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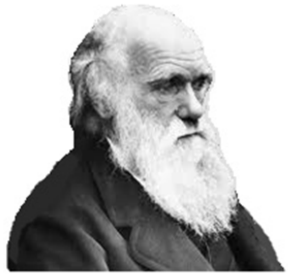

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Comparative assessment of potential trace elements in soil: a case study of Abattoir Gariki, Imo State, Nigeria

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ABSTRACT

Slaughterhouse operations, sometimes referred to as abattoir activities, may affect soil media in a number of ways, mainly through the emission of different pollutants and the disposal of waste. Therefore, the purpose of this study was to determine the concentration of possible trace elements in the soil from the Gariki slaughterhouse (abattoir) in Obinze, Owerri West Local Government Area, Imo State, Nigeria. Soil samples were taken at depths of 0-15 cm, 15-30 cm, and 30-45 cm from three distinct locations using a soil auger. Soil samples were taken 200 meters distant from the abattoir as control point. The investigation included nine (9) samples that were evaluated for probable trace elements (arsenic, cadmium, lead, copper, and zinc) using an Atomic Absorption Spectrophotometer (PG equipment and AA 500). The generated data was statistically analyzed using Genstat Statistical Package version 18, and means were separated using least significant difference (LSD). There were lower concentrations of these potential trace elements in control point soils than other sampling points within the abattoir. Across the sampling point, Zn, Pb, Cu, Cd and As as 0.90 mg/g, 0.61 mg/g, 0.21 mg/g, 0.11 mg/g and 0.01 mg/g varied respectively. Mean concentrations of Pb (7.62 mg/g), Cd (4.21 mg/g), Cu (2.68 mg/g), Zn (1.87 mg/g) and As (1.08 mg/g) were higher in soils of abattoir compared to the control point. Across the different sampling points, both Pb (12.7 mg/g) and Cd (9.48 mg/g) were higher in Animal stand and the dump site. Activities within Gariki Abattoir impacts negatively on the surrounding arable soils; therefore, pollution control procedures which are sustainable should be implemented for abattoirs operations.

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***Keywords*:** Abattoir, Effluents, Imo state, Potential trace elements, Soil contamination

1. INTRODUCTION

Waste from slaughterhouse is capable of having negative impacts on soil media if handled improperly. Nigeria lacks provisional infrastructure for handling slaughterhouse wastewater which is different from what is obtainable in industrialized nations, where such amenities are available. The abattoir in Obinze is a relatively large one, despite its size and importance to the state, there is no proper management of the waste emanating from the facility. The impact on how people interact with contaminated soils is one of the resulting repercussions.

Soil is an important resource for agriculture, human settlement, and recreation (Diagi et al., 2023). Human activities have led to the accumulation of heavy metal contaminants in soil, making it toxic. Both plants and soil microbes are at risk from the presence and ubiquity of hazardous metals in the soil. It has been found that many animal body components, including the flesh, blood, liver, kidney, internal organs, and hair, contain possible trace elements, which might raise the pH of the soil (Chukwu and Anucha, 2016). Development and harvest of crops have decreased in these soils due to inability of crop to survive (Robinson, et al., 2009).

The majority of the wastewater produced by abattoir operations comes from tasks like cleaning slaughtered animals after removing hair and hide, eviscerating them, rendering them, cleaning their equipment, handling paunches, cutting them, and scorching them (Mittal, 2004). Several authors have reported heavy metals in abattoir liquid waste (Mohammed, et al 2020; Akan, et al., 2010; Dauda, et al., 2016; Hassana and Nuradeen, 2021). These metals seriously endanger human health, the environment, and aquatic life. Heavy metal toxicity has numerous serious health implications because of its persistence in the environment, toxic effects, tendency to accumulate in organisms and promote food chain amplification, and non-degradable nature (Singh Sankhla et al., 2016).

