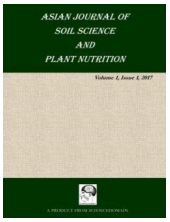

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Assessment of Soil Properties around Industries of Jharkhand

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AKJ and AKS designed the study. Author AKJ performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KC managed the analyses of the study. Authors AKJ and KC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Accumulation of trace metals and their bio-availability in soils is likely to have for reacting consequences on soil health as well as growth, yield and quality of crops. To assess the soil properties samples were collected from farmers fields around industries of Patratu, Bokaro and Jamshedpur. Analysis of soil pH, electrical conductivity and organic carbon content revealed that soils collected from Patratu were moderately acidic in soil reaction. Soil reaction in case of Bokaro and Jamshedpur ranged from acidic to neutral or alkaline. The electrical conductivity was within the safe limit, while the organic carbon content was medium to high. The soils were low in available N and P, while low to medium in available K status. Available micronutrients were above the critical value. DTPA-Cd was detected in 50 per cent soil samples of Patratu, 45 per cent of Bokaro and 80 per cent of Jamshedpur. All soil samples from Patratu and nearly 50 per cent samples of Bokaro and Jamshedpur contained high DTPA extractable Pb, Ni and Co.

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Keywords: Soil properties near industrial area of Jharkhand; chemical properties; biological properties; micronutrient content; Cd, Pb; Ni and Co content.

1. INTRODUCTION

Soil is the key component of natural ecosystems because environmental sustainability depends largely on a sustainable ecosystem. Unlike other environmental components, pollutants have long residence time in soil. Therefore, soil acts as a sink or a filter in which pollutants are accumulated rapidly and depleted slowly. The application of city and industrial waste to land has become popular during recent years as an alternative means of treatment and disposal. Besides being a useful source of plant nutrients in most cases, these materials often contain high amounts of various organic and inorganic materials as well as heavy metals [1]. Industrialization has resulted in problems in safe disposal of wastes generated, which are mostly dumped in the soil directly. This has a profound influence in areas near the industries on the quality of soil, plant as well as human and animal life. Non-degradable pollutants like heavy metals are much more problematic than others. Though several regulatory steps have been implemented to reduce or restrict the release of pollutants in soil and water, they have proved to be in-sufficient. The Jharkhand state has several coal mines. The Damodar river basin is a repository of approximately 46 per cent of the Indian coal reserves. Due to extensive coal mining and rapid growth of industries, soil and water resources have been badly contaminated. Besides mining, coal based industries like coal washeries, coke oven plant, coal fired thermal power plant, steel plants and other related industries in the region are responsible for degradation of environmental quality. Therefore, soil samples were collected around industries of Ramgarh, Bokaro and East Singhbhum districts of Jharkhand to evaluate the effect of industrial activities on soil properties.

2. MATERIALS AND METHODS

Sixty soil samples were collected around Patratu Thermal Power Station, Patratu (Ramgarh), Gobindpur and Kathara Project Central Coalfield Limited (Bokaro) and solid waste disposal site, Jamshedpur (East Singhbhum) following standard sampling methods. Description of soil samples are presented in Table 1. The pH of soils were measured in 1: 2.5 (Soil: Water) suspension with the help of glass electrode digital pH meter (ELICO LI614) [2]. The soil water suspension was prepared in 1:2.5 (Soil: Water) ratio and electrical conductivity of the filtrate of suspension was determined by conductivity bridge (ELICO CM183) [2]. Organic carbon of the soils was estimated by chromic acid wet digestion method [3]. Available nitrogen is estimated by distilling soil with alkaline potassium permanganate and determining the ammonia liberated [4]. The soil was extracted with Bray P_1 extractant (0.03N NH_4F in 0.025N HCl solution) and was determined [5] as described [2] on double beam spectrophotometer (SPECTRASCAN UV2600). Available potassium was determined by flame photometer (ELICO CL361) after extraction of soil with neutral normal ammonium acetate [6] in soil to solution ratio 1:5 (w/v). The available trace metals including Zn, Cu, Mn, Fe, Cd, Pb, Ni and Co were determined by extracting soil with Diethylene tri-amine penta-acetic acid (0.005M DTPA, 0.01M $CaCl_2$, 0.1M TEA), pH adjusted to 7.3 with the help of dilute HCl, maintaining 1:2 soil to extractant ratio and shaking for 2 hrs at 120 rpm [7]. Total bacterial, actinomycetes and fungal population in soil were determined following the standard pour plate technique using soil extract agar [8] and Kenknight and Munaires media [8] for bacteria and actinomycetes and Rose Bengal agar media [9] for fungi. Triplicate plates (for each soil and microbial group) were incubated at 30°C ± 2°C for a week. Population for each microbial group was expressed as colony forming unit (CFU) per gram.

