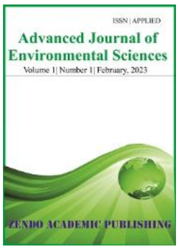

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ASSESSMENT OF HEAVY METAL CONCENTRATIONS IN FADAMA SOILS UTILIZED FOR AGRICULTURAL ACTIVITIES WITHIN THE VICINITY OF DUMPSITES IN LOKOJA, NIGERIA

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ABSTRACT This study aimed to assess the concentration and contamination levels of heavy metals in Fadama soils utilized for agricultural activities within the vicinity of dumpsites in Lokoja, Nigeria. Soil samples were collected from four different locations and analyzed using atomic absorption spectrophotometry. The results showed that the levels of Zn, Mn, Iron, Cu, and Pb in the soil varied among the different locations, but were generally lower than the European Union's maximum permissible levels. There was no significant correlation between the heavy metal content and the particle size fractions and organic matter of the soil. While the levels of heavy metals in this study may not be threatening for now, continuous monitoring is necessary for agricultural sustainability in the future. This study highlights the need for further research on heavy metal contamination in Fadama soils in Nigeria, especially in areas close to dumpsites.

Keywords: Heavy metals, Fadama soil, agricultural activities, contamination, dumpsites, Lokoja

INTRODUCTION:

Heavy metal contamination of soils is a global environmental problem, particularly in urban areas and surrounding dumpsites or industries. This contamination poses significant ecological risks, including affecting the quality and safety of crops grown in these areas. In addition, heavy metal accumulation in soils and plants can lead to potential human health risks, making it an important challenge for researchers, environmentalists, and policy makers alike (Luoma and Rainbow, 2008).

In recent years, the accumulation of heavy metals in agricultural soils through runoff from dumpsites has been a growing concern in Nigeria. This is because such contamination not only results in soil-to-plant contamination but also leads to elevated heavy metal uptake by crops, posing potential food safety and quality risks (Jaiyeoba, 2018). Furthermore, the accumulation of heavy metals in plants depends on the plant species and the efficiency of different plants in absorbing these metals, which can be evaluated by either plant uptake or soil-to-plant transfer factors (Mwegoha and Kihampa, 2010).

Heavy metals such as cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), and zinc (Zn) are essential for plant growth, but only in small amounts. When present in high levels, however, they can be harmful to plants (Chandrasekaran et al., 2015). Thus, it is important to monitor heavy metal concentrations in agricultural soils to ensure sustainable agriculture and protect human health.

In Nigeria, several studies have reported heavy metal contamination of soil environments in industrial sites and contaminated areas in urban centers (Bamgbose et al., 2000; Onianwa and Fakayode, 2000; Onianwa, 2001; Ana and Sridhar, 2004; Umoren and Onianwa, 2005; Iwegbue et al., 2006a,b; Iwegbue, 2007; Nwajei et al., 2007; Inuwa et al., 2007; Oviasogie and Ofomaja, 2007; Nwajei and Iwegbue, 2007; Osakwe and Egherevba, 2008). However, relatively few studies have investigated heavy metal contamination in Fadama

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soils in Nigeria. Mashi and Alhassan (2007) reported the effect of wastewater discharge on heavy metal pollution of Fadama soil in Kano city, but there is a need for further studies to provide data on Fadama soil contamination in other parts of Nigeria.

This study aims to assess the concentration and contamination levels of selected heavy metals in Fadama soils around the vicinity of dumpsites in Lokoja, Kogi State, Nigeria. The findings of this study will help to identify potential risks and provide valuable information for policymakers and stakeholders in the agriculture and environmental sectors to mitigate potential adverse effects on human health and the environment. Furthermore, this study will contribute to the existing body of knowledge on heavy metal contamination in Fadama soils in Nigeria and provide a basis for further research on this issue.

