Chapter - V

EFFECT OF FOREST DEGRADATION ON SOIL PROPERTIES

5.1 Introduction

The openness of forest due to human influence also changes the microclimate like soil properties, temperature and moisture content of the area. The relation between soil composition and forest community has been an important aspect for natural ecosystem. Braun-Blanquet (1934) has pointed out the close relationship between the natural evolution of the vegetation and the development of the soil (Sharma et al., 2010). Recently works on phytosociology and soil-vegetation interrelationship in the different forest types of Garhwal Himalayan region was done by Sharma et al. (2009a, 2009b, 2010a, 2010b, 2010c) and Gairola (2010). Sundarpandian and Swamy (2004) investigated the soil organic matter dynamics and carbon balance in disturbed tropical forest ecosystem in Western Ghats. Nitrogen in soil can change the spatial and temporal dynamics of vegetation (Knap et al., 1999). The plant species influences the rate of nutrients cycle within an ecosystem through litter-quality feedbacks (Wedin & Tilman 1996, Evans et al., 2001).The pattern of forest plant diversity is very much depended on the variation of altitude that linked diverse soil organic matter and NPK availability (Tomer and Tripathi, 2004). Impact of human activities on plant diversity and soil properties in Nokrek biosphere reserve, Meghalaya was well documented by Prabhu et al. (2004). The gradient of temperature and moisture in combination with different soil conditions and altitudinal changes results in a mosaic of different vegetation types (Hilbig, 1995). The post disturbance light environment impacted the shade tolerate vegetation composition (Kemball et al., 2005). Disturbances and environmental variability do ultimately create niche opportunities by modifying resource availability or supply rates. It is their proximate density independent effects on tree germination, establishment and/or mortality (Sankaran et al. 2004). In open forest the level of NPK is responsible for spread of weed species *Argemone maxicana* (Ramakrisnan, 1991). Natural vegetation of the Indian subcontinent has been subjected to dramatic alteration through human interference (Saxena, 1991).

Himalayan forests play an important role in tempering the inclemency of the climate, in cooling and purifying the atmosphere, in protecting the soil, in holding the hill slopes in position and in buffering up huge reserves of soil nutrients (Sharma et al. 2010). Eastern Himalayan region is very significant in terms of rich biodiversity for which it is under the two global biodiversity hotspots namely Himalaya and Indo-Burma amongst the world's 34 biodiversity hotspot. The different alluvial soil with diverse topography and unique climatic condition in terms of rainfall, temperature followed by annual flood plays a key role in development of rich soil profile. It is also enriched by the litter deposition from diverse forest types and nutrient deposition has mainly influenced by the rainfall in undulating hilly region. The availability of the nutrient contents that specially impact the vegetation pattern in a particular landscape also depended on the canopy of the forest. With continued forest destruction in the foothills of Indo-Bhutan areas there might be drastic change in the soil nutrient components in the areas. The reserve forest in the buffer of Manas biosphere reserve located in the Indo-Bhutan border areas have lost significant forest cover and described in earlier chapters (Ch I, Ch III and Ch IV).

From the above discussion it is found that there is no study carried out in the eastern buffer forest of Manas biosphere reserve or other parts of the reserve in terms of effects of forest degradation in relation to soil nutrient contents. The present chapter will cover the soil properties in different forest types and how the soil nutrients in different types of forests were influenced by forest degradation.

5.2 Methods

Different soil parameters like – organic matter content, nitrogen, phosphorus, potassium, soil texture, soil moisture content, etc. are evaluated following standard soil testing laboratory methods after collection of soil samples from disturbed and undisturbed forest areas. Estimation of organic matter and NPK were done by the methods described by Wakley and Black (1934) and Jackson (1973) respectively. Total nitrogen was determined by using micro-Kjeldahl method, phosphorus by colorimetrically and potassium by flame photometric method.

Statistical analysis was carried out with support of software SPSS 9.0. Analysis of Variance (ANOVA) and Pearson correlation and regression were used to confirm significant of the result as well as finding relation between soil and forest community structure.

