Comparative Analysis of Different Physical and Chemical Components on Different Horizons of Soil Profile Pit in Challawa Industrial Area and Adjacent Area not Affected by Industrial Effluent.

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ABSTRACT

The effects of Industrial effluents on the soils and water resources of Challawa Industrial Area, Kano, Nigeria was studied by assessing the physical and chemical characteristics of natural horizon of profile pits and profile pits at different distances from the effluent sludge. Different samples were collected and analyzed with High Powered Atomic Absorption Spectrophotometer. The results showed that for the soils collected at the area not affected by effluents, sand, silt, and clay of the profile pits decreased down the horizons. Also, OC, Ca, Mg, K, Na, and N decreased down the horizons. pH was generally high across the horizons and there was no significant difference in the concentration of pH and ECEC. At the area affected by the effluents, sand increased down the horizons and with distance away from the sludge, OC, Ca, Mg, K, Na, ECEC and N were high and decreased down the horizons and with distances away from the pit, although, pH and AP increased down the horizon and with distance away from the sludge.

(Keywords: soil contamination, industrial effluent, physical and chemical profile, environmental analysis)

INTRODUCTION

Effect of industrial effluent is one of the most important problems around the world in which billions of world inhabitants suffer health problems (Martinez *et al*., 2001). 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.

The trace metals enter into our environment from both natural and anthropogenic sources (Katabapendias and Pendias, 1986). They contaminate food sources and accumulate in both agricultural products and sea foods through water, air and soil contamination (Lin *et al.,* 2004). All trace metals are toxic at soil concentrations above permissible levels. 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 reactions in soil may vary with pH, organic matter content, particle size distribution, vegetation, and total hydrocarbon content (Esser *et al*., 1991).

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 (Dike, 1991 and UN, 2011). The growing intensity of industrialization inevitably imposes an increasing burden on the environment as both the source of raw materials and the recipient of all effluents (UN, 2011). 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 (UN, 2011).

AIM AND OBJECTIVES

The aim of this study was to investigate the effects of the industrial effluents on the soil environment of Challawa industrial area of Kano, Nigeria. The aim is achieved through the following objectives:

i. To characterize the physical and chemical components of different horizons of profile pit soil at the area not affected by industrial effluent.

ii. To assess the quality of different horizons of soil profile pit at the area affected by industrial effluent.

iii. To characterize physical and chemical components of different profile pits at different distances from the effluent sludge.

METHODOLOGY

Profile Pit Soil Sample Collection

The site for the soil profile pit sampling for the affected area was at a distance of 4m, 104m, and 204m away from the sludge site. The pits were 95m away from the river bank. 95m was the distance of the sludge from the river bank. Geo-reference of the area was lat. N11^{0}52.756^l, long. E 008^{0}28.296^l and the elevation was 432m.

Plate 1: Digging of Soil Profile Pit at the Affected Site.

The site was cleared and exposed. The pit was dug 2m length, 1m width and 1.50m depth. The soil profile pits were, described and sampled according to various natural horizons. One face of the pit was cleared carefully with a spade, noting the succession of the horizons.

Plate 2: A Typical Soil Profile Pit in Area Affected by Industrial Effluent Discharge.

About six natural horizons were noticed in this profile pit and they were carefully demarcated from each other with the aid of a knife. The surface was pricked with a knife or edge of the spade to show structures, colors, and compactness.

The samples were collected starting from the bottom-most horizon first (so as 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 was collected differently and put in separate polythene bags with labels and sent for analysis. The analysis was done with a high powered spectrophotometer.

The pit at the control area was dug far away from the industrial area and about six horizons were identified. The samples were also collected and sent for analysis.

RESULTS

Table 1: Soil Profile Pit Horizons Data from Area not Affected by Industrial Effluent.

Horizons	Depth cm	Sand g/kg	Silt g/kg	Clay g/kg	Text Ure	pH (Hw)	pH $CaCl_2$	OC g/kg	N g/kg	AP Mg/kg	Ca cmol/g	Mg cmol/g	K cmol/g	Na cmol/g	ECEC cmol/g
1.	0-28	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.	28-49	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.	47-61	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.	61-100	600	100	300	SL	6.5	6.2	2.8	1.3	3.2	1.2	0.4	0.0	0.2	1.8

Table 2: Mean Concentration of Particles on Soil Pit Horizons from the Area Affected by Industrial Effluent.