2.0. Methodology

2.1. Study area

Lokoja town has a land mass of 3,518 km^2 (Abenu, 2016). Lokoja is located between latitude 7^0 45’ N - 7^0 51’ N and longitude 6^0 41’ E - 6^0 45’ E (Figure 1 and 2) of the Greenwich meridian (Audu and Rizama, 2012) with an altitude of 45-125m. Lokoja is located near the confluence of river Niger and Benue on the western bank of the river Niger. The wet and dry seasons are two distinct seasons in the town. The wet season, records about 1215mm of rain annually, mainly from April to October, with its peak occurring in September (Audu, 2012; Abenu, 2016). In addition to river Niger and Benue, which are the main sources of surface water in the area, there are also other smaller streams like Mmeme, Akpomoba and Danko.

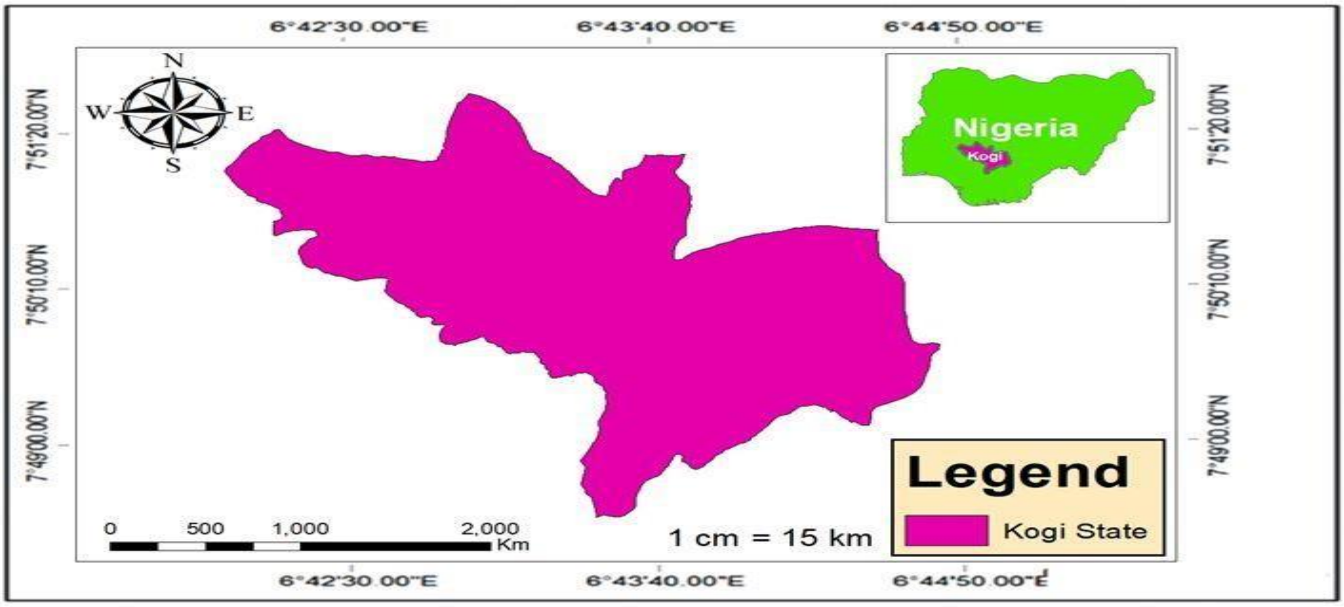

Figure 1: Kogi State in Nigeria
Source: GIS LAB. Department of Geography UNN, 2020

