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Assessment of Impact of Anthropogenic Disturbances on Soil Characteristics in the Sub-tropical Forests of Aizawl, Mizoram

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Abstract

Objectives: Soil degradation has become a global concern. Understanding the soil health is necessary as it plays a crucial role in conserving the forest resources, along with ensuring food security in the twenty-first century. The study area under investigation has witnessed drastic change in land use given the anthropogenic activity like agricultural and developmental activity. Therefore, this study aims to understand the impact of these disturbances on soil characteristics. **Methods**: To understand the effect of anthropogenic disturbance on the soil of sub-tropical forest in Aizawl district, each soil profile was analyzed for texture, soil moisture content (SOM), soil organic content (SOC), soil organic matter (SOM), available nitrogen (AN), available potassium (AK) and available phosphorus (AP). The correlation was applied among the physical and chemical properties of soil samples. **Findings:** There values varied from undisturbed to disturbed stand for pH (5.06-5.53), SMC (18.5-30.71), SOC (.552-1.43), SOM (-0.949-2.431) BD (0.9-1.22), AN (40.39 to 108.71kg/ha), AK (69.72 to 108.59kg/ha) and AP (0.281 to 0.851kg/ha). The findings reveal that there is disturbance affects the physical and chemical properties of soil. **Novelty:** and therefore we need to adapt the management strategies that are specific to requirements of the sites.

Keywords: Anthropogenic Disturbance; Agriculture; Desertification; Soil degradation; Soil health

1 Introduction

Soil is a binding factor between the plant and its nutrients thus we need healthy soil for good agricultural productivity and conserving forest resources, as it ensures economic prosperity to a nation. Soil is crucial natural resource. It helps in ensuring food security in the twenty-first century. Soil degradation is a burning issue with immense pressure due to anthropogenic activity like conversion of forest land into agriculture land, plantation, roadways, railways and residential areas causing change in land use.

The terms disturbance, perturbation, and stress have been applied in various ecological contexts, often synonymously, inconsistently, and ambiguously[(1)]. Disturbances can be natural and human induced can cause stress for the ecosystem. Some level of disturbance is essential for ecosystems as it helps the ecosystem. Intermediate level of ecological disturbances is good for the ecosystem as it helps in distribution of resources[(2)] and increases the diversity of the ecosystem. Resilience of an ecosystem helps it to survive after a disturbance and bounce back to its pristine condition. Therefore, disturbance plays a significant role in determining the function, stability and health of an ecosystem. The disturbance caused to an ecosystem due to anthropogenic activity are difficult to recover. Land use and land cover which are major anthropogenic disturbance can alter the soil physical, chemical, biological properties[(3)].

The North-East region of India comprises of part of eastern Himalaya and is geographically situated in close proximity to China. India and China being the two most populated nations of the world. Therefore, eastern Himalaya is often referred as a 'crisis eco-region', this is due to the massive population that creates huge demand for natural resources putting biodiversity under tremendous pressure and stress to derive benefits[(4)]. Mizoram is also part of eastern Himalaya and Indo-Burman biodiversity hotspot. It is losing the pristine forest rapidly and shifting cultivation is one of the major cause identified by forest survey report of India[(5)].According to a report published by Indian Space Research Organization (ISRO) desertification rate is highest in Mizoram in all of India. ISRO puts Mizoram among states which have less than 10% area under desertification however Lunglei district has the highest increase in land degradation (5.81% from 2003-05 to 2011-13) among all Indian states.[(6)]

Though there are plethora of literature available for the northeastern region of India but there lack of data specific to the state of Mizoram. The existing studies have not explored the soil characteristics in the light of anthropogenic disturbance in the area under investigation. Human induced disturbances has become one of the leading cause of soil degradation in recent times. The exponentially growing population has led to rapid increase in developmental activity in Aizawl. These anthropogenic activities will cause disturbance which may led to reduction in fertility of soil. The study area under investigation has witnessed drastic change in land use given the rapid pace of ongoing agricultural and developmental activity. Thus this study aims to understand the effect of disturbance on the soil of sub-tropical forest in Aizawl district by analyzing the physical and chemical characteristics of soil and to further understand the impact of disturbance on soil characteristics.