According to multiple authors (Adesemoye et al., 2006; Rabah et al., 2010; Magaji and Chup 2012), slaughterhouse wastes can reduce soil fertility, diminish biodiversity, have an impact on human health, and pollute the air, water, and soil with harmful metals. Furthermore, other researchers have noted that significant concentrations of Cu, Fe, Zn, As, and Cr are present in animal diets and other additives (Chang, 2004; Zhang et al., 2012). Elemile et al. (2019) found that the environment, water, and animal foods had an impact on the levels of Ni and Pb in abattoir wastes. Additionally, it has been established that waste from slaughterhouses has the power to increase the concentrations of Fe, Pb, and Zn in the surrounding water (Ezeoha and Ugwuishiwu, 2011).

Once more, some farmers cultivate edible plants on their fields by using animal feces as organic manure. Thus, there may be a large concentration of harmful metal buildup in the soil, and the locality may suffer from the detrimental effects of abattoir wastes. According to Chibuike and Obiora (2014), crops growing on these soils have shown a decline in development and harvest.

According to Elemile et al., (2019), abattoirs are linked to environmental pollution on a global scale through a variety of activities. This study therefore seeks to evaluate the concentration level of possible trace elements in the soil in the vicinity of abattoir, as an increased rate of abattoir activities results in an increased rate of trace elements in the environment that can impact on the soil and consequently enter the food chain (Ajmone, et al., 2010; Danika, et al., 2005; Mitchell, et al., 1979; Yamasaki, 2001; Rao, et al., 2008).

2. MATERIALS AND METHODS

2. 1. Sampling materials

The following materials were used during the field work:

a) Soil auger to get soil samples at different depth from the sampling area
b) Polythene bags for packaging the soil samples obtained
c) GPS meter to get the coordinates of the sampling points.
d) Cello tapes for labeling the samples.
e) Metric rule for measuring length of the auger to be driven into the soil.

2. 2. Sample collection

Samples of soil were taken using a soil auger from three different locations; the samples were acquired from animal stands and effluent dumps. To examine the differences between the two soil samples, a 200-meter distance was utilized as the control point. Samples 1 through 3 (ranging in depth from 0 to 15 cm), Sample 2 (15 to 30 cm), and Sample 3 (30 to 45 cm) were taken from the abattoir waste. The samples were labeled, placed in a polyethylene bag, and shipped to a lab for the analysis of hazardous components.

