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Evaluation and Ecological Risk Assessment of Selected Heavy Metal Pollution of Soils and *Amaranthus cruentus* and *Telfairia occidentalis* Grown Around Dump Site in Chanchaga Minna, Niger State, Nigeria

Oguh C. Egwu[1*], Uzoefuna C. Casmir[1], Ugwu C. Victor[1], Ubani C. Samuel[1], Musa A. Dickson[2] and Okunowo W. Oluwanisola[3]

[1]Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria.
[2]Department of Biochemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria.
[3]Department of Biochemistry, College of Medicine, University of Lagos, Akoka-Yaba, Lagos, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author OCE designed the study, performed the statistical analysis and wrote the protocol. Author UCC wrote the first draft of the manuscript. Authors UCV and UCS managed the analyses of the study. Authors MAD and OWO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study investigate a series of selected heavy metal pollution of soil, the extent of their uptake by *Telfairia occidentalis* and *Amaranthus cruentus* as well as their ecological risk around dumpsite in Chanchaga Minna, Niger State, Nigeria. Soil samples were collected at 15 cm depth with the aid of soil auger and vegetable samples were collected from dumpsite and other samples with no activities served as control. The soil samples were collected at random and their physicochemical parameters such as pH, total nitrogen, total phosphorus, organic matter, total carbon and exchangeable cations (i.e., K^+, Mg^{2+} and Na^+) using a standard method and concentrations of the

**Corresponding author: E-mail: collinsoguh@gmail.com;*

heavy metals in soils and vegetables, As, Cd, Cr, Cu, Hg and Pb were analyzed using flame Atomic Absorption Spectrometer (AAS). The ecological health risk assessment from the consumption of these vegetables was calculated using standard methods. The result showed a significant (p-value) increase of AC and TO in test soil samples relative to the control soils. The pH of the soil in dumpsite and control site was 5.93, and 7.35 respectively. Mean concentrations of As, Cd, Cr, Cu, Hg and Pb in the dump site were 6.35, 4.84, 6.67, 7.35, 5.72 and 4.96 mg/kg while the control site were 1.18, 0.28, 1.26, 6.83, 1.19 and 3.54 mg/kg respectively which was below the WHO/FAO limits of As (20), Cd (3.0), Cr (100), Cu (100), Hg (2.00) and Pb (50 mg/kg) for soil. The concentrations of As, Cd, Cr, Cu, Hg and Pb recorded in AC dump site were As (6.13), Cd (3.67), Cr (5.37), Cu (4.28), Hg (3.46), and Pb (4.52) and in TO As (5.67), Cd (3.13), Cr (4.67), Cu (3.65), Hg (3.19) and Pb (4.27 mg/kg) which were above the WHO/FAO permissible limits (0.5, 0.20, 0.3, 3.0, 0.1 and 0.3 mg/kg) respectively for edible vegetable. The concentrations of heavy metals in soils and vegetables from the dumpsite soil were significant ($p < 0.05$) from the controls. The bioaccumulation factor (BAF) for the vegetable showed that they exclude the element from soil. The Hazard Quotient (HQ) and Hazard index (HI) show that there is no harmful effect since the values obtain were not greater than >1. But continuous consumption can accumulate in the food chain especially for children. This study showed that the soils and vegetables within the vicinity of the dumpsites were polluted by heavy metals which can pose health risk. The study also calls for proper waste management practices and policy implementation.

Keywords: Amaranthus cruentus; Dumpsite; heavy metal; risk assessment; Telfairia occidentalis.

ABBREVIATIONS

DS : Dumpsite;
CS : Control site;
TO : Telfairia occidentalis;
AC : Amaranthus cruentus;
PL : permissible limit;
TOC : Total organic carbon;
OM : Organic matter;
TN : Total nitrogen;
TP : Total phosphorus;
EI : Exchange ions;
DIM : Daily intake of metal;
ADDM : Average daily dose of metal;
FAO : Food and agricultural organisation;
HI : Hazard index;
HQ : Hazard quotient;
RFD : Reference oral dose;
BAF : Bioaccumulation factor;
WHO : World health organization.

1. INTRODUCTION

The biggest challenge in Nigeria and other developing countries is the management of waste. Heavy metal pollution of soil is environmentally problematic because of the high persistence and toxic effects of the metals on the environment. Even at low concentrations, these metals can accumulate in the food chain. Heavy metal pollution at dumpsites remains the most common of all environmental hazards especially in Nigeria. Dumpsites are used as farm areas because of their high content in organic matter and nutrients. As a result, dumpsites are used for farming. Thus farmers take advantage of the dumpsite for agricultural production. However, in addition to nutrients, municipal solid wastes often contain high concentrations of heavy metals in various forms, which may be, under certain physicochemical conditions of the receiving environment, transported as leachate into the surrounding soils and surface and groundwater resource. Crops grown on a polluted agricultural land can absorb heavy metals in the form of mobile ions present in the soil solution through their roots. These absorbed metals get accumulated in the roots, stems, fruits, buds, grains and leaves.

Dumpsites contain high organic matter, nitrogen, phosphorus, organic carbons, micronutrients porosity, aggregate stability, bulk density and water retention and result to increase plant productivity [1]. This dump site also contain potentially toxic elements such as Arsenic (As), Cadmium (Cd) Cromium (Cr), Copper (Cu), Mercury (Hg), Zinc (Zn) and Lead (Pb). Soil is the main reservoir of heavy elements and, thus soil becomes a secondary source of heavy metals in the ecosystem. Heavy metals gradually accumulate in the soil, and its stability will cause accumulation and pollution since they could not be decomposed or are not biodegradable, like other organic pollutants through biological or chemical processes. Soils can be contaminated by the accumulation of heavy metal through dumpsites [2]. Almost all human activities

generate waste and the way in which this is handled, stored, collected and disposed of can pose risk to the environment and human health. However, the dumpsite may result in heavy metals accumulation in the soil. As a result, plants may absorb heavy metals from the contaminated soil above the permissible levels and enter the food chain affecting the human beings health [3].

