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

BOKARO DISTRICT

National Bureau of Soil Survey and Land Use Planning (ICAR)
Regional Centre, Kolkata

In collaboration with :
Deptt. Of Soil Science & Agricultural Chemistry, BAU, Ranchi, Jharkhand

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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 Bokaro district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Bokaro district is lies in the eastern portion of Jharkhand state. It is bounded by the district of Giridih in the north, West Bengal in the south, Dhanbad in the east and Hazaribag in the west. It has an area of 2861 sq. km area and population of 17,75,961 persons (Census of India, 2001). The district comprises two subdivision (Chas and Bermo) and eight development blocks viz. Chas, Bermo, Gomia, Chandankyari, Jaridih, Kasmar, Peterwar and Nawadih.

2.2 Physiography, Geology and Drainage

The district consists of part of Lower Hazaribag plateau, Panch Paragana and Damodar basin. It consists of area of less than 300 metre elevations. The landforms are less undulating. However few smaller hills and waterfalls are present in the district. Geologically the area is comprised with Archean Granites and Gneisses. In northern part Gondwana rock formation occur in patches.The river Damodar passes through the center of the district. Other important rivers in the districts are Jamunia and Chandrapura. The general slope is from north west to south east.

2.3 Climate

The district have climatic condition slightly different because of less elevation and less forest cover. The summers are hot and winters are cold. The highest temperature is recorded as 46^0C. in winter season temperature come down to 3 to 4^0C when cold wind blows, otherwise the temperature ranges between 10 to 15^0C. The average rainfall is 1570 mm.

2.4 Agriculture and Land Use

The vegetation of the area has been considerably affected by mining and industrial activity. However scattered vegetation of sal, mahua, gamhar, semal are observed at some places. The district has less undulating land but due to growth of industries and mining, most of the area become wasteland. Farmers of the area go for vegetable, fruit and dairy due to demand from the city area.

Land Use in Bokaro District (1997-98)

		Bokaro	Jharkhand
1.	Forest	25.00 %	29.2 %
2.	Net sown area	12.56 %	22.7 %
3.	Barren and unculturable waste	8.66 %	7.2 %
4.	Non agricultural use	17.85 %	9.9 %
5.	Orchards	0.89 %	2.5 %
6.	Pasture	0.70 %	
7.	Culturable wasteland	3.63 %	3.5 %
8.	Current and other fallow	30.71 %	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 Bokaro district (Fig.1 and table 1). Alfisols were the dominant soils covering 62.0 percent of TGA followed by Inceptisols (21.4 %) and Entisols (12.7 %).

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	306	10.70
16	Fine, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	45	1.57
17	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	48	1.68
18	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustalfs	98	3.43
23	Fine-loamy, mixed, hyperthermic, Typic Haplustepts Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	127	4.44
24	Fine, mixed, hyperthermic Typic Haplustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	192	6.71
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	200	6.99
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	74	2.59
35	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine-loamy, mixed, hyperthermic Typic Haplustalfs	26	0.91
36	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Rhodustalfs	110	3.84
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	137	4.79
41	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Paleustalfs	6	0.21
77	Fine loamy, mixed, hyperthermic Typic Rhodustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	36	1.26
78	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Ultic Haplustalfs	147	5.14
79	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Ultic Paleustalfs	525	18.35
80	Fine loamy, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	20	0.70
82	Fine loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Aeric Endoaqualfs	63	2.20
84	Fine, mixed, hyperthermic Aeric Endoaqualfs Fine loamy, mixed, hyperthermic Typic Plinthustalfs	103	3.60
85	Fine-loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	31	1.08
86	Fine, mixed, hyperthermic Typic Rhodustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	77	2.69
87	Fine silty, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Aeric Endoaquepts	378	13.21
Miscellaneous		112	3.91
Total		2861	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (73E/9,10,13,14,15 and 73I/1,2,3,6,7) 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 7.3. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that strongly acid soils covers 39.6 percent area fallowed by very strongly acid (25.2 %), moderately acid (19.6 %) slightly acid (4.9 %) and extremely acid (4.7 %) soils. Soils of 2.1 percent area of the district are neutral in reaction.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00ha)	% of the TGA
Extremely acidic (pH 4.0 to 4.5)	135	4.7
Very strongly acidic (pH 4.6 to 5.0)	720	25.2
Strongly acidic (pH 5.1 to 5.5)	1134	39.6
Moderately acidic (pH 5.6 to 6.0)	562	19.6
Slightly acidic (pH 6.1 to 6.5)	139	4.9
Neutral (pH 6.6 to 7.3)	59	2.1
Miscellaneous	112	3.9
Total	2861	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.

In general the organic carbon content in the district ranges from 0.13 to 2.28 percent, however some soils of coal mine area shows high content of organic carbon. They are mapped into three classes i.e., low (below 0.5 %), medium (0.5-0.75 %) and high (above 0.75 %) (Table 3 and Figure 3). From table 3 it is seen that soils of majority of area (65.4 %) have high organic carbon content. Low and medium organic carbon content constitute 15.9 and 14.8 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00ha)	% of the TGA
Low (below 0.50 %)	454	15.9
Medium (0.50-0.75 %)	425	14.8
High (above 0.75 %)	1870	65.4
Miscellaneous	112	3.9
Total	2861	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 92 and 1536 kg/ha and details are given in table 4 and figure 4. Majority soils (57.6 %) of the district are medium (280-560 kg ha^{-1}) in available nitrogen content. Soils of 24.2 and 14.3 percent area have high (>560 kg ha^{-1}) and low (<280 kg ha^{-1}) available nitrogen content respectively.

