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The effects of changes in land use and soil cover on some important soil properties in highland ecosystem of semi arid Turkey

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Abstract

A research was conducted to determine variations in some significant soil properties by land use and soil cover changes in the İ ndağı Mountain Pass of the northern part of Turkey. Thirteen soil pits were opened to examine and classify soils in the area, and 578 soil samples were collected from 289 locations from 0 – 10 cm (D1) and 10 – 20 cm (D2) depths. These samples represented the land use of woodland, plantation, grassland, cropland, and land allocated for recreation. Organic matter (SOM), bulk density (BD), texture, pH, and hydraulic conductivity (HC) were the soil properties that were analyzed to evaluate these kinds of effects. Additionally, soil susceptibility to erosion was estimated using the measured soil properties and soil erodibility nomograph. Variations in all examined soil properties by land use and soil cover were statistically significant at the levels of either $p<0.01$ or $p<0.05$. These results strongly suggested that disturbances of forest and grassland caused decreases in soil sustainability, leaving those lands to the unwanted effects of soil erosion.

Key words: land use, soil properties, soil erodibility, land degradation

Introduction

Transformation of structure of highlands as a result of land use changes represents a widespread threat to the health of ecosystems and results in high risks of soil quality and erosion. Changes in land use can have a marked effect on soil organic carbon content by means of humification, decomposition and mineralization of SOM. Land degradation and loss of soil organic matter is closely linked to the deterioration of such significant soil physical properties as pore size distribution, bulk density, aggregation and aggregate stability (Tisdall and Oades, 1982; Elliot, 1986; Hajabbasi et al., 1997; Celik, 2005)

RUSLE – K factor is an estimation of resistance of a soil material to the impact of raindrops on the soil surface and to the tangential action of concentrated flow, and to a great extent, it has been used to measure soil susceptibility to erosion. Evrendilek et al. (2004) calculated RUSLE – K by the soil-erodibility nomograph (Wischmeier et al., 1971) to quantify the effects of changes in three adjacent ecosystems (forest, grassland, and cropland) in a high altitude Mediterranean plateau of Turkey. The results showed that conversion of grassland

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into the cropland in the southern Taurus Mountains of the Mediterranean region increased soil erodibility. The overall purpose of this study was assessing the effects of land use changes on soil degradation and sensitivity to erosion in a highland ecosystem of İ ndağı Mountain Pass of Çankı rı , Turkey.

Material and Methods

Study site is located in the İ ndağı Mountain Pass of Çankı rı , Turkey . Selected site for this research contains five adjacent land use types, cropland, grassland, woodland, plantation, and recreational land. Dominant soils described in the study area by 13 soil pits are Lithic Exerorthents, Lithic Haploxererts, Typic Haploxererts, Lithic Haploxerepts, and Typic Haploxerepts (Soil Survey Staff, 1999). Generally, soil texture is clay loam (CL) in both cropland and grassland, and sandy loam (SL) in woodland, plantation, and recreational land.

With irregular intervals, soil samples were taken from (D1 and D2), 289 locations of soil sampling, and total of 578 disturbed and undisturbed samples by 100 cm^3 steel cores were analyzed for clay, silt, and sand contents by hydrometer method (Gee and Bauder, 1986), for SOM content by the method of Nelson and Sommers (1982), for pH with glass electrode in a 1:2.5 soil/water suspension (Page et al., 1982), and for soil BD, (Blake and Hartge, 1986), and saturated HC was performed according to Klute and Dirksen (1986).

Results and Discussion

Table 1 shows analysis of variance to compare the effects of different land use types on SOM, BD, pH, and texture of soils for D1 and D2. Conversion of the woodland or grassland into the cropland and recreational land had a significant effect on the SOM in the site. SOM of the cropland decreased by 46% and 38%, respectively, relative to SOM of the woodland and grassland for D_1. This decrease was respectively by 39% and 29% when SOM of the recreational land was compared to those of the woodland and grassland. There were no significant differences in SOM between the cropland and recreational land for either depth. Additionally, SOM contents of the woodland, grassland, and plantation significantly decreased with the soil depth ($p<0.05$), and decreases were by 50%, 25%, and 43%, respectively.

