ASSESSMENT AND MAPPING OF SOME IMPORTANT SOIL PARAMETERS INCLUDING SOIL ACIDITY FOR THE STATE OF JHARKHAND (1:50,000 SCALE) TOWARDS RATIONAL LAND USE PLAN

PALAMU DISTRICT

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Sponsored by : Department of Agriculture & Cane Development, Govt. of Jharkhand

1. INTRODUCTION

Reliable information on the location, extent and quality of soil and land resources is the first requirement in planning for the sustainable management of land resources. The components of land i.e., soils, climate, water, nutrient and biota are organised into eco-system which provide a variety of services that are essential to the maintenance of the life support system and the productive capacity of the environment. Our land mass is fixed, but the competition among different kinds of uses for this land is increasing because of rapidly rising global population. Therefore, integrated land resource planning and management are required to resolve these conflicts and soil resource survey seems to be a viable means in this process and knowledge of soil fertility status and problems of soils like soil acidity/alkalinity become essential for sustainable land use plan.

Soil fertility is an aspect of the soil-plant relationship. Fertility status of the soils is primarily and importantly dependent upon both the macro and micronutrient reserve of that soil. Continued removal of nutrients by crops, with little or no replacement will increase the nutrient stress in plants and ultimately lowers the productivity. The fertility status of the soils mainly depends on the nature of vegetation, climate, topography, texture of soil and decomposition rate of organic matter. Optimum productivity of any cropping systems depends on adequate supply of plant nutrients. GIS is a versatile tool used for integration of soil database and production of a variety of users specific and user-friendly interpretative maps. This further leads to accurately and scientifically interpret and plan some of the aspects like conservation of organic matter, soil reaction (pH) control and fertilization.

Keeping in view NBSS & LUP, Regional Centre, Kolkata in collaboration with Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand undertook a project entitled "Assessment and mapping of some important soil parameters including soil acidity for the state of Jharkhand (1:50,000 scale) towards rational land use plan" from Department of Agriculture, Govt. of Jharkhand. The major objectives of the project were

- Preparation of districtwise soil acidity maps
- Preparation of districtwise soil fertility maps (Organic carbon, available N, P, K, S and available Fe, Mn, Zn, Cu and B)

The above maps will provide information regarding soil nutrients and soil acidity status for the districts, which will be very useful in identification of site specific problems for planning purposes. The present report deals with the above mentioned objectives of the Palamu district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Palamu district is located in the north-western parts of the state. It is surrounded by the districts Rohtas and Aurangabad of Bihar state in north, Latehar in south, Chatra in east and Garhwa in west. Total geographic area of the district is 5044 sq. kms. Total population of the district is 15,33,173 persons. It has 3 subdivisions viz. Daltonganj Sadar, Hussainabad and Chattarpur. There are ten development blocks in the district.

2.2 Physiography, Geology and Drainage

In Palamu district, hills are wildly scattered in south but the north is plain. The general slope of the district is from south to north. Geologically the hill area are made of metamorphic rocks with sandstones, conglomerates and lava cappings having thick mantle of laterite at some places. Alluvium is found in lower parts. This district is drained by the river North Koel and its tributaries - Auranga and Amanat. The general line of drain is from south to north towards river Sone.

2.3 Climate

During winter season the area records 16 to 18 ^{0}C and during summer season the temperature increases upto 41^{0}C. December is the coldest month and May is the hottest month. The area receives annual rainfall less than 1200 mm as it comes under rain shadow part. More than 80 percent precipitation is received during monsoon months.

2.4 Agriculture and Land Use

The forest is full of variety of medicinal plants, kendu leaves, bamboo, sal, teak and other timber species. The district has considerable flat land, which provide suitable site for agricultural use. The hilly areas are mostly under forest with patches of cultivation on scarp areas. Major crops grown in the district are rice, wheat and pulses. Only 23.34 percent area of agricultural use are net irrigated and major source of irrigations are well and canals.

Land Use in Palamu District (1997-98)

		Palamu	**Jharkhand**
1.	Forest	43.23 %	29.2 %
2.	Net sown area	17.36 %	22.7 %
3.	Barren and unculturable waste	6.02 %	7.2 %
4.	Non agricultural use	4.61 %	9.9 %
5.	Orchards	1.38 %	2.5 %
6.	Pasture	0.36 %	
7.	Culturable wasteland	1.90 %	3.5 %
8.	Current and other fallow	25.14 %	25.0 %

Source: Fertilizer and Agriculture Statistics, Eastern Region (2003-2004)

2.5 Soils

The soils occurring in different landforms have been characterised during soil resource mapping of the state on 1:250,000 scale (Haldar *et al.* 1996) and three soil orders namely Entisols, Inceptisols and Alfisols were observed in Palamu district (Fig.1 and table 1). Alfisols were the dominant soils covering 53.9 percent of TGA followed by Entisols (21.5 %) and Inceptisols (20.0 %).

