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ASSESSMENT OF SOIL FERTILITY STATUS IN PARTS OF TUIRIAL WATERSHED, MIZORAM

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Abstract: Soil is vital for human beings and the ecosystem; therefore, determining its potential is necessary. The present study aimed at understanding the soil fertility status using 'Nutrient Index approach' and presenting their spatial variability through maps, which will be beneficial and effective for maintaining nutrients management and sustainable agricultural production. Georeferenced soil samples collected from 20 sites were analyzed using standard procedures for various parameters like 'pH', 'Soil Organic Carbon (SOC)', 'Electrical Conductivity (EC)', available 'Nitrogen (N)', 'Phosphorous (P)' and 'Potassium (K)'. All soils from the study area were acidic with negligible effect of salt for EC. In the case of SOC, N, P and K, the calculated values from Nutrient Index showed high status of SOC, medium for N and K, while low for P. Land use change was observed to have a remarkable influence on soil properties in the study area. The 'Inverse Distance Weighting (IDW)' interpolation method in ArcGIS software was employed to create spatial distribution maps for different soil parameters.

Index Terms: Soil Fertility, Nutrient index, Land use change, GIS software.

1. Introduction

As soil is the key supplier of nutrients for crops, human life and economic conditions are significantly influenced by soil ecosystems (FAO, 2008; NAAS, 2018). However, soil fertility is undergoing rapid alterations due to anthropogenic activities such as intensive farming and improper soil management. As, Soil fertility is continuously declining in tropical regions, Indian soils are also deficient of primary soil nutrients (MoA, 2012; Chase and Singh, 2014). The soil normally has low organic carbon, and the N, P and K status are also generally deficient throughout the country (FAO, 2005).

In north-east India, the traditional shifting cultivation-induced soil erosion has seriously reduced the soil capacity (Bandypadhyay et al., 2016). It resulted in the loss of primary nutrients, N, P and K, at an estimated amount of '10669', '0.372' and '6051' thousand tonnes respectively every year (Sharma, 1998). Mizoram has undergone many land use changes through the present agricultural systems and deforestation, negatively impacting the soil property (Lallianthanga et al., 2014; Singh et al., 2014; Manpoong and Tripathi, 2019). Therefore, soil fertility and nutrient status information is crucial for sustainable soil management in a particular region (Padua et al., 2018). In this regard, a soil fertility map proves highly beneficial, requiring less time to generate efficient results (Mondal and Ramkala, 2016). Hence, the present study aims to understand the soil fertility status and present the spatial variability for each parameter through maps to enable a simple, efficient and proper management of soil resources. Therefore, the current investigation seeks to comprehend the condition of soil fertility and illustrate the spatial variation for each specific parameter using maps, facilitating a simple, efficient, and appropriate approach to soil resource management.

2. Methodology

2.1. Study area

The study area constitutes parts of the upper segment of the Tuirial watershed. It is located between 23°38’30” - 23°43’50” N latitudes and 92°42’55” - 92°47’37” E longitudes and extends to an area of approximately 44.8 sq. km (Fig. 1).

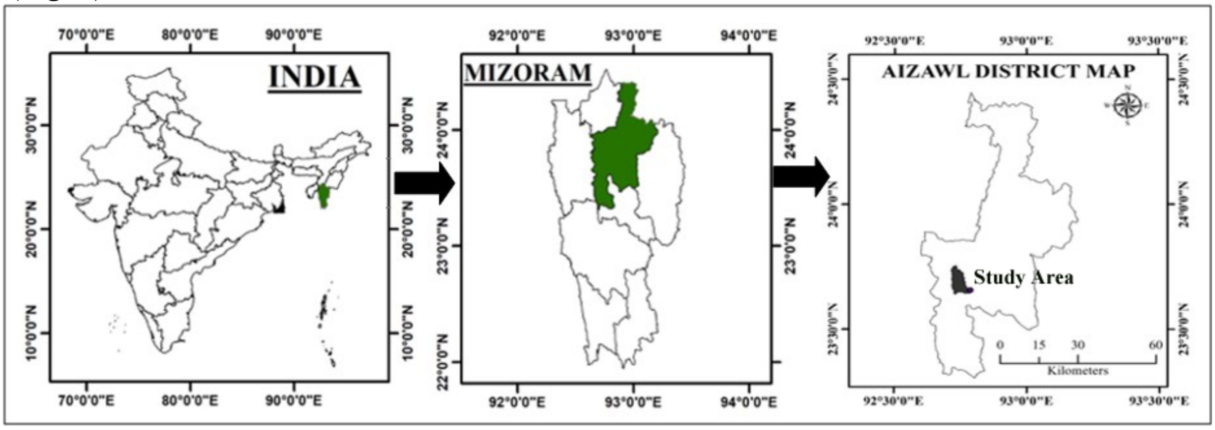

Fig. 1. Study area location map.