Figure 1. Sample collection at Gariki Abattoir

2. 3. Study area

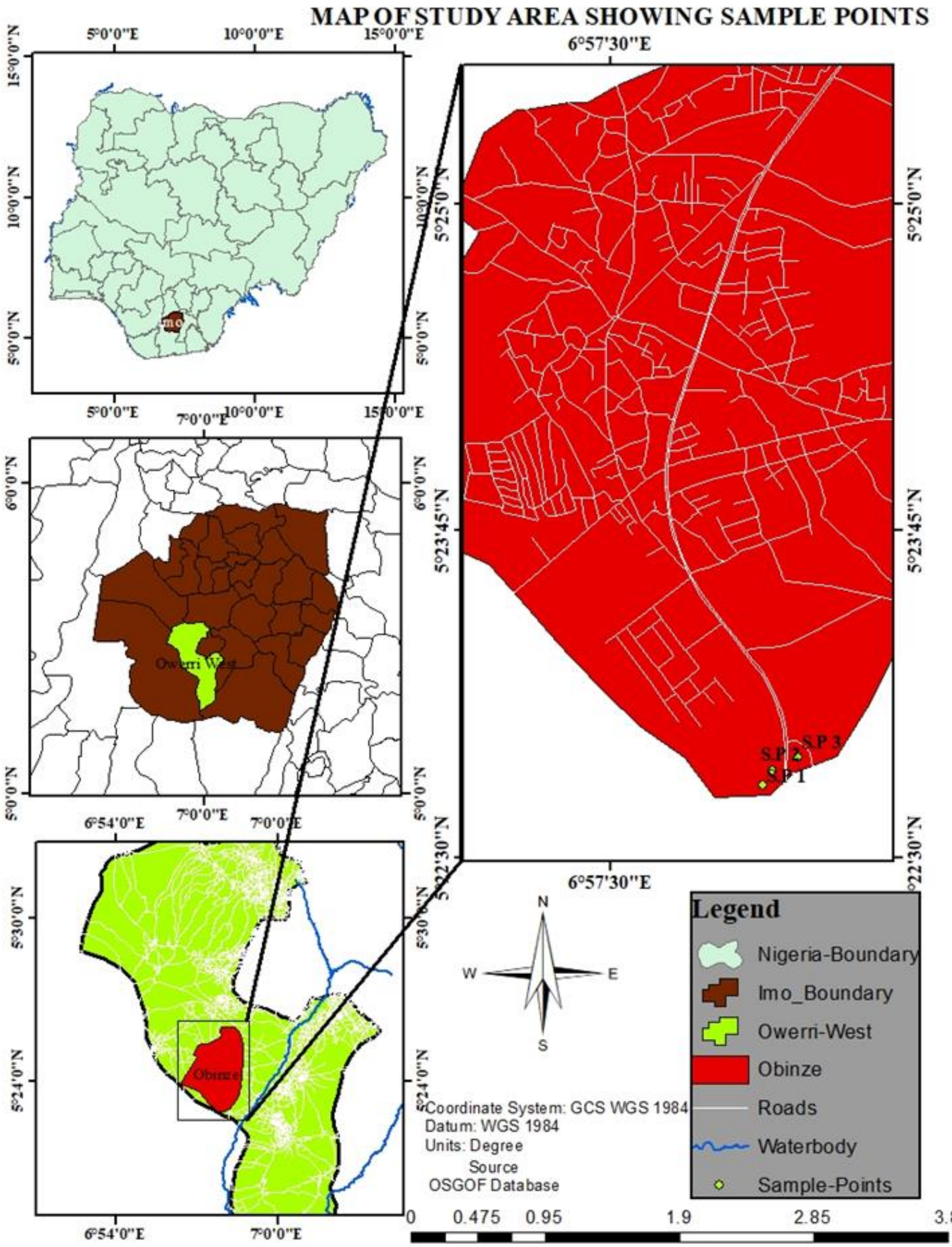

Figure 2. Area of study

The study was conducted in Imo State, which has a population of 4.8 million and a density of between 230 and 1400 persons per square kilometer, and located in the southeast of Nigeria. The state is located between latitudes 5°4 and 6°3 N and longitudes 6°15 and 7°34 E, in the country's southeast vegetation belt.

The region is located in the humid tropics and experiences high surface air temperatures throughout the year (Ajiere et al., 2021). The area's agro-ecological features have been documented by Nwanta, et al., (2010). The state is organized into three agricultural zones, Owerri, Orlu, and Okigwe, which are further subdivided into 27 Local Government Areas (LGAs). One of the largest abattoirs in the metropolitan area, Obinze (Owerri Municipal Abattoir) is the research area.

This slaughterhouse is significant to this study because it is one of the primary sources of beef that is marketed and disseminated to the general population in these three locations. In Owerri West LGA, trade is a significant economic activity. The region is home to a number of marketplaces, including the Umuguma Central Market, which draws hundreds of buyers and sellers.

2. 4. Method of Data analysis

Descriptive statistics were used to quantify different components for each location in order to assess probable trace elements in the soil. The obtained data's means and standard deviation were computed. The statistical software for social sciences (SPSS) Version 20.0 for Windows (Armonk, NY: IBM Corp.) was used to perform mean separation with the least significant difference at $p<0.05$. The data were analyzed using analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

The results in table 1. shows the data collected from the various depth of soil in the abattoir and the control area.

Table 1. Concentration level of trace elements at sampled points.

