Journal of Global Ecology and Environment
5(1): 1-10, 2016
ISSN: 2454-2644

International Knowledge Press
www.ikpress.org

EFFECTS OF INDUSTRIAL EFFLUENTS ON SOIL RESOURCE IN CHALLAWA INDUSTRIAL AREA, KANO, NIGERIA

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Authors EAO and VNO got the concept and design of the study. Author VNO carried out the chemical analysis and drafted the very first version of the manuscript. Author IA participated in the acquisition of data, drafting of the manuscript. Author SIRO carried out the statistical analysis, participated in the interpretation of the results and did the critical revision of the final version for important intellectual content. All authors gave a final approval of the revised version.

Received: 27th March 2016
Accepted: 12th May 2016
Published: 21st July 2016

Original Research Article

ABSTRACT

The study was aimed at determining the effects of industrial effluents on the soil environment of Challawa industrial area, Kano State Nigeria. Profile pit soils were sampled in the areas affected by industrial effluents and the adjacent control area. Sampled soils were carried to the laboratories for physical (sand, silt and clay) and chemical (pH, OC, AP, Ca, Mg, K, Na, N, ECEC) properties determinations. The result of the analysis showed that different horizons of the affected pits had less sand than what was obtained at the unaffected pit (average 615.78 and 670 respectively), Apart from pH, nitrogen, available phosphorus content of the soils that were lower at the horizons from the affected area of the industrial site(on the average, pH 6.45; N- 0.20 g/kg; AP- 3.97 mg/kg), all other chemical properties (exchangeable bases like Ca (1.15 cmol/kg), Mg (0.4 cmol/kg) and Na (0.23 cmol/kg) were lower at the horizons of the unaffected profile pits. Other physical and chemical properties of the soils collected like the pH, organic carbon, total nitrogen and available phosphorus, Ca, Mg, K and Na were low in some pits and in some pits had higher concentration at the affected area. The revelation from the analysis showed that the top and upper horizons of the soil at the industrial site has been seriously tampered with by industrial effluents and inhabitants should be advised to plant mostly shallow rooted crops and cultivate on land farther away from the effluent sludge.

Keywords: Industrial effluents; soil profile; environmental pollution; land.

1. INTRODUCTION

Environmental issues have become important to the scientist as it is to the politician, the business man and to the football administrator. The reason for this state of affair is not far- fetched, for it is within this twenty first century that the activities of man inhabiting the earth has adversely affected the planet. Such activities

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include: industrialization, the use of atomic bomb, nuclear plants, arsenal of mass destruction or killings, improvements in agriculture, health, food processing, the cars, jet and space travels, the plastics revolution, deforestation and desertification, information technology and many others. All of them with their attendant or accompanying stresses on the environment. The compelling need for the awareness of these problems is imperative in the sense that environmental pollution does not respect geographical or political boundaries. For instance, gases released in England caused defoliation in Sweden. Toxic effluent discharged or released to River Niger in Mali can be harmful downstream in Nigeria [1]. Also in recent times, there has been a global traffic of toxic wastes [2]. Effect of industrial effluents is one of the most important problems around the world in which thousands of millions of world inhabitants suffer health problems [3]. The recent years have witnessed significant attention being paid to the problems of environmental contamination by a wide variety of chemicals including the trace metals [4]. Trace metals enter into our environment from both natural and anthropogenic sources [4]. They contaminate food sources and accumulate in both agricultural products and sea foods through water, air and soil contamination [5]. All trace metals are toxic at soil concentration above permissible levels [5]. The addition of these metals to the soil may affect the microbial proliferation and enzymatic activities; this may possibly lead to a decrease in the rate of biochemical processes in the soil environment. The effect of trace metals on biochemical reaction in soil may vary with pH, organic matter content, particle size distribution, vegetation and-total hydrocarbon content [6]. The development of technology is pursued with increasing intensity as a way of remedying ailing economies. In Nigeria, new industries are emerging to reverse the current unpleasant trends in the economy [7,8]. The growing intensity of industrialization inevitably imposes an increasing burden on the environment as both the source of raw materials and the depositor of all effluents [8]. The wide range of new processes, raw materials and wastes rejected in association with emergent technologies in industries expose the environment and society to increasing contamination and related hazards [8]. There is a progressive contraction in the free space available for comfort and safe occupation. The contamination of land, water and food is progressive and imposes new and intensifying demands on the management of resources and services [8]. The ultimate danger posed by either an unmanaged or poorly managed industrializing society is cumulative, emerging as the sum of contributions from individual type of industries. The efficient management of the environment and risks arising from pollution has as a reference point the rules and regulations of the agencies of government charged with responsibilities for the same. Industrial processes such as steel making, chrome plating, dye and pigments, leather tanning processes and wood preservation are common sources of acute environmental pollution if not properly controlled [8]. The movement of destructive materials into soil and ground water through disposal of wastes, discharge of effluents from industries, or release of chemicals through agricultural activities has led to increased vulnerability of ground water and soil [9]. In Challawa industrial area of Kano, many industries are sited, notably, the beverage industries, the leather industries, the textile industries, and many others which have gone out of production due to one reason or the other.

