Journal of Materials and Environmental Science
ISSN : 2028-2508
CODEN : JMESCN

J. Mater. Environ. Sci., 2020, Volume 11, Issue 8, Page 1250-1263

http://www.jmaterenvironsci.com

Index of Pollution Status in Soil and Health Risk Assessment of Heavy Metals in Vegetable Crops of a Municipal Abattoir

J.A. Olusola[1]*, O.B. Akintan[2], M.O. Adeyemi[3]

[1] *Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.*
[2] *Department of Geography and Planning Sciences, Ekiti State University, Ado Ekiti, Nigeria*
[3] *Department of Geology, Crawford University, Igbesa, Ogun State, Nigeria.*

Received 14 April 2020,
Revised 06 July 2020,
Accepted 07 July 2020

Keywords
- ✓ Abattoir,
- ✓ health risk,
- ✓ heavy metals,
- ✓ vegetable crops,
- ✓ soil.

johnsonolusola06@gmail.com ; Phone: +2348034777507;

Abstract

This study assessed the pollution status of a municipal abattoir and also evaluated the health risk assessment of heavy metal uptake by vegetable crops commonly grown and consumed by people living within the study area. The soil mean heavy metal concentrations in the study area decreases with depths at both depths. Most of the heavy metals concentrations in the abattoir soil were within the DPR maximum allowable limits except Cd. The contamination factor (CF) follows the order Cd> Cu> Zn> Ni> Pb >Cr at 0-15cm while at 15-30cm, the CF follows the order Cd> Cu> Zn> Ni> Pb > Cr. Based on the index of contamination, the shows index ranging from very slight contamination to severe pollution. The I-geo index also ranged from moderate contamination to very highly contamination. The health risk assessment shows that the DIM values of heavy metals in *amaranthus spinosus* were higher than that of *talinium triangulare*. For *talinium triangulare*, Cu, Zn, Cr and Ni DIM values were lower than that of WHO/FAO allowable limit while Pb with a DIM value of 0.357 was slightly higher than that of the WHO/FAO limit. The study shows Pb, Cu and Zn with HRI >1, an indication that the consumers of these vegetables are not safe from the risk associated with consumption of these vegetables. Constant monitoring by Government of the site should be given priority especially to the inhabitants who lives and utilizes wastewater of the abattoir as source of manure to grow crops

1. Introduction

Abattoir can be defined as a premise approved and registered by controlling authorities for hygienic slaughtering, inspection, processing, effective preservation and storage of meat products for human consumption [1]. Abattoir wastes remains a great concern though it has always been overlooked by, wastes like paunch manure, animal blood, animal feaces and abattoir effluents pollutes soils, water bodies etc. [2] observed that abattoir wastes are hazardous as they may contain varying quantities of components which are dangerous or potentially dangerous to the environment. Echoing this further [3] submitted that abattoirs are known all over the world in polluting the environment directly or indirectly through various processes.

The improper disposal of these wastes onto the lands and into water bodies leads to contamination of the environment [2, 4]. Indiscriminate discharges of abattoir effluents into soils have been reported to accumulate metals in receiving soils [5]. Most of these heavy metals not only pollute the soil but invariably increases its toxicity. Concerns about heavy metals in soils are not just limited to their toxicity to living organisms inhabiting the soil but also heavy metal built-up ̀ in soils which may result in immobilization within different organic and inorganic colloids and mobilization into the flora and fauna and subsequently become available in food chain with harmful health effects [6, 7].

Soil is a vital resource for humans because its chemical and physical conditions affect agricultural production and the quality of its products which constitute one of the fundamental factors of the life of the earth. Heavy metals may determine a potential toxicity to plants. Depending on their concentration in the soil, their entrance in the food chain represents a geochemical risk because of their toxicity to human health, especially for the occurrence of bioaccumulation phenomena. Heavy metals can be present in the soil as product of weathering of the natural rocks, or because they as part of pollution loads generated by human activities.

Too much accumulation of heavy metals in agricultural soils through wastewater irrigation may in addition to soil contamination, also lead to elevated heavy metal uptake by crops, thus affecting the quality and safety of food which could lead to high health risk to consumers of such crops [8]. Within the study area of Ado-Ekiti municipal abattoir lies farmlands where vegetables are grown for consumption, most of the abattoir wastes are used as source of manure to grow such crops, this study therefore aims to assess the pollution status of this municipal abattoir and to evaluate the health risk assessment of heavy metal uptake by vegetable crops commonly grown and consumed by people living within the abattoir site.

2. Material and Methods

2.1. Study Location

The study location is Ado Ekiti municipal abattoir, Ekiti State, Southwest, Nigeria (Figure 1). The town lies on latitude 7° 40' N and longitude 5° 16' E with a land area of 265km^2 and an elevation of 400 meters above sea level [9]. It has an estimated population of about 427,700 people. The area is characterized with the underlain precambrian basement complex of Southwestern Nigeria and migmatite rock type [10]. It is located within a land area of about 200 meters, which makes it the largest abattoir in the State as it slaughters over 700 cattle per week. It has sections such as lairage, slaughter slabs and butchering sections. . One characteristic of this abattoir is its high traffic of humans and carcasses. Water used for processing is from well and borehole within the abattoir as well as harvested rainwater collected in a reservoir [11].The wastewater is discharged uncontrollable into nearby running rivers, pits and adjoining farmlands in the study area.

Table 1: Samples Position Coordinates

Sample code	GPS coordinates		
	North	East	Elevation (metres)
A_1, A_2	07°40.261	005°16.593'	391
B_1, B_2	07°40.260	005°16.640'	390
C_1, C_2	07°40.213	005°16.638'	388
D_1, D_2	07°40.164	005°16.639'	390
E_1, E_2	07°40.261	005°16.794'	389
F_1, F_2	07°40.360	005°16.729'	379
G_1, G_2	07°40.372	005°16.722'	381
H_1, H_2	07°40.340	005°16.666'	382
I_1, I_2	07°40.347	005°16.659'	385
J_1, J_2	07°40.303	005°16.619'	390
K_1, K_2	07°40.308	005°16.612'	387
L_1, L_2	07°40.100	005°16.639'	385

A_1-L_1 (Soil l depth at 0-15cm) A_2-L_2 (Soil depth at 15-30 cm)

2.2. Soil sampling and preparation

Twenty four (24) soil samples were collected within the abattoir site at depths of 0 – 15cm and 15 – 30 cm with the aid of soil auger. Collected samples from each point were scooped inside a well labelled polythene sampling bags. The sampling bags were kept inside clean containers to prevent contamination during the process of transporting to the laboratory for analysis.