5.3 Results and Discussion

In Manas biosphere reserve, soil samples were collected from differnt forest types, namely – evergreen/semievergreen forests, mixed decidous forest, scrub forests or degraded barren land and grassland areas including encroached areas having agricultural practices or human habitation with vegetable/kitchen garden. The results of the soil analysis for different reserve forests are shown in figures 5.1(a) – 5.1(d).

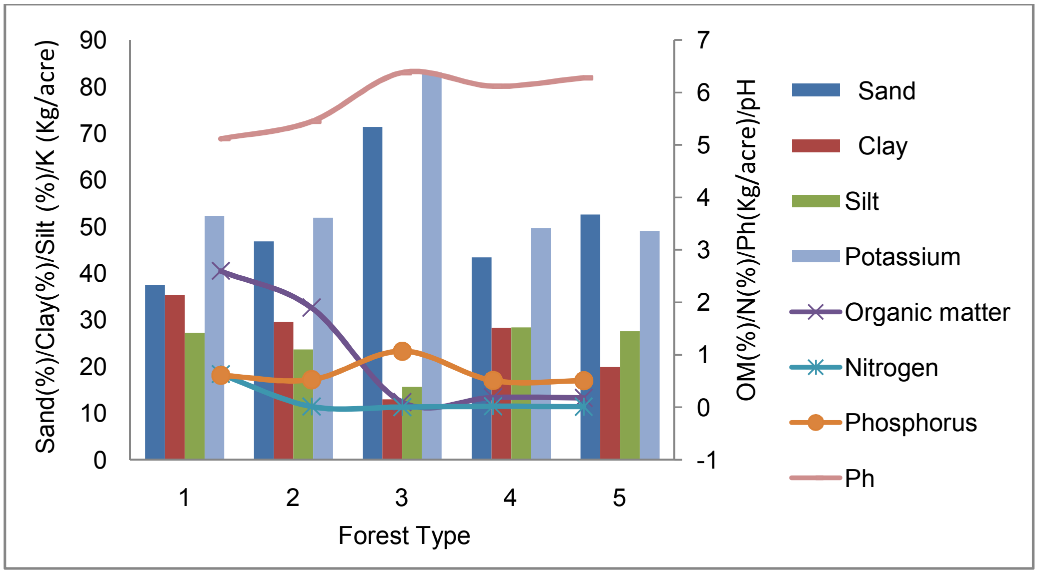

Fig. 5.1(a): Soil Characteristics in different landuse of Daodhora RF (1: Deciduous forest, 2: Scrub, 3: Grassland, 4: Agriculture land, 5: Vegetable garden)