Some heavy metals like Cr, Pb, Cu, Hg, As and Cd are hazardous to plants, animals and humans and the environment. High dose of Cr can cause chronic bronchitis, diarrhea, emphysema, headache, irritation of the skin, itching of respiratory tract, liver diseases, lung cancer, nausea, renal failure, reproductive toxicity, vomiting. It causes Chlorosis, delayed, senescence, wilting, biochemical lesions, reduced biosynthesis germination, stunted growth, and oxidative stress. On microorganism, heavy metals elongates lag phase, growth inhibition, inhibition of oxygen uptake [4,5]. Pb accumulates in the brain, which may lead to poisoning or even death. Children exposed to Pb are at risk for impaired development, lower IQ, hyperactivity and mental deterioration. Children under the age of five are more substantial risk. Adults also experience decreased reaction time, loss of memory, reduced fertility, renal system damage, nausea, insomnia, anorexia and weakness of the joints when exposed to lead. In plant lead affects photosynthesis and growth, chlorosis, inhibit enzyme activities and seed germination. On microorganism, lead denatures nucleic acid and protein, inhibits enzymes activities and transcription. Lead is not an essential element and can be toxic even at low concentration [6].

Copper is essential in the body, but in high doses it can cause anaemia, diarrhea, headache, metabolic disorders, nausea, vomiting, liver damage, kidney damage, stomach and intestinal irritation on human health. In plant Cu lead to chlorosis, oxidative stress, and retard growth, it disrupt cellular function, and inhibit enzyme activities in microorganisms [7]. Mercury poisoning symptoms are blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation. The ability of plants to accumulate essential metals also enables them to acquire other nonessential metals [8], Tanee and Eshalomi-Mario [9] reported that Pb causes acute and chronic poisoning and thus, poses adverse effects on kidney, liver, vascular and immune system. The most prominent chronic manifestations of As involve the skin, lungs, liver and blood systems. According to Liu et al. [10] atmospheric deposition is a major factor for high metal accumulation of metal in plant samples, and this could therefore be the cause of the As in the samples analysed. Concentration of Cd may have gastrointestinal effect and reproductive effect on livestock [11]. Cadmium causes adverse effect on kidney, liver, vascular and the immune system and also both acute and chronic poisoning [12].

The effects of the metals on the environment call for public health concerns and an immediate need for an increase awareness in order to remediate heavy metal pollution. Thus, it is imperative to remove or reduce heavy metal contamination in order to prevent or reduce contamination in the environment and the uptake through food chain [13]. To achieve this, bioremediation is employed in order to increase metal stability, which in turn reduces the bioavailability of heavy metal [14]. Bioremediation is a technique or method used for heavy metal removal from polluted environments. The technique utilizes biological mechanisms to eradicate hazardous contaminants using microorganisms and plants, or their products, to restore polluted environments to their original condition [7].

Fluted pumpkin (*Telfairia occidentalis*) has diverse traditional names; among the Igbos, it is known as Ugu, in Yoruba, it is known as Ewe Iroko/Aporoko, in Hausa it is known as Kabewa, Ekong in Efik, Umee in Urhobo and Umeke in Edo ethnic group [15,16]. African spinach (*Amaranthus cruentus*) also known as alayyafoo in Hausa, efo tete in Yoruba and inine in Igbo. Vegetables contain nutrient such as protein, essential minerals, fiber, vitamins, carotene and some essential amino acids required for normal metabolic activities of the body [17,18]. The nutrients help to repair worn out tissues, reduce cancer risks, lower cholesterol levels, normalize digestion time, improve eye vision, fight free radicals, and boost immune system. The vegetables also act as antioxidants that help to protect human body from oxidant stress, cardiovascular diseases and cancers [19].

Risk assessment is an effective tool which enables decision makers to manage and control contaminated sites in a cost-effective manner while preserving public and ecosystem health. Ecological risk is the likelihood that a given

activity or series of activities may have damaged or will damage the habitat, ecosystem or environment immediately or over a given period of time. Metal pollution index is a value that shows the level of contamination and pollution on a given substance under scientific investigation. On the other hand, human health risk assessment are usually done through a series of calculations to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environment [20].

In vegetables, heavy metals can be accumulate in edible parts (leaves). Heavy metals are generally more mobile at low pH than at high pH [21]. However, metals pose a significant health risk to humans, leading to various chronic diseases, particularly in elevated concentrations or in prolonged dietary intakes [22]. The high level of metals in the soil could indicate similar concentration in plant by accumulation at high concentrations causing serious risk to human health when consumed [23]. Plants are exposed to heavy metals through the uptake of water from the contaminated soil and animals eat these plants; consumption of plant and animal as food is the largest sources of heavy metals in accumulation to human [24]. In human, exposure to high levels of heavy metals is known to pose severe health risk such as damage to the organs (liver, kidney), cancer and may result in death, and also pose risk for, animals, plant and whole environment of our modern society [25]. Hence, this study evaluate and assess the ecological risk of selected heavy metal pollution of soils and *Amaranthus cruentus* and *Telfairia occidentalis* grown Around dump Site in Chanchaga Minna, Niger State, Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

Two commonly consumed leafy vegetables were selected for the study; Fluted pumpkin (*Telfairia occidentalis*) and African spinach (*Amaranthus cruentus*). The vegetable leaves used for the study were harvested fresh from the sites located in Chanchaga Minna Niger State.

2.2 Study Area

The study was conducted in a farm around the dumpsite at Chanchaga, Bosso Local Government Area in North-central, Niger State of Nigeria from March to April 2019. Nigeria lies approximately between latitude 4 and 14 °North and longitude 3 and 15º East. Chanchaga is situated at 9º34' North latitude, 6º33' East longitude, with an area of 72 km^2 (Fig. 1) and a population of 201, 429 at the 2006 census.

2.3 Experimental Design

A randomized complete block design with three replications for each sample was used to evaluate physicochemical properties of the soil samples and the heavy metal load on the leafy vegetables of Fluted pumpkin *Telfairia occidentalis* (TO) and African spinach *Amaranthus cruentus* (AC). The physicochemical properties including pH, Total Nitrogen, Total Phosphorus, Organic matter, Total Organic carbon, and exchangeable cations (K^+, Mg^+ and Na^+) of the soil were collected at random and done in two groups, from group 1 to 2, which are dumpsite and a control site (no activities), respectively. The concentrations of elements As, Cd, Cr, Cu, Hg and Pb in soils and vegetables, done in six groups, from group 1 to 6, which are dumpsite soil, control soil, AC dumpsite, AC control, TO dumpsite and TO control vegetables collected randomly.