3. RESULTS AND DISCUSSION

3.1 Soil Reaction, Electrical Conductivity and Organic Carbon

Analytical results on pH, EC and OC content in soil samples show that it ranged from 4.88 to 7.18, 0.03 to 0.54 dS m^{-1} and 3.37 to 49.46 g kg^{-1} in Patratu, 3.53 to 6.92, 0.04 to 0.51 dS m^{-1} and 6.73 to 29.27 g kg^{-1} in Bokaro while 4.75 to 8.29, 0.05 to 0.89 dS m^{-1} and 4.39 to 10.68 g kg^{-1} in Jamshedpur (Table 2). The soils collected from Patratu showed moderately acidic pH value (65 per cent). Extremely acidic to neutral soil reaction was noticed in case of Gobindpur and Kathara. Thirty per cent of the total soils were moderately acidic (pH 5.6 to 6.0) and 20 per cent were strongly acidic (pH 5.1 to 5.5) and slightly acidic (pH 6.1 to 6.5) in nature. However, a wide variation from very strongly acidic to alkaline reaction was noticed in soils collected from

Table 1. Description of soil samples

Sl. no.	Location	Topography	land use
	PTPS, Patratu (Ramgarh)		
1	0-1 km North to PTPS	Low land	Paddy-Fallow
2	0-1 km North to PTPS	Medium land	Paddy-Fallow
3	0-1 km North to PTPS	Medium land	Paddy-Fallow
4	0-1 km North to PTPS	Upland	Paddy-Fallow
5	0-1 km North to PTPS	Upland	Paddy-Fallow
6	1-2 km North to PTPS	Upland	Maize-Vegetables
7	1-2 km North to PTPS	Upland	Paddy-Fallow
8	1-2 km North to PTPS	Upland	Paddy-Fallow
9	1-2 km North to PTPS	Upland	Paddy-Fallow
10	1-2 km North to PTPS	Upland	Paddy-Fallow
11	4-5 km West to PTPS (Vill. – Labga)	Upland	Maize-Vegetables
12	4-5 km West to PTPS (Vill. – Labga)	Medium land	Maize-Mustard
13	4-5 km West to PTPS (Vill. – Labga)	Medium land	Maize-Mustard
14	4-5 km West to PTPS (Vill. – Labga)	Medium land	Maize-Mustard
15	4-5 km West to PTPS (Vill. – Labga)	Low land	Paddy-Paddy
16	2-3 km South to PTPS (Vill. –Rasada)	Upland	Maize-Mustard
17	2-3 km South to PTPS (Vill. –Rasada)	Medium land	Vegetables
18	2-3 km South to PTPS (Vill.–Rasada)	Medium land	Vegetables
19	2-3 km South to PTPS (Vill.–Rasada)	Low land	Paddy-Mustard
20	2-3 km South to PTPS (Vill.–Rasada)	Low land	Paddy-mustard
	Gobindpur and Kathara Project CCL (Bokaro)		
1	0-1 km near Gobindpur Project	Low land	Paddy-Fallow
2	0-1 km near Gobindpur Project	Low land	Paddy-Fallow
3	0-1 km near Gobindpur Project	Medium land	Paddy-Fallow
4	0-1 km near Gobindpur Project	Medium land	Paddy-Fallow
5	0-1 km near Gobindpur Project	Medium land	Paddy-Fallow
6	1-2 km near Gobindpur Project	Upland	Maize-Vegetables
7	1-2 km near Gobindpur Project	Upland	Maize-Vegetables
8	2-3 km near Gobindpur Project	Upland	Vegetables
9	2-3 km near Gobindpur Project	Upland	Vegetables
10	2-3 km near Gobindpur Project	Upland	Vegetables
11	0-1 km near Kathara Project	Low land	Paddy-Fallow
12	1-2 km near Kathara Project	Medium land	Paddy-Fallow
13	0-1 km near Kathara Project	Low land	Paddy-Fallow
14	0-1 km near Kathara Project	Medium land	Paddy-Fallow
15	1-2 km near Kathara Project	Upland	Paddy-Fallow
16	1-2 km near Kathara Project	Medium land	Paddy-Fallow
17	1-2 km near Kathara Project	Medium land	Paddy-Fallow
18	0-1 km near Kathara Project	Upland	Paddy-Fallow
19	1-2 km near Kathara Project	Upland	Paddy-Fallow
20	1-2 km near Kathara Project	Upland	Paddy-Fallow
	Waste disposal site, Jamshedpur (East Singhbhum)		
1	4-5 km from Dimna Nala	Low land	Paddy-Fallow
2	4-5 km from Dimna Nala	Low land	Paddy-Fallow
3	4-5 km from Dimna Nala	Low land	Paddy-Fallow
4	4-5 km from Dimna Nala	Low land	Paddy-Fallow
5	4-5 km from Dimna Nala	Upland	Paddy-Fallow
6	3-4 km from Dimna Nala	Medium land	Maize-Vegetables
7	3-4 km from Dimna Nala	Medium land	Paddy-Fallow
8	3-4 km from Dimna Nala	Medium land	Paddy-Fallow
9	3-4 km from Dimna Nala	Medium land	Paddy-Fallow
10	3-4 km from Dimna Nala	Medium land	Paddy-Fallow
11	2-3 km from Dimna Nala	Medium land	Maize-Vegetables

