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VARIATIONS IN SOIL PROPERTIES AS AFFECTED BY DEFORESTATION ON LOESS-DERIVED HILLSLOPES OF GOLESTAN PROVINCE, NORTHERN IRAN

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ABSTRACT

Deforestation and shift of land use to agriculture, is of great concern in Golestan Province and has brought hazardous problems of flooding, landslide and soil loss. Soil organic carbon, total nitrogen content, available phosphorous and potassium, calcium carbonate content, thickness of A horizons and some important soil properties were studied on forested soils and compared with the adjacent deforested and cultivated soils. The studied soils were formed on a hillslope with parent material consisted mainly of loess deposits. Forested and deforested soils were classified as Calcic Hapludolls and Typic Hapludolls, respectively. The studied soils were all calcareous with the pH value of 7-7.9. The soil texture was silty clay loam with the silt content of 54-60%. The results revealed that the soil organic carbon, total nitrogen content and available potassium, were significantly lower in the deforested soils. The thickness of mollic horizons was also reduced after deforestation in all studied pedons. While calcium carbonate contents of the subsurface horizon of the forested soils are significantly higher compared to the surface horizon due to the leaching processes, it is considerably high in the surface horizons of the deforested soils and does not change significantly with depth. This points to the effect of deforestation and cultivation practices which has led to soil erosion and the subsequent exposure of the highly calcareous subsurface horizon. Available soil phosphorous did not show any significant change by deforestation.

Keywords: Deforestation, land use change, loess, Iran

INTRODUCTION

Increase in population and a continuous decline in the amount of agricultural land have led to an indiscriminate exploitation of natural forests and fragile lands for agriculture (Mahtab and Karim, 1992). Soil organic matter and soil nutrient depletion are among the major forms of

soil degradation. This land degradation in arid, semiarid and dry subhumid areas that results from various factors, including climatic variations and human activities is one of the major issues threatening sustainable land use in drylands (Dumanski and Pieri, 2000). Khormali *et al.*, (2005) investigated the land use effects on the degradation of Mollisols, clay mineralogy and soil potassium status in Kurdistan Province, western Iran. The results revealed that unlike rangelands, cultivated soils lack enough organic carbon to meet the requirements of Mollisols and have only ochric epipedons. They are classified either as Inceptisols or Entisols. Comparison of the potassium status of the cultivated and noncultivated soils showed that all of the four types of K^+ in soils (exchangeable, nonexchangeable, soil solution, and mineral) were higher in the noncultivated soils. Major parts of Golestan Province are covered with loess deposits. Floodings in this area are now the most threatening natural disasters. Deforestation and shift of land use to agriculture, is of great concern in this area and has brought hazardous problems of flooding, landslide and soil loss. Every year these destructive events cause a lot of damage in farmlands and civil constructions. According to Kiani *et al.*, (2004) during the past three decades, the forest coverage of northern Iran has decreased from 18 to 12.2 million hectares. Forest degradation has also negative consequence on soil quality and health. Study of different land uses including forest, rangeland, degraded rangeland and farmland in Province of Golestan, showed that the amount of organic matter decreased three units when it turns from forest to farmland, and increased two units from farmland to rangeland (Kiani *et al.*, 2004). Soil N, Bulk density, porosity, mean weight diameter (MWD) and soil respiration are assumed as suitable indicators for soil quality evaluation in this area. The main objectives of the present study are: 1. the deforestation and its effects on some soil quality attributes, and 2. soil forming processes and taxonomic differences affected by change in land use.

MATERIALS AND METHODS

Site description: The study area i.e Narmab is a part of the Gorganrood watershed located between Azadshahr and Minoodasht cities in south-eastern Golestan Province (Fig.1). The land area is about 10000 ha. The annual average soil temperature and the mean annual precipitation are 15 °C and 750 mm, respectively. The soil moisture and temperature regimes of the study region are udic and thermic, respectively. The major parts of the study area are occupied by mountains and hills with the parent materials mainly composed of loess deposits. The main plant species of the forest land are *Alanus subcordata*, *Parrotia persica*, *Corpinus betulus* and *Cretaegus spfarmland*. The farmlands are mainly under wheat cultivation.

Field work: Eight pedons from both forest and farmland systems were described and classified, according to the Soil Survey Manual (Soil Survey Staff, 1993) and Keys to Soil Taxonomy (Soil Survey Staff, 2003), respectively. The different horizons were sampled and the physico-chemical analyses were carried out in the laboratory. Laboratory analyses results of the two representative pedons are shown in Table 1.

