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Assessing the Status of Available Micro, Secondary and Pollutant Elements in Soil of Khunti District, Jharkhand, India

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ABSTRACT

The current study was carried out to assess the status of available micro, secondary and pollutant elements in soil of Khunti district, Jharkhand (subzone IV of VIIth ACZ, India). Total 257 geo-referenced surface (0.0-15.0 cm) soil samples were collected from six blocks of the district (Lat. 22^{0}48'52.4" to 23^{0}26'40.7", Log. 85^{0}00'08.9" to 85^{0}37'32.6" and Alt. 234 to 694 msl). Soils were strongly acidic to neutral in reaction (pH 4.32-7.58) with low electrical conductivity (0.04 to 0.29 dS m^{-1}) and organic carbon content varied from low (1.48 g kg^{-1}) to high (15.12 g kg^{-1}) status with mean value 7.28 g kg^{-1}. DTPA extractable cationic micronutrients *i.e.*, Zn Cu, Fe and Mn content were well sufficient except available Zn that was deficient in 21.40 % soil samples of the district and reflected initiation of emerging deficiency in red and lateritic soils. Deficiency of Boron has reached at alarming stage and 66.93 % soils suffering from B deficiency. Content of Pb, Ni and Co in soil of Khunti district were found in the range of 0.08 to 3.84, 0.02 to 6.50 and 0.02 to 5.12 mg kg^{-1}, respectively. A wide variation of S content (1.45 to 66.36 mg kg^{-1}) in soil was observed with mean value 10.72 mg kg^{-1}. On the other hand 63.04% soils were found deficient in S. Hence, deficiencies of B and S are most common in Khunti district soils. Therefore, for successful and profitable crop production maintaining soil and plant health immediate need to give more attention to supply B and S fertilizers at village level and create awareness to use these fertilizers in judicious and scientific way among the farmers. In organic matter concern farmers of the tribal dominated Khunti district should be encouraged to apply organic matters along with the balance use of fertilizers for optimum yield potential.

Key Words: Soil Health; Lateritic Soil; Trace Elements; Secondary Elements, Pollutants

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 production goal and consequently supplement of nutrition in animal and human being. Appropriate management of plant nutrients is largely governed the fertility status of soil and its translocation in plant. To consider these aspects a detail study of micro, secondary and polluted elements were under taken in a Khunti district, Jharkhand which is a representative location of subzone IV of VIIth ACZ, India (Figure 1). It is a small district in the state having only six blocks and is the second least populated district (531,885 people) in Jharkhand state. This district has the highest populations of tribal farmers and more than 90% residing in rural areas. The total geographical area of the district is 7,59,250 hectares, while net shown area is only 2,76,091 hectors. The forest coverage (>40% canopy) in the district is about 18% of TGA having hilly and forest terrains. Economy and livelihood of the tribal farmers mainly depends upon rain-fed agriculture and trading of forestry products. The average annual rainfall varies from 1050 mm to 1500 mm and district experiences a prolonged dry period during January to May which keeps the soil dry for more than 90 days.

Agriculture is characterized by mono cropping practices with only the net irrigated area is 36,620 hectares, which is about 14% of the net cultivated area. Paddy based primary cropping system is in practice in the district while vegetables, mustard and pulses also in cultivation practice as secondary crop as per availability of water resources in the district.

Fertility status of the district mainly affected by severe soil erosion in undulating topography and whole the district as per variation in topography, slope and cultivation pattern mainly divided in up, medium, low and badi land (around household of the farmers). All these situation having its own merit and constraints particularly related to soil fertility and adoption of cropping system. These situations is very much peculiar and found at the pedon level in plateau area of Chotanagpur, Jharkhand and make cultivation difficult particularly for resource poor tribal farmers. Fertility of the soil in the district consequently also affected due to low organic matter in tropical climate, use of HYV/ Hybrid rice cultivars, imbalance use of nutrients, indiscriminate use of irrigation water, natural sink of effluents and dump of waste materials particularly in industries and mining areas of the district. So, regular monitoring of soil fertility status as per topographical variation in the district is mandatory and therefore, GPS based delineation programme to assessing the status of available micro, secondary and pollutant elements in soil of Khunti district, Jharkhand was planned.