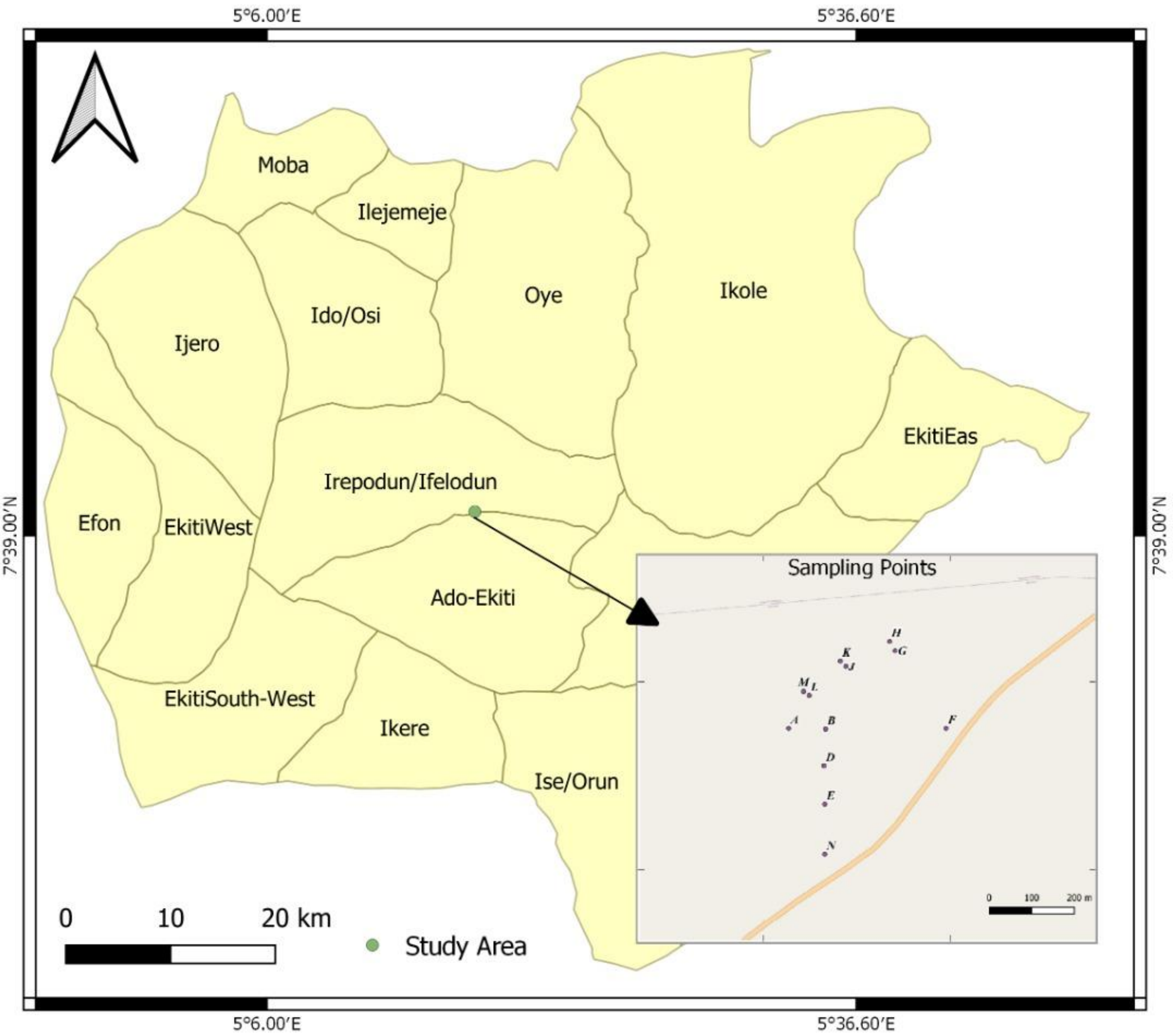

Figure 1: Study area showing sampling points

Soil samples were air dried and ground to pass through 0.15 mm sieve.1g of the sieved samples was weighed into a digest tube and 10 mL of concentrated Trioxonitrate five acid ($HN0_3$) was added and allowed to soak for 30 minutes. The sample was placed on a block digester and heated at 25°C until frothing stopped and nitric acid almost evaporated. 5 mL of concentrated perchloric acid was added and heating continued until the sample turned light straw in colour. This was allowed to cool, distilled water was added and the sample filtered into 100 mL volumetric flask and made up to the mark with distilled water. Blank was prepared using the samples and were determined using a Buck scientific Atomic Absorption spectrometer (Model: 210VGP) at various wavelengths of the metal and detection limits. Quantification of metals was based upon calibration curves of standard solutions of metals. Blanks were included in each batch of analysis and certified reference standard were used to evaluate the accuracy of the analytical method. The blank determination was applied when the blank analysis gives results with a non-zero standard deviation. Wavelength and detection limits (L_OD) of the various heavy metals using blank calibration method is shown in Table 2.

2.3. Plant preparation

Water leaf (*Talinium triangulare*) and green amaranth (*Amaranthus spinosus*) crops were harvested within the study area. The harvested crops were cleaned to remove visible soil and then washed severally with water. Thereafter, it was air dried for several days and then ground into a powdery form and stored in polythene bags for heavy metal uptake analysis. The following metals were analysed; Nickel (Ni), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Lead (Pb) and Copper (Cu).

