IMPACT OF DIFFERENT LAND USES ON SOIL CHARACTERISTICS IN RANIPUR RAO WATERSHED IN HARIDWAR DISTRICT, UTTARAKHAND

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ABSTRACT: The impact of urbanization on land resources has a major concern over past few decades, and in particular, to those involved in soil studies. Variations in soil properties in different land use might be due to dynamic interactions among environmental factors such as climate, parent material, topography and land use and land cover. This study was initiated to investigate the impact of different land uses on the soil characteristics in the Ranipur Rao Shiwalik hill Watershed at Haridwar. However, for the study point of view, the total length of Ranipur Rao is divided into five zones having forest area, industrial area residential area, agro-residential area and agricultural area. Mean value of pH in agricultural land showed the highest pH (7.38-7.56) followed by the industrial and residential areas. Soil of forest area showed highest Organic Matter (4.85%) and minimum Organic Matter (0.87%) found in industrial area due to the impact of industrial activities. A correlation matrix of 12 soil parameters representing soil physico- chemical properties resulted at $P<0.05$ or $P<0.01$ level and interrelationship among the nutrients offers a better understanding of the soil system. Thus, it may be concluded that the different land uses have significant effects on soil characteristics which in turn lead to the change in the nutrient status of soil. These findings will be useful for helping to describe and classify the soils and predict their potential for sustainable land uses and effective technologies to avoid the soil quality from further deterioration.

Keywords: Urbanization; Environmental degradation; Soil properties; Land Uses and Soil quality.

INTRODUCTION

In the last few decades, land use practices (agriculture, mining, logging, housing, recreation, etc.) have become so intense and predominant that we can see their impacts in forms of uncontrolled development (urbanization and sprawl), deteriorating environmental quality, loss of prime agricultural lands, destruction of wetlands, and loss of fish and wildlife habitats everywhere on the earth. These impacts have decreased the local capacity of lands to support both ecosystem and human enterprise at global scale. Therefore the effect of land use change is no longer a local environmental problem but a global one. Therefore, the effect of land use change is no longer a local environmental problem, but a global one (Houghton, 2009)[8]. To address such a problem, detailed information on existing land use patterns and sound knowledge of the changes in land use through time is important for legislators, planners as well as state and local governmental officials (Anderson *et al*., 1976) [1]. The accessibility of nutrients in soil depends on the soil pH, Organic Matter, absorptive surfaces and other physical, chemical and biological conditions in the rhizosphere (Jiang *et al.* 2009) [10]. Soil quality is controlled by physical, chemical and biological properties of soil and their interaction (Papendick & Parr, 1992) [14].

The land use/land cover change information is very important for decision making of sustainable land use planning at both national and regional levels (Bhardwaj & Kumar, 2009) [5]. Vegetation is naturally free tool for controlling soil erosion leading to floods and landslides. Grasses have their own role to play in soil erosion treatment, controlling soil characteristics and watershed balance (Kamboj, 2013) [12]. Soil surveys help to describe and classify the soils and predict their potential for sustainable land uses. Classification of soil allows determining the best possible use, management of soils and exchange soil information world-wide. Identifying, delineating and mapping of land use/land cover are important for global monitoring studies, resource management and planning activities.

Keeping above in the consideration, the present study was undertaken to understand the properties of soil under different land use pattern which were managed through different ways by the local people. In order to achieve this objective, soil properties were analyzed at a soil depth (0-15cm) under five major land uses in the watershed area in Haridwar district, Uttarakhand.

MATERIALS AND METHODS

Study area

The study was conducted on Ranipur Rao seasonal hill river watershed in Haridwar district. In the Ranipur Rao Shiwalik hill Watershed area, Ranipur Rao is a seasonal stream and carrying the industrial and sewage effluent. The total length of the Ranipur Rao seasonal stream is about 12.83 km. Out of the its total length, approximately 2.15 km is under forest area of Rajaji National Park and remaining 10.68 km part is under industrial, residential and agricultural areas. However, for the study point of view the total length of Ranipur Rao seasonal hill river watershed is divided into five zones showing in Table 1 and fig. 1.

