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# Heavy Metals Contamination of *Abelmoschus esculentus*, Cultivated along River Ngadda in Maiduguri, Northeast Nigeria

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***Abstact:*** *Irrigation with contaminated water with heavy metals poses threat to human beings. This study aimed to investigate the potential human health risks associated with the consumption of Abelmoschus esculentus (okra) contaminated with toxic heavy metals. The vegetable was grown on a soil irrigated with contaminated water from river Ngadda in Maiduguri Nigeria. The heavy metals under study were Cd, Cu, Pb and Zn. Translocation factor (TF), daily intake metal; health risk index (HRI) and target hazard quotients (THQ) of these metals were calculated. This indicates the pollution level of the metals contamination. The concentrations of Pb and Cu in the edible portions were above the safe limit (Cu concentrations 0.043±0.031, 0.097±0.015, 0.087±0.015) and Pb (0.123±0.012, 0, 0.027±0.015) in Abelmoschus sp were above the WHO (0.04 and 0.01 respectively) permissible limits in all the locations while Cd and Zn were not detected in the vegetable sample. The Health Risk Index (HRI) of Pb was >1 indicating a potential health risk. The THQ was less than 1. This result indicates a slow exposure of humans to poisoning by heavy metals due to the indiscriminant disposal of wastewater into the river that contaminates the vegetable grown with irrigation by contaminated water sources. The findings reveal that Abelmoschus esculentus was not safe for human consumption. The irrigation source was identified as the source of pollution in this study.*

***Keywords***: *Abelmoschus esculentus, accumulation, heavy metals, wastewater, vegetable, river Ngadda*

## 1. Introduction

Wastewater contributes significantly to heavy metal accumulation in soils and vegetables [30; 41]. Developing countries such as China and India are prone to heavy metal contaminations due to its extensive usage of untreated industrial wastewater [39]. Heavy metals accumulate in edible parts of the vegetables (leaves, fruits and roots). Heavy metals most often found in vegetables include cadmium, copper, arsenic, chromium, lead, zinc, cobalt and nickel. Accumulation of toxic heavy metals leads to stress conditions in the plant system by interfering with the metabolic activities and physiological functioning of the plants. Vegetables grown around urban areas are prone to heavy metal contamination due to various urban and industrial activities including vehicular pollution. Continuous use of wastewater for irrigation accumulates heavy metals in vegetables [42; 40, 37; 15]. However, these risks can be reduced by applying some precautions or treating the wastewater before usage. Okra (*Abelmoschus esculentus* (L) Moench) is an annual vegetable and belongs to the family Malvaceae. Okra is a good source of carbohydrates, protein, dietary fiber, calcium, magnesium, potassium and vitamins A and C [28]. It contains glycans, substances responsible for the viscosity of aqueous suspensions and the stringy, gum-like consistency that is desired in good quality soups. Glycans are also an excellent source of iodine, which is useful for the treatment of goiters. The powdered root of okra is consumed along with sugar as a treatment for leucorrhoea and backache. Okra acts as a tonic for both men and women and enables them to increase their vitality and vigor. The tender pods are used as vegetable. Maiduguri is an arid city with no permanent rivers or lakes and have short period of rainfall. Maiduguri urban, with a land mass of 137.356 Sq km [34], is located between latitude N11° 46'18" to N 11° 53' 21" and longitude E13° 03' 23" to E 13° 14' 19" [45]. The area lies within the lake Chad Basin formation, which is an area formed as a result of down-warping during the Pleistocene period [45]. Maiduguri has the population of 1,197497 [34]. Due to scarcity of water in certain areas of Maiduguri, couple with rapid growth of migration from insurgency leads to increased demand for vegetables cultivation all year round. As a result, farmers depend on wastewater which is cheaper and abundantly available during the dry seasons. There is lack of awareness on the effects of wastewater irrigation on vegetable production. The agricultural use of treated, partially treated or untreated wastewater or surface water contaminated with wastewater is common. An estimated 20 million hectares worldwide are irrigated with wastewater, more of it with untreated than treated wastewater[23;]. This misbalance in favour of untreated wastewater will continue to increase as long as the pollution of streams, by effluents from growing urban populations is not matched by treatment facilities. Therefore, the aim of this research is to evaluate the effect of heavy metals accumulation in *Abelmoschus esculentus* (okra) in Maiduguri.

