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

DEOGHAR 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

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, fertilization etc.

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 Deoghar district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Locations and Extent

Deogarh district is located in the western portion of Santhal paraganas. It is bounded by Bhagalpur district in north, Dumka in south and east and Giridhi in west. The district extends from $24^0$03′ and $23^0$38′ N latitude and $86^0$28′ and $87^0$04′ E longitude and comprises 2481 sq. km area. It has population 11,65,390 persons (Census of India, 2001). The district is composed of 7 community development blocks namely Deogarh, Madhupur, Mohanpur, Sarwan, Palolori, Sarath and Karon.

.2.2 Physiography, Geology and Drainage

The district contains several clusters of rocky hills covered with forest, but series of long ridges with intervening depressions. Most of the rolling uplands are cultivated by highland crops. The average elevation of the district is 247 m above msl, However hill ranges like Phuljari (750 m), Teror (670 m) and Degaria (575 m) break the monotony of the landscape. The general slope of the district is from north west to south east. Geologically the district is mainly covered by chhotanagpur granite gneiss of Archean age with paches of alluvium, sandstone and shale of Gondawana formations. Important rivers flowing in the district are the Ajay, the Paltro etc. These rivers gather a large number of tributaries which form the land scape full of *Tanrs* and *Dons*.

2.3 Climate

The district experience hot summer (March to May) heavy monsoon rains (June to September) and cool dry winters (October to February). Avarage annual rainfall is 1239 mm, mean summer maximum temperature is 43^0C and mean winter minimum temperature is 8^0C .

2.4 Agriculture and Land Use

Nearly 44 per cent of the total area of the district is utilized for cultivation, out of which only 10.55 per cent is irrigated. The most common sources of irrigation are dug well, surface flow water, lift irrigation etc. Rice is the main crop followed by maize, sugar cane and wheat and vegetables are also grown in a limited scale.

Land Use in Deoghar District (1997-98)

		Deoghar	**Jharkhand**
1.	Forest	13.96 %	29.2 %
2.	Net sown area	29.25 %	22.7 %
3.	Barren and unculturable waste	5.02 %	7.2 %
4.	Non agricultural use	11.13 %	9.9 %
5.	Orchards	1.09 %	2.5 %
6.	Pasture	4.03 %	
7.	Culturable wasteland	5.61 %	3.5 %
8.	Current and other fallow	29.91 %	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 Deoghar district (Fig.1 and table 1). Alfisols were the dominant soils covering 50.0 percent of TGA followed by Inceptisols (42.0 %) and Entisols (6.3 %).

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	15	0.61
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	35	1.41
23	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	330	13.31
26	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	182	7.34
27	Fine-loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Haplustalfs	40	1.62
30	Loamy-skeletal, mixed, Typic Haplustepts Fine-loamy, mixed, hyperthermic Typic Haplustalfs	704	28.40
31	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Typic Paleustalfs	683	27.55
32	Fine-loamy, mixed, hyperthermic Typic Haplustepts Coarse loamy, mixed, hyperthermic Typic Ustorthents	321	12.95
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	124	5.00
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	3	0.12
Miscellaneous		42	1.69
Total		2479	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (72L/7,8,10,11,12,14,15,16 and 72P/3,4) 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 five soil reaction classes according to Soil Survey Manual (IARI, 1970).

The soils are acidic to neutral in reaction. The soil pH ranges from 4.5 to 7.2. The soil reaction classes with area are given in table 2 and figure 2. From table 2 it is seen that the dominant soil reaction class in the district are moderately acidic (pH 5.6 to 6.0) which covers 31.6 per cent area and very strongly acid (pH 4.5 to 5.0) which covers 29.4 percent area fallowed by slightly acid (25.3 % of TGA), strongly acid (9.0 % of TGA) and neutral (2.9 % of TGA).

