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

HAZARIBAG 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 Hazaribag district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Hazaribag district comprising majority area of Hazaribag plateau and bounded by district Kodarma in the north, Giridih and Bokaro in the east, Ranchi in south and Chatra in the west. Total geographical area of the district is 5049 sq. km area and population is 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 has uneven land surfaces characterized by plateau and sharply sloping hills. Virtually its topography corresponds to Ranchi plateau being separated by Damodar valley as it has residual hills and interplateau valley. The highest hill of the district is Marangburu south of Damodar. The general slope of the district is from north-west to south east. Geologically the area is comprised with Archean granites and gneisses with Gondwana series in the southern part of the district. Major river is Damodar but there are few tributaries namely Jamunia, Baranki etc.

2.3 Climate

The district enjoy healthy, pleasant climate throughout the year. The district receives annual rainfall of 1350 mm and more than 80 percent rainfall occur during monsoon season. Annual average temperature is 23^0 C. In summer season the temperature in extreme cases increases to 44^0C and during winter the same come down to 2 to 3^0C.

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 Hazaribag District (1997-98)

		Hazaribag	**Jharkhand**
1.	Forest	43.94 %	29.2 %
2.	Net sown area	16.20 %	22.7 %
3.	Barren and unculturable waste	8.96 %	7.2 %
4.	Non agricultural use	7.90 %	9.9 %
5.	Orchards	1.01 %	2.5 %
6.	Pasture	0.65 %	
7.	Culturable wasteland	1.34 %	3.5 %
8.	Current and other fallow	20.00 %	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 Hazaribag district (Fig.1 and table 1). Alfisols were the dominant soils covering 71.9 percent of TGA followed by Entisols (18.1 %) and Inceptisols (7.8%).

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	319	6.32
16	Fine, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	280	5.55
17	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	175	3.47
23	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine-loamy, mixed, hyperthermic Typic Haplustalfs	176	3.49
25	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Rhodic Paleustalfs	39	0.77
26	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	171	3.39
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	466	9.23
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	670	13.27
35	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine-loamy, mixed, hyperthermic Typic Haplustalfs	185	3.66
36	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Rhodustalfs	993	19.67
38	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	52	1.03
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	290	5.74
41	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Paleustalfs	182	3.60
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	85	1.68
51	Fine loamy, mixed, hyperthermic Typic Haplustepts Loamy, mixed, hyperthermic Lithic Ustorthents	12	0.24
77	Fine loamy, mixed, hyperthermic Typic Rhodustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	36	0.71
78	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Ultic Haplustalfs	18	0.36
79	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Ultic Paleustalfs	90	1.78
80	Fine loamy, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	216	4.28
81	Fine, mixed, hyperthermic Typic Rhodustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	410	8.12
85	Fine-loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	33	0.65
86	Fine, mixed, hyperthermic Typic Rhodustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	36	0.71
87	Fine silty, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Aeric Endoaquepts	3	0.06
Miscellaneous		112	2.22
Total		5049	100.00

3. METHODOLOGY

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

The soil pH ranges from 4.5 to 7.8. The soil reaction classes with area are given in table 2 and figure 2. Majority of soils (88.2 % of TGA) of the area are acidic in reaction. Neutral soils cover 8.7 % area of the district and slightly acidic soils cover 0.9 percent of the district.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00 ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	911	18.0
Strongly acidic (pH 5.1 to 5.5)	1753	34.7
Moderately acidic (pH 5.6 to 6.0)	1134	22.5
Slightly acidic (pH 6.1 to 6.5)	654	13.0
Neutral (pH 6.6-7.3)	439	8.7
Slightly alkaline (pH 7.4-7.8)	46	0.9
Miscellaneous	112	2.2
Total	5049	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 0.08 to 5.54 percent. 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 64.5 percent area have high surface organic carbon content. Medium and low organic carbon content constitute 17.4 and 15.9 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	803	15.9
Medium (0.50-0.75 %)	878	17.4
High (above 0.75 %)	3256	64.5
Miscellaneous	112	2.2
Total	5049	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 Hazaribag district ranges between 68 and 710 kg/ha and details are given in table 4 and figure 4. Soils of majority area (69.4 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 17.9 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)	904	17.9
Medium (280-560)	3502	69.4
High (above 560)	531	10.5
Miscellaneous	112	2.2
Total	5049	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 27.2 kg/ha and area and distribution is given in table 5 and figure 5. Data reveals that soils of the 57.8 percent area are low (below 10 kg ha^{-1}) in available phosphorous content, whereas 38.5 and 1.5 % area have medium (10-25 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)	2919	57.8
Medium (10-25)	1942	38.5
High (above 25)	76	1.5
Miscellaneous	112	2.2
Total	5049	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 65 and 952 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that most of the soils (48.2 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 38.0 percent area are high (above 280 kg ha^{-1}) and 11.6 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)	587	11.6
Medium (108-280)	2431	48.2
High (above 280)	1919	38.0
Miscellaneous	112	2.2
Total	5049	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 0.54 to 106.50 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 33.8 percent of the area are deficient (<10 mg kg^{-1}) whereas soils of 30.4 and