This research therefore sought to determine the extent of harm done to this area by comparing the quality of soils of different soil profile pit at the affected area with those of the unaffected area.

2. METHODS

The site for soil profile pit sampling for the affected area was at a distance of 04 m, 104 m and 204 m away from the effluent sludge site and was 95 m away from the river bank. The geo-reference of the area was latitude N11°52.756^{I}, longitude E 008°28.296^{I} and the elevation was 432m. The sites were cleared and exposed. The pits were dug 2 m length, 1 m width and 1.98 m depth. The water table was at the depth of 1.98 m. The soil profile pits were, cleared and sampled according to various horizons. The faces of the pits were cleaned carefully with a spade, noting the succession of the horizons.

About nine natural horizons were noticed in the first profile pit, six in the second and five in the third profile pit at the affected area, while four horizons were noticed at the pit at the unaffected area. The horizons were carefully demarcated from each other with the aid of a knife as shown on Plates 1 and 2. The surface was pricked with a knife to show the structures, colours and compactness. The samples were collected starting from the bottom-most horizon first (to avoid contamination) by holding a large basin at the bottom-limit of the horizon while the soil above is loosened by a khupi. Soil from different horizons were collected differently and put in separate polythene bags with labels and sent to the laboratory for analysis.

Plate 1. Affected area marked for sample collection

Plate 2. Digging of a typical Profile pit

2.1 Laboratory Analysis

Some of the physical and chemical parameters of the samples (sand, silt, clay, pH, Organic matter, Total Nitrogen, Available Phosphorus, Exchangeable Bases, Exchangeable Acidity and Cation Exchange Capacity were analysed using appropriate methods: sand, silt and clay by hydrometer method (Separation by sieving), organic matter by Colorimetric method using Colorimeter [10], Nitrogen by [11] (using Tecator model 1016 digester in conjunction with model 1012 autostep controller), ECEC by ammonium acetate saturation using Aeration units [12]. Available Phosphorus by Ammonium Molybdate method [13], Exchangeable Bases was done using Atomic Absorption Spectrophotometer.

3. RESULTS AND DISCUSSION

The effects of industrial effluent on some chemical and physical properties of soil resources at the Challawa industrial area are described in Tables 1-5.

Sand from the horizons of the unaffected area, decreased down the horizon as shown on Table 1. This may not be unconnected with the effects of industrial effluents. The coarse texture of the soils in these horizons conferred on the soils poor nutrient and water retention ability and low structural stability which aid high erosion and makes the land vulnerable to degradation [14]. The profile horizons may possibly have greater infiltration capability than the top soil and so greater chances of the effluent being transported down the horizons. This may also account for the depth of erosion noticed in the area.