2.4 Sample Collection

Soil samples were collected using a hand auger in random replicates of three, at 15 cm depth and were bulked to form a composite sample from the dumpsite and control site (no activities), both in Chanchaga Minna Niger State, Nigeria. The samples were air-dried under room temperature 27ºC to ensure constant weight for 3 days. Samples were homogenized using a ceramic mortar and pestle to obtain finer texture and to remove sticks, pebbles and rock particles. The homogenized soil samples were then sieved through a 2 mm sieve and stored in a dry container prior to analysis. Vegetable Leaves were also randomly sampled within the farms (dumpsite leaves and control leaves) to get a representative sample. All samples were collected aseptically in a sterilized universal container and plastic bags.

2.5 Laboratory Analysis

2.5.1 Determination of the Physico-chemical Properties

The physicochemical properties measured in all the groups were soil texture, pH, TOC, OM, TN, TP, and EI (Na^+, Mg^{2+} and K^+). The Physico-chemical properties of the soil were analysed in

order to check the biodegradable process. Physicochemical parameters of the contaminated soil and the control soil samples were determined according to Nimyel et al. [26].

2.5.1.1 Soil pH

Triplicate quantities (20 g) of air-dried of the soil samples were weighed into two separate groups of 50 mL beaker and 20 mL of distilled water was added to one group and 30 ml of 1M KCl_2 was added to the other group. Mixtures was allowed to stand for 30 minutes with occasional stirring using a glass rod. The electrode of the calibrated pH meter, MI 806 pH/EC/Temperature Portable Meter was inserted into the partly settled suspension and the pH value read. pH of soil sample was taken by using pH meter. The results were reported as soil pH in 1M KCl_2 and soil pH in water (H_2O). Three readings were recorded and then mean of it was calculated.

2.5.1.2 Organic matter

The soil samples were grounded to pass through 0.5mm sieve after which 1 g was weighed in triplicate and transferred to 250 mL Erlenmeyer flasks. Exactly 10 ml of 1M potassium dichromate was pipetted into each flask and swirled gently to disperse the soil followed by addition of 20 ml of concentrated, tetraoxosulphate (IV) acid. The flask was swirled gently until soil and reagents were thoroughly mixed. The mixture was then allowed to stand for 30 minutes on a glass plate to allow oxidation of potassium dichromate to chromic acid. Distilled water (100 ml) was added then 3- 4 drops of ferroin indicator or 1ml of diphenylamine indicator, after which the mixture was titrated with 0.5 M ferrous sulphate solution or ferrous ammonium sulphate till the colour flashes from blue-violet to green or bright green. A blank titration was similarly carried out.

The percentage of organic matter is given by the following equation:

% organic matter = ($M1e1K_2Cr_2O_7$ – $M2e2FeSO_4$) × 0.0031 × 100 × F/Mass(g) of air dried soil F = correction factor (1.33), M1 = mole of $K_2Cr_2O_7$, e1 = volume of $K_2Cr_2O_7$, M2 = mole of $FeSO_4$, e2 = volume of $FeSO_4$.

2.5.1.3 Total organic carbon

Soil sample 1 g was accurately weighed into a 500 mL conical flask. Than 10 mL of 1 M potassium dichromate ($K_2Cr_2O_7$) solution was added to the sample using a bulb pipette, followed by 20 mL of concentrated sulphuric acid (H_2SO_4) while gently swirling the flask in a fume cupboard. It was allowed to stand and cool slowly on insulated pad like sheet of asbestos for about 30 minutes after which 200 mL of distilled water was added using a measuring cylinder. After this, 1 g of crystal sodium fluoride (NaF) was added to avoid interference by complexing $Fe^{3+,}$ obtaining a black colour mixture which was shaken vigorously. Finally, 1 mL of 1% diphenylamine was added as an indicator and the mixtures were titrated immediately with 1 M ferrous sulphate ($FeSO_4$) solution in the burette. A blank without soil was prepared alongside the sample and titrated likewise. End point was indicated a colour change from deep purple to green.

% Carbon content = (B-T)×M×0.003×100× 1.33/weight of soil sample taken

Where;

B = Blank titre, T = Test sample titre, M = Molarity of $FeSO_4$, 1.33 = correction factor, 0.003 = mg equivalent of carbon.

2.5.1.4 Total phosphorus

Air-dried soil 2 g was weighed and dispensed in 20 ml of (0.025N HCl + 0.03N NH_4F) solution, shaken for 5 minutes and then filtered. After filtration, 3 ml of the preparation was put into a test tube, 3 ml of (0.87N HCl, 0.38N ammonium molybdate, 0.05% H_3BO_3) solution and 5 drops of (2.5 g of 1–amino 2- tetraoxosulphsate (vi) acid, 5.0 g Na_2SO_3, 146 g $Na_2S_2O_5$) solution were sequentially added to the preparation. A colorimeter (at wave length of 660 nm) was then used to take readings.

2.5.1.5 Total nitrogen

The total Nitrogen was determined using the kjeldahl digestion method. Than 20 ml of concentrated tetraoxosulphate (VI) acid was added to a 1 g measurement of air dried soil. A catalyst known as Kjeldahl TAB was also added and the solution was digested. After digestion, a clear solution was observed; this clear solution was distilled and subsequently titrated with 0.01M HCl.

2.5.1.6 Sodium, magnesium and potassium ion (Na^+ $Mg^{2+}$and K^+)

The exchange ions was determined calorimetrically using Flame photometer. Soil

sample (5 g) was accurately weighed into No. 1 filter paper fitted into a funnel on a leaching rack with 100 mL volumetric flask for collecting the leachate. The soil sample was leached with 1 N NH_4OAC solution obtaining 100 mL volume of leachate. Optical density readings for Na^+ Mg^{2+} and K^+ were obtained from the flame photometer.