2 Methods and Materials

2.1 Study area

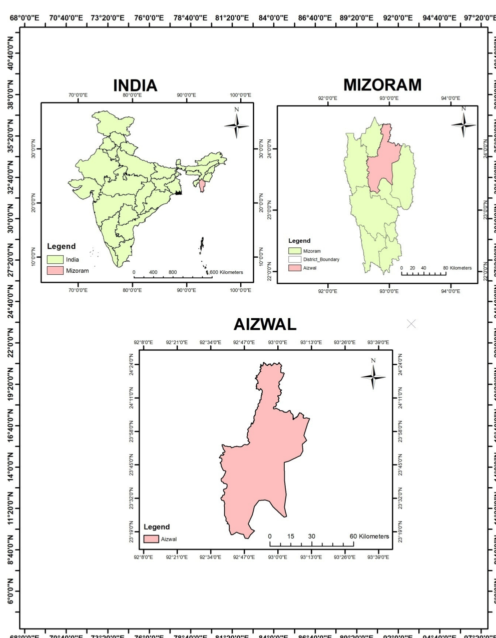

Fig 1. Map of study area

Mizoram is located in the northeastern corner of India blessed with magnificent landscape and green forest covering 85% of its geographical area[5]. The study area lies in Aizawl city which is the capital of Mizoram having mild summer and winter with an average rainfall of 2500 mm annually mainly confined to monsoon. Aizawl has been subjected to rapid infrastructure development and urbanization due to increasing population. The study area houses beautiful green sub-tropical forest located at coordinates 23.7307° N, 92.7173° E. Some of the commonly found plant species Schima wallichii *Bamboa ceiba* L, *Semecarpus anacardium* L.f., *Crotalaria anagyroides* Kunth, *Derris Robusta* (Roxb. ex DC) Benth, *Acacia pennata* (L) Willd, *Acacia eburnean* (L.f.) Willd. *Combretum flagrocarpum*, *Passiflora foetida* L, *Alangium chinense (Lour.) harms.*

2.2 Data collection

The anthropogenic disturbances like shifting cultivation, construction work, and other developmental activity can affect the light intensity, number of stumps and canopy cover. Thus, sampling area was classified based on the light intensity, number of stumps and canopy cover into undisturbed and disturbed sites. The study was conducted in year 2021 and soil samples were collected from across 20 sites, 10 for each disturbed and undisturbed. The samples were taken using a soil core with a scale of 10 cm and inner diameter of 10 cm, from two depths of 0–10 and 10–20. Each soil profile was analyzed for temperature, relative humidity (RH), texture, pH, soil moisture content (SMC) and bulk density (BD), soil Organic Matter (SOM), soil organic content (SOC), available nitrogen (AN), available potassium (AK) and available phosphorus (AP).

2.2.1 ***Methods***

The various methods applied for analysis of soil characteristics are as follows; Temperature: Soil temperature was measured by using a soil thermometer. RH: hygrometer, Texture analysis of soil: Hydrometer method, USDA. Soil pH: The pH of the soil was determined in 1:5 soil: water suspension with the help of a glass electrode. SOC: Organic carbon content of the soil samples was determined by titrimetric method[7] and represented in percentage. Bulk density: Core method. Soil Moisture Content: Gravimetric method [8]. SOM: Oven dried method [8]. Available nitrogen (N): Available N was determined by titrimetric method[7]. Available phosphorus: The available phosphorus of the soil was determined using a spectrophotometer. Available potassium: using flame photometer.

2.2.2 ***Statistical analysis***

The correlation was applied to the data obtained from the physicochemical analysis of soil sample using SPSS.

3 Results and Discussion

The top soil is the most fertile layer rich in organic material and it generally extends up to 20cm; the erosion of surface soil by water or wind leads to decrease in soil aggregation and stability, and hence soil fertility[9]. The correlation matrix shows correlation among soil physical and chemical properties (Table 3). The correlation matrix can be inferred to indicates how strongly one factor affects the other components of soil properties. Any change in one factor will affect the other factor based on the strength and nature of the correlation. The available nitrogen shows strong positive correlation with soil moisture .861($p>0.05$). Bulk Density has strong positive correlation with the pH at .733 ($p>0.05$). The soil organic matter has strong positive correlation with soil organic carbon of .994 ($p>0.05$). The available potassium has strong correlation with available nitrogen .987 ($p>0.01$).