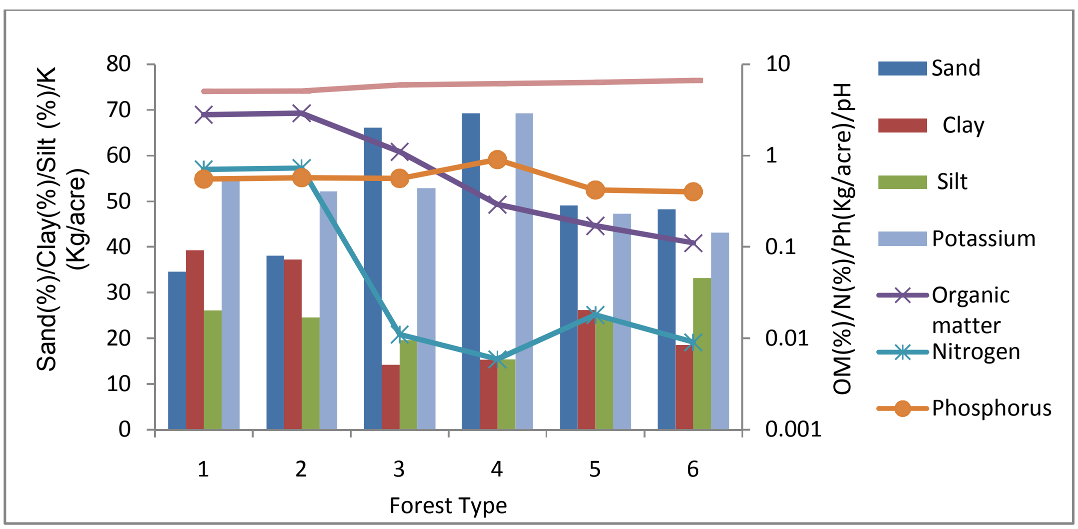

Fig. 5.1(b): Soil Characteristics in different landuse of Batabari RF (1:Evergreen/semievergreen forest,2: Deciduous forest, 3: Scrub, 4: Grassland, 5: Agriculture land, 6: Vegetable garden)

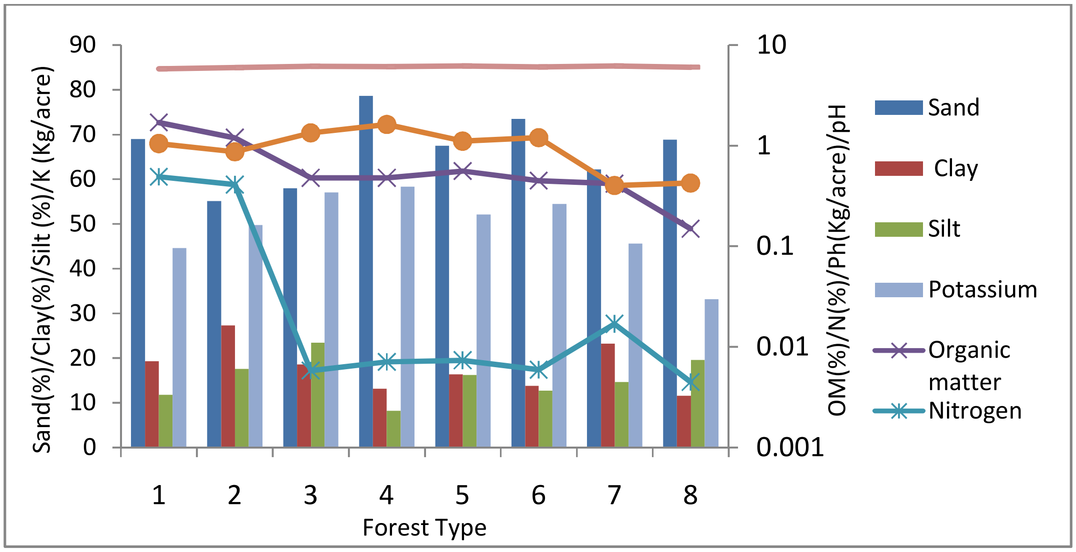

Fig. 5.1(c): Soil Characteristics in different landuse of Subonkhata RF (1:Evergreen/semievergreen forest, 2: Deciduous forest, 3: Scrub, 4: Grassland, 5 &6 Restored land, 7: Agriculture land, 8: Vegetable garden)

