

GIS BASED SOIL MAPPING OF AVAILABLE MACRO AND MICRONUTRIENTS IN RAIPUR DISTRICT OF CHHATTISGARH

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ABSTRACT

A systematic set of geo-referenced samples was collected from the Raipur district covering the entire area using GPS (Global positioning system) and fertility status map was generated by integrating the individual nutrient cation map in GIS. In general, the soils were low in soluble salts, neutral to alkaline in reaction and medium in organic carbon content. The average values of available N, P and K were 237, 11.29 and 558 kg ha⁻¹ in soil of Dharsinwa block; 229, 12.02 and 448 kg ha⁻¹ in soil of Arang block; 230, 10.95 and 421 kg ha⁻¹ in soil of Abhanpur block soil and 277, 10.97 and 44 8kg ha⁻¹ in soil of Tilda block respectively. In Dharsinwa block, 79% soil samples were low and 21% medium in N; 79% low, 19% medium and 2% high in P; and none was deficient in K. In Arang block, 76% soil samples were low and 24% medium in N; 48% low and 52% medium in P; and 14% medium and 86% high in K. In Abhanpur block, 81% soil samples were low and 19% medium in N; 75% low and 25% medium in P; and 31% medium and 69% high in K. In Tilda block, 51% soil samples were low and 49% medium in N; 75% low and 25% medium in P; and 22% medium and 78% high in K. As regards deficiency of micronutrients, 45, 2, 2 and 8 % were deficient in Zn, Fe, Cu and Mn, respectively in Dharsinwa block; 48, 5 and 7 % deficient in Zn, Fe and Mn, in Arang block; 19, 6, 2 and 8 % deficient in Zn, Fe, Cu and Mn, in Abhanpur block and 27, 10, 1 and 7 % deficient in Zn, Fe, Cu and Mn, in Tilda block. Results of the study indicate that the soils of Raipur district were low in nitrogen and phosphorus and high in potassium. Nearly 50% soils of Dharsinwa and Arang block showed deficiency of Zn.

Keyword: Soil Fertility, Map, GIS, GPS, macronutrient, micronutrient

INTRODUCTION

Soil fertility is one of the important factors controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agriculture production. Because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years. Introduction of high yielding varieties (HYV) in Indian Agriculture in mid- sixties compelled the farmers to use high doses of NPK fertilizers along with micronutrient fertilizers. Present agricultural systems are exploitive of nutrients through intensive tillage, monocropping year after year, use of high yielding varieties, imbalanced use of nutrients coupled with limited use of organic manures, less recycling and burning of crop residues, soil erosion, undulated topography and indiscriminate use of irrigation water. Balanced use of organics, fertilizers and biofertilizers plays an important role to maintain soil fertility in long run. The availability of macro and micronutrients

to plants is influenced by several soil characteristics. Land use pattern also plays a vital role in governing the nutrient dynamics and fertility of soils (Venkatesh *et al.* 2003). Similarly, different cropping systems are suitable for different soil groups as regards to production and productivity. For understanding the reasons of deficiency of available nutrients in soils, correlation of physico-chemical properties with available macro and micronutrients was needed. Hence, present investigation was undertaken to study the status of macro, micronutrients and their relationship with important soil properties in Raipur district of Chhattisgarh.

MATERIALS AND METHODS

Raipur District is situated in the fertile plains of Chhattisgarh Region. This District is situated between 22°33' N to 21°14'N Latitude and 82°6' to 81°38'E Longitude with an altitude of 280 m above the mean sea level. The Raipur district consists of four tahsil/blocks viz., Dharsinwa, Abhanpur, Arang and Tilda. The different blocks of Raipur district have been taken for fertility evaluation on various aspects. A total of 33 villages were selected based on stratified multistage random sampling method