Of the adjacent lands uses examined, the recreational land had the highest BD (1.48 g cm^{-3} and 1.47 g cm^{-3}, respectively for D1 and D2) while the lowest BD was determined in the woodland (1.12 g cm^{-3} and 1.18 g cm^{-3}, respectively for D1 and D2). At the D1, the cropland had a greater BD than the woodland and less BD than grassland. In spite of having higher SOM than the cropland, the fact that the grassland had unexpectedly greater BD could be attributed to overgrazing of this land for this depth (Celik, 2005; Evrendilek, 2004).

Statistics of clay, silt, and sand showed that these did not change with depth but changed with the land use types ($p<0.01$). The highest clay content was found in the cropland (43.9% as an average of both depths) while the lowest clay content was determined in the woodland (25.1% as an average of both depths). The difference between clay contents of the plantation and recreational land was statistically insignificant. However, these land uses had statistically different silt contents (20.6% and 23.1%, respectively). In inverse proportion to the clay contents, the highest sand content was found in the woodland (50.1% as an average of both depths) while the lowest sand content was determined in the cropland (31.5% as an average of both depths). Similar to the contents of silt, in terms of sand contents the plantation and recreational land had statistically similar values (46.7% and 43.8%, respectively).

There were statistically significant differences in mean pH values among the land uses ($p<0.01$). The cropland had the highest pH (7.2 as an average of both depths) and the woodland had the lowest pH (6.3 as an average of both depths). The grassland, recreational land, and plantation had the pH values of 6.9, 6.7, and 6.6, respectively. Excluding the woodland, the average pH of the land uses could be placed in the neutral side of the pH scale (between 6.6 and 7.3). The pH of the woodland that was never plowed was relatively lower than those of the others and placed in the slightly acidic side of the pH scale (<6.5).

Table 1. Analysis of variance for soil properties as affected by land uses at two different sampling depths.

	Depth	Woodland	Grassland	Plantation	Recreation	Cropland
SOM	D_1	$4.9^{A*a**} \pm 0.2$	$4.3^{Aa} \pm 0.2$	$4.9^{Aa} \pm 0.2$	$3.1^{Ba} \pm 0.2$	$2.7^{Ba} \pm 0.1$
	D_2	$2.5^{ABb} \pm 0.1$	$3.1^{Ab} \pm 0.1$	$2.9^{ABb} \pm 0.1$	$2.6^{Aba} \pm 0.4$	$2.3^{Ba} \pm 0.1$
	Mean	3.7 ± 0.1	3.7 ± 0.1	3.9 ± 0.1	2.8 ± 0.2	2.5 ± 0.08
BD	D1	$1.12^{Db} \pm 0.01$	$1.35^{Bb} \pm 0.01$	$1.27^{Cb} \pm 0.01$	$1.48^{Aa} \pm 0.03$	$1.30^{Cb} \pm 0.01$
	D2	$1{,}18^{Ca} \pm 0.01$	$1.40^{Ba} \pm 0.01$	$1.39^{Ba} \pm 0.01$	$1.47^{Aa} \pm 0.04$	$1.41^{Ba} \pm 0.009$
	Mean	1.15 ± 0.01	1.38 ± 0.008	1.33 ± 0.01	1.48 ± 0.02	1.36 ± 0.008
C	D_1	24.7 ± 0.6	38.1 ± 1.1	30.6 ± 1	31.6 ± 2.3	44 ± 1.2
	D_2	25.6 ± 0.8	38.5 ± 1.2	34.6 ± 1	34.2 ± 1.8	43.8 ± 1.4
	Mean	$25.1^{D***} \pm 0.5$	$38.3^{B} \pm 0.8$	$32.6^{C} \pm 0.7$	$32.9^{C} \pm 1.4$	$43.9^{A} \pm 0.9$
Si	D_1	24.4 ± 0.6	22.6 ± 0.7	21.6 ± 0.4	24.8 ± 1.2	24.4 ± 0.5
	D_2	24.9 ± 0.8	21.8 ± 0.6	19.6 ± 0.3	22.3 ± 1	24.5 ± 0.7
	Mean	$24.6^{A} \pm 0.5$	$22.2^{BC} \pm 0.4$	$20.6^{C} \pm 0.3$	$23.1^{AB} \pm 0.8$	$24.4^{A} \pm 0.4$
S	D_1	50.8 ± 0.9	39.2 ± 1.2	47.7 ± 1.1	44.3 ± 2.7	31.4 ± 1.2
	D_2	49.4 ± 1.3	39.5 ± 1.2	45.7 ± 1	43.4 ± 2.3	31.5 ± 1.3
	Mean	$50.1^{A} \pm 0.8$	$39.3^{C} \pm 0.8$	$46.7^{B} \pm 0.7$	$43.8^{B} \pm 1.7$	$31.5^{D} \pm 0.9$
HC	D_1	$7.3^{Aa} \pm 0.89$	$1.05^{Ba} \pm 0.15$	$5.8^{Aa} \pm 0.7$	$0.47^{Ca} \pm 0.09$	$0.59^{Ba} \pm 0.13$
	D_2	$4.7^{Aa} \pm 0.7$	$1.19^{Ba} \pm 0.18$	$3.9^{Ab} \pm 0.56$	$1.22^{Ba} \pm 0.48$	$1.41^{Cb} \pm 0.11$
	Mean	6.00 ± 0.58	1.12 ± 0.12	4.86 ± 0.47	0.85 ± 0.25	0.84 ± 0.09
pH	D1	6.4 ± 0.06	6.9 ± 0.07	6.6 ± 0.05	6.7 ± 0.11	7.2 ± 0.05
	D2	6.2 ± 0.05	6.9 ± 0.07	6.6 ± 0.04	6.7 ± 0.1	7.24 ± 0.05
	Mean	$6.3^{D} \pm 0.04$	$6.9^{B} \pm 0.05$	$6.6^{C} \pm 0.03$	$6.7^{BC} \pm 0.07$	$7.2^{A} \pm 0.03$
K	D_1	0.114 ± 0.006	0.152 ± 0.006	0.117 ± 0.006	0.198 ± 0.021	0.176 ± 0.005
	D_2	0.144 ± 0.006	0.170 ± 0.007	0.134 ± 0.006	0.191 ± 0.018	0.205 ± 0.007
	Mean	$0.129^{C} \pm .004$	$0.161^{B} \pm 0.005$	$0.126^{C} \pm 0.004$	$0.199^{A} \pm 0.013$	$0.190^{A} \pm 0.004$