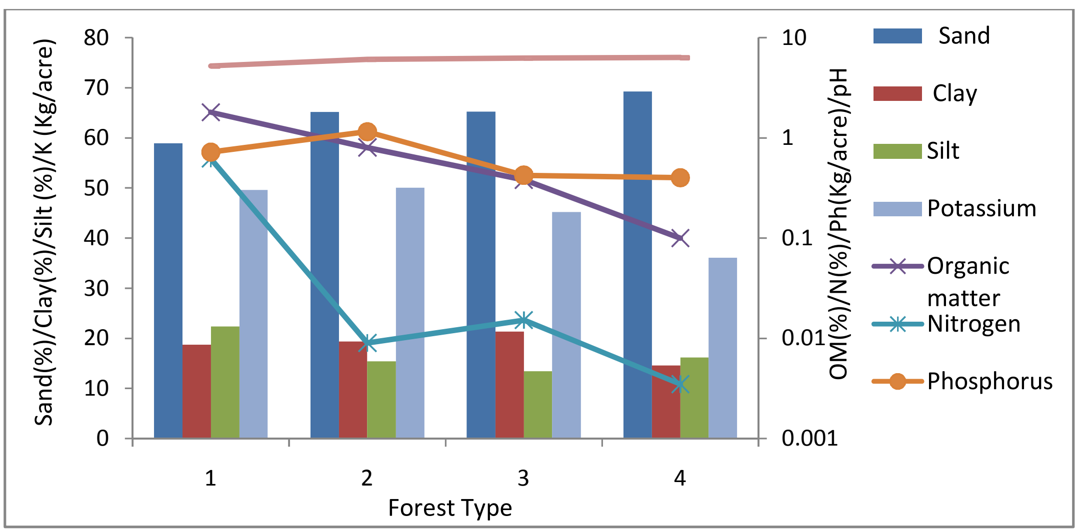

Fig. 5.1(d): Soil Characteristics in different landuse of Dihira PRF (1: Deciduous forest, 2: Scrub, 3: Grassland, 4: Agriculture land, 5: Vegetable garden)

The result indicated that the soil texture of the all the four reserve forests namely Daodhora, Batabari, Subonkhata and Dihira (proposed) are comprised of higher percentage of sand, low to moderate percent of clay and silt particles depending upon the different landuse in different topographical (altitude) variation. The sand percentage ranged between 37.2-71.4% in Daodhora, 34.5-69.2% in Batabari, 55.2-

78.6% in Subonkhata and 58.9-69.2% in Dihira proposed reserve forest. Interstingly highest sandy particles are observed in the grassland of the different reserve forest which turned to maximize in Subonkhata RF. This may be due to the excess loss of the forest in the riparian vegetation with undulating altitudianl variation. The opening of the land having poor forests cover favour loss of binding capacity of the soil and erosion resulted more sandy characters.

The average value of different soil parameters for all the four reserve forests and logging pressure in relation to different landuse is presented in Table 5.1. It has been observed that the nitrogen and organic matter content significantly increased in the natural/undesturbed evergreen/semievergreen forest and mixed deciduous forest in comparison to disturbed scrubland, grassland and human habitation or agricultural land. Increased nitrogen content in soil under undisturbed condition depicts high rate of litter decomposition, since the decomposition rate is more rapid on nitrogen rich sites (Gosz, 1981; Vitousek et al., 1994; Prescott, 1995). Nutrient supply to the soil due to decomposition of litter is reduced with increase in degree of disturbance (Conn and Dighton, 2000; Zimmer, 2002).

Interestingly there are no significant differences between the change of phosphorus and potassium contents and the other soil properties like – soil texture (sand, silt, clay), soil pH and moisture content (Table 5.1) in all the reserve forests. This may be due to the diverse soil dynamics in relation to forest community structure that still has some good forest. Moreover, rainfall and hydrological activities might effect the distribution of the soil minerals like potassium and phosphorus. The change of soil texture due to anthropogenic and hydrologic activities is possible only after a sufficiently long period of time. The undulating forest and grassland patches, grazing of the wildlife and domestic cattle in the forest might also influence overall similar properties of the soil. But the microclimate of the different sites and landuse might give different picture of the change of the soil texture and availability of potassium and phosphorus change. On the other hand, significant change of the the average values of canopy cover, canopy height and logging pressure was noticed in different forest types and disturbed lands (Table 5.1).

Table 5.1 : Average value of different soil parameters and logging pressure in relation to different landuse in MBR.