## 2. Experimental Methods

This section explains the population, sampling, Preparation and determination of heavy metals

### 2.1. Vegetable sampling

### 2.2. Population

Data was collected from soil and Vegetables okra (*Abelmoschus esculentus*) along River Ngadda**.** These vegetable is the most commonly used vegetable in preparing soups and ingredients in most diets of the Maiduguri people which are cultivated in irrigated farm lands along River Ngadda. The coordinates of the vegetable population are presented in Table 1:

TABLE I: Coordinates of samples collections site along River Ngadda

| | | | |
|---|---|---|---|
| A (Abattoir) | N $11^0$ 51′ 54.5″ | E $013^0$12′ 06.1″ | Vegetable & soil |
| B (Gamboru Market) | N $11^0$ 51′ 28.8″ | E $013^0$10′54.4″ | Vegetable & soil |
| C (Munucipal) | N$11^0$ 51′ 32.3″ | E$013^0$ 10′47.4″ | Vegetable & soil |

The experimental design was a purposive randomized block design involving 3 blocks (sampling locations).the samples are collected randomly at the three locations and were replicated three times. The samples were collected as described in [14 and11].

Note that each of the point of sample collection was selected based on its wastewater peculiarity. Preliminary survey conducted at the site revealed that, Wastewater from these sources and other minor sources were used majorly for irrigation of vegetable especially during the dry seasons

Soil and *Abelmoschus esculentus* (okra) was collected from the selected sampling sites. The farms irrigated with wastewater from Ngadda were identified and owners consent sought. Such farms are monitored regularly up to time of harvest. Soil and *Abelmoschus esculentus* (okra) samples produced by the farmers in 3 replicates along the river were collected. The vegetable *Abelmoschus esculentus* (okra) samples collected from the farmers were produced under three (3) different plot of 5 x 6 m of farms along the River were cultivated for these vegetable. Soil samples were collected from the vegetables farm lands, at depths of 0-10cm using a spiral auger of 2.5cm at each of the three farm land. The randomly selected soil samples were bulked together to form a composite sample before being placed in clean plastic bags labeled with an identification number and transported to Agricultural Science laboratory A.T.B.U for analysis.

***Sample preservation and Pretreatment***

In the early hours in the morning fresh sample of *Abelmoschus esculentus* fruits was collected and transported in clean polythene bags labeled with an identified number to the laboratory. The samples were stored in the Department of Chemistry laboratory University of Maiduguri freezer prior to treatment and analysis [35].The samples vegetables were dried in a hot air oven at $120^0$C for 48 hours as described in [14 and 11]. The samples were grinded into powder using pistle and mortar then sieved through 2mm sieve the samples were kept in desiccators to obtain a constant weight. The fine powder was then dispensed into plastic bottles and ready for analysis.

The soils samples were air-dried at room temperature, ground to fine powder by using mortar and pestle, then sieved through 2mm sieve, then kept in clean polyethylene containers before analysis.

### 2.3. Determination of heavy metals in soil and vegetables

Digestion of both sampled soil and vegetable (*Abelmoschus esculentus* fruits), was done in ATBU laboratory. A quantity of 0.5g vegetable samples oven dried ground, sieved were weighed into a 125ml Erlenmeyer flask and digested with mixture of conc. $HNO_3$, 60% $HClO_4$ and conc. $H_2SO_4$ (32.5:4:1 v/v) under a fume hood. The mixture were cooled and filtered into a 100ml volumetric flask and the volume made up to the mark with distilled water. The concentration of Cd, Cu, Pb and Zn in the samples was then being determined using Atomic Absorption Spectrophotometer while the results are expressed in mg/l. This procedure was also adopted by several researchers [1;2;12and 37].

