

Effect of Activities at the Gboko Abattoir on Some Physical Properties and Heavy Metals Levels of Surrounding Soil

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Abstract

The study determined the levels of some heavy metals and pH, organic matter and particle size distribution of soil within the vicinity of Gboko abattoir. Soil samples were collected at depth of 0-20 cm and analyzed using standard laboratory methods. The results of AAS analysis of the heavy metals showed that the soil had mean value of Zn²⁺ 3.0195 ppm, Pb²⁺ 0.5413 ppm, Ni²⁺ 0.1949 ppm, Cr³⁺ 0.1134 ppm and Cd²⁺ 0.0185 ppm. These values were higher than similar results obtained from the control soil but the mean levels of the metals were lower than the permissible limits set by the Nigerian Department of Petroleum Resources (NDPR) and European Union (EU) respectively. The soil heavy metals were positively correlated. The mean pH of the soil (6.03) indicates acidity, the organic matter was very high and the particle size distribution revealed sandy-loam texture. The results of the analysis showed some levels of pollution which indicated that the activities at the abattoir were contributing to the pollution load of soil in the environment. It is therefore, recommended that the activities at the abattoir should be monitored closely by relevant agencies in order to prevent full-blown environmental problems in the near future and avert the attendant health hazards.

Keywords: abattoir, soil pollution, heavy metals, environment, physico-chemical parameters

1. Introduction

Almost all industries in Nigeria generate wastes which, in most cases, are disposed of without due regard to sound environmental management practices. This practice is common with small scale and even some large scale industries. Most of wastes generated are either useful or harmful to humans. Most wastes especially the solids are carried to the rivers and streams through surface runoffs while some drain into the soil. In many parts of the world, human activities such as animal production and meat processing impact negatively on soil and natural water composition. This leads to pollution of such soils, natural water resources and the entire environment (Adesemoye et al., 2006). Meat processing is usually carried out in a specialized environment known as abattoir or slaughter house. An abattoir is a place or building where animals are killed for their meat (Hornby, 2006). Abattoir can also be defined as premises approved and registered by regulatory authorities for hygienic slaughtering, inspections, processing, effective preservation and storage of meat products for human consumption (Alorge, 1992). The major activities involved in the operations of an abattoir are: receiving and holding of livestock; slaughter and carcass dressing of animals; chilling of carcass products; carcass boning and packaging; freezing of finished carcass and cartooned product; rendering processes; drying of skins; treatment of wastes and transport of processed material. However, meat processing activities in Nigeria are mostly carried out in unsuitable buildings and by untrained personnel or butchers who are mostly unaware of sanitary principles (Olanike, 2002). Abattoir activities are aimed at optimizing the recovery of edible portions of the meat processing cycle for human consumption. However, significant quantities of secondary waste materials; blood, fat, organic and inorganic solids, salts and chemicals wastes are also generated during this process (Red Meat Abattoir Association, 2010; Steffen, Roberts and Kirsten Inc., 1989). Various organs of cattle such as: muscle, blood, liver, kidney, viscera and hair have been found to contain heavy metals (Kruslin et al., 1999; Jukna, 2006). In ruminants, the first stomach or paunch contains undigested materials called paunch manure, which can contain long hairs, whole grain and large plant fragments. The faeces of livestock (animal manure) consist of undigested food, mostly cellulose-fibre, undigested protein, excess nitrogen from digested protein, residue from digested

