British Journal of Environmental Sciences
Vol.9, No.6, pp. 55-66, 2021
ISSN 2054-6351 (print),
ISSN 2054-636X (online)

ENVIRONMENTAL ASSESSMENT OF HEAVY METAL CONCENTRATIONS OF *COLOCASIA ESCULENTA* L., *VERNONIA AMYGDALINA* DEL. AND *AMARANTHUS SPINOSUS* L. AND SOILS COLLECTED AROUND SOME ABATTOIRS IN LAGOS STATE, NIGERIA

Oluwole, Surukite O; *Ogun, Mautin, L; Oyetunji, Opeyemi S; Asokere, Simeon Y; O'Daniel, Samuel C.; Shittu, Azeez O. and Usamot, Qudus

Botany Department, Lagos State University, Ojo, Nigeria.

ABSTRACT: *Wastes from abattoirs may have significant effects on the soil and the surrounding plants in Lagos State of Nigeria where there are poor abattoir practices. Thus, this study aimed at assessing some heavy metals' concentrations of Colocasia esculenta, Vernonia amygdalina and Amaranthus spinosus and soils collected around some selected abattoirs in Lagos State, Nigeria. Samples of C. esculenta, V. Amygdalina, A. Spinosus and soils were obtained from three different abattoirs in three local government areas of Lagos State. Heavy metal analysis was done on plants and soil samples using standard analytical procedures and mean-standard-deviation were used for analysis. Analysis of heavy metal revealed the concentration range of Lead (Pb) [0.001-0.053mg/100g]; Cadmium (Cd) [0.001-0.008mg/100g]; Manganese (Mn) [0.006-0.053mg/100g]; Cobalt (Co) [0.003-0.007mg/100g], Nickel (Ni) [0.001-0.003mg/100g]; Zinc (Zn) [0.246-0.7441 mg/100g] and Chromium (Cr) value was 0.001mg/100g in three vegetables across the three abattoirs. Also, the soil analysis showed that the concentrations range of Pb [0.110-0.123mg/100g]; Cd [0.017-0.019mg/100g]; Mn [0.340-0.695mg/100g]; Cr [0.001-0.004mg/100g]; Co [0.011-0.013mg/100g]; Ni [0.005-0.006mg/100g] and Zn [1.104-1.267mg/100g]. These metallic concentrations were below or within metallic limits set by World Health Organization and thus, are safe for consumption at time of this study. However, efforts should be made to reduce these metals in order to prevent abattoirs' effluents accumulation. This study therefore suggest that abattoir effluents should be correctly channelled and controlled into cesspit or treated to avoid plants and surrounding soils' heavy metal build-up.*

KEYWORDS: abattoir, waste, heavy metal, *Colocasia esculenta*, *Vernonia amygdalina Amaranthus spinosus* and soils

INTRODUCTION

The sporadic insurgence of industries has led to occurrence of pollution and contaminations due to several pollutants which are expelled into ecosystem through man's actions and normal sources (Ubwa *et al*., 2013; Sharma *et al*., 2014). These pollutants released into the ecosystem from relevant pollution sources (UNEP, 2004).

ECRTD-UKhttps://www.eajournals.org/
ULR:https://doi.org/10.37745/bjes.2013

Heavy metals are often one of these pollutants are found in minute degrees. Several kinds of these metals are found even though in little quantities, are poisonous to the ecosystem and often leads in bio-accumulation or bio-concentration in tissues of most animates (Wong *et al.,* 2002; Seaward, 2004).

Large quantities of animals' wastes are secondary waste materials produced in abattoirs (Red Meat Abattoir Association, 2010). Several parts of animal such as, flesh, blood, innards, and many others reported to house toxic substances (Kruslin *et al*., 1999; Jukna, 2006) as well as increase the pH of the soil (Chukwu and Anuchi, 2016).

