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

LATEHAR 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 Latehar district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Latehar district is located in the north-western part of the state. It is new district created in 2001. Earlier it was part of Palamu district. It is bounded by Palamu in north, Chatra in the east, Lohardaga and Gumla in the south and Garhwa and Chattisgarh in the west. It has an area of 3661 sq. km area and 5,58,831 persons (Census of India, 2001). The district has one subdivision and seven development blocks viz. Barwadih, Manika, Balumath, Chandwa, Latehar, Garu and Mahuatanr.

2.2 Physiography, Geology and Drainage

Latehar district is highly hilly and forested in the south and comparatively less hilly in the north. The average elevation of the district is 400 meters. The highest spot found is Netarhat. Geologically hills found near Netarhat area are of metamorphic rock. The remaining hill are composed of sandstone, conglomerate, and lava capping having thick mantle of laterite. Major rivers of the area of Auranga and North Koel.

2.3 Climate

As this area consist of higher landforms in south and plains in the north, it presents diversities in climatic conditions. The southern portion provide bitting cold and mild summer. During winter season the area records 16 to 18 ^{0}C in north and during summer season the temperature increases upto 41^{0}C. The higher areas in south receives anuual rainfall upto 2000 mm. but northern part of the district remain in rain shadow and receive less than 1200 mm rainfall.

2.4 Agriculture and Land Use

Since the area has partly hilly terrain and partly homogenous plains, land use also varies. In northern part, as it is plain most of the area is under agriculture. Rice and wheat are major crops grown in the district. In southern part the majority area is engaged in forest cover only patches of agricultural land are found.

Land Use in Latehar District (1997-98)

		Latehar	**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 Latehar district (Fig.1 and table 1). Alfisols were the dominant soils covering 63.7 percent of TGA followed by Entisols (28.2 %) and Inceptisols (7.2%)

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of the TGA
15	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Ultic Haplustalfs	641	17.51
16	Fine, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	12	0.33
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	21	0.57
20	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	70	1.91
21	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Rhodic Paleustalfs	45	1.23
22	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	157	4.29
24	Fine, mixed, hyperthermic Typic Haplustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	78	2.13
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	19	0.52
35	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine-loamy, mixed, hyperthermic Typic Haplustalfs	311	8.49
36	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Rhodustalfs	52	1.42
37	Loamy, mixed, hyperthermic Lithic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	901	24.61
38	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	64	1.75
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	136	3.71
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	926	25.32
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	88	2.40
45	Fine, mixed, hyperthermic Aeric Endoaquepts Fine loamy, mixed, hyperthermic Typic Haplustepts	28	0.76
78	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Ultic Haplustalfs	1	0.03
79	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Ultic Paleustalfs	66	1.80
81	Fine, mixed, hyperthermic Typic Rhodustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	1	0.03
85	Fine-loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	2	0.05
86	Fine, mixed, hyperthermic Typic Rhodustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	10	0.27
Miscellaneous		32	0.87
Total		3661	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (64M/14,15, 73A/1,2,3,5,6,7,9,10,13,14 and 72D/12,16) 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 four soil reaction classes according to Soil Survey Manual (IARI, 1970).

The soil pH ranges from 4.7 to 7.4. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that 34.7 % area of the district is slightly acid followed by moderately acid (25.2% of TGA), neutral (20.2% of TGA) and strongly acid soils (14.0% of TGA). Very strongly acid and slightly alkaline soils are found in patches.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00 ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	115	3.2
Strongly acidic (pH 5.1 to 5.5)	740	20.2
Moderately acidic (pH 5.6 to 6.0)	1272	34.7
Slightly acidic (pH 6.1 to 6.5)	921	25.2
Neutral (pH 6.6 to 7.3)	511	14.0
Slightly alkaline (pH 7.4 to 7.8)	70	1.9
Miscellaneous	32	0.9
Total	3661	100

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 0.02 to 3.63%. 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 soils of majority area (55.9% TGA) are high in organic carbon content. Low and medium organic carbon content constitute 22.1 and 21.2 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	809	22.1
Medium (0.50-0.75 %)	775	21.2
High (above 0.75 %)	2045	55.9
Miscellaneous	32	0.9
Total	3661	100

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 Latehar district ranges between 175 and 670 kg/ha and details are given in table 4 and figure 4. Majority area (63.1 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 24.3 percent area have low available nitrogen content (<280 kg ha^{-1}).

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 280)	891	24.3
Medium (280-560)	2309	63.1
High (above 560)	429	11.7
Miscellaneous	32	0.9
Total	3661	100

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 0.5 and 85.1 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils (93 %) are low to medium in available phosphorous content.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 10)	1693	46.3
Medium (10-25)	1711	46.7
High (above 25)	225	6.1
Miscellaneous	32	0.9
Total	3661	100

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 85 and 980 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that soils of 47.9 percent area of the district are high in available potassium content (above 280 kg ha^{-1}) and 42.0 percent area are medium (108-280 kg ha^{-1}) in available potassium content.

