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Assessment of Selected Heavy Metal Content on Dumpsites Soil and Vegetables Grown in Muwo Metropolis, Niger State, Nigeria

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ABSTRACT: This study examines the concentration of heavy metals in soil samples and some vegetables (spinach, water leaf, bitter leaf and jute mallow) cultivated around dumpsites in Muwo Metropolis, Niger State, Nigeria. The soil samples and vegetable were analyzed for Ni, Zn, Cu, Pb and Cd using AA500 spectrophotometer after acid digestion. Data obtained show that, the Pb (1.684 mg/kg of Jute) content was high compared to other metals study in this work. Concentration of Zn was 1.993, 0.862 and 0.443 mg/kg for water leaf, soil and control sample respectively. The content of Pb was 1.727, 1.738 and ND mg/kg for water leaf, soil and control sample respectively. Also, the concentration of Pb was 1.736, ND and 0.457 mg/kg for spinach, soil and control sample respectively. However, the content of Zn was 0.786, 0.751 and 0.554 mg/kg for spinach, soil and control sample respectively The accumulation of heavy metals in agricultural soils is of increasing concern because of, potential health risks, food safety as well as its detrimental effects on the soil ecosystem and human health. The pollution indexes of Ni contents are 0.439, 0.378, and 0.083 for jute, soil and control sample respectively. While Zn concentration was 1.117, 0.858 and 0.492 for jute, soil and control sample respectively. The result of this study shows that Pb concentrations are present in high levels in the study area at the different level of contamination.

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Heavy metals are chemical elements found in the environment and mostly with density greater than 5g/dm^3; the generally low level of their contents in soils and plants as well as the biological value of most metals makes them microelements (Ali, *et al*., 2019). Toxic heavy metals, such as cadmium (Cd), lead (Pb), nickel (Ni), iron (Fe), and chromium (Cr) contaminate agricultural crops as well as soils, like cereals, garden vegetables, and fruits, as a result of their concurrent and harmful consequences from their persistence and non-biodegradability. (Iyama *et al*., 2021). The heavy metal contamination of plant, soil, water, and atmosphere, caused by urbanization and rising anthropogenic activity is a developing environmental issue that has impact on food quality and people's health in urban areas. Environmental factors that contribute to the presence of heavy metals in cities such as industrial and domestic wastes, agricultural activities, traffic pollution, metal works and mining (Muhammad, *et al*., 2011). Vegetable consumption is

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one of the ways that heavy metals enter the food chain. Long-term exposure to hazardous levels of heavy metals through dietary products can result in chronic heavy metal accumulation in the kidney and liver of humans, which can disrupt a number of biochemical processes and cause disorders of the heart, brain, kidneys, and bones. (Mitra, *et al*., 2022). Heavy metals no doubts are important for plants and humans but only in small amounts. They are persistent and non-biodegradable as they are neither removed by normal cropping nor are they easily leached by rain water (Opaluwa, *et al*., 2013). According to research, numerous vehicles emitted a range of harmful heavy metals such as As, Cu, Hg, Se, Cr, Ni, Cd, Pb, and Zn into the environment. There are different types of pollution, such as soil contamination, that have impact on living organisms, including crops (Odukoya, 2015). Because heavy metals are poisonous and tend to bioaccumulate in the body, they provide serious health and environmental problems (Opaluwa *et al.,* 2012). Metals including Cd, Cr, Pb, Ni, and Fe may be poisonous and have a negative effect on human health when they accumulate over time. Food contaminated with Cd can cause both immediate and long-term health issues, including artery issues and others. (Echem and Kabari, 2013). Cardiovascular problems, exhaustion, heart problems, and respiratory illnesses can all result from ingestion of nickel (Muhammad *et al*., 2011). The two most prevalent heavy metals found in vegetables, Pb and Cd, can cause a number of health problems, including kidney, bone, and heart issues (Tchounwou, *et al*. 2012; Verma *et al*., 2020). To estimate their concentration in the edible leaf section, it is therefore helpful to know how much of these heavy metals are present in the soil and plant. (Shidali, *et al*., 2018). In most large urban areas, the issue of environmental contamination caused by hazardous metals has started to raise concerns (Sonawane, *et al*., 2013; Shidali, *et al*., 2018; Shaba *et al.,* 2021). With each tropical level of the food chain, heavy metals get more concentrated, a process known as bioaccumulation, in contrast to energy, which tends to deplete and become distributed (Adamu *et al*., 2017; Shaba *et al.,* 2019). Urban farming is a widespread practice in advanced nations like Nigeria. Many of the people who live in these cities work in agriculture. Non-farmers who want to supplement their income also work in agriculture. Land areas for agricultural activities are typically limited as a result of the current land tenure structure. Urban farmers often use whatever open land available. Such terrain often includes dumpsites, rail and road sides, and others near markets, contaminated water bodies, automobile mechanic shops, and industrial districts, among others, which are possible sources of heavy metal contamination (Shaba *et al*., 2015; Olumba, *et al*., 2021). The objective of the study is to evaluate the levels of Cd, Ni, Cu, Zn and Pb in dumpsite soils and spinach, water leaf, bitter leaf and jute mallow grown in Muwo metropolis, Niger State, Nigeria.