Soil is an essential template for man because its physicochemical conditions affect plants' production and the lives on earth rely on its products for sustenance. Thus, unlawful release of wastes from abattoirs into soils has been documented to increase toxic metals in soils found around abattoirs (Yahaya *et al*., 2009). Most of these heavy metals increase their toxicity in the soil. "Hence, implication of soils with heavy metals are not just narrowed to their lethality to soil inhabiting organisms but also their build up which may lead to mobilization within flora and fauna and immobilization of living and nonliving colloids and these heavy metals consequently become present in the ecosystem chain with side effects" (Nannipieri, *et al*., 1997; Trueby, 2003). The occurrence of toxic substances in the soil is also harmful to the soil microbes in and not just the flora. And regarding the soil metallic concentration of the soil, it introduces heavy metals into the food chain which may pose a challenge due to their toxic effects on human health, especially bioaccumulation (Chibuike and Obiora, 2014).

Therefore, sourcing for vegetables like *Amaranthus spinosus*, *Vernonia amygdalina* and *Colocasia esculenta* growing naturally on non-agricultural land or polluted land may expose man to toxic pollutants especially in cosmopolitan city like Lagos in Nigeria where there is increase demand for food. Hence, on the basis of this premise, this research tends to determine the degree of heavy metal concentrations in *Amaranthus spinosus*, *Vernonia amygdalina*, *Colocasia esculenta* and soils sampled from some Lagos State's abattoirs of Nigeria.

LITERATURE/THEORETICAL UNDERPINNING

The zeal to facilitate populace meat tastes for growth and development is often confronted with pollutions of air, water, food and soil (Rabah *et al*., 2010; Ezeoha and Ugwuishiwu, 2011). Wastes from Abattoir have been reported to be a great challenge to many inhabitants in Nigeria (Ezeoha and Ugwuishiwu, 2011). Abattoir produces great effluents and waste water; these effluents are chemical substances which may change the soil compositions due to their complex nature (Ediene *et al.,* 2016) which may be toxic to the ecosystem at large. However, in Lagos State of Nigeria where animal processing are mostly carried out at inappropriate environment by butchers who are unskilled and mostly devoid of personal hygiene (Olanike, 2002). Although,

British Journal of Environmental Sciences
Vol.9, No.6, pp. 55-66, 2021
ISSN 2054-6351 (print),
ISSN 2054-636X (online)

abattoirs are often recognised as a source of contaminant to the ecosystem globally through various slaughtering activities (Elemile *et al*., 2019), in Nigeria, there is no mechanism to handle slaughterhouse wastes, compared to advanced nations where these amenities are available (Ogbonnaya, 2008).

MATERIALS AND METHODS

Sample Collection

Soils and leaves samples of *Amaranthus spinosus*, *Vernonia amygdalina*, *Colocasia esculenta* were collected from three different abattoirs in three local Governments: Odo Eran Abattoir, Igando in Alimosho LGA, New Abattoir, Agege in Agege LGA, and Barracks Abattoir, Ojo in Ojo LGA of Lagos State in Nigeria (Figure 1). Soils and plants were obtained around the plants' roots at 15 cm deep and at 20 meter away from the slaughter points respectively.

Figure 1: Fig. 1: Map of Lagos State showing Sample Locations

Processing of Plant Materials

Fresh vegetables' leaves sampled were carefully and differently washed with distilled water deionized. Then, leaves were placed in oven to constant temperature at 55°C for 3-4 days for dryness. The pulverized leaves were made into fine powder using dried pestle and mortar (Oluwole *et al*., 2021).

Heavy Metal Analysis

The soil and plant samples (leaves and stems) were dried and the dried plants were milled to powder. The powdered samples of *Amaranthus spinosus*, *Vernonia amygdalina*, *Colocasia esculenta* were mixed with nitric acid and perchloric acid and metals' contents- Zinc, Nickel, Cobalt, Manganese, Lead, chromium and Cadmium contents determined using aliquots in Atomic Absorption Spectrophotometer (A.O.A.C., 1990). Some metals (Mn, Co, Cr, Ni, Zn, Pb, and Cd) evaluated with AAS (Buck Scientific Model 200A). The soil samples' metals' contents were done using same procedure.

