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Original Research Article

Assessing the Status of Available Micro, Secondary and Pollutant Elements in soil of Dumka District, Jharkhand, India

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A B S T R A C T

The current study was carried out to assess the status of available micro, secondary and pollutant elements in soil of Dumka district, Jharkhand. Total 251 geo-referenced surface (0.00-15.0 cm) soil samples were collected from different blocks of Dumka district using GPS. Soils were strongly acidic to neutral in reaction (pH 4.04-7.50) with electrical conductivity ranging from 0.03 to 0.80 dS m^{-1} and organic carbon content varied from low (2.0 g kg^{-1}) to high (10.0 g kg^{-1}) with overall mean value 6.0 g kg^{-1}. DTPA extractable cationic Zn Cu, Fe and Mn content were well sufficient except available Zn was slightly deficient (0.40 %) in all analyzed soil samples. Boron content among 251 soil samples varied from low (0.09 mg ka^{-1}) to medium (0.98 mg ka^{-1}) with 64.54 % soils was deficient. Pb, Ni and Co contents in soil of Dumka district varied from 0.14 to 5.46, 0.84 to 5.60 and 1.40 to 5.92 mg kg^{-1}, respectively. A wide variation of S content (1.01 to 31.00 mg kg^{-1}) was observed in soil of Dumka district with mean value 9.05 mg kg^{-1}. On the basis of <10 mg kg^{-1} critical limit of S in soil 64.54% soils were found deficient in S. Available Zn, Fe, Mn Pb, Ni and Co were negatively correlated with pH whereas S showed significantly positive correlation. Available Zn, Cu, Fe, Mn, B, Pb, Ni and Co were positive correlated with OC. Available Co was positive correlation with Fe and Mn content in soil. Hence, deficiencies of B and S are most common in Dumka district soils. Straitening involving the soil/foliar application of B and S or use of organic manures can be adopted to sustain an optimum yield potential and enhanced their content in soil.

Keywords

Fertility status, micro, secondary and pollutant elements, soil

Introduction

Fertility status of soil that are of relevance in the present day context of keeping pace with the productivity-driven production goal of the country's agricultural sector. The role of balanced plant nutrition is well established to attain the target of productivity-driven production goal. Therefore, the appropriate management of plant nutrients is largely governed by their status in soil. The present study is going to quality status in soil of Dumka district of Jharkhand.

Dumka is one of the oldest districts of Jharkhand state under Santhal Parganas. This homeland of tribals is full of stunning landscapes, majestic mountains, verdant valleys and serpentine rivers. The district of Dumka enjoys the status of sub-capital of Jharkhand since 2000. It is located at the Central and Northeastern plateau zone of Jharkhand at N24^{0}02.983' - N 24^{0}35.881' latitude and E87^{0}00.897' - E87^{0}31.871' longitude with an altitude ranging from 74

to 211 m above the sea level. It is bounded by Godda and Banka district in the north, Pakur in the east, West Bengal in the south and Jamtara and Deoghar in the west Total geographical area of the district is 4410 sq. km. and population of 17,54,571 persons (Census of India, 2001). The district comprises one subdivision namely Dumka and there are 10 blocks *viz*., Dumka, Gopikander, Jama, Jarmundi, Kathikund, Maslia, Ramgarh, Raneshwar, Shikaripara and Saraiyahat. It has an agriculture based economy. Agriculture is characterized by mono cropping. The district has a total cultivated area of 1,97,124 ha. Net sown area is 1,28,126 ha. and only 11,532 ha. is irrigated (*i.e*., 15% of the net cropped area). The average rainfall varies from 1300 to 1400 mm. The district experiences a prolonged dry period during January to May which keeps the soil dry for more than 90 days. Present fertility status of the cultivable soil are exploitive due to nutrients through intensive tillage, mono-cropping year after year, use of high yielding varieties, imbalance use of nutrients coupled with limited use of organic manures, less recycling and burning of crop residues, soil erosion, undulation topography and indiscriminate use of irrigation water. Therefore, present investigation was undertaken to delineate that status of micro (Zn, Cu, Fe, Mn and B), secondary (S) and pollutant elements (Pb, Ni and Co) in Dumka district of Jharkhand.

