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Heavy Metals Toxicity and Chemical Assessment of Contaminated Soils With Abattoir Waste and Effluents In Southwestern Nigeria

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Abstract

Increasing human population has influenced increase Abattoir facilities contributing to the escalating volume of abattoir generated wastes and effluents that are discharged onto the environment in southwestern Nigeria. These wastes may contain heavy metals that are toxic to humans and animals. There is limited work-done on these potentially harmful elements (PHE's) in abattoir wastes in Nigeria. Therefore, this work examined the potentially harmful elements (PHE's) and chemical qualities of the soils surrounding abattoirs in Oyo, Ogun and Lagos provinces. Nine (9) composite samples from 108 contaminated soils with abattoir wastewater were collected randomly controlled by flaying and singeing activities before they were prepared and analyzed with Atomic Absorption Spectrometry (AAS) in ACME laboratory Canada. The pH range between 5.1±0.1 and 6.1±0.1 in Oyo, Ogun and Lagos provinces exceeding the permissible limit (pH:6-9) signifying acidic contaminated abattoir soils . This may likely indicate the nature of the soils and other anthropogenic materials derived from high density areas. The temperatures recorded at all the locations exceeded the maximum permissible limit of FEPA (26^{o}C). Pb (0.32mg/kg) at Ijebu-Igbo abattoirs exceeded the standard value (0.25mg/kg) that can be attributed to flaying and singeing activities in the processing and production of animal skin (Ponmo) that is aided by burning of woods, tyres and other materials that produce carbon and soot. Copper contents in abattoir soils at Abule-Egba (0.45mg/kg) and Ikorodu(0.41mg/kg) indicate continuous contamination which may cause health hazards when the limit/standard (Cu-0.50 mg/kg) is exceeded. Chromium continuous increase in Sagamu (0.31mg/kg) beyond the FEPA standard can cause health problems. Pb possesses weak to moderate positive correlation indicating its non chelating, prominence and controlling capabilities from another source in that geochemical environment. Fe and Zn correlated strongly and positive with Ca, Mg, Na, K, Fe, Ni and Cd with correlation coefficient of between r$^{=}$0.75 to r$^{=}$0.99 specifying metals increase. The study revealed that Pb at Ijebu-Igbo abattoirs exceeding the standard value set by the Federal Environmental Protection Agency (FEPA/FMEnv), an indication of imminent Pb toxicity with other heavy metals which is precarious to human health.

Keywords: Pb; **T**oxicity; Bio-accumulate; Abattoir; Effluents

Introduction

Efforts have been geared towards curbing the menace of environmental pollution globally and bringing them to the fore (Oyesola, 1998**)**. However, human activities with, animal production, have been contributing to this menace and impact negatively on the environment and biodiversity.

The continuous drive to increase meat production to meet the protein needs of the population is usually associated with some contamination problems (Hinton *et al*., 2000, Yahaya *et al,* 2009). Animal production is a good source of protein and other bye-products such as leather, skin and bones. The processing activities involved sometimes result in environ-

mental contamination which may threaten animal and human health (Fig 1a).. Abattoirs are generally known all over the world to pollute the environment either directly or indirectly from their various processes (Adelegan, 2002). Wastes from slaughter houses typically containning fat, grease, hair, feathers, flesh, manure, grit and undigested feed, blood, bones, and process water are characterized with high organic levels (Coker *et al*., 2001; Nafamda *et al*., 2006**)** are usually discharged onto the environment without attention to their environmental implications.

Sangodoyin and Agbawe (1992), (Osibanjo and Adie (2007**)**, identified improper management and supervision of abattoir activities as a major source of risk to public health in Southwestern Nigeria. Some of the consequences of these contamination processes are transmission of diseases by water borne pathogens, eutrophication of natural water bodies, accumulation of toxic or recalcitrant chemicals in the soil, destabilization of ecological balance and negative effects on human health (Bridges *et al.,* 2000; Boadi and Kuitunen, 2003; Amisu *et al*., 2003; Yahaya *et al*, 2009).