Samples were kept in clean polythene bags and bottles well covered during transportation to the laboratory to avoid contamination from external environment. Reagent blanks were used in all analysis to check reagent impurities and other environmental contamination during analysis [4]. Analytical reagent (AnalaR) grade chemicals and distilled water were used throughout the study. Detergent and 20% (v/v) concentrated Trioxonitrate (IV) acid were used in washing the glassware and plastic containers then rinse with water and finally with distilled water [5 cited in 37]. Furthermore the instruments were calibrated prior to use, equally the tools and work surface were carefully cleaned for each sample to avoid cross contaminations.

### 2.4. Analysis of variance (ANOVA)

All the data were analyzed using statistical software “R” 2013 version. One way ANOVA was used to determine whether there is significant difference in the levels of heavy metals concentration in leafs and fruits and between the vegetables crop. All data were checked beforehand for normality. The data which were not normally distributed were transformed using kruskal- wallis test.

### 2.5 Ecological and health risk assessment

To determine the health risk rate of heavy metals associated with consumption of vegetable cultivated along River Ngadda, ecological and health risk assessments were analyzed using the following formulas:

### 2.6 Translocation factor calculation

As stated by [24] heavy metals have the capability to translocate from the soil to the edible parts of the vegetables and can be determined by the accumulation factor (AF). The AF values for the selected heavy metals were calculated according to the following equation:

$$AF = \frac{\text{heavy metal concentration in vegetables edible part}}{\text{heavy metal concentration in soil}} \quad (1)$$

2.7 Daily intake of metals (DIM)

The DIM was calculated using the following equation:

$$DIM = \frac{Cmetal * Cfactor * Dintake}{Bweight} \quad (2)$$

where, $C_{metal}$, represent the heavy metal concentrations in the food items, $C_{factor}$, the conversion factor, 0.085 was used as reported by [35 and 2] that fresh weight of vegetables should be converted to dry weight by using the conversion factor, $D_{intake}$ the daily intake of the food items and $B_{weight,}$ the average body weight, respectively. The average daily intake of the vegetables was 0.4 kg $person^1$ $d^1$,(146kg per year per person) and the average body weight for adult in Nigeria is 55.2 kg; these values were used for the calculation of HRI as well.

### 2.7 Health risk index (HRI)

The HRI refers to the ratio of the daily intake of metals in the food item to the oral reference dose (RfD) [13;32;26;] and was calculated using the following equation:

$$HRI = \frac{DIM}{RfD} \quad (3)$$

where DIM is the estimated daily intake of each heavy metals ($mg/kg^{-1}d^{-1}$) and the RfD represents safe level of the heavy metals exposure by oral intake. As in USEPA (2007) the values of RfD for Cd, Cu, and Zn are 0.001, 0.04, and 0.3 mg/kg$^{-1}$d$^{-1}$ while for Pb as according to EFSA (2010) and JECFA (2010) is 0.0015mg/kg$^{-1}$d$^{-1}$ respectively. An HRI > 1 for any metal in food items indicates that the consumer population faces a health risk.

