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Research Paper

Assessment Of Soil Quality Around An Industrial Setup In Odisha, India

Pramod Ranjan[1], Chandan Sahu[1,2], Sradhanjali Basti[1], Sanjat Kumar Sahu[1*]
[1]*P.G. Department of Environmental Sciences, Sambalpur University, Jyoti Vihar, Odisha, India – 768019*
[2]*Gangadhar Meher University, Amruta Vihar, Odisha, India – 768004*
**Corresponding Author*

ABSTRACT: *Periodic soil quality assessment gives the picture of soil health status. This is especially important around an industrial setup to study the cumulative impact of industrial operation on soil quality. A study was therefore envisaged to evaluate the impact of industrial activity on physicochemical characteristics of soil around an alumina refinery in Odisha, India. The results reveal that although most of the soil parameters showed consistent behavior concerning values in the range of normal soil characters, there existed significant spatial and seasonal fluctuations. These shows that some of the study sites might have started to be impacted due to industrial units under operation while seasonality also adds to the impact imposed by the industrial activity. Thus, separate plans should be developed to address the impact of industrial activities in soils during different seasons.*
KEYWORDS: *Soil Quality, Physical Parameters, Chemical Parameters, Industry*

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I. INTRODUCTION

The florish of industrial growth has had a serious impact on the soil quality. Loss of soil fertility, conversion into waste land, reduction in microbiological population, etc. are a few notable negative impacts of industrialization. Unsupervised industrial activities, ill-planned mitigation strategies and uncontrolled production often lead to the loss in soil-quality [1]. The physicochemical properties are first hand indicators of soil quality. A rapid assessment of these parameters can reflect the soil health status and provide an initial assessment about the ambient conditions. Subsequently, these assessment can be cross-verified with biological assessment for managerial decisions. Soils near industrial areas are therefore assessed for their physicochemical behavior on regular basis so as to get an insight into the industrial influence on the surrounding and take necessary remedial steps if needed [2]

Several studies in the past have reported that the enzymatic activities, soil health, and microbiological process including soil respiration have decreased in soil due to anthropogenic pressure [3] while, heavy metal induced toxicity are a direct consequence of it. It is therefore very important to conduct regular soil monitoring and assess the physicochemical and biological condition of soil to help soil retain its vitaility for a reasonable stretch of time.

Lanjigarh is a small place coming under the sub-urban category in the Odisha state of India, has witnessed negligle attention regarding the impact of industrial activities on soil quality of the region. A work was therefore envisaged to (i) to assess the physicochemical characteristics of soil around the industrial setup in Lanjigarh, and (ii) to study the seasonal impact on the soil quality of the same area. The work is expected to reveal important informations relating to the co-existence of soil quality with industrial operation.

II. MATERIALS AND METHODS

Study area

The area selected for the present study is located in the Eastern part of India namely Lanjigarh, situated in the Kalahandi district of Odisha state. The industrial setup build in this area is an alumina refinery operating with a capacity of 1.4 MTPA (million tonnes per annum) since last one and a half decade. Being a mining industry, the manufacturing unit involves bauxite and coal crushing, processing, handling and refining, thus are prime source of particulate emitters. Since, the plant is under its expansion project, it experiences routine civil activities through construction and demolition besides having regular vehicular activities. The plant also has a 90 MW thermal power plant involving the use of crushed coal. The area is built from a rural background with the residents opting for agriculture as their primary occupation. The study area experiences very hot summer and a cold winter with the temperature ranging between 5 and 43º C. While the relative humidity of the area ranges from 34 to 81%, the annual precipitation is 1290 mm.

