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ASSESSMENT OF THE IMPACTS OF INDUSTRIAL ACTIVITIES ON THE SOILS OF RECEIVING ENVIRONMENT AROUND SELECTED OPERATIONAL SITES IN IBADAN METROPOLIS, OYO STATE

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Abstract

The study examined the heavy metal components, physical and chemical parameters of soil samples around selected industrial establishments. This was to ascertain the level that industrial activities impacts on the soil quality with a view to providing a platform for rapid generation of data for environment related decision making and promoting compliance to environmental standards in Ibadan metropolis. Twelve composite soil samples to the depths of 0-15 cm, 15-30 cm, 30-45 cm to represent top and subsoil were collected at each of the selected industrial locations using soil auger for soil physical and chemical properties determination. Data collected were analysed using descriptive and inferential statistics. The mean Pb values for 0-15, 15–30, 30-45 cm soil depths were 5.66± 0.55, 4.58±0.68, 4.52±1.35mg/kg; Cd values were 10.23± 0.60, 9.40 ± 1.33 and 10.55± 0.36mg/kg; Co values were 9.76± 1.00, 9.98 ± 2.57 and 13.58 ± 4.16mg/kg; Cr were 10.18 ± 2.40, 12.53 ±3.17 and 12.1 ± 3.75 and Ni were 11.17 ± 3.55, 12.24 ± 2.19 and 12.53 ± 2.34 mg/kg. For Macro nutrients, Total Organic Carbon (TOC) mean values for BC was 33.50 ± 2.48, 29.3 ± 3.91, 26.6 ± 2.74 and 3.60 ± 0.16 and TN values were 3.60 ± 0.16, 3.40 ± 0.12, and 2.90 ± 0.28 respectively while AC had Total Organic Carbon mean values of 28.03 ± 0.65, 23.5 ± 2.01, 19.24 ± 1.43 and Total Nitrogen (TN) mean values 2.90 ± 0.07, 2.43 ± 0.21 and 1.99 ± 0.15 respectively. For Micro nutrient Mn, Fe, Cu, Zn, the mean values at 0-15, 15-30 and 30-45 soil depth for BC were 39.08 ± 9.57, 32.43 ± 11.93 and 18.78 ± 4.80 for Mn, mean values for Fe were 39.53 ± 15.58, 51.83 ± 14.62 and 34.33 ± 10.68, also mean values for Cu was 8.53 ± 0.32, 8.26± 0.29, 7.99 ± 0.06 and mean values for Zn were 9.01 ± 0.66, 6.62 ±0.21 and 4.42 ± 1.11 respectively. There was a decrease in value with depth which may be associated with downward movement of organic materials and nutrients. The study concluded that industrial activities are impacting on the soil quality with special reference to nutrient and heavy metal contents within and around industrial facilities.

Key words: *Industrial Activities, Soil Characteristics, Heavy Metals, Industrial pollution*

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Introduction

Industrial activities result in heavy metals and toxic components that accumulate in soils. Metal and toxic contaminated soils can cause problems to animals and plants as well as human beings when they consume such plants and animals (Tiller, 1986). Heavy metals can accumulate in soil when industrial effluents are used for irrigation purposes or when not properly disposed (EL-Nennah et al., 2006). Heavy metal pollution in soils arises from various anthropogenic activities such as industrial operations that releas treated and untreated sewage water and sewage sludge on soils (EL Handy, 2007, Aghabarati, 2008, Aiyesami, 2005, Liu and Richard, 2010, Adams 2010, Adedeji et al, 2011)

Environmental pollution from industries in many major urban centres in Nigeria such as Ibadan has increased noticeably and has continued to have adverse effect on the immediate and distant environment of the industries (receiving ecosystems) (Osibanjo *et a*l., 2011, Tijani and Onodera, 2004). The impacts include physical landscape changes/disturbance, surface and ground water pollution, air pollution, noise, soil erosion, sedimentation, destruction of biodiversity, destruction of water biota, and land degradation (Tijani *et al*., 2004, Awomeso *et al*., 2009, Ogedengbe and Akinbile, 2010).