ECRTD-UKhttps://www.eajournals.org/
ULR:https://doi.org/10.37745/bjes.2013

Statistical Analysis

Statistical analyses were done on all the triplicate data collected using mean standard deviation with the aid of the software SPSS 2007 version 20.

RESULTS

Heavy Metals' Concentrations of *Colocasia esculenta* collected from different Abattoirs

Table 1 reveal the analysis of heavy metal concentrations in *Colocasia esculenta* sampled from abattoirs in the three locations. The result showed that the *Colocasia esculenta* harvested from Ojo has the highest Lead (Pb), (Mn)-Manganese and Zinc (Zn) concentrations with values of 0.045 mg/100g, 0.018 mg/100g, and 0.271 mg/100g respectively. This was followed by those from Agege (0.042 mg/100g, 0.017 mg/100g and 0.269 mg/100g respectively) while; those in Igando had the least concentrations for the three metals with values 0.039 mg/100g, 0.016mg/100g and 0.246mg/100g respectively (Table 1). Cadmium (Cd) and Cobalt (Co) concentrations were not detected in both Ojo and Agege areas but were present in minute quantities (0.008 mg/100g and 0.003 mg/100g) in Igando *C. esculenta.* Chromium (Cr) was completely absent in all three locations but Nickel content in the three areas shows similar mean concentrations (0.002 mg/100g) (Table 1).

Heavy Metals' Concentrations in *Vernonia amygdalina* collected from different Abattoirs

Table 2 reveal the analysis of heavy metals' levels in *Vernonia amygdalina* collected from the three different abattoirs. The result showed that *Vernonia amygdalina* collected from Ojo has the highest Zinc (Zn) contents with the value of 0.560 mg/100g. This was followed by those from Agege (0.542 mg/100g) while, those in Igando had the least concentrations with the value of 0.490 mg/100g (Table 2). Cadmium (Cd) and Nickel (Ni) had similar mean concentrations of 0.009 mg/100g and 0.002 mg/100g at both Ojo and Agege abattoirs but were completely negligible at Igando. Chromium (Cr) concentration was not detected in both Ojo and Agege areas but was sparingly present (0.001 mg/100g) in Igando *V. amygdalina.* Manganese (Mn) and Cobalt (Co) contents were also similar in mean concentration (0.007 mg/100g and 0.002 mg/100g) at Ojo and Agege abattoirs but appeared with just a little drop in concentration at Igando (0.006 mg/100g and 0.001 mg/100g). But then, the Lead (Pb) concentration showed equal mean value of 0.007 mg/100g in all three locations (Table 2).

Heavy Metals' Concentrations in *Amaranthus spinosus* harvested from different Abattoirs

Table 3 showed the analysis of levels of heavy metals in *Amaranthus spinosus* harvested from the three different abattoirs. The result showed that Agege abattoir's *Amaranthus spinosus* has the highest Lead (Pb) and Zinc (Zn) concentrations with the values of 0.004 mg/100g and 0.742mg/100g respectively while vegetables from Igando and Ojo abattoirs had similar values (Table 3) but Manganese contents in Ojo and

Vol.9, No.6, pp. 55-66, 2021
ISSN 2054-6351 (print),
ISSN 2054-636X (online)

Igando abattoirs were the highest. Cadmium (Ca) concentrations was not detected in three abattoirs but were present in minute quantities (0.001 mg/100g) in Ojo abattoir *Amaranthus spinosus*. Nickel (Ni) content of *A. spinous* collected from Agege has the highest concentration of 0.003 mg/100g followed those of Ojo. Chromium (Cr) and Cobalt (Co) were completely absent in all locations (Table 3).Heavy Metals' Concentrations in Soils obtained in different Abattoirs

