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Land Use Effects on Soil Properties Derived from Various Parent Materials in Northern Iran

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This study investigated the 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, pH,organic carbon, humic acid, exchangeable bases excluding Na (highest mean value in andesitic basalt), bacteria and fungal population were decreased in soil surface under tea cultivation. However, bulk density, exchangeable acidity and fulvic acid content(greater amount in granite)increased significantly. Furthermore, a negative correlation was found between pH values and fungal population (r = -0.616) as well as fulvic acid content (r = -0.874) but positive correlation with bacterial population. Higher carbon dioxide volatilization (respiration) was related to the forest of basaltic andesite. Fulvic acid content was increased much more than the fungal population by decreasing pH. Lower amount of clay and cation exchange capacity was related to granite whereas higher amounts of them related 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 cation exchange capacity, 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.

Key Words: Land use, Deforestation, Acidification.

INTRODUCTION

The effects of various type of land use change on some soil properties have been reported[1]. Land is a non renewable resource at a human time-scale. The land use result in the land cover change directly influences the terrestrial ecosystem and

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biogeochemical process and lead to soil degradation[2]. 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[3].

Deforestation and agricultural practice deteriorates soil structure over time as evidenced by reduced pore space and increased bulk density. Soil compaction or depletion of soil organic matter (SOM) because of the removal of large biomass and increasing soil organic matter 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. Reduced action and population of micro/macro organism partially related to the poor structure of many agricultural soils due to the decrease in soil porosity[4]. Several studies have given credence to the role of soil organic matter in improving soil physical, chemical and biological properties[5]. Because of its positive influence on several soil processes, crop productivity and environmental qualities, soil organic matter is often considered to be the single most important indicator of soil quality and sustainable land management. Parent materials influences soil properties such as acidity, base saturation percentage, clay and cation exchange capacity 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 soil organic matter or clay content the higher the soil's pH buffering capacity[6].

Soil bacteria and fungi play pivotal roles in various biogeochmical cycles[7] and are responsible for the cycling of organic compound. Soil microorganism also influence above-ground ecosystems by contributing to soil structure[8]. While soil biological characteristics play no direct role in soil classification and survey, edaphic factors used to classify soils are expected to influence soil biological characteristic. Soil microorganisms are primary agents in soil organic matter, residue decomposition and soil structure formation. Nontheless, we still have a limited understanding of how soil microbial activities and populations respond to land use change. Present objective is to determine changes in surface soil properties from two different land uses under different parent materials.

EXPERIMENTAL

The vegetation in forest of the study area is dominated by *Quercus macranthera*, *Carpinus*, *Aspleninum femina* and *Potentilla*.The study area located in Lahidjan (37º3′, 37º12.5′ N to 50º2′, 50º9′ E) of Guilan province, with annual precipitation of 1200 mm, in north of Iran. The soil moisture and temperature regime is udic and thermic, respectively. The native broad leaves forest has been changed to tea (*Camellia sinensis*) plantation on 80 years ago. Five sites including different parent materials (Table-1) that located in mountain landform were selected. The type of parent materials was granite (Bijarbagh), basaltic andesite I (Zemeidan), phyllite (Aliserod), basaltic andesite II (Khorma) and andesitic basalt (Leil). In each site, one representative soil profile (pedon) in forest and adjacent 80 years old tea cultivation was used to classify the soils[9]. The soil samples were collected from surface horizon