Table 1: Details of the sampling locations

Station Code	Name of the Site	Distance from the plant site (km)	Direction from the plant site	Geographical Coordinates
SSL1	Lanjigarh	4	West	19.71º NL, 83.37º EL
SSL2	Rengopali	2	South	19.70º NL, 83.39º EL
SSL3	Chhatrapur	1.6	North	19.73º NL, 83.40º EL
SSL4	Near Red Mud Pond	1.5	South-West	19.70º NL, 83.39º EL
SSL5	Near Ash Pond	4	North-West	19.73º NL, 83.38º EL
SSL6	Bundel	4	West	19.71º NL, 83.39 º EL
SSL7	Rehab Colony	3	South-West	19.73º NL, 83.38 º EL

Sampling and Analysis

The soil samples were collected from seven strategic locations around the alumina setup in the study area within an aerial distance of 5 km from the plant. The geographical details of all the sampling locations is presented in Table 1. All sampling points were identified as per the convenience of accessibility to the area. The upper soil samples (0-15 cm) were collected using a soil core sampler. The samples were placed in an air tight polythene bag, insulated under cold condition, and transported to the laboratory for analysis of physicochemical parameters.

In the laboratory, a part of the soil samples were oven dried for the analysis of bulk density [4], while the other part was air-dried for the analysis of other physicochemical parameters by following methods described in IS (Indian Standard): 2720 [5]. The pH and EC of the soil samples were analyzed electrometrically using respective standard buffers at soil: distilled water ratio being 1: 5(w/v). The organic matter was determined by tritration method using potassium dichromate and sulphuric acid [6]. The nitrate nitrogen was determined by using phenol disulphonic acid method [7] while, the phosphate was determined by the ammonium molybdate method [8]. The potassium content, on the other hand, was estimated flame photometrically [9]. While the magnesium content was estimated through EDTA method, the chloride estimation was done through argentometric method [8]. Zinc and Boron were estimated used ICP-OES following acid digestion of soil samples. Bouyoucos hydrometer method was adopted for the determination of sand, silt and clay [10].

Statistical Test

The results were subjected to a two-way analysis of variance test for the determination of effect spatial and temporal variations of different soil parameters. Secondly, a Pearson’s correlation text was also perfomed among various parameters to determine their inter-relationships. All the analysis were performed using MS-Excel 2019 software.

III. RESULTS

Table 2 depicts the physicochemical characteristics of the soil quality around the study area during 2018-2019. It is evident from the table, that the pH varied from 7.26±2.35 to 6.27±3.65 in post-monsoon, 7.27±3.56 to 6.62±3.23in pre-monsoon, and 7.63±3.21 to 6.89±3.23 in the monsoon season. While station SSL2 (Rengopali) showcased the highest pH concentration irrespective of season, the lowest value was observed in SSL5 (Near Ash pond) station. On the other hand, EC ranged from 182.25±4.32 to 116.7±3.22in the post-monsoon, 196.25±5.21 to 119.85±5.23 in the pre-monsoon and 168.5±4.30 to 117.6±5.21 in the monsoon season. While Station SSL1 (Lanjigarh) showcased the highest EC concentration irrespective of season, the lowest value was observed in station SSL3 (Chhatrapur). pH displayed a significant variation concerning both stations and seasons ($F \geq 39.64$, $p < 0.05$; Table 3) but EC displayed a significant variation concerning stations only ($F = 91.36$, $p < 0.05$; Table 3).

The bulk density, on the other hand, ranged between 1.135±0.06 and 1.1165±0.04 in the post-monsoon, 0.9±0.09 and 0.8±0.04 in the pre-monsoon, and 1.13±0.05 and 1.116±0.07 in the monsoon season. While Station SSL7 (Rehab colony) showcased the highest bulk density irrespective of seasons, the lowest value was observed in station SSL2 (Rengopali)(Table 2). Bulk density displayed a significant variation concerning both stations and seasons ($F \geq 3.25$, $p < 0.05$; Table 3). While the organic matter ranged between 2.11±5.21 and 1.25±4.21, 2.21±3.29 and 1.29±3.20, 1.45±4.20 and 1.17±3.41 in the post-monsoon, pre-monsoon, and monsoon seasons respectively, station SSL5 (Near Ash pond) showcased the highest organic matter concent irrespective of season and the lowest value was observed in SSL4 (Near Redmud pond) station(Table 2). In the variance test, organic matter displayed a significant variation concerning both stations and seasons ($F \geq 3.34$, $p < 0.05$; Table 3). Similarly, the chloride content ranged between 158.3±4.44 and 38.55±4.32, 168.4±5.67 and 42.15±4.56, and 157.35±5.87 and 39.35±5.43 in the post-monsoon, pre-monsoon, and monsoon seasons respectively. While, station SSL4 (Near Redmud pond) showcased the highest chloride concentration irrespective of seasons, the lowest value was observed in SSL2 (Rengopali) station(Table 2). Chloride also displayed significant variations concerning both stations and seasons ($F \geq 8.00$, $p < 0.05$; Table 3).