NO	PARAMETER (ANIMAL STAND)	METHOD	FMEV LEVEL	15 cm	30 cm	45 cm
1	Zn (mg/g)	APHA3111B	<1.0	2.346	2.584	3.496
2	Pb (mg/g)	APHA3111B	<1.0	10.540	12.936	14.849
3	As (mg/g)	APHA3030C	0.1	1.456	2.082	2.198
4	Cd (mg/g)	APHA3111B	<1.0	4.786	6.896	9.223
5	Cu (mg/g)	APHA3111B	<1.0	2.112	4.215	7.223
6	pH	INSTRUMENTAL		6.8	7.3	7.3

	(DUMP SITE)						
7	Zn (mg/g)	APHA3111B	<1.0	1.239		2.845
8	Pb (mg/g)	APHA3111B	<1.0	6.512	9.306	12.611
9	As (mg/g)	APHA3030C	0.1	0.196	1.569	2.219
10	Cd (mg/g)	APHA3111B	<1.0	3.316	5.435	7.897
11	Cu (mg/g)	APHA3111B	<1.0	1.245	3.254	5.452
12	pH	INSTRUMENTAL	<1.0	6.8	7.2	7.2
	(CONTROL POINT)						
13	Zn (mg/g)	APHA3111B	<1.0	0.124	1.124	1.452
14	Pb (mg/g)	APHA3111B	<1.0	0.034	0.345	0.458
15	As (mg/g)	APHA3030C	0.1	0.008	0.011	0.016
16	Cd (mg/g)	APHA3111B	<1.0	0.037	0.089	0.199
17	Cu (mg/g)	APHA3111B	<1.0	0.124	0.245	0.268
18	pH	INSTRUMENTAL	<1.0	7.0	7.0	7.3

Source: Authors Field work.

Animal stand (point A) The distributions of PTEs found in the soils in various areas as depicted in Animal Stand (point A), with Lead exhibiting a greater concentration. at contrast to the 0–15 cm and 15–30 cm depths with lower concentration, these PTEs have a high deposit at the 30-45 cm depth range. The type of feed that the animals are fed can increase the concentration of trace elements in their tissues, which would then be excreted into the soil. The use of supplements and medications by the animals can also cause an accumulation of trace elements in the soil. Additionally, the drinking water containers, particularly those made of lead, can change the quality of the water. All of these factors contribute to the deposition of PTEs in the animal stand.

DUMP SITE (point B) The dump site is the location where leftovers, such as animal feces, bones, horn, tissues, etc., are disposed of as solid and liquid waste. This point documents the existence of PTEs such as arsenic, lead, cadmium, zinc, copper, and so on. According to Table 1, lead has the highest concentration, totaling 28.429 mg/g, with its largest deposit occurring at a depth of 45 cm. Some actions that might have led to the high concentration level observed here include the incorrect disposal of animal carcasses, offal, and blood as well as the use of chemicals like pesticides, cleaning solutions, and disinfectants inside the abattoir.

Control point (point C) The point is a point 200m or above to the point A and B. It is most likely to be a location outside the abattoir which is used to compare the concentration level of

PTEs in the abattoir soil with the outside location .it helps to show the effect or result of the various activities carried out in the abattoir. from the table above it shows that the control point has a very little deposition of PTEs as a result of the little or no activity been carried out in that location

Table 2. Tests of between-subjects' effects of location, depth and interaction of depth and location on quantity of potential trace elements measured.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	536.089[a]	12	44.674	10.370	.000	.795
Intercept	548.754	1	548.754	127.385	.000	.799
Location	236.051	2	118.025	27.398	.000	.631
Depth	46.489	2	23.245	5.396	.010	.252
Location * Depth	13.608	4	3.402	.790	.540	.090
Parameter	239.941	4	59.985	13.925	.000	.635
Error	137.851	32	4.308			
Total	1222.694	45				
Corrected Total	673.940	44				
a. R Squared = .795 (Adjusted R Squared = .719)						

The tests of between subjects' effects in Table 2 shows that. The corrected model which is the model for prediction of quantity of potential trace elements using location, depth and the interaction (location and depth) is statistically significant (p-value = 0.000 is less than 0.05). The Partial Eta Squared value of 0.795 means that the combinatorial effect of location and depth on the quantity of toxic elements is 79.5%. The marginal effect of location on the quantity of potential trace elements is accounted for by the Partial Eta Squared value of 0.631. This means that the location accounts for about 63.1% of the variations in the quantity of potential trace elements.

