers, 5 properties (sand, clay, permeability, bulk density, organic matter amount) showed statistically significant differences in the forest and agricultural soils. The agricultural lands and the destroyed forest lands within the watershed including the research area are constantly under the threat of erosion. Therefore, firstly improper land use should be ceased, the misuses of soils should be decreased, and the necessary measures should be taken and implemented to stop the erosion. Increasing the yield in agricultural lands should be provided by the application of modern technologies and obtaining more yields per unit area, not by the expansion of agricultural areas.

REFERENCES

Anonim, (2014). Devlet Meteoroloji İşleri Genel Müdürlüğü, Artvin İli'nin 1954-2013 Yılları Arasındaki Bazı İklim Verileri [General Directorate of State Meteorology Affairs, Some Climate Data of Artvin Province between 1954-2013], Ankara;

Anşin, R. (1983). Türkiye'nin Flora Bölgeleri ve Bu Bölgelerde Yayılan Asal Vejetasyon Tipleri [The Floristic Regions and the Major Vegetation Types of Turkey], KTÜ Orman Fakültesi Dergisi, 6(2), 318-339;

Blake. G.R. and Hartge, K.H. (1986). Bulk Density And Particle Density. In: A. Klute (Editors), Methods of Soil Analysis Part 1. Physical And Mineralogical Methods. ASSA No. 9. 363–381;

Doğan, O. (2002). Türkiye'de Erozyon Sorunu ve Çözüm Önerileri [Erosion Problems and Solutions in Turkey], Su Havzalarında Toprak ve Su Kaynaklarının Korunması, Geliştirilmesi ve Yönetimi Sempozyumu Bildiri Kitabı, Hatay.

Grossman, R.B. ve Reinsch, T.G. (2002). The Solid Phase, Bulk Density And Linear Extensibility: In W.A. Dick (Editor), Laboratory Methods, Methods of soil analysis, part 4- physical methods, SSA book series:5, Published by SSSA, Inc, Madison, WI., 201-228;

Göl, C. (2002). Çankırı-Eldivan Yöresinde Arazi Kullanım Türleri İle Bazı Toprak Özellikleri Arasındaki İlişkiler [Relationships Between Land Use Types and Some Soil Properties in Çankırı-Eldivan Region], Ankara Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi, Ankara;

Gülçur, F. (1974). Toprağın Fiziksel ve Kimyasal Analiz Metodları [Physical and Chemical Analysis Methods of Soil], İ.Ü. Orman Fakültesi Yayın No: 201, İstanbul;