Materials and Methods

Surface (0.00-15.0 cm) soils used for the study were collected from Dumka district at block level (ten blocks). Altogether a total of 251 geo-referenced [(varied from N24^{0}02.983' to N24^{0}35.881' latitude and E87^{0}00.897' to E87^{0}31.871' longitude with an altitude ranging from 74 to 211 m above the sea level (Table 1)] soil samples were collected from farmer's field randomly of these blocks. Soil samples were air-dried, ground in wooden pestle and mortar. These ground soil samples were passed through 2.0 mm sieve and stored in properly labeled plastic bags for analysis. Processed soil samples were analyzed for pH, electrical conductivity (EC) by employing the method (1: 2.5:: soil: water) as outline by Jackson (1973), organic carbon (potassium dichromate and sulfuric acid method) by Walkley and Black (1934). The DTPA-extractable Zn, Cu, Fe, Mn, Pb, Ni and Co was extracted with di-ethelene tri-amine penta-acetic acid (DTPA) solution (Lindsay and Norvell, 1978). 0.1M salicylic acid solution boron of soils was estimated as per method outlined by Datta *et al.,* (1998) using Azomethine-H through UV-spectrophotometer at 420 nm. Sulphur was analyzed by employing the method (0.15 % $CaCl_2$) of Willium and Steinberg (1954). Descriptive statistical and simple correlation coefficients were analyzed with the help of statistical software (XLSTAT-2015).

Results and Discussion

pH, EC and OC content in soil

The pH of the surface soils of Dumka district were varied from strongly acidic (4.04) to neutral (7.50) with the mean value of 5.34 pH (Table 2). The mean value of pH clearly indicated that soil reaction in all ten block of Dumka district was acidic in nature having <6.0 pH. Only 17.13% collected soil samples were found pH >6.0 and rest 82.87% soils having pH <6.0. Among all collected soil, 25.50% soil were found strongly acidic (pH< 5.0) and 33.47% soil found in between pH range 5.0-5.5 (Table 7). The EC of soils in different blocks did not show wide variation (Table 2). Mean lower EC 0.10 dS m^{-1} was found in soil of Dumka block, while higher 0.18 dS m^{-1} was

found in soil of Kathikund block of Dumka district. Organic carbon status (Table 2) in cultivated soil of different block were found in medium fertility range and its lower mean value was found 5.2 g kg^{-1} in soil of Shikaripara block, while higher mean value of OC status 6.5 g kg^{-1} was found in soil of Ramgarh block of Dumka district. Organic carbon status in collected soil samples from cultivated farmers field showed satisfactory result with 53.39, 35.06 and 11.55 per cent soil having organic carbon status >7.5, 5.0-7.5 and <5.0 g kg^{-1}, respectively (Table 7). Though the earlier study also reported that the pH varies from extremely acidic to moderately alkaline (pH 3.9-7.9) (soil survey staff, 1997) and organic carbon varied from low to medium (2.90-6.32 g kg^{-1}) in some soils of Plateau region of Jharkhand (Kumar *et al.*, 2001).

DTPA extractable cationic micronutrients and B content in soil

Zinc content in collected 251 soil samples were varied from 0.48 mg kg^{-1} to 7.00 mg kg^{-1} with its mean value 1.97 mg kg^{-1} (Table 3). A narrow variation was observed in mean value of collected soil samples among different blocks of Dumka district. The lower mean value of Zn was1.64 mg kg^{-1} whereas higher mean value of Zn was 2.50 mg kg^{-1}, respectively in soils of Dumka and Masalia block of Dumka district. Very interesting result was found in respect of Zn availability in acidic soil, results indicated that emerging deficiency of Zn has been started especially in low land paddy soil of Dumka district. The increase in DTPA-Zn with decrease in soil pH was substantiated by the overall negative correlation obtained between DTPA-Zn and soil pH (Table 6) which is also supported by finding of several workers (Dhane and Shukla, 1995; Nayak *et al.*, 2000; Sood *et al.*, 2009; Sidhu *et al.*, 2010).

Similar trend also was observed in Cu, Fe and Mn content in soil of different block (Table 3 and 4). The mean Cu content in soil of Saraiyahat was found lower (2.01 mg kg^{-1}) and higher observed in soils of Gopikandar block (5.55 mg kg^{-1}). Such variations in Cu status of acid soil of Jharkhand plateau have also been reported by Kumar *et al.*, 2001. Considering 0.2 mg ka^{-1} as critical limit for Cu in soils (Lindsay and Norvell, 1978), measured all soil samples were sufficient content of available Cu (Fig. 1). Available Cu was positive correlated with OC and Zn (Table 6) which is in conformity with the finding of kumar *et al.*, 2001 and Chartterjee and Khan, 1997.

