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Analysis of Nutrient Index of Soil for Green Environment

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The current study aims at monitoring the nutrient index of soil in an agri-fed zone having variety of crops, especially hybrid coconuts and paddy. The study area was selected in the high rainfall zone. In the current study, 13 soil samples were randomly collected from the top soil (0-30 cm) in the selected agri-fed zones at the base of Thekkumalai hill in Thovalai-Agesteeswaram belt in Kanyakumari district of India. The soil samples were analyzed for their texture and chemical properties and total concentration of nitrogen, phosphorous and potash. Soil textures in the study area were classified as sandy clay loam (SCL) as more than 60 % of soil grains in the soil samples were coarse grained of greater than 75 μ in size and more than 30 % of the soil grains were fine grained of less than 75 μ in size. The pH of soil samples ranged from 6.3 to 7.5 with an average of 6.9. The electric conductivity ranged from 0.06 to 0.11 dS m^{-1}. The nitrogen ranged from 21 to 99 kg/acre with a mean value of 60 kg/acre, phosphorus ranged from 1.9 to 16.3 kg/acre with a mean value of 9.1kg/acre and potassium ranged from 12.5 to 99 kg/acre with a mean value of 55.75 kg/acre. The nitrogen content in the soil samples was found low in the soil samples and the phosphorous level was low in five soil samples; medium with six soil samples; and high in two soil samples. The potash content was low except the samples 11 and 12.

Keywords: Buffer solutions, Crops, Electrical conductivity, Hill region, Plant nutrients.

INTRODUCTION

Soil is a non-renewable resource and the precious gift of nature to the mankind. In general, soil may be of saline soil or sodic soil (non saline soil) or saline sodic soil. The sliding and rolling of soil particles by erosive agents like storm run-off, wind storm *etc*. leads to changes in chemical properties of soil. There will be strong variations in soil characteristics in any landscape due to certain environmental and management factors. Changes in chemical characteristics of soil will highly affect nutrients in crops, degrading the structure of soil and decreasing the storage capacity of soil for crop production. The nutrient level of soil gets changed due to weathering process and in turn, the physical and chemical properties of soil are also affected. According to Grisso *et al*. [1], the soil reaction get varies habitually due to changes in the soil properties. The quality of such soils could be ascertained with the help of its chemical characteristics such as pH of soil and electrical conductivity (EC) or salt content of soil. Due to the presence of excessive amount of soluble salts as well as the excessive amount of sodium in such soils brings the soil pH value greater than 8.0-8.5. Higher value of pH in soil leads to soil erodibility. Mohan *et al.* [2] stated that with pH 8.5 and more, soil is predictable to have more sodium in the swap complex is classified as an alkaline soil. Helyar and Porter [3] illustrated that more acidity in soil may also decrease microbial activity and reduces nitrogen fixation. Moreover, according to Ministry of Agriculture, Government of India [4], saline soil with EC > 4 dS/m, sodic soil with EC < 4.0 dS/m and saline sodic soil with EC > 4.0 dS/m are not suitable for the growth of many crops unless treated with appropriate techniques, in general. nutrient enrichment ratio is the indication of chemical and organic losses in soil. Gachene *et al*. [5] defined the nutrient enrichment ratio as the ratio of concentration of nutrients in eroded sediments to that of the original soil. According to Almas and Jamal [6], nutrient enrichment ratio greater than 1 is the indication of nutrient deficiency in soil. Testing of chemical characteristics of soil is well recognized as a sound scientific tool to assess inherent power of soil to supply plant nutrients. The assessment of the quality of soil is the main tool to help farmers to implement certain management practices in the field [7]. Test on soil properties could be done periodically for assessing the chemical aspects of soil quality [8]. Soil quality indicators play a vital role for maintaining and improving the soil condition and to weigh up soil management practices and techniques [9].

Study area: The study area is the upper part of Thovalai channel at the base of Thekkumalai hill, connecting both Thovalai taluk and Agesteeswaram taluk in Kanyakumari district, India. The study area is agri-fed region and bounded by latitudes 8.2165 and longitudes 77.5103. The district enjoys both the monsoons namely southwest monsoon (June to September) and the north-east monsoon (October-November). However there will be summer rains for some days around March and April. In the hill region, the rainfall is uniformly distributed in both the monsoons and maximum rainfall occurs during October and November. The main cultivation in the study area includes paddy, coconut, banana plantation, flowers, vegetables and mango [10,11].

