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

GARHWA 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 Garhwa district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Garhwa district is located in the north-western part of the state. It came into existence on 31st March 1991. It is bounded by Bhabna-Rohtas south district of Bihar in north, Chattisgarh and Uttar Pradesh in the west and Palamu district in the east. It has an area of 4044 sq. km area and 10,34,151 persons (Census of India, 2001). The district has two subdivisions and fourteen development blocks.

2.2 Physiography, Geology and Drainage

The district provides diverse physiographic features because northern part has relatively homogenous land formed by river Son and the southern portion is hilly and undulating. In the southern portion the land is more dissected and narrow valleys are found. Because of that smaller plain associated with rivulets are found. The northern portion have comparatively larger plains subdivided into *Tanrs* and *Dons* which provide contrasting landscape than that of the southern region. The general slope is from south to north. Geologically the area is comprised with Archean granites and gneisses. Alluvium of recent to sub-recent age is found in the river valley. The area is drained by the Satbahinia, Banro, Panda, Bayochanki, Dhina, Tahle, Khjuri, Ranji and Saraswati river.

2.3 Climate

The southern portion having hilly areas covered with forest provide relatively mild summer and cold winter. During winter season temperature ranges from 9.5 to 35^{0}C and during summer season the temperature ranges from 18 to 45^{0}C. the average rainfall is about 120cm. During winter season it hardly records 1 cm rainfall but most of the rain occur during rainy season.

2.4 Agriculture and Land Use :

The southern portion of the district have considerable forest cover where trible people depends on forest products but in northern area people have converted forest covered areas to agricultural land and grow rice, maize, ragi and millet etc. Plain areas of the north have rice areas with irrigation facilities are also growing wheat and vegetables.

Land Use in Garhwa District (1997-98)

		Garhwa	Jharkhand
1.	Forest	44.58 %	29.2 %
2.	Net sown area	14.71 %	22.7 %
3.	Barren and unculturable waste	5.77 %	7.2 %
4.	Non agricultural use	4.54 %	9.9 %
5.	Orchards	0.53 %	2.5 %
6.	Pasture	0.48 %	
7.	Culturable wasteland	1.54 %	3.5 %
8.	Current and other fallow	27.85 %	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 Garhwa district (Fig.1 and table 1). Alfisols were the dominant soils covering 54.5 percent of TGA followed by Entisols (29.7 %) and Inceptisols (14.7 %)

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	130	3.22
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	40	0.99
23	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine-loamy, mixed, hyperthermic Typic Haplustalfs	34	0.84
24	Fine, mixed, hyperthermic Typic Haplustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	689	17.04
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	299	7.39
37	Loamy, mixed, hyperthermic Lithic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	330	8.16
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	59	1.46
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	54	1.34
48	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	304	7.52
63	Loamy, mixed, hyperthermic Lithic Haplustalfs Loamy-skeletal, mixed, hyperthermic Typic Ustorthents	132	3.27
64	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Paleustalfs	64	1.58
65	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	614	15.18
85	Fine-loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	29	0.72
86	Fine, mixed, hyperthermic Typic Rhodustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	20	0.49
95	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Rock outcrops	320	7.91
96	Loamy-skeletal, mixed, hyperthermic Typic Ustorthents Rock outcrops	34	0.84
97	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustalfs	658	16.27
98	Fine loamy, mixed, hyperthermic Typic Paleustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	189	4.67
Miscellaneous		45	1.11
Total		4044	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (63P/6,7,8,10,11,12,14,15,16, 64M/9,10,13,14 and 73A/1,2) 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 4.9 to 8.4. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that neutral soils cover 27.3 % area of the district followed by slightly acidic (25.7 % of TGA), slightly alkaline (16.0% of TGA) and moderately alkaline soils (12.6 % of TGA). Strongly and very strongly acidic 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)	96	2.4
Strongly acidic (pH 5.1 to 5.5)	126	3.1
Moderately acidic (pH 5.6 to 6.0)	479	11.8
Slightly acidic (pH 6.1 to 6.5)	1039	25.7
Neutral (pH 6.6-7.3)	1105	27.3
Slightly alkaline (pH 7.4-7.8)	647	16.0
Moderately alkaline (pH 7.9-8.4)	507	12.6
Miscellaneous	45	1.1
Total	4044	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 0.20 to 1.78%. 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 46.8 percent area have high surface organic carbon content. Medium and low organic carbon content constitute 37.1 and 15.0 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	607	15.0
Medium (0.50-0.75 %)	1500	37.1
High (above 0.75 %)	1892	46.8
Miscellaneous	45	1.1
Total	4044	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 Garhwa district ranges between 168 and 717 kg/ha and details are given in table 4 and figure 4.