Most pollution of soil resources are observed at surrounding areas of the industries (Adeboye, 2002). Resistance and stability of the heavy elements in soil is very long than other pollutants and soil pollution by the heavy metals is relatively permanent. The heavy metals include lead, cadmium, silver and mercury which their detrimental effects have been proven on the living creatures and have repeatedly caused environmental incidents (Lin, 2010, Ogunyemi, 2003, Tiller, 1986). Some of these detrimental effects of the heavy metals include as follows: disorder of biological activities of the soil, toxic effects on plants and harmful effects on human being as a result of entrance of materials to the food chain (Adedipe et al, 2005, Adeoye, 2008).

The study area which was Ibadan consisted of 11 Local Government Areas (LGAs) for governance and administrative purposes. Five of the LGAs are located in the metropolis, while the remaining six are either predominantly peri-urban or rural settlements. Ibadan has a total land area of 3 123 km^2, of which about 15 percent is urban and the remaining 85 percent is classified as peri-urban (Adelekan *et al*., 2014). Ibadan North LGA is the largest among the urban LGAs (145.58 km^2) while Ibadan North West is the smallest at 31.38 km^2. The peri-urban LGA of Ido (865.49 km^2) covers the largest land area (Adelekan *et al*., 2014).

The soils of Ibadan region were formed from rocks of the Pre-cambrain basement complex formation, especially, granites gneisses, guartz-schist, biotite gneisses and schists. They were formed under moist semi-deciduous forest cover (Brady, 2009) and belong to the major soil group called Ferruginous tropical soils (Aweto, 1994). The soils have been mapped and classified into soil associations and series by Smyth and Montgomery (1962). Four soil associations occur in Ibadan region. They are: (i) Iwo, (ii) Okemesi, (iii) Egbeda and (iv) Mamu soil associations. The classification is largely based on soil parent materials.

Materials and Method

The selected industrial facilities were divided into five points namely Southern, Northern, Eastern, Western portions and Central (middle) points. Three sampling depths were taken at the selected industrial locations using soil auger, namely; 0 -15 cm, 15 – 30 cm, 30 – 45 cm to represent the top and sub soils. Soil samples from the related axis of the factory were bulked to produce a composite. The soil samples were taken to the laboratory, air dried and

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sieved through two millimeter sieve for soil chemical and physical analysis. The soil total nitrogen (TN) and total organic carbon (TOC) were determined by kjeldahl method. Soil pH was determined using 1:2 soil water suspension. Particle size was determined by the hydrometer method. Available P was determined by Bray P1. Exchangeable K, sodium (Na), calcium (Ca) and magnesium (Mg) were first extracted using neutral normal ammonium acetate (NH_4OAC). Thereafter, K and Na were determined by flame emission while Mg and Ca were determined by atomic absorption. Soil samples were digested in Teflon beakers with a mixture of HNO_3, HCl and HF. Similarly, Blanks were prepared to check for background contamination by the reagents used. The digested samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer (AAS). Descriptive and inferential statistic was used to determine the mean values, range and standard errors of each soil property.