Table 2: Wavelengths and detection limit of the calibrated instrument use

Elements	Wavelength (m)	Detection Limit (LoD)
Ni	232	0.05
Zn	213.9	0.005
Cd	228.9	0.01
Pb	283.3	0.08
Cr	357.9	0.04
Cu	324.8	0.005

2.4. Heavy metals analysis

Heavy metal analysis of the sampled soils and the plants (*Talinium triangulare* and *Amaranthus spinosus*) was analyzed using Atomic Absorption Spectrophotometer (AAS) (AAS **Bulk Scientific Model 210 VGP)** at the Ekiti State University Analytical Laboratory, Ado Ekiti, Nigeria.

2.5. Statistical Data Analysis

Mean, range, correlational interrelationship between soil samples at various depths of the study area and the plants was calculated.

2.6. Pollution index calculation

The geochemical index (I-geo) is defined with the formula:

$$I_{geo} = log_2 \frac{Cn}{1.5 * Bn} \quad (1)$$

Where **Cn** is indication of content of the individual heavy metals in the study area, **Bn** is background value of individual heavy metals, 1.5 is constant factor introduced to analyze natural fluctuations in the contents of a given substance in the environment and very small anthropogenic influences. The background value taken is considered from world average value in shale (mg kgG1) of the metals determined in the study. The values are Zn = 95, Pb = 20, Cu = 45, Cr = 90, Ni and Cd = 0.3. Table 3 shows the I-geo ranges and description.

Table 3: Geo-accumulation index range and description

N/S	Class	Description
1	<0	practically uncontaminated
2	0-1	Uncontaminated to slightly contaminated
3	1-2	moderately contaminated
4	2-3	moderately to highly contaminated
5	3-4	highly contaminated
6	4-5	highly to very highly contaminated
7	>5	very highly/strongly contaminated

2.7. Contamination factor

This was calculated by using the modifications of [12]:

$$CF = \frac{Concentration\ of\ the\ metal\ in\ soil}{Target\ value} \quad (2)$$

The target value was obtained by using the standard formulated by the [13], for maximum allowed concentration of heavy metals in soils as shown in Table 4.

Table 4: Maximum allowed for concentration of heavy metals in soils

S/N	Heavy metal in soil	*Maximum allowed Contamination/pollution index
1	Cd	0.8
2	Cr	100.0
3	Pb	85.0
4	Ni	35.0
5	Zn	140.0
6	Co	20.0
7	Hg	0.30
8	Cu	36.0
9	Mn	476.0
10	Fe	5000.0

*Standard formulated by the Department of Petroleum Resources of Nigeria [13]

2.8. Pollution Index (PI):

Pollution index is a measure of the degree of overall contamination in a sample station. The procedure of [14] was used to calculate the pollution Index (PI) for each metal is given in the calculation;

$$PI = (Cf_1 * Cf_2 * Cf_3 * \ldots Cf_n)^{\frac{1}{n}} \tag{3}$$

where, **n** is the no. of metals and **Cf** is the contamination factor. The **Cf** is the metal concentration in soil/background values of the metals. The PI is a potent tool used in heavy metal pollution assessment. Pollution range and their significance is shown in Table 5.

Table 5: Significance of intervals of contamination factor/pollution index (Cf/PI)

CF/PI	Significance
<0.1	Very slight contamination
0.10-0.25	Slight contamination
0.26-0.5	Moderate contamination
0.51-0.75	Severe contamination
0.76-1.00	Very severe contamination
1.1-2.0	Slight pollution
2.1-4.0	Moderate pollution
4.1-8.0	Severe pollution
8.1-16.0	Very severe pollution
>16.0	Excessive pollution

Source [15]

The values less than 1 defines the contamination range, while greater than 1 defines pollution range.

2.9. Transfer Factor (TF):

This is defined as the ratio of the mean plant concentration over the mean soil concentration:

$$TF = \frac{\text{concentration of metal in plant}}{\text{concentration of metal in soil}} \tag{4}$$

2.10. Health Risk Assessment

Human health risk assessment is considered as characterization of the potential adverse health effects of humans as a result of exposures to environmental hazards [16]. This process employs the tools of science, engineering, and statistics to identify and measure a hazard, determine possible routes of exposure, and finally use that information to calculate a numerical value to represent the potential risk [17]. A health assessment (HRA) identifies the following relevant steps;

1-Hazard identification
2-Dose-response assessment
3-Exposure assessment
4-Risk characterization.

Health risk assessment classifies elements as, carcinogenic or non-carcinogenic. The classification determines the procedure to be followed when potential risks are calculated. Non-carcinogenic chemicals are assumed to have a threshold; a dose below which no adverse health effects will be observed where an essential part of the dose-response portion of a risk assessment includes the use of a reference dose (RfD). Also, carcinogens are assumed to have no effective threshold. This assumption implies that there is a risk of cancer developing with exposures at low doses and, therefore, there is no safe threshold for exposure to carcinogenic chemicals. Carcinogens are expressed by their Cancer Potency Factor [17].

Health risks of heavy metal consumption through vegetables were assessed based on the daily intake of metal (DIM) [18], health risk index (HRI) [19] and the target hazard quotient (THQ) [20.21]. The daily intake of metals (DIM) was calculated to averagely estimate the daily metal loading into the body system of a specified body weight of a consumer. This will inform the relative phyto-availability of metal. This does not take into cognizance the possible metabolic ejection of the metals but can easily tell the possible ingestion rate of a particular metal. The estimated daily intake of metal in this study was calculated based on the formula below:

$$DIM = \frac{Concentration\ of\ metal\ Conversion\ factor * Daily\ vegetable\ intake}{Body\ Weight} \quad (5)$$

where concentration of metal is the heavy metal concentration in vegetables (mg/kg), Conversion factor is 0.085, the conversion factor was used to convert fresh vegetable weight to dry weight [22] and Daily food intake is the average daily intake of vegetables using 65 g/day [23] while the average body weight for adult used was 65 kg for this study [23].The health risk index (HRI) was calculated using the formula below:

$$HRI = \frac{DIM}{RFD} \quad (6)$$

The THQ (Hazard Quotient) was calculated using the formula:

$$THQ = \frac{EF \times ED \times FIR \times C}{RFD \times WAB \times TA \times 10^{-3}} \quad (7)$$

where EF is the exposure frequency (350 days/year);ED is the exposure duration (55 years**,** equivalent to the average lifetime of the Nigerian population WHO (2017); FIR is the food ingestion rate (vegetable consumption values for South Western adult, Nigerian is 65 g/person/day) [23]; **C** is the metal concentration in the edible parts of vegetables (mg/kg); RFD is the oral reference dose (Pb, Cd, Cu, Zn, Cr and Ni values are 0.0035, 0.001, 0.040,0.300, 1.5 and 0.020 mg/kg/day, respectively) [24]; WAB is the average body weight (65 kg for adults vegetable consumer in South western Nigeria)[23] and TA is the average exposure time for non-carcinogens (ED x 365 days/year). If the THQ value is greater than 1, the exposure is likely to cause obvious adverse effects.