Table 2. Soils under different reaction classes

Soil reaction	Area ('00 ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	730	29.4
Strongly acidic (pH 5.1 to 5.5)	223	9.1
Moderately acidic (pH 5.6 to 6.0)	783	31.6
Slightly acidic (pH 6.1 to 6.5)	628	25.3
Neutral (pH 6.6-7.3)	73	2.9
Miscellaneous	42	1.7
Total	2479	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 0.10 to 3.23 %. They are mapped into three classes i.e., low (below 0.5 %), medium (0.5-0.75

%) and high (above 0.75 %). The details are given in table 3 and figure 3. From table 3 it is seen that 47.9 percent area have high surface organic carbon content. Medium and low organic carbon content constitute 20.5 and 29.9 percent area respectively. Low organic carbon content may be due to high temperature regime of the area, which accelerates the rate of decomposition of organic carbon.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	741	29.9
Medium (0.50-0.75 %)	508	20.5
High (above 0.75 %)	1188	47.9
Miscellaneous	42	1.7
Total	2479	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 Deoghar district ranges between 47 and 756 kg/ha and details are given in table 4 and figure 4.

It is seen that soils of 56.1 percent area have medium available nitrogen content (280-560 kg ha^{-1}) and 33.9 percent area have low (below 280 kg ha^{-1})available nitrogen content.

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 280)	840	33.9
Medium (280-560)	1391	56.1
High (above 560)	206	8.3
Miscellaneous	42	1.7
Total	2479	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 6.0 and 126.4 kg/ha and area and distribution is given in table 5 and figure 5. Most of the soils (54.8 % of TGA) are medium in available Phosphorous content (10-25 kg ha^{-1}). 30.7 percent area have high and 12.8 percent area were low in available P content.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 10)	316	12.8
Medium (10-25)	1360	54.8
High (above 25)	761	30.7
Miscellaneous	42	1.7
Total	2479	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 101 and 1137 kg/ha and details about area and distribution is given in table 6 and figure 6. The soils of majority area (60.9 % of TGA) have high available potassium content (above 280 kg ha^{-1}). Soils of 26.7 percent area are medium (108- 280 kg ha^{-1}) and soils of 10.7 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)	265	10.7
Medium (108-280)	663	26.7
High (above 280)	1509	60.9
Miscellaneous	42	1.7
Total	2479	100.0

4.3.4 Available Sulphur

Sulphur is essential in synthesis of sulphur containing amino acids (cystine, cysteine and methionine), chlorophyll and metabolites including co-enzyme A, biotin, thiamine, or vitamin B1 and glutathione. It activates many proteolytic enzymes, increase root growth and nodule formation and stimulate seed formation.

The available sulphur content in the soils ranges from 0.54 to 95.15 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 35.3 percent of the area are low (<10 mg kg^{-1}) whereas soils of 21.5 and 41.5 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)	875	35.3
Medium (10-20)	532	21.5
High (>20)	1030	41.5
Miscellaneous	42	1.7
Total	2479	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 promote starch formation and seed maturation.

The available iron content in the surface soils ranges between 12.3 and 201.9 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. 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	211	8.5	Sufficient
15-25	175	7.0	
25-50	537	21.7	
50-100	677	27.3	
100-200	803	32.4	
200-400	34	1.4	
Miscellaneous	42	1.7	
Total	2479	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 8.5 and 245.6 mg kg^{-1}. As per the critical limit of available manganese (> 2 mg kg^{-1}), all the soils are sufficient in available manganese. They are grouped and mapped into six classes. Soils of 34.6 % area have available Mn content between 100 to 200 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	184	7.4	Sufficient
10-25	104	4.2	
25-50	238	9.6	
50-100	521	21.0	
100-200	858	34.6	
200-300	532	21.5	
Miscellaneous	42	1.7	
Total	2479	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 of district ranges between 0.40 and 4.80 $mg\ kg^{-1}$. They are grouped and mapped into five classes. Majority of soils (91.7 % of TGA) are sufficient (>0.5 $mg\ kg^{-1}$) and soils of 6.6 per cent area are deficient 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	163	6.6	Deficient
0.5-1.0	272	11.0	Sufficient
1.0-2.0	1088	43.9	
2.0-3.0	636	25.6	
3.0-5.0	278	11.2	
Miscellaneous	42	1.7	
Total	2479	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 0.1 and 6.0 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (90.8 % of TGA) are sufficient (>0.2 mg kg^{-1}) and soils of 7.5 per cent area are deficient in available copper. 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	187	7.5	Deficient
0.2-0.5	104	4.2	Sufficient
0.5-1.0	240	9.7	
1.0-2.0	526	21.2	
2.0-4.0	858	34.6	
4.0-6.0	522	21.1	
Miscellaneous	42	1.7	
Total	2479	100.0	

4.4.5 Available Boron

Boron increases solubility and mobility of calcium in the plant and it act as regulator of K/Ca ratio in the plant. It is required for development of new meristematic tissue and also necessary for proper pollination, fruit and seed setting and translocation of sugar, starch and phosphorous etc. It has role in synthesis of amino acid and protein and regulates carbohydrate metabolism.