### 2.8 Determination of Target Hazard Quotients (THQ)

THQ which is refers to the ratio of the average dietary intake or dose (ADI) to the reference dose (RfD), is used to express the risk of non-carcinogenic effects. If the ratio is less than 1, then the exposed population (consumers) will not be at risk. However, if the dose is equal to or greater than the RfD the exposed population of concern will be at health risks. The method for the determination of THQ was provided in the United States EPA Region III risk-based concentration table [44]. The dose calculations were carried out using standard assumptions from an integrated United States EPA risk analysis.

the models for estimating THQ are:

$$THQ = \frac{EFr \times EDtot \times FIR \times C}{RfDo \times BWa \times A\,Tn} \times 10^{-3} \quad (4)$$

where THQ is the target hazard quotient; EFr is exposure frequency (365 days/year); EDLT is the exposure duration (55.2 years, average lifetime of Nigerians); FIR is the food ingestion rate (according to WHO vegetable intake entails a consumption of at least 0.4kg/day/person); C is the heavy metal concentration in samples (mg/kg); RfD is the oral reference dose (mg/kg/ day, Bwa is the average adult body weight (60.7 kg adult average body weight of Nigerians); and ATn is the averaging exposure time for non-carcinogens (365 days/ year number of exposure years, assuming 55.2 years in this study). The RfD is an estimation of the human daily exposure that is unlikely to pose an appreciable risk of adverse health effects during a lifetime. It has been reported that exposure to two or more pollutants may result in additive and/or interactive effects [18] In this study, the total THQ is derived by the method of [36; and 33], which is used as the arithmetic sum of the individual metal THQ values.

Total THQ (TTHQ) = THQ (toxicant 1) + THQ (toxicant 2) +…….+ THQ (toxicant n)

## 3. Result

### 3.1 Mean Cconcentration of Heavy Metals in Fruit of *Abelmoschus sp*

The mean level of heavy metals concentration in fruit of *Abelmoschus sp as* revealed in Table 4 Zn and Cd were not detected in the samples in all the locations. The concentration of Cu in *Abelmoschus esculentus* obtained from the study area is significantly high compared to the control site. There are no any significant differences in concentration of Cu in *Abelmoschus esculentus (*$P \geq 0.01$) among the sites because the p-value is greater than 0.01. The mean concentration of Pb as it is shown in table 1 at location B Pb was not detected but there is no significant difference in concentration of Pb in *Abelmoschus esculentus.* However the concentrations of Cu, and Pb in Abelmoschus esculentus exceeded the WHO safe limits**.**

TABLE II: Mean Accumulation of heavy metals in *Abelmoschus esculentus*

| location/Plots | Cu (mg/L) | Zn (mg/L) | Pb (mg/L) | Cd (mg/L) |
|---|---|---|---|---|
| A | 0.043 ± 0.031 | ND | 0.123 ± 0.012 | ND |
| B | 0.097 ± 0.015 | ND | 0 | ND |
| C | 0.087 ± 0.015 | ND | 0.027 ± 0.015 | ND |
| Control | 0.003 ± 0.006 | ND | 0.013 ± 0.006 | ND |
| p-value (0.01) | 0.194 | | 0.396 | |
| **WHO safe limit** | **0.04** | | **0.01** | **0.003** |

The mean concentrations of heavy metal in the agricultural soil of *Abelmoschus esculentus* from Table 2 it indicate the highest value was recorded in Cu (0.369 ± 0.54) from location A while the least was found in Zn (0.005 ± 0.003) in location B. Statistically there is no any significant differences between the study site / location because the p value is greater than 0.01 *(*$P \geq 0.01$). Furthermore strong correlations were found between Cu and Zn(r =0.591) in location A, no significant correlation was found in location B while location C, Cu and Cd (r = 0.723) Cd and Zn (r =0.944) at the $p < 0.01$ level. There were relative strong positive correlations between Cu, Cd, and Zn, but Pb did not show significant correlations with these metals.