3. Results and discussion

Table 6 shows the concentrations of heavy metals in the soil at various depths while Figure 2 shows the various mean concentration of soil heavy metals in the study area also at various depths; Figure 2 shows Pb, Cu, Zn, Cr, Ni and Cd having mean concentrations of 2.55 mg/l, 19.37 mg/l, 40.28 mg/l, 1.33 mg/l, 4.38 mg/l and 5..22 mg/l respectively at depths 0-15cm; Figure 1 also shows the various concentrations of the heavy metals at depths 15-30cm to be Pb (1.991mg/l), Cu(20.52mg/l), Zn(39.68mg/l), Cr(0.98mg/l),Ni(3.86mg/l) and Cd (4.78mg/l) respectively. The mean values of the various heavy metals were higher at depths 0-15 cm except at depth 15-30cm where Cu is higher than that at depth 0-15cm; generally the various concentrations of the heavy metals decreases with depth, this could be explained based that most of these metals are always concentrated at the cultivable level of most soil profile; this study is similar to that of [25].

Table 6: Concentration of heavy metals in the abattoir soil (mg/kg)

Sample code	Pb_1	Pb_2	Cu_1	Cu_2	Zn_1	Zn_2	Cr_1	Cr_2	Ni_1	Ni_2	Cd_1	Cd_2
A	ND	ND	25	28	25	34	3.1	2.1	11	9.8	7.1	7.2
B	ND	ND	14	13	22	21	4	2.1	3.1	3.9	9.1	8.8
C	2.1	2.2	11	17	63	50	ND	ND	2.1	2.5	2.1	2
D	1.4	1.8	14	23	18	18	ND	ND	1.8	2	5.1	5.2
E	2.4	2	25	26	45	42	0.3	ND	5.1	5.6	4.1	3.8
F	3.5	3	40	30	82	90	1	0.8	19	13	4.1	4
G	5.5	3.2	15	15	23	20	1.7	1.9	1.2	1.1	7.2	7.1
H	3.5	3.2	16	15	89	90	ND	ND	ND	ND	3.1	2.8
I	2	1.2	28	28	66	61	ND	ND	4.2	4.5	3.1	3.1
J	3.5	1.3	24	24	24	23	0.7	0.5	ND	ND	8.1	5.6
K	2.5	2	7.1	15	18	15	4.5	3.8	2.3	2.2	5.1	3.8
L	4.2	4	14	13	8.2	12	0.8	0.6	2.4	2.4	4.4	4

Pb_1-Cd_1 (Soil at 0-15cm depth); Pb_2-Cd_2 (Soil at 15-30cm depth)

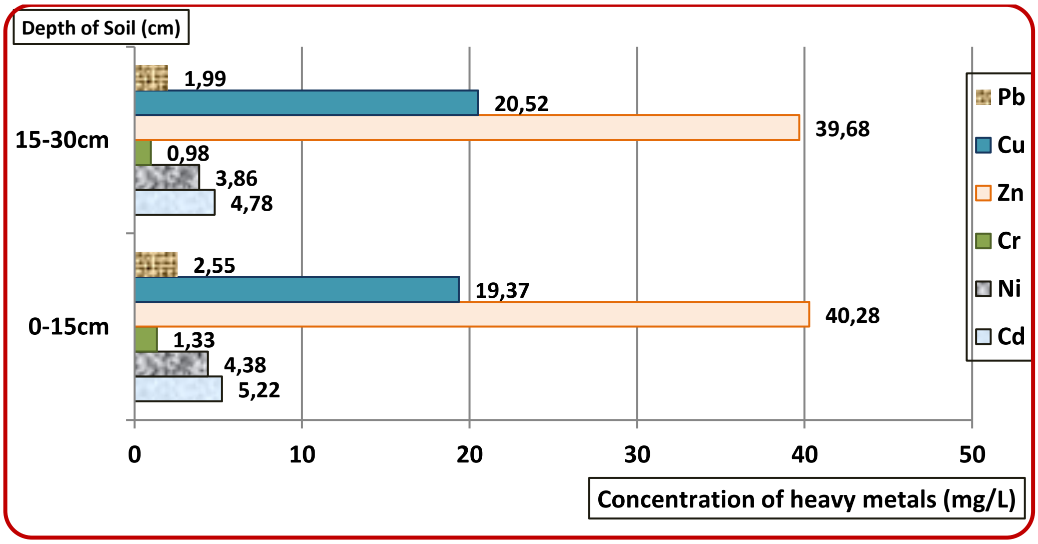

Figure. 2: Mean Concentration of soil heavy metals in the study area

Most of the heavy metals concentrations were within the [13] maximum allowable limits except Cd which is above the [13] allowable limits at various soil depths, this is an indication of the pollution status of the abattoir; this is different from similar studies carried out by [26, 27, 28]. The concentration of heavy metals in the abattoir soil according to [29] could be due to process generated during the slaughtering process. These wastes include its blood, fat, urine, organic and inorganic content of the animal stomach and other chemicals that may be used during the process. Figure 3 shows the Contamination Factor(CF) of heavy metals at depth 0-15cm and depth 15-30cm;all the metals except Cd has a contamination factor <1;Cd has a contamination factor of 6.52(0-15cm) and 5.98(depth 15-30cm).The CF follows the order below;

0 – 15cm Cd> Cu> Zn> Ni> Pb >Cr

15 – 30cm Cd> Cu> Zn> Ni> Pb > Cr

Based on the index of contamination (Figure 4), the study area can be categorized as very slight contamination (Cr) at depth 0-15cm and depth 15-30cm; slightly contamination (Pb and Ni) at depth 0-15cm and 15-30cm; moderate contamination (Zn) at 0-15cm and 15-30cm; severe contamination of (Cu) at depths 0-15cm and 15-30cm; severe pollution(Cd) at both depths.