In a similar vein, silt content at the horizon of the profile pit not affected by industrial effluent decreased down the horizon (120 g/kg at 1st horizon to 100 g/kg at 4th horizon as shown on Table 1), it also decreased at different profile pits as one moves away from the sludge (340 g/kg at 4 m and 140 g/kg at 204 m) as shown on Table 4. At the top soil, silt content was more at the area not affected by effluents than at the area affected (362.4 and 322.7 g/kg) respectively as shown on Table 1. There was a significant difference between the concentrations. High presence of silt at different horizons of profile pits at the affected area confirmed the fact that these effluents contain a lot of silt which may have come from the tanneries and beverage industries, possibly from skin and food components which was still less than what was obtained at the unaffected area. In a similar vein, the value of silt at the top soil in the area affected was significant at $p>0.05$ as shown on Table 4. This result in the soils at the affected area being more friable than the one at the unaffected area and so will promote greater agricultural yield as shown on Plate 1 [11,15]. The silt content at the top soil was higher than what was obtained at the profile pits (535.5 g/kg against 340 g/kg at the affected site and 561.2 g/kg against 120 at the unaffected sites. The clay content of the sampled soils increased down the horizon of the profile pits. Comparatively, the value of clay at the site not affected by industrial effluent increased higher down the horizon than that obtained at the site affected by effluent. Generally, the soil texture in these areas is sandy loamy.

3.1 Chemical Properties of Profile Pits Soil

The Table 1 shows that pH was generally higher in the soils collected from area not affected by effluents (6.9) than in the area affected by effluents (6.1). There was no significant difference in the value of pH at horizons of pits at the affected and the unaffected areas. The value of pH increased as the distance of pit from the sludge increased. At pit 204 m from the sludge, the value of pH was 7.4. There was also no significant difference between the pH (water) and pH ($CaCl_2$) along the different horizons of the different profile pits at both areas. In most soils, pH tends to increase with depth because the upper horizons receive maximum leaching by rainfall and by dissolved carbonic acids which remove metal cations

(Ca^{++}, $K^{+,}$ Mg^{++}) and replace them with H^+. Lower horizons are not strongly leached [16]. The acidity of soils from the affected pits may be as a result of the presence of aluminum. Aluminum contributes to the acidity of soils because, when Al^{3+} is displaced from an exchange site into the soil solution, it hydrolyses splitting water into hydrogen ion (H^+) and Oxygen (O) and releasing a hydrogen ion to solution [16].

$$Al^{3+} + H_20 = Al0H^{2+} + H^+$$

Organic and chemical fertilizers may make soil more acidic. Hydrogen is added in form of aluminum based fertilizers [NH_4^+], Urea based fertilizers (Co $\{NH_2\})_2$ and as protein (amino acid) in organic fertilizer. Transformation of these sources: N in nitrates (NO_3) releases H^+ to create soil acidity. Therefore, enrichment with fertilizer containing ammonium or even adding large quantity of organic matter to a soil ultimately increases the soil acidity and lowers the pH [17]. This may have possibly caused the top soil to have lower pH than the soils from profile pits as shown on Table 2. Increase in exchangeable bases; Ca and Mg in the soils of the horizons affected by the effluent as shown on Tables 1, 2, 3 and 4 may have neutralized part of the acidity, thereby increasing the pH. The organic content can also react with aluminum to form aluminum complexes [18,19], thereby reducing the potential acidity of the soil. Apart from the industrial effluents which greatly contribute to the increase of micronutrients in the soils, some nutrients also are available in more acidic ranges [20-22], which may also have contributed to the increase in higher level of micronutrients in the soil. The acidity of the top soils was significant at $p>0.05$. The acidity, pH ($Cacl_2$) of the soils was lower than that of pH (water). Table 1-4 shows that the soils at affected and unaffected areas have low pH.

Organic carbon was comparatively lower at the horizons of the pit at the area not affected by the industrial effluent than at the area affected as shown on Tables 1 - 4. The highest value of organic carbon was obtained at the first horizon of the pit 4 m from the sludge (5.4 g/kg), while the lowest was at the first horizon of the pit 204 m from the effluent sludge (0.2 g/kg) as shown on Tables 2 - 4. There was no significant difference between the levels of organic carbon at the first horizon of the pit at the area affected and the value obtained at the top soil, but there was a significant difference between the values obtained at the top soil of the area affected and that of the area not affected (0.79 g/kg and 5.55 g/kg respectively). Comparatively, the soils from the pits that were not affected had lower carbon content than those from the affected area. The high level organic matter at the affected areas agrees with Chakraborty [23,24] findings that 79–80% of the total dissolved volatile solids in the settled and filtered composite tannery wastes is composed of organic matter present in the form of protein compounds. Harihara et al. [25] also confirmed this. The mean value of top soil organic carbon in the unaffected area was 76% while that of the area affected was 55.5% and the change % was 630%. The low carbon content of the soil from unaffected area agrees with those of the soils in West African savanna [26]. This can be attributed to high rates of mineralization and disappearance of organic matter in Tropical climate. Burning of crops residues, grasses and erosion before the commencement of next planting season, may have also contributed to low organic content at the unaffected area. At the affected area, the organic content at the top soil was significant at ($P<0.05$).