TABLE-1
SOME SOIL PROPERTIES AND SOIL CLASSIFICATION OF STUDY AREA

Site/ Plant material	Land use	Horizon	Depth (cm)	OC (%)	pH H_2O 1;1	pH $CaCl_2$ 1:2	CEC cmol/kg	BS (%)	Clay (%)	BD (g cm^3)	Soil classification
Bijarbagh/granite	Forest	A	0-20	3.20	4.9	4.6	19.2	48.8	16.3	1.29	Coarse Loamy-skeletal, mixed, mesic Typic Udorthents
		Cr1	20-70	0.55	4.6	4.3	18.3	45.3	14.1	1.46	
		Cr2	70-120	0.09	4.7	4.3	16.4	45.1	13.2	1.67	
	Tea	Ap	0-25	2.70	3.9	3.8	15.1	42.8	18.5	1.66	Coarse Loamy-skeletal, mixed, mesic Typic Hapludalfs
		Bt	25-67	0.90	4.1	4.7	13.7	41.9	25.7	1.67	
		Cr1	67-100	0.35	4.1	4.7	12.7	42.5	20.1	1.70	
		Cr2	100-130	0.29	4.2	4.7	12.6	42.2	19.6	1.70	
Zemidan/basaltic andesit, I	Forest	A	0-15	6.56	5.9	5.8	49.0	63.2	28.3	1.31	Fine Loamy, mixed, mesic typic udorthents
		C	15-45	1.66	6.0	5.7	38,0	48.6	29.1	1.52	
		Cr	45-85	0.51	6.2	5.8	35,0	72.0	30.7	1.58	
	Tea	Ap	0-20	4.61	5.5	5.1	40.4	58.4	33.3	1.37	Fine Loamy, mixed, mesic typic udorthents
		Cr1	20-62	1.70	5.6	5.2	29.4	43.4	32.6	1.61	
		Cr2	62-90	0.50	5.6	5.2	27.5	62.4	32.4	1.68	
Aliserod/Phyllite	Forest	A	0-9	4.33	4.8	4.7	22.0	64.0	28.7	1.04	Clayey (fine), mixed, mesic Ultic Hapludalfs
		ABt	9-35	1.68	4.8	4.3	15.0	37.3	31.1	1.35	
		Bt1	35-60	0.70	4.8	4.3	16.0	33.7	38.3	1.33	
		Bt2	60-90	0.34	4.9	4.4	17.0	20.4	40.4	1.37	
		Cr	90-130	0.25	4.9	4.4	16.0	33.7	30.1	1.42	
	Tea	Ap	0-32	2.90	4.5	4.0	19.5	49.2	29.8	1.20	Clayey(fine), mixed, mesic Ultic Hapludalfs
		Bt1	32-65	0.90	4.6	4.1	15.0	28.1	37.0	1.41	
		Bt2	65-95	0.62	4.6	4.1	15.0	24.3	38.2	1.45	
		Bt3	95-120	0.30	4.7	4.2	16.7	21.2	40.3	1.49	
		Cr	120-140	0.22	4.7	4.2	15.5	26.2	31.5	1.51	
Khorma/basaltic andesite, II	Forest	A	0-11	2.70	6.1	5.8	50.4	60.9	29.9	1.28	Fine Loamy, mixed, mesic Typic Udorthents
		C	11-36	2.10	6.2	5.7	47.7	55.9	31.6	1.35	
		Cr	36-48	0.95	6.3	5.8	40.4	60.3	33.3	1.42	
	Tea	Ap	0-20	2.10	6.0	5.0	40.7	59.7	31.2	1.40	Fine Loamy, mixed, mesic Typic Udorthents
		AB	20-55	1.80	6.1	5.5	41.7	71.8	33.5	1.51	
		C	55-78	0.81	6.5	5.6	39.7	60.1	35.4	1.55	
		Cr1	78-92	0.56	6.5	5.6	39.1	60,0	37.9	1.57	
Leil/ andesitic basalt	Forest	A	0-18	1.70	6.4	5.9	57.4	54.1	31.1	1.24	Fine Loamy, mixed, mesic Typic Hapludolls
		Bw	18-49	0.35	6.6	5.6	46.5	67.7	33.0	1.26	
		C1	49-85	0.26	6.7	5.8	45.2	70.7	32.8	1.28	
		C2	85-110	0.20	6.8	5.9	44.3	73.3	24.1	1.30	
	Tea	Ap	0-20	1.12	5.7	5.0	45.2	50.9	35.5	1.31	Fine Loamy, mixed, mesic Typic Dystrudepts
		Bw1	20-41	0.49	6.0	5.2	45.1	51.8	33.8	1.35	
		Bw2	41-75	0.40	6.0	5.2	44.7	54.3	32.6	1.36	
		C	75-95	0.27	6.1	5.4	43.9	56.9	30.6	1.38	
		Cr1	95-120	0.20	6.3	5.5	42.7	59.6	28.1	1.40	

(0-30 cm). Soil samples crushed and passed to 2 mm sieve after air-drying. Bulk density was determined using core method[10]. Some physical and chemical properties of soil such as texture (Pipette method)[11], pH (1:1 soil/water and 1:2 soil/$CaCl_2$ 0.01 M) and cation exchange capacity[12], organic carbon (walkely-Black method)[13], humic and fulvic acid (gravimetric method)[14] were determined.