Table 4 reveal the analysis of heavy metal concentration of soils obtained from the three different abattoirs. The result revealed that the soils obtained in Ojo had the highest Lead (Pb), Cadmium (Cd), Manganese (Mn) and Cobalt (Cd) contents with values of 0.123 mg/100g, 0.019 mg/100g, 0.695 mg/100g and 0.013 mg/100g respectively and this was closely followed by those from Agege (0.110 mg/100g, 0.018 mg/100g, 0.692 mg/100g and 0.012 mg/100g respectively) while, those in Igando had the least contents for the four metals with values 0.102 mg/100g, 0.01 7 mg/100g, 0.340 mg/100g and 0.011 mg/100g respectively (Table 4). Soil samples from Agege had the highest value for Zinc (Zn) mean concentration (1.267 mg/100g) followed by samples from Ojo (1.256 mg/100g) with Igando having the least (1.104 mg/100g). Nickel had similar mean concentrations of 0.006 mg/100g at both Ojo and Agege abattoirs but was a little bit reduced at Igando with mean values 0.005 mg/100g. Chromium (Cr) concentration was not detected in both Ojo and Agege areas and was almost negligible (0.004 mg/100g) in Igando soil also (Table 4).

ECRTD-UKhttps://www.eajournals.org/
ULR:https://doi.org/10.37745/bjes.2013

Table 1: Heavy Metal Analysis (mg/100g) of *Colocasia esculenta*

Location		Lead	Cadmium	Manganese	Chromium	Cobalt	Nickel	Zinc
Agege	Mean ± S.D	0.042 ± 0.001	0.000 ± 0.000	0.017 ± 0.000	0.000 ± 0.000	0.000 ± 0.000	0.002 ± 0.000	0.269 ± 0.001
Ojo	Mean ± S.D	0.045 ± 0.002	0.000 ± 0.000	0.018 ± 0.000	0.000 ± 0.000	0.000 ± 0.000	0.002 ± 0.000	0.271 ± 0.007
Igando	Mean ± S.D	0.039 ± 0.001	0.008 ± 0.000	0.016 ± 0.000	0.000 ± 0.000	0.003 ± 0.000	0.002 ± 0.000	0.246 ± 0.006

Table 2: Heavy Metal Analysis (mg/100g) of *Vernonia amygdalina*

Location		Lead	Cadmium	Manganese	Chromium	Cobalt	Nickel	Zinc
Agege	Mean ± S.D	0.007 ± 0.000	0.009 ± 0.000	0.007 ± 0.000	0.000 ± 0.000	0.002 ± 0.000	0.002 ± 0.000	0.542 ± 0.010
Ojo	Mean ± S.D	0.007 ± 0.000	0.009 ± 0.001	0.007 ± 0.000	0.000 ± 0.000	0.002 ± 0.000	0.002 ± 0.000	0.560 ± 0.004
Igando	Mean ± S.D	0.007 ± 0.000	0.001 ± 0.000	0.006 ± 0.000	0.001 ± 0.000	0.001 ± 0.000	0.000 ± 0.000	0.490 ± 0.002

Table 3: Heavy Metal Analysis (mg/100g) of *Amaranthus spinosus*

Location		Lead	Cadmium	Manganese	Chromium	Cobalt	Nickel	Zinc
Agege	Mean ± S.D	0.004 ± 0.000	0.000 ± 0.000	0.007 ± 0.001	0.000 ± 0.000	0.000 ± 0.000	0.003 ±0.000	0.742 ± 0.010
Ojo	Mean ± S.D	0.020 ± 0.001	0.000 ± 0.000	0.052 ± 0.001	0.000 ± 0.000	0.000 ± 0.000	0.001 ± 0.001	0.438 ± 0.002
Igando	Mean ± S.D	0.022 ± 0.001	0.000 ± 0.000	0.053 ± 0.0008	0.000 ± 0.000	0.000 ± 0.000	0.000 ±0.000	0.419±0.009