When the nutrient contents (NPK) were analyzed, it was found that the available nitrogen ranged from 2.85±1.34 to 2±1.22 in the post-monsoon, 2.95±1.30 to 2.05±1.43 in the pre-monsoon and 2.91±1.30 to 2.34±1.23 in the monsoon season. Similarly, the available phosphorus was found to be in the range of 1.45±0.34 to 0.85±1.29, 1.2±1.10 to 0.945±1.45, and 1.53±1.39 to 1.28±2.89 in the post-monsoon, pre-monsoon, and monsoon seasons respectively. The available potassium content on the other hand, ranged from 0.87±0.20 to 0.665±0.23 in the post-monsoon, 0.65±0.26 to 0.41±0.28 in the pre-monsoon and 1.08±0.34 to 0.77±0.45 in the monsoon season(Table 2). While station SSL4 (Near Vedanta Redmud pond) showcased the highest available nitrogen concentration irrespective of seasons, the lowest value was observed in station SSL3 (Chhatrapur). Similarly, station SSL5 (Near Vedanta Ash pond) showcased the highest available phosphorus concentration irrespective of seasons and the lowest value was observed in SSL7 (Rehab colony) station. Station SSL6 (Bundel) showcased the highest available potassium concentration irrespective of seasons while the lowest value was observed in station SSL5 (Near Vedanta Ash pond). In the ANOVA test, available nitrogen displayed significant variations concerning both stations and seasons ($F \geq 5.73$, $p < 0.05$; Table 3) and the same was true in case of available phosphorus and available potassium content for seasons only ($F \geq 12.07$, $p < 0.05$; Table 3).

Magnesium content in soil ranged from 2.81±0.78 to 2.49±0.98 in the post-monsoon, 2.81±0.78 to 2.47±0.78 in the pre monsoon and 2.67±0.89 to 2.27±0.93 in the monsoon season. Similarly, the Zn content in soil ranged between 3.18±4.56 and 2.01±4.56 in the post-monsoon, 3.76±4.54 and 2.15±4.34 in the pre-monsoon, and 3.12±4.32 and 1.96±4.45 in the monsoon season. The boron content on the other hand, in the range of 0.07±0.01 to 0.04±0.01, 0.08±0.01 to 0.05±0.01, and 0.07±0.01 to 0.05±0.01 in the post-monsoon, pre-monsoon, and monsoon seasons respectively(Table 2). While the station SSL4 (Near Redmud pond) showcased the highest magnesium, zinc, and boron concentrations in its soil irrespective of seasons, the lowest value was observed in station SSL6 (Bundel) for magnesium, station SSL2. (Rengopali) for zinc, and station SSL3 (Chhatrapur) for boron. Magnesium and zinc displayed significant variations concerning both stations and seasons ($F \geq 5.74$, $p < 0.05$; Table 3),but boron exhibited significant variation with seasons only ($F \geq 3.77$, $p < 0.05$; Table 3).

Sand ranged from 12.50±3.42 to 11.04±3.14 in the post-monsoon, 12.54±2.98 to 11.29±3.12 in the pre-monsoon and 12.67±2.67 to 11.23±3.42 in the monsoon season. On the other hand, silt ranged between 12.77±2.89 and 11.71±1.98, 12.85±2.95 and 11.75±2.12, 12.56±2.18 and 11.87±3.16 in the post-monsoon, pre-monsoon, and monsoon seasons respectively.Similarly, clay ranged from 76.25±5.45 to 74.02±3.18 in the post-monsoon, 76.45±5.67 to 73.95±4.70 in the pre-monsoon and 76.83±4.75 to 75.42±3.17 in the monsoon season(Table 2). While Station SSL5 (Near Vedanta Ash pond), SSL4. (Near Vedanta Redmud Pond) and SSL3 (Chatrapur) showcased the highest percentage for sand, silt and clay irrespective of seasons, the lowest values were observed in station SSL4 (Near Vedanta Redmud pond), SSL1 (Lanjigarh) and SSL5 (Near Vedanta Ash pond) for the same parameters. Further, sand and silt displayed a significant variation concerning stations only ($F \geq 29.22$, $p < 0.05$; Table 3) and clay exhibited significant variations concerning both stations and seasons ($F \geq 3.71$, $p < 0.05$; Table 3).

