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

GUMLA 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 Gumla district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Gumla district is located in the South-Western part of the state. It came into existence on 18th March 1983. It is bounded by state boundaries on west by Chattisgarh. The district is surrounded by Latehar and Lohardaga district in the North, Ranchi and West Singhbhum in the East and Simdega in the South. The total geographic area of the district is 5320 sq. km area and population of 8,31,513 persons (Census of India, 2001). The district has eleven development blocks.

2.2 Physiography, Geology and Drainage

The district is a part of Ranchi plateau. The Northern part of the district has higher plateau area where undulations are more marked and the land has an average elevation of 700 meters. The general slope of the district is from north to south. Geologically the area is comprised with Archean Granites and Gneisses. In the uplands considerable thickness of laterite of Pleistocene age is found in the granite and gneisses tracts. Alluvium of recent to sub-recent age is found in the river valley. The major rivers in the districts are South Koel Sankh and Deo Nadi.

2.3 Climate

Average annual rainfall of the area is about 900 mm. But in areas of high elevations, the amount of rainfall increases. The average temperature ranges between 16 to 29^{0} C.

2.4 Agriculture and Land Use

As the area is highly dissected and has rough terrain, contiguous agricultural lands are found in limited areas. The low lying *Don* area provide ideal condition for rice production and comparatively higher *Tanr* areas are grown for ragi, maize, pulses and vegetables.

Land Use in Gumla District (1997-98)

		Gumla	Jharkhand
1.	Forest	15.06 %	29.2 %
2.	Net sown area	29.02 %	22.7 %
3.	Barren and unculturable waste	7.37 %	7.2 %
4.	Non agricultural use	6.95 %	9.9 %
5.	Orchards	1.75 %	2.5 %
6.	Pasture	0.05 %	
7.	Culturable wasteland	5.07 %	3.5 %
8.	Current and other fallow	34.73 %	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 Gumla district (Fig.1 and table 1). Alfisols were the dominant soils covering 42.8 percent of TGA followed by Inceptisols (40.3 %) and Entisols (16.2 %)

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of the TGA
15	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Ultic Haplustalfs	748	14.06
16	Fine, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	65	1.22
18	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustalfs	5	0.09
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	102	1.92
20	Loamy, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	30	0.56
21	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Rhodic Paleustalfs	399	7.50
22	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	153	2.88
23	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine-loamy, mixed, hyperthermic Typic Haplustalfs	76	1.43
33	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	37	0.70
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	66	1.24
37	Loamy, mixed, hyperthermic Lithic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	59	1.11
38	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	811	15.24
39	Fine, mixed, hyperthermic Rhodic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Haplustepts	1097	20.62
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	492	9.25
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	122	2.29
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	982	18.46
50	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	20	0.38
51	Fine loamy, mixed, hyperthermic Typic Haplustepts Loamy, mixed, hyperthermic Lithic Ustorthents	17	0.32
Miscellaneous		39	0.73
Total		5320	100.00

3. METHODOLOGY

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

The soil pH ranges from 4.1 to 6.7. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that majority of the area is strongly acidic (42.5% of TGA) followed by very strongly acidic (24.3% of TGA), moderately acidic (23.7% of TGA). Extremely acidic and slightly acidic soils are found in patches.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00 ha)	% of the TGA
Extremely acidic (pH 4.0 to 4.5)	137	2.6
Very strongly acidic (pH 4.5 to 5.0)	1294	24.3
Strongly acidic (pH 5.1 to 5.5)	2260	42.5
Moderately acidic (pH 5.6 to 6.0)	1260	23.7
Slightly acidic (pH 6.1 to 6.5)	203	3.8
Neutral (pH 6.6-7.3)	127	2.4
Miscellaneous	39	0.7
Total	5320	100

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 1.75%. 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 37.3 percent area shows low organic carbon content. Medium and high organic carbon content constitute 33.5 and 28.5 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	1982	37.3
Medium (0.50-0.75 %)	1784	33.5
High (above 0.75 %)	1515	28.5
Miscellaneous	39	0.7
Total	5320	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 Gumla district ranges between 48 and 578 kg/ha and details are given in table 4 and figure 4. Majority area (64.8 % of TGA) of the district have medium status of available nitrogen (280-560 kg ha^{-1}) and 33.3 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)	1770	33.3
Medium (280-560)	3445	64.8
High (above 560)	66	1.2
Miscellaneous	39	0.7
Total	5320	100

