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

WEST SINGHBHUM 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 West Singhbhum district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

West Singhbhum district is located in the southern portion of the state. it is bounded by Ranchi in the north, Saraikela in the east, Orissa in south and Simdega in the west. It has an area of 7182 sq. km area and population of 12,31,958 persons (Census of India, 2001). The district comprises two subdivisions (Chakradharpur and Chaibasa) and fifteen development blocks.

2.2 Physiography, Geology and Drainage

This area is dominated by hiily ranges, valleys and plateaus. Hilly and steep sloping areas provide dense forest cover. The plain areas have the elevation about 300 metres but the hilly areas have about 300 to 500 metres. There are few hills having elevation of 650 m. Important ridges are Desbar, Dalma, Chandri Pahar, Raisindri, etc. Geologically the area is comprised with Archean granites and gneisses. Dharwarian formations occur at some places. Important rivers in the area are South Koel, Sanjay Baitarni, Roso, Brahamini, Deo, Koyana, Kharkai etc.

2.3 Climate

The district receives an annual rainfall of 1420 mm. and most of the rainfall occurs during the rainy season. The winter season remains reasonably cold when minimum temperature is 3 to 4^0C and the average temperature remains at 16^0C. During summer highest temperature goes upto 43^0C but the average temperature is recorded to be 33^0C.

2.4 Agriculture and Land Use

The area reveals variation in land use pattern. All the hilly ranges are under forest cover and only in patches cultivation observed. Chaibasa plain area is mostly under agricultural use. Rice is the major crop of the area and limited area is under wheat cultivation. Apart from this oilseed and vegetables are grown with irrigation. Main sources of irrigation are canals and reservoirs.

Land Use in West Singhbhum District (1997-98)

		West Singhbhum	Jharkhand
1.	Forest	40.44 %	29.2 %
2.	Net sown area	25.09 %	22.7 %
3.	Barren and unculturable waste	8.89 %	7.2 %
4.	Non agricultural use	6.34 %	9.9 %
5.	Orchards	1.03 %	2.5 %
6.	Pasture	0.56 %	
7.	Culturable wasteland	4.17 %	3.5 %
8.	Current and other fallow	13.48 %	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 West Singhbhum district (Fig.1 and table 1). Entisols cover 34.8 percent area fallowed by Inceptisols (33.2 %) and Alfisols (31.1 %).

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of TGA
20	Loamy, mixed, hyperthermic, Lithic Ustorthents Fine, mixed, hyperthermic, Typic Rhodustalfs	4	0.05
36	Fine, mixed, hyperthermic, Typic Paleustalfs Fine loamy, mixed, hyperthermic, Typic Rhodustalfs	50	0.69
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	171	2.38
48	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	2093	29.14
49	Fine loamy, mixed, hyperthermic Typic Haplustepts Coarse loamy, mixed, hyperthermic Typic Ustorthents	172	2.39
50	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	634	8.83
51	Fine loamy, mixed, hyperthermic Typic Haplustepts Loamy, mixed, hyperthermic Lithic Ustorthents	295	4.11
52	Loamy-skeletal, mixed, hyperthermic Lithic Haplustepts Loamy, mixed, hyperthermic Lithic Ustorthents	51	0.71
53	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Typic Haplustalfs	74	1.03
54	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	507	7.06
55	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	169	2.35
56	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Endoaqualfs	320	4.46
57	Fine, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Aeric Endoaqualfs	57	0.79
58	Fine, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Fluventic Haplustepts	130	1.81
59	Fine, mixed, hyperthermic Aeric Endoaquepts Fine loamy, hyperthermic Typic Haplustepts	207	2.89
64	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Paleustalfs	59	0.83
67	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	519	7.22
70	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Aeric Endoaqualfs	203	2.83
71	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	1111	15.46
73	Fine, mixed, hyperthermic Aeric Endoaquepts Very fine, mixed, hyperthermic Vertic Endoaquepts	150	2.09
75	Fine, mixed, hyperthermic Typic Rhodustalfs Fine, mixed, hyperthermic Rhodic Paleustalfs	138	1.93
Miscellaneous		68	0.95
Total		7182	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (73B/16,73F/1,2,3,4,5,6,7,8,9,10,11,12,14,15,16,73J/3,4 and 73G/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 7.5. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that majority of the area is acidic (95.9 % of TGA), in which 46.0 percent area is strongly acidic, 24.3 percent very strongly acidic, 16.9 percent moderately acidic and 5.5 percent slightly acidic and 3.2 percent extremely acidic in reaction. Soils of 2.3 percent area of the district are neutral whereas 0.9 percent area is slightly alkaline in reaction.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00ha)	% of the TGA
Extremely acidic (pH 4.0-4.5)	233	3.2
Very strongly acidic (pH 4.5 to 5.0)	1743	24.3
Strongly acidic (pH 5.1 to 5.5)	3301	46.0
Moderately acidic (pH 5.6 to 6.0)	1216	16.9
Slightly acidic (pH 6.1 to 6.5)	396	5.5
Neutral (pH 6.6 to 7.3)	162	2.3
Slightly alkaline (pH 7.4 to 7.8)	63	0.9
Miscellaneous	68	0.9
Total	7182	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 0.11 to 2.26 %. 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). Majority soils (67.7 % TGA) are high in available organic carbon content. Medium and low organic carbon content constitute 21.6 and 9.8 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00ha)	% of the TGA
Low (below 0.50 %)	702	9.8
Medium (0.50-0.75 %)	1553	21.6
High (above 0.75 %)	4859	67.7
Miscellaneous	68	0.9
Total	7182	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 185 and 614 kg/ha and details are given in table 4 and figure 4. Majority soils (86.4 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and soils of 5.8 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)	415	5.8
Medium (280-560)	6202	86.4
High (above 560)	497	6.9
Miscellaneous	68	0.9
Total	7182	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 17.0 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils are low (95.3 % of TGA) 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)	6844	95.3
Medium (10-25)	270	3.8
Miscellaneous	68	0.9
Total	7182	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 41 and 470 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that most of the soils (57.3 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 30.9 percent area are low (below 108) and 10.9 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)	2217	30.9
Medium (108-280)	4114	57.3
High (above 280)	783	10.9
Miscellaneous	68	0.9
Total	7182	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 0.5 to 32.3 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Majority of soils (61.6 % TGA) are low (<10 mg kg^{-1}) whereas soils of 28.9 and 8.6