TABLE III: Mean Concentration of heavy metals in soils obtained from *Abelmoschus esculentus*

| Location | Conc.Cu±SD(mg/l) | Conc.Zn±SD(mg/l) | Conc.Cd±SD(mg/l) | Conc.Pb±SD(mg/l) |
|---|---|---|---|---|
| A | 0.369 ± 0.54 | 0.008± 0.002 | 0.008 ± 0.002 | 0.099 ± 0.012 |
| B | 0.067 ±0.05 | 0.005 ±0.003 | 0.012 ± 0.002 | 0.158 ±0.040 |
| C | 0.097 ± 0.098 | 0.064± 0.050 | 0.030 ± 0.01 | 0.201 ± 0.062 |
| p-value | 0.956 | 0.0124 | 0.0321 | 0.06081 |
| Standard | | | | |

## 3.2 Ecological Risk Assessment

The TF values which is used to evaluates the heavy metal transfer capability from the soil to the edible parts of the vegetables are presented in Table 3 The TF of different heavy metals of *Abelmoschus esculentus* as presented in Table 3 the overall TF for the vegetable followed the order Pb (3.05), Cu (2.06) in location A. while Cu (1.46), Pb (0.131) in location B for location C Cu (0.98) and Pb (0.30). Zn and Cu were not detected

TABLE IV: TF values of heavy metals in different vegetables along River Ngadda

| Locations | heavy metals | Vegetable | Soil | TF |
|---|---|---|---|---|
| A | Cu | 0.043 | 0.369 | 0.116531165 |
| | Pb | 0.123 | 0.099 | 1.242424242 |
| B | Cu | 0.097 | 0.067 | 1.447761194 |
| | Pb | | 0.158 | |
| C | Cu | 0.087 | 0.097 | 0.896907216 |
| | Pb | 0.027 | 0.201 | 0.134328358 |

## 3.3 Estimated DIM and HRI for Consumption of Vegetable Cultivated Along from River Ngadda

The DIM and HRI exposure level in consuming the fruit *Abelmoschus esculentus* cultivated along river Ngadda (in adult) are presented in Table 4.

Table 4 shows the estimated daily intake of metal and exposure level of heavy metals in consuming the fruits of *Abelmoschus esculentus* in adult along river Ngadda. It reveals that all the values recorded from the calculation of the DIM did not exceed the safe level of the heavy metals exposure by oral intake. While the value of HRI for individual metals has revealed that Pb had the highest value in all the location. This indicates that HRI values of Pb exceeded the safe level of the heavy metals. Cu values were below the safe level of the heavy metals (that is the reference dose)

TABLE 5: Estimated daily intake of metals and health risk index for consumption of vegetable along river Ngadda

| locations | Heavy metals | RfD (mg/kg$^{-1}$d$^{-1}$) | DIM(mg/kg$^{-1}$d$^{-1}$) | HRI |
|---|---|---|---|---|
| A | Cu | 0.04 | 2.40 x $10^{-5}$ | 6 x $10^{-4}$ |
| | Pb | 0.0015 | 6.88 x $10^{-5}$ | 4.5 x $10^{-2}$ |
| B | Cu | 0.04 | 5.43 x $10^{-5}$ | 1.3 x $10^{-3}$ |
| | Pb | 0.0015 | | |
| C | Cu | 0.04 | 4.87 x $10^{-5}$ | 1.2 x $10^{-3}$ |
| | Pb | 0.0015 | 1.51 x $10^{-5}$ | 1x $10^{-2}$ |

## 3.3 Estimated THQ for Individual Metals and Total THQ from Consumption of Abelmoschus Esculentus Cultivated along River Ngadda

The THQ values for individual metals and total THQ from consumption (adult) of *Abelmoschus esculentus* cultivated along river Ngadda were presented below (Table 5)

As reveals from Table 5 THQ values of Pb was highest throughout the locations and the least THQ was recorded in Cu in all the locations cultivated along river Ngadda. The estimated THQ of each metal due to consumption of *Abelmoschus esculentus,* is less than 1, this implies that the exposed population (consumers) will not be at health risk from the intake of individual metals through consumption of these vegetable.