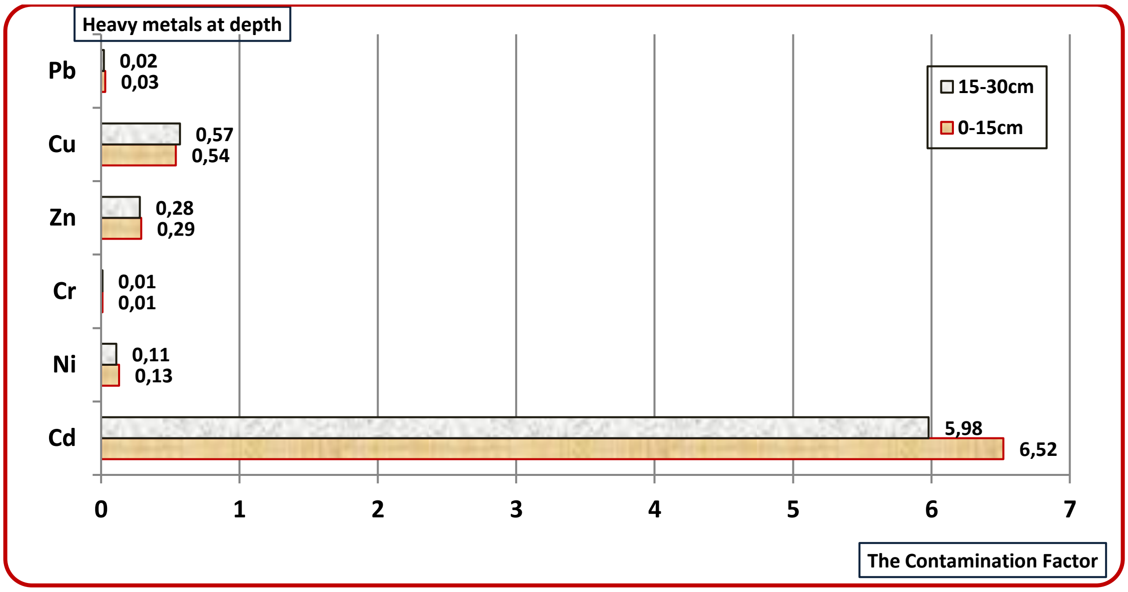

Figure 3: Contamination Factor (CF) at depth 0-15cm et 15-30cm

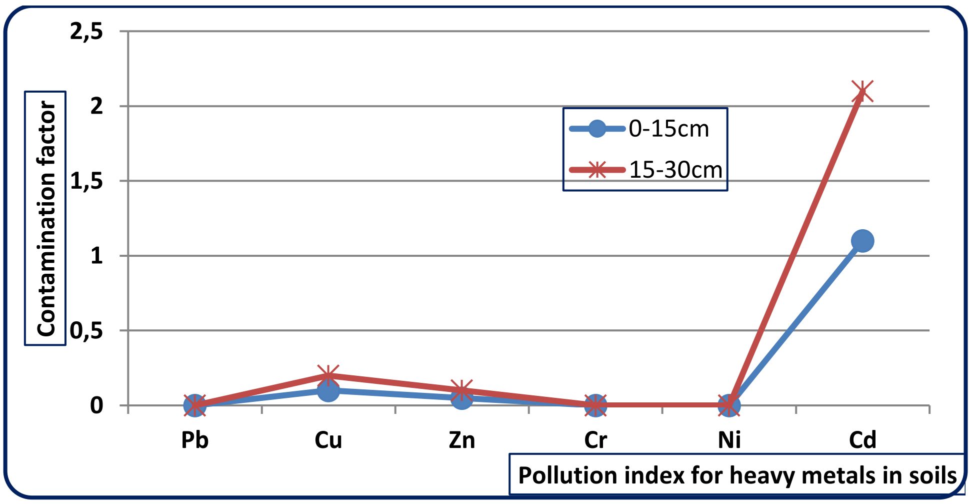

Figure 4: Significance of contamination (Contamination factor/pollution index for heavy metals in soils)

Table 7 shows the Geo-accumulation index (I-geo) of the various heavy metals; they range from Pb-1.2-1.9(moderately contaminated), Cu-2.3-3.1(moderately contaminated to highly contaminated), Zn- 2.7-3.8 (moderately contaminated to highly contaminated), Cr-1.3-2.4(moderately contaminated), Ni-1.7-2.9 (moderately contaminated) and Cd-4.2 - 4.9(highly to very highly contaminated).

Table 7: Geo-accumulation index range and description in the study area

Metal	Class Range	Description
Pb	1.2 – 1.9	Moderately contaminated
Cu	2.3 – 3.1	Moderately contaminated to highly contaminated
Zn	2.7 – 3.8	Moderately contaminated to highly contaminated
Cr	1.3 – 2.4	Moderately contaminated
Ni	1.7 – 2.9	Moderately contaminated
Cd	4.2 – 4.9	Highly to very highly contaminated

Table 8 shows the pollution load index of the heavy metals at various depths while Tables 9 and 10 shows interrelationship between the heavy metals also at various depths. It shows strong positive correlation between Ni/Cu (.850) at depth 0-15cm and Ni/Cu (.671) at depth 15-30cm, positive correlation value could be indication that the source of the abattoir soil contamination is from the same source of pollutants. Similar results has been recorded by [28, 29].