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covering all the four talukas comprising four blocks and a total of 198 surface soil samples (six from each village) were collected using GPS representing small, medium and large farmers' category. Surface soil samples (15 cm) were collected from soil with the help of auger. Soil samples collected from the study area were dried and crushed and passed through 2 mm sieve and stored in properly labeled plastic bags for analysis. Soil pH was determined by glass electrode pH, meter electrical conductivity with Solu-bridge organic C by wet digestion method (Walkley and Black's, 1934). Available nitrogen was estimated by alkaline KMnO_4 method (Subbiah and Asija, 1956), Available phosphorus extracted by 0.5M NaHCO_3 solution buffer at pH 8.5 (Olsen *et al.*, 1954) was used for neutral-alkaline soils while the Bray and Kurtz P1 method (Bray and Kurtz 1945) for acid soils. Available potassium was estimated through neutral normal ammonium acetate by flame-photometer. (Jackson, 1967). The micronutrients (Zn, Cu, Fe and Mn) were extracted with 0.005M diethylene triamine penta acetic acid (DTPA), 0.01M calcium chloride dehydrate and 0.1M triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analyzed by atomic absorption spectrophotometer 4129. The data on available Fe, Cu, Mn and Zn of soils were characterized for deficient and adequate status using the threshold values 4.5 mg kg^{-1} for Fe, 0.2 mg kg^{-1} for Cu, (Katyal and Randhawa, 1983), 3 mg kg^{-1} for Mn (Shukla and Gupta, 1975) and 0.6 mg kg^{-1} for Zn (Katyal, 1985). The formula of nutrient index (NI) and classification of available nutrients as low (<1.5), medium (1.5 to 2.5) and high (>2.5) as suggested by Parker *et al.* (1951) was evaluated as follows:

Nutrient index = [(1 × samples in low category) + (2 × samples in medium category) + (3 × samples in high category)]/Total no. of samples.

Table 2: Range and mean values of EC (dS m^{-1}) in different Blocks of Raipur district

Tahsil/Blocks	Range	Mean	% Samples category		
			Non-saline <1	Slightly saline	Saline
Dharsinwa	0.03-0.23	0.114	100	-	-
Arang	0.03-0.39	0.124	100	-	-
Abhanpur	0.02-0.37	0.102	100	-	-
Tilda	0.04-0.44	0.120	100	-	-
Over all mean	0.02-0.44	0.115	100	-	-

(0.61 %), Arang and Abhanpur (0.59 %). The organic carbon content was found to be

The values (deficient or sufficient) were tagged with each geo referenced point. The points having similar values were grouped and marked as a polygon, manually and the maps for individual micronutrients were digitized using Arc GIS (Sharma *et al.* 2006; 2008). The maps thus generated for different parameters were integrated in Arc GIS (union of layers) to prepare fertility status map.

RESULTS AND DISCUSSION

Physico-chemical properties

The pH of the surface soil ranged from 5.70 to 8.20 with an overall mean of 7.25 and about 11.1, 54.0 and 32.8 % of the samples were acidic, neutral and saline, respectively (Table 1).

Table 1: Range and mean values of pH in soils of Raipur district

Tahsil/Blocks	Range	Mean	% Samples category		
			Acidic <6.5	Neutral 6.5-7.5	Saline >7.5
Dharsinwa	6.7-7.9	7.49	-	58.49	41.51
Arang	5.7-8.2	7.22	14.28	47.62	38.10
Abhanpur	5.7-8.2	7.14	18.75	45.83	35.42
Tilda	6.3-7.9	7.13	12.73	61.82	25.45
Over all mean	5.7-8.2	7.25	11.11	54.04	32.83

In Arang and Tilda block, only 14.3 and 12.7 % of the samples, respectively, were acidic whereas in Dharsinwa and Tilda, 58.5 and 61.8 % samples were under neutral pH. With regard to soil pH, the soils were predominantly neutral followed by saline and acidic. Out of the total samples, 3, 72 and 25 % were under acidic, neutral and alkaline, respectively. The electrical conductivity of the soils ranged from 0.02 to 0.44 dS m^{-1} with a mean of 0.11 dS m^{-1} . All the soils were non-saline condition (Table 2). The overall organic carbon status of the soil ranged from 0.23 to 0.96 with a mean value of 0.64 %. Tilda block recorded the highest mean organic carbon content of 0.76 % followed by Dharsinwa block

distributed to 25, 44 and 30 % in low, medium and high categories respectively. The nutrient

index values ranged from 1.88 to 2.44 with a mean value of 2.05. The fertility rating ranged from medium to high with an overall rating of medium (Table 3). The organic carbon status

was predominantly medium accounting 85% of the total samples followed by high (8%) and low (7%).

Table 3: Range and mean values of organic carbon (%) in different Blocks of Raipur district

Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
			Low <0.5	Medium 0.5-0.75	High >0.75		
Dharsinwa	0.24-0.96	0.61	26	53	21	1.94	Medium
Arang	0.25-0.88	0.59	36	40	24	1.88	Medium
Abhanpur	0.23-0.96	0.59	35	42	23	1.88	Medium
Tilda	0.29-0.96	0.76	7	42	51	2.44	High
Over all mean	0.23-0.96	0.64	25	44	30	2.05	Medium

Available major nutrients

The overall available nitrogen status (Table 4) in the surface soils ranged from 113 to 386 kg ha⁻¹ with a mean value of 245 kg ha⁻¹.