MATERIALS AND METHODS

GPS based 257 surface (0.0-15.0 cm) soils from farmers' cultivated farmers field were collected from six blocks of Khunti (Lat. 22^0 48' 52.4" to 23^0 26' 40.7", Long. 85^0 00' 08.9" to 85^0 37' 32.6" and Altitude 234 to 694 m) district during December 2015 to February 2016 under the delineation programme of "All India Coordinated Research Project on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (ICAR)", Ranchi Centre. Soil samples were categorized in four groups as per the land situation and on the basis of utilization pattern *viz*., low, medium, up and badi land (near the house hold of farmers) (Table 1). Soil samples were air-dried, ground in wooden pestle and mortar and passed through 2.0 mm sieve, 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 Williams and Steinbergs (1954). Descriptive statistical and simple correlation coefficients were analyzed with the help of statistical software (Microsoft XL 2007).

RESULTS AND DISCUSSION

pH, EC and OC content in soil

The pH of the surface soils of Khunti district varied from strongly acidic (4.32) to neutral (7.58) in reaction

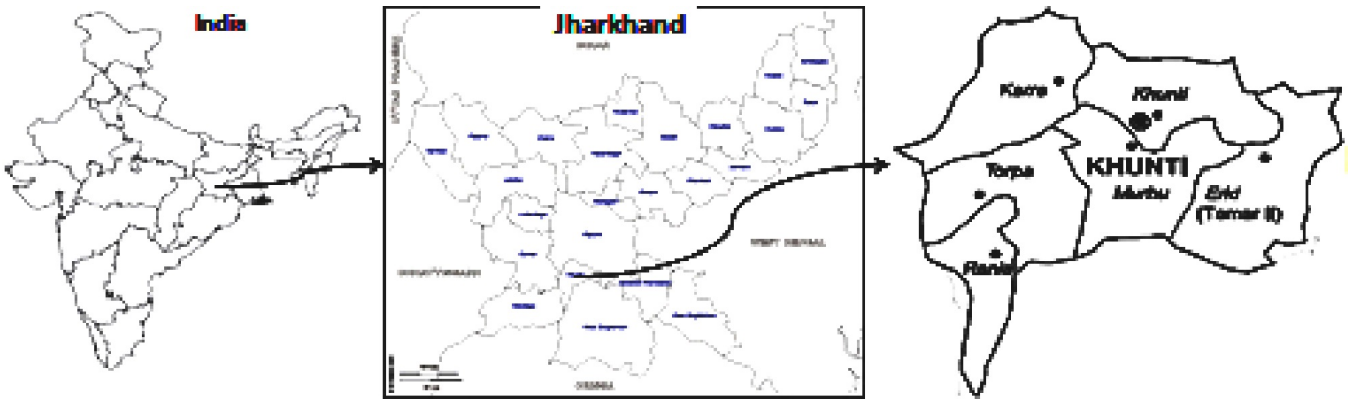

Figure 1. Location map of Khunti district

Table 1. Blockwise GPS based collection of soil samples as per land situation in Khunti district of Jharkhand

Block	No. of soil samples	Land situation				GPS reading		
		Upland	Medium Land	Lowland	Badi land	Latitude	Longitude	Altitude (m)
Khunti	16	4	5	5	2	N 23 02 51.1 to N 23 26 40.7	E 85 16 37.4 to E 85 18 52.5	573-617
Karra	24	8	8	4	4	N 23 07 52.4 to N 23 15 09.7	E 85 07 35.6 to E 85 13 28.0	642-694
Arki	55	15	21	9	10	N 23 00 00.1 to N 23 03 36.4	E 85 32 23.1 to E 85 37 32.6	234-308
Rania	41	12	15	8	6	N 22 48 52.4 to N 22 50 26.6	E 85 01 30.6 to E 85 05 05.1	393-505
Murhu	57	15	18	16	8	N 22 53 25.1 to N 23 04 27.2	E 85 12 28.2 to E 85 20 07.4	567-631
Torpa	64	19	20	18	7	N 22 52 06.4 to N 23 00 31.9	E 85 00 08.9 to E 85 29 52.5	492-553
Overall	257	73	87	60	37	N 22 48 52.4 to N 23 26 40.7	E 85 00 08.9 to E 85 37 32.6	234-694

Table 2. Variation of soil reaction, electrical conductivity and organic carbon content in soil as per land situation in Khunti district of Jharkhand.