Table 8: Pollution Load Index (PLI) of heavy metals at depths 0-15cm and 15-30cm

Sample Code	Pb	Cu	Zn	Cr	Ni	Cd	PLI	Description
A_1	0.00	0.7	0.2	0.0	0.3	8.9	0.41	Moderate Contamination
A_2	0.00	0.8	0.2	0.0	0.3	9.0	0.40	Moderate Contamination
B_1	0.00	0.4	0.2	0.0	0.1	11.4	0.30	Moderate Contamination
B_2	0.00	0.4	0.1	0.0	0.1	11.0	0.27	Moderate Contamination
C_1	0.0	0.3	0.5		0.1	2.6	0.46	Moderate Contamination
C_2	0.0	0.5	0.4		0.1	2.5	0.49	Moderate Contamination
D_1	0.0	0.4	0.1		0.1	6.4	0.44	Moderate Contamination
D_2	0.0	0.6	0.1		0.1	6.5	0.50	Moderate Contamination
E_1	0.0	0.7	0.3	0.0	0.1	5.1	0.28	Moderate Contamination
E_2	0.0	0.7	0.3		0.2	4.8	0.70	Severe Contamination
F_1	0.0	1.1	0.6	0.0	0.5	5.1	0.51	Severe Contamination
F_2	0.0	0.8	0.6	0.0	0.4	5.0	0.44	Moderate Contamination
G_1	0.1	0.4	0.2	0.0	0.0	8.9	0.27	Moderate Contamination
G_2	0.0	0.4	0.1	0.0	0.0	8.9	0.26	Moderate Contamination
H_1	0.0	0.4	0.6			3.9	1.01	Very Severe Contamination
H_2	0.0	0.4	0.6			3.5	0.99	Moderate Contamination
I_1	0.0	0.8	0.5		0.1	3.9	0.71	Moderate Contamination
I_2	0.0	0.8	0.4		0.1	3.9	0.70	Moderate Contamination
J_1	0.0	0.7	0.2	0.0		10.1	0.38	Moderate Contamination
J_2	0.0	0.7	0.2	0.0		7.0	0.33	Moderate Contamination
K_1	0.0	0.2	0.1	0.0	0.1	6.4	0.28	Moderate Contamination
K_2	0.0	0.4	0.1	0.0	0.1	4.8	0.28	Moderate Contamination
L_1	0.0	0.4	0.1	0.0	0.1	5.5	0.20	Moderate Contamination
L_2	0.0	0.3	0.1	0.0	0.1	5.0	0.20	Moderate Contamination

$A_1 – L_1$ (Soil depth at 0-15cm) $A_2 – L_2$ (Soil depth at 15-30cm)

Table 9: Correlation between heavy metals (mg/kg) at 0 – 15cm depth

Heavy Metals	Pb	Cu	Zn	Cr	Ni	Cd
Pb	1					
Cu	0.3	1				
Zn	-0	0.5	1			
Cr	-0	-1	-0.4	1		
Ni	0.1	.850	0.6	-0.2	1	
Cd	0.5	-0	-.643	0.4	-0	1

$A_1 – L_1$ (Soil depth at 0-15cm) $A_2 – L_2$ (Soil depth at 15-30cm)

Table 11 and 12 shows heavy metals contents in the vegetable crops and their transfer factors. Heavy metal uptake is highest in Zn and Cu for both vegetables, this is also reflected in its transfer factor. Heavy metal accumulation in table 10 follow the order Zn >Cu> Pb >Cr >Ni for *talinium triangulare* while for *amaranthus spinosus* it follows the order Zn> Pb> Cu> Cr> Ni. The recommended maximum limit of cadmium, chromium, lead and copper ,nickel and zinc for vegetables by [30] is 0.2, 2.3, 0.3,40,0.1and 99 (mg/kg). Pb concentration is above the [30] maximum recommended limits in both vegetable crops. High level of Pb in the study area could be due to the use of tires by butchers to singe the carcass of slaughtered animals, most times they apply kerosene and lubricating oil when singeing such carcass which could be possible pathways to Pb pollution

Table 10: Correlation between heavy metals at 15 – 30cm depths

Heavy Metals	Pb	Cu	Zn	Cr	Ni	Cd
Pb	1					
Cu	-1	1				
Zn	0.1	0.4	1			
Cr	0.1	-0	-0.4	1		
Ni	0.1	0.71	0.4	0.1	1	
Cd	0.1	-0	-0.5	0.5	0.1	1

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

Table 11: Heavy metals in edible vegetables from the abattoir

Plant	Pb	Cu	Ni	Zn	Cr	Cd
Talinium traingulare (Water Leaf)	4.2	4.5	0.04	45	0.05	ND
Amaranthus spinosus (Amaranth)	2.7	1.7	0.08	47	0.17	ND

Table 12: Transfer Factor

Plant/Heavy metals	Pb	Cu	Ni	Zn	Cr	Cd
Talinium traingulare (Water Leaf)	2.111	0.219	0.01	2.193	0.001	ND
Amaranthus spinosus (Amaranth)	1.357	0.828	0.021	2.29	0.002	ND

To estimate the health risk associated with consumption of the two vegetable crops (*Talinium triangulare* and *Amaranthus spinosus)*, Daily adult Intake of metals (DIM), Target hazard quotient (THQ) for heavy metals in vegetables from the study area and Target Hazard Quotient (THQ*)* was calculated from tables

13, 14 and 15. In general the DIM values of heavy metals in *amaranthus spinosus* were higher than that of *talinium triangulare*. For *talinium triangulare*, Cu, Zn, Cr and Ni DIM values were lower than that of [30] allowable limit while Pb with a DIM value of 0.357 was slightly higher than that of the [30] standard, this calls for concern especially to the people who consumes these vegetable. Pb when ingested has been shown to cause severe health risk [31]. This study is similar to the results obtained by [32], where the Pb accumulation in vegetables was found to be within the range of 2.32 – 5.76 mg/kg. Lead pollution has been shown to be related with population/vehicular density [33]. Pb contaminations occur in vegetables grown on contaminated soils, through air deposition or through sewage sludge/waste water application [34]. Lead poisoning is a global reality, and fortunately is not a very common clinical diagnosis yet in Nigeria except for few occupational exposures [35]. Low levels of Pb have been reported in *Telfaria occidentalis* [36]. Lead influences the nervous system, slowing down nervous response. This influences learning abilities and behaviors [37].