Sl. no.	Location	Topography	land use
	PTPS, Patratu (Ramgarh)		
12	2-3 km from Dimna Nala	Low land	Maize-Mustard
13	2-3 km from Dimna Nala	Upland	Maize-Mustard
14	2-3 km from Dimna Nala	Medium land	Maize-Mustard
15	1-2 km from Dimna Nala	Low land	Maize-Vegetables
16	1-2 km from Dimna Nala	Upland	Maize-Vegetables
17	1-2 km from Dimna Nala	Medium land	Vegetables
18	1-2 km from Dimna Nala	Medium land	Vegetables
19	1-2 km from Dimna Nala	Low land	Paddy-Maize
20	1-2 km from Dimna Nala	Low land	Paddy-Maize

Jamshedpur. Twenty five per cent of the total soils were neutral to alkaline (pH 6.5 to 7.5), 20 per cent were slightly acidic and very strongly acidic while 15 per cent were moderately acidic and alkaline (pH > 7.5) in nature. Majority of soils collected around PTPS, Patratu and CCL project Gobindpur and Kathara were slightly acidic. It may be ascribed due to leaching of bases in high rain fall area [10]. Slightly acidic to alkaline soils of Jamshedpur may be attributed to the dumping of solid wastes of steel factory on road side observed during sample collection. The electrical conductivity of soil samples were within the safe limit (EC < 0.8 dS m^{-1}) except one sample each in Bokaro (2.08 dS m^{-1} in soil no 11) and Jamshedpur (0.89 dS m^{-1} in soil no 5). High organic carbon content in the soil samples was observed during the present study. Among the soils collected from Patratu, Bokaro and Jamshedpur 55, 80 and 60 per cent were high in OC content. Some of the soil collected from Patratu and Bokaro showed very high value of organic carbon viz. soil no 5, 6 and 7 in Patratu (49.46, 32.34 and 24.59 g kg^{-1}) and 11 in Bokaro (29.27 g kg^{-1}).

3.2 Available N, P and K

Results presented in Table 3 indicate the status of available nitrogen, phosphorus and potassium in soils collected from Patratu, Bokaro and Jamshedpur. The available N content in soil ranged between 188 – 330 kg ha^{-1} in Patratu, 220 – 283 kg ha^{-1} in Bokaro and 210 – 265 kg ha^{-1} in Jamshedpur. Low available nitrogen status in soil was observed. Ninety per cent of the soil collected from Patratu, 65 per cent from Jamshedpur while all soils collected from Gobindpur and Kathara showed the low N rating (< 280 kg ha^{-1}). The soils collected from the three districts were low in available P content. The extent of deficiency was 60, 55 and 50 per cent in Patratu, Bokaro and Jamshedpur, respectively. However, 25 per cent of total soils in Patratu, 20 per cent in Bokaro and 30 per cent in Jamshedpur were high in available P content (> 28 kg ha^{-1}). Low available P in the soil may be due to the acidic nature of lateritic soil where precipitation of soil phosphate with iron and aluminum reduces the P availability. Available K content ranged from 84 to 389 kg ha^{-1}, 59 to 446 kg ha^{-1} and 27 to 243 kg ha^{-1} in soils collected from Patratu, Bokaro and Jamshedpur. Low available K content in soils to the extent of 85 per cent were noticed in Jamshedpur, however, 60 per cent of the total soils collected in Patratu and Bokaro reported to be low in available K status.