2.2. Procurement and analysis of soil samples

The present study gathered composited soil samples from 20 sites encompassing several land-use systems. All the soil samples underwent examination through established analytical procedures. Parameters like ‘pH’ and ‘Electrical Conductivity (EC)’ were determined using a calibrated DiST 4 meter. At the same time, the ‘Soil Organic Carbon (SOC)’, available ‘Nitrogen (N)’, ‘Phosphorous (P)’ and ‘Potassium (K)’ were analyzed at the State Soil Testing Laboratory, District Agriculture Office, Aizawl.

2.3. Nutrient Index (NI) Method

The concept of Nutrient Index (NI) Method, as introduced by Parker et al. (1951), was utilized to calculate the status of soil fertility employing the subsequent equation:

$$\text{Nutrient Index (NI)} = \frac{(N_1 \text{ x } 1)+(N_m \text{ x } 2)+(N_h \text{ x } 3)}{N_t} \tag{2.1}$$

Where,

N_1 = no. of samples categorized as a low class of nutrient status,
N_m = no. of samples classified as having a medium class,
N_h = no. of samples corresponding to high class,
N_t = total no. of samples examined within a specified area.

Parker classified the NI Values as <1.5 = ‘low nutrients status’, 1.5 – 2.5 = ‘medium’ and >2.5 = ‘high nutrient status’. For the present study, the NI Values modified by Ramamurthy and Bajaj (1969) were used to classify the nutrient index values (Table 1).

Table 1. Chart depicting the Nutrient Index Values (NIV) Ratings:

S. No	Nutrient Status	NIV	Interpretation
1	Low	Below 1.67	‘Low fertility Status’
2	Medium	1.67 to 2.33	‘Medium fertility Status’
3	High	Above 2.33	‘High fertility Status’

2.4. Mapping of Soil Fertility

The generated results for various sample sites were interpolated through the ‘Inverse Distance Weighted (IDW)’ method in the ArcGIS platform to develop maps showing the spatial variability of different soil quality.

3. Results and Discussion

Table 2: Sampling Sites and obtained soil sample values.

Sample Site		pH	EC ‘mS/cm’	SOC ‘%’	N ‘kg/ha’	P ‘kg/ha’	K ‘kg/ha’
1	**DF**	4.47	0.30	2.18	391.61	6.95	103.14
13		4.84	0.29	1.87	297.13	7.55	117.02
12		4.83	0.30	2.25	348.72	8.47	102.256
6	**OF**	4.49	0.31	1.95	337.73	7.01	212.13
7		4.59	0.30	1.57	288.31	9.33	124.23
10		5.20	0.33	1.64	280.65	9.42	139.83
11		4.60	0.31	1.49	289.34	7.29	201.91
2		5.12	0.29	0.94	320.11	8.71	177.32
14		4.16	0.31	1.71	293.47	8.31	106.94
18		4.63	0.32	1.57	286.13	6.56	110.38
19		4.25	0.30	1.55	343.39	7.33	182.4
20		4.98	0.31	1.75	290.08	8.17	199.34
1	**FL**	5.3	0.32	0.89	221.19	8.27	280.71
5		5.02	0.32	1.27	289.72	7.94	217.86
9		5.04	0.34	1.51	283.50	9.31	190.5
15		4.56	0.38	0.71	268.96	9.55	217.34
4	**SC**	5.53	0.43	0.48	201.85	11.56	283.63
8		4.88	0.41	0.74	187.91	9.39	169.81
16		5.12	0.39	1.18	198.83	10.64	281.31
3		4.58	0.40	0.49	207.11	10.37	174.11
Mean±SD		4.81±0.36	0.33± 0.04	1.39±0.53	281.29±54.80	8.61±1.34	179.61±59.36
Range		4.16-5.53	0.29-0.43	0.48-2.25	187.91-391.61	6.56-11.56	102.26-283.63

“DF: Dense Forest; OF: Open Forest; FL: Fallow Land; SC: Shifting Cultivation; EC: Electrical Conductivity; SOC: Soil Organic Carbon; N: Available Nitrogen; P: Available Phosphorous; K: Potassium.”