Table 4: Heavy Metal Analysis (mg/100g) of soil samples

Location		Lead	Cadmium	Manganese	Chromium	Cobalt	Nickel	Zinc
Agege	Mean ± S.D	0.110 ± 0.001	0.018 ± 0.000	0.692 ± 0.012	0.000 ± 0.000	0.012 ± 0.000	0.006 ± 0.000	1.267 ± 0.006
Ojo	Mean ± S.D	0.123 ± 0.002	0.019 ± 0.000	0.695 ± 0.014	0.000 ± 0.000	0.013 ± 0.000	0.006 ± 0.000	1.256 ± 0.019
Igando	Mean ± S.D	0.102 ± 0.007	0.017 ± 0.000	0.340 ± 0.393	0.004 ± 0.000	0.011 ± 0.001	0.005 ± 0.000	1.104 ± 0.026

DISCUSSION

Several livestock products have previously been documented to house heavy metals (Saskia *et al.,* 2013) and this has spike the assertion that all effluents from abattoirs must house heavy metals. Therefore, evaluating the degree of the soils and plants' heavy metals from some selected abattoirs becomes necessary since many edible plants are cultivated within or around these areas. However, some trace elements are nutrients required in sparing quantities for plant uptake and higher concentrations of these elements may results in eco-toxicity and plants' death (Fuentes *et al.*, 2014).

This study indicates the Pb concentration in *Colocasia esculenta* ranged from0.039-0.045 mg/100g in the abattoirs from the three local government areas; *Vernonia amygdalina* had a concentration of 0.007 mg/100g for Pb; while, *Amaranthus spinosus* had a concentration range of 0.020-0.040mg/100g but in the soil samples, Pb was between 0.110 and 0.123mg/100g from abattoirs in the three local government areas. The most Pb concentration was observed in the soil samples from Ojo abattoir with 0.123 mg/100g. These values for Pb were found to be lower than 5.38 and 5.54mg/100g of close study conducted by Hanlon (2015). Also, the plants observed had lower lead than in abattoir soils and this was in consonance with the findings of Chukwu and Anuchi (2016). The values of lead for both *Colocasia esculenta, Vernonia amygdalina* and *Amaranthus spinosus* were both found to be lower than the WHO limits of 0.05mg/10g (WHO, 2014), but the Pb concentration in the soils was found to be above the permissible level.

Cadmium (Cd) was not detected in *Colocasia esculenta* except at Igando abattoir where it recorded 0.008 mg/100g. For *Vernonia amygdalina*, Cd had a similar mean concentration of 0.009 mg/100g at both Ojo and Agege abattoirs but was completely undetected at Igando while, Cd in *Amaranthus spinosus* were not detected in Agege and Igando with negligible concentration in Ojo (Table 3). Cd concentrations in the various soils ranged from 0.017-0.019 mg/100g, with the highest found in the soil sample from Ojo abattoir (0.019 mg/100g).These Cd values for the abattoir sites in the three local governments however, lower than the 1.31 – 3 mg/100g reported by Yahaya *et al.* (2009) for abattoir environments in Sokoto and also well below the permissible limits of cadmium in vegetables which is 0.1-1.5 mg/100g (WHO, 2014).

Manganese concentration in *Colocasia esculenta* from the three locations was 0.016-0.018mg/100g respectively. A lower range of values 0.006-0.007mg/100g was recorded for *Vernonia amygdalina* at three abattoirs for Mn while range of 0.007-0.053mg/100g Mn was recorded for *Amaranthus spinosus* in all three abattoirs. For the soil samples, the range recorded was 0.340-0.695mg/100g at three abattoirs for Mn. These results for Mn found in three abattoir plants and soils samples were all below than the WHO maximum standard limit of 200mg/100g (WHO, 2014).

