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Effect of sandstone quarry on soil characteristics of sub-tropical forests in Mizoram, North-East India

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ABSTRACT

The present study was conducted during 2012-2013 in the sub-tropical forest of Mizoram. Three study sites representing undisturbed (un-mined area), moderately disturbed (mining 10 years back) and highly disturbed (ongoing mining operation) were selected for detailed investigation. The soil samples were collected seasonally during monsoon and post-monsoon seasons considering top-soil (0-10 cm depth) and sub-soil (10-20 cm depth), for analysis of various soil characteristics namely, moisture content, pH, organic carbon, total nitrogen, and available phosphorus. The findings depicts that soil pH ranged from 5.57 (undisturbed stand) to 6.83 (highly disturbed stand) indicating acidic nature of soil. Soil moisture content was ranged from 31.4 to 18.6 % from undisturbed to the highly disturbed stand. There was sharp decrease in organic carbon from undisturbed (3.64 %) to the highly disturbed (2.08 %) stand. Similarly, total nitrogen decreased from 0.31% to 0.12 % and phosphorus content decreased from 0.32 ppm to 0.11 ppm, from undisturbed to highly disturbed stand. The C:N ratio also decreased from highly disturbed stand (20.0) to the undisturbed (11.28). A similar trend in result was observed for both top-soil and sub-soil. There was significant correlation between various parameters and study sites.

Key words: Anthropogenic activities, Sandstone quarry, Soil fertility, Sub-tropical forest

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INTRODUCTION

In India, the sandstone quarry has been in practice since pre-historic time. The nature of quarrying processes creates a potential negative impact on the environment both during and after the mining. In Mizoram, sandstone quarry is prevalent and it provides employment opportunities to the rural people at a large. Primarily, it is beneficial from socio-economic point of view. But, there are several negative impacts on environment. Unscientific quarry leads to destroy large tracts of forest, resulting into loss of soil fertility on one hand and soil erosion on other hand.

Soil is one of the most important renewable natural resource. It forms the basis of all life on the earth. With advent of industrialization, the society had neglected the environment that adversely impacting soil (Ramaswamy *et al*, 2007). Loss of soil fertility and soil pollution problem are enhanced due to continous accumulation of small stones and fine particles without preserving the soil on the land under highly disturbed sites which later deteriorate the soil physico-chemical properties (Young, 1997). It is obvious that there is paucity of information on status of soil in the sandstone mining areas, as limited efforts have been made by the researcher particularly in the north east India. Thus, the present investigation has been carried out to study soil characteristics in un-mined area, abandoned mining area and ongoing mining area, with an aim to assess the impact of sandstone quarry on soil characteristics in Mizoram.

EXPERIMENTAL SECTION

Description of study area and study sites:
The study was carried out at two villages namely Sihhmui and Sairang in Aizawl district of Mizoram. The study area lies between 21°58'N - 21°85'N longitude and 90°30'- 90°60'E latitude. For detailed investigation, three study sites representing undisturbed-UD (un-mined area), moderately disturbed-MD (mining 10 years back) and highly disturbed-HD (ongoing mining operation) were selected.

Soil sample collection and analysis:
Soil samples were collected from selected sites during 2012-2013 for top-soil (0-10 cm) and sub-soil (10-20 cm) on seasonal basis in triplicate. The soil samples were analyzed for total nitrogen (Kjheldahl method), organic carbon (Walkley and Black, 1934) and available phosphorus (Molybdenum Blue Method). Soil moisture content was determined by gravimetric method and soil pH was measured electromically by digital pH meter using 1:2:5 suspension of soil and water. The methods as outlined in Allen *et al.*, (1974) and Anderson and Ingram (1993) were adopted for analysis of soil chemical characteristics.

Statistical Analyses:
The statistical analyses namely, mean and standard errors were computed. The Pearson's correlation coefficient (r) using sigma plot 12 was computed to determine relationship between the parameters.