Among all ten blocks, lower mean Fe content in soil of Gopikandar block was observed 49.88 mg kg^{-1} and higher 62.29 mg kg^{-1} was found in soils of Jarmundi block. The Mean Mn content also varied from 19.76 to 47.99 mg kg^{-1} respectively in soils of Kathikund and Saraiyahat block of Dumka district. Higher content of available Fe and Mn may probably be due to presence of mangniferrous concentrations in the soil (Rashmi Baruah *et al.*, 2014 and Sing *et al.*, 2011). Considering 4.5 mg ka^{-1} as critical limit for Fe and 2.0 mg kg^{-1} for Mn in soils (Lindsay and Norvell, 1978), measured all soil samples were well sufficient content of available Fe and Mn (Fig. 1). Sakal *et al.*, 1996 also reported higher content of available Fe and Mn in the soils of plateau region of Jharkhand. The increase in DTPA-Fe/Mn was observed with decrease in soil pH, while increase in soil OC.

This is substantiated by the overall negative correlation of DTPA-Fe/Mn with soil pH and positive correlation obtained between DTPA-Fe/Mn and OC (Table 6) which is in conformity with the finding of Bhuyan *et al.*, 2014, Nazif *et al.*, 2006, Sharma *et al.*, 2003 and Dhan and Shukla, 1995.

Table.1 GPS range of collected samples in Dumka district, Jharkhand

Name of block	No. of Soil samples	GPS range		
		Latitude	Longitude	Altitude (Meter)
Jama	27	N $24^0$18.818' – N $24^0$23.017'	E $87^0$05.757' – E $87^0$13.107'	121 – 174
Jarmundi	37	N $24^0$23.301' – N $24^0$28.276'	E $87^0$02.277' – E $87^0$03.991'	176 – 211
Saraiyahat	22	N $24^0$29.191' – N $24^0$32.493'	E $87^0$00.897' – E $87^0$01.623'	183 – 206
Ramgarh	15	N $24^0$34.476' – N $24^0$35.881'	E $87^0$05.229' – E $87^0$07.839'	171 – 199
Dumka	22	N $24^0$10.357' – N $24^0$13.605'	E $87^0$15.947' – E $87^0$18.004'	125 – 143
Shikaripara	28	N $24^0$03.911' – N $24^0$14.197'	E $87^0$18.386' – E $87^0$22.514'	88 – 156
Ranishwar	29	N $24^0$02.983' – N $24^0$06.144'	E $87^0$22.930' – E $87^0$25.428'	74 – 102
Kathikund	13	N $24^0$21.018' – N $24^0$22.753'	E $87^0$23.148' – E $87^0$28.226'	141 – 173
Gopikandar	28	N $24^0$14.604' – N $24^0$29.316'	E $87^0$11.590' – E $87^0$31.871'	102 – 178
Masalia	30	N $24^0$06.050' – N $24^0$10.225'	E $87^0$09.664' – E $87^0$11.273'	135 – 175
Overall	251	N $24^0$02.983' – N $24^0$35.881'	E $87^0$00.897' – E $87^0$31.871'	74 – 211

Table.2 pH, EC and OC content in soil of Dumka district, Jharkhand

Name of block	No. of soil samples	pH		EC (dS m^{-1})		OC (g kg^{-1})	
		Range	Mean *	Range	Mean *	Range	Mean *
Jama	27	4.33-6.40	5.05±0.49	0.03-0.26	0.11±0.06	2.6 – 9.5	6.0±1.8
Jarmundi	37	4.30-6.54	5.31±0.46	0.05-0.42	0.16±0.09	2.3 – 9.9	6.4±2.0
Saraiyahat	22	4.64-6.71	5.52±0.65	0.06-0.46	0.17±0.10	2.6 – 9.5	5.8±2.1
Ramgarh	15	4.49-6.25	5.12±0.52	0.03-0.36	0.14±0.10	3.3 – 9.9	6.5±2.1
Dumka	22	4.56-6.86	5.12±0.50	0.03-0.31	0.10±0.06	2.1 – 8.0	5.9±1.9
Shikaripara	28	4.04-7.02	5.47±0.68	0.06-0.49	0.17±0.10	2.1 – 9.9	5.2±2.1
Ranishwar	29	5.19-7.50	5.80±0.54	0.05-0.28	0.13±0.05	2.2 – 9.7	6.1±2.4
Kathikund	13	5.30-6.77	5.99±0.49	0.03-0.80	0.18±0.21	2.6 – 8.8	6.1±1.9
Gopikandar	28	4.82-7.43	5.73±0.58	0.04-0.37	0.16±0.09	2.5–10.0	5.9±2.2
Masalia	30	4.29-6.09	5.21±0.50	0.05-0.32	0.14±0.07	2.0 –10.0	6.2±2.4
Overall	**251**	**4.04-7.50**	**5.43±0.54**	**0.03-0.80**	**0.15±0.09**	**2.0– 10.0**	**6.0±2.0**
Where, *Mean value and ± Standard division							

