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

LOHARDAGA DISTRICT

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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 Lohardaga district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Lohardaga district is located in the western part of the Ranchi plateau and come into existence in 1983 by separating from Ranchi district. It is bounded by Latehar district in north, Gumla in south and west and Ranchi in the east. It extends from $23^0$16′45″ to $23^0$40′30″ N latitude and $84^0$23′50′ to $84^0$56′50′ E longitude and comprises 1491 sq. km area and 3,64,521 persons (Census of India, 2001). The district is divided into 5 development blocks namely Lohardaga, Bhandra, Kisko, Senha and Kuru.

2.2 Physiography, Geology and Drainage

The district is divided into two major physical divisions viz. the hilly tract and the plateau region. The hilly tract is extended in the west and north western part of the district, which includes part of Kisko, Senha and Kuru development blocks. The high hill tops of the region is known as pat. The plateau region is the part of the Gumla plateau comprised with entire part of Lohardaga and Bhandra and some part of Senha, Kisko and Kuru development blocks. This region has a number of small hillocks. The general slope of the district is from west to east. Geologically the area is comprised with Archean granites and gneisses. In the uplands considerable thickness of laterite of Pleistocene age is found in the Granite and Gneisses tracts. Alluvium of recent to sub-recent age is found in the river valley. The most important mineral of the district is bauxite. Other minerals found in the district are feldspar, fire clay and china clay and have less economic importance. The main rivers of the districts are South Koel, Sankh, Nandini, Chaupat and Fulijhar etc. These are mainly rainfed rivers and dried up in the summer months. Some springs are also seen in the hilly tract.

2.3 Climate

The district enjoy healthy, pleasant climate throughout the year. The annual average temperature is 23^0 C, the highest temperature goes to 36 ^{0}C in summer and lowest of 10^0C in winter. The district receives annual rainfall of 1000 to 1600 mm and it increases from west to east.

2.4 Agriculture and Land Use

About 90 percent of the population is dependent on agriculture. Net sown area of the district is 77,744.78 hectors. Out of which only 7034.20 hectors area is irrigated. The main crop of the district are rice fallowed by millets (marua, gondli and maize), pulses, wheat oilseed (sarguja and groundnut) and vegetables. There is scarcity of sufficient and dependable source of irrigation because of the district being hilly. The main sources of irrigation in the district are river canal, pond and wells. One fourth of the area is under forest cover with majority of sal, mahua, jamun and neem vegetation.

Land Use in Lohardaga District (1997-98):

		Lohardaga	Jharkhand
1.	Forest	28.87 %	29.2 %
2.	Net sown area	30.05 %	22.7 %
3.	Barren and unculturable waste	6.12 %	7.2 %
4.	Non agricultural use	7.17 %	9.9 %
5.	Orchards	0.54 %	2.5 %
6.	Pasture	0.04 %	
7.	Culturable wasteland	3.51 %	3.5 %
8.	Current and other fallow	23.70 %	25.0 %

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 Lohardaga district (Fig.1 and table 1). Alfisols were the dominant soils covering 52.6 percent of total geographical area followed by Inceptisols (25.1 %) and Entisols (21.1 %)

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	394	26.43
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	10	0.67
21	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Rhodic Paleustalfs	64	4.29
22	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	21	1.41
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	8	0.54
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	445	29.84
37	Loamy, mixed, hyperthermic Lithic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	8	0.54
39	Fine, mixed, hyperthermic Rhodic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	25	1.68
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	134	8.99
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	83	5.56
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	280	18.78
Miscellaneous		19	1.27
Total		1491	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (73A/6,7,10,11,14,15) 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).

All the soils are acidic in reaction. The soil pH ranges from 4.5 to 6.4. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that strongly acidic soils cover 57.6 % area of the district followed by moderately acidic (25.6 % of TGA), very strongly acid (14.0% of TGA) and slightly acid (1.5 % of TGA).

Table 2. Soils under different reaction classes

Soil reaction	Area ('00 ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	209	14.0
Strongly acidic (pH 5.1 to 5.5)	859	57.6
Moderately acidic (pH 5.6 to 6.0)	381	25.6
Slightly acidic (pH 6.1 to 6.5)	23	1.5
Miscellaneous	19	1.3
Total	1491	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 0.25 to 1.17%. They are mapped into three classes i.e., low (below 0.5 %), medium (0.5-0.75 %) and high (above 0.75 %). The details are given in table 3 and figure 3. From table 3 it is seen that 37.6 percent area have low surface organic carbon content.