RESULTS AND DISCUSSION

The findings of the present study has been presented and discussed as follows.

***Soil moisture content*:**
The findings reveal that the soil moisture content in top-soil varied from 25.4 % (HD) to 31.4 % (UD) during monsoon season, and from 20.67 % (HD) to 30.6 % (UD) during post-monsoon season. A similar trend in results was established for sub-soil with lower values. There was a decreasing trend in values from undisturbed to the highly disturbed stand with respect to the both season and soil depth. Low retention of moisture content under disturbed condition could be linked with removal of vegetation and destruction of top-soil. The findings on soil moisture content were in conformity with the work of Tiwari *et al*., (1992). Fig. 1.

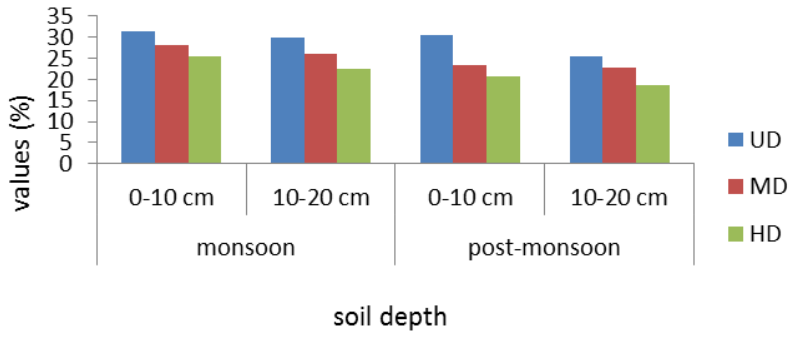

Fig.1.Soil moisture content (%) along disturbance gradient

Soil pH:
The pH of soil is of utmost importance and it helps in breaking down the organic matter. The soil pH in top-soil varied from 6.3 (HD) to 5.57 (UD) during monsoon season, and from 6.83 (HD) to 5.87 (UD) during post-monsoon season. In some cases, sub-soil was more acidic than top-soil. This could be due to leaching through percolating water. The soil was slightly acidic at all the sites. This could be due to high rate of litter decomposition. Lower values at undisturbed site may be due to more accumulation of organic matter on the soil surface. Arunachalam and Pandey (2003), Mishra (2011) and Elango *et al*. 1(992) supports the findings of the present study. Fig.2.

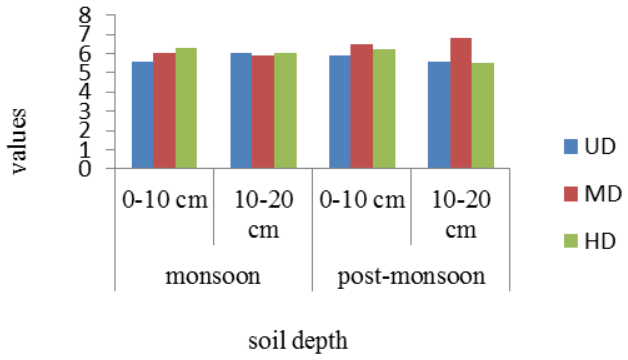

Fig.2.Soil pH along disturbance gradient

Soil organic carbon

The findings reveal that soil organic carbon in top-soil varied from 2.4 % (HD) to 3.64 % (UD) during monsoon season, and from 2.08 % (HD) to 3.27 % (UD) during post-monsoon season. The sub-soil showed lower values than top-soil in all the cases. There was a decreasing trend in values from undisturbed to highly disturbed stand with respect to both the seasons and soil depth. This may be due to destruction of top-soil during mining operation. High soil organic carbon content in the undisturbed stand indicates sufficient litter accumulation on top-soil and subsequently high rate of litter decomposition. High amount of soil organic carbon in the soil is known to develop soil fertility which encourages plant growth in the long run (Bandel *et al*., 2002; Aweto,1981 a,b). More organic carbon content in top-soil at undisturbed site signifies more microbial biomass which may be due to increased moisture content (Arunachalam *et al*., 1996; Arunachalam and Pandey, 2003; Mishra and Laloo, 2006; Mishra, 2011). Greater accumulation of organic carbon in the top-soil could be attributed to the accumulation of litter fall over a long period of time. On the contrary, low values at degraded sites may be due to the influence of sandstone extraction of the land over a period of time. It may also be attributed to the insignificant canopy cover at disturbed sites that minimizes surface runoff and resulting in loss of soil nutrients. Fig.3.