fluids, waste mineral matter, worn-out cells from intestinal linings, mucus, bacteria, and foreign matter such as dirt consumed, calcium, magnesium, iron, phosphorous, sodium, etc (Ezeoha et al., 2011). Abattoir effluent wastewater has a complex composition and can be very harmful to the environment. For example, discharge of animal blood into streams would deplete the dissolved oxygen (DO) of the aquatic environment. Improper disposal of paunch manure may exert oxygen demand on the receiving environment or breed large population of decomposers (micro-organisms) which may be pathogenic. Furthermore, improper disposal of animal faeces may cause oxygen-depletion in the receiving environment. It could also lead to nutrient-over enrichment of the receiving system and increase rate of toxins accumulation in biological systems (Nwachukwu et al., 2011). Mohammed et al. (2012) reported that the improper disposal of abattoir effluent could lead to transmission of pathogens to human which may cause outbreaks of water borne diseases e.g. diarrhea, pneumonia, typhoid fever, asthma, wool sorter diseases, respiratory and chest diseases, etc. Studies have shown that *E. coli* infection source was reported to be from undercooked beef which had been contaminated, in abattoirs, with faeces containing the bacterium (Bello et al., 2009). It had also been reported that abattoir activities were responsible for the pollution of surface and underground waters, air quality as well as reduction quality of health of residents within the surrounding environment (Patra et al., 2007; Katarzyna et al., 2009; Odoemelan & Ajunwa, 2008). This study is therefore aimed at analysis the effects of the activities at Gboko abattoir on the surrounding soil. The results will create public awareness about the state and health implications of abattoir activities on the environment.

2. Materials and Methods

2.1 The Study Area

Gboko is one of the largest and most populous Local Government Areas in Benue State. It has a land mass of 2,645 km² with a population of 298,387 people according to Nigeria's National Population Commission census of 1990. It is bounded by Tarka Local Government on the North, Ushongo Local Government to the south, Buruku Local Government on the east, Gwer on the west and Konshisha Local Government on the south west. It lies between latitude 7°05'–7°31'N and longitude 9°13'–9°35'E in the savannah region of Nigeria with typical savannah vegetation and climate. The integrated Gboko abattoir is located along km8 Gboko-Aliade road and close to a stream that flows into Ushongo LGA. Several animals (cows, goats, sheep and pigs) are slaughtered everyday in this abattoir. Normal abattoir operations however are carried out every week (Monday to Saturday) during the morning hours.

2.2 Sampling

Six sampling stations (AS, BS, CS, DS, ES, and FS) were mapped out around the abattoir at a distance of 50 m from each other. Composite soil samples were collected at depth of 0–20 cm using soil auger (Odoemelan & Ajunwa, 2008). The samples were collected between July and August, 2011 at an interval of ten days beginning from July 1, 2011. A control soil was also collected 60 m north of the abattoir during the sampling period. A total of forty-two composite soil samples were collected across the sampling points, packed in labeled polythene and conveyed to laboratory for preparation and analysis.

2.3 Sample Preparations

The soil samples were air-dried to constant weight at room temperature, ground separately in a porcelain mortar and sieved through a 0.063 mm nylon sieve. A 1.0 g of each soil samples was weighed into a 100 mL beaker and 10 mL of concentrated nitric acid was added. This was heated to dryness. Then, 10 mL 16M HNO₃ and 3 mL 11M HClO₄ were added and the solution heated to fuming after which the residue was dissolved with 4 mL of hot 6M HCl, filtered and diluted with distilled water to 100 mL (Allen et al., 1974). A reagent blank solution was also prepared using the same procedure.

2.4 Analysis of the Samples Digests

Samples digests were analyzed for the levels of Cd²⁺, Zn²⁺, Ni²⁺, Cr³⁺, and Pb²⁺ using Atomic Absorption Spectrophotometer (AA 6800) at National Research Institute for Chemical Technology (NARICT), Zaria, Nigeria.

2.5 Determination of pH and Temperature

The pH of the soil was determined using soil to water ratio of 1:1, 10.0 g of the air-dried, ground soil sample was weighed into a 50 mL plastic beaker and 10 mL of distilled water was added, stirred gently and allowed to stand undisturbed for 30 minutes. Then, the pH meter was calibrated using buffer 4, 7 and 9 after which the electrode was immersed into the soil suspension and the pH read after 30 seconds. Temperature was taken at the same time using pH meter temperature probe (Natural Resources Conservation Service [NRCS], 2011).