Table 2: Soil quality parameters around the refinery plant in Lanjigarh during 2018-2019

Parameters	Stations	Post-monsoon	Pre-monsoon	Monsoon
pH	SSL1	6.68±3.45	6.78±3.45	6.99±4.23
	SSL2	7.26±2.35	7.27±3.56	7.63±3.21
	SSL3	6.46±3.78	6.62±3.23	6.99±2.32
	SSL4	6.71±3.65	6.72±4.56	7.00±2.43
	SSL5	6.27±3.65	6.66±3.78	6.89±3.23
	SSL6	7.07±2.21	7.11±3.23	7.34±3.45
	SSL7	7.14±4.23	7.21±2.54	7.43±2.30
EC (µS/cm)	SSL1	182.25±4.32	196.25±5.21	184.80±6.21
	SSL2	117.10±4.90	119.85±5.23	117.60±5.21
	SSL3	116.70±3.22	125.20±4.39	121.50±4.39
	SSL4	124.00±3.45	124.50±3.67	135.70±4.36
	SSL5	124.05±3.45	134.85±4.72	128.90±5.29
	SSL6	181.90±4.30	180.05±3.90	168.50±4.30
	SSL7	129.95±4.33	133.70±4.33	135.25±4.32
BD (gm/cm^3)	SSL1	1.10±0.05	0.89±0.04	1.10±0.08
	SSL2	1.08±0.08	0.80±0.04	1.08±0.09
	SSL3	1.12±0.04	0.87±0.07	1.12±0.07
	SSL4	1.09±0.02	0.90±0.03	1.08±0.08
	SSL5	1.02±0.05	0.90±0.02	1.00±0.08
	SSL6	1.10±0.07	0.90±0.07	1.10±0.09
	SSL7	1.14±0.06	0.90±0.09	1.13±0.05
OM (%)	SSL1	1.92±3.65	2.11±5.31	1.79±4.21
	SSL2	1.47±3.42	1.70±4.23	1.45±4.20
	SSL3	1.25±4.21	1.51±2.81	1.40±4.21
	SSL4	2.11±5.21	2.17±3.51	1.17±3.41
	SSL5	2.11±5.34	2.21±3.29	1.25±3.40
	SSL6	1.33±3.29	1.29±3.20	1.29±4.20
	SSL7	1.40±3.20	1.68±4.23	1.19±2.22
Cl (mg/kg)	SSL1	156.65±4.32	157.35±5.55	142.15±3.56
	SSL2	38.55±4.32	42.15±4.56	39.35±5.43
	SSL3	52.75±3.23	52.60±2.53	48.80±4.33
	SSL4	158.30±4.44	168.40±5.67	157.35±5.87