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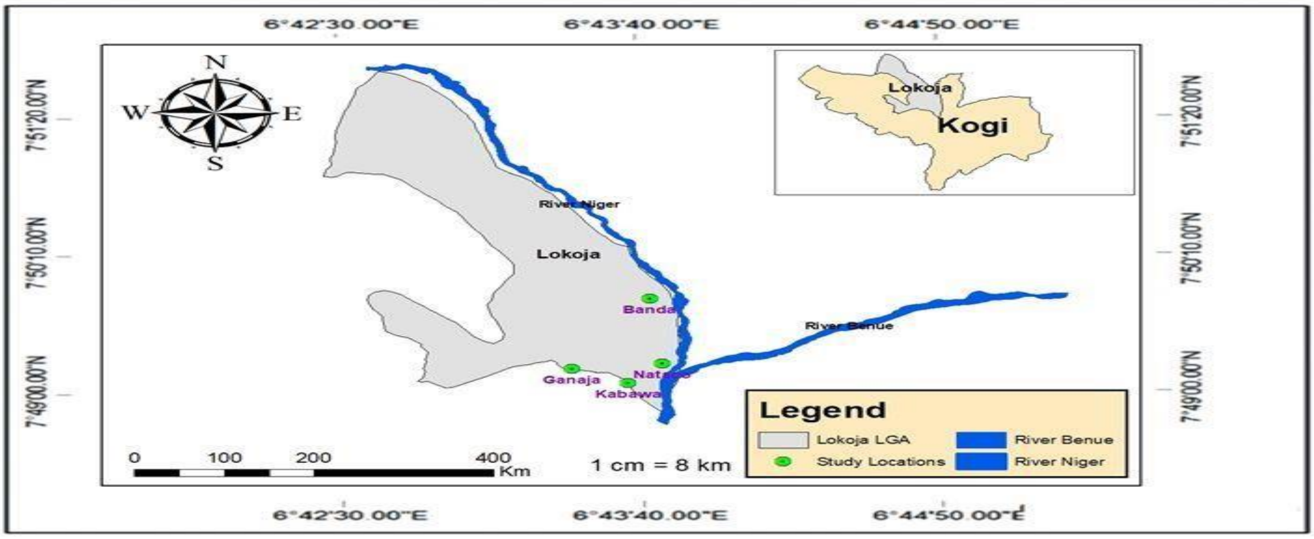

Figure 2: Lokoja in Kogi state showing the sampled points *Source: GIS LAB. Department of Geography UNN, 2020*

2.2. Geology

Lokoja area is underlayed by crystalline basement complex rock; it is overlaid by gently deepened cretaceous and tertiary sediments. The alluvium soil covers a considerable area around the Niger/Benue confluence in a continuous stripe up to about four kilometer wide along the valley of the Lower Niger between Lokoja and Idah (Geological Survey of Nigeria 1986). The land elevates from about 300 meters along the Niger - Benue Confluence, gradually reaching up to 900 meters above the sea level in the uplands of mount Patti (Abenu, 2016), these highlands are capped by indurated and ferruginous sandstones. They also extended across the Niger River towards Bassa and terminating around Gboloko – Monzum area. The eastern, southwestern and southeastern parts of Lokoja area have altitudes raging between 50 meters and 90 meters, and are underlain by Basement rocks (Omali, 2003). The basement complex rock comprise of migmatite, undifferentiated older granite, mainly porphyro-blastic granite, granitic gneiss with porhyro-blastic gneiss and fine-grained biotite granite. The Lokoja region is characterized by rugged topography. Two prominent hills of the regions are the mount Patti and Agbaja, both following the basin and perpendicular to the main axis of the Benue trough. Despite the hilly terrain there are small numbers of streams debouching from the hills. This probably reflects the high permeability to be expected from the coarse sandstone regolith that covers the area.

2.3. Reconnaissance survey

A preliminary survey of the Fadama region in Lokoja was first carried out. The purpose of the survey was to get acquainted with the environment, where extensive fadama farming activities are on-going as well as to conduct preliminary interview with selected fadama farmers, whose farmland suites this study since the select plots that was used for the detailed-field investigations and data collection were owned by the selected farmers.