Physico-chemical analyses: Air-dried soil samples were crushed and passed through a 2 mm sieve. Particle-size distribution was determined after dissolution of CaCO_3 with 2N HCl and decomposition of organic matter with 30% H_2O_2 . After repeated washing for removal of salts, samples were dispersed using sodium hexametaphosphate for determination of sand, silt, and clay fractions by pipette method. Alkaline-earth carbonate (lime) was measured by acid neutralization. Organic carbon was measured by wet oxidation with chromic acid and back titrated with ferrous ammonium sulphate according to Nelson (1982). Soil pH was measured with glass electrode in a saturated paste. Electrical conductivity (total soluble salts) was determined in saturation extract. Total Nitrogen, available P and K are also determined by the standard methods described in the methods of soil analysis (1992).

RESULTS AND DISCUSSION

Soil genesis and taxonomic changes affected by deforestation: The studied soils were formed on a hillslope with parent material consisted mainly of loess deposits. Forested and deforested soils were classified as Calcic Hapludolls and Typic Hapludolls, respectively. Formation and development of mollic epipedons and the calcium carbonate illuviation were the major processes affected by the change in land use. Although both soils of two land uses are classified as Mollisols, the mollic epipedon is thicker under forest vegetation (Table 1). Intensive tillage and the consequent water erosion are the main factors responsible for reduction of the thickness of mollic epipedons in farmland system. While calcium carbonate contents of the subsurface horizon of the forested soils are significantly higher compared to the surface horizon due to the leaching processes, it is considerably high in the surface horizon of the deforested soils and does not change significantly with depth. This points to the effect of deforestation and cultivation practices which has led to soil erosion and the subsequent exposure of the highly calcareous subsurface horizon. The formation of pedogenic carbonates involves complex processes of dissolution (weathering), translocation and precipitation. Lithogenic carbonate dissolves under ambient moisture and a relatively high

soil CO₂ partial pressure and the dissolved Ca²⁺, Mg²⁺ and CO₃²⁻ ions move downward with the percolating soil water. As the moisture content decreases, calcite precipitates (Wang and Anderson, 1998). Water availability together with vegetation, creating higher soil respiration and providing extra acidity, control the dissolution/precipitation of calcium carbonate in soils (Treadwell-Steitz and McFadden, 2000). Pedogenic calcites observed are mainly in the form of hard concretions and nodules. Due to the lack of the conditions described above, the process of calcification has not resulted in the formation of calcic horizon.

The deforestation effects on some soil quality attributes: Soil organic carbon, total nitrogen content, available phosphorous and potassium, calcium carbonate content, and some other properties were studied on forested soils and compared with the adjacent deforested and cultivated soils. The studied soils were all calcareous with the pH value of 7-7.9. The soil texture was silty clay loam with the silt content of 54-60%. The results revealed that the soil organic carbon, total nitrogen content and available potassium, were significantly lower in the deforested soils. The reduction in the soil organic carbon by deforestation is in accordance with the findings of Kiani *et al.*, (2004) and Wang *et al.*, (2003). Available soil phosphorous did not show any significant change by deforestation. The reduction in all types of soil potassium by change from rangeland to farmland has also reported by Khormali *et al.*, (2005) for the semiarid regions of western Iran.

CONCLUSION

Deforestation of loess derived hilly landscapes causes major changes in soil quality attributes, and soil forming processes, which in turn threaten the soil fertility and the resistance of soil to erosion. Destructive flooding are the obvious consequences of the human impact on the natural land use in Golestan Province. Care, therefore should be taken on the shift of natural land use to farmlands on sloping loess derived landscapes.

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Fig.1. Location map of the study area

Table 1- Physico-chemical and morphological properties of the selected pedons

Horizon	Depth cm	Particle Size Distribution			structure [@]	pH				EC dS m ⁻¹	total N	available	
		Sand	Silt	Clay		paste	*OC	#CCE	&SP			P	K
		-----%-----											
Soil under Forest - <i>Calcic Hapludolls</i>													
A	0-30	14	58	28	m3gr	7	3.3	2.5	66.4	0.5	0.33	3.6	230
Bk	30-65	14	56	30	m3sbk	7.7	1.2	15.5	57.3	0.4	0.12	2.3	110
Deforested farmland Soil - <i>Typic Hapludolls</i>													
Ap	0-20	12	60	28	f1gr	7.9	0.8	18	46.1	0.4	0.08	4	140
Bw	20-50	10	58	32	f1sbk	7.9	0.5	21	48.6	0.6	0.05	1.9	100

[@] m3gr and m3sbk = well developed granular and subangular blocky structure, respectively, f1gr and f1sbk= weakly developed granular and subangular blocky structure, respectively

*OC=Organic Carbon (%)

#CCE=Calcium Carbonate Equivalent (%)

&SP=Saturation Percentage (%)

[¶]CEC=Cation Exchange Capacity

EC=Electrical Conductivity

** c=clay, si= silty, l= loam, s= sandy