This effect is statistically significant at 5% level of significance (p-value = 0.000 is less than 0.05). About 25.2% of the variability in the amount of possible trace elements in each location can be attributed to the depth. Location and depth interact to provide an insignificant interaction term (p-value = 0.540 is not less than 0.05). The quantity measured for the five distinct possible trace elements varies significantly at each location (p-value = 0.000 is less than 0.05). The partial eta squared value of the variance explained by the potential trace elements is 0.635, meaning that the potential trace element type was responsible for 63.5% of the variability in the potential trace element observed.

Estimated Marginal Means

Table 3. Estimated Marginal Means of Quantity of potential trace elements measured in mg/g for each Location.

Study location	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Point A	5.796	.536	4.705	6.888
Point B	4.312	.536	3.220	5.403
Point C	.369	.536	-.723	1.460

Table 3 shows that the average quantity of potential trace elements in point A is 5.796, point B is 4.312 and point C is 0.369. This means that more potential trace elements were measured in Animal stand (point A) and followed by dump site (point B). The least quantity was measured in Control point (point C).

Table 4. Estimated Marginal Means of Quantity of potential trace elements measured in mg/g for each depth.

Depth	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
15 cm	2.272	.536	1.180	3.363
30 cm	3.445	.536	2.353	4.536
45 cm	4.760	.536	3.668	5.852

Table 4, shows that the average quantity of potential trace elements measured at depth 15cm is 2.272, 30cm is 3.445 and 45cm is 4.760. This means that the quantity of potential trace elements measured increased as we dig deeper. The implication means that as we dig deep down the soil below will be highly contaminated also there would be contamination of surface water table below the earth surface.

Table 5 shows the average amount of possible trace elements for each of the five categories of trace elements. According to the table, lead (Pb) had the largest average quantity of trace element (7.621) among the probable trace elements, while as had the lowest average quantity (1.084).

The average amount of copper (Cu) was 2.682, the average amount of zinc (Zn) was 1.865, and the highest trace element after lead (Pb) was (Cd).

Table 5. Estimated Marginal Means of Quantity of potential trace elements measured in mg/g for each type of trace element.

PTEs	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Zn(mg/g)	1.865	.692	.456	3.274
Pb (mg/g)	7.621	.692	6.211	9.030
As (mg/g)	1.084	.692	-.325	2.493
Cd (mg/g)	4.209	.692	2.799	5.618
Cu (mg/g)	2.682	.692	1.273	4.091

Table 6. Homogeneous Subset Tukey HSD PostHocTest for Quantity of potential trace elements measured in mg/g for different Locations.

	Study location	N	Subset	
			1	2
TukeyHSD[a,b]	Point C	15	.36853	
	Point B	15		4.311533
	Point A	15		5.796133
	Sig.		1.000	.139

To determine which location(s) have the same average quantity of potential trace elements and which location(s) have significantly different average quantities of potential trace elements, Table 6 potential trace element measurements were further tested in subsets. Table 6 subset column shows that, although point C appeared alone in subset one, the average number of potential trace elements for points B and A appeared in the same subset two. This indicates that, at the 5% level of significance, there is no significant difference between the average quantity of possible trace elements detected in point B and point A. The average amount of possible trace elements, however, was very different from the one at point C.

To determine which depth(s) have the same average quantity of potential trace elements and which depth(s) have significantly different average quantities of potential trace elements, Table 7 potential trace element measurements at various depths were further evaluated in subsets. Table 7 subset column shows that whereas 15 cm appeared alone in subset one, the average quantity of potential trace elements for 30 and 45 cm appeared in the same subset. This indicates that, at the 5% level of significance, there is no significant difference between the average quantity of possible trace elements measured at 30 cm and 45 cm. The average amount of possible trace elements, however, was very different from the one observed at 15 cm.

Table 7. Homogeneous Subset Tukey HSD Post HocTest for Quantity of potential trace elements measured in mg/g for different Depths.

	Depth	N	Subset	
			1	2
TukeyHSD[a,b]	15 cm	15	2.271667	
	30 cm	15	3.444533	3.444533
	45 cm	15		4.760000
	Sig.		.283	.208

Figure 8. Homogeneons Subset Tukey HSD PostHoc Test for Quantity of Potential trace elements measured in mg/g for different heavy metal types.