2.6 Determination of Organic Matter

The method of Walkley and Black (1934) was used to determine the soil Organic Matter. A 1.0 g of soil was weighed into a 250 mL Erlenmeyer flask and 10 mL of 0.167 M $K_2Cr_2O_7$ was added using a pipette and then swirled. A 10 mL 18M H_2SO_4 was added and the flask swirled gently until the contents were mixed thoroughly. Thereafter, it was swirled more vigorously for one minute and allowed to stand for 30 minutes. Then 100 mL of distilled water was added and allowed to cool. Furthermore, 4-5 drops of ferroin indicator were added and titrated against 0.5 M iron (II) ammonium sulphate solution. Blank determinations were similarly made and Percentage organic matter was calculated using the following formulae;

$$\text{Organic Carbon \%} = \frac{\text{Blank titre} - \text{Actual titre}}{\text{Weight of air dry soil taken}} \times 0.003 \times M \times F \times 100 \quad (1)$$

$$\text{Organic matter \%} = \% \text{Organic carbon} \times \frac{1.724}{0.58} \quad (2)$$

Where F = Correction factor = 1.33, M = Concentration of ferrous ammonium sulphate.

2.7 Determination of Soil Particle Size

The soil particle size was determined using the improved Hydrometer Method as described by Ibitoye (2006). A 50.0 g of 2 mm sieved soil sample was weighed into a 250 mL plastic beaker. Then, 100 mL of 5% w/v calgon solution (sodium hexametaphosphate), $(NaPO_3)_6$ was added and stirred with glass rod. Then, about 100 mL of distilled water was added, stirred and the beaker allowed standing for 30 minutes with occasional stirring. Thereafter, the sample was transferred into a mixing cup and stirred for five minutes after which it was transferred into a 250 mL plastic container and shaken on an end to end shaker for ten minutes. The mixture was transferred into a 1000 mL measuring cylinder and filled up to the mark with distilled water. The suspension was mixed vigorously using a long handle plunger to ensure that the sediment at the bottom was thoroughly agitated disturbed before starting the hydrometer reading. The hydrometer was lowered into the suspension and readings taken after 40 seconds with the corresponding temperature. After 2 hours, the hydrometer was again lowered into the suspension and readings taken at the top of the meniscus and temperature was also recorded. A blank solution was prepared by making 100 mL of 5% w/v calgon solution and made up to one litre with distilled water and the readings taken as previously done. The corrected hydrometer readings C (g/L) were obtained by subtracting the blank reading R_L (g/L) from the hydrometer readings in the soil suspensions R (g/L) and adding 0.36 g/L for every degree above 20 °C:

$$C = R - R_L + (0.36T)$$

Where T = Room Temperature.

The percentages by weight of silt, clay and sand fractions were calculated as follows:

$$\% \text{Clay} = \frac{\text{Corrected two hours reading} - \text{blank}}{\text{Weight of soil taken}} \times 100 \quad (3)$$

$$\% \text{Silt} = \frac{\text{Corrected 40 secs. reading} - \text{blank} - \% \text{Clay}}{\text{Weight of soil taken}} \times 100 \quad (4)$$

$$\% \text{Sand} = 100 - \% \text{clay} + \text{silt} \quad (5)$$

3. Results and Discussion

The results are presented in Tables 1–3 and Figure 2–4 as follows:

Table 1. Heavy metals level (ppm) in soils around the vicinity of the Gboko Abattoir

Sampling Point	Metal				
	Cd ²⁺	Zn ²⁺	Ni ²⁺	Cr ³⁺	Pb ²⁺
AS	0.0035±0.00290	2.3765±0.0130	0.0781±0.0730	0.0717±0.0303	0.3634±0.1783
BS	0.0110±0.0068	1.1818±0.6656	0.1999±0.1030	0.1007±0.0356	0.1854±0.1783
CS	0.0720±0.0151	5.1523±0.6068	0.2860±0.0262	0.1170±0.0267	1.6757±0.0105
DS	0.0098±0.0009	5.2362±0.0008	0.3032±0.1030	0.1358±0.0214	0.2077±0.1049
ES	0.0079±0.0064	4.0943±0.1294	0.2039±0.0300	0.1270±0.0373	0.3114±0.0839
FS	0.0066±0.0053	1.1302±0.2003	0.0980±0.0037	0.1283±0.0214	0.5042±0.1888
GS (ctrl)	0.0021±0.0007	0.2037±0.0102	0.0070±0.0021	0.0562±0.0234	0.0010±0.0032
MEAN	0.0185±0.0028	3.0195±0.3201	0.1949±0.0240	0.1134±0.1701	0.5413±0.1083
RANGE	0.0035-0.0720	1.1302-5.2362	0.0781-0.3032	0.0717-0.1358	0.1854-1.6757