The study area is also famous for flower cultivation and the flowers include jasmine, rose flower, chrysanthemum, marigold, kanagambaram, anthuriams, orchids gerbera and gladiola. Small water bodies called Thovalai channel which originating from Pechiparai dam and flows at the foot of Thekkumalai hill catering to the requirements of farmers. In the study area, farmers also rely upon water from wells and bore wells.

EXPERIMENTAL

The periodical rainfall data were collected using the rain gauge, which was established in the PWD office, near the study area. The texture of soil was identified upon the test on sieve analysis. Auger and hand tools were used to collect the soil samples from 13 different soil erosion prone zones in the study area. The soil samples for testing for their properties were collected from the suitable locations where gullies were found. One set of soil samples were collected in the month of May 2016 immediately after the summer rain and the other set of soil samples from the same locations were collected in the months July-August 2016 during south-west monsoon. From each location, about 5 kg of soil samples were packed in the plastic bags for testing. The soil sample was prepared such that it has identical particle size, sieved through a Indian Standard Sieve. Plastic bags were used for hauling the soil samples to the department laboratory by marking with a permanent marker. A dry wooden tray was used to dry the wet soil samples and the trays were numbered in order. Hot air oven was also used to dry some of the soil samples. After drying the soil samples, it was sieved through a standard 2 mm Indian Standard Sieve. Sieving and grinding processes were continued till all aggregate particles were fine enough to pass through the sieve and only pebbles, organic residues and their concretions remain. The available nutrient status of soil samples were classified as low, medium and high. ESRI ArcGIS 9.3 was used to carry out GIS operations to produce the thematic maps showing the gradation type (Fig. 1), sand percentage (Fig. 2), level of soil pH (Fig. 3), electric conductivity (Fig. 4) and calcium carbonate (Fig. 5).

pH value of soil samples: pH of the soil was measured using pH meter. Moreover, pH 4, 7 and 9 buffer solutions;