Plate 3. A typical soil profile pit in area affected by industrial effluent discharge

Nitrogen content of the soil obtained at area not affected and area affected by effluent decreased down the horizon (0.4 g/kg - 0.1 g/kg) respectively except in the fourth horizon where there was an increase (1.3 g/kg) as shown in Tables 1-4. The value of nitrogen decreased as the distance of pits moved away from the sludge. At the pit 4 m away from the sludge, the value was 0.6 g/kg, at 104 m away, the value was 0.4 g/kg while at 204m, and the value was 0.1 g/kg as shown on Tables 2 - 4. The value of nitrogen at these areas was not significantly different from each other. Based on the complaints by the inhabitants of the area that their agricultural produce decreased by day, it shows that the available nitrogen is still being tampered with by the industrial effluent which manifests in the pale green or yellow colour of the leaves of the produce which is a sign of nitrogen deficiency as shown on Plates 1, 5 and 6 [23]. Though the value of nitrogen at top soil of the affected area was higher than that at the unaffected area, the concentration was not significant as shown on Table 5.

There was no significant difference between the soils collected from the affected and unaffected areas of the sites in terms of their available phosphorus content as shown on Table 1 - 5. The element had a low value of change % of 3.7% at the top soil as shown on Table 5. According to Brady and Weil [21,27], one of the factors that influence the availability of phosphorus is soil pH. AP becomes much more available at pH levels between 6.0 and 8.0 while it becomes less available at lower pH (< 6.0) where the element is liable to be fixed by Al, Fe and Mn [19,20,24,28]. Since the pH (water, $CaCl_2$) of the soils at the unaffected area is higher than that at the affected area, then, the former had higher AP as shown on Table 1- 4. The available phosphorus at the area not affected by effluent decreased down the horizon (8.4 g/kg - 3.7 g/kg), but it increased at the area affected down the horizon (3.0 g/kg- 3.3 g/kg) as shown on Table 1- 4. There was no significant difference in the concentration of available phosphorus at different pits but the effects of the effluents on the soil affects the vegetation in the area as shown on Plates 5 and 6.

a. Affected profile pit at site A

b. Affected profile pit at site B

c. Affected profile pit at site C

d. Unaffected profile pit at site D

Plate 4. Profile of the various pits

Plate 5. Soil and bushes affected by effluents

Plate 6. Farmland destroyed by industrial effluent

Table 1. Soil profile data from area not affected by industrial effluent

Horizons	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Texture	pH (water)	pH $CaCl_2$	OC (g/kg)	N (g/kg)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	ECEC (cmol/kg)
1	760	120	120	SL	6.9	6.6	2.4	0.4	8.4	1.0	0.4	0.0	0.3	1.4
2	720	100	180	SL	6.8	6.6	1.8	0.2	5.1	1.2	0.1	0.0	0.3	1.6
3	600	100	300	SL	6.9	6.4	2.2	0.1	4.6	1.2	0.4	0.0	0.2	1.8
4	600	100	300	SL	6.5	6.2	2.8	1.3	3.2	1.2	0.4	0.0	0.2	1.8

OC=Organic carbon; N=Nitrogen; AP=Available Phosphorus; ECEC=Effective Cation Exchange Capacity; SL= sandy loam

Table 2. Soil profile data from the area affected by effluents at 4m from effluent sludge