Hızal, A. (1991). İzmit Yöresi'nde Sel ve Erozyon Olaylarını Etkileyen Öğelerin İrdelenmesi ve Bu Olaylara Karşı Alınabilecek Önlemler [Examination of the Factors Affecting Flood and Erosion Events in İzmit Region and the Measures That Can Be Taken Against These Events], Orman Mühendisliği Dergisi, Sayı: 5, 28-32;
Kacar, B. (1996). Toprak Analizleri (Bitki ve Toprağın Kimyasal Analizleri III) [Soil Analyses (Plant and Soil Chemical Analyses III)], Ankara Üniversitesi Ziraat Fakültesi Eğitim, Araştırma ve Geliştirme Vakfı Yayınları No: 3, Ankara.
Karagül, R. (1994). Trabzon-Söğütlüdere Havzasında Farklı Arazi Kullanım Şartları Altındaki Toprakların Bazı Özellikleri İle Erozyon Eğilimlerinin Araştırılması [Investigation of Some Properties of Soils under Different Land Use Types in Trabzon-Söğütlüdere Watershed and Erosion Trends], Doktora Tezi, K.T.Ü. Fen Bilimleri Enstitüsü, Trabzon;
Karagül, R. (2002). Türkiye'de Orman Alanlarında Yapılan Tarımın İrdelenmesi [Examination of Agriculture Performed in Forest Areas in Turkey], Su Havzalarında Toprak ve Su Kaynaklarının Korunması, Geliştirilmesi ve Yönetimi Sempozyumu Bildiri Kitabı, Hatay;
Karaöz, Ö. (1989a). Toprakların Su Ekonomisine İlişkin Bazı Fiziksel Özelliklerinin Laboratuvarda Belirlenmesi Yöntemleri [Methods of Determining Some Physical Properties of Soils Regarding the Water Economy in the Laboratory]. İÜ Orman Fakültesi Dergisi, Seri B, Cilt 39, Sayı 2, 133-144;
Karaöz, Ö. (1989b). Toprakların bazı kimyasal özelliklerinin (ph, karbonat, tuzluluk, organik madde, total azot, yararlanılabilir fosfor) analiz yöntemleri [Analysis Methods of Some Chemical Properties of Soils (pH, carbonate, salinity, organic matter, total nitrogen, utilisable phosphorus)]. İÜ Orman Fakültesi Dergisi, Seri B, 39(3) 64-82;
Kalay, H.Z. and Karagül, R. (1992). Doğu Karadeniz Bölgesinde Ekolojik Bozulma, Orman Tahribi, Sel ve Toprak Erozyonu [Ecological Impairment, Forest Destruction, Flood and Soil Erosion in the Eastern Black Sea Region], Ekoloji Çevre Dergisi, 5, 23-27;
Kalay, H.Z., Yüksek, T. (2001). Artvin Kafkasör Havzasında Farklı Arazi Kullanım Şekilleri Altındaki Toprakların Bazı Fiziksel Özellikleri İle Aşınım Eğilimi Değerlerinin Araştırılması [Investigation of Some Physical Properties of Soils under Different Land Use Types in Artvin Kafkasör Watershed and Erosion Trend Values], III. Ulusal Hidroloji Kongresi, İzmir, Bildiriler Kitabı, 535-544;
Klute, A., and C. Dirksen (1986). Hydraulic Conductivity And Diffusivity: Laboratory Methods. In Methods Of Soil Analysis, Part 1, 2nd ed., ed. A. Klute, 687–734. Madison, Wisc.: ASA and SSSA;
Mc Conkey, B.G. (1997). Wrich, D.J. and Dyck, F.B., Slope Position And Subsoiling Effects on Soil Water and Spring Wheat Yield, Canadian Journal of Soil Science, 77, 1;
Özalp, M., Erdogan Yuksel, E., Yuksek, T. (2016). Soil property changes after conversion from forest to pasture in the mount Sacinka, Artvin, Turkey, Land Degradation and Development, 27(4), 1007-1017, DOI: 10.1002/ldr.2353;
Özyuvacı, N. (1976). Arnavutköy Deresi Yağış Havzasında Hidrolojik Durumu Etkileyen Bazı Bitki-Toprak-Su İlişkileri [Some Plant-Soil-Water Relations Affecting the Hydrologic Situation in Arnavutköy Creek Watershed], İ.Ü. Orman Fakültesi, Yayın No: 221, İstanbul;
Özyuvacı, N. (1978). Kocaeli Yarımadası Topraklarında Erozyon Eğiliminin Hidrolojik Toprak Özelliklerine Bağlı Olarak Değişimi [Change of Erosion Trend Depending on Hydrologic Soil Properties in Kocaeli Peninsula Soils], İ.Ü. Orman Fakültesi, Yayın No:233, İstanbul;
Wall, A., Heiskanen, J. (1998). Physical Properties of Afforested Former Agricultural Peat Soils in Western Finland SUO, 49, 1, 1-12;
Yüksek, T. (2001). Rize-Pazar Deresi Yağış Havzasında Farklı Arazi Kullanım Şekilleri Altındaki Toprakların Bazı Özellikleri İle Aşınım Eğilimi Değerlerinin Araştırılması [Investigation of Some Properties of Soils under Different Land Use Types in Rize-Pazar Creek Watershed and Erosion Trend Values]., Doktora Tezi, K.T.Ü. Fen Bilimleri Enstitüsü, Trabzon;
Yüksek, T. ve Ölmez Z. (2002). Artvin Yöresinin İklim, Toprak Yapısı, Orman Alanları, Ağaç Serveti ve Ormancılık Çalışmalarıyla İlgili Genel Bir Değerlendirme [General Evaluation Regarding the Climate, Soil Structure, Forest Area, Growing Stock of Artvin Region and Forestry Studies], KÜ Artvin Orman Fakültesi Dergisi, 1, Artvin;