$Na^+/mg^{2+}/K^+$ meq/100 g = Optical density× correction factor×100/5

2.6 Heavy Metals

2.6.1 Vegetables

The edible portion of the vegetable samples were properly separated and thoroughly washed under a running tap water to remove dust, dirt and possible parasite or their eggs. Then, 1% nitric acid solution was use to remove surface contaminants, and then rinsed with double distilled water. Samples was chopped into small pieces using a clean stainless table knife and afterward dried to a constant mass in an oven at 80°C for 48h. Replicate samples of each dried vegetable from the site were combined and pounded to fine powder using a porcelain mortar and pestle. Particle sizes of 0.05 to 0.2 mm were obtained using laboratory sieves. Than 2 g of each vegetable powder was transferred into a clean dry round-bottomed flask and digested in a mixture of 4, 25, 2 and 1 ml of concentrated $HClO_4$, HNO_3, H_2SO_4 and 60% H_2O_2, respectively, at 100°C on a hot plate for two hours in a fume cupboard. Each digest was filtered through a separate Whatman No. 42 filter paper and the resulting solution was left over night and made up to 100 ml with deionized water and concentrations of As, Cd, Cr, Cu, Hg and Pb were determined using flame AAS [27].

2.6.2 Soil

About 1 g of each topsoil sample was weighed into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated $HClO_4$, HNO_3 and H_2SO_4 respectively, on a hot plate in a fume cupboard. On completion of digestion, the samples were cooled and 50 ml of deionized water was added and then the samples were filtered. The samples were made up to 100 ml with deionized water and concentrations of As, Cd, Cr, Cu, Hg and Pb were analyzed using atomic absorption spectrophotometer [27].

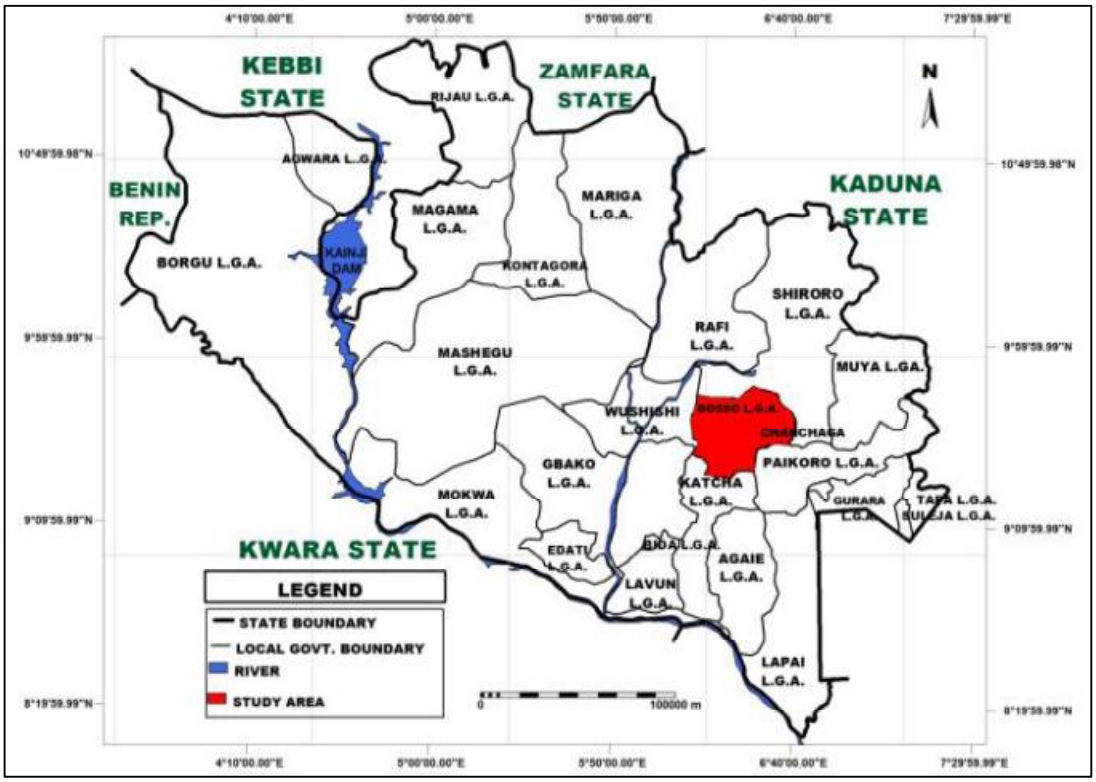

Fig. 1. Showing map of Niger state and the study area indicated with red

2.7 Ecological Risk Assessment

2.7.1 Estimation of Bioaccumulation Factor (BAF)

The BAF was calculated by dividing the concentrations of potentially heavy metals in vegetables their total concentrations in the soil. The index of soil to plant transfer or intake of heavy metals from soil to vegetables was calculated using the following equation described by Olowoyo et al. [28].

$$BAF = C_{veg}/C_{soil}$$

Where;

BAF represent the transfer factor of vegetable
C_{veg} = Concentration of heavy metal in vegetable tissue, mg/kg fresh weight
C_{soil} = Concentration of heavy metals in soil, mg/kg dry weight
BAF > 1 indicates that the vegetable are enriched with heavy metal from the soil (Bio-accumulation)
BAF < 1 means that the vegetables do not take up much heavy metal from soil (excluder)

2.7.2 Estimation of the Daily Intake of Metal (DIM)

The Daily intake of a given heavy metal was calculated using the following equation used by Olowoyo and Lion [29].

$$ADDM = DI \times M_{veg}/WB$$

Where;

ADDM = represents the average daily dose (mg, kg/d) of the metal.
DI = represent the daily intake of leafy vegetable (0.182 kg/d for adults and 0.118 kg/d for children according to Nabulo et al. [30].
M_{veg} = represent the trace metals concentration in the vegetables tissues (mg/kg).
WB = is the body weight of investigated individuals (55.7 kg for adults and 14.2 kg for children) as used by Olowoyo and Lion [29].