3.3 DTPA-extractable Trace Metal

The DTPA extractable Zn, Cu, Mn, Fe, Cd, Pb, Ni and Co content in soil samples ranged from 0.14 – 4.51, 0.44 – 3.62, 10.78 – 24.94, 11.50 – 62.46, ND – 0.05, 0.28 – 2.52, 0.04 – 1.38 and 0.04 – 2.40 mg kg^{-1} in Patratu, 0.15 – 5.25, 1.38 – 5.13, 12.64 – 24.64, 25.08 – 70.18, ND – 0.04, ND – 5.16, 1.30 – 6.54 and 1.04 – 3.59 mg kg^{-1} in Bokaro while 0.09 – 2.41, 0.84 – 2.83, 2.23 – 23.86, 16.35 – 52.08, ND – 0.08, ND – 2.50, 1.38 – 3.37 and 1.13 – 3.00 mg kg^{-1} in Jamshedpur, respectively (Tables 4 and 5).

It was noticed that DTPA-Zn was above the critical value (0.6 mg kg^{-1}) in 70 per cent soil samples, however, all soils collected from these districts contained Cu (0.2 mg kg^{-1}), Mn (2.0 mg kg^{-1}) and Fe (4.5 mg kg^{-1}) above their respective critical values (Fig. 1). Thus the soils may be regarded as sufficient in micronutrient content. Alarming presence of toxic trace metal was noticed. Cadmium was detected in 47 per cent samples; however, none of the samples crossed the critical limit for toxicity (0.5 mg kg^{-1}). One sample each collected from Bokaro and Jamshedpur had DTPA-Pb above maximum allowable limit (3.0 mg kg^{-1}), while Pb was detected in 70 per cent samples. DTPA extractable Ni and Co were found in all soil samples and it was observed that 33 per cent samples crossed the maximum allowable limit for

Ni (2.0 mg kg^{-1}), while all samples for Co (0.5 mg kg^{-1}). Analysis of mean toxic metal content indicates that DTPA-extractable Cd, Pb, Ni and Co in soils was within the maximum allowable limit for heavy metal used in different countries [11]. However, detection of toxic metals in many soils in considerable amount is a matter of concern as acidic condition favors their accumulation in growing plants and edible parts and there is chance to enter these metals in food chain [12].

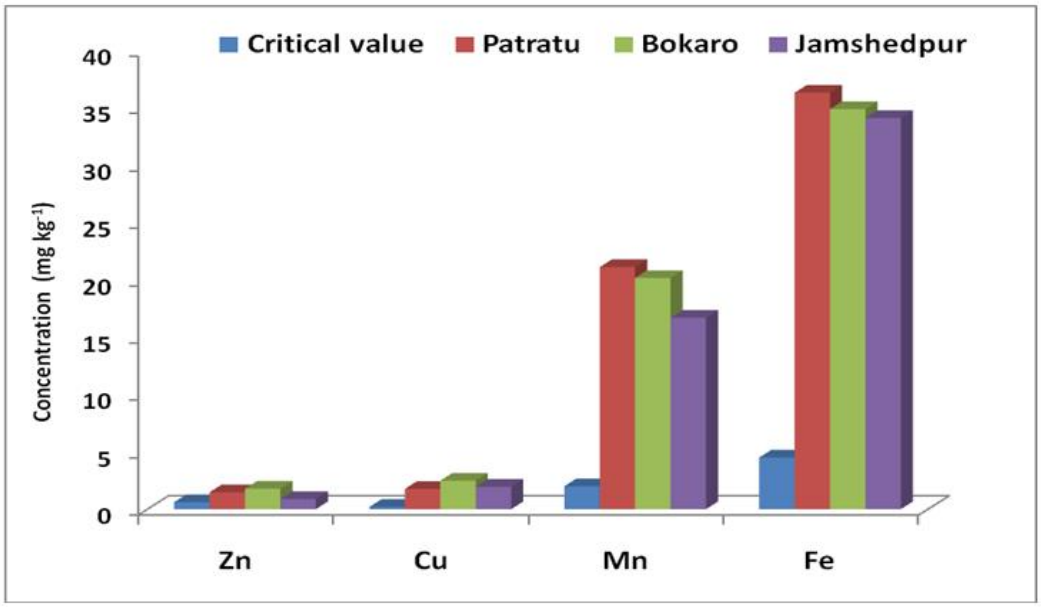

Fig. 1. Mean micronutrient content in soil around industries of Patratu, Bokaro and Jamshedpur