Results and Discussion

The chemical properties and means of the soils of the study area comprising pH, Total organic carbon, Total Nitrogen, Available phosphorous, exchangeable acidity, extractable alkalinity, exchangeable bases, micro nutrient and their mean are presented on Tables 1,2,7 and 8 below. The heavy metal distribution and their mean are presented in Tables 3 and 9, while the particle size distribution and textural classes of the soil with their means are presented in Tables 6 and 12, that is mean values of heavy metals at various depth 0-15 cm, 15–30cm and 30-45cm soil depths. The acidity of the soil is a measure of the Cation Exchange Capacity (CEC) occupied by H+ and Al_3+, mean pH values of AC at depth 0-15, 15-30 and 30-45cm were 6.25 ± 0.50, 6.28 ± 0.08, 6.4 ± 0.05 respectively while mean values for BC were 6.63 ± 1.80, 6.77 ± 0.048 and 6.80 ± 0.17 respectively indicating that the soils were slightly acidic. The more acidic the soil is, the lower the value of pH and as soil acidity increases soluble aluminium and manganese increase to toxic levels (Agdex, 2010). Macro nutrients, Total Organic Carbon (TOC) mean values for BC were 33.50 ± 2.48, 29.3 ± 3.91, 26.6 ± 2.74 and 3.60 ± 0.16 and Total Nitrogen (TN) values were 3.60 ± 0.16, 3.40 ± 0.12, and 2.90 ± 0.28 respectively while AC had Total Organic Carbon (TOC) mean values of 28.03 ± 0.65, 23.5 ± 2.01, 19.24 ± 1.43 and Total Nitrogen mean (TN) values 2.90 ± 0.07, 2.43 ± 0.21 and 1.99 ± 0.15 respectively. Micro nutrient worked on were Mn, Fe, Cu, Zn, the mean values at 0-15, 15-30 and 30-45 soil depth for AC were 39.08 ± 9.57, 32.43 ± 11.93 and 18.78 ± 4.80 for Mn, mean values for Fe were 39.53 ± 15.58, 51.83 ± 14.62 and 34.33 ± 10.68, also mean values for Cu were 8.53 ± 0.32, 8.26± 0.29, 7.99 ± 0.06 and mean values for Zn were 9.01 ± 0.66, 6.62 ±0.21 and 4.42 ± 1.11 respectively. Like pH there was a decrease in value with depth which may be associated with downward movement of organic materials and nutrients. Mn, Fe, Cu, and Zn showed regular decrease values were high for plant (Zia et al, 2006) but below contamination levels of soil (Thorton et al., 2006). Heavy metals reported in plants may mainly come from the soil in which they were grown (Lin et al, 2010). Heavy metals analyzed were Pb, Cd, Co, Cr and Ni. Mean values recorded for Pb at AC were 66 ± 0.55, 4.58 ± 0.68, 4.52 ± 1.35, Cd was 10.23 ± 0.63, 9.4 ± 1.33 and 10.55 ± 0.36, Co was 9.76 ± 1.00, 9.98 ± 2.59, 13.58 ± 4.16 and 12.1 ± 3.75 while Ni had values of 11.17 ± 3.55, 12.34 ± 2.9 and 12.53 ± 2.34 respectively at different soil depths. Mean of heavy metal distribution of the soil at BC were Pb: 1.62 ± 0.72, 1.25 ± 0.69 and 1.44 ± 0.76, Cd values were 1.12 ± 0.60, 1.24 ± 0.71 and 1.29 ± 0.73, Co was 1.43 ± 0.73, 1.44 ± 0.76 and 1.42 ± 0.77, Cr value was 3.00 ± 1.00, 3.09 ± 1.17 and 3.20 ± 1.10 while Ni had values of 5.13 ± 1.17, 3.09 ± 0.75 and 4.05 ± 1.82 respectively at stated soil depths. The mean values for heavy metals were higher than the first normal level but has not reached critical contamination levels. The range of soils particle size distribution was as follows; clay 113 ± 12.58 – 183 ± 51.23 g/kg, 165 ± 15.00 – 215 ± 33.04 g/kg for silt and 647 ± 50.58 – 662 ± 35.12 for sand of

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AC while BC had values 106 ± 13.50 – 172 ± 54.37 g/kg for clay, 155 ± 15.55 – 208 ± 28.69 g/kg silt and 574 ± 50.23 – 609 ± 21.36 g/kg sand. Textural classes ranged from sandy loam to sandy clay loam suggesting a sandy soil which was vulnerable to leaching especially of toxic chemicals.

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Table 1: Soil Chemical Properties at BC, Ibadan