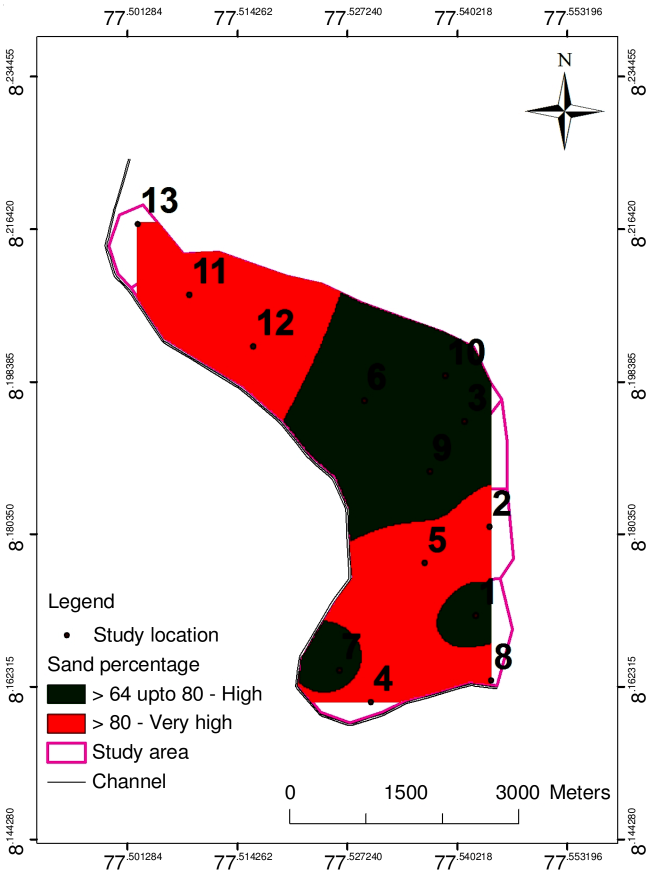

Fig. 1. Sand percentages

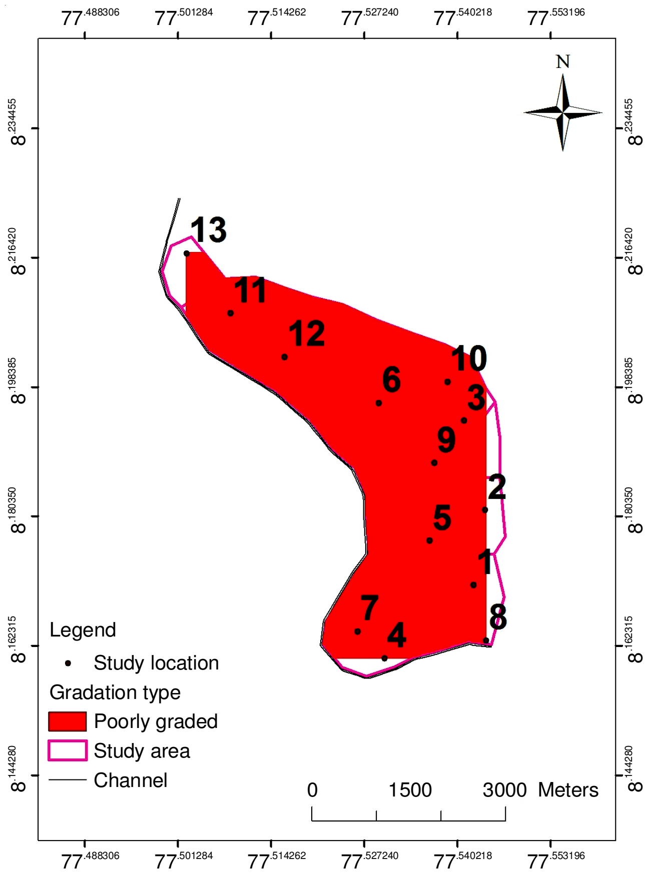

Fig. 2. Gradation type

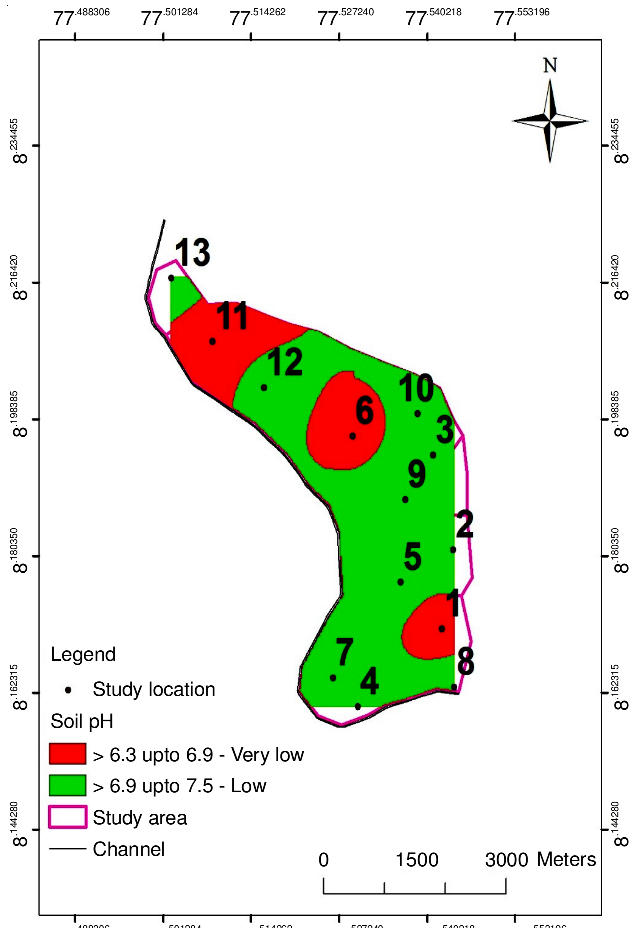

Fig. 3. Soil pH ranges

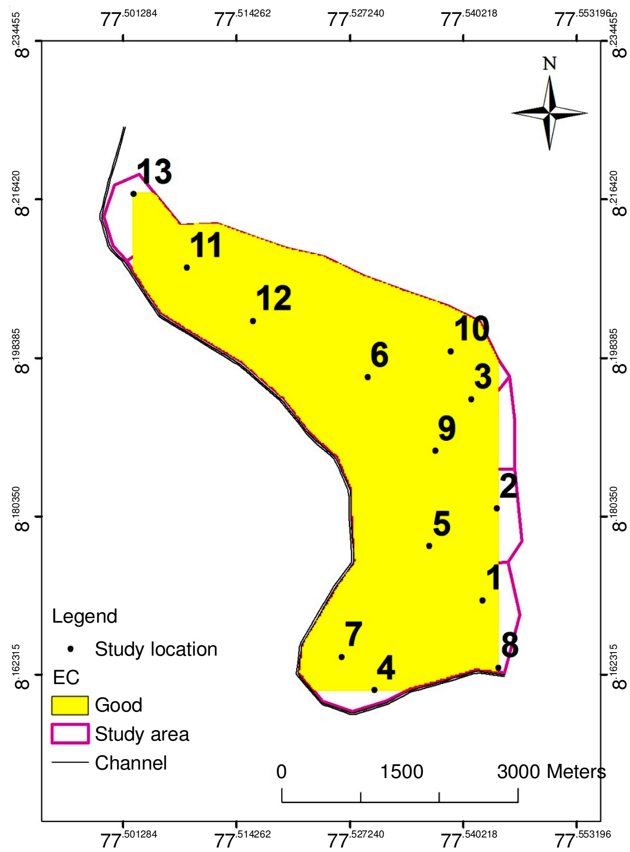

Fig. 4. EC levels of soil samples

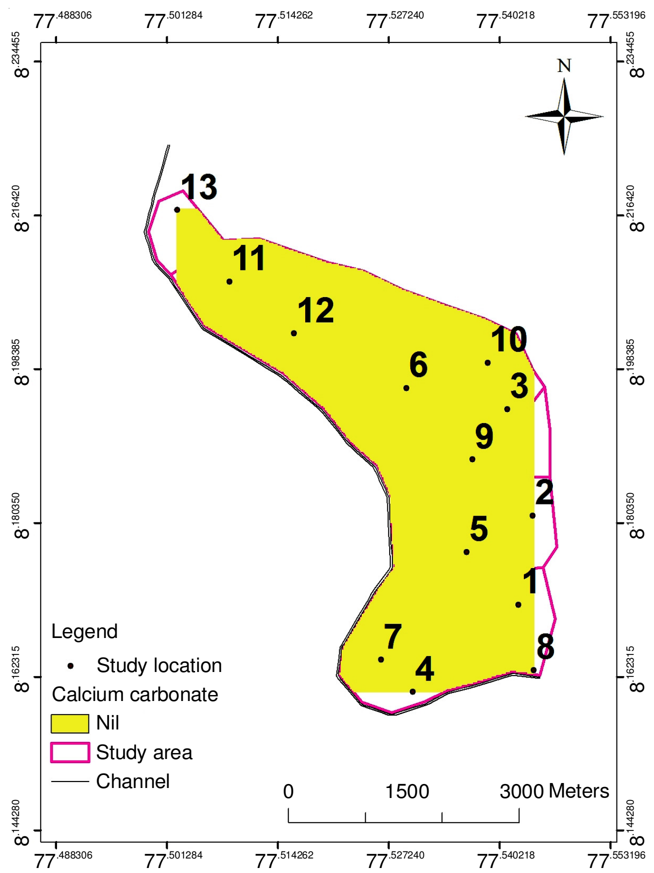

Fig. 5. Calcium carbonate levels

calcium chloride solution (0.01 M) were used as the reagents for the test. By dissolving 15 g of $CaCl_2{\cdot}2H_2O$ in 10 L of water, the calcium chloride solution was prepared. pH meter was first calibrated as per the Indian standard. The electrode was inserted into the buffer solution and the pH was adjusted. 10 g of soil sample was weighed using the electronic balance and poured into 100 mL beaker and 20 mL of $CaCl_2$ solution was added to it. The suspension was stirred regularly for about 0.5 h. The pH of soil sample was recorded on the calibrated pH meter as shown in Table-5. Referring Table-1, the observed pH values of soil samples were correlated against the soil rating to ascertain the level of acidity and alkalinity.