Land Situation	No. of soil sample	pH		EC (dS m^{-1})		OC (g kg^{-1})	
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Up land	73	4.32 - 6.65	5.41±0.50	0.04 - 0.26	0.09±0.038	1.48 - 8.16	5.04±1.74
Medium Land	87	4.49 - 6.35	5.42±0.51	0.05 - 0.19	0.09±0.056	2.60 - 9.76	6.99±1.73
Low Land	60	4.67 - 7.08	5.42±0.40	0.05 - 0.29	0.12±0.025	3.84 -12.68	7.42±2.43
Badi Land	37	4.77 - 7.58	5.70±0.73	0.07 - 0.27	0.13±0.051	4.24 - 15.12	9.67±2.03
Overall	257	4.32 - 7.58	5.49±0.54	0.04 - 0.29	0.11±0.043	1.48 - 15.12	7.28±1.98

with the mean value of 5.49 pH (Table 2). The soil reaction (pH) was found in increasing order with decreasing slope of undulating topography (upland to low land), while in badi land higher pH value was observed due to receiving various types of the house hold materials. Soil acidity adversely affected the soil fertility in the district and showed < 6.0 pH in 86.00 % soil samples (Table 6), very few samples (14.00%) fall in the neutral range (6.0 to > 7.0 pH). The EC of soils in different lands situation did not show wide variation (Table 2). Mean lower EC 0.09 dS m^{-1} was found in soil of up and medium land, while higher 0.13 dS m^{-1} was found in soil of low land situation of Khunti district. Organic carbon status (Table 2) in cultivated soil of different lands situation were varied from very low (1.48 g kg^{-1}) to high (15.12 g kg^{-1}) with the mean value of 7.28 g kg^{-1} (Table 2). The lower mean value was found 5.04 g kg^{-1} in soil of upland, while higher mean value of OC 9.67 g kg^{-1} was observed in soil of badi land of Khunti district. Organic carbon content in soil was observed 19.46, 43.58 and 36.96 per cent, respectively in low (<5.0 g kg^{-1}), medium (5.0-7.5 g kg^{-1}) and high (>7.5 g kg^{-1}) status, (Table 6). Almost similar results in respect to soil reaction and organic carbon content in soil of Jharkhand also reported by Agarwal et al. (2013), Agarwal et al. (2007), Kumar et al. (2001) and by Bhuyan et al. (2014) in Assam.

DTPA-Extractable Cationic Micronutrients and B and Sulfur Content in Soil

Zinc content was found in the range of 0.06 to 4.74 mg kg^{-1} with its mean value 0.96 mg kg^{-1} (Table 3). A narrow variation was observed in Zn content as per variation in land situation of the district. In upland soil Zn content was found 0.78 mg kg^{-1}, while comparatively higher content 1.54 mg kg^{-1} observed in soil near the house hold of the farmers (badi land). Considering the Zn distribution as per topographical situation in the district, reflected that in paddy land/ low land situation emerging deficiency of Zn has been started under red and lateritic soil condition and need proper attention (Table 6).

Table 3. Variation of zinc, copper and Iron content (mg kg^{-1}) in soil as per land situation in Khunti district of Jharkhand.

Land Situation	No. of soil sample	Zn		Cu		Fe	
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Up land	73	0.06 - 3.22	0.78±0.51	0.74 - 3.56	1.85±0.75	39.27 – 107.1	70.50±18.01
Medium Land	87	0.12 - 2.82	0.76±0.45	0.04 - 3.66	1.61±0.80	29.20 - 92.0	62.39±14.31
Low Land	60	0.08 - 1.98	0.77±0.35	0.02 - 4.62	1.88±0.91	46.80 - 100.0	72.84±11.21
Badi Land	37	0.28 - 4.74	1.54±1.01	0.08 - 2.48	1.17±0.72	22.80 - 93.80	50.38±17.44
Overall	257	0.06 - 4.74	0.96±0.58	0.02 - 4.62	1.63±0.79	22.80 - 100.0	64.03±15.24

Copper content in soils was varied from 0.02 to 4.62 mg kg^{-1} with its mean value 1.63 mg kg^{-1} (Table 3). A narrow variation was observed in Cu content among different land situation. The mean Cu content in soil of badi land was found lower (1.17 mg kg^{-1}) and higher observed in soils of low land (1.88 mg kg^{-1}) situation. Such variations in Cu status of acid soil of Jharkhand plateau have also been reported by Kumar et al. 2001. Considering 0.2 mg kg^{-1} as critical limit for Cu in soils (Lindsay and Norvell 1978), moreover 96.89% soil samples were found sufficient in available Cu (Table 6) in the district.