Location	Depth (cm)	pH	TOC (g/kg)	TN (g/kg)	AVP (mg/kg)	Ex. Acidity (mg/l)	Ext. Alkalinity (mg/l)	Mn (mg/l)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/l)	K (mg/l)	Ca (cmol/kg)	Mg (cmol/l)	Na (cmol/kg)
	0-15	6.9	30.04	3.52	39.10	0.6	1.3	9.4	9.2	6.9	4.51	0.60	8.62	1.24	2.22
ETP A	15-30	6.7	29.26	3.30	37.12	0.3	1.1	3.8	7.6	6.20	4.30	0.24	6.30	1.00	1.90
	30-45	6.3	24.13	2.14	37.10	0.2	1.2	3.5	6.4	5.21	4.12	0.22	6.19	1.00	2.98
	0-15	6.7	34.26	3.89	37.30	0.2	1.8	8.0	7.1	5.22	4.11	1.18	5.90	0.64	3.00
Central	15-30	6.7	20.22	3.42	36.75	0.1	1.4	20.2	6.2	4.12	3.80	1.05	4.70	0.53	2.87
	30-45	6.9	20.15	3.10	36.58	0.1	1.1	14.1	5.2	4.10	3.00	0.23	4.20	0.89	1.78
	0-15	6.8	29.47	3.20	38.62	0.5	1.4	20.2	8.2	3.31	2.20	0.31	7.54	0.22	2.99
Western	15-30	6.8	28.36	3.15	37.32	0.1	1.4	15.2	6.1	2.50	1.21	0.15	6.42	0.20	2.00
fenceline	30-45	6.9	29.52	3.12	36.63	0.1	1.2	18.8	4.9	2.30	1.20	0.12	6.30	0.12	2.21
Eastern	0-15	6.1	40.23	3.80	37.38	0.1	1.1	28.0	9.1	2.54	1.30	1.26	8.12	0.22	2.62
Fenceline	15-30	6.9	39.31	3.73	37.22	0.1	1.5	20	8.9	1.82	1.22	0.40	7.86	0.20	2.14
	30-45	7.1	32.42	3.45	36.46	0.1	1.0	18	8.6	1.21	1.10	0.25	6.74	0.20	2.81

N:B ETP A= Effluent Treatment Plant Axis; Ex. Acidity= Exchangeable acidity, Ext. Alkalinity = Extractable alkalinity, TN = Total Nitrogen, Mn, Fe, Cu, Zn (mg/kg), Ca, K, Mg, Na (cmol/kg)., TOC = Total Organic Carbon.

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Table 2: Mean of Soil Chemical Properties at BC, Ibadan

Depth (cm)	pH	TOC (g/kg)	TN (g/kg)	AVP (mg/kg)	Ex. Acidity (mg/l)	Ext. Alkalinity (mg/l)	Mn (mg/l)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/l)	K (mg/l)	Ca (cmol/kg)	Mg (cmol/l)	Na (cmol/kg)
0-15	6.63±0.180	33.50±2.48	3.60±0.16	38.09±0.44	0.35±0.12	1.40±0.15	16.40±4.73	8.40±0.49	4.59±0.98	3.03±0.77	0.83±0.23	7.54±0.59	0.58±0.24	2.71±0.18
15-30	6.77±0.048	29.3±3.91	3.40±0.12	37.10±0.12	0.15±0.05	1.20±0.09	14.80±3.84	7.20±0.66	3.66±0.97	2.63±0.82	0.46±0.20	6.32±0.65	0.48±0.19	2.22±0.22
30-45	6.80±0.17	26.6±2.74	2.90±0.28	36.69±0.14	0.12±0.03	1.12±0.05	13.60±3.52	6.30±0.84	3.21±0.90	2.35±0.73	0.20±0.03	5.80±0.57	0.55±0.23	2.44±0.28

Source: Fieldwork

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Table 3: Heavy Metal Distribution of the soils at BC, Ibadan

Location	Depth (cm)	Pb (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Ni (mg/kg)
	0-15	2.80	2.18	2.89	5.22	8.01
ETP A	15-30	2.70	2.12	2.76	4.21	5.02
	30-45	1.90	2.00	2.50	3.76	4.34
	0-15	2.90	2.90	2.88	5.10	8.32
Central	15-30	2.90	2.87	2.76	4.90	3.56
	30-45	2.80	2.22	2.62	6.20	9.10
	0-15	0.66	0.13	0.25	0.80	2.21
Western fenceline	15-30	0.15	0.01	0.15	0.45	1.90
	30-45	0.10	0.01	0.13	1.70	1.89
Eastern	0-15	0.12	0.10	0.10	1.90	2.00
Fenceline	15-30	0.10	0.10	0.10	1.82	1.90
	30-45	0.10	0.04	0.06	1.44	0.90

Table 4: Mean of Heavy Metal Distribution of the soils at BC, Ibadan

Depth (cm)	Pb (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Ni (mg/kg)
0-15	1.62±0.72	1.12±0.60	1.43±0.73	3.00±1.00	5.13±1.75
15-30	1.25±0.69	1.24±0.71	1.44±0.76	3.09±1.17	3.09±0.75
30-45	1.44±0.76	1.29±0.73	1.42±0.77	3.20±1.10	4.05±1.83