Majority area (73.7 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 16.6 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)	673	16.6
Medium (280-560)	2980	73.7
High (above 560)	346	8.6
Miscellaneous	45	1.1
Total	4044	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 55.0 kg/ha and area and distribution is given in table 5 and figure 5. Data reveals that soils of the 48.8 % area are medium (10-25 kg ha^{-1}) in available phosphorous content, whereas 36.6 and 13.5 % area have low (below 10 kg ha^{-1}) and high (above 25 kg ha^{-1}) available phosphorous content respectively.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 10)	1479	36.6
Medium (10-25)	1973	48.8
High (above 25)	547	13.5
Miscellaneous	45	1.1
Total	4044	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 67 and 482 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that majority of soils (65.1 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 25.2 percent area are high (above 280 kg ha^{-1}) and 8.6 percent area are low 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)	347	8.6
Medium (108-280)	2634	65.1
High (above 280)	1018	25.2
Miscellaneous	45	1.1
Total	4044	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 0.90 to 45.65 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. soils of 29.5 percent of the area are deficient (<10 mg kg^{-1}) whereas soils of 31.3 and 38.1 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)	1192	29.5
Medium (10-20)	1267	31.3
High (>20)	1540	38.1
Miscellaneous	45	1.1
Total	4044	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 13.2 and 501.6 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 (77.1 % 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	31	0.8	Sufficient
15-25	19	0.5	
25-50	265	6.5	
50-100	1323	32.7	
100-200	1796	44.4	
200-400	565	14.0	
Miscellaneous	45	1.1	
Total	4044	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 3.2 and 242.2 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 58.2 % 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 ('00 ha)	% of the TGA	Rating
<10	671	16.6	Sufficient
10-25	188	4.6	
25-50	886	21.9	
50-100	1467	36.3	
100-200	687	17.0	
200-300	100	2.5	
Miscellaneous	45	1.1	
Total	4044	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 0.24 and 3.64 mg kg^{-1}. They are grouped and mapped into five classes. Majority of soils (93.5 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 3.9 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	157	3.9	Deficient
0.5-1.0	605	15.0	Sufficient
1.0-2.0	1858	45.9	
2.0-3.0	1320	32.6	
3.0-5.0	59	1.5	
Miscellaneous	45	1.1	
Total	4044	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 0.18 and 4.36 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (94.4 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 4.5 % 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	181	4.5	Deficient
0.2-0.5	180	4.5	Sufficient
0.5-1.0	370	9.1	
1.0-2.0	1275	31.5	
2.0-4.0	1858	46.0	
4.0-6.0	135	3.3	
Miscellaneous	45	1.1	
Total	4044	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 0.01 to 2.99 and details about area and distribution is given in table 12 and figure 12. Soils of

70.8 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 28.1 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	1658	41.0	Deficient
0.25-0.50	1204	29.8	
0.50-0.75	678	16.8	Sufficient
>0.75	459	11.3	
Miscellaneous	45	1.1	
Total	4044	100.0	

5. SUMMARY

The soil pH ranges from 4.9 to 8.4. The data reveals that neutral soils cover 27.3 % area of the district followed by slightly acidic (25.7 % of TGA), slightly alkaline (16.0% of TGA) and moderately alkaline soils (12.6 % of TGA). Strongly and very strongly acidic soils are found in patches. Organic carbon content in these soils ranges from 0.20 to 1.78 percent. Soils of 46.8 percent area have high organic carbon content (above 0.75 %) whereas soils of 37.1 percent area are medium (0.50-0.75 %) in organic carbon content.

Available nitrogen content in surface soils ranges between 168 and 717 kg ha^{-1}. Majority of soils (73.3 percent of TGA) are medium (280-560 kg ha^{-1}) in available nitrogen content whereas soils of 16.6 percent area are low (below 280) in available nitrogen content. Available phosphorous content ranges between 0.2 and 55.0 kg ha^{-1}. Soils of 48.8 percent area are medium (10-25 kg ha^{-1}) and 36.6 percent area are low (below 10 kg ha^{-1}) in available phosphorous content. Available potassium ranges between 67 and 482 kg ha^{-1}. Majority of soils (65.1 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 25.2 and 8.6 percent area are high (above 280 kg ha^{-1}) and low (below 108 kg ha^{-1}) in available potassium content respectively. Available sulphur content ranges between 0.90 to 45.65 mg kg^{-1} and soils of 29.5 percent of the area is low (<10 mg kg^{-1}) whereas soils of 31.3 and 38.1 percent area are medium and high 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 3.9 and 4.5 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.01 to 2.99 mg kg^{-1} and 70.8 percent area of district is deficient (<0.50 mg kg^{-1}).

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