2.4. Selection of plots

Four plots under Fadama cropping were selected for this study. The size of the plots ranged between 0.8 ha and 1.2 ha. The selection of the plots was as a matter of necessity constrained by two major factors. One was based on the availability of reliable information on the management history of plots in the area, which was obtained from the farmers. The other was the need to keep, as much as possible, all other environmental

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conditions at the sites the same, in other to minimize the likelihood of error arising from initial soil spatial variability (Jenny, 1948). All the plots selected were located over a single drainage basin and at the lower slope position of a catena; which was underlain by similar geology and granite gneiss. The selected plots are confined within a single drainage basin, and are assumed to experience the same climatological condition. The preparation of land for farming in the area involves clearing of the predominantly herbaceous vegetation cover by burning and clearing.

2.5. Sample collection and preparation

The sampling method that was employed for this study was a combined systematic and random sampling. Over each plot, a quadrat of either 25m by 25m was first demarcated. Each of the plots were subsequently subdivided further into 25, (of 5 by 5m) subquadrat of which 5 was randomly selected for soil sampling. Soil samples were taken at the four corners and the center of each selected subquadrat. The samples were bulk to give a sample per subquadrat. Thus in all, five bulked samples per plot were collected for laboratory analysis. To further minimize the problem of soil spatial variability, all samples were taken over sites where the slope gradient did not exceed two degrees. The samples were taken with the aid of hand trowel at the surface horizon (0-10cm), after an initial scraping off and clearing of the covering plant debris. Soil samples were collected in April when the irrigated crops were still on. Samples collected were put in polythene bags and labelled serially. The bulk soil samples drawn from the field was air dried, crushed lightly, and then passed through a 2mm sieve.

2.6. Laboratory analysis

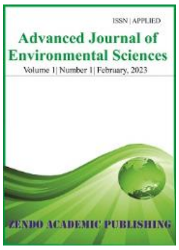
Soil organic matterwas determined by Walkey – Black digestion methods; A 10g sub- sample for the fine earth fraction prepared for laboratory analysis was put into a 250ml conical flask and 10ml of potassium clichromate [$K_2Cr_2O_2$] solution was pipetted into 500ml conical flask and swirled gently to disperse the soil. From then, 20ml of concentrated tetraoxosulphate (Ul) acid [H_2SO_4] was added and gently rotated for one minute; it was then allowed to stand on a sheet of asbestos for 30 minutes in order to cool the mixture. The solution was diluted with 100ml of distilled water, orthophosphate acid, 0.2gm sodium chloride [Nacl] and four drops of diphenylamine indicator. The solution was then titrated with ferrous ammonium sulphate solution in a burette. After this was done, a blank determination was then made in the same way but without the soil with a view to standardizing the dichromatic. The organic matter content was then estimated as follows:

$$\%\text{organic matter } 10\left[1 - \frac{s}{t}\right] \times 1.3 \qquad (1)$$

where s = blank titration.

2.7. Soil analysis

The collected soil samples were oven-dried at 105^0C in order to obtain constant weights. The dried samples were then crushed and sieved through a 2mm sieve to remove gravel fraction. One gram subsample was taken into crucibles to which few drops of distilled water were added to prevent sputtering. DTPA (diethylenetriamine pentaaceticacid) extraction method (Hanlon *et al.,* 1996) was then used to extract the metals from the samples because it has widely been used to indicate the bioavailability of numerous heavy metals in soils (Chlopecka, 1996). The concentrations of various heavy metals in the extracted soils were determined by atomic absorption spectrophotometry.



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2.8. Statistical analyses

Analysis of variance (ANOVA) and simple regression and correlation analysis was used to test for significant differences amongst the different sites used for the study. The regression and correlation analysis was used for the establishment of the extent of dependency of the heavy metals on the measured soil physicochemical properties. All tests were performed at the 0.05 level of significance.

3.0. Results and Discussion

3.1. Summary of Physico-chemical and heavy metal parameters of fadama soils from Lokoja, Kogi state

The table below shows the organic matter, particle size distribution and heavy metal content of the study area. The results of organic matter and the amount of sand, silt and clay shows that there was no significant difference (p>0.05) between Fadama soils of the study area.