Horizons	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Texture	pH (water)	pH $CaCl_2$	OC (g/kg)	N (g/kg)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	ECEC (cmol/kg)
1	560	340	100	SL	6.1	5.2	5.4	0.6	3.0	3.2	0.8	0.1	0.1	4.1
2	440	400	160	L	5.9	5.2	5.0	0.5	3.2	2.6	0.7	0.2	0.1	2.9
3	480	360	160	L	6.6	6.2	3.2	0.4	3.3	2.2	0.6	0.2	0.6	3.5
4	620	260	120	SL	6.9	6.4	1.8	0.4	3.3	1.8	0.5	0.1	0.4	2.8
5	780	140	80	SL	6.8	6.2	1.6	0.1	3.0	0.6	0.2	0.0	0.2	1.0
6	860	60	80	LS	6.7	6.2	5.0	0.4	4.2	1.0	0.3	0.0	0.1	1.4
7	640	220	140	SL	6.7	6.5	0.6	0.1	4.6	1.6	0.4	0.1	0.1	2.2
8	680	180	140	SL	6.5	6.1	1.8	0.1	4.7	1.8	0.5	0.1	0.1	2.4
9	720	140	140	SL	6.6	6.0	0.4	0.1	6.5	2.8	0.6	0.1	o.1	3.6

OC=Organic carbon; N=Nitrogen; AP=Available Phosphorus; ECEC=Effective Cation Exchange Capacity; SL= sandy loam

Table 3. Soil profile data from the area affected by effluent at 104m from effluent sludge

Horizons	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Texture	pH (water)	pH $CaCl_2$	OC (g/kg)	N (g/kg)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	ECEC (cmol/kg)
1	560	320	120	SL	6.1	5.3	3.0	0.4	3.0	1.6	0.2	0.0	0.1	2.0
2	540	340	120	SL	5.9	5.5	0.2	0.1	3.3	1.6	0.3	0.0	0.1	2.0
3	460	360	180	L	6.0	5.6	0.2	0.1	3.3	1.4	0.6	0.0	0.1	2.1
4	580	140	280	SCL	5.0	4.4	4.0	0.1	2.6	1.4	0.5	0.1	0.1	2.1
5	560	320	120	SL	5.8	5.4	3.2	0.3	4.2	1.0	0.4	0.0	0.1	1.5
6	320	500	180	L	6,0	5.3	6.2	0.5	5.4	3.2	0.5	0.1	0.2	4.0

OC=Organic carbon; N=Nitrogen; AP=Available Phosphorus; ECEC=Effective Cation Exchange Capacity; SL= sandy loam

Table 4. Soil profile data from the area affected by effluents at 204 m from effluent sludge

Horizons	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Texture	pH (water)	pH $CaCl_2$	OC (g/kg)	N (g/kg)	AP (mg/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	ECEC (cmol/kg)
1	700	140	160	SL	7.4	6.2	0.2	0.1	3.9	2.2	0.6	0.0	0.8	3.5
2	760	160	80	SL	7.1	6.2	0.2	0.1	2.8	0.4	0.2	0.0	0.4	1.0
3	560	360	80	SL	7.4	6.7	0.8	0.1	1.6	0.8	0.3	0.0	0.7	1.8
4	740	160	100	SL	6.8	5.7	0.8	0.1	2.5	1.1	0.3	0.0	0.1	1.6
5	660	240	100	SL	6.3	5.7	1.2	0.1	3.2	1.2	0.3	0.0	0.1	1.6

OC=Organic carbon; N=Nitrogen; AP=Available Phosphorus; ECEC=Effective Cation Exchange Capacity; SL= sandy loam

NOTE:

H. depth - Horizon depth
OC - Organic carbon
N - Nitrogen
AP - Available phosphorus
ECEC - Effective Cation Exchange Capacity

Table 5. Summary of top soil variables

Soil var.	Mean				Soil data interpretation		
	Area unaffec.	Area affected	t-value	% change	Low%	Medium%	High %
Sandg/kg	562±24.38	535.5±109	-1.2	4.6			
Siltg/kg	362±23.32	322.7±51.6	-3.7	11			
clayg/kg	78.8±12.69	141.6±0.81	9.7	81			
pH(H2O)	7.81±0.39	6.3±0.86	-13	20	8.5-9	5.6-6	<4.5
pH(cacl2)	6.92±0.46	5.69±0.86	-9.1	18	,,	,,	,,
OC(g/kg)	0.76±0.46	5.55±3.96	10	630	<2	2 to 3	>3
N(g/kg	0.15±1.48	1.02±2.16	7.1	580	0-1.5	0.15-0.2	>0.2
APmg/kg	5.09±1.48	5.29±2.16	0.5	3.7	0-10	10 to 20	>20
Ca(cmol/kg)	1.12±0.52	2.32±1.73	5	94	0-2	2 to 5	>5
Mg(cmol/kg)	0.31±0.14	0.83±0.72	5.9	165	0-0.3	0.3-1	>1
K(cmol/kg)	0.9±0.07	0.1±o.06	-5.6	89	0-0.15	0.15-0.2	>0.3
Na(cmol/kg)	1.06±0.09	0.25±0.14	-4.5	76	0-0.1	0.1-0.3	>0.3
ECECcmol/kg	3.46±1.56	3.48±2.59	0	0.6	<4	4 to 10	>10