Horizons	Horizon depth	Sand g/kg	Silt g/kg	Clay g/kg	Texture	pH (w)	pH CaCl2	OC g/kg	N g/kg	AP mg/kg	Ca cmol/g	Mg cmol/g	K cmol/g	Na cmol/g
1	10-22cm	606.7	266.7	126.7	SL	6.53	5.57	2.87	0.37	3.3	2.3	0.53	0.03	0.23
2	22-35cm	580	300	120	L	6.3	5.63	1.8	0.23	3	1.5	0.4	0.07	0.2
3	35-54cm	500	360	140	L	6.67	6.2	1.4	0.2	2.7	1.46	0.5	0.06	0.46
4	54-76cm	646	186.6	166.6	SL	6.2	5.5	2.2	0.2	2.8	1.43	0.43	0.03	0.2
5	76-87cm	666.6	233.3	120	SL	6.3	5.76	2	0.6	4.1	0.93	0.3	0	0.13

Table 3: Mean Concentration of Particles in Different Profile Pits.

	Sand g/kg	Silt g/kg	Clay g/kg	pH (w)	pH $CaCl_2$	OC g/kg	N g/kg	AP Mg/kg	Ca Cmol/g	Mg cmol/g	K cmol/g	Na cmol/g	ECEC cmol/g
Not affected	670	105	225	6.8	6.5	2.3	0.5	3.4	1.1	0.4	0.0	0.2	1.6
Affected;													
04m	660	226.7	133.3	6.6	6.1	2.6	0.3	4.5	1.9	0.5	0.0	0.2	2.7
104m	503.3	330	166.7	5.8	5.3	2.8	0.2	3.7	1.7	0.4	0.0	0.1	2.3
204m	684	212	104	7.0	6.1	1.0	0.1	2.8	1.1	0.3	0.0	0.4	1.9

Note;
OC – Organic Carbon
N – Total Nitrogen
AP – Available Phosphorus
Ca, Mg, K, Na – Exchangeable Cations
ECEC – Effective Cation Exchange Capacity

DISCUSSION

Industrial effluents have greatly modified the quantity of sand in the affected area in contrast to what was obtained at the adjacent unaffected area. At the profile pits, the quantity of sand obtained at the area not affected by the effluents decreased from the first profile horizon (760g/kg) to the fifth horizon (600g/kg) as shown on Table 1.

At the profile pits at different distances (04, 104 and 204m) from the effluent sludge, the quantity of sand increased as one moves away from the sludge (670g/kg at 4m to 684g/kg at 204m) and also increased down the horizon (606.7g/kg at 1st horizon to 666.6g/kg at 5th horizon) as shown on Tables 2 and 3. This shows that the addition of industrial wastes has reduced the proportion of sand particles and also increased the proportion of silt particles from 105g/kg (1st pit) to 212g/k (3rd pit). However, the quantity of silt decreased down the profile pit at the areas affected and unaffected. Hence it shows that the industrial waste particles mostly have the same size (0.002 – 0.02 cm) with silt particle size.

The difference in the value of the quantity of sand at the unaffected and the affected area was further buttressed by the wide gap between their standard deviations (24.28 and 108.9). T- test revealed a significant difference at $p>0.05$. The soils from different horizons of profile pits at the affected area had less sand than the soils from the horizons of the unaffected area). 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 erodibility and makes the land vulnerable to degradation (Aruleba and Ogunkunle, 2006). 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. T-test analysis confirmed the high value of sand in the industrial area. This may also account for the depth of erosion noticed in the area.

High presence of silt at different horizons of profile pits at the affected area confirmed that these effluents contain a lot of silt which may have come from the tanneries and beverage industries, possibly from skin and food component. The silt content at the first horizon of the profile pit at the area not affected by effluent is 120g/kg while at area affected is 266.67g/kg, but this value decreases as one moves away from the sludge of effluent (105g/kg). The silt content decreases down the horizons at the affected area, increases with distance and decreases at the area not affected by effluent. This results in the soils at the affected area being more friable than the one at the unaffected area and so will promote greater agricultural yield (Chackra, 1972; Mckee, 1973; Chapman, 1963).