	SSL5	148.80±4.56	158.95±5.43	148.75±2.33
	SSL6	47.65±4.32	51.00±4.32	46.95±5.34
	SSL7	62.45±5.23	66.95±3.22	63.35±4.32
Ava. N (mg/kg)	SSL1	2.65±0.33	2.85±1.43	2.67±1.32
	SSL2	2.25±0.22	2.45±1.33	2.42±1.22
	SSL3	2.00±1.22	2.05±1.43	2.34±1.23
	SSL4	2.85±1.34	2.95±1.30	2.91±1.30
	SSL5	2.60±1.40	2.75±1.50	2.67±1.45
	SSL6	2.05±1.32	2.05±1.20	2.41±1.22
	SSL7	2.00±0.32	2.15±0.81	2.43±1.21
Ava. P (mg/kg)	SSL1	1.10±0.10	1.14±1.23	1.33±1.21
	SSL2	1.45±0.34	1.13±1.29	1.41±1.89
	SSL3	0.94±0.29	0.95±1.45	1.28±2.89
	SSL4	1.26±1.10	1.20±1.10	1.51±1.21
	SSL5	1.36±1.30	1.05±1.32	1.52±1.21
	SSL6	1.35±1.21	1.01±1.28	1.43±1.99
	SSL7	0.85±1.29	1.10±1.66	1.53±1.39
Ava. K (mg/kg)	SSL1	0.67±0.23	0.55±0.29	0.86±0.33
	SSL2	0.79±0.29	0.65±0.26	0.88±0.89
	SSL3	0.77±0.28	0.41±0.28	0.77±0.45
	SSL4	0.87±0.20	0.63±0.23	1.02±0.78
	SSL5	0.77±0.89	0.40±0.29	0.82±0.98
	SSL6	0.66±0.23	0.66±0.25	1.08±0.34
	SSL7	0.75±0.27	0.65±0.21	1.01±0.67
Mg (mg/kg)	SSL1	2.58±0.88	2.76±0.23	2.58±0.99
	SSL2	2.61±0.89	2.47±0.78	2.31±0.95
	SSL3	2.73±0.23	2.67±0.29	2.48±0.67
	SSL4	2.81±0.78	2.81±0.78	2.67±0.89
	SSL5	2.49±0.98	2.6±0.89	2.49±0.56
	SSL6	2.56±0.45	2.58±0.78	2.27±0.93
	SSL7	2.57±0.78	2.66±0.89	2.34±0.78
Zn (mg/kg)	SSL1	2.77±2.45	3.51±3.45	2.88±3.56

	SSL2	2.01±4.56	2.15±4.34	1.96±4.45
	SSL3	2.28±3.28	2.80±3.23	2.30±3.45
	SSL4	2.24±3.32	3.76±4.54	3.12±4.32
	SSL5	3.18±4.56	3.50±5.10	3.10±4.25
	SSL6	2.36±2.67	2.58±3.89	2.23±2.45
	SSL7	2.84±4.34	2.67±6.78	2.27±3.45
B (mg/kg)	SSL1	0.07±0.01	0.07±0.01	0.07±0.01
	SSL2	0.07±0.01	0.08±0.01	0.07±0.01
	SSL3	0.04±0.01	0.06±0.01	0.05±0.01
	SSL4	0.05±0.01	0.08±0.01	0.07±0.01
	SSL5	0.07±0.01	0.06±0.01	0.07±0.01
	SSL6	0.06±0.01	0.05±0.01	0.05±0.01
	SSL7	0.07±0.01	0.07±0.01	0.07±0.01
Sand (%)	SSL1	11.45±2.12	11.49±2.09	11.47±2.67
	SSL2	11.31±2.87	11.37±2.98	11.34±2.56
	SSL3	11.35±2.58	11.29±3.12	11.23±3.42
	SSL4	11.04±3.14	11.02±2.18	11.26±2.56
	SSL5	12.50±3.42	12.54±2.98	12.67±2.67
	SSL6	11.73±3.12	11.59±3.12	11.74±2.89
	SSL7	11.78±2.93	11.53±2.49	11.80±3.12
Silt (%)	SSL1	11.71±1.98	11.75±2.12	11.89±2.76
	SSL2	11.77±2.87	11.90±3.19	11.87±3.16
	SSL3	12.18±2.95	12.25±2.91	11.98±3.32
	SSL4	12.77±2.89	12.85±2.95	12.56±2.18
	SSL5	12.11±2.29	12.20±2.78	11.91±2.59
	SSL6	12.10±2.78	12.20±2.38	12.20±2.01
	SSL7	11.90±2.11	11.95±2.78	11.95±2.16
Clay (%)	SSL1	75.99±4.15	75.85±5.17	76.64±5.89
	SSL2	74.43±5.78	74.25±5.89	76.78±5.56
	SSL3	74.73±4.87	74.60±5.89	76.83±4.75
	SSL4	75.33±5.54	75.15±5.78	76.18±5.78
	SSL5	74.02±3.18	73.95±4.70	75.42±3.17

	SSL6	76.15±4.67	76.20±5.56	76.05±5.89
	SSL7	76.25±5.45	76.45±5.67	76.20±4.78

Table 3: Two-way ANOVA test between stations and seasons for different soil parameters