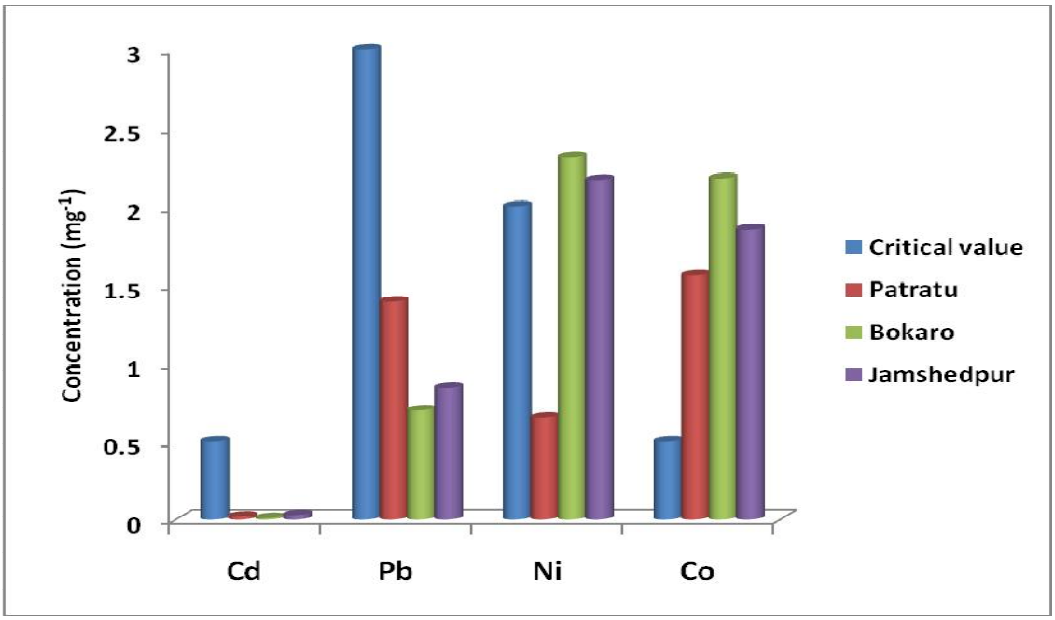

Fig. 2. Mean trace metal content in soil around industries of Patratu, Bokaro and Jamshedpur

Table 2. pH (1:2.5), EC (dS m^{-1}) and Org. C (g kg^{-1}) content in soils around industries of Patratu, Bokaro and Jamshedpur

Sample No.	Patratu			Bokaro			Jamshedpur		
	pH	EC	Org.C	pH	EC	Org.C	pH	EC	Org.C
1	6.04	0.17	9.95	6.46	0.15	10.08	6.32	0.14	8.20
2	6.04	0.10	5.85	4.71	0.51	10.23	8.10	0.21	4.39
3	5.77	0.14	7.61	5.29	0.12	8.47	5.03	0.09	6.59
4	6.39	0.09	4.83	6.39	0.16	7.74	5.12	0.11	5.42
5	5.43	0.07	49.46*	5.94	0.12	10.08	4.75	0.89	10.68
6	7.18	0.54	32.34*	5.89	0.05	8.33	5.35	0.09	6.73
7	5.99	0.14	24.59*	6.09	0.09	8.91	5.86	0.15	8.49
8	5.08	0.04	5.12	6.92	0.26	13.00	4.88	0.10	7.92
9	4.88	0.04	3.37	6.73	0.19	9.06	5.99	0.23	6.88
10	5.55	0.03	8.49	6.56	0.24	11.69	6.60	0.38	9.51
11	5.81	0.16	6.15	3.53	2.08	29.27*	6.44	0.18	6.15
12	5.70	0.13	7.76	5.74	0.24	9.95	6.65	0.17	5.85
13	6.99	0.13	6.29	6.29	0.04	6.88	7.87	0.61	9.66
14	5.26	0.11	6.88	6.18	0.06	13.15	6.28	0.12	8.20
15	5.92	0.09	7.90	4.85	0.04	7.46	8.29	0.17	5.12
16	6.05	0.11	9.85	5.18	0.04	6.73	5.88	0.07	8.63
17	5.76	0.05	6.59	5.13	0.09	7.46	6.31	0.13	8.63
18	6.04	0.09	7.46	5.71	0.09	14.61	6.81	0.05	7.90
19	6.04	0.08	9.37	6.17	0.11	13.73	7.24	0.25	10.54
20	5.77	0.13	10.10	5.51	0.13	11.56	7.18	0.25	8.78
Range	4.88– 7.18	0.03– 0.54	3.37– 49.46	3.53– 6.92	0.04– 2.08	6.73– 29.27	4.75– 8.29	0.05– 0.89	4.39– 10.68
Mean	5.90	0.12	11.00	5.76	0.24	10.90	6.35	0.22	7.70
SD ±	0.53	0.10	10.80	0.81	0.45	4.90	1.04	0.20	1.80