Table 6. Available potassium status in the surface soils

Available potassium (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 108)	338	9.2
Medium (108-280)	1536	42.0
High (above 280)	1755	47.9
Miscellaneous	32	0.9
Total	3661	100

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 0.30 to 30.88 $mgkg^{-1}$ and details about area and distribution is given in table 7 and figure 7. Soils of 70.9 percent of the area are low (<10 mg kg^{-1}) whereas soils of 25.7 and 2.5

percent area are medium (10-20 mg kg^{-1}) and high (>20 mg kg^{-1}) in available sulphur content respectively.

Table 7. Available sulphur status in the surface soils

Available sulphur (mg kg^{-1})	Area ('00 ha)	% of the TGA
Low (<10)	2595	70.9
Medium (10-20)	942	25.7
High (>20)	92	2.5
Miscellaneous	32	0.9
Total	3661	100

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 is ranges between 12.88 and 88.40 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 four classes. Majority of the soils (80 % of TGA) have available iron content between the range of 25 to 100 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 ('00 ha)	% of the TGA	Rating
<15	211	5.8	Sufficient
15-25	455	12.4	
25-50	1801	49.2	
50-100	1162	31.7	
Miscellaneous	32	0.9	
Total	3661	100	

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 6.3 and 196.1 $mg\ kg^{-1}$. 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 five classes. All the soils are sufficient in available manganese content. Soils of 56.3 % area of district have available Mn content between 25 and 200 $mg\ kg^{-1}$ and 5.3 percent area have available manganese content of below 10 $mg\ kg^{-1}$. 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 ('00 ha)	% of the TGA	Rating
<10	192	5.2	Sufficient
10-25	1375	37.6	
25-50	394	10.8	
50-100	1476	40.3	
100-200	192	5.2	
Miscellaneous	32	0.9	
Total	3661	100	

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 0.74 and 8.62 mg kg^{-1}. They are grouped and mapped into six classes. Soils of Majority of soils (95.6 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 3.5 per cent 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 ('00 ha)	% of the TGA	Rating
<0.5	129	3.5	Deficient
0.5-1.0	197	5.4	Sufficient
1.0-2.0	1294	35.3	
2.0-3.0	1071	29.3	
3.0-5.0	750	20.5	
5.0-9.0	188	5.1	
Miscellaneous	32	0.9	
Total	3661	100	

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 0.08 and 7.50 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (92.2 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 6.9

% 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 ('00 ha)	% of the TGA	Rating
<0.2	254	6.9	Deficient
0.2-0.5	382	10.4	Sufficient
0.5-1.0	837	22.9	
1.0-2.0	1116	30.5	
2.0-4.0	849	23.2	
4.0-6.0	94	2.6	
6.0-8.0	97	2.6	
Miscellaneous	32	0.9	
Total	3661	100	

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 1.62 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 84.5 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 14.6 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 ('00 ha)	% of the TGA	Rating
<0.25	1927	52.6	Deficient
0.25-0.50	1167	31.9	
0.50-0.75	416	11.4	Sufficient
>0.75	119	3.2	
Miscellaneous	32	0.9	
Total	3661	100	

5. SUMMARY

The soil pH ranges from 4.7 to 7.4. Soils of 34.7 % area of the district is slightly acid followed by moderately acid (25.2% of TGA), neutral (20.2% of TGA) and strongly acid soils (14.0% of TGA). Majority area (55.9% TGA) of the district have high in organic carbon content. Low and medium organic carbon content constitute 22.1 and 21.2 percent area respectively.

Available nitrogen content in the surface soils of the district ranges between 175 and 670 kg/ha. Majority area (63.1 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 24.3 percent area have low available nitrogen content (<280 kg ha^{-1}). Available phosphorus content in these soils ranges between 0.5 and 85.1 kg/ha. Majority of the soils (93.0 %) are low to medium in available phosphorous content. Available potassium content in these soils ranges between 85 and 980 kg/ha. Soils of 47.9 percent area of the district are high in available potassium content (above 280 kg ha^{-1}) and 42.0 percent area are medium (108-280 kg ha^{-1}) in available potassium content. The available sulphur content in the soils ranges from 0.3 to 30.88 mg kg^{-1}. Soils of 70.9 percent of the area are low (<10 mg kg^{-1}) whereas soils of 25.7 and 2.5 percent area are medium (10-20 mg kg^{-1}) and high (>20 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 3.5 and 6.9 percent area are deficient in available zinc and copper respectively. The available boron content in the soils ranges from 0.02 to 1.62. Soils of 84.5 percent area of district are deficient (<0.50 mgkg^{-1}) whereas 14.6 percent area are sufficient (>0.50 mgkg^{-1}) in available boron content.

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