Parameters	Evergreen/Semi-evergreen Forest	Mixed deciduous Forest	Barren land/ Scrub	Grassland	Agriculture	Human habitation cum vegetable garden
Silt (%)	15.04^{z}	17.34^{z}	20.52^{z}	9.81^{z}	20.26^{z}	24.11^{z}
Sand (%)	40.61^{o}	32.69^{o}	59.03^{o}	54.81^{o}	54.96^{o}	59.72^{o}
Clay (%)	19.33^{c}	24.96^{c}	20.43^{c}	10.37^{c}	24.77^{c}	16.15^{c}
Soil Moisture (%)	16.12^{j}	23.26^{j}	12.75^{j}	22.16^{j}	13.75^{j}	14.12^{j}
pH	4.01^{v}	4.03^{v}	5.89^{v}	4.63^{v}	6.22^{v}	6.31^{v}
Organic Matter (%)	1.57^{a}	1.67^{a}	1.07^{ab}	0.21^{b}	0.29^{b}	0.13^{b}
Nitrogen (%)	0.45^{x}	0.44^{x}	0.01^{y}	0.004^{y}	0.017^{y}	0.007^{y}
Phosphorus (Kg/acre)	0.58^{m}	0.51^{m}	0.895^{m}	0.898^{m}	0.44^{m}	0.43^{m}
Potassium (Kg/acre)	37.2^{d}	38.55^{d}	52.97^{d}	52.65^{d}	46.94^{d}	40.37^{d}
Logging (point)	1^{r}	1.25^{rs}	2.75^{s}	2^{rst}	3^{t}	3^{t}
Canopy cover (%)	48.75^{p}	42^{p}	10.5^{q}	1^{q}	0^{q}	0^{q}
Canopy Height (m)	5.75^{e}	4.5^{ef}	2.75^{ef}	0.82^{f}	1^{f}	1^{f}

Note: *Superscript alphabets indicate closeness/difference of the values of a particular parameter. Same superscript indicates closeness, while different superscripts indicate differences among the values of a particular parameter. Different alphabets are used for different parameters.*

Table 5.2: Analysis of varience (ANOVA) of different soil parameters and logging pressure in relation to different landuse in MBR (Duncan post Hoc test performed to know level of change)

		Sum of Squares	df	Mean Square	F	Sig.
Sand	Between Groups	2444.552	5	488.910	0.934	0.483
	Within Groups	9425.713	18	523.651		
	Total	11870.264	23			
Clay	Between Groups	611.648	5	122.330	1.098	0.396
	Within Groups	2005.957	18	111.442		
	Total	2617.605	23			
Silt	Between Groups	500.146	5	100.029	1.274	0.318
	Within Groups	1413.509	18	78.528		
	Total	1913.656	23			
Orgnic Matter	Between Groups	9.906	5	1.981	3.322	**0.027**
	Within Groups	10.735	18	0.596		
	Total	20.640	23			
Nitrogen	Between Groups	1.025	5	0.205	6.038	0.002
	Within Groups	.611	18	3.395E-02		
	Total	1.636	23			
Phosphorus	Between Groups	.932	5	0.186	1.169	0.362
	Within Groups	2.870	18	0.159		
	Total	3.802	23			
Potassium	Between Groups	998.514	5	199.703	0.445	0.811
	Within Groups	8077.284	18	448.738		
	Total	9075.798	23			
pH	Between Groups	23.436	5	4.687	1.153	0.369
	Within Groups	73.162	18	4.065		
	Total	96.597	23			
Soil Moisture	Between Groups	343.318	5	68.664	1.025	0.436
	Within Groups	1071.768	16	66.986		
	Total	1415.086	21			
Canopy Cover	Between Groups	10037.208	5	2007.442	6.104	0.002
	Within Groups	5919.750	18	328.875		
	Total	15956.958	23			
Canopy Height	Between Groups	87.269	5	17.454	3.191	0.031
	Within Groups	98.468	18	5.470		
	Total	185.736	23			
Logging	Between Groups	15.833	5	3.167	3.257	0.029
	Within Groups	17.500	18	.972		
	Total	33.333	23			

The Analysis of Varience (ANOVA) was also performed to validate the change of the soil charactersitcs in relation to logging pressure in different landuse of the Manas biosphere reserve and the results are presented in Table 5.2. ANOVA was also supported by Duncan post hoc test to know the change or significant difference of the soil and logging factors in different forest communities.