In Nigeria, the total amount of waste (dung, bone, blood, hair, horn and hoofs) produced per animal slaughtered is about 35% its body weight which amounts to 328.5kg on the average. This ineptitudes often lead to contaminations of the environment which include soil (Fig 1b)., surface and groundwater. Therefore, the physicochemical properties of the soil may become altered (Hinton *et al.,* 2000; Laukova *et al.,* 2002; Sridhar, 1998**)**. This is most likely because of large quantity of wastewater involved in abattoirs which drains into surrounding soils (Amisu *et al*., 2003).

At the discharge of untreated abattoir wastewater (Fig 1c) into the soil, certain elements were released such as Fe, Pb, P, Ca and Zn (Tortora *et al.,* 2007) which may be toxic to the microbial, floral and faunal communities of the soil. Some of the abattoirs wastewater drains into the surrounding soil while the remaining is channeled through drainages into water ways which lead into nearby rivers. The resultant consequences could be the degradation of soil fertility, destructions of aquatic lives and zoonotic diseases cannot be ruled out. Wastes generated from abattoirs are potential environmental quality problems posing a big threat to waste management. This may be more dependent upon the abattoir activities, operation practices and waste management techniques than the size of the operation, the number of cattle or amount of waste involved.

The composition of slaughter house waste and effluents vary from day to day depending on the number of animal to be slaughtered, types of stock being processed and the methods (skinning or roasting) (Tove, 1985)**.** These wastes (solid waste, made up of paunch content, hairs, bones, horns, hoofs, faecal components, slurries, fat, blood and soluble materials) can affect water, land or air qualities when proper hygiene and waste management practices are not strictly followed (Fig 1c and Fig 1d). Some of these wastes are valuable for crops as manure while some may be detrimental to soil quality which may contain organic solids, heavy metals, salts, bacteria, viruses, other micro organisms and sediment which may be

washed into streams. When these abattoir wastes are not protected and properly handled; water oxygen is reduced thereby endangering aquatic life. Abattoir effluents reaching streams contribute significantly $N0_2$, PO_4^- chemical oxygen demand (COD), biochemical oxygen demand (BOD) and other materials resulting in stream contamination. Also, excessive NO_3^- found in groundwaters had been attributed to concentrated livestocks, manure usage and activities within the nearby abattoirs (George, 1987; Sangodoyin and Agbawe, 1992).

The concern over the possible ecological effect on the increasing accumulation of metallic contaminants in the environment is the basis for this study. Therefore, the investigation of heavy metals in soil contaminated with abattoir effluents is essential anthropogenic factors that can result in serious environmental and subsequent health problems. (Fangueiro *et al*., 2002, Sandroni and Smith, 2002). Therefore, the objective of this study is to investigate heavy metals toxicity and chemical qualities of some selected contaminated abattoir soils from Oyo, Ogun and Lagos provinces.

Materials and Methods

The study area

The study area covers Oyo, Ogun and Lagos provinces in Southwestern Nigeria. These lie within 003.00^0E-006.00^0E and 04.00^0N-08.30^0N. The abattoirs used for the study include Apata, Idi-Ayunre and Bodija for Oyo; Sagamu, Ijebu-igbo and Ijebu-Ode - Ogun; while Abule-Egba, Ikorodu and Bariga is for Lagos provinces respectively (Fig. 2). These abattoirs are the most actively patronized because they are the veterinary approved slaughter points for the proper regulation of hygienic meat products. One hundred and eight (108) abattoir contaminated soils samples (with abattoir wastewater) converted to 9 composite samples were collected with sterile polythene bags from these provinces in between January-March 2011. The samples were randomly collected due to the activities on each abattoir. Soil samples were collected from these abattoirs soils from areas where flaying and singeing had taking place or is taking place. Also, singeing of hides with wood fuelled with different substances also occurred on these abattoir soils in order to get ready to eat singed hides or singed – washed hides.

Sample analysis

A sediment sample was collected as control sample from an enclosed spring, air dried at room temperature to remove moisture content on white textile cloth for a period of seven days under room temperature and subsequently disaggregated to get the 63µm grain size which was used for analysis. The homogenized clay fractions of the sample was digested using a combination of HNO_3 and HCl aqua-regia mixtures in microwave oven (Loring and Rantala 1992). Partial digestion method was employed using Aqua Regia. The sample was treated with the acid between 80^o and 95^oC for a period of one to three hours. The digested samples were then analysed for elemental content using Inductively Coupled Plasma Mass Spectrometry Method (ICP-MS). Duplicate samples were analysed to check analytical precision and consistency. These was

carried out using the above mentioned technique at the Activation Laboratories Limited and ACME Laboratories Ontario, Canada.

