Soil degradation of forest lands under udic soil moisture regime of Iran

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1. Abstract

This study was investigated on five sites of mountain landforms consisting granite, phyllite, basaltic andesite (two sites) and andesitic basalt parent materials located in western part of langaroud area (Lahijan). Each site had forest and tea with two plots including one representative profile and three locations around the profile for soil sampling (0-30 cm). The experimental design was completely randomized blocks as factorial and three replications.

Results indicated that cation exchange capacity (CEC), pH, organic carbon ,humic acid, exchangeable bases excluding Na (highest mean value in andesitic basalt), bacteria and fungal population were decreased ($p< 0.01$) in soil surface under tea cultivation; however, bulk density, exchangeable acidity and fulvic acid content(greater amount in granite)increased significantly ($p< 0.01$).Furthermore, a negative correlation ($p< 0.01$) was found between pH values and fungal population ($r = - 0.616$) as well as fulvic acid content ($r = - 0.874$) but positive correlation ($p< 0.01$)with bacterial population ($r = 0.899$). Higher carbon dioxide volatilization (respiration) was related to the forest of basaltic andesite. By decreasing pH,fulvic acid content was increased much more than the fungal population.Lower amount of clay and CEC was related to granite parent material whereas higher amount to andesitic basalt.

Classification of these soils changed from Typic Hapludolls (andesitic basalt) and Typic Udorthents (granite) under forest to Typic Dystrudepts and Typic Hapludalfs under tea plantation, respectively. Deforestion and tea plantation under different parent material caused to decrease pH values and promote soil acidification, thus, influences on declining the CEC, nutrient supplying and soil organism population which is partly attributed to cultivation effect leading to lower organic matter as well as blocking the charge sites of the clay fraction by aluminum.

2. Introduction

Land degradation will remain an important global issue for the 21st century because of its adverse impact on agronomic productivity and its effect on the quality of life (Eswaran et al. 2001).Because land is a non – renewable resource at a human time–scale,land use result in the land cover change directly influences the terrestrial ecocystem and biogeo- chemical process and lead to soil degradation (Houghton 1994, Giller et al. 1997). Deforestation and agricultural practice deteriorates soil structure over time as evidenced by reduced pore space and inceased bulk density.

Soil compaction or depletion of soil organic matter (S.O.M) because of the removal of large biomass and increasing S.O.M decomposition rate due to enhanced biological activity caused by soil mixing from tillage as well as higher temperature from increased soil exposure and acidification are important in soil degradation. Ruduced action and population of micro/ macroorganism partially related to the poor structure of many agricultural soils due to the decrease in soil porosity (Morris et al. 1999).

Several studies have given credence to the role of S.O.M in improving soil physical, chemical and biological properties (Dick et al. 1998, Karlen et al.1994, Post et al. 2000). Because of its positive influence on several soil processes, crop productivity and environmental qualities, S.O.M is often considered to be the single most important indicator of soil quality and sustainable land management (Bewket et al. 2003, Dick 1992). Parent materials influences soil properties such as acidity, base saturation percentage, clay and CEC content ;for instance ,soils developed on felsic rocks have lighter textured soils but lower buffering capacity to changes in soil pH,hence,the higher the S.O.M or clay content the higher the soil's pH buffering capacity (Akhiro et al. 2002).

The objective of this study is to evaluate the impact of long term tea cultivation (greater than 30 y.old) on some soil properties under different parent materials.

3. Methods

Study area located between latitudes $37^{\circ},12'$ and $37^{\circ},13'$ N and longitudes $49^{\circ},59'$ and $50^{\circ},0'$ E with annual precipitation of 1200 mm, udic soil moisture regime and thermic soil temperature regime(Fig 1). Five sites of granite, basaltic andesite(I, II), andesitic basalt and phyllitic parent material on mountains were selected. Each site consist of two pedons (forest and tea plantation) on shoulder and west facing.In deed, in each site, soil samples were collected from 0-30 cm at 3 points. The experimental design was completely randomized blocks as factorial (FE – CABD) and three replications.

Air dried soil samples were crushed and Passed to 2 mm sieve . Soil analyses were done according to standard methods (Gee,1986, National Soil Survey, 1996,Page,1986) as follows: particle size by pipette method , Fe_d by citrate - bicarbonate – dithionate, organic carbon by walkely-black method, exchangeable bases by I N NH_4 -acetate. Soil reaction was potentially determined in water (1:1 soil/water) and 0.01 M $CaCl_2$ ($1:2.5$ soil / solution). Cation exchange capacity by 1M Na – acetate at pH 8.2 and replacement by 1M NH_4 - acetate at pH 7, fulvic and humic acid by gravimetric method , microorganism population by the spread plate method and microbial respiration by titration

The data were subjected to analysis of variance using the ANOVA procedures of SAS program.

4. Results

Results from mean values (Table 1) indicated that there was a significant difference ($P<0.01$) between parent material, land use and clay content so that maximum was for andesitic basalt and for tea land use. This is related to higher clay content in rock and lower pH in surface of tea plantation.

Also, significant difference ($P<0.01$) was present between bulk density values in three parent materials and land use (the highest value belongs to granite and tea plantation). Decrease in S.O.M and increased soil compaction due to tillage as well as soil structure deterioration are causes of increased bulk density.