2.7.3 Estimation of Hazard Quotient (HQ)

The Hazard Quotient (HQ) was used to calculate the possible human health risks associated with the consumption of contaminated vegetables. The following equation for calculating human health risk (HQ) from consumption of leafy vegetables [30].

HQ is the ratio between exposure and the reference oral dose (RFD).

If the ratio is lower than one (1), means there will be no obvious risk.

$$HQ = ADDM/RFDM$$

Where;

ADDM = the average daily dose (mg, kg/d) of the metal
RFDM = the reference dose of the heavy metal (mg, kg/d)
RFDM = represent the maximum tolerable daily intake of metal with no adverse effect

2.7.4 Estimation of hazard index

The hazard index (HI) was calculated to determine the overall risk of exposure to all the heavy metals via the consumption of contaminated vegetable [62]. The hazard index (HI) was calculated as the summation of the hazard quotient (HQ) arising from all the heavy metals examined. The value of the hazard index is the magnitude of the toxicity of the vegetables consumed. HI greater than 1 indicates that the predicted exposure is likely to pose risks. However, a hazard index less than 1 does not necessarily indicate that a potential adverse health effects will result, but only indicates a high probability of posing health risks.

$$HI = \sum HQ_{As} + HQ_{Cd} + HQ_{Cr} + HQ_{Cu} + HQ_{Hg} + HQ_{Pb}$$

2.8 Statistical Analysis

Data were analysed using IBM Statistical Product and Service Solution (SPSS) version 21. The results were expressed as mean $\pm$ standard deviation (SD). One way analysis of variance (ANOVA) was carried out as $p<0.05$ considered statistically significant. Duncan's multiple range test (DMRT) was used to compare mean values of test groups and control as well as differences within group means of the various test groups.

3. RESULTS

3.1 Physicochemical Properties of Soil

The physicochemical properties was presented in Table 1. The texture of dumpsite soil and

control soil is loamy and sandy loam. The pH of the soil in water and KCl were 5.93 and 6.03 in dumpsite and control site were 7.35 and 7.57 respectively. The nitrogen, phosphorus, organic carbon, organic matter, and exchangeable cation (K^+, Mg^{2+}, and Na^+) of dumpsite and control soil were 2.55 and 1.67, 11.32 and 13.95, 3.67 and 1.24, 3.50 and 1.63, (2.29 and 3.17, 4.42 and 9.20, 6.73 and 5.59) respectively. The dumpsite soil is dark in color which indicates the presence of high organic matter content due to the decomposition.

Table 1. Physicochemical properties of soil samples

Soil properties	Dumpsite soil	Control soil
Texture	Loamy	Sandy loamy
pH in H_2O	5.93 ± 0.08	7.35 ± 0.02
pH in KCl	6.03 ± 0.04	7.57 ± 0.03
Total nitrogen %	2.55 ± 0.05	1.67 ± 0.07
Total phosphorus %	11.32 ± 0.12	13.95 ± 0.10
Total organic carbon %	3.67 ± 0.09	1.24 ± 0.08
Organic Matter %	3.50 ± 0.06	1.63 ± 0.02
K^+ meq/100g	2.29 ± 0.01	3.17 ± 0.04
Mg^{2+} meq/100g	4.42 ± 0.02	9.20 ± 0.07
Na^+ meq/100g	6.73± 0.07	5.59 ± 0.01

Results was expressed as Mean ± SD, n=3

3.2 Heavy Metal Concentration in Soils Samples

The mean concentrations (mg kg-1) of heavy metals (As, Cd, Cr, Cu, Hg and Pb) were analysed in dumpsite soil and the farm soil were presented in Table 2. The concentrations of Cd and Hg in dumpsite soil were 4.84 and 5.72 mg/kg and the control soil 0.28 and 1.19 mg/kg, respectively. The dumpsite soil were above the WHO/FAO [37] limits of 3.0 mg/kg Cd and 2.0 mg/kg Hg of metal in soil, but the control soil recorded a value that was within the permissible limit. The concentrations of As, Cr, Cu, and Pb in the dump site were 6.35, 6.67, 7.35, and 4.96 mg/kg while these of control site were 1.18, 1.26, 6.83, and 3.54 mg/kg respectively which was below the WHO/FAO [37] maximum limit of 20 mg/kg As, 100 mg/kg Cr, 100 mg/kg Cu and 50 mg/kg Pb for soil. The study revealed that the mean concentrations of most of the metals were significantly ($p < 0.05$) higher at the dumpsite soil compared to the control soil samples (Table 2).

3.3 Heavy Metal Concentration in AC and To Grown Around Dumpsite and Controls

The mean concentrations (mg kg) of As, Cd, Cr, Cu, Hg and Pb analysed in *Amaranthus cruentus* and *Telfairia occidentalis* around dumpsites contaminated soil and a control with no dump was presented in Table 3. The concentrations of As and Cd measured in AC and TO dump site were As (6.13), As (5.67 mg/kg) and Cd (3.67), Cd (3.13 mg/kg) which were above the WHO/FAO [43] limits of 0.5 mg/kg and 0.20 mg/kg, respectively for edible vegetables. The concentrations of Cr and Cu recorded in AC and TO dumpsite were Cr (5.37), Cr (4.67 mg/kg) and Cu (4.28), Cu (3.65 mg/kg) were above the WHO/FAO [43,44] permissible limit of 0.3 mg/kg and 3.0 mg/kg respectively for leafy vegetables. The concentrations of Hg and Pb recorded in AC and TO dumpsite were Hg (3.46), Hg (3.19 mg/kg) and Pb (4.52), Pb (4.27 mg/kg) which were above the WHO/FAO [43] permissible limit of 0.1 mg/kg and 0.3 mg/kg respectively for edible vegetables (Table 3).

