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

RANCHI 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 Ranchi district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Ranchi district is located in the centre of the state. It is bounded by the districts of Hazaribag and Chatra in the north, West Singhbhum in the south, Latehar, Lohardaga and Gumla in the west and Bokaro and Saraikela in the east. It has an area of 7698 sq. km and population of 27,83,577 persons (Census of India, 2001). The district comprises three subdivisions namely Ranchi Sadar, Bundu and Khunti and twenty development blocks.

2.2 Physiography, Geology and Drainage

Ranchi consists of tabular landmass. It has even flat surface with isolated hillocks known as Tongri. Hills lying on west have elevation above 800 metres and those lying in east have elevation less than 75 metres. The average elevation of the district is 650 metres but western portion is relatively higher than eastern part. The entire area is full of *tanrs* and *Dons* on account of rolling topography. *Tanrs* are the comparatively highlands and *Dons* are lower lands. Geologically the area is comprised with Archean granites, gneisses and schists. Important rivers in the district are Subarnarekha, South Koel and Shankh.

2.3 Climate

The district experiences pleasant climatic condition though tropic of capricorn passes over it due to higher elevation. Relative humidity also remains low, so summer season is also not uncongenial. December is the coldest month with minimum temperature of 10.3^{0}C and May is the hottest month with maximum temperature of 37.2^{0}C. Average annual rainfall of the district is 1375 mm and more than 80 percent precipitation received during monsoon months.

2.4 Agriculture and Land Use

The lower area provide suitable condition for paddy cultivation. The higher elevations provide condition for orchards and cultivation of pulse, millet and vegetables. The forest cover 20.99 % of total area of the district. Major crops grown in the district are rice and pulses. Only 8.30 percent area of agricultural use have irrigation facility and major source of irrigations are well and canals.

Land Use in Ranchi District (1997-98)

		Ranchi	Jharkhand
1.	Forest	20.99	29.2 %
2.	Net sown area	33.18	22.7 %
3.	Barren and unculturable waste	5.21	7.2 %
4.	Non agricultural use	10.95	9.9 %
5.	Orchards	1.39	2.5 % (Orchards and Pasture combined)
6.	Pasture	0.27	
7.	Culturable wasteland	3.47	3.5 %
8.	Current and other fallow	24.54	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 Ranchi district (Fig.1 and table 1). Alfisols were the dominant soils covering 71.0 percent of TGA followed by Inceptisols (17.2 %) and Entisols (9.6 %).

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	354	4.60
17	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	134	1.74
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	85	1.10
24	Fine, mixed, hyperthermic Typic Haplustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	4	0.05
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	1800	23.38
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	1316	17.10
36	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Rhodustalfs	910	11.82
37	Loamy, mixed, hyperthermic Lithic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	77	1.00
38	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	256	3.33
39	Fine, mixed, hyperthermic Rhodic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	835	10.85
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	657	8.53
41	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Paleustalfs	37	0.48
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	26	0.34
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	345	4.48
48	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	293	3.81
50	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	190	2.47
54	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	2	0.03
64	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Paleustalfs	11	0.14
67	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	108	1.40
71	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	35	0.46
78	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Ultic Haplustalfs	55	0.71
Miscellaneous		168	2.18
Total		7698	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (73A/14,15,16, 73B/13, 73E/2,3,4,6,7,8,10,11,12,,15,16 and 72F/1,2,5,9,13) 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 seven soil reaction classes according to Soil Survey Manual (IARI, 1970).