Table 13: Estimation of Daily Adult Intake of metals (mg/person/day) by consumption of the vegetables grown within the study area

Plant/Heavy metals	Pb	Cu	Ni	Zn	Cr	Cd
Talinium traingulare (Water Leaf)	0.357	0.383	0.003	3.825	0.004	ND
Amaranthus spinosus (Amaranth)	0.2295	1.445	0.007	3.995	0.014	ND
WHO/FAO	0.214	3	1.4	60	0.05-0.2	0.06

Table 14 shows the various HRI in the two vegetable crops ranging from 89.25-57.375(Pb), 9.563-36.125(Cu), 0.170-0.340(Ni), 12.750-13.(Zn) and 0.003-0.010(Cr).The study shows Pb, Cu and Zn with HRI >1, an indication that the consumers of these vegetables are not safe from the risk associated with consumption of these vegetables, similar result has been reported by [38,39]. Table 15 shows THQ of the heavy metals in both vegetable crops which are all < 1 except in Pb with a THQ marginally above 1 only for *Talinium traingulare* in Pb but for *Amaranthus spinosus* THQ > 1 in Pb

Table 14: Health Risk Index (HRI) of the metals for adults for vegetable consumption around the abattoir site

Sample	Health Risk Index(HRI)					
	Pb	Cu	Ni	Zn	Cr	Cd
Talinium traingulare (Water Leaf)	89.25	9.563	0.170	12.750	0.003	ND
Amaranthus spinosus (Amaranth)	57.375	36.125	0.340	13.317	0.010	ND

Table 15: Target Hazard Quotient (THQ) for heavy metals in vegetables from the study area

Sample	Target hazard quotient(THQ)					
	Pb	Cu	Ni	Zn	Cr	Cd
Talinium traingulare	1.007	0.108	0.002	0.144	0.000	ND
Amaranthus spinosus	0.647	0.408	0.004	0.150	0.000	ND

Conclusion

This study shows that soil mean heavy metal concentrations decreases at both depths. Most of the heavy metals concentrations in the abattoir soil were within the Department of Petroleum Resources (DPR) maximum allowable limits except Cd which is above the DPR allowable limits at various soil depths. The contamination factor (CF) follows the order Cd> Cu> Zn> Ni> Pb >Cr at 0-15cm while at 15-30cm, the CF follows the order Cd> Cu> Zn> Ni> Pb > Cr. The study shows a strong correlation between Ni/Cu (.850) at depth 0-15cm and Ni/Cu (.671) at depth 15-30cm .Based on the index of contamination, the shows index ranging from very slight contamination to severe pollution. The I-geo index also ranged from moderate contamination to very highly contamination. The health risk assessment shows that the DIM values of heavy metals in *amaranthus spinosus* were higher than that of *talinium triangulare.* For *talinium triangulare*, Cu, Zn, Cr and Ni DIM values were lower than that of WHO/FAO allowable limit while Pb with a DIM value of 0.357 was slightly higher than that of the WHO/FAO standard. The study shows Pb, Cu and Zn with HRI >1, an indication that the consumers of these vegetables are not safe from the risk associated with consumption of these vegetables. Constant monitoring of the site by the Government should be given priority especially to the inhabitants who lives and utilizes the various waste/waste water of the abattoir as source of manure to grow their crops.

Acknowledgement-Special thanks go to the Veterinary Section, Ekiti State Ministry of Agriculture for allowing us to use their Municipal abattoir for this study.

References

1. D.O. Alonge, Abattoir design, management and effluent disposal in Nigeria. 1st ed. Nigeria: University Press Ibadan (1992).
2. O. Chukwu, H.I. Mustapha, H.B. Abdu l- Gafar, The effect of Minna Abattoir Wastes on Surface Water Quality I. *Environmental Research Journal* 2(6), (2008) 334 – 338
3. J.A Adelegan, Environmental policy and slaughterhouse waste in Nigeria. Proceedings of the 28th WEDC Conference Kolkata (Calcutta) India pp3-6 (2002)
4. H.B. Abdul - Gafar, Analysis of Surface and Groundwater Pollution from Abattoir Wastes: Case Study of Minna Abattoir". Unpublished B.Eng. Project Department of Agricultural Engineering, Federal University of Technology, Minna, Nigeria (2006)
5. M.I. Yahaya, S. Muhammad, and B. K. Abdullah, Seasonal variations of heavy metals concentration in abattoir dumping site soil in Nigeria, *J. Appl. Sci. Environ. Manag*., 13(4) (2009) 9–13
6. P. Trueby Impact of heavy metals on forest trees from mining areas. In: International Conference on Mining and the Environment. Sudbury, Ontario, Canada (2003)
7. P. Nannipieri, L. Badalucco, G. Pietramellara, Measurement in assessing the risk of chemicals to the soils ecosystem. In: Zellkoff JT. (ed.). Ecotoxicology; Responses, biomarkers and risk assessment. OCED Workshop. SOS Publ. Fair Haven, New York (1997) 507-534
8. M. Muchuweti, J.W. Birkett, E. Chinyanga, R. Zvauya, M.D. Scrimshaw, J.N.Lester, Heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: implications for human health. *Agriculture, Ecosystem and Environment*, 112 (2006) 41-48
9. O. Akintan, S. Jewitt, M. Clifford, Culture, tradition, and taboo: Understanding the social shaping of fuel choices and cooking practices in Nigeria, *Energy Research and Social Science*, 40(C) (2018)14– 22
10. E. Olagunju, O. Badmus, F. Ogunlana, M. Babalola, Environmental Impact Assessment of Waste Dumpsite using Integrated Geochemical and Physico-Chemical Approach: A Case Study of Ilokun Waste Dumpsite, Ado - Ekiti, Southern Nigeria. *Civil Eng Res J*.,4 (2) (2018) 555-631
11. J.O. Ojo, Assessment of Sanitary Conditions and Quality of Water Used for Processing at Ado - Ekiti Municipal Abattoir, Ekiti State, Nigeria; *Sch J Agric Vet Sc*, 2(B)(2015) 131-134
12. O.T. Ogunmodede, E. Adewole, O. Ojo, Quantitative changes in soils properties and uptake of metals on municipal solid waste dumpsite in Nigeria, *Int Lett Chem Phy Astron*, 52 (2015) 152-162
13. DPR, Environmental guidelines and standards for the petroleum industry in Nigeria. *Department of Petroleum Resources*, Lagos, Nigeria (2002)
14. D.L. Tomlinson, J. G. Wilson, C. R. Harris, D. W. Jeffrey, Problem in the assessment of heavy metals levels in estuaries and the formation of a pollution index, *Helgoländer Meeresuntersuchungen*, 33(1980) 566–575
15. R. Lacutusu, Appraising levels of soil contamination and pollution with heavy metals In Heinike HJ, Eckselman W, Thomasson AJ, et al. Land information systems for planning the sustainable use of