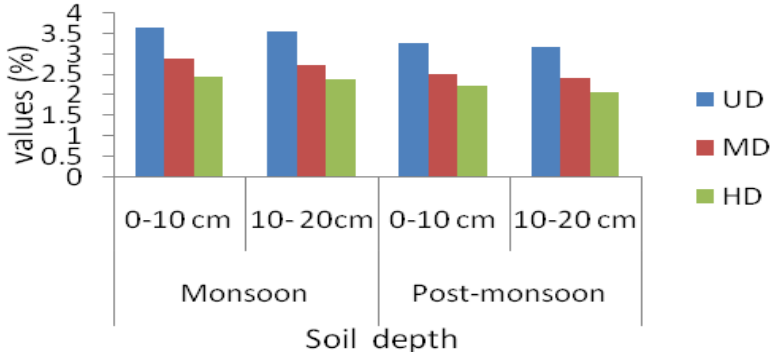

Fig.3.Soil organic carbon (%) along disturbance gradient

Total nitrogen

The total nitrogen content in top-soil varied from 0.12 % (HD) to 0.31 % (UD) during monsoon season, and from 0.12 % (HD) to 0.29 % (UD) during post-monsoon season. The sub-soil showed lower values than top-soil. The anthropogenic disturbance adversely affected soil fertility, as a result, a decreasing trend in values from undisturbed to the disturbed stand was established with respect to both the seasons and soil depth. High Nitrogen content in the soil at undisturbed site indicates greater accumulation of leaf litter and its decomposition at faster rate (Gosz, 1981; Nitousek *et al*., 1994; Prescott, 1995). Fig. 4.

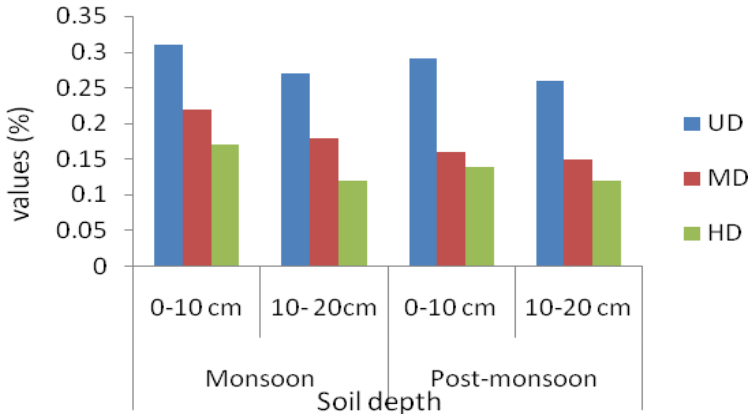

Fig.4.Total nitrogen (%) along disturbed gradient

Available Phosphorus

The findings reveal that available phosphorus in top-soil varied from 0.15 ppm (HD) to 0.19 ppm (UD) during monsoon season, and from 0.22 ppm (HD) to 0.32 ppm (UD) during post-monsoon season. The sub-soil showed lower values than top-soil. The decreasing trend in values from undisturbed to the disturbed stand with respect to both the seasons and soil depth could be linked with degree of disturbance. The findings of the present study are in conformity with the works of (Henrot and Robertson, 1994; Soave, 2003; Haneif *et al*., 2007). Fig. 5