**Soil no 5, 6 and 7 of Patratu were collected from bari heavily amended with fly ash. Soil no 11 of Bokaro was collected from field continuously receiving discharge from coal washery*

Table 3. Available N, P and K (kg ha^{-1}) status of soils around industries of Patratu, Bokaro and Jamshedpur

Sample no.	Patratu			Bokaro			Jamshedpur		
	N	P	K	N	P	K	N	P	K
1	234	106	131	262	3	195	211	2	44
2	197	3	121	283	2	196	261	4	64
3	206	3	134	231	3	127	230	8	43
4	188	5	151	234	42	196	225	16	123
5	234	7	213	261	4	194	231	21	27
6	197	60	389	280	7	165	260	3	63
7	209	50	388	231	16	290	245	1	50
8	259	3	129	253	202	446	210	10	40
9	219	4	102	231	122	138	241	4	92
10	336	7	85	256	205	424	265	7	72
11	253	39	250	221	13	554	235	2	76
12	286	22	127	208	14	222	240	3	35
13	213	49	332	226	2	69	234	32	130
14	274	17	91	234	16	211	229	5	87
15	299	3	100	231	7	59	213	133	57
16	258	9	178	236	5	106	225	12	41
17	293	3	84	240	5	78	246	30	65
18	311	8	122	220	3	418	249	20	43
19	330	13	148	240	12	119	230	134	243
20	317	3	149	262	5	152	240	111	114
Range	188–330	3–106	84–389	220–283	2–205	59–446	210–265	1–134	27–243
Mean	256.5	21.5	180.6	242.0	34.4	217.9	236.0	27.9	75.4
SD±	45.6	25.9	95.7	19.9	63.6	138.7	15.6	43.4	49.2

Table 4. DTPA-extractable micronurient content (mg kg^{-1}) in soils

Sample no.	Patratu				Bokaro				Jamshedpur			
	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe	Zn	Cu	Mn	Fe
1	1.60	3.62	22.84	41.90	0.33	1.76	22.96	68.24	0.65	2.76	16.9	26.10
2	0.43	1.63	24.94	19.94	1.43	1.84	23.60	70.18	0.48	2.03	14.7	16.35
3	0.74	1.53	23.96	27.56	0.95	2.36	17.32	42.08	0.46	1.76	8.1	44.56
4	1.16	3.20	24.88	11.50	0.90	1.95	22.94	39.24	0.40	1.40	2.2	39.50
5	3.98	1.49	14.90	62.46	1.79	2.47	16.03	31.42	1.97	2.26	20.3	41.52
6	4.51	1.34	11.78	14.52	0.93	1.47	22.64	29.32	0.75	2.09	16.1	32.34
7	1.61	0.77	19.17	36.76	0.51	2.09	21.60	27.66	0.25	2.83	19.2	33.90
8	0.31	0.79	18.31	27.10	1.08	3.37	19.80	29.50	1.16	2.36	10.3	52.08
9	0.14	0.44	10.78	30.88	5.25	1.76	19.79	27.94	0.48	2.41	22.9	25.72
10	0.90	1.78	18.60	36.10	2.81	1.38	19.57	25.36	0.57	2.47	23.9	48.04
11	1.53	1.29	24.00	46.22	4.74	2.70	20.90	25.08	0.59	1.70	19.3	41.34
12	1.36	2.30	19.95	52.92	5.13	3.08	22.64	31.34	0.49	2.66	21.1	38.86
13	1.85	1.15	21.78	20.58	1.04	3.09	14.54	30.26	0.62	1.40	13.0	26.10
14	1.06	2.34	24.62	51.90	1.16	2.76	12.64	28.76	0.54	2.39	19.8	36.72
15	1.11	2.47	23.80	41.26	0.52	2.03	20.30	26.52	1.60	0.98	7.08	26.64
16	0.99	1.40	24.66	35.00	0.77	1.93	23.14	25.42	0.09	1.65	22.0	28.44
17	0.26	1.50	24.32	35.00	0.15	1.57	24.62	26.32	1.03	1.90	19.5	32.42
18	0.61	2.34	23.94	37.48	2.95	5.13	20.94	44.34	1.40	1.55	16.6	30.30
19	1.16	1.98	18.78	46.86	2.41	3.49	18.13	38.62	2.41	1.84	19.9	36.82
20	0.83	2.74	21.48	40.14	0.78	3.52	19.33	30.40	1.95	0.84	21.0	24.78
Range	0.14– 4.51	0.44– 3.62	10.78– 24.94	11.50 – 62.46	0.15– 5.25	1.38– 5.13	12.64– 24.62	25.08– 70.18	0.09– 2.41	0.84– 2.83	2.23– 23.9	16.35– 52.08
Mean	1.47	1.77	21.12	36.33	1.78	2.49	20.17	34.90	0.89	1.96	16.7	34.13
SD ±	1.18	0.80	4.20	12.61	1.60	0.92	3.17	13.01	0.64	0.56	5.83	8.91