It showed that the evergreen/semievergreen forests were converted to scrub forest due to moderate to heavy logging (P value 0.029) pressure in different forests and later encroached by the villagers. It resulted in significant decrease of the soil organic matter (P value 0.027), nitrogen (P value 0.002) due to low canopy cover (P value 0.002), height (P value 0.031) as indicated by ANOVA. Sundarpandian and Swamy (2004) found similar findings where the soil organic matter decreased in disturbed tropical forest ecosystem in Western Ghats. The low availability also influenced the vegetation dynamics of the study sites with invasion of new species using the microclimate of increased moisture, temperature as well as available soil nutrients. Knap et al. (1999) also observed nitrogen in soil that changed the spatial and temporal dynamics of vegetation types. Forest strata were found to change significantly in Namdopha national park due to forest exploitation as indicated by Nath et al. (2004). The plant species influences the rate of nutrients cycle within an ecosystem through litter-quality feedbacks (Wedin and Tilman, 1996; Evans et al., 2001).

Correlation among the different soil properties was also computed and the results are presented in Table 5.3. The values of correlation among different soil properties indicated that sand showed significant negative correlation with clay. This may be due to opening of the forest resulting excess deposition of the sand particle during rainy season in disturbed site or landuse with low altitude. The silt also showed significant negative correlation with potasium, while organic matter significantly changed the pH in the reserve. Silt percentage was changed with the disturbance of

Table 5.3: Correlations between different soil parameters of the reserve forests of Manas Biosphere reserve

		pH	Potasium	Phosphorus	Nitrogen	Organic Mater	Silt	Clay
Potasium	PC	0.432						
	Sig. (2-tailed)	0.468						
	N	5						
Phosphorus	PC	0.380	0.993**					
	Sig. (2-tailed)	0.529	0.001					
	N	5	5					
Nitrogen	PC	-0.762	-0.205	-0.100				
	Sig. (2-tailed)	0.135	0.741	0.873				
	N	5	5	5				
Organic Mater	PC	-0.990**	-0.340	-0.286	0.768			
	Sig. (2-tailed)	.001	0.576	0.641	0.130			
	N	5	5	5	5			
Silt	PC	-0.338	-0.954*	0-.925*	0.305	0.237		
	Sig. (2-tailed)	.578	.012	0.024	0.618	0.702		
	N	5	5	5	5	5		
Clay	PC	-0.875	-0.725	-0.681	0.655	0.799	0.690	
	Sig. (2-tailed)	0.052	0.166	0.206	0.230	0.105	0.198	
	N	5	5	5	5	5	5	
Sand	PC	0.729	0.877	0.835	-0.567	-0.636	-0.872	-0.956*
	Sig. (2-tailed)	0.162	0.051	0.078	0.319	0.248	0.054	0.011
	N	5	5	5	5	5	5	5

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

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

the forest while Potassium stays with clay particle and favoured by plants for its metabolic activity. In disturbed forest or undisturbed forest potassium cycle going on through natural forest or scrub weed vegetation but silts drained to lower altitude in disturbed condition resulting negative coorelation. The organic matter deposited due to decomposition of litterfall and dead vegetation changed the H ion resulting acidic soil and vise versa in disturbed area. Phosphorus and Potassium showed significant correlation in the overall biosphere reserve. May be with increase of the vegetation, both the components mixed with soil through respective cycle or gradually showed slow decrease with disturbance resulted in positive coorelation.

Sand showed insignificant negative correlation with silt, organic matter and nitrogen, and positively correlated to phosphorus, pottasium and pH (Table 5.3). Though insignificant in overall situation, the increase of sand may decreases the silt, organic matter, nitrogen at micro-level. Figures 5.1(a) – 5.1(d) also showed that sand content increases in the disturbed sites in all the reserve forest and proposed reserve forest resulting decrease in nitrogen and organic matter including other particle like clay and silt. The change of the potasium and phosphorus seems to be slow indicated their postive correlation mentioned earlier. Of course, there is slight improvement of the soil minerals in agricultural and human habitation vegetable garden. This is due to the use of cowdung in the agricultural practice by the local people. While nitrogen and organic matter is low in disturbed forests, the sharp decrease of nitrogen can be seen from the figures of the Subonkhata (Fig.5.1(c)) and Dihira (Fig.5.1(d)). This is due to the excessive opening of the forest by human activity in the Subonkhata RF and Dihira PRF that already indicated through remote sensing based study in chapter IV. The high slopping and altitude of the disturbed Subonkhata RF in comparison to Daodhora RF and Batabari RF also favoured high speed of the water current and carrying of the large amount of soil to the low lying areas resulting poor nutrient contents in the remaining distrbed forests while soil is highly composed of sandy particle. The pattern of forest plant diversity and types are very much depended on the variation of altitude that linked diverse soil nutrient availability (Tomer and Tripathi, 2004).