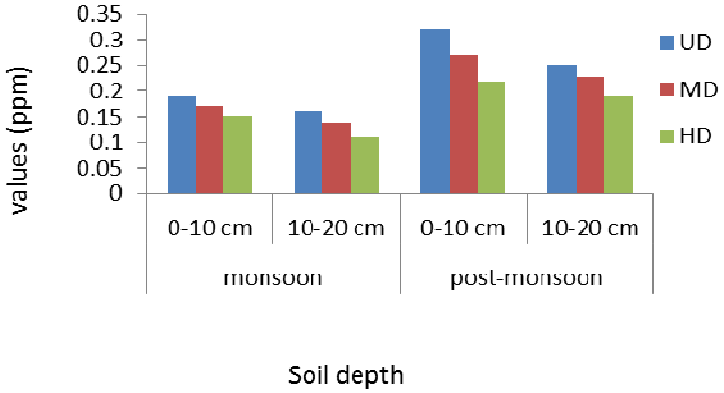

Fig.5. Available phosphorus along disturbance gradient

C:N Ratio

The findings reveal that C:N ratio of top-soil varied from 11.74 (UD) to 20.00 (HD) during monsoon season and 11.28 (UD) to 17.33 (HD) during post-monsoon season. The sub-soil showed higher values than top-soil unlike other parameters. There is a increasing trend in the values from undisturbed to highly disturbed stand with respect to both the season and soil depth. Fig. 6

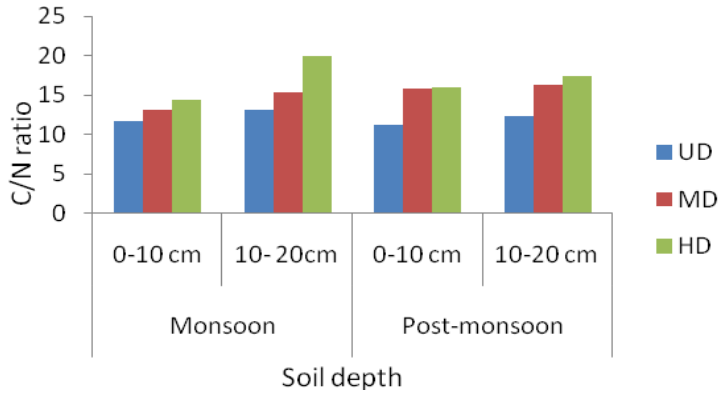

Fig.6. C:N ratio along disturbance gradient

Statistical analyses

A positive and significant correlation was established between nitrogen and phosphorus; nitrogen and pH; phosphorus andsoil moisture content; pH and soil organic carbon. The nitrogen showed a positive and significant correlation with soil organic carbon in both the disturbed and undisturbed sites which could be attributed since organic carbon acts as main natural source for nitrogen (Brady and Weil, 1999). On the contrary, nitrogen and phosphorus were negatively correlated during post-monsoon at highly disturbed site. Likewise, other parameters such as nitrogen, pH, phosphorus, soil organic carbon showed negative and significant correlation in both monsoon and post-monsoon seasons. Table.1

Table.1.Pearson Product Moment Correlation between parameters along disturbed gradient

Parameters	UD		MD		HD	
	Monsoon	Post-monsoon	Monsoon	Post-monsoon	Monsoon	Post-monsoon
N:P	0.846*	0.764	0.278	0.560	-0.860	-0.913*
N:pH	0.558	0.794	-0.0694	0.183	-0.872*	0.935*
N:SMC	0.0496	0.646	0.764	-0.487	0.741	-0.0979
N:SOC	0.462	0.854*	0.256	0.755	0.931*	0.902
P:pH	0.702	0.596	0.702	0.556	0.628	-0.848*
P:SMC	-0.0251	0.952*	-0.0740	-0.0218	-0.489	0.0576
P:SOC	0.679	0.529	0.698	0.713	-0.774	-0.909*
pH:SMC	-0.0754	0.462	-0.0247	0.683	-0.537	-0.373
pH:SOC	0.663	0.429	0.190	0.530	-0.977*	0.947*
SMC:SOC	0.525	0.394	-0.0911	-0.251	0.533	-0.221