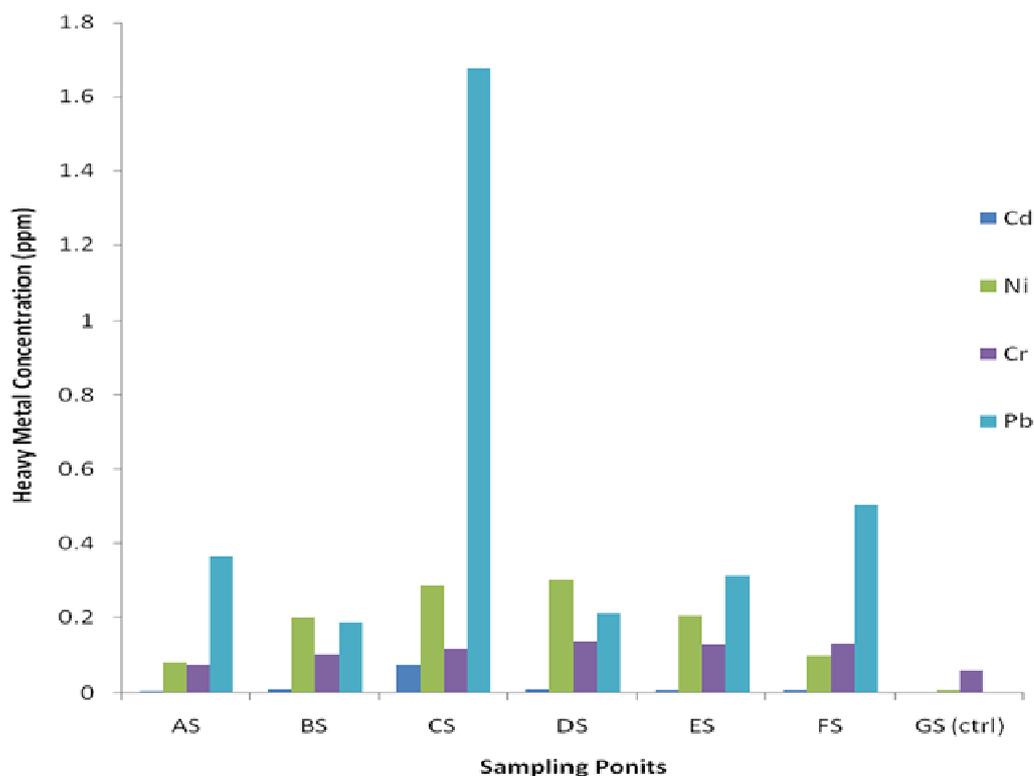


Figure 2. Mean concentration (ppm) of heavy metals in soil in the vicinity of Gboko Abattoir