Iron and Mn content variation in soil also followed similar trend to Cu variation in soil of Khunti district. Among all the four lands situation, lower Fe (50.88 mg kg^{-1}) and Mn (29.50 mg kg^{-1}) content in soil of badi land was observed, while higher 72.84 and 44.97 mg kg^{-1} was noticed in soils of lowland (Tables 3 and 4). Higher content of available Fe and Mn may probably be due to presence of mangniferrous concentrations in the soil (Rashmi Baruah et al. 2014, Singh et al. 2004). Considering 4.5 mg kg^{-1} as critical limit for Fe and 2.0 mg kg^{-1} for Mn in soils (Lindsay and Norvell, 1978), found all soil samples were well sufficient in available Fe and Mn (Table 6) availability. Sakal et al. 1996 also reported higher content of available Fe and Mn in the soils of plateau region of Jharkhand. Agarwal et al. 2007, Mishra et al. 2016, Bhuyan et al. 2014 also reported almost similar trend of micronutrients variation in acidic soil of Jharkhand, Odisha and Assam, respectively.

Boron deficiency in soil of Khunti district has reached at alarming stage and content of B in soil was found in the range of 0.03 to 4.90 mg kg^{-1} with average value of 0.54 mg kg^{-1} (Table 4). Considering the critical limit for B as 0.5 mg kg^{-1}, 66.93% soil samples were found to be deficient in Khunti district (Table 6). Agarwal et al. 2013 also reported that the available B content varied from 0.01 to 4.2 mg kg^{-1} and about 63.3 % areas were deficient of B in soils of Jharkhand. 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 and more leaching due to course texture soil and high precipitation.

A wide variation was observed in the S content (1.45 to 66.36 mg kg^{-1}) of the soils of Khunti district with mean value 10.72 mg kg^{-1} (Table 4). Among four levels of land situation lower mean S content in soil were found 9.00 mg kg^{-1} in upland and higher mean content 13.18 mg kg^{-1} S was observed in lowland (Table 4) topographical situation. On the basis of 10.0 mg kg^{-1} critical limit of S in soil 63.04% soils were found deficient in S and 25.29% soils felt in between 10 to 20.0 mg kg^{-1} S availability. In analyzed 257 soil samples only 2.39% soils were found having >20 mg kg^{-1} S content in soil (Table 6). Earlier Agarwal et al. 2013 observed S availability in the range of 0.30 to 80.3 mg kg^{-1} with 37.7% soil suffering from severe S deficiency in Jharkhand.

Heavy Metal Content in Soil

Content of Pb, Ni and Co in soil of Khunti district varied from 0.08 to 3.84, 0.02 to 6.50 and 0.02 to 5.12 mg kg^{-1} with its mean values 1.56, 1.84 and 1.51 mg kg^{-1} respectively (Table 5). The cadmium content was not detected in Atomic Absorption Spectrophotometer. The lower mean content of Pb and Ni respectively 1.41 mg kg^{-1} and 1.47 mg kg^{-1} found in upland situation and Co 1.36 mg kg^{-1} in lowland situation of Khunti district, while respectively higher mean content of Pb and Ni were observed 1.74 and 2.40 mg kg^{-1} in lowland and 1.62 mg kg^{-1} for Co in medium land situation of the district.

Table 4. Manganese, boron and sulfur content (mg kg^{-1}) in soil as per land situation in Khunti district of Jharkhand.

