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

KODARMA 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 Kodarma district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Kodarma district lies in the northern portion of the state. It is surrounded by Nawada district of Bihar in the north, Hazaribag in the south, Giridih in the east and Chatra in the west. It has an area of 2410 sq. km and 4,98,683 persons (Census of India, 2001). There are six development blocks in the district. They are Kodarma, Jainnagar, Chauparan, Satgama, Markacho and Barkatha.

2.2 Physiography, Geology and Drainage

Most part of the district is occupied by Kodarma plateau. This area has more slope, which differentiate it from the Hazaribag plateau which lies in the south. The northern scarps have steep slopes. Average elevation of the area ranges 300 to 500 meters above mean sea level. The plateau of the district has Dharwanian rocks like quartz and schist containing Pegmatite veins in which good quality mica is found. Southern part of the district comprised with Archean granites and gneisses.The general slope of the district is from south to north. Major rivers of the district are Sakri, Dhdhar and Barsoni.

2.3 Climate

Due to lower elevation than Hazaribag plateau the area receives comparatively low rainfall and show higher temperature. The average rainfall of the area is 1200 mm. and most of the rainfall takes place during rainy season. The average annual temperature remains about 25^0C, but summer and winter season records much variations in temperature ranging from the lowest temperature of 2 to 3^0C in January to 40 to 45^0C in May.

2.4 Agriculture and Land Use

Hilly and more scarp areas have more land under forest, while the flat plateau areas are used for cultivation. Paddy is the main crop, while maize, pulses and vegetables are grown in some part of the district.

Land Use in Kodarma District (1997-98):

		Kodarma	Jharkhand
1.	Forest	42.42 %	29.2 %
2.	Net sown area	13.56 %	22.7 %
3.	Barren and unculturable waste	11.36 %	7.2 %
4.	Non agricultural use	6.82 %	9.9 %
5.	Orchards	2.01 %	2.5 %
6.	Pasture	1.11 %	
7.	Culturable wasteland	1.52 %	3.5 %
8.	Current and other fallow	21.20 %	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 Kodarma district (Fig.1 and table 1). Alfisols covers 41.4 percent of TGA followed by Inceptisols (34.6 %) and Entisols (22.9 %)

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of the TGA
16	Fine, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	32	1.33
23	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine-loamy, mixed, hyperthermic Typic Haplustalfs	119	4.94
25	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Rhodic Paleustalfs	298	12.37
26	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	160	6.64
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	106	4.40
35	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine-loamy, mixed, hyperthermic Typic Haplustalfs	50	2.07
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	88	3.65
41	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Paleustalfs	134	5.56
48	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	16	0.66
49	Fine loamy, mixed, hyperthermic Typic Haplustepts Coarse loamy, mixed, hyperthermic Typic Ustorthents	98	4.07
51	Fine loamy, mixed, hyperthermic Typic Haplustepts Loamy, mixed, hyperthermic Lithic Ustorthents	6	0.25
53	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Typic Haplustalfs	27	1.12
54	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	35	1.45
61	Fine, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Typic Paleustalfs	217	9.00
64	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Paleustalfs	8	0.33
65	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	87	3.61
66	Loamy-skeletal, mixed, hyperthermic Typic Haplustepts Coarse loamy, mixed, hyperthermic Typic Ustorthents	702	29.13
67	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	31	1.29
70	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Aeric Endoaqualfs	76	3.15
75	Fine, mixed, hyperthermic Typic Rhodustalfs Fine, mixed, hyperthermic Rhodic Paleustalfs	8	0.33
76	Fine loamy, mixed, hyperthermic Typic Haplustalfs Fine loamy, mixed, hyperthermic Typic Paleustalfs	85	3.53
Miscellaneous		27	1.12
Total		2410	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (72H/3,6,7,10,11,12,13,14,15,16) 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 4.6 to 7.8. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that majority of the area (81.0 % of TGA) is acidic in reaction. Neutral and slightly alkaline soil covers 13.8 and 4.1 percent area 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)	279	11.6
Strongly acidic (pH 5.1 to 5.5)	344	14.3
Moderately acidic (pH 5.6 to 6.0)	644	26.7
Slightly acidic (pH 6.1 to 6.5)	684	28.4
Neutral (pH 6.6 to 7.3)	333	13.8
Slightly alkaline (pH 7.4 to 7.8)	99	4.1
Miscellaneous	27	1.1
Total	2410	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 0.04 to 2.78 %. 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 majority of area (52.2% of TGA) shows high organic carbon content. Low and medium organic carbon content constitute 30.6 and 16.1 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	737	30.6
Medium (0.50-0.75 %)	387	16.1
High (above 0.75 %)	1259	52.2
Miscellaneous	27	1.1
Total	2410	100

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 43 and 723 kg/ha and details are given in table 4 and figure 4. Majority area (62.1 % of TGA) of the district have medium status of available nitrogen

(280-560 kg ha^{-1}) and 22.1 percent area have low available nitrogen content (<280 kg ha^{-1}).