Table 2. Heavy metal concentration in dumpsite soils and control soils

Heavy metals (mg/kg)	Soil samples		
	Dumpsite soil	Control site soil	PL(mg/kg) in soil (37)
As	6.35 ± 0.10	1.18 ± 0.09	20
Cd	4.84 ± 0.11	0.28 ± 0.08	3.0
Cr	6.67 ± 0.06	1.26 ± 0.12	100
Cu	7.35 ± 0.09	6.83 ± 0.06	100
Hg	5.72 ± 0.06	1.19 ± 0.02	2.0
Pb	4.96 ± 0.12	3.54 ± 0.05	50

Results was expressed as Mean ± SD, PL= Permissible limit, n=3

Table 3. Heavy metal concentration in AC and TO grown around dumpsite and controls

Heavy metals (mg/kg)	Vegetable samples				
	AC dumpsite	AC control	TO dumpsite	TO control	PL(mg/kg) in plant FAO /WHO, [43]*, [44]**
As	6.13 ± 0.06[a]	0.40 ± 0.04[c]	5.67 ± 0.01[b]	0.39 ± 0.04[c]	0.5*
Cd	3.67 ± 0.01[a]	0.18 ± 0.05[c]	3.13 ± 0.09[b]	0.14 ± 0.05[d]	0.2*
Cr	5.37 ± 0.02[a]	1.24 ± 0.14[c]	4.67 ± 0.07[b]	0.71 ± 0.01[d]	0.3*
Cu	4.28 ± 0.04[a]	3.43 ± 0.12[c]	3.65 ± 0.04[b]	2.28 ± 0.07[d]	3.0**
Hg	3.46 ± 0.07[a]	0.09 ± 0.17[c]	3.19 ± 0.06[b]	0.09 ± 0.04[c]	0.1*
Pb	4.52 ± 0.04[a]	0.25 ± 0.05[c]	4.27 ± 0.03[b]	0.19 ± 0.08[d]	0.3*

Results was expressed as Mean ± SD. Mean values with same superscript letters on the rows are considered not significant (P>0.05), PL= Permissible limit, n=3

3.4 Estimation of Bioaccumulation Factor

The Bioaccumulation factor (BAF) of heavy metals indicates the amount of heavy metals in the soil that ended up in the vegetable crop. The BAF for the same metal in the farm lands were significantly different from those for control and according to the type of plants. All the control metals were below one (<1) which indicate that the vegetable do not take up much toxic element from the soil. The highest BAF value obtained in AC and TO dumpsite were As (0.96, and 0.89) and Pb (0.91 and 0.86) respectively which indicates that the vegetable are not enriched relative to the soil (Bio-accumulation) (Table 4).

3.5 Daily Intake and Hazard Quotient for Individual

The hazard quotient and Daily intake was calculated for both adults and children from trace metals in leaves of *Amaranthus cruentus* and *Telfairia occidentalis.* The daily intake of heavy metals (DIM) was estimated according to the average vegetable consumption. The estimated DIM through the food chain for both adults and children is summarized in Table 5. The DIM values for heavy metals were significantly high in the vegetables on dumpsite than the controls grown were there was no dumpsite.

3.6 Estimation of Hazard Index (Hi) of Metal for Individuals

The calculated HI for both Adult and children in both *Amaranthus cruentus* (AC) and *Telfairia occidentalis* (CO) dumpsite and also control without dump were all less than <1. The highest value obtain in the vegetables from dumpsite were in children AC (0.80) and TO (0.72). The result indicated that children are more likely to be affected with continuous consumption of *Amaranthus cruentus* and *Telfairia occidentalis* grown on dumpsite in (Table 6).

4. DISCUSSION

The low pH in water and KCl (5.93, 6.03) at dumpsite were as a result of the dump which moves toward acidity. Research has shown that heavy metals are more mobile at pH < 7 than at pH > 7 [31,21]. However, low pH can pose a significant health risk to humans, leading to various chronic diseases, particularly in elevated concentrations or in prolonged dietary intakes [32,22]. The low pH of the dump soil may be due to the accumulation of waste materials, and high content of organic matter. Metal solubility tends to increase at lower pH and decrease at higher pH values.

Table 4. Estimation of Bioaccumulation Factor (BAF)

Heavy metals (mg/kg)	Bioaccumulation factor BAF			
	AC dumpsite	AC control	TO dumpsite	TO control
As	0.96	0.33	0.89	0.33
Cd	0.70	0.64	0.64	0.50
Cr	0.80	0.96	0.70	0.56
Cu	0.58	0.50	0.49	0.33
Hg	0.60	0.07	0.55	0.07
Pb	0.91	0.07	0.86	0.05

TF > 1 indicates that the vegetable are en-riched in elements from the soil (Bio-accumulation), TF < 1 means that the vegetables exclude the element from soil (Excluder)

Table 5. Daily intake, potential hazard of metal (Hazard quotient) individual

Heavy metals	DIM and HQ for individuals					
	Individuals	Hazard	AC dump	AC control	TO dump	TO control
As	Adult	DIM	0.02	0.001	0.02	0.001
		HQ	0.04	0.002	0.03	0.002
	Children	DIM	0.05	0.003	0.04	0.003
		HQ	0.10	0.006	0.09	0.006
Cd	Adult	DIM	0.01	0.001	0.01	0.000
		HQ	0.05	0.002	0.05	0.002
	Children	DIM	0.03	0.001	0.02	0.001
		HQ	0.15	0.007	0.13	0.005
Cr	Adult	DIM	0.01	0.004	0.01	0.002
		HQ	0.05	0.013	0.05	0.007
	Children	DIM	0.04	0.002	0.03	0.005
		HQ	0.14	0.008	0.12	0.019
Cu	Adult	DIM	0.01	0.011	0.01	0.007
		HQ	0.00	0.003	0.00	0.002
	Children	DIM	0.03	0.028	0.03	0.018
		HQ	0.01	0.009	0.01	0.006
Hg	Adult	DIM	0.01	0.000	0.01	0.000
		HQ	0.11	0.002	0.10	0.002
	Children	DIM	0.02	0.000	0.02	0.000
		HQ	0.28	0.007	0.26	0.007
Pb	Adult	DIM	0.01	0.001	0.01	0.000
		HQ	0.04	0.002	0.04	0.002
	Children	DIM	0.03	0.002	0.03	0.001
		HQ	0.12	0.006	0.11	0.005