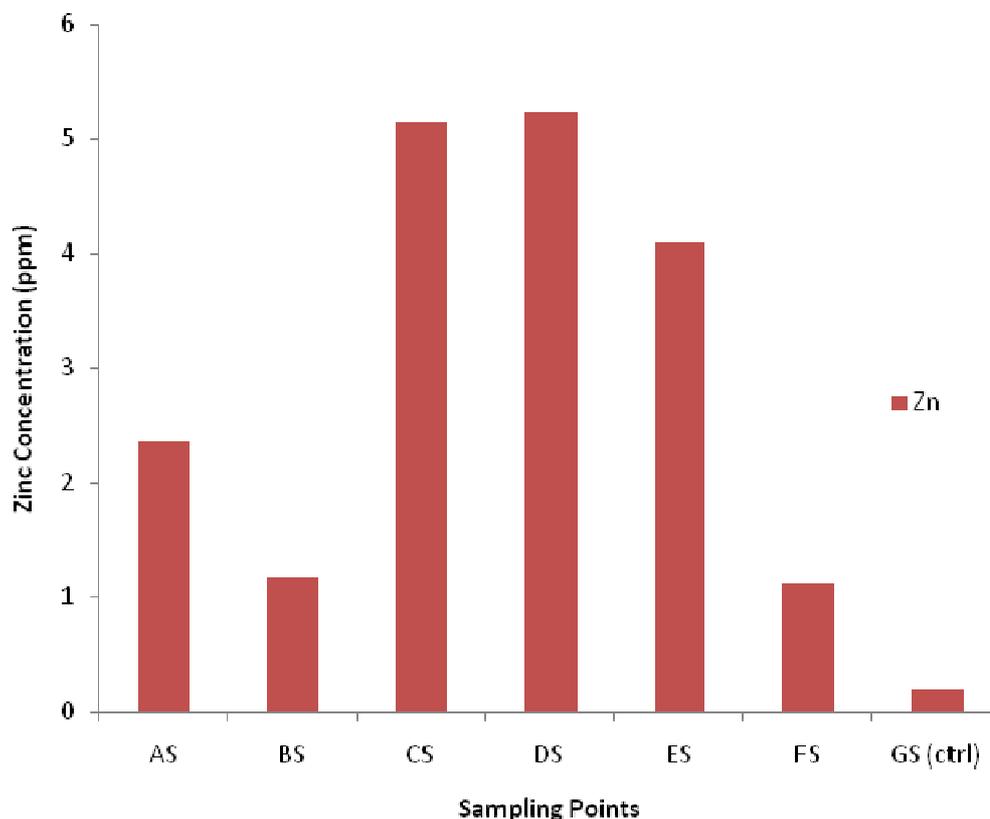


Figure 3. Mean concentration (ppm) of zinc in Abattoir soil

Table 1 and Figures 2 and 3 show results of the levels of some heavy metals in soil at the various sampling stations. The analysis was restricted to the top soil (0-20 cm) since it has been reported that surface soils are better indicators of metallic load (Adriano et al., 2003). Differences in metal concentrations across the sampling stations and that of the control area were also recorded. Zinc was the most abundant metal recorded (Figure 3) with range between 1.1302–5.2362 ppm followed by Pb with a range between 0.1854–1.6757 ppm. The mean concentrations of the metals were observed to be 3.0195 and 0.5413 ppm respectively. Cd^{2+} , Ni^{2+} and Cr^{3+} have ranges from 0.0035–0.0720, 0.0781–0.3032 and 0.0717–0.1358 ppm respectively. Cd was the least in terms of abundance. In general, metal abundance was observed to be in the order $\text{Zn}^{2+} > \text{Pb}^{2+} > \text{Ni}^{2+} > \text{Cr}^{3+} > \text{Cd}^{2+}$. The concentrations of metals in the soil under study were generally higher than their control indicating some degree of contamination; though these were within the maximum permissible limits of 380 ppm Cd^{2+} , 720 ppm Ni^{2+} , 240 ppm Cr^{3+} and 210 ppm Pb^{2+} of Nigeria's Department of Petroleum Resources (DPR) (2002) and 3.0 ppm Cd^{2+} , 300 ppm Zn^{2+} , 75 ppm Ni^{2+} , 150 ppm Cr^{3+} and 300 ppm Pb^{2+} of European Union (EU) (2001). Unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals do not undergo microbial or chemical degradation, therefore, their total concentration in soils persists for a long time after introduction (Agyarko et al., 2010; Okoronkwo et al., 2006). However, changes in their chemical forms and bioavailability are possible. Their persistence in soil may lead to increase up-take by plants and vegetables grown in the area. This will subsequently lead to increased risk of transfer through food chain and their possible accumulation in the human tissue to lethal concentration over time is a thing of concern.