For all microbial population measures,soil samples were stored at 4 ºC overnight before use. Dilutions were plated onto media for cultural fungi and bacteria. Fungal population was determined by soil dilution plate method[15]. Sizes of culturable bactria were determined by dilution plating onto nutrient agar (spread plate technique) for total bacteria[16]. Microbial respiration was determined by titration method[17].

The experimental design was completely randomized block as factorial (FE-CRBD). The factors were parent material and land use change with three replications. The data were subjected to analysis of variance using the ANOVA procedures of SAS program.

RESULTS AND DISCUSSION

The soil surface horizon in all pedons (Table-2) of forest lands had moist colour of 10YR 3/3 to 3/2 with well developed friable, granular structure and lower bulk density than deeper horizons. However, surface soils of all pedons in tea plantation had lighter moist colour (10YR 4/4) with less developed friable, granular, massive structure and lower bulk density than deeper horizons. Soil classification (Table-1) changed in the most of the soils in family categorical level due to deforestation[9].

TABLE-2
SOME MORPHOLOGICAL SOIL SURFACE PROPERTIES OF THE REPRESENTATIVE PEDONS IN STUDY AREA

Consistency		Structure	Colour Moist	Land use	Parent material
Moist	Wet				
fr	ss,ps	3cgr	10YR3/3	Forest	Granite
vfr	ss,ps	m-1fgr	10YR5/4	Tea	
fr	s,p	3cgr	10YR3/2	Forest	Basaltic andesite 1
vfr	s,p	1fgr-m	10YR4/4	Tea	
fr	ss,ps	3mgr	10YR3/2	Forest	Phyllite
vfr	ss,ps	m-1fgr	10YR4/4	Tea	
fr	s,p	3mgr	10YR3/3	Forest	Basaltic andesite 2
vfr	s,p	1fsbk-1fgr	10YR4/4	Tea	
fr	s,p	3cgr	10YR3/2	Forest	Andesitic basalt
vfr	s,p	1fsbk-m	10YR4/4	Tea	

1 = weak, 3 = strong, sbk = subangular blocky, m = massive, gr = granular, f = fine, c = coarse, vfr = very friable, ss = slightly sticky, ps = slightly plastic

Effect of parent material and tea plantation on clay content and bulk density of soil was significant (Table-3). Amount of clay increased after tea plantation (Table-4). The greater amount of clay was exceeded in soils with andesitic basalt parent material in Leil (Table-4). The highest bulk density value observed in soils formed on granitic parent material under tea plantations (Table-4). The results showed that soil chemical properties significantly changed after tea plantation in all sites (Table-5). The soil acidity significantly increased (pH decreased) due to tea plantation (Table-6). The highest soil pH occurred in soils formed on andesitic basalt parent material in native forest site (Table-6). The lowest soil organic carbon observed on soils formed on andesitic basalt under tea plantation (Table-6). Soils formed on granite had minimum of Ca^{2+} + Mg^{2+} (Table-6).Minimum amount of cation exchange capacity belongs to soils of granite (Table-5). Amount of cation exchange capacity significantly decreased

TABLE-3
ANALYSIS OF VARIANCE OF EFFECTS OF LAND USE ON SOME SOIL PHYSICAL PROPERTIES

MSE		DF	Source of variation
Bulk density (g/cm^3)	Clay (%)		
0.0004 $^{n.s}$	0.044 $^{n.s}$	2	Block
0.1640**	58.240**	1	Land use
0.0590**	228.960**	4	Parent material
0.0210**	8.260**	4	Land use* Parent material
0.0007	0.025	18	Error

Significant at 0.05(*), 0.01(**) level of probability; ns= not significant

TABLE-4
EFFECT OF LAND USE CHANGE AND PARENT MATERIAL ON SOME SOIL PHYSICAL PROPERTIES

Bulk density (g/cm^3)	Clay (%)	Land use	Parent material
1.21^{de}	16.26^{h}	Forest	Granite
1.55^{a}	18.50^{g}	Tea	
1.23^{cd}	27.60^{f}	Forest	Basaltic andesite 1
1.29^{b}	33.50^{b}	Tea	
1.01^{f}	26.84^{e}	Forest	Phyllite
1.19^{de}	29.80^{d}	Tea	
1.18^{e}	29.90^{d}	Forest	Basaltic andesite 2
1.27^{bc}	31.20^{c}	Tea	
1.20^{de}	31.10^{c}	Forest	Andesitic basalt
1.26^{bc}	35.10^{a}	Tea	

Numbers with same letters in each column are not significantly different.