Chromium (Cr) was completely undetected in *Colocasia esculenta* and *Amaranthus spinosus* at the three locations, but was sparingly present (0.001 mg/100g) in *V. amygdalina* at Igando. For the soil analysis, Cr was only detected in Igando soil with a value of 0.004 mg/100g. The values were well below the 2.86 and 5.67mg/100g from a similar study by Chukwu and Anuchi (2016) and also below the WHO permissible limits of1.30mg/100g (WHO, 2014). Chromium has been reported in man to result in allergic dermatitis (Musa *et al*., 2017). It has been documented that chromium may easily be translocated via surface runoff to soil and water which may be adsorbed from groundwater by plants (Morgan *et al.,* 2008).

The recommended daily intake of Co is 0.40 mg (Food and Nutrition Board, 2011). In *C. esculenta*, Cobalt (Co) metal was not detected at Ojo and Agege areas, but was present in minute quantities (0.003 mg/100g) at Igando. Cobalt (Co) content in *Vernonia amygdalina* was also similar in mean concentrations (0.007 mg/100g and 0.002 mg/100g) at Ojo and Agege abattoirs whereas Co was not detected in *Amaranthus spinosus* from three locations. The Co content in the soils from the three abattoirs ranged 0.011-0.013mg/100g. WHO (2014) provided 0.4mg/100g as the cobalt standard limit and so all plants samples and the soils are all free from Co contamination since the levels are way below the advised limit.

Nickel found in abattoir effluents begins from the feed and water, is taken by animals, and is discharged as faeces and leaches into the soil (Elemile *et al.,* 2019). Sumayya *et al.* (2013) documented that when the limits are exceeded, Ni is hazardous because it is one of the causes of cancer. Food chain bioaccumulation of nickel have not been documented, but it is an essential mineral in animals' food (Sreekanth *et al.,* 2013).The result of the heavy metal analysis showed that the Nickel content in *C. esculenta* from the three abattoirs had a concentration of 0.002 mg/100g. Ni also had a similar mean concentration of 0.002 mg/100g in *V. amygdalina* at both Ojo and Agege abattoirs but was not detected at Igando. While, Ni content in *A. Spinosus* ranged 0.001-0.003mg/100g in three abattoirs. From the analysis of the soils, Ni had a similar mean concentration of 0.006 mg/100g at both Ojo and Agege abattoirs but showed a slight decline at Igando with a value of 0.005 mg/100g. Maximum permissible level for Ni in plants and soil is 1.50 mg/100g (WHO, 2014). Therefore, all samples were free of Nickel contamination.

It has been documented that zinc (Zn) improves the well-beings of human when consumed minimal quantity (Sreekanth *et al.,* 2013) and zinc deficiency can lead to babies' congenital defects if not consumed (Garba *et al.,* 2010).The result reveals that the *Colocasia esculenta* has Zn range of 0.246-0.271 mg/100g from three abattoirs. For *Vernonia amygdalina*, the samples collected had a range of 0.490-0.560mg/100g from the three abattoirs while A. spinosus had a Zn range of 0.419-0.742mg/100g. Soil samples showed a range of 1.104-1.267mg/100g for all the sampled location. Mihaela *et al.* (2010) reported that zinc concentration in plants from their study varied between 0.21 mg/100g and 0.72 mg/100g. Hanlon (2015) recorded values of 1.58 and 1.7 mg/100g from a similar study which is way higher than all values recorded in this experiment. This study revealed that the vegetables were within the standard acceptable limit in plants for zinc which is 5mg/100g (Gherghi *et al.,* 2001), thus the plants samples are fit for consumption.

CONCLUSION

From the results of this study, it could be concluded that are some levels of plants and soil contamination within the abattoirs (Ojo, Agege and Igando) with lead, cadmium, manganese, zinc, cobalt, nickel and chromium at varying concentrations. These metals were within or lower than the maximum standard limits set by WHO and so, all the *Colocasia esculenta*, *Vernonia amygdalina* and *Amaranthus spinosus* samples are free for consumption as at time of this study. Hence, efforts should be taken to reduce these metals in order to prevent the continuous effluent release and its bioaccumulation abattoirs. This study therefore suggest that abattoir effluents should be correctly channelled and controlled into cesspit or treated to avoid plants and surrounding soils' heavy metal build up.