Table: 1 Details of sampling sites along with their geo-coordinates and land use area

S.No.	Sampling zone	Location	Type of land use area	Geo-coordinates	Elevation
1.	Zone-A	Sureshwari temple trail sector	Forest Area	29º58'10.66" N, 78 º06'27.73" E	1057ft
2	Zone-B	between the SIDCUL and BHEL industrial area	Industrial Area	29º57'11.31" N, 78 º05'10.62" E	984ft
3.	Zone-C	Tehri colony& Shivalik Nagar	Residential Area	29º55'29.60" N, 78 º04'43.57" E	931ft
4.	Zone-D	Alipur Ibrahim village	Agro-Residential Area	29º54'20.93" N, 78 º04'30.14" E	898ft
5.	Zone-E	Bhagtanpur Abidpur village	Agricultural area ending point of the Ranipur Rao seasonal river	29º52'35.18" N, 78 º04'36.43" E	872ft

Figure 1. Map of Ranipur Rao watershed showing sampling zones

Methods for sample collection, preservation and analysis

In every sampling zone, five sampling sites were selected. The soil samples at five different sampling sites were collected through composite soil sampling method. These collected soil samples were brought to the laboratory in sterilized polyethylene bags and further stored at 4ºC temperature until further analysis (Behera, 2014).

Laboratory analysis

The soil samples were air dried and sieved through 2 mm sieve before use for physico-chemical analysis except Soil Moisture Content, expressed in percentage. The other physico-chemical parameters like pH, Electrical Conductivity, Organic Carbon, Organic Matter, Calcium, Magnesium, Sodium, Potassium, Total Nitrogen and Available Phosphorus content were analyzed as per the standard methods. The pH and Electrical Conductivity were measured by the glass electrode using soil double distilled water in a ratio of 1: 5 (w/v). Organic Carbon and Organic Matter were analyzed according to Walkley and Black's (1934) [20] rapid oxidation procedure. The Nitrogen content was estimated by - Kjeldahal distillation method (Jackson, 1973) [9]. Available Phosphorus content was determined spectrophotometric method by the molybdenum blue method using H_2SO_4 as an extractant. The Sodium and Potassium content were determined flame photometrically following the method of

Hanways and Heidel (1952) [7]. Ca and Mg were determined in ammonium acetate extract of soil by direct titration with EDTA (Trivedy and Goel, 1986) [18].

Data Analysis

Data were analyzed using Microsoft excel 2007 and SPSS Statistics 20.0 for Pearson's Correlation. Pearson's Correlation was employed to determine the nature of association between soil variables to understand possible factors that affected their buildup in the soil.

RESULT AND DISCUSSION

The physico-chemical characteristics of the soil from different land use patterns are summarized in Table 2 and the relationship between among parameters in different land uses are presented in Table 3. The results of correlation studies of physico-chemical characteristics are detailed and discussed below;

Table 2. Mean values of soil characteristics of surface soil samples:

S.No.	Parameters	(Forest area-Control site)	(Industrial area)	(Residential area)	(Agro-residential area)	(Agricultural area)
1.	Moisture Content (%)	21.20± 0.93	10.52±0.51	12.60±0.33	16.03±0.04	16.23±0.10
2.	Water Holding Capacity (%)	51.11±0.76	40.70±0.37	41.97±1.18	42.11±1.38	46.22±1.95
3.	pH	6.39±0.12	6.55±0.08	7.38±0.16	7.56±0.19	7.11±0.04
4.	Electrical Conductivity ds/cm	3.41±0.16	2.25±0.20	0.81±0.05	0.60±0.04	0.78±0.07
5.	Organic Carbon (%)	2.39±0.34	0.52±0.04	1.05±0.02	1.00±0.02	0.78±0.06
6.	Organic Matter (%)	4.85±0.08	0.87±0.13	1.59±0.17	1.47±0.21	1.55±0.26
7.	Calcium (meq/100gm)	11.04±0.01	6.95±0.65	7.82±0.05	9.87±0.82	7.33±0.06
8.	Magnesium (meq/100gm)	8.70±0.01	5.54±0.47	6.32±0.13	6.66±0.79	8.49±0.13
9.	Total Nitrogen (%)	1.41±0.04	0.14±0.05	0.43±0.04	1.23±0.04	1.47±0.01
10.	Phosphorus (%)	0.69±0.02	0.33±0.04	0.47±0.02	0.69±0.05	0.58±0.08
11.	Sodium (%)	6.04±0.02	1.74±0.05	4.96±0.07	1.62±0.03	1.43±0.08
12.	Potassium (%)	0.23±0.08	0.19±0.01	0.33±0.03	0.15±0.02	0.17±0.04

The data indicated that Moisture Content ranged from 10.52% (industrial area soil samples) to 21.20% (forest area soil samples). From table 2, it was seen that forest soil had a higher Moisture Content as compared to industrial, agricultural, residential and agro residential area. Moisture Content showed significant and positive correlation with Water Holding Capacity (0.854), Organic Carbon (0.854), Organic Matter (0.864), Calcium (0.809), Magnesium (0.839), Nitrogen (0.861) and Phosphorus (0.820) respectively at 0.01 level, but showed non-significant and negative correlation with pH (-0.224) and Potassium (-0.168). Moisture Content showed positive and non-significant correlation with Electrical Conductivity (0.415) and Sodium (0.453).