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 27.2 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils are low (80.4%) followed by medium (18.0 %) and high (0.9%) content of available phosphorous.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 10)	4279	80.4
Medium (10-25)	955	18.0
High (above 25)	47	0.9
Miscellaneous	39	0.7
Total	5320	100

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 56 and 924 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that majority of soils (57.8 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 24.0 percent area are high (above 280 kg ha^{-1}) and 17.5 percent area are low (below 108 kg ha^{-1}) 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)	932	17.5
Medium (108-280)	3075	57.8
High (above 280)	1274	24.0
Miscellaneous	39	0.7
Total	5320	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 1.06 to 69.57 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 34.8 percent of the area are deficient (<10 mg kg^{-1}) whereas soils of 35.1 and 29.4 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 ('00 ha)	% of the TGA
Low (<10)	1850	34.8
Medium (10-20)	1869	35.1
High (>20)	1562	29.4
Miscellaneous	39	0.7
Total	5320	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 is ranges between 7.7 and 446.0 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 six classes. Majority of the soils (59.1 % of TGA) have available iron content between the range of 50 to 200 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	293	5.5	Sufficient
15-25	352	6.6	
25-50	1127	21.2	
50-100	1788	33.6	
100-200	1354	25.5	
200-450	367	6.9	
Miscellaneous	39	0.7	
Total	5320	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 3.6 and 282.4 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 six classes. Soils of 60.4 % area of district have available Mn content between 25 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	187	3.5	Sufficient
10-25	439	8.3	
25-50	1546	29.1	
50-100	1666	31.3	
100-200	1213	22.8	
200-300	230	4.3	

Available manganese (mg kg^{-1})	Area ('00 ha)	% of the TGA	Rating
Miscellaneous	39	0.7	
Total	5320	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 0.35 and 2.94 mg kg^{-1}. They are grouped and mapped into five classes. Soils of majority area (98.6 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 0.7 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	38	0.7	Deficient
0.5-1.0	868	16.3	Sufficient
1.0-2.0	4012	75.4	
2.0-3.0	363	6.9	
Miscellaneous	39	0.7	
Total	5320	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 0.06 and 5.04 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 2.4 % 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	128	2.4	Deficient
0.2-0.5	410	7.7	Sufficient
0.5-1.0	1601	30.1	
1.0-2.0	2203	41.4	
2.0-4.0	909	17.1	
4.0-6.0	30	0.6	
Miscellaneous	39	0.7	
Total	5320	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 3.34 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 48.8 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 50.5 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	1115	21.0	Deficient
0.25-0.50	1479	27.8	
0.50-0.75	1326	24.9	Sufficient
>0.75	1361	25.6	
Miscellaneous	39	0.7	
Total	5320	100	

5. SUMMARY

The soil pH ranges from 4.1 to 6.7. Majority of the area is strongly acidic (42.5% of TGA) followed by very strongly acidic (24.3% of TGA), moderately acidic (23.7% of TGA). Extremely acidic and slightly acidic soils are found in patches. The organic carbon content in the district ranges from 0.04 to 1.75%. 37.3 percent area shows low organic carbon content. Medium and high organic carbon content constitute 33.5 and 28.5 percent area respectively.

Available nitrogen content in the surface soils the district ranges between 48 and 578 kg/ha. Majority area (64.8 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 33.3 percent area have low available nitrogen content (<280 kg ha^{-1}). Available phosphorus content in these soils ranges between 1.0 and 27.2 kg/ha. Majority of the soils are low (80.4%) followed by medium (18.0 %) and high (0.9%) content of available phosphorous. Available potassium content in these soils ranges between 56 and 924 kg/ha. Majority of soils (57.8 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 24.0 percent area are high (above 280 kg ha^{-1}) and 17.5 percent area are low in available potassium content. The available sulphur content in the soils ranges from 1.06 to 69.57 mg kg^{-1}. Soils of 34.8 percent of the area are deficient (<10 mg kg^{-1}) whereas soils of 35.1 and 29.4 percent area are medium (10-20 mg kg^{-1}) and high (>20 mg kg^{-1}) 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 0.7 and 2.4 percent area are deficient in available zinc and copper respectively. Soils of 48.8 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 50.5 percent area are sufficient (>0.50 $mgkg^{-1}$) in available boron content.

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