*Abbreviation: N-Total Nitrogen, P- Available phosphorus, SMS-Soil moisture content, SOC-Soil organic carbon, UD-Undisturbed, MD-Moderately Disturbed, HD-Highly Disturbed, * - significant (p>0.05).*

Table 2. Mean ± Standard Deviation

Soil characteristics	Soil Depth (cm)	Seasons/Forest Stands					
		Monsoon			Post-Monsoon		
		UD	MD	HD	UD	MD	HD
Soil Moisture Content(%)	0-10	31.4±0.09	28.0±0.11	25.4±0.12	30.6±0.03	23.4±0.12	20.6±0.033
	10-20	30.0±0.10	26.0±0.11	22.6±0.12	25.4±0.09	22.8±0.09	18.6±0.15
Soil pH	0-10	5.57±0.09	6.0±0.15	6.3±0.06	5.87±0.12	6.47±0.09	6.83±0.15
	10-20	5.27±0.09	5.9±0.12	6.03±0.12	5.57±0.09	6.23±0.09	5.5±0.06
Organic carbon (%)	0-10	3.64±0.09	2.9±0.12	2.46±0.09	3.27±0.12	2.53±0.12	2.24±0.12
	10-20	3.56±0.12	2.75±0.12	2.4±0.12	3.19±0.09	2.44±0.09	2.08±0.18
Total Kjeldahl- N (%)	0-10	0.31±0.01	0.22±0.02	0.17±0.01	0.29±0.09	0.16±0.09	0.14±0.01
	10-20	0.27±0.09	0.18±0.02	0.12±0.09	0.26±0.003	0.15±0.09	0.12±0.003
C/N ratio	0-10	11.74±0.91	13.18±1.11	14.47±1.15	11.28±0.77	15.81±0.69	16.00±0.65
	10-20	13.19±0.86	15.27±1.45	20.0±1.70	12.27±0.63	16.27±0.77	17.33±0.83
Available Phosphorus (ppm)	0-10	0.19±0.01	0.17±0.01	0.15±0.09	0.32±0.01	0.27±0.01	0.22±0.01
	10-20	0.16±0.01	0.14±0.01	0.11±0.01	0.25±0.09	0.23±0.01	0.19±0.09

A positive and significant correlation was established between organic carbon and total nitrogen at all the sites. Nitrogen, phosphorus and soil moisture content also showed a positive and significant correlation. Likewise, the soil moisture content and organic carbon were positively correlated. The results were in conformity with the work of Amba *et al*. (2011) and Singh (2013). Table. 2

CONCLUSION

From the present investigation it can be concluded that there is loss of soil fertility with increase in degree of disturbance in form of sandstone quarry. The organic carbon, total nitrogen and available phosphorus decreased from un-mined to ongoing mining areas. The top-soil had more values than sub-soil. Monsoon season had higher organic carbon and total nitrogen content. On the contrary available phosphorus was more during post-monsoon season. Similarly, soil moisture content also decreased with disturbance. The soil was acidic in nature at all the sites during both seasons. Accumulation of small stones and fine particles changed the soil characteristics and leading to marked deterioration of soil fertility at disturbed sites.

Unscientific sandstone quarry leads to change in soil characteristics and resulting into degradation of land. A large area of forest is cleared for sandstone quarry and left behind without any management measure. This activity is also responsible for reduction in dense forest cover and loss of biodiversity. It seems that sandstone quarry is linked with economy of the rural people on one hand, but it may cause adverse impact on soil and vegetation on other hand. Thus, it is recommended that the clearing of forest should be made phase-wise and abandoned areas be re-vegetated using suitable species. For proper management of abandoned areas, there is an ample scope of an integrated approach involving local people, NGOs and Government organizations.

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