33.6 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 ('00 ha)	% of the TGA
Low (<10)	1709	33.8
Medium (10-20)	1533	30.4
High (>20)	1695	33.6
Miscellaneous	112	2.2
Total	5049	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 6.9 and 76.0 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 (50.4 % of TGA) have available iron content between the ranges 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 ('00 ha)	% of the TGA	Rating
<15	413	8.2	Sufficient
15-25	672	13.3	
25-50	2544	50.4	
50-100	1308	25.9	
Miscellaneous	112	2.2	
Total	5049	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 9.3 and 53.6 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 four classes. Soils of 72.2 % area of district have available Mn content between 50 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	37	0.7	Sufficient
10-25	817	16.2	
25-50	3643	72.2	
50-100	440	8.7	
Miscellaneous	112	2.2	
Total	5049	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 0.10 and 9.40 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (93.6 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 4.2 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 ('00 ha)	% of the TGA	Rating
<0.5	213	4.2	Deficient
0.5-1.0	402	8.0	Sufficient
1.0-2.0	1941	38.4	
2.0-3.0	1207	23.9	
3.0-5.0	858	17.0	
5.0-10.0	316	6.3	
Miscellaneous	112	2.2	
Total	5049	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 0.12 and 5.26 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (92.3 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of

5.5 % 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	276	5.5	Deficient
0.2-0.5	318	6.3	Sufficient
0.5-1.0	741	14.7	
1.0-2.0	1674	33.1	
2.0-4.0	1667	33.0	
4.0-6.0	261	5.2	
Miscellaneous	112	2.2	
Total	5049	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 0.03 to 7.87 mg kg^{-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 38.9 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 58.9 percent area are sufficient (>0.50 mg kg^{-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	1055	20.9	Deficient
0.25-0.50	909	18.0	
0.50-0.75	901	17.9	Sufficient
>0.75	2072	41.0	
Miscellaneous	112	2.2	
Total	5049	100.0	

5. SUMMARY

The soil pH ranges from 4.5 to 7.8. Majority of soils (88.2 % of TGA) of the area are acidic in reaction. The organic carbon content in the soils ranges from 0.08 to 5.54 percent. Soils of 64.5 percent area have high surface organic carbon content. Medium and low organic carbon content constitute 17.4 and 15.9 percent area respectively.

Available nitrogen content in the surface soils of the district ranges between 68 and 710 kg/ha. Soils of majority area (69.4 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 17.9 percent area have low available nitrogen content (<280 kg ha^{-1}). Available phosphorus content in these soils ranges between 0.5 and 27.2 kg/ha. Soils of the 57.8 percent area are low (below 10 kg ha^{-1}) in available phosphorous content. Available potassium content in these soils ranges between 65 and 952 kg/ha. Most of the soils (48.2 % of TGA) have medium (108-280 kg ha^{-1}) available potassium content. Soils of 38.0 percent area are high (above 280 kg ha^{-1}) and 11.6 percent area are low in available potassium content. The available sulphur content in the soils ranges from 0.54 to 106.5 mg kg^{-1}. Soils of 33.8 percent of the area are low (<10 mg kg^{-1}) whereas soils of 30.4 and 33.6 percent area are medium (10-20 mg kg^{-1}) and high (>20 mg kg^{-1}) in available sulphur content respectively.

Soils are analyses for available (DTPA extractable) micronutrients and seen that all the soils are sufficient in available iron and manganese whereas soils of 4.2 and 5.5 percent area are deficient in available zinc and copper respectively. Soils of 38.9 percent area of district are deficient (<0.50 mgkg^{-1}) whereas 58.9 percent area are sufficient (>0.50 mg kg^{-1}) in available boron content.

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