TABLE 6: Estimate THQ for individual metals and total THQ from consumption of some selected vegetable by the general populace base on locations along River Ngadda

| Locations | Vegetables | Cu | Pb | Cd | Zn | TTHQ |
|---|---|---|---|---|---|---|
| A | *Abelmoschus* | $7.08 \times 10^{-6}$ | $5.4 \times 10^{-4}$ | ND | ND | $5.47 \times 10^{-4}$ |
| B | *Abelmoschus* | $1.59 \times 10^{-5}$ | ND | ND | ND | |
| C | *Abelmoschus* | $1.43 \times 10^{-5}$ | $1.18 \times 10^{-4}$ | ND | ND | $1.33 \times 10^{-4}$ |

# 4. Discussion

## 4.1 Heavy Metals in Abelmoschus esculentus

It can be deduced that the result supports the hypothesis, that Cd, Pb, Cu and Zn concentration level in *Abelmoschus sp* fruit cultivated in the given locations proved to be higher than the standard limits stipulated by the Food and Agricultural Organization (FAO). These findings show the likelihood of the effects of persistence inflow of wastewater into the irrigation Water-Supply-River used for cultivation of the studied vegetables. Furthermore, the identified wastewater supplied points into the river over time are consistency recharged from aftermath of activities within the urban residential settlements. These activities are predominantly domestic chaos, abattoir, markets and other water-base municipal activities where large volume of water is used for cleaning up and sanitation. Consequently, their contaminated used water are therefore, continuously disposed through various channels which eventually flow into the river based on defend points. As this volume of contaminated water flow into the river particularly at a period when the highly season river resided, the remnant water became overwhelmed with the influx wastewater, thereby becomes polluted. Note, the longer period the wastewater is used for irrigating the vegetable, the higher is likely to be the concentration of the heavy metals queried in the garden soil which served as medium through which the vegetable absorbed. This could therefore be the reasons for the high mean values obtained.

The study is in consonant with [7 and 30] that reported similar findings on levels of the queried heavy metals in *Abelmoschus* cultivated with wastewater. [42] equally studied similarly situation. The study reveals the presence of heavy metal concentrations in spinach and okra (*Abelmoschus*), cultivated along river water in New Delhi. From the findings, it is evident that vegetable cultivated with wastewater are prone to infestation with heavy metals. Although 7; 31 and 42] reported high concentrations of heavy metals in vegetable, soil and water, However, this study established low levels of the heavy metals (Cu, Pb, and Zn), in the river, whilst in the vegetables, they are much high. Whereas, the Cd in the river was above World Health Organization (WHO) stipulated standard. According to [17] high levels of heavy metals in vegetables irrigated with polluted water in river were observed. In retrospect, it is highly likely that river or stream which is polluted with waste easily becomes enriched with heavy metals, thus polluting the soil and consequently, the crops irrigated with it. These assertions confirmed the findings of this study given the accumulation of the heavy metals in the *Abelmoschus* (okra) plant studied.

As reveals in the study, Cd and Zn were not detected in *Abelmoschus sp* fruit cultivated along the study site. However, [31;42and 17] reported their presences in vegetable cultivated along river in Delhi, India. These surface water bodies were known to suffer pollution through influx of wastewater from various activities in their municipalities. The variation in the findings may be attributed to the type of activities that generated the wastewater and the constituents of the wastewater. In Maiduguri urban, the activities that generate wastewater channel into river Ngadda are multifaceted, ranging from domestic chaos, animals slaughters in abattoir, and market sanitation. Whereas the wastewater generated as reported by the study reviewed, include among others, industrial and institutional waste. The waste constituents produced by these categories of institutions are not the same due to the products they process. As a result, the likely presence of heavy metals as pollutants if any might have been the reason for the non-detection along river Ngadda, Maiduguri.