TABLE-1
SOIL pH RANGE AND REACTION RATING

pH Range	Soil rating
< 4.6	Extremely acidic
4.6 – 5.5	Strongly acidic
5.6 – 6.5	Moderately acidic
6.6 – 6.9	Slightly acidic
7.0	Neutral
7.1 – 8.5	Moderately alkaline
> 8.5	Strongly alkaline

Source: L.A. Alban and K. Mildred [Ref. 12]

Electrical conductivity (EC): Soil and water suspension with the ratio of 1:2 was taken for the test. Potassium chloride solution was used as the reagent. Certain amount of dried potassium chloride was dissolved in distilled water to make 1 L solution. The Erlenmeyer flask in which 40 g of soil sample was poured

TABLE-2
GENERAL CONCEPT OF EC VALUES OF SOIL

Soil	EC (dS m^{-1})	Total salt (%)	Crop reaction
Free saline	0-2	< 0.15	Negligible
Slightly saline	4-8	0.15-0.35	Growth will be affected
Moderately saline	8-15	0.35-0.65	Fit for growth
Highly saline	> 15	> 0.65	Satisfactory yield

Source: P. Ravikumar and R.K. Somashekar [Ref. 14]

and 80 mL of distilled water was added, tightly closed with a stopper and shaked with the help of reciprocating shaker for about 1 h. The solution was then filtered through filter paper. A minimum amount of KCl solution was poured into a beaker and the electrode was inserted in the solution. Based on the method of Alban and Mildred [12], the digital display was recorded in dS m^{-1}as electrical conductivity of soil sample which is the measure of the soluble salt content in the extract and an indication of salinity status of the soil sample as shown in Table-5. With the help of general interpretation of electrical conductivity values shown in Table-2, the level of salt and salinity of soil was analyzed.

Total nitrogen, phosphorous and potassium: Available total nitrogen, phosphorous and potassium were analyzed for the soil samples based on the standard testing procedures. Total nitrogen was determined by alkaline permanganate method. Olsen's method was followed in the laboratory to determine the phosphorous content of the soil samples by using spectrophotometer. Flame photometer was used for the determination of available potassium in the soil samples. The values of available N, P and K were compared with soil nutrient fertility rating shown in Table-3, by which the nutrient index was calculated. The fertility condition of the soil samples can be denoted using the nutrient index (NI) values in the study area. NI < 1.5 is pinpointing the low nutrient status and NI in the range between 1.5 and 2.5 is pinpointing medium nutrient status and NI > 2.5 is pinpointing higher nutrient status. However, Ramamoorthy and Bajaj [13], Ravikumar and Somashekar [14], Singh and Mishra [15] were proved that the values less than 1.7 is denoting the low fertility condition, range between 1.71 to 2.33 as medium and more than 2.33 as high.

TABLE-3
SOIL NUTRIENTS FERTILITY RATINGS

Soil nutrients	Low	Medium	High
Available N	< 280	280-560	> 560
Available P	< 10	10-24.6	> 24.6
Available K	< 108	108-280	> 280

Source: R.P. Singh and S.K. Mishra [Ref. 15]

The nutrient index (NI) value of soil samples is calculated using the following equation:

$$NI = (Nl \times 1) + (Nm \times 2) + (Nh \times 3)/Nt \quad (1)$$

where, Nt = Total number of samples analyzed for a nutrient in any given area. Nl = Number of samples declining in the low grouping of nutrient status. Nm = Number of samples declining in the medium grouping of nutrient status. Nh = Number of samples declining in the high grouping of nutrient status.

RESULTS AND DISCUSSION

The average gradation of soil samples collected from the study area is presented in Table-4. Of the total number of 13 samples collected, the particle size ranged between 0.08 and 4.75 mm.The finer particles collected in the bottom pan passing through 75 µ was 35 % indicative of the fact that it is the combination of clay and silt. The average gradation of soil samples shows 64 % of sand (> 75 µ upto 4.75 mm) and 35 % of clayey silt (< 75 µ and thus the type of soil samples was classified as sandy clay loam (SCL). The soil samples 2, 4, 5, 8, 11 and 12 were found to be very high in sand (> 80 %) and the remaining were high (> 64 %) as shown in Fig. 3. More than 50 % of soil samples are highly dominated with sand and thus regarded as "poorly graded" as shown in Fig. 4. Bunga *et al.* [16] as well as Rose & Jayashree [17] was concluded that soil with 74.54 % of coarser fractions and 25.46 % of finer fractions are considered as sandy clay loam (SCL) and with 62.50 % of sand and the remaining with silty clay is referred as sandy clay loam. The textural value of soil samples collected from 13 different stations and their electric conductivity, pH and chemical composition such as nitrogen, phosphorus and potassium are presented in Table-5. In the current study, the pH values show that sample 1 and 11 are "moderately acidic"; samples 2, 4, 5, 8, 9 and 13 are "moderately alkaline"; samples 3, 6, 7 and 10 are "slightly acidic"; and sample 12 is of "neutral". According to Merry [18], the soil pH values are mostly between 6 and 8 and these soils are in an environmental equilibrium where acidification processes and alkaline inputs are about