TABLE-5
ANALYSIS OF VARIANCE OF EFFECTS OF LAND USE ON SOME SOIL CHEMICAL PROPERTIES

MSE						DF	Source of variation
Fulvic acid (mg/g soil)	Humic acid (mg/g soil)	OC %	(Ca^{2+}+Mg^{2+}) (cmol/kg)	CEC (cmol/kg)	pH $CaCl_2$ 1:2		
0.012$^{n.s}$	0.021 $^{n.s}$	0.053$^{n.s}$	0.054 $^{n.s}$	0.124 $^{n.s}$	0.012 $^{n.s}$	2	Block
36.542**	1477.148**	2.850*	72.416**	3894.780**	0.469**	1	Land use
48.735 **	1154.546**	22.640**	328.145**	1537.598**	3.133**	4	Parent material
3.402**	37.770**	0.383*	10.920**	25.844**	0.012**	4	Land use* Parent material
0.002	0.0033	0.007	0.115	0.111	0.002	18	Error

Significant at 0.05(*), 0.01(**) level of probability; ns= not significant

TABLE-6
EFFECT OF LAND USE CHANGE AND PARENT MATERIAL ON SOME SOIL CHEMICAL PROPERTIES

Fulvic acid (mg/g soil)	Humic acid (mg/g soil)	$(Ca^{2+}+Mg^{2+})_{ex}$ (cmol/kg)	CEC (cmol/kg)	%OC	pH (1:2$CaCl_2$)	Land use	Parent material
8.82^{c}	69.00^{c}	6.73^{f}	19.53^{g}	3.13^{d}	4.70^{g}	Forest	Granite
12.53^{a}	51.70^{f}	4.41^{h}	15.06^{h}	2.66^{f}	3.85^{f}	Tea	
5.72^{f}	93.66^{a}	20.13^{b}	49.80^{c}	6.55^{a}	5.57^{d}	Forest	Basaltic andesite 1
7.51^{d}	73.20^{b}	19.70^{b}	41.40^{e}	5.36^{b}	5.01^{c}	Tea	
6.82^{e}	68.30^{c}	8.85^{e}	22.10^{f}	4.34^{c}	4.69^{f}	Forest	Phyllite
10.71^{b}	54.90^{e}	5.19^{g}	19.78^{g}	2.95^{e}	4.07^{e}	Tea	
3.32^{j}	60.03^{d}	18.36^{c}	51.30^{b}	2.73^{f}	5.56^{d}	Forest	Basaltic andesite 2
4.16^{i}	51.93^{f}	15.40^{d}	41.33^{e}	2.11^{g}	5.02^{b}	Tea	
4.33^{h}	51.83^{f}	25.00^{a}	58.13^{a}	1.75^{h}	5.85^{d}	Forest	andesitic basalt
5.14^{g}	47.96^{g}	17.94^{c}	45.53^{d}	1.13^{i}	5.05^{a}	Tea	

Numbers with same letters in each column are not significantly different

TABLE-7
ANALYSIS OF VARIANCE OF EFFECTS OF LAND USE ON SOME SOIL BIOLOGICAL PROPERTIES

MSE			DF	Source of variation
Bacteria	Fungi	Soil respiration		
$0.001^{n.s}$	$0.210^{n.s}$	$0.520^{n.s}$	2	Block
390.82^{**}	$0.24^{n\ s}$	12.35^{**}	1	Land use
726.66^{**}	0.911^{**}	4.38^{**}	4	Parent material
19.40^{**}	$0.28^{n.s}$	0.10^{**}	4	Land use* Parent material
0.004	0.160	0.010	18	Error

Significant at 0.05(*), 0.01(**) level of probability; ns = not significant

TABLE-8
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*	Microbial respiration $mgCO_2$/g.dm.24h
Granite	Forest	17.55^{h}	6.75^{ab}	2.86^{de}
	Tea	14.03^{j}	7.25^{a}	1.50^{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}	3.30^{cd}
	Tea	16.36^{i}	6.11^{bc}	2.06^{f}
Basaltic andesite 2	Forest	41.36^{b}	3.49^{f}	4.10^{b}
	Tea	31.46^{e}	3.83^{f}	2.91^{de}
Andesitic basalt	Forest	32.41^{d}	4.90^{e}	3.65^{bc}
	Tea	22.03^{f}	5.32^{de}	2.68^{e}

*Colony forming units/gram of dry matter due to tea plantation (Table-6). Soils formed on granitic parent material under tea plantation had minimum content of cation exchange capacity (Table-6). The microbial respiration was also significantly higher in forest than tea and was higher in basaltic andesite I than others which are related to more soil organic matter; more released CO_2 and more pH in forest and Parent rock. There was a significant (Table-7) difference between parent materials ($p < 0.01$) in bacterial population (greater for forest and bsaltic andesite I) and fungal population (greater in granite due to lower pH) however, there was no significant difference of fungal population in two land use (Table-8).