The heavy metals studied generally, could either be essential and non-essential based on their environmental challenges. Cu and Zn for instance, are considered essential as they are necessary for the survival and growth of flora and fauna. However, could pose health challenges if consume above threshold quantity through any medium. Pb and Cd are non-essential for the survival and growth of flora and fauna. The presence of each, even in low concentration therefore, has the potentials of causing adverse health effects to human through consumption of contaminated food items [29]. A particular reference is the study by [26 ;8]who reported the tendency of health challenges such as the central and peripheral nervous system as well as kidney, liver and anemia as a result of consumption of Pb and Cu in food items. The result therefore indicates that, the presences of Pb and Cu in *Abelmoschus* cultivated along river Ngadda could be risky to consumers.

### 4.2 Heavy metals in soil obtained from Abelmoschus esculentus

The differences in the sampling locations/sites had no significant variation on mean of Cd, Cu, Zn and Pb concentration in the agricultural soil collected under *Abelmoschus esculentus.* The mean values for Cd and Zn statistically similar. There were relative strong positive correlations between Cu, Cd, and Zn, but Pb did not show significant correlations with these metals. This implies that they have different pollution source from the other metals. The heavy metal concentration in the agricultural soil are presented in Table 2 when compared with the soil standard limit Cu, Zn , Pb and Cd concentration were within the permissible limit. Relatively higher concentration of Cu,Zn, Pb Cd were reported by [46] in garden soil obtained from mining site in china which are higher than the standard. However in this study all the values recorded did not exceed the threshold limit. This result is in agreement with the finding of [7] who reveals that concentrations Cu, Cd, Pb and Zn in soil were below the standard. However, long term application of water polluted by indiscriminant dumping and disposal of solid waste, cottage industries, institutions, commercial, municipal and domestic wastewater at the study site (river Ngadda) will accounts for high level of metals polluting the river whose on the soil increase the heavy metal contents.

### 4.3 Metal Transfer from soil to vegetables (TF)

The TF values which is used to evaluates the heavy metal transfer capability from the soil to the edible parts of the vegetables was presented in Table 3.The accumulation factor (AF) for Pb, and Cu from the result obtained in location B reveals that there is a greater accumulation because the studied vegetable accumulation are greater than 1 while Zn and Cd were not detected. This implies that metals with a high transfer factor migrate to the edible part of the plant easier than do those with a low transfer factor [26]; this might be the reason of the metals concentration values in variety of the vegetables to such a high ratio. TFs for Cu ranges from 0.1 to 1.5 Cu are among the essential element which are needed for vegetable growth which the transfer capability from the soil to the edible part of the vegetables take place easily through the uptake of roots. Similar study by [9] reported higher transfer ability of Cu than Pb in shanghai, China. Cu in the present study appears to be with higher transfer capability than Pb The low Pb concentration in the fruit *Abelmuschus* may be because of anthropogenic activities as well as the low level of atmospheric Pb in the study area (Maiduguri). This study is contrary with most studies who reported that leafy vegetables are found to be with higher transfer factor among studied vegetables [47; 24]. This may be due to the differences in the climatic conditions and soil types of the study area. Similar study reported high transfer of Pb from soil to plant of two vegetables in Bangladesh.

The AF values varied for heavy metals in the various vegetables and locations. The AF values were revealed to be high throughout the studied metals from cultivated vegetables with polluted water from River Ngadda which may be among the reasons for human's health risks via their consumption. Although, Low concentration values for heavy metals were confirm in the soil. This means that the degree of uptake of heavy metals by the vegetable did not rise sequentially with increasing metal concentrations in the soil. This study is in agreement with the previous findings of [7; 36]. This fact is important to be worthy of attention in terms of long-term irrigation so that the same coherence would not be part of the food chain.