Table 1: Variations of soil parameters and heavy metals of sampled plots

Soil heavy metals and parameters	Banda $\bar{X} \pm SD$	Nataco $\bar{X} \pm SD$	Kabawa $\bar{X} \pm SD$	Ganaja $\bar{X} \pm SD$	p-value at 0.05
Organic Matter	2.09±0.16	2.4±0.77	2.1±.28	2.3±.47194	0.56
Clay	26.92±2.48	27.42±1.49	25.96±3.62	26.38±1.23	0.79
Silt	21.54±3.39	20.98±3.27	20.32±3.41	23.36±2.52	0.49
Sand	51.54±1.73	51.60±4.09	53.72±4.21	50.26±3.42	0.49
Zinc	37.10±14.39	49.08±10.71	50.96±9.93	41.68±15.30	0.32
Copper	6.14±3.33	6.84±2.43	5.82±2.40	3.56±1.78	0.24
Manganese	316.80±139.59	212.82±101.31	452.14±277.17	314.08±106.15	0.22
Iron	1071.80±465.11	1913.40±548.25	1696.40±777.09	1468.80±891.59	0.29
Lead	1.80±1.05	3.38±2.06	2.56±0.97	2.08±1.31	0.34

The Zinc content is highest at Kabawa (50.96mg/kg) and lowest at Banda (37.1mg/kg), while the values for Nataco and Ganaja are intermediate. The differences amongst the various locations show no statistical significant difference at 0.32 which is (p>0.05) confidence limit. The coefficient of variability present ranged between 19% at Kabawa, through 22 and 37% at Nataco and Ganaja, respectively, and 39% at Banda. The general low value at Nataco and Kabawa showed relatively homogenous values of the heavy metals within those locations compared to those at Banda and Ganaja. The result shows that the main sources of differences in the Zinc content among the different locations is between Banda and Kabawa, which shows no significant difference values at the 0.05 probability level. The Copper content did not show statistically significant differences amongst the different plots. The value ranges between 3.5mg/kg at Ganaja, 5.82mg/kg at Kabawa, 6.14 mg/kg at Banda, and 6.84mg/kg at Nataco. The relatively high value of the Coefficient of Variability percent over all plots suggests that the elements show high variability within the respective plots. The Manganese content shows significant differences amongst the various study locations. The mean value is highest at Kabawa (452.14mg/kg), followed by Banda (318.88mg/kg) and Ganaja (314.08mg/kg). The lowest values on the other hand occur at Nataco
(212.92mg/kg). Like Copper, the coefficient of variability percent is generally high, indicating high heterogeneity within the respective plot. The differences in the iron content amongst the different plots show statistical significant differences. The value varies from 1071.80mg/kg at Banda, through 1468.80mg/kg at Ganaja and 1696.40mg.kg at Kabawa, to 1913.40mg/kg at Nataco. The coefficients of variability percent are generally high, over 40%, except at Nataco, indicating high spatial variability within the plots. The Lead

content ranges between 1.80mg/kg at Banda, through 2.08mg/kg, and 2.56mg/kg at Ganaja and Kabawa, respectively, and 3.38mg/kg at Nataco. The differences amongst the plots are not significant statistically. The coefficient of variability percent is generally above 50, except at Kabawa, suggesting considerable high spatial variability within the respective plots. The comparatively high mean value at Nataco and Kabawa suggest possible addition from waste dumps and high traffic characteristics of these areas. A comparison of values obtained with result obtained in several countries indicated that, soils of the study area generally have low concentrations of most of the heavy metals studied. For example, levels of Lead concentration in soil ranging from 25.0 to 1198 mg/kg have been reported on roadside soil in England, 0.00 to 50.10 mg/kg in India, 78.4 to 832 mg/kg in Tanzania 9.27 ± 0.23 to 45.92± 22.06 mg/kg and 47-151 mg/kg on major highway in Lagos, Nigeria (Othman *et al.*,1997.., Akbar *et al*., 2006a; Atayese*et al.*, 2008; Luilo and Othman, 2006; Sharma and Prasade, 2010). Normal concentrations of zinc in soil range from 1 to 900 mg/kg (Akbar *et al.*, 2006b). The observed level in this study is lower than Zinc 56.7- 480.0 mg/kg, reported in roadside soil of England.