Table 1 Effect of land use change and parent materials on some physico- chemical properties

Parent material	Land use	Humic acid (mg/gr soil)	Fulvic acid (mg/gr soil)	CEC (meq/100gr)	O.C %	pH (CaCl2 1:2)	B.D g/cm3	Clay %
granite	Forest	69^{c}	8.82^{c}	15.06^{h}	3.13^{d}	4.1^{g}	1.21^{de}	16.26^{h}
	Tea	51.7^{f}	12.53^{a}	19.53^{g}	2.66^{f}	3.95^{f}	1.55^{a}	18.5^{g}
Basaltic andesite 1	Forest	93.66^{a}	5.72^{f}	41.4^{e}	6.55^{a}	5.46^{d}	1.23^{cd}	27.6^{f}
	Tea	73.2^{b}	7.51^{d}	49.8^{c}	5.36^{b}	5.76^{c}	1.29^{b}	33.5^{b}
phyllite	Forest	68.3^{c}	6.82^{e}	19.78^{g}	4.34^{c}	4.79^{f}	1.01^{f}	28.66^{e}
	Tea	54.9^{e}	10.71^{b}	22.1^{f}	2.95^{e}	4.07^{e}	1.19^{de}	29.8^{d}
Basaltic andesite 2	Forest	60.03^{d}	3.32^{j}	41.33^{e}	2.73^{f}	0.07^{d}	1.18^{e}	29.9^{d}
	Tea	51.93^{f}	4.16^{i}	51.3^{b}	2.11^{g}	0.32^{b}	1.27^{bc}	31.2^{c}
Andesitic basalt	Forest	51.83^{f}	4.33^{h}	45.53^{d}	1.75^{h}	5.65^{d}	1.20^{de}	31.1^{c}
	Tea	47.96^{g}	5.14^{g}	58.13^{a}	1.13^{i}	5.25^{a}	1.26^{bc}	35.1^{a}

Same letters within the table (mean values) are not significant

Based on the results from chemical analysis (Table 1), pH values changed significantly ($P<0.05$) between andesitic basalt, phyllite and granite (the highest pH occurred in soils formed on andesitic basalt and on forest). The reasons is apparently attributed to the minerals present in rock (e.g, granite and phyllite with lower mafic and smectitic minerals) as well as irreversible return of litter to the soil and use of nitrogen fertilizer. In tea cultivated, greater amonnt of S.O.M found in andesitic basalt, high clay content present in this rock and formation of organo – mineral complex may inhibit the losses of S.O.M. Furthermore, shifting the forest to tea leads to significantly ($P<0.05$) decrease of S.O.M in tea plantation due to the fast oxidation and higher decomposition rate of S.O.M and slow return of lilter to soils.

Minimum amount of CEC belongs to soils derived from granite and decreased significantly due to tea plantation. Amount of humic and fulvic acid decreased significantly after tea plantation (Table 1). The maximum content of humic acid occurred in forest soils developed on basaltic andesite while maximum amount of fulvic acid observed in soils derived from granite under tea plantation due to lower pH. Moreover, lower pH was important to be responsible in increasing the amount of fulvic acid according to equation as follows:
Al+H= - 14.4+1.8 (fulvic acid).

Also, microbial respiration was significantly higher in forest than tea and was higher in basaltic andesite I than others which is related to more S.O.M; more released CO_2 and more pH in forest and Parent rock.There was a significant difference ($P<0.01$) in bacterial population (greater for forest and bsaltic andesite I) and fungal population (greater in granite due to lower pH) but no significant difference of fungi in two land use.Equation of regression revealed that higher pH can decrease the fungal population and fulvic acid content as follows: pH =4.43+0.45 (bacteria) – 0.132 O.C– 0.122 (fungi) – 0.41 (fulvic acid) but increase the bacterial population as follows: Bacteria = - 60+17.6 pH – 2.3 O.C

Dick (1992) reported that little O.M is lost on forest and maintained by relatively slow oxidation resulting cool and shaded condition and from the lack of disturbing effects of cultivation; however, in soil pH below 5, microbial process that facilitate nutrient recycling and soil fauna population that favor soil structure, can be reduced (Reuss,et.al.1998).

Consequently, this study revealed that the conversion of forest into other land use resulted in changing the soil classification (Soil Survey Staff, 2006) and a remarkable decline in the amounts of soil nutrient and microbial C.Therefore,the strength of the human land use effect in slowing or hampering forest succession is strongly related to the nature ,duration and intensity of the land use.

Table 2 Effect of land use change and parent material on some soil biological properties

Parent material	Land use	Bacterial population cfu/g.dm	Fungal population cfu/g.dm[1]	Microbial respiration mgCO2/g.dm.24h
granite	Forest	17.55 ^{h}	6.75 ^{ab}	2.86^{de}
	Tea	14.03 ^{j}	7.25 ^{a}	1.5^{g}
Basaltic andesite 1	Forest	45.36^{a}	4.91 ^{e}	5.26^{a}
	Tea	36.16^{c}	5.51^{cde}	3.6^{bc}
phyllite	Forest	19.46^{g}	5.82^{cd}	3.3^{cd}
	Tea	16.36 ^{i}	6.11 ^{bc}	2.06^{f}
Basaltic andesite 2	Forest	41.36 ^{b}	3.49^{f}	4.1^{b}
	Tea	31.46^{e}	3.83^{f}	2.91^{de}
Andesitic basalt	Forest	32.41^{d}	4.9 ^{e}	3.65^{bc}
	Tea	22.03^{f}	5.32^{de}	2.68^{e}

Same letters are not significant

1 -Colony forming units/gram of dry matter

Figure 1 Study area located in north of Iran

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