DIM = Daily intake of metal, HQ = Hazard quotient

Table 6. Estimation of Hazard Index (Hi) of metal for individuals

	HI for individuals				
HI = ∑HQ (HM)	**Individuals**	**AC dumpsite**	**AC control**	**TO dumpsite**	**TO control**
	Adult	0.29	0.02	0.27	0.02
	Children	0.80	0.04	0.72	0.05

HI = Hazard index, ∑ = Summation of the Hazard Quotient (HQ) arising from all the heavy metals (HM) examined. AC = Amaranthus cruentus, TO = Telfairia Occidentalis

The pH values obtained in this study are similar to that reported for dumpsites by other researchers [33-35]. The high total nitrogen in the dump soil is as a result of the waste nitrogenous substances such as decay plant and animals materials in the dump. The nitrate-nitrogen contents in this research is lower than that reported by Uba et al. [33] which ranged from 4.17 to 11.33 % for dumpsite soil of dumpsites in Zaria Metropolis, Nigeria. However, the results reported by Osazee et al. [36] had the range 3.476 to 4.522 % which is also significantly higher than the concentration reported in this research. Significant decrease in total phosphorus content in the dumpsite soil can be attributed to low phosphorus content in the waste. The results showed that organic matter and total organic carbon in the dump soil were higher than that of the control sample. The organic matter contents of the soil play a vital role in adsorption process in the soil, hence preventing a pollutants from reaching the groundwater sources. Cation exchange capacity therefore increases due to the increases of clay content and also as the organic matter. The Analysis of variance (ANOVA) carried out shows

significant differences ($p < 0.05$) in the dump site soil and control soil (Table 1). The result of physicochemical changes the soil physicochemical properties, especially the dumpsite soils. The alteration of the physicochemical properties of the soil is therefore expected to affect the survival of certain plant species and hence their diversity. The increase of heavy metals in the soil, which is then likely transferred to plants that grow on such soils, with the associated risks of long term toxicity to humans that consume them and other biota in the ecosystem (Table 1).

ANOVA revealed a significant ($p < 0.05$) variation in the concentrations of the two (2) groups analyze for elements in the soil, which is an indication of the extent of metal pollution in the soils. The mean Cd value obtained for the dumpsite soils were lower than those reported by (38) with 219 – 330 mg/kg. From the results, the level of Cd and Hg in the soils may lead to environmental hazard. The high concentration of these metals in the study areas could be link to the location of the dumpsite and the nature of the waste been dumped. Human activity can also contribute the increased Cd level as a result of urbanization or agricultural practices. The levels of Cr measured in this study were lower than those recorded by Awokunmi et al. [38] (212.00 – 2020.00 mg/kg). The levels of Cu recorded in this study were higher than the levels recorded by Opaluwa et al. [39] with range (0.82 – 0.91 mg/kg). Sources of Cr and Cu in the soils could be due to automobiles, cable wire, coloured polythene bags, discarded plastic materials, empty paint containers and electronic waste [40]. On the other hand, the concentrations of Pb reported in this study were higher than those reported by [39] with range 0.90 – 4.20 mg/kg. The mean Cd, Cr, Cu, and Pb values in the control site studied in Chanchaga, Minna Miger State Nigeria were generally lower than those in the studied areas. This result is similar to the findings of Steve and Edith [41] which recorded high concentrations of heavy metals on soil amended with sludge in Obunga Slum, Kisumu County, Kenya. Heavy metals exhibit toxic effects towards soil biota by affecting key microbial processes and decrease the number and activity of soil microorganisms. According to Chen et al. [42], the heavy metals are likely to reduce bacterial species richness and a relative increase in soil actinomycetes or even decreases in both the biomass and diversity of the bacterial communities in contaminated soils (Table 2).

The high mean concentrations of As and Cd at dumpsite may be due atmospheric deposition of the metal from non – ferrous metal activities, combustion, which can be adsorbed into foliage and translocated through the plant. Studies have shown that Cd is easily translocated through plants [45]. Arsenic affects almost all organs during its acute or chronic exposure. Liver has been reported as target organ of As toxicity. Toxicity is due to arsenic's effect on many cell enzymes, which affect metabolism, DNA repair and brain problem. The prominent chronic manifestations of as involve the skin, lungs, liver and blood systems. According to Liu et al. [10], high metal accumulation in plant samples is due to atmospheric deposition, and this could therefore be the cause of the as in the analysed samples. The levels of Cd recorded in this study was however much higher than the values of 0.01 – 0.03 mg/kg reported by Fatoba et al. [46] and was also higher than the highest mean values of 0.08 mg/kg reported by Amusan et al. [47]. Toxic effects of cadmium on plants include reduced shoot growth and inhibit root growth [48]. The significant concentration of Cd may have gastrointestinal effect and reproductive effect on humans [11]. Researchers reported that Cd causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and the immune system [12].

The concentration of Cr and Cu could be attributed to the continuous sewage water on the farm. In a similar study, [49] find that the concentration of Cu from all the site S1 (95.56), S2 (10.13), S4 (6.92) and S5 (5.48) were all above the FAO/WHO [44] limit of 3.0 mg/kg at Korle Lagoon area in Accra, Ghana. High Cr is observed to cause bronchopneumonia, chronic bronchitis, diarrhea, emphysema, headache, irritation of the skin, itching of respiratory tract, liver diseases, lung cancer, nausea, renal failure, reproductive toxicity, and vomiting. High Cr in plant causes chlorosis, delayed senescence, wilting, biochemical lesions, reduced biosynthesis germination, stunted growth, and oxidative stress [2,4,50]. Copper ends up in soils, it strongly attach to organic matter and minerals. As a result, it does not travel very far after release and consequently copper tends to accumulate in soil [51]. Perhaps, this might explain why the soil had high concentrations of Cu, whereas the fruits had lower levels. Copper in high doses it can cause anaemia, diarrhea, headache, metabolic disorders, nausea, vomiting, liver and kidney damage, stomach and intestinal irritation on human health. In plant it

can lead to chlorosis, reduction in root growth, seed growth, oxidative stress, retarded growth and biomass which could eventually lead to plant mortality [52] and in microorganism, it can disrupt cellular function, and inhibit enzyme activities [7]. According to Maobe et al. [11] high levels of Cu cause metal fumes fever with flu-like symptoms, hair and skin decolouration, dermatitis, irritation of the upper respiratory tract, metallic taste in the mouth and nose.