References

A.O.A.C. (1990). Official Methods of Analysis. Association of Official Analytical Chemists 15th Ed. Washington. DC.

Chibuike, G.U. and Obiora, S.C. (2014). Heavy Metal Polluted Soils: Effect on Plants and Bioremediation Methods. *Applied and Environmental Soil Science*; 1-13

Chukwu, O., Mustapha, H.I., and Abdul-Gafar, H.B. (2008). The effect of Minna Abattoir Wastes on Surface Water Quality I. *Environmental Research Journal* 2(6), 334 – 338

Chukwu, U.J. and Anucha, S.O. (2016). Impact of Abattoir Wastes on the Physicochemical Properties of Soils within Port Harcourt Metropolis. *The International Journal of Engineering and Science (IJES)*, 5(6):17-21

Ediene, V.F., Iren, O.B. and ldiong, M.M. (2016). Effects of abattoir effluent on the physicochemical properties of surrounding soils in Calabar metropolis. *Int. J. Adv. Res*, 4:37-41.

Elemile, O.O., Raphael, O.D., Omole, D.O., Oloruntoba, E.O., Ajayi, E.O. and Ohwavborua, N. (2019). Assessment of the impact of abattoir effluent on the quality of groundwater in a residential area of Omu-Aran, *Nigeria Environmental Sciences Europe*31:11

Ezeoha, S. L. and Ugwuishiwu, B. O. (2011). Status of Abattoir Wastes Research in Nigeria. *Nigerian Journal of Technology*, 30(2).143-148.

Fuentes, A., Lloren, M., Saez, J., Soler, A.,Aguilar, M.I., Ortuno, J.F., Meseguer, V.F. (2004). Simple and sequential extractions of heavyMetals from different sewage sludge.Chemosphere; 54:1039-1047.

Garba, Z.N., Hamza, S.A. and Galadima, A. (2010). Arsenic Level Speciation in Fresh Water from Karaye, Local Government Area, Kano State, Nigeria. *International Journal of Chemistry*. 20(2):113-117

Gherghi, A., Burzo, I., Bibicu, M., Mărgineanu, L., and Bădulescu L. (2001). Biochimia si fiziologia legumelor si fructelor. Ed. Academiei Romane Bucuresti.

Hanlon, E.A. (2015). Soil pH and Electrical Conductivity: A County Extension Soil Laboratory Manual.

ULR:https://doi.org/10.37745/bjes.2013

Jukna, C., Jukna, V., and Suigzdaite, J. (2006). Determination of Heavy metals in Viscera and Muscles of cattle. Bulgarian Journal of Veterinary Medicine, 9(1), 35-41.

Khalil, I. A. and F. Mannan. (1990). Colorimetry and Flame photometry. In: Chemistry One (Bioanalytical chemistry) 2nd edition. Taj printing press, Peshawar, Pakistan. pp. 131-157.

Kruslin, E., Hodel, C. M., &Schurgast, H. (1999). Progress in diagnosis of Chronic Toxic metal Poisoning by Hair analysis.Toxicol.Lett. 88, 84.

Mihaela, S., Badulescu, L., Burzo, I., Dobrescu, A., Badea, M., Lagunovschi-Luchian, V., Delian, E., Dán, M. (2010). Research on trace elements and heavy metal accumulation in eggplant organs depending on the applied technology. *Lucrăriştiinţifice USAMVB, Seria B*, vol. LIV.

Morgan, S.C., Relaix, F., Sandell, L.L., and Loeken, M.R. (2008). Oxidative stress during diabeticpregnancy disrupts cardiac neural crest migration and causes outflow tract defects. *ClinicalMolecular Teratology*, 82(6): 453–463.

Musa, J. J., Mustapha, I., Bala, J. D., Ibrahim, Y.Y., Akos, M.P., Daniel, E.S., Oguche, F. M. and Kuti, I. A. (2017). Heavy Metals in Agricultural Soils in Nigeria: A Review Arid Zone *Journal of Engineering, Technology and Environment*. 13(5):593-603

Nannipieri, P., Badalucco, L. and Pietramellara, G. (1997). 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 507-534.