The available boron content in the soils ranges from 0.03 to 1.94 $mgkg^{-1}$ 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 45.1 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 53.2 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	411	16.6	Deficient
0.25-0.50	706	28.5	
0.50-0.75	534	21.5	Sufficient
>0.75	786	31.7	
Miscellaneous	42	1.7	
Total	2479	100.0	

5. SUMMARY

Most of the soils of Deoghar districts are acidic in reaction. Soils of 38.5 per cent area of the district have pH range between 4.5 and 5.5. Organic carbon content in these soils ranges from 0.1 to 3.23 percent and 47.9 percent soils have high organic carbon content (>0.75 per cent)..

Available nitrogen content in surface soils ranges between 47 to 756 kg ha^{-1}. Soils of 56.1 per cent area have medium and soils of 33.9 per cent area have low available nitrogen content. Available phosphorous content ranges between 6.0 to 126.4 kg ha^{-1}. Majority of the soils of the district (85.5 percent of TGA) have medium to high in available phosphorous whereas soils of 12.8 percent area are low in available phosphorous (below 10 kg ha^{-1}). Available potassium content ranges between 101 and 1137 kg ha^{-1}. Soils of 87.6 per cent area have medium to high available potassium content. The available sulphur content in the soils ranges from 0.54 to 95.15 mg kg^{-1}. Soils of 35.3 percent of the area are low (<10 mg kg^{-1}) whereas soils of 21.5 and 41.5 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 6.6 and 7.5 percent area are deficient in available zinc and copper. The available boron content in the soils ranges from 0.03 to 1.94 $mgkg^{-1}$. Soils of 45.1 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 53.2 percent area are sufficient (>0.50 $mgkg^{-1}$) in available boron content.

REFERENCES

Berger, K. C. and Truog, E.(1940) J. Am. Soc. Agron. 32,297.

Census of India (2001) Primary Census Abstract.

FAI (2003 – 2004) Fertiliser and agriculture statistics, Eastern Region.

Follet, R. H. and Lindsay , W. L.(1970) Tech. Bull. Colo. Agric. Exp. Station 110.

Haldar, A. K., Srivastava, R., Thampi, C. J., Sarkar, D., Singh, D. S., Sehgal, J and Velayutham, M. (1996) Soils of Bihar for optimizing land use. **NBSS Publ. 50b**. (Soils of India Series), National Bureau of Soil Survey and Land Use Planning, Nagpur, India, pp. 70+4 sheets soil Map (1:500,000 scale).

Hatcher, J. T. and Wilcox, L. V. (1950) Analyt. Chem. **22**, 567

I.A.R.I. (1970). Soil survey manual, All India Soil and Land Use Organization, Indian Agricultural Research Institute, New Delhi

Lindsay , W. L. & Norvell, W.A.(1978). Development of a DTPA micronutrients soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. Proceedings*: 42, 421-428

Mehta, V. S. , Singh, V and Singh, R. P. (1988) J. Indian Society of Soil Science, 36, 743.

Page, A. L., Miller, R. H. and Keeney, D. R.(1982) Method of Soil Analysis, Part-II, Chemical and Microbiological Properties, Soil Sci. Soc. Am. And Am. Soc. Agron. Madison, Wisconsin, USA.

Singh Dhyan, Chhonkar, P. K. and Pandey, R. N.(2004) Soil Plant and Water Analysis, A Manual, IARI, New Delhi.

Subbaiah, B.V. and Asija, G.L. (1956). A rapid procedure for determination of available nitrogen in soil. Current Science 25, 259-260 .

Tandon, H. L. S. (Ed) (1999) Methods *of analysis of soils, plants, waters and fertilizers*. Fertilizer Development and Consultation Organisation, New Delhi, India

William, C. H. and Stainbergs, A. (1959) Aust. J. Agric. Res. **10,** 342