The Water Holding Capacity increases with increasing level of Organic Carbon and with increasing percentage of silt and clay particle in the soil because clay and silt particle have a much higher surface area to hold a greater quantity of water. Water Holding Capacity showed highly significant and positive correlation with Organic Matter (0.829) at 0.01 level. The highest Water Holding Capacity was found in forest area (51.11%) soil samples as compared to industrial area (40.70%), residential area (41.97%), agro-residential area (42.11%)

and agricultural area (46.22%). There was a similar studied by Awotoye *et al.* (2009) [2] reported the values of WHC, pH, OM and Ca as 56.86%, 6, 3.13% and 5.13meq/100gm respectively.

Table 3. Correlation between soil characteristics of surface samples of different land uses

	MC	WHC	pH	EC	OC	OM	Ca	Mg	N	P	Na	K
MC	1											
WHC	.854**	1										
pH	-.224	-.433	1									
EC	.415	.549*	-905**	1								
OC	.854**	.790**	-.417	.658**	1							
OM	.864**	.829**	-.501	.725**	.957**	1						
Ca	.809**	.555*	-.075	.417	.813**	.778**	1					
Mg	.839**	.824**	-.250	.266	.600*	.673**	.411	1				
N	.861**	.669**	.079	.002	.499	.527*	.565*	.821**	1			
P	.820**	.488	.182	.017	.580*	.575*	.731**	.674**	.816**	1		
Na	.453	.519*	-.315	.542*	.793**	.768**	.511	.288	.040	.191	1	
K	-.168	-.053	.021	.068	.180	.179	-.113	-.084	-.417	-.161	.669**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

Variations in soil pH were found in soil samples of different land use patterns. The pH usually increases more for built-up area soil than for forest soil because of lime is applied and agricultural management (tillage) mixes soil. The data indicated that pH ranged from 6.39 (forest area soil samples) to 7.56 (Agro-residential area soil samples) which is similar to the findings of Singh and Ramakrishnan (1981) [16] *i.e*. 6.1 to 6.5. From table 2, it was seen that agricultural soil had higher pH as compared to industrial, residential and forest area. Variations in pH among land use systems reflect differences in uptake of exchangeable bases and N- fixation. Joshi and Negi (2015) [11] had studied the physico-chemical properties along the soil profile of two dominant forest types in western Himalaya (Chamoli and Champawat district of Uttarakhand) viz, Oak and Pine Soils. They had recorded the pH of the Oak Soil samples (range 4.2-6.2) was comparable to that of Pine Soil samples (range 4.3-6.3). Both the soil samples were found to be slightly acidic. The result of the study indicated that the forest soil samples had lower pH as compared to the other land use areas due to soil acidification. A highly significant and negative correlation (-0.905 at 0.01 level) was observed between pH and Electrical Conductivity and non-significant and negative correlation with Organic Carbon (-0.417), Organic Matter (-0.501), Calcium (-0.075), Magnesium (-0.250), pH (-0.224) and Water Holding Capacity (-0.433) respectively. In other hand, soil pH was non-significant and positive correlation with Nitrogen (0.079), Phosphorus (0.182) and Potassium (0.021) respectively. The available source of nutrients has also significant effect on the pH of the soil of different land use patterns (Bhuyan, 2012) [6]. Urbanization alters the biological, chemical and physical properties of soil and hence degrading its quality resulting in loss of vegetation, poor water infiltration, accumulation of heavy metal, excess water runoff and soil erosion (Marcotullio *et al*., 2008) [13]. Soil Electrical Conductivity is one of the soil characteristics which have good interaction with the other soil characteristics. The values of Electrical Conductivity were observed to be in 0.60-3.41 ds/cm, where Electrical Conductivity was not found very high.

Hence, suitable fertilizer should be added to the soil for ensuring the maximum crop production. Relatively higher conductivity observed in forest area because of nature environment. Soil surface Electrical Conductivity showed significant and positive correlation with Organic Matter (0.725).