Table 5. DTPA-extractable toxic trace metal content (mg kg^{-1}) in soils

Sample no.	Patratu				Bokaro				Jamshedpur			
	Cd	Pb	Ni	Co	Cd	Pb	Ni	Co	Cd	Pb	Ni	Co
1	ND	2.10	1.38	2.06	ND	ND	1.52	1.29	0.02	ND	3.03	1.98
2	ND	0.91	0.89	2.06	ND	ND	2.34	1.98	ND	ND	1.72	1.30
3	0.02	1.02	0.48	2.15	ND	ND	1.99	1.64	ND	ND	1.58	1.13
4	0.01	1.42	0.69	2.32	0.01	ND	1.58	1.30	ND	ND	1.58	1.13
5	0.02	0.68	0.41	1.21	ND	1.42	1.79	2.15	0.01	1.19	2.13	1.72
6	0.05	1.31	0.62	0.87	0.01	1.14	1.45	1.81	0.01	1.08	1.38	1.47
7	0.04	1.99	0.41	0.79	ND	0.85	1.44	1.98	0.03	1.08	2.07	1.89
8	0.02	0.79	0.27	1.04	0.03	0.80	1.31	1.47	ND	2.50	2.27	1.89
9	ND	0.63	0.28	0.87	0.01	0.45	1.30	1.46	0.03	1.36	2.27	1.80
10	ND	1.14	0.48	1.47	ND	0.68	2.27	1.04	0.06	1.42	2.07	1.80
11	0.03	0.45	0.04	1.29	ND	0.28	6.54	2.83	0.05	1.25	1.79	2.23
12	ND	0.85	0.07	1.64	ND	1.36	2.69	2.06	0.02	1.36	2.07	2.15
13	ND	0.80	0.41	1.55	ND	1.08	1.86	2.66	0.05	1.65	1.93	1.38
14	ND	1.40	0.89	2.23	0.01	5.16	1.65	1.89	0.04	2.04	2.34	3.00
15	ND	0.97	0.96	2.23	ND	0.79	2.20	2.57	0.01	1.19	1.86	1.64
16	0.01	0.57	1.10	1.72	ND	ND	2.13	2.49	0.04	0.74	2.96	2.49
17	0.01	0.28	1.38	2.40	0.01	ND	2.27	3.59	0.01	ND	2.00	2.32
18	ND	1.20	0.90	1.98	0.04	ND	4.48	3.17	0.05	ND	2.34	1.98
19	0.01	2.52	1.17	1.64	0.02	ND	2.75	3.17	0.08	ND	3.37	1.90
20	ND	1.58	1.03	1.89	0.01	ND	2.62	3.00	0.05	ND	2.55	1.81
Range	ND–0.10	0.28–4.24	0.04–1.38	0.79–2.32	ND–0.04	ND–5.16	1.30–6.54	1.04–3.59	ND–0.08	ND–2.50	1.38–3.37	1.13–3.00
Mean	0.02	1.39	0.65	1.56	0.01	0.70	2.31	2.18	0.03	0.84	2.17	1.85
SD ±	0.03	1.01	0.41	0.62	0.01	1.17	1.23	0.73	0.02	0.79	0.51	0.46

**ND means Not Detected*

Table 6. Population of bacteria (x 10^6 CFU g^{-1}), actinomycetes (x 10^6 CFU g^{-1}) and fungi (x 10^4 CFU g^{-1}) in soils around industries of Patratu, Bokaro and Jamshedpur