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Table 5: Physical Properties of the Soils at BC, Ibadan

Location	Depth (cm)	Clay (g/kg)	Silt (g/kg)	Sand (g/kg)	Textural Class
	0-15	90	260	496	Sandy Loam
ETP A	15-30	124	170	596	Sandy Loam
	30-45	94	120	646	Sandy Loam
	0-15	104	140	716	Sandy Loam
Central	15-30	204	180	656	Sandy Clay Loam
	30-45	244	140	596	Sandy Clay Loam
	0-15	144	250	596	Loamy Sand
Western fenceline	15-30	264	170	556	Loamy Sand
	30-45	284	170	426	Loamy Sand
Eastern	0-15	84	180	616	Sandy Clay Loam
Fenceline	15-30	64	190	626	Sandy Clay Loam
	30-45	64	190	626	Sandy Clay Loam

Table 6: Mean of Soil Particle Size Distribution at BC, Ibadan

Depth (cm)	Clay (g/kg)	Silt (g/kg)	Sand (g/kg)
0-15	106±13.50	208±28.69	606±45.09
15-30	164±43.97	178±4.79	609±21.36
30-45	172±54.37	155±15.55	574±50.23

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Table 7: Soil Chemical Properties at AC, Ibadan

Location	Depth (cm)	pH	TOC (g/kg)	TN (g/kg)	AVP (mg/kg)	Ex. Acidity (mg/kg)	Ext. Alkalinity (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	K (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Na (cmol/kg)
	0-15	6.3	26.64	2.76	37.34	0.1	1.9	11.2	60.7	8.63	5.24	0.2	11.85	1.83	3.09
Pit	15-30	6.2	21.46	2.22	36.66	0.1	1.4	4.9	32.3	7.52	3.77	0.14	8.26	1.14	3.09
	30-45	6.3	16.28	1.68	35.98	0.1	1.3	4.7	31.9	8.02	3.31	0.17	9.28	1.22	3.13
	0-15	6.1	29.6	3.06	35.83	0.2	1.6	54.8	70.2	8.72	8.23	0.34	10.2	0.91	2.96
Central	15-30	6.1	27.38	2.83	34.48	0.1	1	62.7	89.9	8.73	5.44	2.05	11.22	0.47	2.87
	30-45	6.4	21.09	2.18	33.33	0.4	1.3	22.1	59.5	8.06	7.75	0.23	13.9	0.63	2.91
	0-15	6.3	27.38	2.83	34.01	0.6	1.5	45.4	23.1	9.14	6.19	3.94	10.6	0.66	2.7
E/W	15-30	6.4	18.87	1.95	34.01	0.2	1.4	27.1	25.8	8.05	3.76	0.24	10.53	0.45	3.13
	30-45	6.5	17.39	1.8	34.78	0.1	1.1	26.3	38.3	7.81	3.12	0.22	10.63	0.74	2.83
	0-15	6.3	28.49	2.95	41.24	0.1	1.1	44.9	4.1	7.64	16.37	0,47	11.43	0.58	2.83
N/S	15-30	6.4	26.27	2.75	36.56	0.2	1	35	59.3	8.72	13.51	0.21	13.37	0.69	2.74
	30-45	6.5	22.2	2.3	36.14	0.2	0.8	22	7.6	8.06	3.51	0.2	7.86	0.64	2.96

N.B E/W= East/West; Ex. Acidity = Exchangeable acidity, N/S= North/South, Ext. Alkalinity = Extractable alkalinity, TN = Total Nitrogen, Mn, Fe, Cu, Zn (mg/kg), Ca, K, Mg, Na (cmol/kg)., TOC = Total Organic Carbon.