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 280)	533	22.1
Medium (280-560)	1496	62.1
High (above 560)	354	14.7
Miscellaneous	27	1.1
Total	2410	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 1.0 and 20.6 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils are low (76.8 % of TGA) in available phosphorous content. Soil of 22.1 percent area have medium available phosphorous content.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 10)	1851	76.8
Medium (10-25)	532	22.1
Miscellaneous	27	1.1
Total	2410	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 69 and 1232 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that soils of 44.1 percent area have high available potassium content (above 280 kg ha^{-1}). Soils of 32.8 and 22.0 percent area have medium (108-280 kg ha^{-1}) and low in available potassium content respectively.

Table 6. Available potassium status in the surface soils

Available potassium (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 108)	531	22.0
Medium (108-280)	789	32.8
High (above 280)	1063	44.1
Miscellaneous	27	1.1
Total	2410	100

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 0.29 to 68.36 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 33.1 percent of the area are low (<10 mg kg^{-1}) whereas soils of 19.1 and 46.7 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)	798	33.1
Medium (10-20)	460	19.1
High (>20)	1125	46.7
Miscellaneous	27	1.1
Total	2410	100

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 7.5 and 71.8 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 (50.4 % 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 ('00 ha)	% of the TGA	Rating
<15	200	8.3	Sufficient
15-25	396	16.4	
25-50	1213	50.4	
50-100	574	23.8	
Miscellaneous	27	1.1	
Total	2410	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 8.2 and 54 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 61.8 % 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 ('00 ha)	% of the TGA	Rating
<10	16	0.7	Sufficient
10-25	34	1.4	
25-50	1490	61.8	
50-100	843	35.0	
Miscellaneous	27	1.1	
Total	2410	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 0.3 and 11.4 mg kg^{-1}. They are grouped and mapped into six classes. Soils of majority of soils (82.0 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 16.9 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	408	16.9	Deficient
0.5-1.0	350	14.5	Sufficient
1.0-2.0	783	32.6	
2.0-3.0	367	15.2	
3.0-5.0	255	10.6	
>5.0	220	9.1	
Miscellaneous	27	1.1	
Total	2410	100	

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 5.44 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (89.0 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 9.9 % 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	239	9.9	Deficient
0.2-0.5	103	4.3	Sufficient
0.5-1.0	319	13.2	
1.0-2.0	698	29.0	
2.0-4.0	822	34.1	
4.0-6.0	202	8.4	
Miscellaneous	27	1.1	
Total	2410	100	

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 5.84 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 23.9 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 75.0 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 ('00 ha)	% of the TGA	Rating
<0.25	345	14.3	Deficient
0.25-0.50	231	9.6	
0.50-0.75	314	13.0	Sufficient
>0.75	1493	62.0	
Miscellaneous	27	1.1	
Total	2410	100.0	

5. SUMMARY

The soil pH ranges from 4.6 to 7.8. Majority of the area (81.0 % of TGA) is acidic in reaction. The organic carbon content in the district ranges from 0.04 to 2.78 %. Majority of area (52.2 % of TGA) shows high organic carbon content. Low and medium organic carbon content constitute 30.6 and 16.1 percent area respectively.

Available nitrogen content in the surface soils of the district ranges between 43 and 723 kg/ha. Majority area (62.1 % of TGA) of the district have medium availability status of available nitrogen and 22.1 percent area have low available nitrogen content. Available phosphorus content in these soils ranges between 1.0 and 20.6 kg/ha. Majority of the soils are low (76.8 % of TGA) in available phosphorous content. Available potassium content in these soils ranges between 69 and 1232 kg/ha. Soils of 44.1 percent area have high available potassium content (above 280 kg ha^{-1}) and soils of 32.8 and 22.0 percent area have medium (108-280 kg ha^{-1}) and low in available potassium content respectively. The available sulphur content in the soils ranges from 0.29 to 68.36 mg kg^{-1}. Soils of 33.1 percent of the area are low (<10 mg kg^{-1}) whereas soils of 19.1 and 46.7 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 16.9 and 9.9 percent area are deficient in available zinc and copper respectively. Soils of 23.9 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 75.0 percent area have sufficient (>0.50 $mgkg^{-1}$) in available boron content.

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