Ten (10)g of the soil sample was measured into 250ml conical flask with 10ml of aqua regia added. These samples were then treated in the laboratory using wet digestion methods as adopted from Association of Official Analytical Chemist (1979) and Levinson (1968). The mixture was evaporated and made up to 50ml mark with distilled water. The filtrates were analyzed using Atomic Absorption Spectrometry (AAS) analysis (Perkin Elmer A200 model). Also, pH, water temperature (°C), conductivity (µs/cm) and total dissolved solids (mg/L) were conducted in-situ with the use of HANNA Combo pH and EC multi meter Hi 98129 and Mercury-in-glass thermometer while dissolved oxygen (mg/l), nitrate (mg/l), phosphate (mg/l), alkalinity (mg/l) and hardness (mg/l) were also determined using standard methods.

Data Interpretation

The data obtained were subjected to statistically analysis using Statistical Analysis System (SAS, 1999); Duncan new multiple range test (DNMRT) for means separation; Pearson Correlation for significance/ relationship levels while the result were further interpreted with arc-view, sulfer-8, spss-15 and excel-2007 softwares.

Result and Discussions

The physicochemical results (Table 1) revealed acidic contaminated abattoir soil samples with pH that range between 5.1 - 6.1 in Oyo, Ogun and Lagos provinces (Fig. 3a). The standard measure of how acidic or alkaline a solution is the measure of Hydrogen ion concentration (pH) which scale from 0-14 indicating pH's of 7 as neutral; <7 – acidic while >7 is basic. The pH scale measure is logarithmic signify a unit decrease in pH equals a tenfold increase in acidity. When pH tends to 1, acidity increases while alkalinity increases as pH gets closer to 14 (Kelly-Addy et al., 2004). Hydrogen ion concentration ranged between 5.1±0.10 and 6.1±0.10 between January and March, 2011 at the peak of the dry season. These values exceeded the maximum permissible limit of the standard but with the exception of pH-6.1 from Sagamu while the pH recorded at Ijebu-Igbo and Ijebu-Ode may become more acidic if the environmental condition changes with the trend of acidity in abattoir soils and when compared with the pH of the control sample.

The abattoir soils in Lagos province (Abule – Egba, Bariga and Ikorodu) were more toxic than samples from other provincial areas. This may likely indicate the nature of the soils, presence of different industrial sites coupled and supported with reports of acid rains in this vicinity (Abimbola *et al.,* 2002; Fig. 3a). The abattoir soils in Ogun province observed was the least acidic (6.0 - 6.1) in the study area. This may indicates the presence of chlorides and other anions as dominants ions which might have influenced the environment (Abimbola *et al.,* 2008). Observations from the study revealed that densely populated areas were more acidic than the less dense areas.

Temperature has direct and indirect effects on nearly all aspects of ecology. Water temperature ranged between 27.8 °C

Table 1: Mean of the physico-chemical parameters of Abattoir contaminated soils (all parameters in mg/kg except pH and temperature)

Abattoir (N=108)	Pb	Cd	Fe	Zn	Cu	Cr	Ni	K	Na	Ca	Mg	pH	Temp(°C)
Bodija	0.06	0.05	1.41	0.13	0.05	0	0.02	1.06	0.15	2.31	0.45	5.2	29.6
Idi-Ayunre	0.05	0.03	1.61	0.15	0.06	0.01	0.01	1.06	0.16	2.36	0.41	5.2	29.6
Apata	0.05	0.05	1.81	0.15	0.07	0.02	0.01	1.8	0.18	2.46	0.32	5.1	29.7
Ijebu-Igbo	0.32	0.04	1.56	0.16	0.06	0	0.01	1.48	0.16	2.01	0.39	6	29.3
Ijebu-Ode	0.03	0.04	2.01	0.15	0.06	0	0.03	1.51	0.19	2.93	0.44	6	27.8
Sagamu	0.04	0.05	1.81	0.16	0.05	0	0.012	1.45	0.17	2.45	0.41	6.1	28.2
Abule Egba	0.08	0.05	1.48	0.44	0.45	0.31	0.03	1.56	0.18	2.91	0.45	5.1	28.6
Bariga	0.07	0.05	1.51	0.35	0.05	0.03	0.05	2.03	0.11	2.49	0.45	5.1	29
Ikorodu	0.08	0.05	1.47	0.44	0.41	0.04	0.04	1.75	0.18	2.65	0.46	5.1	28.7
Control	0.063	0.00	9.12	0.012	0.019	0.023	0.007	0.02	0.03	0.04	0.02	7.1	23.1
Minimum	0.30	-	1.41	0.13	0.05	0.00	0.01	1.06	0.11	2.01	0.32	5.1	27.8
Maximum	0.32	-	2.01	0.44	0.45	0.31	0.05	2.03	0.19	2.93	0.46	6.1	29.7
Mean	0.87	0.05	1.63	0.24	0.14	0.05	0.02	1.52	0.16	2.51	0.42	5.43	28.9
Std. Dev.	0.89	-	-	0.13	0.16	0.10	0.02	0.32	0.02	0.29	0.04	0.45	0.67
FEPA/FMEnv Standard	0.25	0.05	15	5	0.5	0.5	0.25	200	200	200	200	6 - 9	26