Among the different blocks, Abhanpur contained highest percentage of 'low' available N status (81%) followed by Dharsinwa (79%), Arang (76%) and the lowest in Tilda block (51%).

Table 4: Range and mean values of available nitrogen (Kg ha⁻¹) in different Blocks of Raipur district

Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
			Low <280	Medium 280-560	High >560		
Dharsinwa	111-378	237	79	21	0	1.21	Low
Arang	118-308	229	76	24	0	1.24	Low
Abhanpur	114-335	230	81	19	0	1.19	Low
Tilda	140-386	277	51	49	0	1.49	Low
Over all mean	113-386	245	71	29	0	1.30	Low

With regard to available N, about 71% of the total samples were predominantly under low category and only 29% under medium status and none in high category. Nutrient index value for available nitrogen ranged from 1.19 to 1.49

with a mean value of 1.30. The fertility rating for available N of all four blocks was rated under low category. The overall available Olsen – P (Table 5) ranged from 5.05 to 30.50 kg ha⁻¹ with mean value of 11.27.

Table 5: Range and mean values of available phosphorus (Kg ha⁻¹) in different Blocks of Raipur district

Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
			Low <12.5	Medium 12.5-25	High >25		
Dharsinwa	5.59-30.50	11.29	79	19	2	1.23	Low
Arang	5.16-19.17	12.02	48	52	0	1.52	Low
Abhanpur	5.16-18.55	10.95	75	25	0	1.25	Low
Tilda	5.05-23.83	10.97	75	25	0	1.25	Low
Over all mean	5.05-30.50	11.27	70	29	1	1.30	Low

The over all per cent sample category under low, medium and high was 70, 29 and 1, respectively. Among the four talukas, the highest per cent sample category of "medium" was noticed (52 %) in Arang and the highest category of "low" in Dharsinwa block (79 %). In the case of available P, the status was predominantly under low status representing 70% of the total samples followed by medium in 29% of the sample. Nutrient index value for available

phosphorus ranged from 1.23 to 1.52 with a mean value of 1.30. The overall rating for available phosphorus in the Raipur district was low. The available potassium status (Table 6) in surface soils of different tahsil/blocks ranged from 200 to 614 kg ha⁻¹. Considering the mean values, the highest value of 558 kg ha⁻¹ was recorded in Dharsinwa block and the lowest value of 421 kg ha⁻¹ in Abhanpur block.

Table 6: Range and mean values of available K (Kg ha⁻¹) in different Blocks of Raipur district

Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
			Low <135	Medium 135-335	High >335		
Dharsinwa	348-614	558	0	0	100	3.00	High
Arang	207-606	448	0	14	86	2.86	High
Abhanpur	200-602	421	0	31	69	2.69	High
Tilda	293-605	448	0	22	78	2.78	High
Over all mean	200-614	481	0	17	83	2.83	High

The percentage sample category under low, medium and high was 0, 17 and 83, respectively. The highest status of available K to the tune of 100 % was observed in Dharsinwa block followed by Arang, Tilda and Abhanpur. Nutrient index values ranged from 2.69 to 3.00

with a mean value of 2.83. The overall fertility rating for available potassium was high. Similar results were also reported by Motsara (2002), Muralidharudu *et al.* (2011) and Singh *et al.* (2014). Dixit (2014) reported similar results Kiran Reddy *et al.* (2014) reported that DTPA Zn in

Table 7: Range and mean values of available micro nutrients (mg kg⁻¹) in different Blocks of Raipur district

Tahsil/ Blocks	Total samples	DTPA extractable micronutrient status (mg kg ⁻¹)			
		Zn	Fe	Cu	Mn
Dharsinwa	53	0.20-3.87 (0.78)	2.28-118.96 (23.01)	0.18-2.76 (1.19)	2.10-56.64 (21.59)
Arang	42	0.26-1.82 (0.70)	3.36-76.34 (19.37)	0.28-4.38 (1.56)	0.76-47.48 (19.38)
Abhanpur	48	0.44-2.04 (0.80)	3.44-69.76 (21.22)	0.20-3.74 (1.05)	1.78-46.10 (20.73)
Tilda	55	0.54-2.84 (1.05)	2.86-82.94 (16.00)	0.32-5.06 (2.18)	0.52-44.72 (19.37)
Over all mean	198	0.20-3.87 (0.84)	2.28-118.96 (19.85)	0.18-5.06 (1.51)	0.52-56.64 (20.30)