D_1 and D_2: soil depths of 0 to 10 and 10 to 20 cm, respectively. SOM: soil organic matter; HC: hydraulic conductivity; C: clay; Si: silt; S: sand; pH: soil reaction;RUSLE-K: soil erodibility factor of RUSLE determined by nomograph (Wischmeier et al., 1971).

* Upper case letters indicate statistically significant differences among soil properties affected by the different land uses,

** Lower case letters show statistically significant differences between soil depths for the cases that there were interactions between land use type and depth.

Of the adjacent lands uses, the woodland had the highest HC (7.3 cm h^{-1} and 4.7 cm h^{-1}, respectively for both D_1 and D_2) while the lowest HC was determined in the recreation (0.47 cm h^{-1} and 1.22 cm h^{-1}, respectively for both D_1 and D_2). HC values of the plantation and grassland were, respectively, for both D_1 and D_2, 5.8 cm h^{-1} and 3.9 cm h^{-1} and 1.05 cm h^{-1}

and 1.19 cm h^{-1}. While HC values of the woodland, grassland, and recreational land did not varied with depth, those of the plantation and cropland differed significantly.

RUSLE-K factor, as an indicator of the soil erodibility, was significantly different among land uses ($p<0.01$) but it did not vary with depth. The highest RUSLE-K was found in the recreation land (0.199 as an average of both depths) and the plantation had the lowest RUSLE-K (0.126 as an average of both depths). Analysis of variance also showed that RUSLE-K factors of the recreational land and cropland and RUSLE-K factors of woodland and plantation were statistically not different.

Conclusions

Soils of five neighboring land use types (woodland, grassland, plantation, recreation, and cropland) in İ ndağı Mountain Pass-Çankı rı , Turkey were examined to assess the effects of land use changes on soil degradation and sensitivity to water erosion. Soil samples collected from depths of 0-10 cm and 10-20 cm with irregular intervals in an area of 1200 m by 4200 m were characterized for SOM, BD, pH, texture, HC, to algebraically estimate RUSLE-K together with field assessment of soil structure. Analysis of variance were performed to evaluate the dynamic relationships between SOM, BD, pH, texture, HC, to algebraically estimate RUSLE-K as affected by land use changes.

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