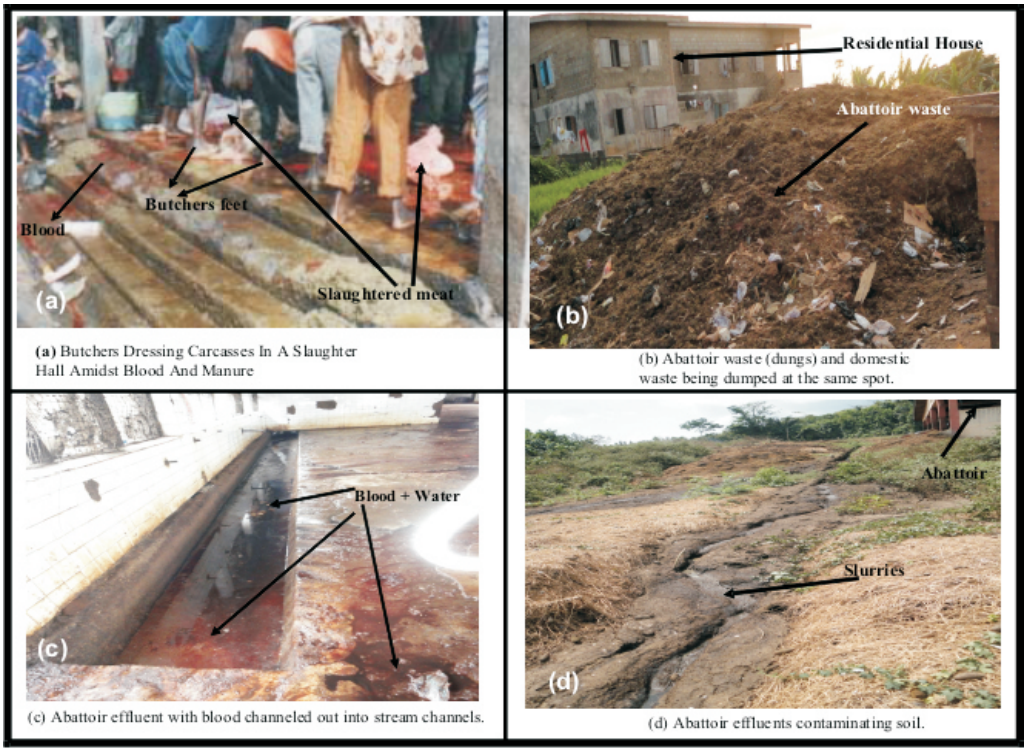

Fig. 1. Abattoir wastes and contaminated soil with abattoir effluents and slurries