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of TGA
15	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Ultic Haplustalfs	46	0.91
16	Fine, mixed, hyperthermic, Typic Haplustalfs Loamy, mixed, hyperthermic,Lithic Ustorthents	149	2.95
19	Loamy-skeletal, mixed, hyperthermic,Lithic Ustorthents Fine loamy, mixed, hyperthermic, Typic Haplustepts	90	1.78
23	Fine-loamy, mixed, hyperthermic, Typic Haplustepts Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	387	7.67
24	Fine, mixed, hyperthermic Typic Haplustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	647	12.83
25	Fine, mixed, hyperthermic, Typic Paleustalfs Fine, mixed, hyperthermic, Rhodic Paleustalfs	158	3.13
30	Loamy-skeletal, mixed, Typic Haplustepts Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	67	1.33
31	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Typic Paleustalfs	153	3.03
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	23	0.46
35	Loamy-skeletal, mixed, hyperthermic, Lithic Ustorthents Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	1068	21.17
37	Loamy, mixed, hyperthermic, Lithic Haplustalfs Fine, mixed, hyperthermic, Typic Paleustalfs	76	1.51
38	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	15	0.3
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	286	5.67
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	121	2.4
43	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	16	0.32
46	Fine, mixed, hyperthermic Aeric Endoaqualfs Fine, mixed, hyperthermic Typic Endoaqualfs	83	1.65
47	Fine, mixed, hyperthermic Aeric Endoaqualfs Fine, mixed, hyperthermic Aeric Endoaquepts	25	0.5
48	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	5	0.1
63	Loamy, mixed, hyperthermic Lithic Haplustalfs Loamy-skeletal, mixed, hyperthermic Typic Ustorthents	33	0.65
65	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	331	6.56
78	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Ultic Haplustalfs	36	0.71
79	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Ultic Paleustalfs	481	9.54
85	Fine-loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	269	5.33
86	Fine, mixed, hyperthermic Typic Rhodustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	198	3.93
99	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Vertic Haplustepts	50	0.99
Miscellaneous		231	4.58
Total		5044	100.0

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (63P/14,15,16,64M/13,72D/2,3,4,6,7,8,12 and 73A/1,5,9) and all the maps were demarcated with grid points at 2.5 km interval.

Surface soil samples from demarcated grid points and other related informations were collected through field survey. Soil samples were air dried, processed and analysed for pH, organic carbon, available phosphorous and potassium (Page *et al.*, 1982), available nitrogen (Subbaiah and Asija, 1956), available sulphur by using 0.15 percent $CaCl_2$ as the extractant (William and Steinbergs, 1959), available (DTPA extractable) Fe, Mn, Zn and Cu (Lindsay and Norvell, 1978) and available B (hot water soluble) by Carmine method (Hatcher and Wilcox, 1950).

The soils are grouped under different soil reaction classess viz extreamely acidic (pH<4.5), very strongly acidic (pH 4.5 – 5.0), strongly acidic (pH 5.1 – 5.5), moderately acidic (pH 5.6-6.0), slightly acidic (pH 6.1-6.5), neutral (pH 6.6-7.3), slightly alkaline (pH 7.4-7.8), moderately alkaline (pH 7.9-8.4), strongly alkaline (pH 8.5-9.0) according to Soil Survey Manual (IARI, 1970).The soils are rated as low (below 0.50 %), medium (0.50-0.75 %) and high (above 0.75 %) in case of organic carbon, low (<280 kg ha^{-1}), medium (280 to 560 kg ha^{-1}) and high (>560 kg ha^{-1}) in case of available nitrogen, low (< 10 kg ha^{-1}), medium (10 to 25 kg ha^{-1}) and high (> 25 kg ha^{-1}) for available phosphorus, low (< 108 kg ha^{-1}), medium (108 to 280 kg ha^{-1}) and high (> 280 kg ha^{-1}) for available potassium and low (<10 mg kg^{-1}), medium (10-20 mg kg^{-1}) and high (> 20 mg kg^{-1}) for available sulphur (Singh *et. al.* 2004, Mehta *et. al.*1988). Critical limits of Fe, Mn, Zn, Cu and B, which separate deficient from non-deficient soils followed in India are 4.5, 2.0, 0.5, 0.2 and 0.5 mg kg^{-1} respectively. (Follet and Lindsay, 1970 and Berger and Truog, 1940).