### 4.4 Estimated daily intake of metals and health risk index for consumption of vegetable along river Ngadda

Health risk assessments are used to quantify the most frequent and high exposures of metals that serve as a pathway to food chain which is of significant in cities like Maiduguri. The highest HRI values (>1) were observed in Pb, in the studied vegetable and the three locations perhaps might be due to the pollution of River Ngadda from anthropogenic activities such as waste disposal institutional, commercial, cottage industrial and domestic wastewater which remain unregulated. High Pb concentrations observed in the *Abelmoschus esculentus* may be attributed to their location. The main sources of this element to humans are inhalation of airborne Pb from vehicle emissions and from direct atmospheric deposition on soils, water, and crops, constituting the gateway into the food chain [6].This result is indicating a possible potential human health risk through the intake of vegetables. Whereas, Cu have a HRI < 1 probably this may be due to the high values of the reference dose but however the vegetable as reveal from the study have high concentration of Cu which is also of great concern while Zn and Cd HRI cannot be determine because were not detected in the vegetables samples. This study is in consonance with [7 ;47;21] who also reported a HRI value for Cd and Pb that are above the permissible limits in vegetables and cereals. Furthermore, the study is in deviation with the study of [21] who reported that leafy vegetables can accumulate higher level of metals and have potential risk than fruit vegetables. In this study, the exposure of Pb were higher in location B and A both in fruit vegetables which in is not in line with the aforementioned.

The route of exposure through food chain is one of the key pathways of heavy metal exposure to humans [32]. Maiduguri urban population like many other urban in Nigeria highly patronizes vegetables and relies on food grains as a staple food. The vegetables in the present study are consumed directly by the local or are sold in markets for public consumption. Moreover, Pb as non-essential heavy metals even presence in low concentration causes adverse health effects to human through the consumption of food items [47; 21; 29]. As reported in [8 and 26] that Pb and Cu affect the central and peripheral nervous system as well as kidney, liver and anemia. This shows that the findings of this study reveals the wide spread risk potentials of this heavy metals in the consumption population. This is attested in an article by Daily Trust (2018) reporting severe and prevalent problems of kidney and other related diseases among Maiduguri urban population.

### 4.5 Estimated THQ for individual metals and Total THQ from consumption Abelmoschus esculentus cultivated along river Ngadda

THQ was used in order to identify the risk related to consumption of *abelmuschus esculentus* contaminated with toxic heavy metals. The reason for the THQ values for all metal in all the three studied locations are below 1 this may be due to the values used for the formulas in the study were not made for Nigerians. Unfortunately Nigeria has no standard values for Reference dose, average daily intake of metals, conversion factor and average body weight. The study used the international standard which might be the reason for recording less than 1 value. This means that the intake of these vegetable contaminated by heavy metals did not result a significant health hazard, by the consumer. This result is in consonant with the finding of [3; 47;11 and 43] who reported THQ values less than 1.

Despite this THQ values, however the results obtained in this study from the individual vegetable were above this limit and suggested possible metal contamination through the consumption of *abelmuschus esculentus (*okra). Base on the THQ values, the continues consumption of Pb present in vegetables has the potential of posing health risk to the local population. This is confirmed with the assertion of [18] that the ingested of which ever dose of heavy metals is not equal to the absorbed pollutant dose in reality because a fraction of the ingested heavy metals may be excreted, with the remainder being accumulated in body tissues where they can affect human health. Although the present study reveals a THQ value less than1, the result indicating a high level of Pb in the vegetable in all the locations is alarming. This may not be unconnected with the facts that cause of Kidney disease in Maiduguri may likely be as a result of Pb because as reported in some literatures, even presence of low concentration of Pb can cause adverse health effects to human via the consumption of food items (47;21;29). With this assertion, it might be justified that the metal contaminated vegetable is among the contributors of health challenges in the study area (Maiduguri).

## 5. Conclusion

Irrigation with contaminated water with heavy metals poses threat to human beings. Slow exposure of humans to poisoning by heavy metals due to the indiscriminant disposal of wastewater into the river Ngadda that contaminates the vegetable grown with irrigation by contaminated water sources were evident. With this therefore, Abelmoschus esculentus in Maiduguri from River Ngadda is risky for human consumption which might be justified that the metal contaminated vegetable is among the contributors of health challenges in the study area (Maiduguri).

## 6. Reference


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