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 280)	408	14.3
Medium (280-560)	1647	57.6
High (above 560)	694	24.2
Miscellaneous	112	3.9
Total	2861	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 0.3 and 18.6 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils are low (66.0 % of TGA) in available phosphorous whereas soils of 30.1 % area have medium 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)	1889	66.0
Medium (10-25)	860	30.1
Miscellaneous	112	3.9
Total	2861	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 54 and 476 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that majority of the soils (57.9 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 21.5 percent area are low (below 108) and 16.7 percent area are high (above 280 kg ha^{-1}) 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)	615	21.5
Medium (108-280)	1658	57.9
High (above 280)	476	16.7
Miscellaneous	112	3.9
Total	2861	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 0.42 to 69.41 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 28.3 percent of the area are low (<10 mg kg^{-1}) whereas soils of 30.4 and 37.4 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)	810	28.3
Medium (10-20)	870	30.4
High (>20)	1069	37.4
Miscellaneous	112	3.9
Total	2861	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 9.0 and 98.8 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 (56.9 % of TGA) have available iron content between the range of 50 to 100 mg kg^{-1}. The details of area and distribution is presented in table 8 and figure 8.

Table 8. Available iron status in the surface soils

Available iron (mg kg^{-1})	Area ('00ha)	% of the TGA	Rating
<15	132	4.6	Sufficient
15-25	261	9.1	
25-50	728	25.5	
50-100	1628	56.9	
Miscellaneous	112	3.9	
Total	2861	100	

4.4.2 Available Manganese

Manganese is essential in photosynthesis and nitrogen transformations in plants. It activates decarboxylase, dehydrogenase, and oxidase enzymes.

The available manganese content in surface soils ranges between 8.8 and 69.0 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 67.9 % 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	14	0.5	Sufficient
10-25	462	16.1	
25-50	1941	67.9	
50-100	332	11.6	
Miscellaneous	112	3.9	
Total	2861	100	

4.4.3 Available Zinc

Zinc plays role in protein synthesis, reproductive process of certain plants and in the formation starch and some growth hormones. It promotes seed maturation and production.

The available zinc in surface soils ranges between 0.22 and 19.20 mg kg^{-1}. They are grouped and mapped into six classes. Soils of majority area (95.1 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 1.0 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	29	1.0	Deficient
0.5-1.0	476	16.6	Sufficient
1.0-2.0	873	30.5	
2.0-3.0	469	16.4	
3.0-5.0	403	14.1	
5.0-20.0	499	17.5	
Miscellaneous	112	3.9	
Total	2861	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 7.80 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (94.8 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 1.3 % 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	36	1.3	Deficient
0.2-0.5	96	3.4	Sufficient
0.5-1.0	436	15.2	
1.0-2.0	641	22.4	
2.0-4.0	1013	35.4	
4.0-8.0	527	18.4	
Miscellaneous	112	3.9	
Total	2861	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 0.09 to 5.03 $mgkg^{-1}$ 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 22.5 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 73.6 percent area are sufficient (>0.50 $mgkg^{-1}$) in available boron content.

Table 12. Available boron status in the surface soils

Available boron ($mg\ kg^{-1}$)	Area ('00ha)	% of the TGA	Rating
<0.25	336	11.8	Deficient
0.25-0.50	305	10.7	
0.50-0.75	399	13.9	Sufficient
>0.75	1709	59.7	
Miscellaneous	112	3.9	
Total	2861	100	

5. SUMMARY

The soil pH ranges from 4.2 to 7.3. Strongly acid soils covers 39.6 percent area followed by very strongly acid (25.2 %), moderately acid (19.6 %) slightly acid (4.9 %) and extremely acid (4.7 %) soils. Soils of 2.1 percent area of the district are neutral in reaction. The organic carbon content in the district ranges from 0.13 to 2.28 %. Soils of majority of area (65.4 %) have high organic carbon content. Low and medium organic carbon content constitute 15.9 and 14.8 percent area respectively. Available nitrogen content in the surface soils of the district ranges between 92 and 1536 kg/ha. Majority soils (57.6 %) of the district are medium (280-560 kg ha^{-1}) in available nitrogen content. Soils of 24.2 and 14.3 percent area have high (>560 kg ha^{-1}) and low (<280 kg ha^{-1}) available nitrogen content respectively. Available phosphorus content in these soils ranges between 0.3 and 18.6 kg/ha. Majority of the soils are low (66.0 % of TGA) in available phosphorous whereas soils of 30.1 % area are medium available phosphorous content. Available potassium content in these soils ranges between 54 and 476 kg/ha. Majority of the soils (57.9 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 21.5 percent area are low (below 108) and 16.7 percent area are high (above 280 kg ha^{-1}) in available potassium content. The available sulphur content in the soils ranges from 0.42 to 69.41 mg kg^{-1} and soils of 28.3 percent of the area are low (<10 mg kg^{-1}) in available sulphur content respectively.

All the soils of district are sufficient in available iron and manganese whereas soils of 1.0 and 1.3 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.09 to 5.03 mg kg^{-1} and 22.5 percent area of district are deficient (<0.50 mg kg^{-1}).

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