() Values in parentheses indicate the mean values

Available Micronutrients

The DTPA-Zn content in Raipur soils ranged from 0.20 to 3.87 mg kg⁻¹ with a mean value of 0.84 mg kg⁻¹. Among the four blocks, Zn

deficiency in Dharsinwa block was in 45 % samples and 48% in Arang blocks (Table 8) whereas moderate Zn status was noticed (1.05 mg kg⁻¹) in Tilda block.

Table 8: Per cent sample category of soil micronutrient status in different Tahsil/Blocks of Raipur district

Name of the taluks	No. of samples	Zinc			Iron			Copper			Manganese		
		D <0.6	M 0.6-1.2	H >1.2	D <4.5	M 4.5-9	H >9.0	D <0.2	M 0.2-0.4	H >0.4	D <3.5	M 3.5-7	H >7.0
Dharsinwa	53	45	43	11	2	4	94	2	6	92	8	8	85
Arang	42	48	45	7	5	29	67	0	7	93	7	7	86
Abhanpur	48	19	77	4	6	29	65	2	15	83	8	10	81
Tilda	55	2	78	20	25	22	53	0	2	98	5	11	84
Over all Mean	198	27	62	11	10	20	70	1	7	92	7	9	84

D- Deficient M-Moderate H-High

soils of Nalgonda district of Andhra Pradesh varied from 0.06 to 1.30 mg kg⁻¹. Only 26 samples were deficient in zinc. The DTPA Fe content varied from 2.28 to 118.9 mg kg⁻¹ with a mean value of 19.85 mg kg⁻¹. Iron was found sufficient in all the blocks except Tilda block

where 25 % samples were categorized as deficient. Kiran Reddy *et al.* (2014) also reported that 29% of the soils are rated as deficient in DTPA – Fe. The availability of Cu ranged from 0.18 to 5.06 mg kg⁻¹ with a mean of 1.51 mg kg⁻¹. The mean Cu status in different taluks showed

that the soils of Raipur district had moderate to higher Cu content. Kiran Reddy *et al.* (2014) reported that DTPA-Cu in Nalgonda district soils varied from 0.23 to 7.90 mg kg⁻¹. These soils are rated adequate in available copper. The Mn availability in the soils varied from 0.52 to 56.64 mg kg⁻¹ with a mean of 20.30 mg kg⁻¹. Like copper status of the Raipur district, high Mn availability percentage was also noticed in all four blocks. Only 7 % samples were deficient in Mn. Similar to Fe, Mn was also found to be sufficient in all the taluks. Kiran Reddy *et al.*

(2014) reported 2.11 to 22.00 mg kg⁻¹ DTPA-Mn in Nalgonda soils. On an average, Zn was found to be deficient (27 %) followed by Fe (10 %), Mn (7 %) and Cu (1.0 %). Among the blocks, 45-48 % of the samples collected from Dharsinwa and Arang block showed Zn deficiency. Almost all the taluks had sufficient Cu, Mn and Fe availability except Tilda block which showed 25 % Fe deficiency. The fertility rating of the soils were assessed by working out the nutrient index values (Table 9).

Table 9: Nutrient index values of soil available micronutrients in different Tahsil/Blocks of Raipur district

Name of the taluks	No. of samples	Nutrient Index value				Fertility rating			
		Zn	Fe	Cu	Mn	Zn	Fe	Cu	Mn
Dharsinwa	53	1.64	2.92	2.9	2.77	Low	Very High	Very High	Very High
Arang	42	1.59	2.64	2.93	2.79	Low	High	Very High	Very High
Abhanpur	48	1.85	2.59	2.81	2.73	Marginal	High	Very High	Very High
Tilda	55	2.18	2.28	2.98	2.78	Adequate	Adequate	Very High	Very High
Over all Mean	198	1.84	2.6	2.91	2.77	Marginal	High	Very High	Very High