Medium and high organic carbon content constitute 28.2 and 32.9 percent area respectively. Low organic carbon content may be due to high temperature regime of the area, which accelerates the rate of decomposition of organic carbon.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	561	37.6
Medium (0.50-0.75 %)	421	28.2
High (above 0.75 %)	490	32.9
Miscellaneous	19	1.3
Total	1491	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 Lohardaga district ranges between 122 and 565 kg/ha and details are given in table 4 and figure 4. Majority area (72.6 % of TGA) of the district have low status of available nitrogen (Below 280 kg ha^{-1}) and 25.7 percent area have medium available nitrogen content (280-560 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)	1083	72.6
Medium (280-560)	383	25.7
High (above 560)	6	0.4
Miscellaneous	19	1.3
Total	1491	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 6.0 and 326.2 kg/ha and area and distribution is given in table 5 and figure 5. Majority of the soils (63.8 % area) are high in available phosphorous content (above 25 kg ha^{-1}). Soils of 19.3 percent area have medium (10-25 kg ha^{-1}) and 15.6 percent area have low (below 10 kg ha^{-1}) 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)	232	15.6
Medium (10-25)	288	19.3
High (above 25)	952	63.8
Miscellaneous	19	1.3
Total	1491	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 56 and 672 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that 47.1 % area of the district have medium available potassium content (108-280 kg ha^{-1}). Soils of 25.8 percent area are high (above 280 kg ha^{-1}) and 25.8 percent area are low (below 108 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)	384	25.8
Medium (108-280)	702	47.1
High (above 280)	386	25.8
Miscellaneous	19	1.3
Total	1491	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 0.71 to 20.61 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Majority of soils (77.9 % of TGA) are low (<10 mg kg^{-1}) in available sulphur content. Soils of 20.4 and 0.4 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 ('00ha)	% of the TGA
Low (<10)	1161	77.9
Medium (10-20)	305	20.4
High (>20)	6	0.4
Miscellaneous	19	1.3
Total	1491	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 11.8 and 301.6 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 (57.8 % of TGA) have available iron content between the range of 50 to 200 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	171	11.5	Sufficient
15-25	77	5.2	
25-50	231	15.5	
50-100	431	28.9	
100-200	431	28.9	
200-400	131	8.7	
Miscellaneous	19	1.3	
Total	1491	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 6.1 and 111.6 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 35.7 % of district have available Mn content between 50 to 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 ('00 ha)	% of the TGA	Rating
<10	306	20.5	Sufficient
10-25	189	12.7	
25-50	368	24.7	
50-100	533	35.7	
100-200	76	5.1	
Miscellaneous	19	1.3	
Total	1491	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 0.39 and 3.70 mg kg^{-1}. Soils of majority of area (84.9 % of TGA) have sufficient amount of available zinc (> 0.5 mg kg^{-1}). They are grouped and mapped into five classes. Majority of soils (84.9 % of TGA) are sufficient (>0.5 mg kg^{-1}) and soils of 13.8 per cent area are deficient 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	206	13.8	Deficient
0.5-1.0	212	14.2	Sufficient
1.0-2.0	784	52.6	
2.0-3.0	134	9.0	
3.0-5.0	136	9.1	
Miscellaneous	19	1.3	
Total	1491	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 0.16 and 4.90 mg kg^{-1}. Majority of soils (81.9 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 16.8 % area are deficient in available copper (<0.2 mg kg^{-1}). They are grouped and mapped into six classes. 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	251	16.8	Deficient
0.2-0.5	128	8.6	Sufficient
0.5-1.0	255	17.1	
1.0-2.0	365	24.5	
2.0-4.0	394	26.4	
4.0-6.0	79	5.3	
Miscellaneous	19	1.3	
Total	1491	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 0.04 to 1.07 $mgkg^{-1}$ 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 71.5 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 27.2 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	423	28.4	Deficient
0.25-0.50	643	43.1	
0.50-0.75	291	19.5	Sufficient
>0.75	115	7.7	
Miscellaneous	19	1.3	
Total	1491	100.0	

5. SUMMARY

All the soils of Lohardaga districts are acidic in reaction. Soils of 71.6 per cent area of the district have pH range between 4.5 and 5.5. Organic carbon content in these soils ranges from 0.25 to 1.17 percent. Low organic carbon content in these soils may be due to high temperature regime of the area, which accelerates the rate of decomposition of organic matter.

Available nitrogen content in surface soils ranges between 122 to 565 kg ha^{-1}. Majority of soils (72.6 percent of TGA) are low in available nitrogen content. Available phosphorous content ranges between 6.0 to 326 kg ha^{-1}. Majority of the soils (63.8 percent of TGA) were high in available phosphorous whereas soils of 15.6 percent area are low in available phosphorous (below 10 kg ha^{-1}). Available potassium ranges between 56 and 672 kg ha^{-1}. Soils of 47.1% and 25.8 % area are medium (108-280 kg ha^{-1}) and high (> 280 kg ha^{-1}) in available potassium respectively. The available sulphur content in the soils ranges from 0.71 to 20.61 mg kg^{-1}. Majority of soils (77.9 % of TGA) are low (<10 mg kg^{-1}) in available sulphur content.

Soils are analysed for available (DTPA extractable) micronutrients and seen that all the soils are sufficient in available iron and manganese whereas soils of 13.8 and 16.8 percent area are deficient in available zinc and copper. The available boron content in the soils ranges from 0.04 to 1.07 mgkg^{-1}. Soils of 71.5 percent area of district are deficient (<0.50 mgkg^{-1}) whereas 27.2 percent area are sufficient (>0.50 mgkg^{-1}) in available boron content.

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