The maximum clay content was observed on andesitic basalt parent material and use of tea land. This is related to higher clay content in rock and lower pH in surface horizon of tea plantation. Increased clay content in surface soil of tea plantation is probably related to more dense roots, more acidic pH and more chemical weathering near the surface. Indeed, tea is a perennial crop grown on sloping terrain and high rainfall areas. The soil under a perennial crop like tea is believed to be protected adequately by canopy and surface litter. Climatic data of the study area indicated that mean monthly precipitation in November was much higher than other months. Forest trees have little leaf in this month, hence forest soil surface are less protected in comparison with soils in tea plantation which has enough canopy due to ever green leaves. Therefore, it is expected that having more area of the tea land without erosion have greater opportunity to inhibit the rainfall incidence to the soil surface to produce and accumulate more clay minerals.

Higher clay content in soils derived from andesitic basalt is related to weathering of plagioclase minerals and vitric materials inherited from parent material. The highest value of bulk density belongs to granite and tea plantation. Decrease in soil organic matter and increased soil compaction due to tillage as well as soil structure deterioration are causes of increased bulk density[18]. In surface soil horizon of granitic and phyllitic parent materials, cation exchange capacity values were lower than other parent materials in both land use. The reasons for decrease in cation exchange capacity of soils derived from granite can be attributed to lower clay content (Table-1) and kind of clay minerals[19] which are dominated by illite and hydroxy-inerlayered of vermiculite (HIV), whereas illite, chlorite and less amount of interstratified chlorite-vermiculite (chlorite was dominant) were present in soils from phyllite that can decline the CEC[19]. Higher cation exchange capacity in soils from other parent materials that were confirmed by XRD[19,20] can be related to higher amount of smectite that were dominant on their soils (data not shown). Decrease in cation exchange capacity of soils in tea plantation is probably related to soil organic matter loss and somewhat to hydroxy-interlayered of vermiculite clay minerals that were present relatively in greater amount in tea plantation.

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[21]. In tea cultivated, greater amount of soil organic matter found in andesitic basalt. It seems that higher clay content present in this rock and formation of organo-mineral complex may inhibit the losses of soil organic matter. Moreover, shifting the forest to tea leads to significantly ($p < 0.05$) decrease of soil organic matter in tea plantation due to the fast oxidation and higher decomposition rate of soil organic matter and slow return of litter to soils. Post and Kwon[5] reported that little soil organic matter is lost on forest and maintained by relatively slow oxidation resulting from cool and shaded condition and from the lack of disturbing effects of cultivation. In addition to soil organic matter losses, other indications of soil degradation were evident. For instance, higher amount of humic acid in basaltic andesite I is related to more organic carbon, but higher fulvic acid content in tea plantation of granite is due to the decrease in humification and lower pH value.

In general, soil fungal population showed the least amount of variation but microbial respiration and bacterial population showed the most variability across parent material and two land use. Higher microbial respiration in forest than tea and basaltic andesite I, than others is related to more soil organic matter; more released CO_2 and more pH in forest land use and parent material. Equation of regression revealed that higher pH can decrease the fungal population and fulvic acid content but increase the bacterial population as follows: pH = 4.43 + 0.45 (bacteria) - 0.122 (fungal) - 0.41 (fulvic acid).

The reason for non significant difference of fungal population between tea and forest land use was not clear but tillage in tea plantation may disturb some of fungal hypha and destroy some of them. The plate growth also favours those fungi with fast growth rates and produce large numbers of spores[22], hence some of the fungi in the samples might have this condition but others probably did not have. Third reason is presumably related to decreasing pH values less than one unit in the most of the soils for tea plantation which is not enough for extending of fungi. Further detailed research is needed for biological properties. In conclusion, this study revealed that the conversion of forest into tea land use resulted mostly in changing the soil classification[9] and a remarkable decline in the amounts of soil nutrient, organic matter and bacteria. 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.

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