Ogbonnaya, C. (2008). Analysis of groundwater pollution from abattoir waste in Minna, Nigeria. *Resource Journal of Dairy Sciences*2(4):74-77

Olanike, K. A. (2002). Unhygienic operation of a city abattoir in south western Nigeria: Environmental implication. AJEAM/RAGEE, 4(1), 23-28.

Oluwole, S.O., Yussuf, K.A., Ogun, M.L. and Ayoade, K.A. (2021). Phytochemical Screening, Proximate Compositions and Heavy Metal Concentrations of Four Commonly Sold Vegetables in Some Lagos Markets, Nigeria. *Asian Journal of Research in Botany*; **5**(2): 42-52.

Rabah, A.B., Oyeleke, S.B., Manga, S. B., Hassan, L. G. and Ijah, U. J. J. (2010). Microbiological and physico-chemical Assessment of soil contaminated with Abattoir effluents in Sokoto metropolis, *Nigeria. Science World Journal* 5(3): 1-4

Red Meat Abattoir Association. (2010). Waste Management-Red Meat Abattoir.

Saskia, R., Nico, B., Nander, V.P., Ronny, B. and Lieven, B. (2013). Metal exposure andaccumulation patterns in free-range cows(*Bos taurus*) in a contaminated naturalarea: Influence of spatial and socialbehaviour. Environmental Pollution.172:186–199.

Seaward, M.R.D. (2004). The use of lichens for environmental impact assessment. *Symbiosis*, 37: 293-305.

Sharma, M.C., Baxi, S., Sharma, K.K., Singh, M. and Patel, S. (2014). Heavy metal ions levels and related physicochemical parameters in soils in the vicinity of a

ISSN 2054-6351 (print),
ISSN 2054-636X (online)

paper industry location in Nahan area of Himachal Pradesh. *Environ. Anal. Toxicology*, Vol. (4) 2161-0525.

Sreekanth, T.V.M., Nagajyothi, P. C., Lee, T.N. and Prasad, V.K.V. (2013). Occurrence, physiological responses and toxicity of nickel in plants. *International Journal of Science and Technology*,10(5) 1129-1140.

Sumayya, B.U., Usman, B.U, Aishat, U., Shahida, A., Mohammad, A., Yakubu, M.S. and Zainab, M. (2013). Determination of Physiochemical Qualities of Abattoir Effluent on Soil and Water in Gandu, Sokoto. *Journal of Environmental Science Toxicology and Food Technology*4: 47-50

Trueby, P. (2003). Impact of heavy metals on forest trees from mining areas. In: International Conference on Mining and the Environment. Sudbury, Ontario, Canada.

Ubwa, S.T., Atoo, G.H., Offem, J.O., Abah, J. and Asemave, K. (2013). Effect of activities at the Gboko abattoir on some physical properties and heavy metals levels of surrounding soil. *International Journal of Chemistry*5(1): 201-213.

UNEP, (2004). Why the marine environment needs protection from heavy metals. United Nations Environmental Protection/Global Program of Action (UNEP/GPA), The Hague, the Netherlands.

WHO (2014). Permissible limits of heavy metals in soil and plants (Geneva: World Health Organization), Switzerland.

Wong, S.C, Li, X.D., Zhang, G., Qi, S.H. and Min, Y.S. (2002). Heavy metals in agricultural soils of the Pearl River Delta, South China. *Environ. Pollut*, 119:33-44.

Yahaya, M.I., Mohammed, S., Abdujahi, B.K. (2009). Seasonal variation of heavy metals concentration in abattoir dumping site soils in Nigeria. *Journal of Applied Science and Environmental Manage*ment; 13(4):9–13.

ECRTD-UKhttps://www.eajournals.org/
ULR:https://doi.org/10.37745/bjes.2013