Table.3 Zinc, copper and iron content (mg kg^{-1}) in soil of Dumka district, Jharkhand

Name of block	No. of Soil samples	Zn		Cu		Fe	
		Range	Mean	Range	Mean	Range	Mean
Jama	27	0.94-5.70	2.09±1.03*	0.62-4.58	2.06±1.06	33.2-100.2	59.50±19.56
Jarmundi	37	0.78-5.20	1.92±1.93	0.68-11.7	2.66±1.87	25.4-98.2	62.29±20.82
Saraiyahat	22	1.20-7.00	2.37±1.49	0.90-3.80	2.01±0.99	15.4-90.8	51.96±18.33
Ramgarh	15	0.92-3.90	1.86±0.87	0.50-3.12	1.86±0.85	33.6-85.4	59.48±15.91
Dumka	22	0.48-3.66	1.64±0.79	0.38-3.40	2.13±1.11	19.9-92.0	52.93±23.37
Shikaripara	28	0.92-5.06	1.75±0.86	0.58-3.68	2.05±0.95	20.8-89.4	51.37±19.06
Ranishwar	29	0.66-3.72	1.84±0.74	0.32-5.48	2.85±1.16	33.6-77.8	55.54±12.70
Kathikund	13	0.72-4.04	1.85±0.92	1.50-11.2	3.85±2.79	38.0-68.6	51.61±9.49
Gopikandar	28	0.70-5.90	1.93±0.99	1.12-10.5	5.55±2.24	17.7-78.8	49.88±16.21
Masalia	30	1.16-5.50	2.50±1.24	0.84-5.30	3.10±1.22	20.6-95.4	52.94±16.57
Overall	**251**	**0.48-7.00**	**1.97±1.08**	**0.32-11.7**	**2.81±1.42**	**15.38-100.2**	**54.75±17.20**
Where, *Mean value and ± Standard division							

Table.4 Manganese, boron and sulphur content (mg kg^{-1}) in soil of Dumka district, Jharkhand

Name of block	No. of soil samples	Mn		B		S	
		Range	Mean	Range	Mean	Range	Mean
Jama	27	22.8-62.6	45.4±10.8*	0.11-0.63	0.40±0.11	1.01-22.6	6.66±4.51*
Jarmundi	37	24.8-56.8	46.5±7.44	0.18-0.86	0.44±0.14	1.34-16.6	7.00±3.27
Saraiyahat	22	38.8-60.4	48.0±5.95	0.15-0.70	0.35±0.12	4.28-29.0	9.90±5.06
Ramgarh	15	22.4-59.0	41.4±9.73	0.22-0.66	0.37±0.12	1.02-10.5	4.39±3.76
Dumka	22	9.94-54.2	26.2±14.2	0.15-0.94	0.33±0.22	2.10-26.4	6.37±4.47
Shikaripara	28	7.78-34.8	21.1±6.83	0.09-0.94	0.37±0.17	7.16-21.1	13.1±3.28
Ranishwar	29	9.54-49.6	23.1±10.1	0.37-0.94	0.64±0.18	8.39-17.7	11.0±2.20
Kathikund	13	7.12-35.2	19.8±7.67	0.27-0.68	0.40±0.12	8.70-2.67	14.0±6.80
Gopikandar	28	11.9-51.0	28.5±8.82	0.24-0.85	0.50±0.17	5.71-14.0	8.20±2.13
Masalia	30	5.16-54.6	21.5±10.6	0.31-0.98	0.71±0.21	4.31-24.2	9.60±4.45
Overall	**251**	**5.16 - 62.6**	**32.2±9.22**	**0.09-0.98**	**0.45±0.15**	**1.01-31.0**	**9.05±3.99**
Where, *Mean value and ± Standard division							