The health implications of elevated levels of zinc (Zn^{2+}) are severe vomiting, diarrhea, bloody urine, liver and kidney failure and anemia (Fosmire, 1990). Lead (Pb^{2+}) poison causes inhibition of hemoglobin synthesis; dysfunction in the kidneys, reproductive systems and cardiovascular system (Ferner, 2001). Other effects of lead poison are damage to gastro-intestinal system, mental retardation in children, abnormalities in fertility and pregnancy (Dara, 2000). It is being found that excess Cd^{2+} can bring about renal dysfunction, anemia, hypertension, bone marrow disorder and cancer. Others are kidney damage, bronchitis, gastric and intestinal disorders, liver and brain disorders (Dara, 2000). Consequences of the exposure to Cr^{3+} beyond the permissible limits may include; irritation, dermatitis and ulceration of the skin, perforation of nasal septum etc (Dara, 2000). Ni can cause respiratory disorders, dermatitis, cancer of the lungs and sinus, and carcinogenicity (Dara, 2000).

Table 2. Mean physicochemical properties of soils around the vicinity of the Gboko Abattoir

Sampling Point	Soil Parameter (physico-chemical parameter)					
	Temp(°C)	pH	% Sand	% Silt	% Clay	% Organic Matter
AS	31.90±0.64	6.06±0.00	75.24±1.41	13.92±0.91	10.84±0.51	7.11±0.38
BS	31.05±0.07	4.99±0.502	68.16±2.94	17.56±6.28	14.28±3.34	5.57±0.71
CS	31.70±1.13	5.43±0.83	64.16±3.73	20.56±2.83	15.28±6.56	12.62±0.54
DS	30.95±1.06	6.39±0.88	62.14±3.71	22.58±0.03	15.28±3.73	24.13±0.64
ES	31.65±0.07	6.73±0.45	67.44±0.91	19.64±0.91	12.92±1.41	18.59±0.43
FS	31.45±0.07	6.59±0.04	67.44±0.91	20.00±2.83	12.56±0.91	7.68±0.11
GS (ctrl)	31.60±0.42	6.44±0.17	68.16±0.91	18.64±1.92	13.30±1.02	3.00±0.00
MEAN	31.45±0.65	6.03±0.51	67.43±2.30	19.04±3.09	13.53±3.20	12.62±0.57
RANGE	30.95-31.90	4.99-6.73	62.14-75.24	13.92-22.58	10.84-15.28	5.57-24.13