Parameter	***Source of Variation***	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***	***S/ NS***
pH	Stations	1.67	6.00	0.28	40.56	0.00	3.00	S
	Seasons	0.55	2.00	0.27	39.64	0.00	3.89	S
EC	Stations	14241.93	6.00	2373.66	91.36	0.00	3.00	S
	Seasons	106.42	2.00	53.21	2.05	0.17	3.89	NS
Bulk Density	Stations	0.01	6.00	0.00	3.25	0.04	3.00	S
	Seasons	0.18	2.00	0.09	153.02	0.00	3.89	S
OM	Stations	1.19	6.00	0.20	3.34	0.04	3.00	S
	Seasons	0.72	2.00	0.36	6.08	0.01	3.89	S
Cl	Stations	56856.37	6.00	9476.06	806.32	0.00	3.00	S
	Seasons	188.14	2.00	94.07	8.00	0.01	3.89	S
Ava. N	Stations	1.75	6.00	0.29	22.11	0.00	3.00	S
	Seasons	0.15	2.00	0.08	5.73	0.02	3.89	S
Ava. P	Stations	0.19	6.00	0.03	1.71	0.20	3.00	NS
	Seasons	0.45	2.00	0.23	12.07	0.00	3.89	S
Ava. K	Stations	0.10	6.00	0.02	2.45	0.09	3.00	NS
	Seasons	0.43	2.00	0.22	30.34	0.00	3.89	S
Mg	Stations	0.21	6.00	0.03	5.88	0.00	3.00	S
	Seasons	0.17	2.00	0.09	14.63	0.00	3.89	S
Zn	Stations	3.46	6.00	0.58	6.77	0.00	3.00	S
	Seasons	0.98	2.00	0.49	5.74	0.02	3.89	S
B	Stations	0.00	6.00	0.00	3.77	0.02	3.00	S
	Seasons	0.00	2.00	0.00	1.96	0.18	3.89	NS
Sand	Stations	4.15	6.00	0.69	94.14	0.00	3.00	S
	Seasons	0.04	2.00	0.02	2.59	0.12	3.89	NS
Silt	Stations	1.77	6.00	0.30	29.22	0.00	3.00	S
	Seasons	0.04	2.00	0.02	2.01	0.18	3.89	NS
Clay	Stations	7.87	6.00	1.31	3.71	0.03	3.00	S
	Seasons	5.27	2.00	2.63	7.45	0.01	3.89	S

Table 4: Correlation matrix between various soil parameters

	pH	**EC**	**Zn**	**OM**	**Cl**	**N**	**P**	**K**	**Mg**	**B**	**BD**
pH	1.000										
EC	0.197	1.000									
Zn	-0.188	0.926*	1.000								
OM	-0.807*	0.419	0.731*	1.000							
Cl	-0.569	0.694	0.915*	0.945*	1.000						
N	0.944*	0.510	0.147	-0.567	-0.265	1.000					
P	0.837*	-0.371	-0.695	-0.999*	-0.926*	0.609	1.000				
K	0.659	-0.607	-0.862*	-0.976*	-0.993*	0.374	0.963*	1.000			
Mg	-0.903*	0.243	0.591	0.983*	0.867*	-0.710	-0.991*	-0.918*	1.000		
B	0.130	0.998*	0.950*	0.480	0.742*	0.450	-0.434	-0.660	0.309	1.000	
BD	0.235	-0.906*	-0.999*	-0.763*	-0.933*	-0.099	0.729*	0.886*	-0.630	-0.933*	1.000