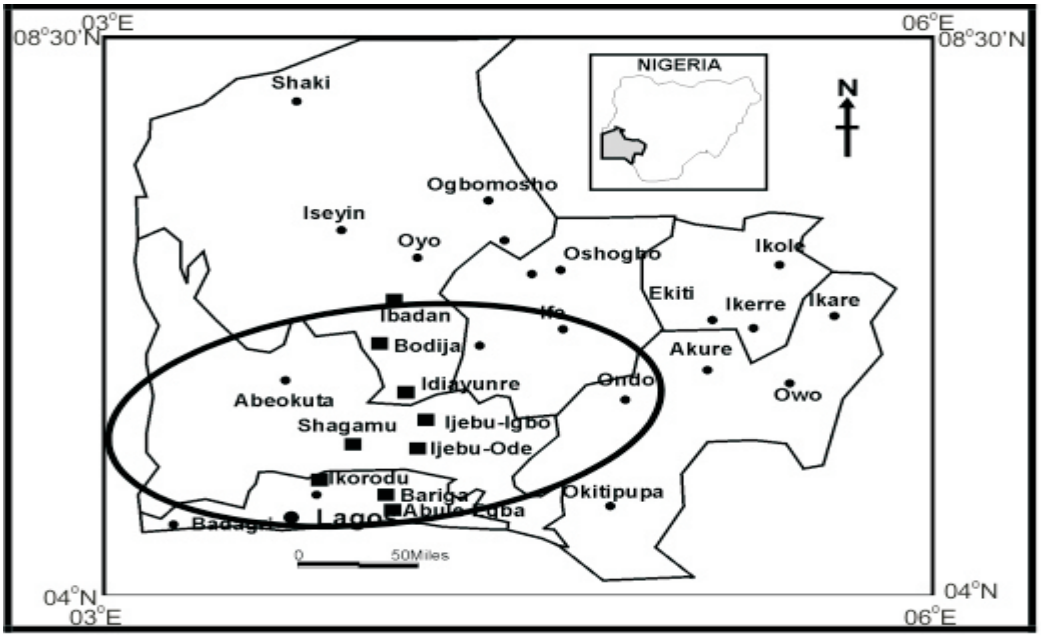

Fig. 2. Map Indicating The Locations of the Abattoirs in Oyo, Ogun and Lagos Provinces

±1.1 and 29.7 °C ±0.5 between January-March, 2011. The temperatures that were recorded in all the locations were above the control value and the specified standard and hence exceeded the maximum permissible limit of FEPA (26°C). This result is similar to the findings of Fafioye *et al.,* (2005) and Dimowo (2013) who reported a range of 26.5°C - 31.5°C in Omi-Adio and Ago Iwoye, which falls in Oyo and Ogun Provinces respectively in southwestern Nigeria.

Pb ranges from 0.03mg/kg– 0.32mg/kg in soils from Ijebu-Ode and Ijebu-Igbo abattoirs, revealing the lowest and highest concentration values, in the study area respectively. This assessment indicates moderate contamination of the environment with Pb at Ijebu Igbo when compared with the control values. The high value of Pb recorded may be due to the processing and production of animal skin (Ponmo) an industry that is prominent in this area. Therefore roasting with woods, tyres and other materials that produces soot and carbon during the processing of slaughtered animal and animal skin might be the reason for the high Pb concentration values in Ijebu Igbo (Fig. 3b; Fig. 4). Other abattoirs recorded low Pb values when compared to FEPA (0.25 mg/kg) standards (Table 1). Cadmium was also increasing from 0.03-0.05mg/kg and trending very close to the WHO standard 0.05mg/kg. Quite a few reports based on different laboratory test indicated that Pb is toxic and can bio-accumulate in the body systems if ingested through plants and veggies on this contaminated soils. High level of Pb in the blood is dangerous to human health and it can cause sudden death, severe abdominal cramps, anaemia, strange headaches and other associated diseases because of the central nervous system (CNS) and gastrointestinal disturbances.