The maps for the above mentioned parameters have been prepared using Geographic Information System (GIS) from data generated by analysis of grid soil samples.

4. SOIL ACIDITY AND FERTILITY STATUS

4.1 Soil Reaction

Soil pH is an important soil property, which affects the availability of several plant nutrients. It is a measure of acidity and alkalinity and reflects the status of base saturation. The soils of the district have been grouped under eight soil reaction classes according to Soil Survey Manual (IARI, 1970).

The soil pH ranges from 4.8 to 8.9. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that soils of most of the area is acidic (47.8 % of TGA), in which 26.6 percent area is slightly acidic, 17.0 percent moderately acidic, 3.8 percent strongly acidic and 0.7 percent very strongly acidic in reaction. Soils of 27.1 percent area of the district are neutral whereas 20.5 percent area is alkaline in reaction.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	37	0.7
Strongly acidic (pH 5.1 to 5.5)	192	3.8
Moderately acidic (pH 5.6 to 6.0)	861	17.1
Slightly acidic (pH 6.1 to 6.5)	1321	26.2
Neutral (pH 6.6 to 7.3)	1369	27.1
Slightly alkaline (pH 7.4 to 7.8)	593	11.8
Moderately alkaline (pH 7.9 to 8.4)	368	7.3
Strongly alkaline (pH 8.5 to 9.0)	72	1.4
Miscellaneous	231	4.6
Total	5044	100.0

4.2 Organic Carbon

The effect of soil organic matter on soil properties is well recognized. Soil organic matter plays a vital role in supplying plant nutrients, cation exchange capacity, improving soil aggregation and hence water retention and soil biological activity.

The organic carbon content in the district ranges from 0.10 to 1.64 %. They are mapped into three classes i.e., low (below 0.5 %), medium (0.5-0.75 %) and high (above 0.75 %) (Table 3 and Figure 3). From table 3 it is seen that 42.6 percent area of the district have high organic carbon content. Medium and low organic carbon content constitute 37.4 and 15.4 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00ha)	% of the TGA
Low (below 0.50 %)	776	15.4
Medium (0.50-0.75 %)	1887	37.4
High (above 0.75 %)	2150	42.6
Miscellaneous	231	4.6
Total	5044	100.0

4.3 Macronutrients

Nutrients like nitrogen (N), phosphorus (P) and potassium (K) are considered as primary nutrients and sulphur (S) as secondary nutrient. These nutrients help in proper growth, development and yield differentiation of plants and are generally required by plants in large quantity.

4.3.1 Available Nitrogen

Nitrogen is an integral component of many compounds including chlorophyll and enzyme essential for plant growth. It is an essential constituent for amino acids which is building blocks for plant tissue, cell nuclei and protoplasm. It encourage aboveground vegetative growth and deep green colour to leaves. Deficiency of nitrogen decreases rate and extent of protein synthesis and result into stunted growth and develop chlorosis.

Available nitrogen content in the surface soils of the district ranges between 120 and 809 kg/ha and details are given in table 4 and figure 4.

Majority soils (68.3 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and soils of 15.8 percent area have low available nitrogen content (<280 kg ha^{-1}).

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 280)	799	15.8
Medium (280-560)	3445	68.3
High (above 560)	569	11.3
Miscellaneous	231	4.6
Total	5044	100.0

4.3.2 Available Phosphorus

Phosphorus is important component of adenosine di-phosphate (ADP) and adenosine tri-phosphate (ATP), which involves in energy transformation in plant. It is essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plant and animal. Phosphorous take part in important functions like photosynthesis, nitrogen fixation, crop maturation, root development, strengthening straw in cereal crops etc. The availability of phosphorous is restricted under acidic and alkaline soil reaction mainly due to P-fixation. In acidic condition it get fixed with aluminum and iron and in alkaline condition with calcium.