Table.5 Heavy metals content (mg kg^{-1}) in soil of Dumka district, Jharkhand

Name of block	No. of soil samples	Pb		Ni		Co	
		Range	Mean	Range	Mean	Range	Mean
Jama	27	0.20 - 4.82	1.71±1.12*	0.84 – 5.60	1.85±1.23	1.78 – 5.92	3.04±0.88
Jarmundi	37	0.32 – 2.96	1.22±0.61	0.84 – 4.74	1.65±1.12	2.44 – 4.94	3.70±0.64
Saraiyahat	22	0.32 – 2.38	1.46±0.57	0.84 – 4.28	1.51±1.02	2.20 – 4.68	3.51±0.16
Ramgarh	15	0.80 – 3.98	1.96±1.06	0.84 – 4.02	1.45±0.94	1.68 – 4.00	2.75±0.36
Dumka	22	0.82 – 4.18	2.51±1.05	0.84 – 2.08	1.10±0.39	1.40 – 4.30	2.45±0.31
Shikaripara	28	0.14 – 3.56	1.65±0.82	0.84 – 3.14	1.47±0.65	1.56 – 3.70	2.25±0.28
Ranishwar	29	0.34 – 3.60	2.12±0.91	0.84 – 3.08	1.22±0.66	1.82 – 4.48	2.48±0.26
Kathikund	13	0.64 – 3.10	1.97±0.70	0.84 – 2.38	1.00±0.44	1.98 – 2.74	2.41±0.25
Gopikandar	28	0.22 – 3.24	1.26±0.89	0.84 – 3.40	1.12±0.58	2.18 – 3.84	2.88±0.24
Masalia	30	0.34 – 5.46	1.77±1.27	0.84 – 3.38	1.22±0.65	1.72 – 3.98	2.51±0.23
Overall	**251**	**0.14 – 5.46**	**1.76±0.9**	**0.84 – 5.60**	**1.35±0.76**	**1.40 – 5.92**	**2.79±0.36**
Where, *Mean value and ± Standard division							

Table.6 Pearson's Correlation matrix

Variables	pH	EC	OC	Zn	Cu	Fe	Mn	B	Pb	Ni	Co
pH											
EC	0.537										
OC	-0.175	-0.102									
Zn	-0.148	0.245	0.178								
Cu	0.618	0.272	0.080	0.003							
Fe	-0.531	-0.239	0.623	-0.057	-0.463						
Mn	-0.462	0.027	0.323	0.271	-0.392	**0.644***					
B	0.193	-0.049	0.302	0.430	0.386	-0.065	-0.410				
Pb	-0.128	-0.626	0.037	-0.404	-0.339	-0.097	-0.446	-0.053			
Ni	-0.561	-0.065	0.007	0.231	-0.572	**0.683***	**0.780***	-0.269	-0.436		
Co	-0.195	0.255	0.352	0.371	-0.092	0.500	**0.884***	-0.201	**-0.666***	0.603	
S	**0.767***	0.531	-0.493	0.014	0.234	-0.594	-0.618	0.182	-0.015	-0.386	-0.431

**significance at ≤0.05*

Table.7 Soil fertility status in Dumka district

Parameters	Rating	No. of soil sample	%
pH	<5.0	64	25.50
	5.0-5.5	84	33.37
	5.5-6.0	60	23.90
	>6.0	43	17.13
OC	<5.0	29	11.55
	5.0-7.5	88	35.06
	>7.5	134	53.39
Zn	<0.5	1	0.40
	0.5-1.0	18	7.17
	>1.0	232	92.43
Cu	<0.2	0	0
	0.2-0.5	3	1.20
	>0.5	248	98.80
Fe	<4.5	0	0
	4.5-10.0	0	0
	>10.0	251	100
Mn	<2.0		
	2.0-5.0		
	>5.0	251	100
B	<0.5	162	64.54
	0.5-1.0	89	35.46
	>1.0		
S	<10.0	162	64.54
	10.0-20.0	83	33.07
	>20.0	6	2.39