Land Situation	No. of soil sample	Mn		B		S	
		Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Up land	73	3.92 - 49.80	29.98±10.72	0.03 - 3.56	0.40±0.48	1.58 - 34.51	9.00±6.45
Medium Land	87	7.80 - 125.0	36.00±21.52	0.03 - 4.90	0.49±0.64	1.45 - 66.36	10.53±8.98
Low Land	60	9.42 - 113.6	44.97±21.78	0.25 - 2.80	0.57±0.35	1.58 - 54.09	13.18±11.1
Badi Land	37	7.80 - 60.80	29.50±12.83	0.14 - 3.52	0.71±0.75	2.18 - 36.47	10.16±6.22
Overall	257	3.92 - 125.0	35.11±16.71	0.03 - 4.90	0.54±0.56	1.45 - 66.36	10.72±8.19

Table 5. Variation of lead, nickel and cobalt content (mg kg^{-1}) in soil as per land situation in Khunti district of Jharkhand.

Land Situation	No. of soil sample	Pb		Ni		Co	
		Range	Mean±SD	Range	Mean±SD	Range	Mean
Up land	73	0.08 - 3.50	1.41±0.58	0.07 - 6.02	1.47±1.46	0.06 - 5.12	1.49±1.32
Medium Land	87	0.46 - 3.30	1.72±0.64	0.02 - 6.26	1.88±1.63	0.08 - 4.12	1.62±1.23
Low Land	60	0.58 - 3.34	1.74±0.60	0.08 - 6.50	2.40±1.68	0.02 - 4.80	1.36±1.30
Badi Land	37	0.32 - 3.84	1.37±0.69	0.07 - 5.42	1.59±1.59	0.02 - 4.60	1.58±1.28
Overall	257	0.08 - 3.84	1.56±0.63	0.02 - 6.50	1.84±1.59	0.02 - 5.12	1.51±1.28

Very merge information so far reported on heavy metal content in soil particularly in plateau area of Jharkhand that is rich in different types of mineral and in situ soil having a wide variation in elemental content.

Correlation Between Soil Characteristics Under Different Situations in Khunti District

Micro, secondary and heavy metals content in soil of Khunti district showed an interesting correlation as per land situation (Table 7, 8, 9 and 10). Zinc content in soil significantly and positively correlated with EC in up, low and badi land situation. While, pH and OC did not showed significant correlation with DTPA-Zn content in soil. Significant correlation was found between Cu and OC content (r=0.354*) in upland soil, which is in conformity with the finding reported by Kumar et al. 2011, Murthy et al. 2005 and Bhuyan et al. 2014. A strong correlation was noticed between EC (r=307*) and OC (r=298*) in low land soil situation. In Badi land soil pH, EC and OC significantly and positively correlated with Cu and respectively showed r values 0.348*, 0.548* and 0.455*. Content of Fe and Mn showed significant and negative correlation in medium and low land situation with soil pH, which is in conformity with the finding of Bhuyan et al. 2014, Murthy et al. 2005, Nazif et al. 2006, Sharma et al. 2003, Dhane and Shukla 1995. Lead content in soil was found negatively correlated to pH in medium land soil. Electrical conductivity was positively correlated with B, S, Ca, Mg in upland soil, while in similar land situation Mn and Co showed significant negative correlation. In medium land and low land situation Mg, Ca, S and B showed a strong positive correlation with EC and OC content in soil. Earlier also positive correlation of B with OC content has been reported (Niaz et al. 2007, Mondal et al. 2007, Bhuyan et al. 2014, Chaudhary and Shukla. 2003). Available Co was negative correlated with soil pH, similar to that was observed by Azad et al. (1986).

Moreover, the increase in DTPA-Zn with decrease in soil pH was showed in soils, which is also supported by finding of several workers (Dhane and Shukla 1995, Nayak et al. 2000, Sood et al. 2009, Sidhu and Sharma 2010). Available Cu was positive correlated with OC and Zn, which is in conformity with the finding of Kumar et al. 2001, Chatterjee and Khan 1997.

Table 6. Soil fertility status in Khunti district

Parameters	Rating	% samples
Soil reaction (pH)	<5.0	10.89
	5.0-5.5	52.92
	5.5-6.0	22.18
	>6.0	14.01
Organic carbon (OC) (g kg^{-1})	<5.0	19.46
	5.0-7.5	43.58
	>7.5	36.96
Zinc (Zn) (mg kg^{-1})	<0.5	21.40
	0.5-1.0	51.75
	>1.0	26.85
Copper (Cu) (mg kg^{-1})	<0.2	3.11
	0.2-0.5	6.23
	>0.5	90.66
Iron (Fe) (mg kg^{-1})	<4.5	0.0
	4.5-10.0	0.0
	>10.0	100.00
Manganese (Mn) (mg kg^{-1})	<2.0	0.0
	2.0-5.0	0.39
	>5.0	99.61
Boron (B) (mg kg^{-1})	<0.5	66.93
	5.0-1.0	25.29
	>1.0	7.78
Sulphur (S) (mg kg^{-1})	<10.0	63.04
	10.-20.0	28.40
	>20.0	8.56