Within the horizons of profile pits affected by the effluent, the exchangeable bases; Ca, Mg, K and Na were significantly higher than what was obtained at the horizons of the control area as shown on Tables 1- 4. This shows that the effluents are laden with Ca, Mg, K and Na. This is evident on Plate 1 and 4 which shows how the effluent destroyed farmland of the inhabitants. The acceptable base saturation limit for sodium is 15% (exchangeable sodium percentage). Exchangeable percentage higher than 15% results in soil dispersion, poor water filtration and possibly sodium toxicity to plants. The reverse happens when it is low [29]. The lower content of these elements at the unaffected area may be attributed to high pH. At higher pH, the solubility of plant nutrient is induced. But, soil pH does not affect nutrient availability in soils and nutrient uptake by plants [30].

Similarly, in the top soil, Ca and Mg were significantly higher at the affected area than at the unaffected area while K and Na were lower at the affected area than at the unaffected area as shown on Tables 1-4. The concentration decreases as one move away from the dump as shown on Tables 2-4. The concentration at the sampled areas was not significantly different from each other at $P<0.05$ and their concentration were not also significant. K is a monovalent cation while Ca and Mg are divalent, therefore the bond or force of attraction between K and soil micelle is weaker, and so the cation is much more susceptible to leaching than exchangeable Ca and Mg. Their individual concentrations and ratios also affect the availability of one another. It was observed that the exchangeable bases had their highest values at the top soils and at the first horizons of the profile pits. These values decrease down the profile and as one move away from the effluent sludge. The change percentages of these metals (Ca, Mg, K, and Na) are; 94%, 164.5%, 88.9% and 76% respectively.

Effective Cation Exchange Capacity in the horizons of profile pits area not affected by the effluent was lower than that at the affected area as shown on Tables 2-4, although at the top soils, there was no difference in their values at different distances from the effluent sludge, generally, the presence of ECEC in both the affected and unaffected area was not significant at $p>0.05$. The mean value of top soil ECEC at the site not affected by industrial effluent was 3.45% (Table 1) while that of the area affected was 3.48% (Tables 2-4). Their change % difference was 0.58%. The ECEC was highest at the affected pit 4m away from the effluent sludge (4.1 cmol$^-$kg) and decreased down the horizon as shown on Table 2. There was no significant difference between the concentrations obtained at different horizons of the pit not affected by effluent as shown on Table 1 but there was a significant difference at the top soils. The value of ECEC decreased as pits shifted away from the sludge. The moderate value of ECEC at the affected area goes to buttress the claim that tannery sludge could be an excellent material for soil amendment as it was found to improve the physical properties of soil and contain considerable amount of plant nutrient [23,31-35]. The low value of ECEC is an indication of activity of clay characteristic of Kaolinite [36,37]. The relative ability of soils to store one particular group of nutrient, the cation is referred to as Cation Exchange Capacity [38-40]. Cation held on the clay and organic matter particles in soils can be replaced by other cations, thus, they are exchangeable, example, potassium can be replaced by cation such as Ca or H. The total number of cation a soil can hold or its negative charge is the CEC [39,40]. The increase in CEC leads to increase in negative charge, this increase the amount of cation that can be held. Increase in organic matter content of a soil increases its CEC.

4. CONCLUSION

This study has revealed that the soil quality at the industrial area is significantly influenced by effluent discharge from the industries (Tanneries, Beverage and Textile) located in the area. The presence of great values of some physical and chemical elements that were above the standard laid by the monitoring bodies for these industries underscores the need for the monitoring bodies to ensure that these industries treat their effluent thoroughly in – house before sending them out to the environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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