The soil temperature varies with depth and disturbance at all sites but it was found to be lower than the ambient air temperature (22°C -26°C, Table 1 and Table 2) at all sites. The texture of the soil in the study area for both disturbed and undisturbed was loamy sand (sand content range from 75%-85%). The loamy sand texture of the soil have characteristics similar to sand which includes good water drainage but this also causes the problem of low nutrient content. The pH scale is used to quantify the acidity of soil as it is one of the most essential parameters to understand soil health[10]. The pH for both disturbed and undisturbed were low (5.06-5.53, Table 1 and Table 2) therefore the soil is acidic in nature. The pH readings are in line with similar studies[11–13]. The upper depth of undisturbed forest is more acidic (5.06) than the lower depth (5.53), this can be attributed to leaching of nutrients due to high precipitation in the study area. The soil of disturbed site is more acidic (5.07-5.09) than undisturbed site. There was slight variation in pH levels at different depths. Acidity of the soil is a common problem for northeastern states. Studies have reported pH in lower range for loamy sand. There was no variation in the pH of upper and lower depth of disturbed site. This is possible because of excessive leaching and soil erosion due to heavy precipitation[14]. Studies support soil pH also determines the microbial activity[15,16]. The SMC lies in range of 18.5%-30% (Table 1 and Table 2), the values of SMC higher in undisturbed forest for all sites and depth as compared to the disturbed site. The high SMC in undisturbed sites can be attributed to dense canopy cover at the sites (>70%)[17] and furthermore the moisture retained in the pores of the soil helps in plants growth. The undisturbed forest has high soil moisture content in the upper layer and the findings are in line with similar studies[11,12,18]. The disturbed site has reported lower SMC, this can be attributed to the lack of vegetation which leaves high exposure to sun causing rapid drying and prone to erosion of top fertile layer. BD for the sample ranges from 0.9 to 1.32 (Table 1 and Table 2) which is similar to the work done[17,19]. The BD varies depending upon the structure of soil[19]. Higher BD of disturbed sites indicated the soil are compactly packed. The BD of the upper depth is comparatively lower than that of lower depth. The lower BD helps in better growth as roots are able to penetrate to more depth to acquire more nutrients. The BD helps us understand the porosity of the soil. Higher porosity makes soil more aerated and allows moisture retention[20].

The soil organic carbon for all sites and depths were fairly low (0.652-1.43, Table 1 and Table 2). This disturbed sites had higher concentration of SOC (1.01-1.43) relativity to undisturbed sites, though both are fairly low when compared with similar studies[12,18]. The loss of soil organic carbon has cascading effects which further leads to diminish the water-holding capacity and reduced nutrient content making on vegetation survival unviable. The very low level of organic carbon, in both undisturbed and disturbed sites are attributed to the high sand content in soil, heavy rainfall that is responsible for topsoil erosion and leaching of nutrient. The selected disturbed sites were mostly current jhum or abandoned jhum. The burning of vegetation is common practice for jhum cultivators which occurred once a year and thus fire is a major disturbance of the ecosystem. The bulk density ranged was within the reported range (0.9-1.31, Table 1 and Table 2). SOM ranged from 0.949-2.431 which is relatively lower similar to soil organic matter. Soil organic matter plays critical role for the stabilization of soil structure, retention and release of plant nutrients and maintenance of water-holding capacity, thus making it a key indicator not only for agricultural productivity, but also for environmental resilience[1].

The available macronutrients in soil represents the concentration of nutrients which are readily available for uptake by plants. Therefore, the available nitrogen, available potassium and available phosphorus were analyzed. The analyzed micronutrients were available in very low concentration in all sites for all depths. In the disturbed sites there was higher level of potassium, whereas undisturbed sites were slightly rich in nitrogen and phosphorus. Though available nitrogen for both sites and depth were in lower range (40.39 to 108.71kg/ha, Table 1 and Table 2), the undisturbed site had relatively higher nitrogen content than the disturbed sites. The available nitrogen is essential element required for plant growth and higher nitrogen content have been reported in loam rich soil than in sandy soil. The range of available potassium was in the range of low to medium for all sites at all depths (69.72 to 108.59 kg/ha, Table 1 and Table 2) however it showed drastically different trend from available nitrogen as it was higher in disturbed site compared to undisturbed sites. The phosphorus is limiting nutrient in all ecosystem. The phosphorus range for the current study lies from 0.281 to 1.003 kg/ha, (Table 1 and Table 2). The highly disturbed sites have relatively lower phosphorus content this can be due to lack of vegetation that makes topsoil more prone to erosion as well as lack of vegetation means lack of litter fall thus no nutrient cycling in the soil. The lower phosphorous in top soil of disturbed sites can be due to leeching of nutrient[16,21,22].