CONCLUSIONS

Soils of all categorized four lands situation of Khunti district are highly deficient in available B and S. Zinc deficiency is also spread to some extent particularly in low land situation and may cause decline in crop yields and total productivity in future, when farmers will adopt double cropping on same land situation by effort of the coming 2nd Green revolution in eastern area of India. Soil pH and organic carbon content were the main factors, which contributing the variability and availability of B and S. Therefore, for profitable crop yield and sustain the soil plant health for poor resource farmers of tribal dominated Khunti district need more attention to make availability of B and S containing fertilizer at village level and to create awareness to apply fertilizer on the basis of soil test result and as per land situation in plateau area of Jharkhand, especially for high B and S responsive crops. As organic matter is quite important for supply of micronutrients, farmers of the district should be encouraged to apply organic matters along with the balance use of fertilizers.

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Table 7. Correlation coefficient (r) between physical and chemical characteristics of soil under up land situation in Khunti district of Jharkhand.

	Zn	Cu	Fe	Mn	B	S	Ca	Mg	Pb	Ni	Co
pH	0.162	0.147	-0.202	-0.062	0.512*	0.643*	0.411*	0.203	0.001	-0.034	-0.09
EC	0.308*	0.06	0.207	0.151	0.529*	0.461*	0.427*	0.094	0.045	0.142	-0.021
OC	0.238	0.354*	0.2	-0.068	0.185	0.268*	0.137	0.263*	-0.023	-0.108	-0.235*

*Significant at $p \leq 0.05$

Table 8. Correlation coefficient (r) between physical and chemical characteristics of soil under medium land situation in Khunti district of Jharkhand.

	Zn	Cu	Fe	Mn	B	S	Ca	Mg	Pb	Ni	Co
pH	-0.046	-0.035	-0.247*	0.101	0.406*	0.358*	0.231*	0.366*	-0.174	0.062	-0.196
EC	0.072	0.18	0.113	0.185	0.600*	0.689*	0.268*	0.276*	-0.145	0.088	-0.114
OC	-0.075	0.018	0.132	0.119	0.386*	0.458*	0.259*	0.039	-0.045	-0.009	-0.042

*Significant at $p \leq 0.05$

Table 9. Correlation coefficient (r) between physical and chemical characteristics of soil under Low land situation in Khunti district of Jharkhand.

	Zn	Cu	Fe	Mn	B	S	Ca	Mg	Pb	Ni	Co
pH	-0.052	0.065	-0.260*	-0.039	0.456*	0.483*	0.315*	0.385*	-0.267*	-0.007	-0.05
EC	0.416*	0.307*	0.429*	0.032	0.137	0.620*	0.289*	0.562*	-0.252	0.156	0.18
OC	0.177	0.298*	0.086	0.268*	0.291*	0.435*	0.22	0.334*	-0.117	0.177	0.106

*Significant at $p \leq 0.05$

Table 10. Correlation coefficient (r) between physical and chemical characteristics of soil under badi land situation in Khunti district of Jharkhand.

	Zn	Cu	Fe	Mn	B	S	Ca	Mg	Pb	Ni	Co
pH	0.273	0.340*	-0.167	-0.2	0.653*	0.408*	0.447*	0.237	0.034	-0.052	-0.142
EC	0.558*	0.548*	0.104	-0.114	0.281	0.192	0.376	0.242	0.12	-0.012	0.158
OC	0.315	0.455*	0.151	-0.19	0.563*	0.527*	0.497*	0.087	-0.211	0.076	0.022

*Significant at $p \leq 0.05$

assistance to this research programme. The second author is a Research Associate and third author is a Senior Research Fellow under the supervision of the first author who is Project In-charge of All India Coordinated Research Project on Micro and Secondary Nutrients & Pollutant Elements in Soils and Plants, at Ranchi Centre.

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