TABLE-4
AVERAGE GRADATION OF SOIL SAMPLE FROM THE STUDY AREA

S. No.	Indian standard sieve used	Particle size (mm)	Soil retained (g)	% Retained	Cumulative (%) retained	Finer (%)
1	4.75 mm	4.75	7	0.7	0.7	99.3
2	2 mm	2.00	64	6.4	7.1	92.9
3	1 mm	1.00	45	4.5	11.6	88.4
4	600 µ	0.60	81	8.1	19.7	80.3
5	425 µ	0.43	200	20	39.7	60.3
6	300 µ	0.30	80	8	47.7	52.3
7	150 µ	0.15	95	9.5	57.2	42.8
8	75 µ	0.08	78	7.8	65	35
9	Bottom pan	–	350	35	100	0

TABLE-5
CHEMICAL PROPERTIES OF SOIL SAMPLES OF THE STUDY AREA

S. No.	Texture	EC (dS m^{-1})	pH	N (Kg/acre)	P (Kg/acre)	K (Kg/acre)
1	SCL	0.07	6.3	59	6.4	12.50
2	SCL	0.08	7.5	67	5.7	12.50
3	SCL	0.11	7.1	56	1.9	12.50
4	SCL	0.08	7.1	55	7.8	15.63
5	SCL	0.11	7.2	53	4.4	9.38
6	SCL	0.06	6.8	97	6.4	44.00
7	SCL	0.07	7.2	99	16.3	47.00
8	SCL	0.06	7.5	46	10.6	13.00
9	SCL	0.09	7.1	62	3.1	28.20
10	SCL	0.06	7.2	77	3.8	41.00
11	SCL	0.08	6.5	50	5.7	79.00
12	SCL	0.08	7.0	56	5.7	63.00
13	SCL	0.09	7.2	21	3.8	28.00

equal, but they are subject to net acidification if used for agriculture and this statement is in accordance with the current agri-fed area. Fig. 3 shows the soil pH ranges between 6.3 and 7.5 and thus falls in neutral level. The neutral pH of soil samples leads to low level of calcium carbonate as shown in Fig. 5. Similarly, as shown in Fig. 4, the electrical conductivity level of soil samples ranges from 0.06 to 0.11 dS m^{-1} at an average of 0.085 dS m^{-1}. The highest value of electrical conductivity was found with samples 3 and 5; the lowest value of electrical conductivity was found with samples 6, 8 and 10. Grisso *et al.* [1] strongly proved that electrical conductivity correlates to soil particle size and texture and sands with low conductivity, which implies with the electrical conductivity level of soil samples in the present study area. Based on the results obtained (Table-5) on nitrogen, phosphorus and potassium, nutrient index was calculated and the values indicate that nitrogen was found to be "less" in all the soil samples of study area, phosphorous was ''low'' with soil samples 3, 5, 9, 10 and 13; "medium" in soil samples-1, 2, 4, 6, 11 and 12 and "high" in soil samples 7 and 8. Potassium was bringing into being to be "low" in soil samples except that with soil samples 11 and 12. According to Isikwwue [19], low concentration of salts in soil can increase its risk of being erodible. The low nutrient status shows the depletion of soil fertility in the study area and the current observation agrees with the reports of Gachene *et al*. [5].

Conclusion

The observed pH level of soil samples indicates that the $CaCO_3$ level was low in the study area. Gypsum can be used to treat the alkali soils. The low level of $CaCO_3$ in the samples is due to the neutral pH of soil. The pH of soil samples ranged between 6.3 and 7.5 shows that the soil reaction is neutral for practical purposes with the maximum availability of all essential plant nutrients. Nevertheless, the salinity effect was negligible in the study area as electrical conductivity of soil is in good status with all the soil. Hence, acidic soils can be limed prior to the typical agricultural practice in the study area. The nutrient index value based on N, P and K shows that there is a higher loss of nutrients due to soil erosion. The nutrient losses in surface runoff may be further attributed to lower aggregate stability, dispersion of nutrient enriched clay particles and break down of aggregates by direct raindrops impact, causing more transportation of soil particles. The thematic maps for the gradation type, soil pH and electrical conductivity level assists for the better understanding of distribution of soil types and behaviour of their components at different levels.

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