Table 1. The result of physico-chemical analysis of soil in the study areas

Soil parameters	Soil depth (0-10 cm)	
	Disturbed stand	Undisturbed stand
Temperature (Celcius)	26	25
Humidity (%)	82	90
BulK Density	1.22	0.9
pH	5.47	5.06
SOC (%)	1.43	0.652
SOM (%)	2.431	1.121
SMC (%)	18.5	30.7
AK (kg/ha)	108.58	79.23
AN (kg/ha)	65.05	108.71
AP (kg/ha)	0.851	0.464
Texture	Loamy sand (sand- 85%)	Loamy sand (sand- 75%)

Table 2. The result of physico-chemical analysis of soil in the study areas

Soil parameters	Soil depth (10-20 cm)	
	Disturbed stand	Undisturbed stand

Continued on next page

Table 2 continued

Temperature (Celcius)	25	22
Humidity (%)	80	85
BulK Density	1.32	1.01
pH	5.6	5.53
SOC (%)	1.018	0.552
SOM (%)	1.7306	0.949
SMC (%)	20.63	28.5
AK (kg/ha)	73.31	69.72
AN (kg/ha)	40.39	71.08
AP (kg/ha)	0.403	0.281
Texture	Loamy sand (sand- 80.6%)	Loamy sand (sand- 77%)

Table 3. The correlations in the physico-chemical analysis of soil.

Correlations									
		SMC	**pH**	**SOC**	**SOM**	**bulk density**	**Ak**	**AN**	**AP**
SMC	**Pearson Correlation**	1	-.756**	-.692*	-.702*	-.903**	-0.245	.861**	-0.172
	Sig. (2-tailed)		0.004	0.013	0.011	0.000	0.442	0.000	0.828
	N	12	12	12	12	12	12	12	4
pH	**Pearson Correlation**	-.756**	1	0.480	0.437	.733**	-0.075	-.814**	0.115
	Sig. (2-tailed)	0.004		0.115	0.156	0.007	0.817	0.001	0.885
	N	12	12	12	12	12	12	12	4
SOC	**Pearson Correlation**	-.692*	0.480	1	.994**	0.533	.815**	-0.383	0.869
	Sig. (2-tailed)	0.013	0.115		0.000	0.074	0.001	0.219	0.131
	N	12	12	12	12	12	12	12	4
SOM	**Pearson Correlation**	-.702*	0.437	.994**	1	0.540	.826**	-0.391	0.858
	Sig. (2-tailed)	0.011	0.156	0.000		0.070	0.001	0.209	0.142
	N	12	12	12	12	12	12	12	4
bulk density	**Pearson Correlation**	-.903**	.733**	0.533	0.540	1	0.036	-.893**	0.287
	Sig. (2-tailed)	0.000	0.007	0.074	0.070		0.911	0.000	0.713
	N	12	12	12	12	12	12	12	4
Ak	**Pearson Correlation**	-0.245	-0.075	.815**	.826**	0.036	1	0.150	.987*
	Sig. (2-tailed)	0.442	0.817	0.001	0.001	0.911		0.642	0.013
	N	12	12	12	12	12	12	12	4
AN	**Pearson Correlation**	.861**	-.814**	-0.383	-0.391	-.893**	0.150	1	0.038

Continued on next page

Table 3 continued

	Sig. (2-tailed)	0.000	0.001	0.219	0.209	0.000	0.642		0.962
	N	12	12	12	12	12	12	12	4
AP	**Pearson Correlation**	-0.172	0.115	0.869	0.858	0.287	.987*	0.038	1
	Sig. (2-tailed)	0.828	0.885	0.131	0.142	0.713	0.013	0.962	
	N	4	4	4	4	4	4	4	4

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

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

4 Conclusion

This present study observed that the disturbed sites in the study area had high acidity, available potassium, available phosphorus, soil organic carbon and soil organic matter, but were poor in soil moisture content and available nitrogen. The soil at disturbed sites have higher percentage of sand. It's apparent that the soil at the undisturbed site have higher essential macronutrients than the disturbed sites that have been affected by anthropogenic activity. The undisturbed site has comparatively better soil quality, thus inferring better agricultural productivity. Therefore, we need to practice soil management specific to the requirements of the sites for better soil fertility.

5 Declaration

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