The soil acidity at the first horizon of the profile pit at the affected area is slightly acidic (6.53pH$_{(H20)}$ 5.57pH$_{(Cacl2)}$) as against the neutral of 7.4 – 7.8 requirement for a good soil. Effect of industrial effluent may have caused the excessive use of fertilizer on the soil. Organic and chemical fertilizer can make soil more acidic. Hydrogen is added inform of aluminum based fertilizer, urea based fertilizer and as protein in organic fertilizer. Therefore, enrichment with fertilizer containing ammonia or even adding large quantity of organic matter to the soil ultimately increases the soil acidity and lowers the pH. Increase in the exchangeable bases at the horizons also increases the pH. The pH decreases down the horizon. At the affected and unaffected areas area, acidity decreases down the horizon and with distance away from the sludge.

The organic carbon ranged between 2.87g/kg – 2.0g/kg (first and the last profile pits respectively) at the affected area. This high carbon content agrees with Chakra's (1972); Harihara et al. (1987). The organic carbon decreased down the horizon and with distance. At the area not affected by effluent, organic carbon increased down the horizon. The result of the organic carbon content as shown in Table 3 revealed that the carbon content of the profile pits was generally high. 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 Chakras findings of 1972, 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, fatty acids, ether soluble tannins, and 20.21% composed of other organic compounds. The work done by Harihara *et al*., (1987) also confirmed this.

The low carbon content of the soil from unaffected area agrees with those of the soils in West African savanna (Jones and Wild, 1975).This can be attributed to high rates of mineralization and disappearance of organic matter in Tropical climate. Burning of crop residues and grasses before the commencement of next planting season and erosion may have also contributed to low organic content at the unaffected area

Comparatively, soils from the unaffected (control) site of pit soils had the highest nitrogen content than those from the affected area (0.4g/kg and 0.37g/kg) respectively. The low value of nitrogen at these affected areas may be attributed to the effect of the effluent in the area. Apart from soils from 204m distance, the level of nitrogen in these areas was not significantly different from one another (Table 1,2 and 3). Since the concentration of nitrogen in the control soil was more than was found in the affected areas, one is left with no option than to believe that decrease in the nitrogen content in the affected areas was caused by industrial effluents.

Because N is mobile within the plant, deficiency symptoms are expressed in older leaves. These leaves are generally pale green or yellow. When N is limited, crop growth is slow and yields are reduced (MSV Care Header, 2010). This confirms the complaint by the inhabitants of the area that there is great reduction in their agricultural production which progresses as years go by.

There was low significant difference between the soils collected from the affected and unaffected areas of the site in terms of their available phosphorus content. The element had a low value of change of 3.79%. According to Brady and Weil (1996) and Landon (1991), one of the factors that influence the availability of phosphorus is soil is its pH. It 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 (Euroconsult, 1985; Mizota and Van Reeuwijk, 1989). Since the pH (H_2O, $Cacl_2$) of the soils at the unaffected area is higher than that at the affected area, then, the former had higher AP (table 1, 2). AP decreases down the horizon at the unaffected area and away from the sludge but increased down the horizon at the affected area.

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 (Tables1, 2). This shows that the effluents are laden with Ca, Mg, K and Na.

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 (Spectrum Analytical, 1997).

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 (Agboola and Corey, 1973). Similarly, at 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 (Tables 1 and 2). The concentration decreases as one move away from the dump (Table 3). The concentration at the sampled areas was not significantly different from each other at $P<0.05$ and their concentration were not also significant.

Exchangeable Ca is higher than Exchangeable Mg, K. and Na because, Ca is more strongly bound to the exchangeable sites than Mg, K, and Na (Beckett, 1965). Furthermore, 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. Again, their individual concentrations and ratios 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.

Similarly, Effective Cation Exchange Capacity in the horizons of profile pits at the affected area showed great difference than what was obtained at the area not affected by the effluent (Tables 1 and 2).. But generally, the presence of ECEC in both the affected and unaffected area was not significant.

CONCLUSION

The overall results showed that the activities of the industries have greatly influenced the chemical and physical characteristics of the soil at the industrial area. This pollution of the soil by industrial effluent decreased down the horizons with the exception of nitrogen and available phosphorus. Although sand increased, silt and clay decreased down the horizons.

RECOMMENDATION

1. There is great need for serious enlightenment program by all stake holders.
2. Strict enforcement measures on the defaulting industries in treating their effluent in- house before sending them into the environment be encouraged and siting of residential quarters at industrial areas should be prohibited.
3. The industries should be forced to always subject their effluent for analysis by research students and the monitoring bodies.
4. Farmers in the area should be advised to cultivate deep rooted crops as pollution decreases down the horizons

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