Table 3. Soil Fertility Status of the Study Area.

Parameters	NI Value	NI Rating		Fertility Level
‘OC’	2.7	Below 1.67	‘Low’	High
‘N’	1.7	1.67 to 2.33	‘Medium’	Medium
‘P’	1.15	Above 2.33	‘High’	Low
‘K’	2			Medium

All soil in the research area exhibits acidity, with pH levels between 4.16 and 5.53 (Table 2). The soil acidity can be mainly attributed to decomposed organic acids, heavy rainfall and topography, which removes the bases (Chase and Singh, 2014). pH shows a positive correlation with available Phosphorous and Potassium at $P < 0.05$ significant level, while a negative correlation is found with the available Nitrogen (Table 4). The observed EC ranges from 0.29 to 0.43 mS /cm, and all the results obtained indicate negligible effects of salinity as EC is directly related to the salinity of the soils (Pathak and Rao, 1998) (Table 2). EC exhibits a significant positive relationship with the available Phosphorous and Potassium while it has a negative relationship with Nitrogen at $P < 0.01$ significance level (Table 4). The N and P show a declining trend with the increase in EC. The recorded SOC have a mean value of 1.32 %, ranging from 0.48 % – 2.25 % (Table 2), which is considerably high despite of the state’s overall status for low organic carbon as per the records of the Ministry of Statistics & Programme Implementation (2019). Higher SOC of the study area may be ascribed to the rich vegetative cover and organic matter decomposition as most of the areas are under forest cover and are highly correlated with the N ($P < 0.01$) (Table 4). However, the SOC and the available P and K have shown a significant negative correlation (Table 4). It shows that the available N increases with the increase in the Organic Carbon content (Deshpande and Salunkhe, 2015), while P and K decrease significantly. In the study area, the available N ranges from 187.9 kg/ha to 391.6 kg/ha, while the available P varies from 6.04 kg/ha to 11.56 kg/ha (Table 2). The low availability of P is one of the main reasons behind poor crop yields in acidic soils of the world (Dey et al., 2017). The mean value for the available K in the study area is 179.61 kg/ha, and this lower K content may be due to leaching conditions and the strong acidity of the soils where potassium retention is not possible (Amara et al., 2017).

Among different land use land cover types, the soils under shifting cultivation and fallow land were observed to have undergone an inevitable reduction in nutrients. The reduction of nutrients may be attributed mainly to the reduction of the soil biomass through burning and the soil loss triggered by high rainfall and steep slopes on bare lands. On the other hand, the depletion in the soils of Dense and Open Forest is found to be comparatively less. The spatial distribution for different soil properties and primary nutrients is given in Fig. 2 and Fig. 3.

The soil fertility status measured using the 'Nutrient Index Method' showed that SOC was high with an NI value of 2.7. The N and K were found in a medium level with NI values of 1.7 and 2, respectively, while the P level was found to be low with 1.15 Nutrient Index value.

Table 4. Correlation between soil parameters.

	pH	EC	SOC	N	P	K
Ph	1					
EC	.353	1				
SOC	-.394	-.762**	1			
N	-.493*	-.816**	.799**	1		
P	.521*	.786**	-.669**	-.718**	1	
K	.552*	.517*	-.614**	-.574**	.451*	1

*. "Correlation is significant at $p < 0.05$ level (2-tailed)."