	PTEsh	N	Subset		
			1	2	3
TukeyHSD[a,b]	As (mg/g)	9	1.083889		
	Zn (mg/g)	9	1.865222	1.865222	
	Cu (mg/g)	9	2.682000	2.682000	
	Cd (mg/g)	9		4.208667	
	Pb (mg/g)	9			7.620556
	Sig.	9	.488	.143	1.000

To determine which specific potential trace elements, have the same average quantity as measured and which ones have a significantly different average quantity measured, subgroups of the five different quantities of potential trace elements measured in Table 8 were further investigated. Table 8's subset column shows that, although Pb appeared alone in subset 3, Zn, Cu, and Cd appeared in subset 2 and the average amount of As, Zn, and Cu appeared in the same subset. This indicates that, compared to other possible trace elements taken into consideration in this investigation, the average amount of Pb observed differs significantly. In particular, Pb was the most prevalent possible trace element in the depths and places taken into consideration for this investigation.

Profile plots

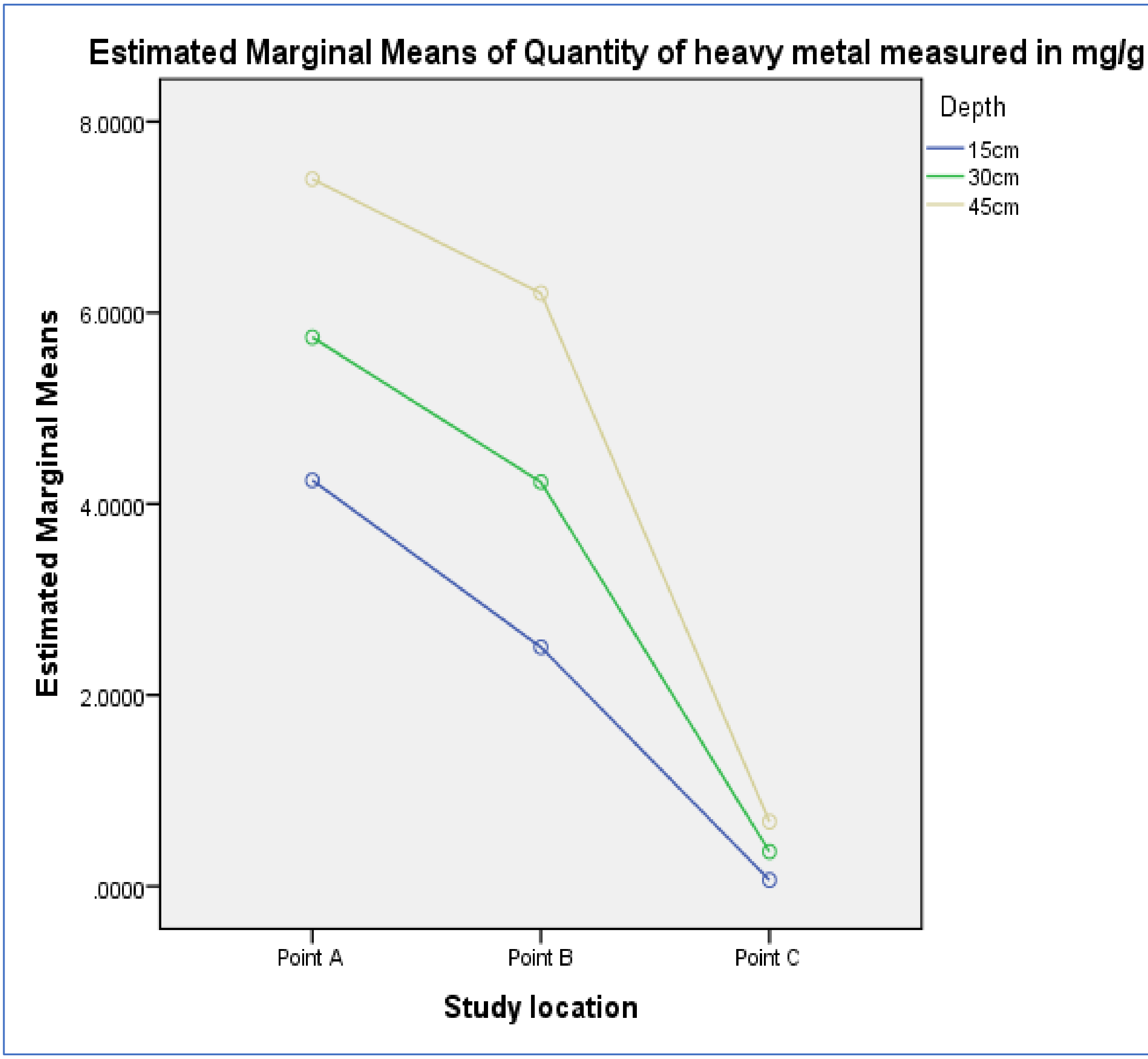

Figure 3. Estimated Means Profile Plot of Study location and depths for quantity of potential trace elements.

Figure 3 shows the estimated marginal means of quantity of potential trace elements at various points (A, B and C) and depths (15cm, 30cm and 45cm). The graph is in agreement with the results in Table 4 that the average quantity of potential trace elements measured at depth 15cm is 2.272, 30cm is 3.445 and 45cm is 4.760. This means that the quantity of potential trace elements measured increased as we dig deeper.

Figure 4 confirms the results in Table 5 which shows that the potential trace elements with the highest quantity of trace elements was lead (Pb) while the one with the least average quantity of heavy metal is As.