Sample no.	Patratu			Bokaro			Jamshedpur		
	B	A	F	B	A	F	B	A	F
1	15.0	3.0	21.7	13.0	2.7	28.7	10.3	3.7	19.7
2	15.7	2.3	23.3	13.7	3.0	31.7	9.3	4.0	20.3
3	12.7	2.7	24.3	10.7	3.3	31.0	9.7	4.0	20.3
4	12.3	2.7	24.7	10.3	3.7	33.3	8.7	4.7	22.0
5	12.7	3.0	23.0	10.7	4.3	33.0	10.7	4.0	22.7
6	12.3	2.3	21.3	10.3	4.7	28.7	9.3	3.7	20.0
7	13.0	3.0	23.0	8.3	5.0	30.0	9.3	4.0	21.7
8	12.3	3.3	23.0	10.3	4.3	32.0	9.0	3.7	18.3
9	11.7	3.3	24.7	11.7	4.3	31.3	9.3	4.3	23.3
10	11.3	3.0	21.3	10.7	4.3	31.7	9.0	3.7	21.7
11	15.0	2.0	25.7	13.0	2.0	18.0	9.7	4.3	22.0
12	16.0	1.7	25.3	12.7	2.3	26.7	9.3	4.0	24.7
13	16.3	2.3	26.7	12.0	2.7	25.3	10.3	3.7	19.3
14	17.7	3.3	27.3	12.3	3.0	27.3	10.0	3.3	18.7
15	17.7	3.7	26.0	11.7	2.3	26.0	9.0	3.0	18.0
16	18.7	4.3	27.0	12.7	2.7	24.7	8.7	2.7	19.7
17	19.7	4.3	29.3	9.3	2.0	24.3	8.0	2.3	20.0
18	19.0	3.3	28.0	9.7	2.7	25.0	8.7	2.7	18.7
19	19.0	3.3	28.3	10.3	3.0	25.3	8.0	3.0	21.0
20	18.3	4.3	32.0	10.7	3.3	25.0	8.7	2.3	19.3
Range	11.3-19.7	1.7-4.3	21.3-32.0	8.3- 13.7	2.0-5.0	24.3-33.3	8.0-10.7	2.3-4.7	18.0-24.7
Mean	15.3	3.1	25.3	11.2	3.3	28.0	9.3	3.6	20.6
SD ±	2.9	0.7	2.8	1.4	0.9	3.9	0.7	0.7	1.8

3.4 Microbial Population

Bacterial, actinomycetes and fungal population in soils collected around industries of Patratu, Bokaro and Jamshedpur are presented in Table 6. Results reveal that bacterial population ranged from 11.3 to 19.7, 8.3 to 13.7 and 8.0 to 10.7 x 10^6 CFU g^{-1}, actinomycetes population from 1.7 to 4.3, 2.0 to 5.0 and 2.3 to 4.7 x 10^6 CFU g^{-1} and fungal population from 21.3 to 32.0, 24.3 to 33.3 and 18.0 to 24.7 x 10^4 CFU g^{-1} in soils collected around PTPS, Patratu, Gobindpur and Kathara Project CCL, Bokaro and waste disposal site, Jamshedpur, respectively. Mean value of microbial population indicate that maximum bacterial, actinomycetes and fungal population was found in Patratu, Jamshedpur and Bokaro soils, respectively. High bacterial population in Patratu and Bokaro soil may be due to high OC content in these soils that may enhance availability of oxidizable substrates for carbon and energy source [13]. Soils collected around Jamshedpur recorded low fungal population. It may be due to high soil pH as low soil reaction favours fungal growth and increase in pH reported to have detrimental effect on fungal growth and development [13]. Little effect of trace metal on microbial population was observed during present study as the range is very narrow and standard deviation is small. However, detrimental effect of trace metal on microbial population was reported earlier [14,15,16]. It was earlier found that bacterial number was not affected by excessive Cu [17] while 50 mg Cd kg^{-1} was inhibitory to bacterial population [18]. The effect of trace metal on microbial population largely depends on the extent of metal in soil as well as soil properties [19,20]. Heavy metal resistance of microbial population was reported by several workers [21,22,23].

4. CONCLUSION

The soils collected around industries of Jharkhand showed wide variation from extremely acidic to alkaline soil reaction, however majority of the soils were acidic in nature, the electrical conductivity of the soils were within the safe limit while high organic carbon content in most of the soil was observed. The soils collected from the three districts were low in available N and P while low to medium in available K status. Micronutrient content in the soils was above their respective critical values and thus rated as sufficient. Higher amount of DTPA-extractable toxic total trace metal particularly Cd, Pb, Ni and Co was noticed, which is a matter of concern as acidic soil condition favours their accumulation in growing plants and edible parts which may enter the food chain and create health hazards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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