**. "Correlation is significant at $p < 0.01$ level (2-tailed)."

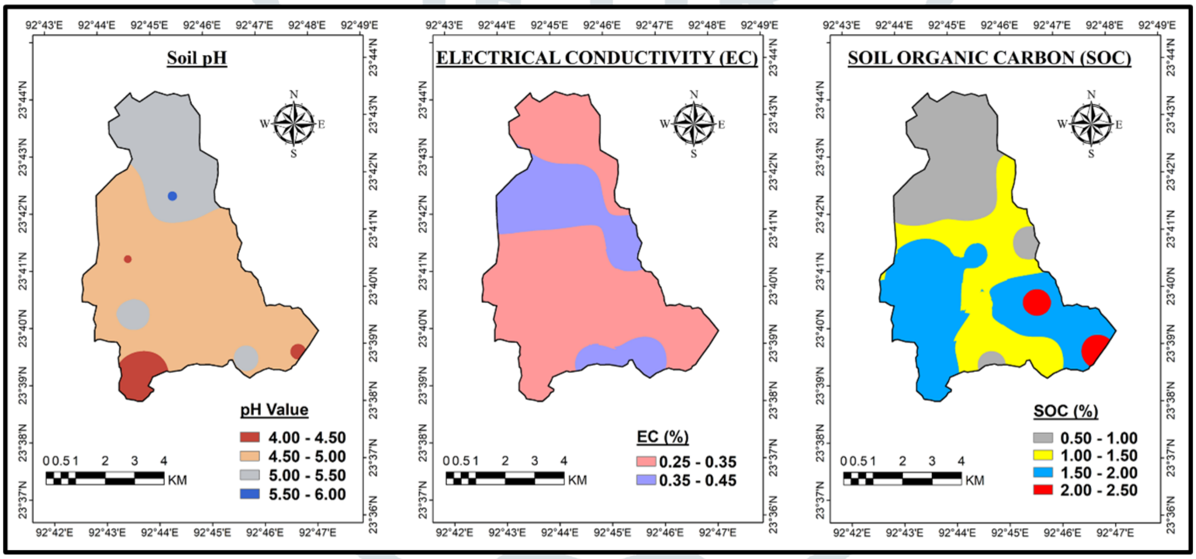

Fig. 2: Maps showing soil physico-chemical properties in the study area.

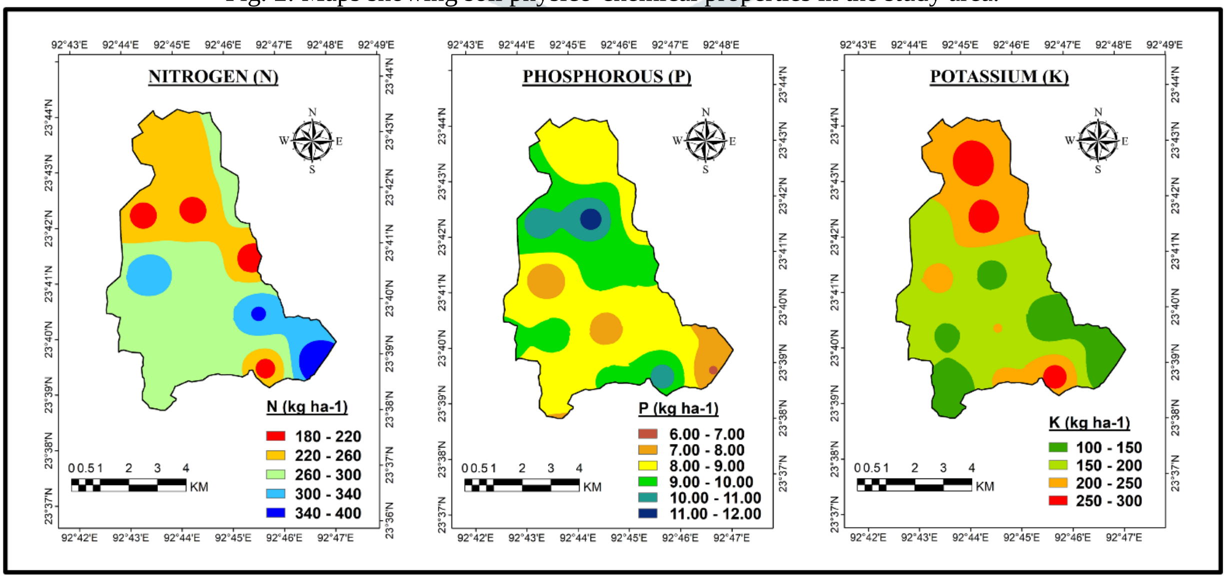

Fig.3: Maps showing the spatial distribution of Primary nutrients in the study area.

4. Conclusion

The present study indicates that varying land use and land cover has significantly affected the diversity in soil fertility conditions. Based on the 'Nutrient Index Method', the calculated soil fertility status was high for SOC, medium for N and K and low for P. The results can be valuable for providing site-specific fertilizer recommendations and nutrient management. Hence, assessing soil fertility status and mapping its spatial distribution will provide essential information for sustainable agricultural production besides maintaining the ecological balance.

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