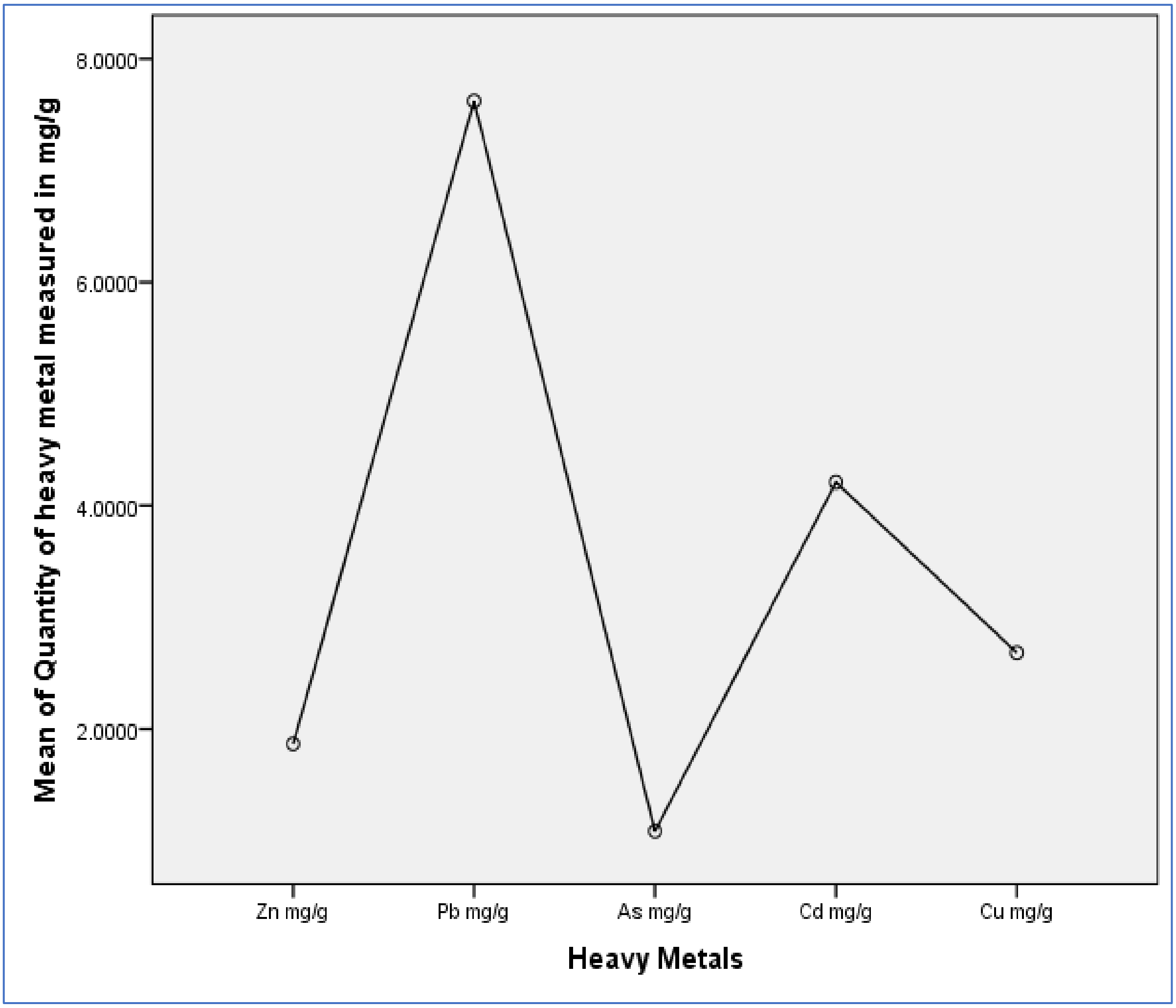

Figure 4. Estimated Means Profile Plot of quantity of different potential trace elements.

Contamination / Pollution (C/P) Index of the studied soils

The following is a breakdown of the levels of soil contamination according to the ratings proposed by Lacatusu (2002): < 0.1: Very Slightly Contamination, 0.10-0.25: Slightly Contamination, 0.26-0.50: Moderate Contamination, 0.51-0.75: Severe Contamination, 0.76-1.00: Very Severe Contamination, 1.1-2.0: Slightly Pollution, 2.0-4.0: Moderate Pollution, 4.1-8.0: Severe Pollution, 8.1-16.0; Very Severe Pollution, > 16; Excessive pollution. Considering the ratings above, Lead severely poisoned the soils of the animal stand and disposal site, while the control point did not have the same level of contamination.

The control point has very minimal arsenic contamination, with the majority of the contamination occurring at a depth of 45 cm. The soils of the animal stand and the dump site were extremely severely contaminated with arsenic. The assessment of the degree of cadium contamination/pollution revealed that the animal abattoir stand and the dump site were severely contaminated; the control point showed very little contamination, with the majority of the contamination occurring at a depth of 45 cm.

Additionally, it was noted that the control point had only a minor level of contamination, whereas the animal stand and disposal site had moderate to severe levels of copper pollution. Zinc contamination of the Animal stand was moderate, the Dump site was little, and the Control point was very slightly contaminated.