The soil pH ranges from 4.2 to 7.6. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that majority of the area is acidic (96.4 % of TGA), in which 41.9 percent area is strongly acidic, 28.6 percent ver strongly acidic, 18 percent moderately acidic, 5.2 percent slightly acidic and 2.7 percent extremely acidic in reaction. Soils of 1.2 percent area of the district are neutral whereas 0.2 percent area is slightly alkaline in reaction.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00ha)	% of the TGA
Extremely acidic (pH <4.5)	206	2.7
Very strongly acidic (pH 4.5 to 5.0)	2205	28.6
Strongly acidic (pH 5.1 to 5.5)	3226	41.9
Moderately acidic (pH 5.6 to 6.0)	1388	18.0
Slightly acidic (pH 6.1 to 6.5)	400	5.2
Neutral (pH 6.6 to 7.3)	90	1.2
Slightly alkaline (pH 7.4 to 7.8)	15	0.2
Miscellaneous	168	2.2
Total	7698	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 0.14 to 3.76 %. 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 43.8 percent area of the district shows high organic carbon content. Medium and low organic carbon content constitute 28.7 and 25.3 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00ha)	% of the TGA
Low (below 0.50 %)	1945	25.3
Medium (0.50-0.75 %)	2211	28.7
High (above 0.75 %)	3374	43.8
Miscellaneous	168	2.2
Total	7698	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 109 and 638 kg/ha and details are given in table 4 and figure 4. Majority soils (67.2 % of TGA) of the district have medium availability status of nitrogen (280-560 kg ha^{-1}) and soils of 26.1 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)	2012	26.1
Medium (280-560)	5171	67.2
High (above 560)	347	4.5
Miscellaneous	168	2.2
Total	7698	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 0.5 and 26.6 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils are medium (56.2 % of TGA) in available phosphorous content. Soils of 40.1 percent area are low and 1.5 percent area are high in available phosphorous content.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 10)	3091	40.1
Medium (10-25)	4323	56.2
High (above 25)	116	1.5
Miscellaneous	168	2.2
Total	7698	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 49 and 941 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that majority of the soils (57.1 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 27.7 percent area are high (above 280 kg ha^{-1}) and 13.0 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)	1004	13.0
Medium (108-280)	4396	57.1
High (above 280)	2130	27.7
Miscellaneous	168	2.2
Total	7698	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 0.64 to 72.13 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 36.7 percent of the area are low (<10 mg kg^{-1}) whereas soils of 30.5 and 30.6 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)	2825	36.7
Medium (10-20)	2350	30.5
High (>20)	2355	30.6
Miscellaneous	168	2.2
Total	7698	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 is ranges between 11.4 and 301.2 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 (50.0 % of TGA) have available iron content between the range of 25 to 50 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	199	2.6	Sufficient
15-25	550	7.1	
25-50	3846	50.0	
50-100	2774	36.0	
100-200	108	1.4	
200-400	53	0.7	
Miscellaneous	168	2.2	
Total	7698	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 9.2 and 179.2 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 five classes. Soils of 78.3 % area of district have available Mn content between 25 and 50 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	90	1.2	Sufficient
10-25	895	11.6	
25-50	6025	78.3	
50-100	463	6.0	
100-200	57	0.7	
Miscellaneous	168	2.2	
Total	7698	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 0.26 and 4.86 mg kg^{-1}. They are grouped and mapped into five classes. Soils of Majority of soils (93.7 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 4.1 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	316	4.1	Deficient
0.5-1.0	1740	22.6	Sufficient
1.0-2.0	3829	49.7	
2.0-3.0	1174	15.3	
3.0-5.0	471	6.1	
Miscellaneous	168	2.2	
Total	7698	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 5.80 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 5.6 % 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	433	5.6	Deficient
0.2-0.5	731	9.5	Sufficient
0.5-1.0	1645	21.4	
1.0-2.0	2366	30.7	
2.0-4.0	2035	26.4	
4.0-6.0	320	4.2	
Miscellaneous	168	2.2	
Total	7698	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 3.52 $mgkg^{-1}$ 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 42.8 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 55.0 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	1523	19.8	Deficient
0.25-0.50	1774	23.0	
0.50-0.75	1807	23.5	Sufficient
>0.75	2426	31.5	
Miscellaneous	168	2.2	
Total	7698	100.0	

5. SUMMARY

The soil pH ranges from 4.2 to 7.6. Majority of the area is acidic (96.4 % of TGA) in reaction. Soils of 1.2 percent area of the district are neutral whereas 0.2 percent area is slightly alkaline in reaction. The organic carbon content in the district ranges from 0.14 to 3.76 %. Soils 43.8 percent area of the district have high organic carbon content. Medium and low organic carbon content constitute 28.7 and 25.3 percent area respectively.

Available nitrogen content in the surface soils of the district ranges between 109 and 638 kg/ha. Majority soils (67.2 % of TGA) of the district have medium availability of nitrogen (280-560 kg ha^{-1}) whereas soils of 26.1 percent area have low available nitrogen content (<280 kg ha^{-1}).Available phosphorus content in these soils ranges between 0.5 and 26.6 kg/ha. Majority of the soils are medium (56.2 % of TGA) in available phosphorous content. Soils of 40.1 percent area are low and 1.5 percent area are high in available phosphorous content. Available potassium content in these soils ranges between 49 and 941 kg/ha. Majority of the soils (57.1 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 27.7 percent area are high (above 280 kg ha^{-1}) and 13.0 percent area are low (below 108) in available potassium content. Available sulphur content in the soils ranges from 0.6 to 72.1 mg kg^{-1}. Soils of 36.7 percent of the area are low in available sulphur, whereas soils of 30.5 and 30.6 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 4.1 and 5.6 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.02 and 3.52 mg kg^{-1} and 42.8 percent area of district is deficient (<0.50 mg kg^{-1}).

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