land resources. European Soil Bureau Research Report No. 4. Office of Official Publication of the European Communities, Luxembourg (2000) 393-402
16. USEPA Waste and cleanup risk assessment. http://www2.epa.gov/risk/waste-and-cleanup-risk-assessment (2012)
17. M.A Lushenko, A risk assessment for ingestion of toxic chemicals in fish from Imperial beach, California: San Diego State University (2010)
18. N.S. Chary C.T. Kamala, D.S.S. Raj, Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxic Environ Safety*, 69 (2008) 513–524
19. F.A. Jan, M. Ishaq, S. Khan, I. Ihsanullah, I. Ahmad, M. Shakirullah, A comparative study of human health risks via consumption of food crops grown on wastewater irrigated soil (Peshawar) and relatively clean water irrigated soil (lower Dir). *Journal Hazardous Materials*, 179 (1-3) (2010) 612–621
20. X. Wang, T. Sato, B. Xing, S. Tao, Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. *Sci Total Envi* 350 (2005) 28–37
21. M.M Storelli, Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: Estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). *Food Chem Toxic*, 46 (2008) 2782–2788
22. K. Sajjad, R. Farooq, S. Shahbaz, M. A. Khan, M. Sadique, Health risk assessment of heavy metals for population via consumption of vegetables, *World Appl Sci Jour*, 6(2009) 1602–1606
23. T. Oguntona, Green Leafy Vegetables. In: Osagie, A.U. and O.U. Eka (Eds.). Nutritional Quality of Plant Foods. Post-Harvest Research Unit, Department of Biochemistry, University of Benin, Benin City, Nigeria (1998) 120-133
24. US-EPA IRIS, United States, Environmental Protection Agency, Integrated Risk Information System (2006)
25. O.B. Akintan, J.A. Olusola, A.M. Azeez, Heavy metals loads in soil, farmlands and plant crop at open dumpsite. *Global J. Environ. Sci. Manage*., 5(8) (2019) 449-460
26. A. Nasiru, C.E. Osakwe, I.M. Lawal, A.U. Chinade, Assessment of physicochemical parameters and heavy metals in Gombe abattoir wastewater. *Am. J. Eng. Res*., 5(2016) 64-69
27. U.J. Chukwu, S.O. Anuchi, Impact of abattoir wastes on the physicochemical properties of soils within Port Harcourt Metropolis. *Int. J. Eng. Sci.*, 5 (2016) 17-21
28. O.S. Edori, F. Kpee, Index models assessment of heavy metal pollution in soils within selected abattoirs in Port Harcourt, Rivers State, Nigeria. *Singapore J. Sci. Res*., 7 (2017) 9-15
29. C. Jukna, V. Jukna, J. Siugzdaite, Determination of heavy metals in viscera and muscles of cattle. *Bulgarian J. Vet. Med*., 9(1) (2006) 35-41
30. WHO/FAO, "Joint WHO/FAO Food Standards Program Code Alimentarius Commission 13th Session," Report of the Thirty Eight Session of the Codex Committee on Food Hygiene, Houston, Texas, USA, ALINORM (2013)
31. N.S. Lawal, O. Agbo, A. Usman, Health risk assessment of heavy metals in soil, irrigation water and vegetables grown around Kubanni River, Nigeria. *J. Phys. Sci*., 28(1) (2017), 49–59
32. A Asdeo, S. Loonker, A Comparative Analysis of Trace Metals in Vegetables *Res Jour Enviro Toxico*, 5(2011) 125-132
33. I. Afolami, C. Anyakora, O. Ebuehi, O. Bolawa, Lead levels in some edible vegetables in Lagos, Nigeria. *Scientific Research and Essays*, 5(8) (2010): 813-818

34. S.O. Oluwole, O.S.C. Makinde, K.A Yusuf, O.O. Fajana, A.O. Odumosu, Determination of Heavy Metal Contaminants in Leafy Vegetables Cultivated By the Road Side, *Inter Jour Eng Res Dev*, 7(3) (2013) 1-5
35. J. I.Anetor, G.O. Anetor, D.C. Udah, F.A. Adeniyi, Chemical carcinogenesis and chemoprevention: Scientific priority area in rapidly industrializing developing countries. *African Journal of Environmental Science and Technology*, 2(7) (2008): 150-156
37. A A. Adesuyi, M.O. Ngwoke, M.O. Akinola, K.L. Njoku, A.O. Jolaoso, Physicochemical Assessment of Sediments from Nwaja Creek, Niger Delta, Nigeria. *J. Geosci Enviro Protection*, 4 (2016) 16–27
38. A I. Tsafe, L.G. Hassan, D.M. Sahabi, Y. Alhassan, B.M. Bala , Evaluation of Heavy Metals Uptake and Risk Assessment of Vegetables Grown in Yargalma of Northern Nigeria. *J. Basic App Sci Res*, 2(7) (2012) 6708-6714
39. A H. Adedokun, K.L. Njoku, M.O. Akinola, A.A. Adesuyi, A.O. Jolaoso, Potential Human Health Risk Assessment of Heavy Metals Intake via Consumption of some Leafy Vegetables obtained from Four Market in Lagos Metropolis, *Nigeria. J. Appl. Sci. Environ. Manage*, 20 (3) (2016) 530-539

(2020) ; http://www.jmaterenvironsci.com