The building up of the heavy metals in the present study reflects the pollution sources existing in the surrounding area. Heavy metals are ubiquitous in the environment, because of both natural and anthropogenic activities (Wilson and Pyatt, 2007). Solid waste disposal, sludge applications, vehicular exhaust and industrial activities are the major sources of soil contamination with heavy metals in the study area.

3.1.1. Soil properties

The mean sand percent is lowest at Ganaja (50.26%) and highest at Kabawa (53.72%), while the values at Banda and Nataco are intermediate and are approximately the same (52%). The coefficient of variability percent is uniformly low over all plots, less than 10%, suggesting relative homogenous values over the respective plots. The result of the t-test analysis similarly did not reveal significant different values between all pairs of plots. Similar to the sand content, silt nor the clay reveals any significant differences amongst the various plots. The silt fractions vary from about 20% at Kabawa to 23% at Ganaja, while the clay varies from 26% at Kabawa to 27% at Nataco. The differences in the fractions between pairs of plots are also not significant statistically, except for silt between Kabawa and Ganaja. Similarly, both fractions show relatively homogenous value over the respective plot as shown by low coefficient of variability percent. Thus, overall, all groups of soils are clayey, a reflection of the deposition nature of the soils.

3.2. Comparison of measured heavy metals with EU regulatory standards

To assess the level of the heavy metals content in the soil study, the comparisons of the values obtained were compared with the European Union regulatory standard in table 2. Table 2 below summarizes the result obtained when the measured heavy metals in the present study were compared with EU regulatory standard. The result shows comparatively lower value of the measured metals compared to the EU standard. The difference between the respective plots and the EU values is consistently and significantly lower at 0.001 probability level. Barring varying discrepancies in laboratory methods employed in this study, as against those employed in the EU standard, the result of the comparison thus seems to suggest that the level of heavy metals in the soil of the study area is obviously presently not threatening yet. However, such a conclusion must be taken with caution, given the differences in environmental condition and environmental impact assessment regulatory standard.

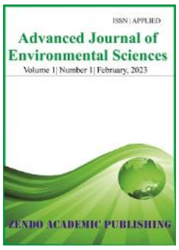

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Table 2: Comparison of level of heavy metal with the EU regulatory standard

	Plots				EU Regulatory
Heavy Metals (mg/kg)	Banda	Nataco	Kabawa	Ganaja	Standard
Zn	37.10*	49.08*	50.96*	41.68*	300
Cu	6.14*	6.84*	5.82*	3.56*	30
Mn	318.88*	212.92*	452.14*	314.08*	1500
Fe	1071.80*	1913.40	1696.40	1468.80*	1500
Pb	1.80*	3.38*	2.56*	2.08*	30

*value significantly lower than the EU regulatory standard

4.0. Conclusions

The result obtained in this study showed comparatively low value of heavy metals obtained from the study area as compared to European Union regulatory standard, with the exception of iron at Nataco and Kabawa with slightly higher values. The comparatively high mean value of iron at Nataco and Kabawa suggest possible additions from waste dumps and discharge from industries around the vicinity. This study recommends that the industries should be compelled to improve their waste treatment process to ensure that they are free from heavy metal, control of irregular dumping of refuse in the environment. Further research is thus required to ascertain the extent of heavy metal contamination on water, air and contaminated plants in details in the future.

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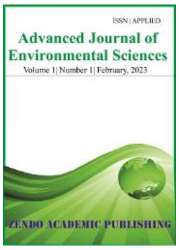

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