Available phosphorus content in these soils ranges between 0.2 and 38.2 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that most of the soils are low (46.8 % of TGA) followed by medium (43.4 % of TGA) and high (5.2 % of TGA) content of available phosphorous.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 10)	2362	46.8
Medium (10-25)	2191	43.4
High (above 25)	260	5.2
Miscellaneous	231	4.6
Total	5044	100.0

4.3.3 Available Potassium

Potassium is an activator of various enzymes responsible for plant processes like energy metabolism, starch synthesis, nitrate reduction and sugar degradation. It is extremely mobile in plant and help to regulate opening and closing of stomata in the leaves and uptake of water by root cells. It is important in grain formation and tuber development and encourages crop resistance for certain fungal and bacterial diseases.

Available potassium content in these soils ranges between 76 and 1680 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that most of the soils (55.9 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 34.0 percent area are high (above 280 kg ha^{-1}) and 5.5 percent area are low (below 108) in available potassium content.

Table 6. Available potassium status in the surface soils

Available potassium (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 108)	276	5.5
Medium (108-280)	2821	55.9
High (above 280)	1716	34.0
Miscellaneous	231	4.6
Total	5044	100.0

4.3.4 Available Sulphur

Sulphur is essential in synthesis of sulphur containing amino acids (cystine, cysteine and methionine), chlorophyll and metabolites including co-enzyme A, biotin, thiamine, or vitamin B1 and glutathione. It activates many proteolytic enzymes, increase root growth and nodule formation and stimulate seed formation.

The available sulphur content in the soils ranges from 0.61 to 82.86 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 48.9 percent of the area are high (>20 mg kg^{-1}) whereas soils of 26.1 and 20.4 percent area are medium (10-20 mg kg^{-1}) and low (<10 mg kg^{-1}) in available sulphur content respectively.

Table 7. Available sulphur status in the surface soils

Available sulphur (mg kg^{-1})	Area (‘00ha)	% of the TGA
Low (<10)	1028	20.4
Medium (10-20)	1319	26.1
High (>20)	2466	48.9
Miscellaneous	231	4.6
Total	5044	100.0

4.4 Micronutrients

Proper understanding of micronutrients availability in soils and extent of their deficiencies is the pre-requisite for efficient management of micronutrient fertilizer to sustain crop productivity. Therefore, it is essential to know the micronutrients status of soil before introducing any type of land use.

4.4.1 Available Iron

Iron is constituent of cytochromes, haems and nonhaem enzymes. It is capable of acting as electron carrier in many enzyme systems that bring about oxidation-reduction reactions in plants. It promotes starch formation and seed maturation.

The available iron content in the surface soils ranges between 13.1 and 399.7 mg kg^{-1}. As per the critical limit of available iron (> 4.5 mg kg^{-1}), all the soils are sufficient in available iron. They are grouped and mapped into six classes. Majority of the soils (55.8 % of TGA) have available iron content between the range of 100 to 400 mg kg^{-1}. The details of area and distribution is presented in table 8 and figure 8.

Table 8. Available iron status in the surface soils

Available iron (mg kg^{-1})	Area ('00ha)	% of the TGA	Rating
<15	198	3.9	Sufficient
15-25	162	3.2	
25-50	655	13.0	
50-100	985	19.5	
100-200	1489	29.5	
200-400	1324	26.3	
Miscellaneous	231	4.6	
Total	5044	100.0	

4.4.2 Available Manganese

Manganese is essential in photosynthesis and nitrogen transformations in plants. It activates decarboxylase, dehydrogenase, and oxidase enzymes.

The available manganese content in surface soils ranges between 9.8 and 296.9 mg kg^{-1}. As per the critical limit of available manganese (> 2 mg kg^{-1}), all the soils are sufficient in available manganese. They are grouped and mapped into six classes. Soils of 73.5 % area of district have available Mn content between 25 and 100 mg kg^{-1}. The details of area and distribution are presented in table 9 and figure 9.

Table 9. Available manganese status in the surface soils

Available manganese ($mg\ kg^{-1}$)	Area ('00ha)	% of the TGA	Rating
<10	77	1.5	Sufficient
10-25	352	7.0	
25-50	1430	28.3	
50-100	2279	45.2	
100-200	599	11.9	
200-300	76	1.5	
Miscellaneous	231	4.6	
Total	5044	100.0	

4.4.3 Available Zinc

Zinc plays role in protein synthesis, reproductive process of certain plants and in the formation starch and some growth hormones. It promotes seed maturation and production.