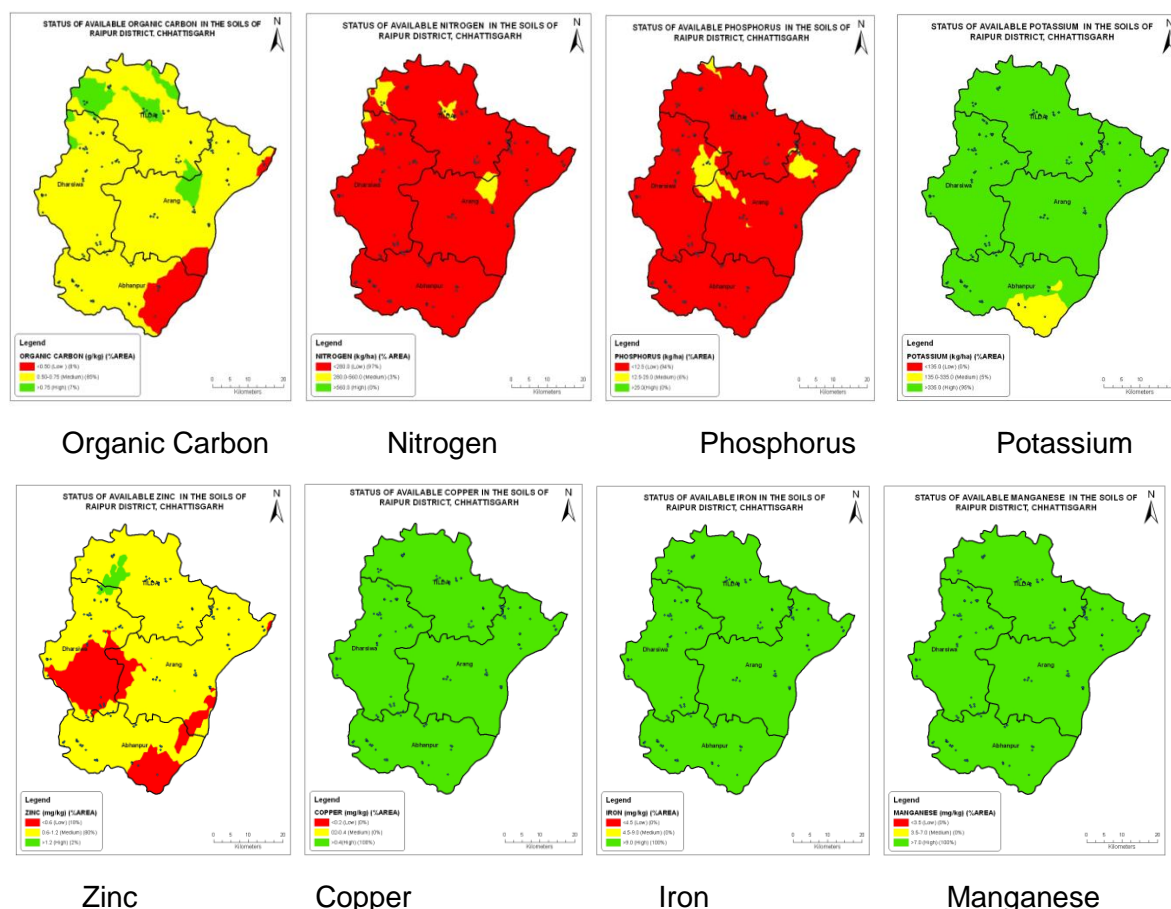


Fig 1: Soil Fertility Map prepared for Organic Carbon, available N, P, K and DTPA-extractable Zn, Cu, Fe, Mn for Raipur District

The nutrient index value ranged from 1.59 - 2.18 for Zn, 2.28 – 2.92 for Fe, 2.81 – 2.98 for Cu and 2.73 – 2.79 for Mn. Notably low fertility rating was recorded for Zn in Dharsinwa and Arang taluks, marginal in Abhanpur and adequate in Tilda blocks. Very high fertility rating was recorded for Mn and Cu, adequate to very high for Fe. The overall fertility rating for micronutrients in the soils of Raipur district revealed marginal Zn, high Fe and very high for Cu and Mn status. As far as available micronutrients are concerned, 80 % samples showed moderate level of Zn followed by 18 % deficient and 2% in high status. In case of

available Cu, Fe and Mn, 100 % samples were under high level. Similar results were reported by Dixit (2014) and Singh *et al.* (2014).

From the results, it may be concluded that the soils were neutral to moderately alkaline in reaction and non-saline in nature. The soils were low in available N and P and medium to high in available K. In general, soils of Raipur district were sufficient in available Zn, Cu, Fe and Mn but Dharsinwa and Arang block showed Zn deficiency. This information can be useful in developing management practices for the cultivated soils of Raipur district.

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