MATERIALS AND METHODS

Sampling: Vegetable and soil samples studied were obtained from five strategic dumpsites in Muwo village, Niger State. The soil samples were obtained at five randomly selected points around each dumpsite within 0-20cm depth. Samples from each dumpsite were pooled together from where composite samples were taken and kept in polythene bags prior to further treatments. The trowel used to collect soil samples was carefully cleaned after each sampling exercise, to avoid cross-contamination (Aralu and Okoye, 2020). The soil sampling spots were cleared of debris before sampling. The soil samples were air dried to constant weight and sieved using a 2 mm mesh (Shaba et al., 2015).

Sample Treatment: For each dried soil sample, 2 g was weighed into a boiling tube which has been washed with concentrated HNO_3 and distilled water. Soil sample was digested using the EPA 3050B (1996) digestion method, concentrated HNO_3 and perchloric acid ($HClO_4$) in the ratio 3:1 is added to the sample the mixture was heated for about 15 min and drop to cool, 5 ml of conc. HNO_3 is added again and heating continues for about 30 min. 5 ml of conc. HNO_3 is added, heating continues to obtain a clear solution and it was drop to cool, heating continues for about 2 hours, 3 ml of 30 % H_2O_2 is added and the mixture is heated for 15 min, additional 2 ml of H_2O_2 is added again, heating continues until the mixture reaches about 5 ml, then drop to cool and 10 ml conc. HCl is added, heating continues for about 15 min, then its allow to cool. The solutions were left to cool, and then distilled water was added to each before being filtered through a Whatman No. 42 filter with a 9-cm diameter into a 100-ml Pyrex volumetric flask. After that, distilled water was used to bring it up to standard. The solutions were then stored for heavy metal determination using Atomic absorption spectrometer (Mustapha *et al.,* 2014). Vegetable samples were collected into paper envelops to prevent absorption of moisture by samples collected. Samples of spinach (*Amaranthus hybridus*), Water leaf **(***Talinum triangulare*), Bitter leaf **(***Vernonia amygdalina***)** and *Chorchorus olitorius* (*jute mallow*) were collected by randomly picking up some mature bottom leaves from the matured plants until a sizable bunch was gathered from each dumpsite where soil samples were taken. Ripe fruits of tomato (Lycopersicon esculentum) were collected randomly by plucking the fruits from the plants (Mapanda *et al.,* 2007). On reaching the laboratory, each plant sample collected from dumpsite was washed with distilled water to remove dirt and particles from the roots and leaves to avoid contamination. The fresh vegetable samples were baked at 70^{o}C until they reached a consistent weight before examination. After being sieved through a 2 mm mesh sieve and crushed using a porcelain mortar, the samples were then stored in polythene bags in preparation for digestion and analysis. Each of the five dumpsites' 1 g oven-dried and ground samples of each species of vegetable were weighed (in triplicates) into a 50 ml beaker. This was followed by the addition of 10 ml mixtures of concentrated HNO_3 and perchloric acid ($HClO_4$) in the ratio 3:1. The beakers were then covered with watch glasses and left overnight for complete contact of material. The samples were then digested at 120 °C for 2 hrs on heating digester until the solution becomes transparent until about 5 ml of the mixture was left in the beaker. It is then cooled to room temperature and diluted with 0.1 M HNO_3. The solution was then filtered into a 100 ml Pyrex volumetric flask using Whatman No 42 filter, 9cm and volume made up to the mark with 0.1 M HNO_3 (Abbas *et al.,* 2010). These were stored in polythene bottles till analysis (Musah *et al.,* 2021).