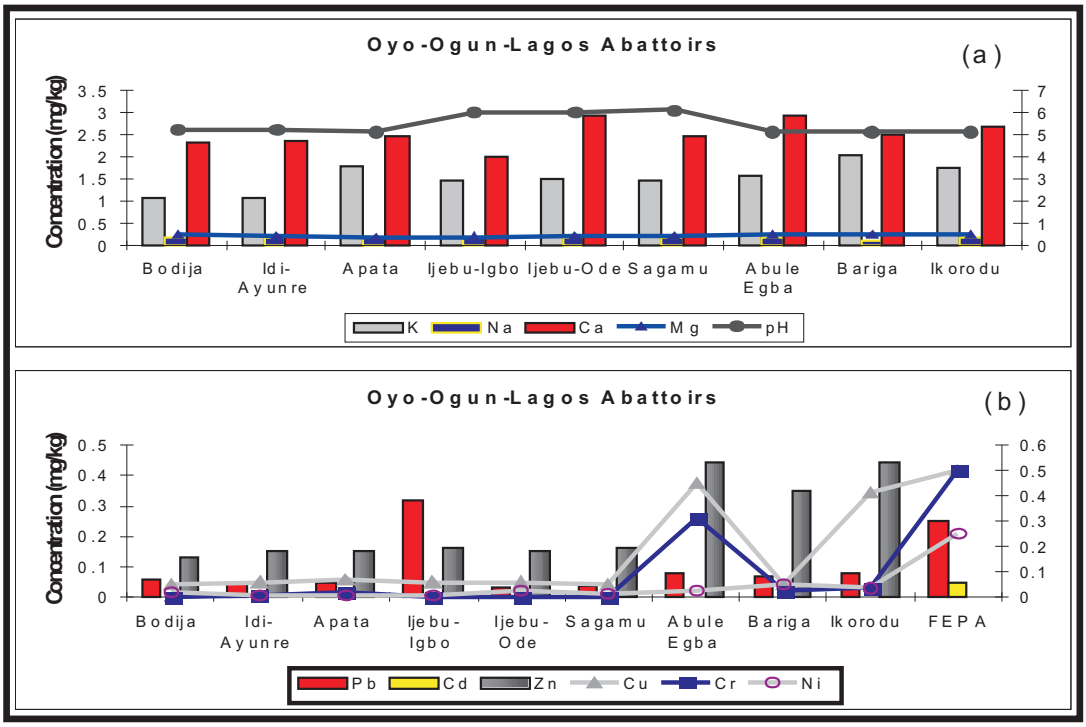

Fig. 3: pH and Metals concentration values in the abattoir contaminated soils

Table 2: Correlation Matrix for Pairs of the Metals, pH and temperature (all parameters in mg/kg Except pH and temperature)

	Pb	Cd	Fe	Zn	Cu	Cr	Ni	K	Na	Ca	Mg	pH	Temp(°C)
Pb	1												
Cd	0.45*	1											
Fe	0.44*	0.99*	1										
Zn	0.44*	0.99*	**0.99***	**1**									
Cu	0.24	0.59*	**0.58***	**0.65***	1								
Cr	0.34	0.79*	**0.78***	**0.81***	0.78*	1							
Ni	0.40*	0.98*	**0.98***	**0.99***	0.65*	0.80*	1						
K	0.44*	0.99*	**0.99***	**0.99***	0.59*	0.79*	0.98*	1					
Na	0.45*	1.00*	**0.99***	**0.99***	0.59*	0.78*	0.98*	0.999*	1				
Ca	0.45*	0.99*	**0.99***	**0.99***	0.60*	0.79*	0.98*	0.999*	0.999*	1			
Mg	0.45*	1.00*	**0.99***	**0.99***	0.59*	0.79*	0.98*	0.999*	1.00*	0.999*	1		
pH	0.50*	0.86*	**0.88***	**0.84***	0.33	0.58*	0.81*	0.86*	0.86*	0.86*	0.86*	1	
Temp	0.49*	0.98*	**0.98***	**0.97***	0.55*	0.76*	0.95*	0.98*	0.98*	0.98*	0.98*	0.80*	1

Pearson's Correlation Matrix
Correlation Rating: >0.91=very strong; 0.90-0.81=strong; 0.80-0.31=moderate; < 0.30=weak.
(*) = correlation is significant at the 0.05 level.

Table 3: Factor analysis for physico-chemical parameters in Abattoir contaminated soils

	Factor			
	1	2	3	4
Pb	-0.29	-0.39	0.145	0.79
Zn	0.94	-0.18	0.04	0.14
Cu	0.84	0.01	0.48	0.17
Cr	0.72	0.01	0.51	0.09
Ni	0.80	-0.10	-0.56	-0.01
K	0.44	0.02	-0.37	-0.03
Na	0.02	0.70	0.64	0.04
Ca	0.72	0.63	0.03	-0.24
Mg	0.65	-0.04	-0.34	0.28
Fe	-0.38	0.86	-0.14	-0.18
pH	-0.50	0.58	-0.20	0.59
TEmp	-0.38	-0.80	0.29	-0.33

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Fig. 4: Animal Skin (Ponmo) Roasting Industry at the Ijebu-Igbo

Other metals such as Fe, Ca, Na, K, Mg (Major) and Cu, Zn, Cr, Ni (Trace) have their concentration below the FEPA standards but with the exception Cu in Abule-Egba (0.45mg/kg) and Ikorodu (0.41mg/kg) indicating a continuous contamination and an impending outbreak of health hazards when the limit/standard (0.50) is exceeded. Some Cd values were below the FEPA standard while others were below detection limits in the abattoir samples (Table 1; Fig. 3b).