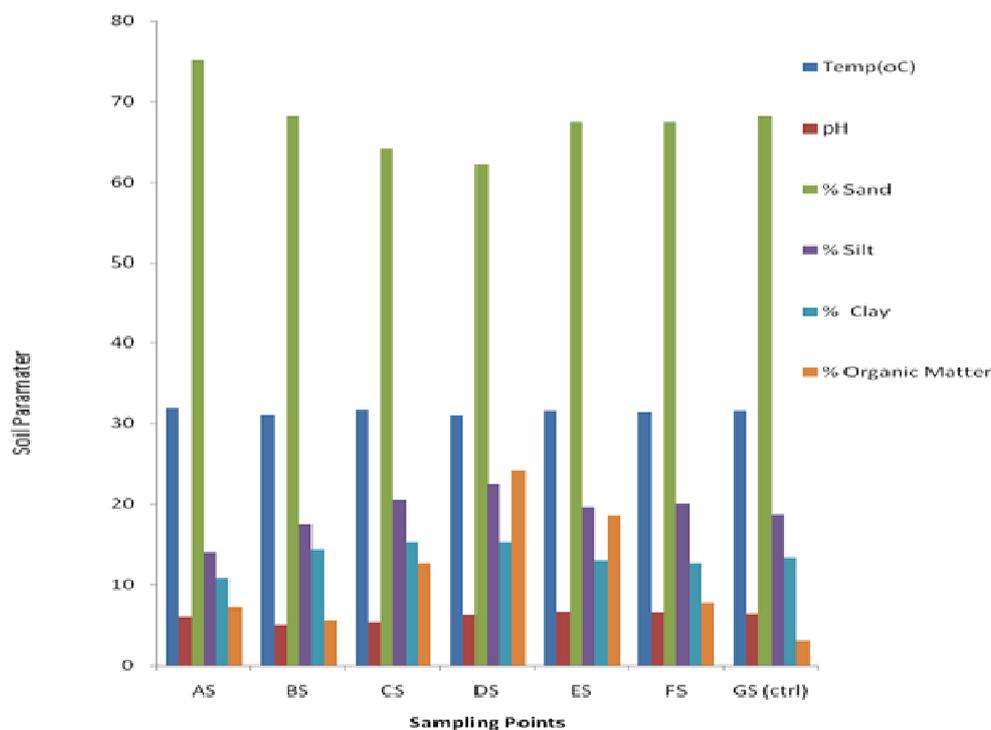


Figure 4. Mean physicochemical properties of soil around the vicinity of Gboko Abattoir

Table 2 and Figure 4 show the mean values of some physicochemical parameters of the soil investigated. The soil temperature was found to range from 30.95–31.90 °C. The soil pH ranges from 4.99–6.73 with a mean pH value of 6.03 indicating that the soil is slightly acidic in nature. This value is lower than the control (6.44) and compares well with 5.8–6.4 reported by David et al. (2009). It is also lower than 6.8–7.5 and 6.9 reported by Agyarko et al. (2003) and Okoronkwo et al. (2006) respectively. At low pH (acidic), metals are more soluble in the soil solution; hence toxicity problems are more severe than alkaline soils. The textural class of the soil is a sandy loam with a mean sand proportion of 67.43%, 19.04% silt and 13.53% clay. The sandy nature of the soil makes it highly permeable and allows large quantities of leachate to pass through, thereby having a potential of

polluting the surrounding underground water. The result of the analysis on textural class is in line with that on the organic matter because sandy soils have low organic matter content and those high in clay and silt are generally higher in soil organic matter. The percentage organic matter ranges from 5.57–24.12 % with a mean value of 12.62 %, this is higher than its control. The higher value may have been resulted from the decomposition and composting processes of the animals waste such as animal dung, body parts and blood. The result of organic matter agrees with the reported pH range of 6.0–7.0 for mineral soil and 5.0–5.5 for organic soils (David, 2009). Organic matter plays an important role in soil structure, water retention, cation exchange and in the formation of complexes (Alloway & Ayres, 1997). Organic matter and pH are the most important parameters controlling the accumulation and availability of heavy metals in soil environment (David, 2009).

Table 3. Correlation Matrix for pairs of the analyzed elements in the soil

	Cd ²⁺	Zn ²⁺	Ni ²⁺	Cr ³⁺	Pb ²⁺
Cd ²⁺	1.000				
Zn ²⁺	0.558	1.000			
Ni ²⁺	0.566	0.859*	1.000		
Cr ³⁺	0.263	0.636	0.760*	1.000	
Pb ²⁺	0.956**	0.531	0.473	0.307	1.000

*Correlation is significant at the 0.05 level (2-tailed);

**Correlation is significant at the 0.01 level (2-tailed).

The Correlation of the heavy metals in the soil was investigated using a statistical tool, statistical package for social sciences (SPSS) and the result presented in Table 3. The correlation coefficient for pairs of the analyzed elements in the soil revealed positive correlations between all the metals. Pb²⁺, Cd²⁺, Ni²⁺, and Cr³⁺ were significantly correlated. The positive and significant correlations existing among the metals suggest that their presence in the soil arose from common source.

4. Conclusion

The results of this study indicate some levels of contamination of the soil around the Gboko Abattoir, Gboko by Cd²⁺, Zn²⁺, Ni²⁺, Cr³⁺, and Pb²⁺. However, the levels of these metals were below the maximum permissible limits of Cd²⁺ 380 ppm, Ni²⁺ 720 ppm, Cr³⁺ 240 ppm and Pb²⁺ 210 ppm (NDPR) and Cd²⁺ 3.0 ppm, Zn²⁺ 300 ppm, Ni²⁺ 75 ppm, Cr³⁺ 150 ppm and Pb²⁺ 300 ppm set by EU. These results point to the conclusion that the activities in and around the abattoir are contributing to the loading of heavy metals and increase in organic matter in the soils around the abattoir.

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