The soil physico-chemical properties like Organic Carbon and Organic Matter and available nutrient concentration were in decreasing order with more accumulation on the top surface soils. The maximum percentage of Organic Carbon was found in forest areas (2.39%), the Organic Carbon in other land use types was 0.52% in industrial area, 1.05% in residential areas, 1.00% in agro-residential area and 0.78% in agriculture area of Bhagtanpur village. Organic Matter and Organic Carbon were found to be low in industrial area due to industrial waste contamination. Higher soil Organic Carbon in the land use system resulted in to high Cation Exchange Capacity, which further affected the availability of Na, Ca and Mg. Organic Matter was also found higher in forest area due to litter decomposition i.e. 4.85%. The lowest concentration of Organic Matter was found in industrial area i.e. 0.87%. The amount of Organic Matter was almost same in a residential area (1.59%) and agricultural area (1.55%). 1.47% Organic Matter was found in agro-residential area which lowers down than the residential and agricultural area. Joshi and Negi (2015) [11] had recorded that in pine soil, Organic Carbon (0.46- 1.64%). Similar results were observed in this study of forest soil. Organic Matter showed highly significant and positive correlation with Organic Carbon (0.957), Moisture Content (0.864) and Water Holding Capacity (0.829), but showed non-significant and positive correlated with Potassium content. The positive correlation between Organic Carbon and Nitrogen could be because of the release of mineralizable Nitrogen from soil Organic Matter in proportionate amounts (Vanilarasu and Balakkrishnamurthy, 2014) [19] and adsorption of NH_4-N by humus complexes in soil. The role of Organic Matter in the buildup of soil nutrients appears crucial in all ecosystems and depends on the high foliage cover and vegetation biomass and higher rate of litter production and subsequent decomposition. Hence, it can be deduced that the nutrient return of vegetation to the soil would depend on the nutrient uptake by the biomass of each plant community (Awotoye *et al.* 2009) [2].

Nitrogen, Phosphorus and Potassium are referred to as the primary macronutrients of soil and most essential to provide the vitality and performance of plant grown. Available Nitrogen varied from 0.14% (industrial area) to 1.41% (forest area). The highest amount of Calcium was found in soil samples of forest area i.e. 11.04 meq/100gm. Minimum values of Calcium content was found in industrial area i.e. 6.95 meq/ 100gm and maximum value in forest area was 11.04 meq/ 100gm. Ca showed significant and positive correlation with Moisture Content and Organic Matter. Magnesium value was also highest in forest area (8.70 meq/ 100gm) and minimum in industrial area (5.54). Magnesium value of soil samples in other land use types was found 6.32 meq/ 100gm in residential area, 6.66 meq/ 100gm in agro-residential area and 8.49 meq/ 100gm in agricultural area respectively. Magnesium content showed positive correlation with Moisture Content, Water Holding Capacity, Organic carbon and Organic Matter. The Availability of Phosphorus was highest under surface soil samples of forest area and agro-residential area 0.69 % and minimum in surface soil samples 0.33% in industrial area due to deficiency of nutrient in the soil profile. It is well known that availability of Phosphorus is highly sensitive to changes in soil pH. With an increase in pH, Phosphorus content decreases as Phosphorus gets bound with Ca and Mg. as pH increased Av-P decreased. The significant and positive correlation between Organic Carbon and available Phosphorus (0.580) might be due to acidulating effect of Organic Carbon, formation of easily accessible organic matter. Available Phosphorus complexes, release of Phosphorus from organic complexes and reduction in Phosphorus fixation by humus due to formation of coatings on iron and aluminum oxides. The results are harmonious with the findings of Ayele *et al*. (2013) [3] and Singh *et al*. (2014) [17]. The Sodium content in soils ranged from 1.43% (agricultural area) to 6.04% of forest area soils. The available Potassium content in soils ranged from 0.15% of agro-residential area to 0.33% of residential area soils. The soil properties like Water Holding Capacity, Organic Carbon, Organic Matter, Nitrogen, Potassium, Phosphorus and Na content, etc. had higher value in forest land use systems as compared to the agriculture, industrial, agro-residential and residential areas of Haridwar city. Adoption of appropriate land use management practices and land use planning would help to minimize the degradation in soil physical quality and would ensure sustainable crop production and productivity (Ramesh *et al*., 2008) [15].

CONCLUSION

The study indicates that the physico-chemical properties of the soil such as Moisture Content, Water Holding Capacity, Electrical Conductivity, Organic Carbon, Organic Matter, Nitrogen, Phosphorus, Potassium and Sodium are negatively affected by industrial, residential, agro-residential and agricultural areas as compared to forest system possibly due to urbanization, exploitation of land, frequent tillage practices and other anthropogenic contamination. The high amount of physico-chemical properties in forest land use system indicates that the forest ecosystem has considerable impact on soil nutrient build up and accumulation by reduction the loss through soil erosion and leaching due to dense canopy and high litter production.

From the above conclusions, it is recommended that developments should be guided by sound knowledge about the soil information of the urban expansion areas. Urban development agencies and government should put greater emphasis on the ecological prospective in their decisions, national and regional planning, and policy formulation for different land uses.

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