Zinc ranges from 0.13-0.44mg/kg in the study area, indicating concentration values below the FEPA standards (Fig. 3b). Zn is relatively harmless but exposure to high doses has toxic effects, making acute zinc intoxication a rare event. In addition to acute intoxication, long-term, high-dose Zn supplementation interferes with the uptake of Cu (Laura *et al*., 2010). One

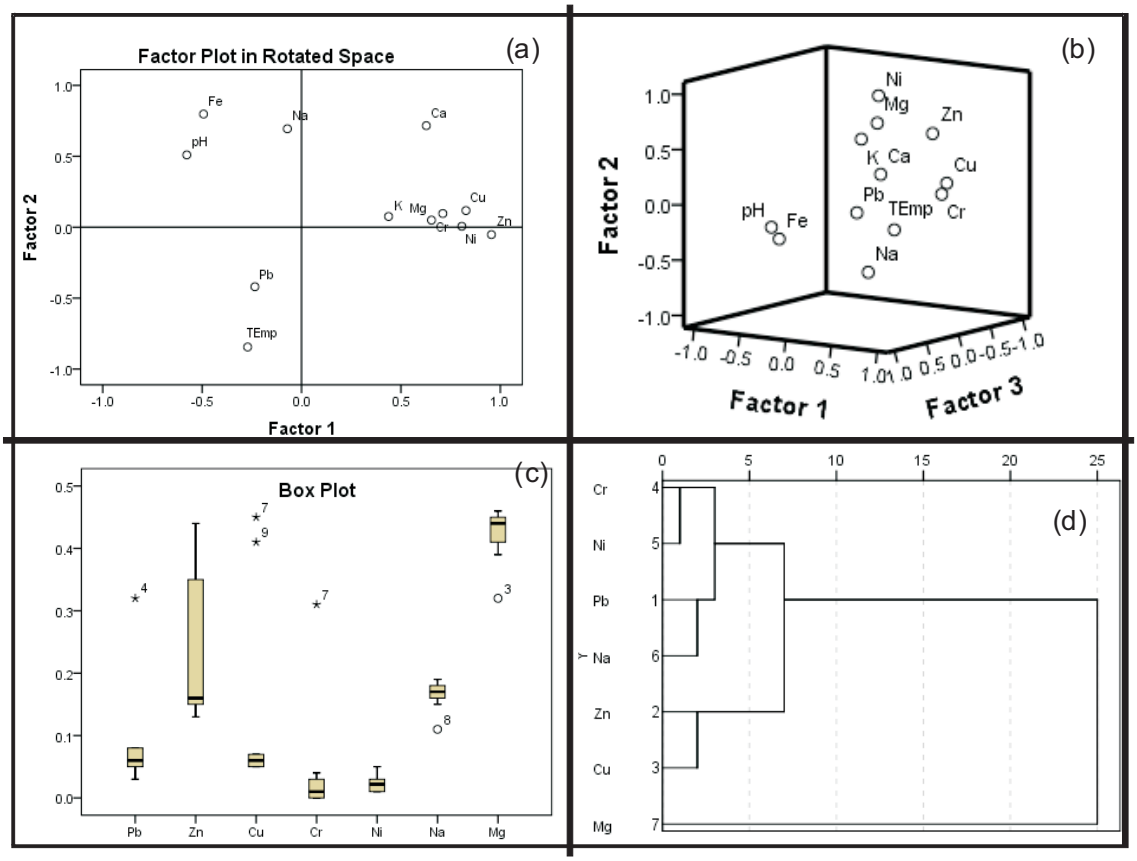

Fig. 5: Multivariate Analysis of Metals in the Abattoir contaminated soils

organ where zinc is prominently involved in cell death is the brain. It deficiency is widespread and has a detrimental impact on growth, neuronal development, and immunity, and in severe cases its consequences are lethal (Laura *et al*., 2010). This deficiency can be linked to malnutrition and foods with low bioavailability, aging, certain diseases, or deregulated homeostasis (Laura *et al*., 2010).