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)	4421	61.6
Medium (10-20)	2077	28.9
High (>20)	616	8.6
Miscellaneous	68	0.9
Total	7182	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 14.8 and 94.6 mg kg^{-1}. As per the critical limit of available iron (> 4.5 mg kg^{-1}), all the soils are sufficient in available iron. They are grouped and mapped into four classes. Majority of the soils (67.8 % 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	77	1.1	Sufficient
15-25	230	3.2	
25-50	1940	27.0	
50-100	4867	67.8	
Miscellaneous	68	0.9	
Total	7182	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 5.1 and 64.0 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 56.1 % 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	113	1.6	Sufficient
10-25	958	13.3	
25-50	4028	56.1	
50-100	2015	28.1	
Miscellaneous	68	0.9	
Total	7182	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 0.16 and 6.42 mg kg^{-1}. They are grouped and mapped into five classes. Soils of majority of soils (93.6 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 5.5 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	395	5.5	Deficient
0.5-1.0	1409	19.6	Sufficient
1.0-2.0	4227	58.9	
2.0-3.0	896	12.5	
3.0-7.0	187	2.6	
Miscellaneous	68	0.9	
Total	7182	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 13.52 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (96.9 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 2.2 % 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	159	2.2	Deficient
0.2-0.5	63	0.9	Sufficient
0.5-1.0	295	4.1	
1.0-2.0	1425	19.8	
2.0-4.0	3566	49.7	
4.0-14.0	1606	22.4	
Miscellaneous	68	0.9	
Total	7182	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 7.21 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 38 percent area of district are deficient (<0.50 mgkg^{-1}) whereas 61 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	1048	14.6	Deficient
0.25-0.50	1681	23.4	
0.50-0.75	2175	30.3	Sufficient
>0.75	2210	30.8	
Miscellaneous	68	0.9	
Total	7182	100.0	

5. SUMMARY

The soil pH ranges from 4.2 to 7.5. Majority of the area is acidic (95.9 % of TGA) in reaction. Soils of 2.3 percent area of the district are neutral whereas 0.9 percent area is slightly alkaline in reaction. The organic carbon content in the district ranges from 0.11 to 2.26 %. Majority soils (67.7 % TGA) are high in organic carbon content. Medium and low organic carbon content constitute 21.6 and 9.8 percent area respectively.

Available nitrogen content in the surface soils ranges between 185 and 614 kg/ha. Majority soils (86.4 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and soils of 5.8 percent area have low available nitrogen content (<280 kg ha^{-1}). Available phosphorus content in these soils ranges between 1.0 and 17.0 kg/ha. Majority of the soils are low (95.3 % of TGA) followed by medium (3.8 % of TGA) and high (0.9 % of TGA) in available phosphorous content. Available potassium content in these soils ranges between 41 and 470 kg/ha. Majority of the soils (57.3 % of TGA) have medium available potassium content. Soils of 30.9 percent area are low (below 108) and 10.9 percent area are high in available potassium content.

The available sulphur content in the soils ranges from 0.47 to 32.26 mg kg^{-1} . Majority of soils (61.6 % TGA) are low whereas soils of 28.9 and 8.6 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 5.5 and 2.2 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.02 to 7.21 mg kg^{-1} and 38 percent area of district is deficient in available boron conent.

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