Mercury is not essential for plant growth [53]. Mercury poisoning symptoms include blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation. The ability of plants to accumulate essential metals also enables them to acquire other nonessential metals [8]. The levels of lead recorded in this study were much higher than the values of 0.01 – 0.03 mg/kg reported by Fatoba et al. [46], and 1.50 – 3.40 mg/kg by Amusan et al. [47]. Pb has no known beneficial biological function and is known to accumulate in the body. Amusan et al. [54] reported that Pb causes both acute and chronic poisoning and thus, poses adverse effects on kidney, liver, vascular and immune system. Lead also causes serious injury to the brain, nervous system, red blood cells, low IQ, impaired development, shortened attention span, hyperactivity, mental deterioration, decreased reaction time, loss of memory, reduced fertility, renal system damage, nausea, insomnia, anorexia, and weakness of the joints when exposed to high Pb. In plant, lead affects photosynthesis and growth, chlorosis, inhibit enzyme activities and seed germination [55] (Table 2).

Generally the heavy metals present in this study can cause serious problems. This study shows that vegetable crops AC and TO have the ability to uptake heavy metals through their roots and transport this metals to the edible portion of the plant because high concentrations were observed in the soil [56]. The differences in the accumulation of heavy metals in the vegetables under study could be attributed and not limited to the varying physiological phenomenon such as absorption rate of different metals through soil physicochemical properties, choice of plants in selecting which mineral is allocated and stored in its parts among other factors [57]. Bio-accumulation of heavy metals in the leaves of *Amaranthus cruentus* and *Telfairia occidentalis* may interact directly with biomolecules such as nucleic acid, protein, lipid, carbohydrate, disrupting critical biological processes, resulting in toxicity and the concomitant transfer of these metals through the food chain could ultimately pose risk to human life [58-60].

In general, ANOVA revealed a significant ($P<0.05$) variation in the concentrations of heavy metals in the vegetables AC and TO grow around dumpsite and that of the controls. Generally AC and TO grow around dumpsite had higher heavy metals concentrations than the controls. Vegetables from soils located around the dumpsite exceed the WHO/FAO maximum limits of metals in edible vegetable. The mean values recorded at all control sites were below the FAO/WHO acceptable value except Cr in TO which was above the WHO/FAO (43) limit of 0.3 mg/kg for edible plants. The sequence of occurrence of the heavy metals in AC and TO grow on contaminated soil decreased in the order As > Cr > Pb > Cu > Cd > Hg and As > Cr > Pb > Cu > Hg > Cd respectively in Table 3. Heavy metals and nutrients absorbed by the roots are usually translocated and sprayed to different parts of the plants which could limit the concentrations in the leaves of the plant. However, availability of metals in the soil and continuous absorption by the roots could lead to higher concentration in the leaves. Plant species have different accumulation rate, some take up toxic substances more than others (Table 3).

The levels of lead in the soil of this study could be attributed to the indiscriminate disposal of lead containing wastes on the dumpsite. Lead accumulation in many plants can exceed several hundred times the threshold of maximum level permissible for human. The BAF of Cu from the soils to AC and TO in this study was low compared to the high mean value of Cu in the dumpsite soil (4.28 and 3.65 mg/kg) and in the leaves (0.58 and 0.49 mg/kg). This could be because copper contents do not mobilize in leaves or fruits and remain stagnant in roots, which would explain the lower content of the metal in fruit as compared to the soils [61]. Yang et al. [62] Showed that copper mainly accumulated in roots while a small fraction (10%) of absorbed copper was transported to the shoots. Plants are known to accumulate trace metals from contaminated soil [39,63]. The soil-plant BAF of different heavy metals in AC and TO dumpsite showed the following sequence of occurrence in decrease order $BAF_{As}>BAF_{Pb}>BAF_{Cr}>BAF_{Cd}>BAF_{Hg}>BAF_{Cu}$. The bio-accumulation factor depend on different species of plants, some plant have the ability to accumulate more metals from the soil than

others. Where BAF > 1 indicates the vegetable are enriched in elements from the soil (Bio-accumulation). TF < 1 means that the vegetables do not take much element from soil (Excluder). BAF is one of the key components of human exposure to heavy metals through the food chain (Table 4).

The highest DIM obtained from AC and TO vegetables were all in children with As (0.05 AC and 0.04 TO). This indicates that children are liable to be affected by the continuous consumption of these vegetables grown on dumpsite. The decrease sequence of the metal occurrence in HQ for both sets of vegetables is Hg>Cd>Cr>Pb>As>Cu. The values indicate that children had the highest values and can cause risk if consumed continuously.

The HQ of metal through the consumption of vegetables for both adults and children were given in Table 5. The HQ values for heavy metals were significantly high in *Amaranthus cruentus* and *Telfairia occidentalis* grown on dumpsite than the controls. The highest HQ of the heavy metal in dumpsite *Amaranthus cruentus* and *Telfairia occidentalis* for both adult and children were in (Hg). Adult (0.11, 0.10), children (0.28 and 0.26 respectively) (Table 5).

For all the metal, the calculated HQ showed that there is no harmful effect on the consumption of the vegetables since the values obtain were not greater than >1. But continuous consumption can accumulate in the food chain (Table 5). The result of this study regarding the HI shows that AC and TO vegetable grown around dumpsite are safe for consumption because the values obtain were not greater than one (Table 6).

5. CONCLUSION

The heavy metals (As, Cd, Cr, Cu, Hg and Pb) analysed were present in soil and in the vegetable samples. The soils and vegetable samples from the study areas recorded significant levels of heavy metals, especially those around dumpsite. The concentration of heavy metals in *Amaranthus cruentus* and *Telfairia occidentalis* around dumpsite exceeded the WHO/FAO permissible limits in edible vegetable while the controls were within the permissible limit. The HQ and HI showed that there is no harmful effect on the consumption of the vegetables since the values obtain were not greater than >1. But continuous consumption can accumulate in the food chain and pose health risk.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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