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Table 8: Mean of Soil Chemical Properties at AC, Ibadan

Depth (cm)	pH	TOC (g/kg)	TN (g/kg)	AVP (mg/kg)	Ex. Acidity (mg/l)	Ext. Alkalinity (mg/l)	Mn (mg/l)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/l)	K (mg/l)	Ca (cmol/kg)	Mg (cmol/l)	Na (cmol/kg)
0-15	6.25±0.50	28.03±0.65	2.90±0.07	37.11±1.54	0.25±0.12	1.53±0.17	39.08±9.57	39.53±15.58	8.53±0.32	9.01±0.66	1.24±1.22	11.02±0.38	0.10±0.29	2.95±0.08
15-30	6.28±0.08	23.5±2.01	2.43±0.21	35.43±0.69	0.15±0.03	1.20±0.12	32.43±11.93	51.83±14.62	8.26±0.29	6.62±0.21	0.66±0.46	10.85±1.05	0.69±0.16	2.90±0.09
30-45	6.43±0.05	19.24±1.43	1.99±0.15	35.06±0.65	0.20±0.07	1.13±0.11	18.78±4.80	34.33±10.68	7.99±0.06	4.42±1.11	0.21±0.01	10.42±1.29	0.81±0.14	2.97±0.06

Source: Fieldwork

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Table 9: Heavy Metal Distribution of the Soils at AC, Ibadan

Location	Depth (cm)	Pb (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Ni (mg/kg)
	0-15	5.80	9.5	10.35	17.1	15.37
Pit	15-30	4.93	9.45	7.8	7.15	14.71
	30-45	4. 41	5.85	2.85	16.95	6.06
	0-15	5.15	11	10.65	18.35	16.69
Central	15-30	4.30	10.4	9.65	17.3	16.14
	30-45	3.11	8.9	5.5	7.25	15.36
	0-15	8.13	11.6	14.05	9.75	13.80
E/W	15-30	6.87	10.7	11.25	18.7	13.09
	30-45	5.42	9.2	2.3	11.25	3.50
	0-15	6.19	11.85	18.05	7	14.10
N/S	15-30	2.78	11.25	13.4	6.65	9.79
	30-45	1.92	11	6.8	1.85	5.59

Source: Fieldwork

Table 10: Mean of Heavy Metal Distribution of the Soils at AC, Ibadan

Depth (cm)	Pb (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Ni (mg/kg)
0-15	5.66 ± 0.55	10.55 ± 0.36	13.58 ± 4.16	12.53 ± 3.17	12.53 ± 2.34
15-30	4.58 ± 0.68	10.23 ± 0.60	9.98 ± 2.57	12.1 ± 3.75	12.34 ± 2.19
30-45	4.52 ± 1.35	9.4 ± 1.33	9.76 ±1.00	10.18 ± 2.40	11.17 ± 3.55

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Table 11: Physical Properties of the Soils at AC, Ibadan

Location	Depth (cm)	Clay (g/kg)	Silt (g/kg)	Sand (g/kg)	Textural Class
	0-15	108	280	612	Sandy Loam
Pit	15-30	148	180	672	Sandy Loam
	30-45	128	140	732	Sandy Loam
	0-15	108	140	712	Sandy Loam
Central	15-30	208	180	652	Sandy Clay Loam
	30-45	248	140	592	Sandy Clay Loam
	0-15	148	260	592	Sandy Loam
E/W	15-30	268	180	552	Sandy Clay Loam
	30-45	288	180	532	Sandy Clay Loam
	0-15	88	180	732	Sandy Loam
N/S	15-30	68	200	732	Sandy Loam
	30-45	68	200	732	Sandy Loam

Table 12: Mean of Soil Particle Size Distribution at AC, Ibadan

Depth (cm)	Clay (g/kg)	Silt (g/kg)	Sand (g/kg)
0-15	113 ± 12.58	215 ± 33.04	662 ±35.12
15-30	173 ± 42.72	185 ± 5.00	652 ± 37.42
30-45	183 ± 51 23	165 ± 15.00	647 ± 50.58

Source: Fieldwork

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Conclusion

The study concluded that industrial activities are impacting on the soil quality with special reference to nutrient and heavy metal contents within and around industrial facilities. Soil Chemical properties, heavy metal distribution, and particle size distribution provided a base for considering the level of impacts industrial facilities have on soil qualities of receiving environments. Four categories of activities that could have affected soil properties or entire soil bodies included low level of enforcement of laws, environmentally unfriendly production methods, discharge of waste (solid, liquid, gaseous) and direct dumping on soils. Attention needs to be given to sustainable land use, safe production methods, increased level of monitoring of industrial operations to ensure they comply with extant laws, policies, standards and regulations that protect environmental quality.

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