The correlation of the soil texture and available nitrogen, phosphorus and potassium including mositure content were examined with the change of the canopy cover, canopy height and logging pressure by the fringe villagers. Impact of human activities on plant diversity and soil properties was confirmed by Prabhu et al. (2004) in Nokrek biosphere reserve, Meghalaya. With open forest the heliophytes replaced the schiophytes with increased sun lights and temperature. The gradient of temperature and moisture in combination with different soil conditions and altitudinal changes results in a mosaic of different vegetation types (Hilbig, 1995).

It has been established that with the increase of the logging pressure by human activities, there occurs rapid change in forest types. Therefore, correlation of the soil paramaeters with canopy cover and canopy height were also computed for different forest types and and the results are presented in Table 5.4. It has been observed that the canopy cover and canopy height are negatively related with loging pressure indicating the significance of the study. Logging pressure is positively correlated with forest degradation, sand, silt and potassium contents in soil. The forest degradation was ranked as - Deciduous forest: rank 1, Scrub: rank 2, Grassland: rank 3, Agriculture land: rank 4 and Vegetable garden: rank 5. The logging pressure helped positive increase of the sand through natural and man made drainage and streams during the heavy rain in all the reserve forests.

Percentage of clay present in soil showed significant positive relation with soil moisture, canopy cover and height which signifies the soil binding properties of the clay particle in undisturbed forests. This is also favoured more nitrogen and organic matter availability and confirmed through significant postive correlation beween them in the same analysis. One intersting point is that logging has showed in significant increased of the potassium in the soil. This may be due to rich depostion of the potasium in the

Table 5.4 : Correlation of soil paramaeters with canopy cover, canopy height, loging pressure and altitude in different forest types (sample size = 24)

		Nitrogen	Phosphorus	Pottasium	pH	Soil Moisture	Canopy Cover	Canopy Height	Logging Pressure	Altitude
Forest degradation	PC	-.65**	-.12	.10	.41*	-.17	-.71**	-.64**	.60**	.23
	Sig. (2-tailed)	.000	.591	.635	.047	.463	.000	.001	.002	.284
Sand	PC	-.07	.70	.77	.90	.03	-.03	.07	.70	.05
	Sig. (2-tailed)	.730	.000	.000	.000	.888	.886	.762	.000	.820
Clay	PC	.62**	.23	.59**	.58**	.53*	.61**	.67**	.25	-.06
	Sig. (2-tailed)	.001	.275	.002	.003	.011	.002	.000	.242	.776
Silt	PC	.30	.18	.61**	.71**	.54**	.29	.38	.53**	.09
	Sig. (2-tailed)	.155	.401	.002	.000	.009	.172	.069	.008	.683
Organic matter	PC	.89**	.17	.31	.14	.42	.91**	.92**	-.15	-.22
	Sig. (2-tailed)	.000	.418	.146	.525	.054	.000	.000	.497	.307
Nitrogen	PC		.10	.19	.04	.48*	.97**	.89**	-.28	-.14
	Sig. (2-tailed)		.63	.38	.84	.02	.00	.00	.19	.53
Phosphorus	PC			.73**	.59**	.27	.15	.24	.25	.08
	Sig. (2-tailed)			.000	.002	.218	.488	.268	.231	.711
Potassium	PC				.85**	.66**	.22	.32	.59**	-.07
	Sig. (2-tailed)				.000	.001	.311	.134	.003	.736
pH	PC					.31	.07	.18	.75	.12
	Sig. (2-tailed)					.155	.759	.397	.000	.600
Soil Moisture	PC						.44*	.40	.10	-.26
	Sig. (2-tailed)						.039	.069	.649	.253
Canopy cover	PC							.93**	-.31	-.10
	Sig. (2-tailed)							.000	.142	.638
Canopy Height	PC								-.27	-.10
	Sig. (2-tailed)								.206	.660
Logging Pressure	PC									-.18
	Sig. (2-tailed)									.426