Analysis: The digested vegetable plants and soil samples were analyzed for Ni, Zn, Cu, Pb and Cd using a flame Atomic Absorption Spectrophotometer (AA500 spectrophotometer) (Ndamitso *et al.,* 2019)

RESULTS AND DISCUSSION

The heavy metal contents (mg/kg) of soil and *Chorchorus olitorius* (jute) from dumpsite are given in Table 1.Concentrations of the metals were generally higher in samples from the study site than the control site. Concentrations of the control had significantly lower heavy metals concentration than in all the samples. It also showed that the *Chorchorus olitorius* (jute) and soil samples were moderately enriched with Ni, Cd, and Cu, but strongly enriched with Pb and Zn, due to anthropogenic activities. The order of accumulation of metals in both *Chorchorus olitorius* (jute) and soil samples is Pb > Zn > Ni >Cu>Cd. Plants generally have low uptake of Pb; high concentration of Pb in *Chorchorus olitorius* (jute) in this study could be attributed to high concentration of Pb in the soil and possibly atmospheric deposition and absorption. Lead (Pb) exposure can result in weakness of the joints, failures of reproduction, nausea and loss of memory (Mathew *et al.,* 2018). Thus, the concentration of heavy metals obtained in this study were below the FAO/WHO permissible limit except lead (Pb) with concentrations of 1.684 and 0.901 mg/kg in plant and soil samples respectively. These values were higher than the standard maxima of 0.01 mg/kg (WHO 1993). However, the concentration of lead was lower than EU upper limit of 300 mg/kg (EU 1986) and was at lower concentration than the maximum tolerable levels proposed for agricultural soil, 90-300 mg/kg.

Table 1: Heavy metal contents (mg/kg) of soil and *Chorchorus olitorius* (jute) from dumpsite A

Sample	Ni	Zn	Cu	Pb	Cd
Jute	0.439	1.117	0.181	1.684	0.045
Soil Sample	0.378	0.858	0.086	0.901	0.060
Control	0.083	0.492	0.014	ND	ND

Key: ND= Not detected

Table 2: Heavy metal contents (mg/kg) of soil and Water leaf (*Talinum triangulare*) from dumpsite B

Sample	Ni	Zn	Cu	Pb	Cd
Water leaf	0.022	1.993	0.122	1.727	0.024
Soil Sample	0.321	0.862	0.095	1.738	0.079
control	0.098	0.443	0.073	ND	0.009

Key: ND= Not detected

The heavy metal contents (mg/kg) of soil and water leaf (*Talinum triangulare*) from dumpsite are given in Table 2. The concentrations of the metals were generally higher in samples from the study site than the control site. The concentrations of heavy metals in the control were significantly lower than those in the samples except Pb that was not detected.

The result also showed that water leaf and soil samples were moderately enriched with Cu, Cd, and Ni, but strongly enriched with Pb and Zn, due to anthropogenic contributions. The order of accumulation of metals in both water leaf and soil samples was Zn >Pb >Cu>Cd>Ni. Zinc concentrations were lower than the WHO/FAO limit of 99.4 mg/kg. Elevated concentrations of Zn can also interfere with the activities of earthworms and microorganisms thereby stunting the biodegradation of organic matter (Wuana and Okieimen, 2011).

However, Lead concentrations were higher than the WHO/FAO concentration of 0.3 mg/kg. Soils affected by Pb could be ingested by children through the breathing in of dust ($PM_{2.5}$) containing Pb, resulting to cardiovascular and respiratory complications (Xie *et al*., 2016). High levels of cadmium exposure may cause anemia, excruciating joint pain, lung, and kidney issues (Mathew *et al.,* 2018a; Giuseppe *et al.* 2020).

It also impacts sperm and birth weight, has been linked to cardiovascular disease and hypertension, and decreases blood pressure (Mathew *et al.,* 2020a). In addition, the observed concentrations of Cd, Ni, Cu and Zn lies within the permissible limits set by WHO/FAO (Alkhatib *et al.,* 2022).