'*' – $p < 0.05$

When a correlation matrix between various parameters was worked out irrespective of seasons, it was found that pH exhibited a significant negative correlation with OM and Mg content ($r \geq -0.807$, $p < 0.05$, Table 4), and a significant positive correlation with the nutrients N and P ($r \geq 0.837$, $p < 0.05$, Table 4). On the other hand, the electrical conductivity displayed significant positive correlation with Zn and B ($r \geq 0.926$, $p < 0.05$, Table 4) and significant negative correlation with BD ($r = -0.906$, $p < 0.05$, Table 4) only. While Zn exhibited significant positive correlations with OM, Cl, and B ($r \geq 0.731$, $p < 0.05$, Table 4) and significant negative correlation with K and BD ($r \geq -0.862$, $p < 0.05$, Table 4); the OM content displayed significant positive correlations with Cl and Mg ($r \geq 0.945$, $p < 0.05$, Table 4) and significant negative correlations with P, K, and BD ($r \geq -0.763$, $p < 0.05$, Table 4). Similarly, Cl exhibited significant positive correlations with Mg and B ($r \geq 0.742$, $p < 0.05$, Table 4) and significant negative correlations with P, K, and BD ($r \geq -0.926$, $p < 0.05$, Table 4). Phosphorus displayed significant positive correlation with K and BD ($r \geq 0.729$, $p < 0.05$, Table 4), and significant negative correlation with Mg only ($r = -0.991$, $p < 0.05$, Table 4). Significant positive correlation was also observed between K and BD ($r = 0.886$, $p < 0.05$, Table 4) while significant negative correlations were observed between K and Mg and B and BD ($r \geq -0.918$, $p < 0.05$, Table 4).

IV. DISCUSSION

Soil pH and electrical conductivity are chief indicators of soil physicochemical status. Our study observed the soil pH in the range of slightly acidic to mildly alkaline category. The electrical conductivity too was non-saline in character which builds a conducive platform for vegetation growth in the soil. These results are reflections of negligible or no adverse impact of industrial activities on soil physicochemical characteristics. Since the pH and conductivity have not displayed any major erratum in their behavior, it is presumed that the animal and human interference is also under control in the same area. Our results observed a strong relationship between electrical conductivity and zinc content which suggests that the zinc was the responsible factor for maintenance of reasonable conductivity in studied soil.

Bulk density and organic matter content are negatively related to each other. Organic matter occupancy in void soil spaces reduces its density while assisting the plant growth and microbial infestations in soil. The findings of a strong negative correlation was consistent with results reported by Mohanty et al. [11] who reasoned the release of soil compression with organic matter resisdence to be the primary factor in an antagonistic relationship. Moreover, both organic matter and bulk density displaying significant spatial and temporal variation suggests that the influence of soil quality was impacted both due to seasonal change and industrial operation.

The chloride content shared a negative relationship with the bulk density and the nutrient contents (NPK) in this study. Our findings was constant with the results reported by Bhadoria et al. [12] who also suggested the declining impedence factor associated with chlorine with increasing bulk density of soil. This suggests that the source of chloride content may be from the metal associated salts derived from chemical weathering of rocks. This is well displayed by the significant positive association with the Zn, Mg and B content of soil. The nutrient content (NPK) on the other hand displayed erratic behavior. While the available nitrogen showed spatial and temporal variability, available phosphorus and available potassium displayed temporal changes only. This indicate that the later were seasonally impacted which might have been influenced by the dilution effect during the monsoon. Moreover, all the three nutrients exhibited significant negative correlation with organic matter indicating different source of entry into the soil than the natural mineralization process. However, this result was against the findings of Khadka [13] who showcased a positive significant relationship between organic matter and nutrient contents.

The metal content (Mg and Zn) were influenced by both stations and seasons thereby indicating a dependence on industrial operation and seasonal fluctuation. Their association with chloride further strengthens the fact that the presence of metallic salts (either from natural background or released from the ore processing as gangue materials) might be the reason for such metallic distribution across soil samples in the study area. Zinc, chlorides and phosphates have been reported to be impurities associated with Bayer's process of alumina recovery from bauxite [14].). Boron on the other hand, did not show seasonal fluctuation but varied concerning different sites. This gives an impression that boron too might have been sourced from various byproducts of industrial production.

V. CONCLUSION

A clear influence of seasons on physicochemical makeup of the soil quality is evident. Although, no distinct adverse impact of industrial operation on soil quality was observed in this study, there is still some sites which may have been exposed to soil quality degradation. It is therefore recommended that regular soil quality analysis with proper management planning concerning seasonal changes be mandatorily practiced to reduce any likely chances of future deterioration in soil health status of the study area.

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