The available zinc in surface soils ranges between 0.04 and 4.42 $mg\ kg^{-1}$. They are grouped and mapped into five classes. Soils of Majority of soils (85.7 % of TGA) are sufficient (>0.5 $mg\ kg^{-1}$) whereas soils of 9.7 percent area are deficient (<0.5 $mg\ kg^{-1}$) in available zinc. The details of area and distribution are presented in table 10 and figure 10.

Table 10. Available zinc status in the surface soils

Available zinc ($mg\ kg^{-1}$)	Area ('00ha)	% of the TGA	Rating
<0.5	491	9.7	Deficient
0.5-1.0	1073	21.3	Sufficient
1.0-2.0	2416	47.9	
2.0-3.0	760	15.1	
3.0-5.0	73	1.4	
Miscellaneous	231	4.6	
Total	5044	100.0	

4.4.4 Available Copper

Copper involves in photosynthesis, respiration, protein and carbohydrate metabolism and in the use of iron. It stimulates lignifications of all the plant cell wall and is capable of acting as electron carrier in many enzyme systems that bring about oxidation-reduction reactions in plants.

The available copper status in surface soils ranges between 0.14 and 5.87 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (94.1 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 1.3 % area are deficient in available copper (<0.2 mg kg^{-1}). The details of area and distribution are presented in table 11 and figure 11.

Table 11. Available copper status in the surface soils

Available copper (mg kg^{-1})	Area ('00ha)	% of the TGA	Rating
<0.2	67	1.3	Deficient
0.2-0.5	93	1.8	Sufficient
0.5-1.0	352	7.0	
1.0-2.0	856	17.0	
2.0-4.0	2865	56.8	
4.0-6.0	580	11.5	
Miscellaneous	231	4.6	
Total	5044	100.0	

4.4.5 Available Boron

Boron increases solubility and mobility of calcium in the plant and it act as regulator of K/Ca ratio in the plant. It is required for development of new meristematic tissue and also necessary for proper pollination, fruit and seed setting and translocation of sugar, starch and phosphorous etc. It has role in synthesis of amino acid and protein and regulates carbohydrate metabolism.

The available boron content in the soils ranges from 0.02 to 4.18 $mgkg^{-1}$ and details about area and distribution is given in table 12 and figure 12. The critical limit for deficiency of the available boron is <0.5. Soils of 67.7 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 27.7 percent area are sufficient (>0.50 $mgkg^{-1}$) in available boron content.

Table 12. Available boron status in the surface soils

Available boron (mg kg^{-1})	**Area ('00ha)**	**% of the TGA**	**Rating**
<0.25	1160	23.0	Deficient
0.25-0.50	2254	44.7	
0.50-0.75	1084	21.5	Sufficient
>0.75	315	6.2	
Miscellaneous	231	4.6	
Total	5044	100.0	

5. SUMMARY

The soil pH ranges from 4.8 to 8.9. Soils of most of the area is acidic (47.8 % of TGA) in reaction. Soils of 27.1 percent area of the district are neutral whereas 20.5 percent area is alkaline in reaction. The organic carbon content in the district ranges from 0.10 to 1.64 %. Soils of 42.6 percent area of the district have high organic carbon content. Medium and low organic carbon content constitute 37.4 and 15.4 percent area respectively.

Available nitrogen content in the surface soils of the district ranges between 120 and 809 kg/ha. Majority soils (68.3 % of TGA) of the district have medium status of available nitrogen and soils of 15.8 percent area have low available nitrogen content. Available phosphorus content in these soils ranges between 0.2 and 38.2 kg/ha. Most of the soils are low (46.8 % of TGA) followed by medium (43.4 % of TGA) and high (5.2 % of TGA) in available phosphorous content. Available potassium content in these soils ranges between 76 and 1680 kg/ha. Most of the soils (55.9 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 34.0 percent area are high (above 280 kg ha^{-1}) and 5.5 percent area are low (below 108) in available potassium content. Available sulphur content in the soils ranges from 0.61 to 82.86 mg kg^{-1}. Soils of 48.9 percent of the area are high (>20 mg kg^{-1}) whereas soils of 26.1 and 20.4 percent area are medium (10-20 mg kg^{-1}) and low (<10 mg kg^{-1}) in available sulphur content respectively.

Soils are analysed for available (DTPA extractable) micronutrients and seen that all the soils are sufficient in available iron and manganese whereas soils of 9.7 and 1.3 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.02 to 4.18 $mgkg^{-1}$ and 67.7 percent area of district is deficient (<0.50 mg kg^{-1}) in it.

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