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

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

rock that barren by the deforestation and drained to the low land areas. With good canopy cover, the vegetation height was also found to increase in evergreen and mixed moist undisturbed forests as indicated positive correlation between them.

5.4 Conclusion

The average nitrogen (0.45-0.007%) and organic matter (1.57-0.13%) contents are significantly high in evergreen and semievergreen forest including mixed deciduous forest in comparison to disturbed scrub land, grass land and human habitation and agricultural sites. There is no significant change of the average phosphorus, potassium contents and soil properties like sand, silt, clay, moisture percentage value, if considered overall landscape of buffer areas of Manas biosphere reserve despite high human disturbances. This may be due to the diverse soil dynamics in relation to forest community structure that still has some good forest and self sustaining mechanism. The undulating forest and grassland patches, grazing of the wildlife and domestic cattle might also influenced soil properties.

Significant change of canopy cover, canopy height and logging pressure was noticed in different forest types and disturbed lands. A detail study in the microhabitat level study in different forests confirmed that the soil texture of the all the four reserve forests namely Daodhora, Batabari, Subonkhata and Dihira proposed reserve forest are comprised of higher percentage of sand with low to moderate clay and silt particles depending upon the different landuse in different topographical variation. The sand percentage ranged between 37.2-71.4% in Daodhora, 34.5-69.2% in Batabari, 55.2-78.6% in Subonkhata and 58.9-69.2% in Dihira proposed reserve forest. Interstingly, highest sandy particles are observed in the grassland of the different reserve forest which turned to maximize in Subonkhata RF. This may be due to the excess loss of the forest in the riparian vegetation with undulating altitudanal variation.

Lands having poor forests cover favour loss of binding capacity of the soil and erosion (Plate 12) resulted more sandy character of soil in these areas. The correlation between different soil properties indicated that sand showed significant negative correlation with clay. This may be due to opening of the forest resulting excess deposition of the sand particle during rainy season in disturbed sites or landuse with low altitudes. Silt content in soil also showed significant negative correlation with potasium. Silt percentage was changed with the disturbance of the forest, while Potassium stays with clay particle and favoured by plants for its metabolic activity. The organic matter deposited due to decomposition of litterfall and dead vegetation makes the soil acidc (negative correlation). Phosphorus and Potassium showed significant correlation in the overall biosphere reserve.

Sand showed insignificant negative correlation with silt, organic matter and nitrogen, while it is positively correlated with phosphorus, pottasium and pH. The increase of sand may decreases the silt, organic matter, nitrogen at micro-level.

There is slight improvement of the soil minerals in agricultural and human habitation vegetable garden. This is due to the use of cowdung in the agricultural practice by the local people. The nitrogen and organic matter is low in disturbed forests and the sharp decrease was observed Subonkhata RF and Dihira PRF. This is due to the excessive opening of the forest by human activity in the Subonkhata RF and Dihira PRF having high slopping and altitude in comparison to Daodhora RF and Batabari RF resulting high speed of the water current and carrying of the large amount of soil to the low lying areas.

The human impact on the forest destruction in eastern buffer forests of Manas Biosphere Reserve leads to the lowering of canopy cover in the diverse forest types namely evergreen, semievergreen forest including mixed decidous forest and influenced the soil degradation in terms of organic matter content, nitrogen as well as accumulation of sandy particle in disturbed forests. The sandy nature of the disturbed forests are the result of drainage system and poor vegetation cover to accelerate soil erosion. The change in soil dynamic also leads to the poor growth of the forests in disturbed sites.

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