4. CONCLUSIONS

The study's findings demonstrated that the concentration levels of possible trace elements varied significantly. In contrast to points A and B, which are situated in the slaughterhouse, the control point had a lower concentration of trace elements. Point C (0.37), the control soil, had lower quantities of these possible trace elements than Point A (5.80) and Point B (4.31) (point A). These ranges for As, Cd, Cu, Pb, and Zn were 0.01 – 1.91 mg/g, 0.11 – 6.97 mg/g, 0.21 – 4.52 mg/g, 0.61 – 12.48 mg/g, and 0.90 – 2.81 mg/g, respectively, across the sampling locations. Still, taking into account the different sample locations, Pb (7.62 mg/g), Cd (4.21 mg/g), and Cu (2.68 mg/g) were all more than other potential trace elements. As (1.48 mg/g), Cd (5.77 mg/g), Cu (4.31 mg/g), Pb (9.64), and Zn (2.60 mg/g) had mean concentrations that were greater in 45 cm of water as opposed to 30 and 15 cm of water. Pb (7.62 mg/g), Cd (4.21 mg/g), and Cu (2.68 mg/g) were higher than other possible trace elements, despite the different depths, heavy metal deposition in soil over time can negatively influence plant physiological processes and impede the growth and accumulation of dry matter, effective waste management practices should be promoted in order to safeguard the environment and soil health.

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