Copper ranges between 0.05 mg/kg at Bodija and Sagamu to 0.45mg/kg at Abule Egba respectively. This value was below the FEPA and Menv standards. Copper concentration value at Abule Egba is increasingly high and is almost at the limit (Fig. 3b). This implies a dangerous trend which makes Cu to be toxic when the standard limit is exceeded. Acute symptoms of Cu poisoning by ingestion include vomiting, hematemesis (vomiting of blood), hypotension (low blood pressure), melena (black "tarry" feces), coma, jaundice (yellowish pigmentation of the skin), and gastrointestinal distress (Van Genderen *et al*., 2005) Chronic or long-term effects of Cu exposure can damage the liver and kidneys (Van Genderen *et al*., 2005). Chromium ranges

between 0 - 0.31mg/kg. The lowest values were recorded at Bodija, Ijebu Igbo, Ijebu Ode and Sagamu while the highest (0.31mg/kg) was recorded at Abule Egba respectively (Fig. 3b). Stomach upsets and ulcers, convulsions, kidney and liver damage and even death were the effects of the most toxic Cr(IV) exposure (Van Genderen *et al*., 2005). The levels of Cr(VI) that caused these effects were far greater than other Cr effects in food or water.

Interelement Relationships

Correlation among metals greatly eased the task of rapid monitoring of abattoir soils. The correlative variables that have coefficient value $r^{=} > 0.05$ (Table 2) were considered significant and these revealed positively correlated values for all the metals since it is a measure of association between elements (Yalcin *et al*., 2009). The relationships show positive (+ve) correlation, which ranged from weak (<0.30) to very strong (>0.91) correlation ratings. This signifies an active geochemical environment with mostly high and positive correlation coefficient ('r') that was noted for all the metals. Also, this suggests co-precipitation and a common source.

Pb showed weak to moderate correlation with Ni, Zn, Cd, Fe, Na, K, Ca, Mg with correlative values ranging from $r^{=}40$ to $r^{=}50$. This Pb possesses weak to moderate correlation indicating its non chelating, prominence and controlling capabilities from another source in that geochemical environment. Pb might have been sourced from burning of woods with the aid of tyres, tubes, paints, black oils and other Pb containing materials. However, with the exception of Pb, other metals such as Fe and Zn show very strong positive correlation with Ca, Mg, Na, K, Fe, Ni and Cd which attain unity or almost unity with correlative values that range between $r^{=}0.75$ to $r^{=}0.99$. This indicates that Fe, Zn, Cd and Ni were increased with increasing these parameters in the abattoir soils. Cd and Ni are the most potentially harmful elements (PHE's) that have been anthropogenically sourced within this geochemical environment. Multivariate analysis show Pb, Zn, Na, Mg, pH and temperature as the major controlling metals and parameters in this study signifying them as the most prominent parameters in that geochemical environment (Fig. 5). Zn, Na, Ca, Mg might have come from blood and bones from the abattoir.

Conclusion

The study revealed that Pb at Ijebu-Igbo abattoirs exceeding the standard value set by the Federal Environmental Protection Agency (FEPA/FMEnv, 1991). This is an indication of imminent Pb toxicity which is precarious to human health. Also, Cu contents in Abule-Egba and Ikorodu abattoirs are very close to FEPA/FMEnv) standard indicating danger in the environment when this value is exceeded over the years or sooner than expected; because they bio-accumulate while some species are not biodegradable. In conclusion, Pb pose an immediate hazard at Ijebu Igbo abattoirs.

Recommendations

Standard equipments for major functional units of the abattoir such as cold rooms, skinning machines, slaughtering machines and changing rooms should be installaed in all the abattoirs. Appropriate technology for abattoir waste water treatment and recycling, biogas production, bones, manure and blood handling treatment should be fixed. Various methods of waste

treatment that resulted into pathogens destruction and mineralization of sewage organic components prior to discharge should also be adopted. Anaerobic wastewater treatment using granular sludge reactor is a method that can be adopted, while the already established Environmental Protection laws from FEPA can be enforced.

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