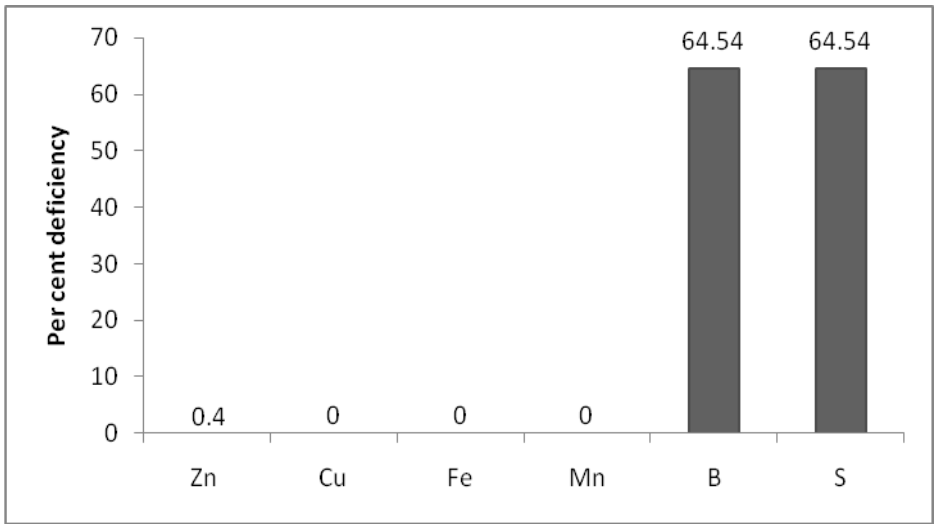

Fig.1 Per cent deficiency of DTPA-Zn, Cu, Fe, Mn; boron and Sulphur in Dumka district

Boron content in soil of whole district was found at critical stage, mean value of B content indicated that the all blocks were found below the critical limit (<0.50 mg kg^{-1}) except Masalia block, where soil mean value of B was observed 0.71 mg kg^{-1} (Table 4). Considering the critical limit for B as 0.5 mg kg^{-1}, 64.54% soil samples were found to be deficient in Dumka district (Fig. 1). However, strongly acid soils also tend to be low in available B because of B sorption to iron and aluminum oxide surfaces of soil minerals. The SA-extractable B content increased with increase in organic carbon content of soil which is substantiated by an overall positive correlation of B with OC content of the soils of Dumka district (Table 6). The finding is in line with the finding of Naiz *et al.,* 2007, Mandol *et al.,* 2007, Bhuyan *et al.,* 2014 and Chaudhary *et al.,* 2003

A wide variation of S content (1.01 to 31.00 mg kg^{-1}) was observed in soil of Dumka district with mean value 9.05 mg kg^{-1} (Table 4). Among ten blocks of the district mean S content in soil were found 4.39 mg kg^{-1} in Ramgarh block and higher mean content 14.00 mg kg^{-1} S was observed in Kathikund block (Table 12). On the basis of <10 mg kg^{-1} critical limit of S in soil 64.54% soils were found deficient in S (Fig. 1) and 33.07% soils having 10 to 20.0 mg kg^{-1} S availability. In analyzed 251 soil samples only 2.39% soils were found having >20 mg kg^{-1} S content in soil (Table 7).

Heavy metal content in soil

Pb, Ni and Co contents in soil of Dumka district varied from 0.14 to 5.46, 0.84 to 5.60 and 1.40 to 5.92 mg kg^{-1} with mean values *viz*., 1.76, 1.35 and 2.79 mg kg^{-1} respectively (Table 5). The cadmium content was not detected in Atomic Absorption Spectrophotometer. The lower mean content of Pb, Ni and Co in soil were respectively found in soil of Jarmundi (1.22 mg kg^{-1}), Kathikund (1.00 mg kg^{-1}) and Shikaripara (2.25 mg kg^{-1}) block of Dumka district (Table 5). While respectively higher content was observed 2.51, 1.85 and 2.88 mg kg^{-1}in Dumka, Jama and Gopikandar blocks of the district. Available Co was positive correlation with Fe Mn content of soil but negatively correlated with soil pH (table 6). Similar report was observed by Azad *et al.,* 1986.

Deficiencies of B and S are most common in Dumka district soils. Zinc deficiency is also emerging in low scale, and may cause decline in crop yields and total productivity in feature. Soil factor such as pH and organic Carbon were the main factors contributing to the variability and availability of B and S. Straitening involving the soil/foliar application of B and S or use of organic manures can be adopted to sustain an optimum yield potential and enhanced their content in soil.

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