Table 3: Heavy metal contents (mg/kg) of soil and Spinach (*Amaranthushybridus*) from dumpsite C

Sample	Ni	Zn	Cu	Pb	Cd
Spinach	0.422	0.786	0.137	1.736	0.069
Soil Sample	0.420	0.751	0.078	ND	ND
Control	0.013	0.554	0.071	0.457	ND

Key ND= Not detected

The heavy metal contents (mg/kg) of soil and spinach (*Amaranthus hybridus*) from dumpsite are presented in Table 3.Concentrations of the studied metals were generally higher in samples from the study site than the control site. The concentrations of the control had significantly no trace of Cd and/or lower concentrations of heavy metals than all the samples. It also indicated that the spinach and soil samples were moderately enriched with Cu, Cd. and Ni. Pb and Cd were not detected in the spinach, but the soil was strongly enriched with Pb and Zn, due to anthropogenic contributions. The order of accumulation of metals in both spinach (*Amaranthus hybridus*) and soil samples was Zn>Pb >Cu>Ni>Cd. The low contents of cadmium noticed when compared to the other heavy metals in the sites might be attributed to the high mobility of cadmium by the use of the soil layers. When compared to other heavy metals, cadmium is liable to be more moveable in soil systems (Mathew et al., 2020a). Anaemia, severe pains in the joints, lung and kidney problems could occur as result of exposure to high amounts of cadmium (Mathew et al., 2018b; Giuseppe et al., 2020). Concentrations of Cd, Ni, Zn and Cu were below the WHO/FAO safety limits (FAO/WHO 2021).

Table 4: Heavy metal contents (mg/kg) of soil and Bitter leaf (*Vernonia amygdalina*) from dumpsite D

Sample	Ni	Zn	Cu	Pb	Cd
Bitter Leaf	0.511	1.144	0.155	1.853	0.045
Soil Sample	ND	1.104	0.094	0.231	0.029
Control	0.327	0.827	0.024	ND	ND

Key: ND= Not detected

The heavy metal contents (mg/kg) of soil and Bitter leaf from dumpsite are given in Table 4. Concentrations of the metals were generally higher in samples from the study site than the control site. Pb and Cd were not detected in the control. Table 4 also showed that the soil samples were moderately enriched with Cd but Ni was not detected in the soil of dump site 4. The Bitter leaf sample was strongly enriched with Pb and Zn, due to anthropogenic contributions.

Table 5: Heavy metal contents (mg/kg) of soil and Tomatoes (Solanum lycopersicum) from dumpsite E

Sample	Ni	Zn	Cu	Pb	Cd
Tomatoes	0.078	0.782	0.135	0.010	0.057
Soil Sample	0.034	0.591	0.065	ND	ND
Control	ND	0.364	0.018	ND	ND

Key: ND= Not detected

The order of accumulation of metals in both water leaf and soil samples was Pb>Zn>Ni>Cu>Cd. Plants generally have low uptake of Pb, high concentration of Pb in Bitter leaf in this study could be attributed to its high concentration in soil and possible aerial deposition and absorption. Lead (Pb) exposure can result in weakness of the joints, failures of reproduction, nausea and loss of memory (Towle, et al., 2017; Mathew et al., 2020b). In addition, the level of metals obtained in this study fell within the FAO/WHO permissible limit in soil.

The concentrations of the heavy metals (mg/kg) in soil and tomatoes (*Solanum lycopersicum*) are given in Table 5. The concentrations of the metals were generally higher in samples from the study site than the control site. The concentrations of the control had significantly lower heavy metals concentration than all the samples but moderately high in Zn concentration. It also showed that the Tomatoes (*Solanum lycopersicum*) and soil samples were moderately enriched with Ni, Cd, and Pb, but strongly enriched with Zn and Cu, due to anthropogenic contributions. The order of accumulation of metals in both tomatoes (*Solanum lycopersicum*) and soil samples was Zn>Cu>Ni >Cd>Pb. However, there was no detection for the levels of both cadmium (Cd) and lead (Pb) concentrations in the soil samples. Thus, Tomato sample having the highest concentration of Zn (0.782 mg/kg) was found within the limit given by the FAO/WHO of 99.40mg/kg. High concentrations of zinc can also interfere with the activities of earthworms and microorganisms in that way stunting the biodegradation of organic matter (Wuana and Okieimen, 2011). In addition, the levels of other metals obtained in this study were all below the FAO/WHO permissible limits (60 mg/kg) (Sheshe, et al. 2022).

Conclusion: The study found that Ni, Zn, Cu, Pb and Cd were present in all dumpsites. Additionally, it was found that some disposal sites had larger concentrations of these metals than others; this might be explained by the nature of domestic activities performed in the locations and the presence of garbage containing more of these heavy metals. The dumpsites were noted not to pose any hazard to human health at the present because the accumulation among these metals remains within the WHO permissible limits. The study area has slightly high levels of heavy metal contamination, which may be attributed to the metropolitan centers' rapid urbanization and subsequent rise in waste production and disposal. It is a bad practice to plant edible fruits and other agricultural goods on landfills, therefore eating such food products puts one’s health at risk.

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