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Evaluation of the Potential Hazard of Consuming *Allium Cepa* (Onion) Cultivated On Farmlands Along Hunkuyi-Zaria Road Kaduna State Nigeria

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Abstract: ***Heavy metal contamination of Allium cepa (onion) cultivated along Hunkiyi-Zaria Kaduna state, Nigeria was determined using standard procedure for the analysis of these metals by Atomic Absorption Spectrometry (AAS) Shimadzu 6800. Metal concentrations were determined in both dry and wet season. The average values for copper, lead, cadmium, zinc, and chromium during dry season were, 1.5, 66.3, 0.7, 89.8 and 12.2 mg/kg respectively. For wet season, the values were 1.7, 120.3, 0.7, 81.9 and 13.4 mg/kg for copper, lead, cadmium, zinc and chromim respectively. With the exception of copper and zinc which have 73.3 and 99.4 mg/kg as their World Health Organization(WHO) permissible limits, these average values were higher than WHO permissible limits of 0.3, 0.2, and 2.3 mg/kg for lead, cadmium, and chromium respectively in vegetables. Target Hazard Quotient (THQ) for each element across the two seasons was above 1.00 except for copper in dry season and chromium in both seasons.***

Keywords: Heavy metals, Target Hazard Quotient, *Allium cepa* and Estimated daily intake

1. Introduction

Vegetables (including *Alliumcepa*) are common diets consumed by most human populations due to their rich vitamin, fibre and anti-oxidant content (Mohammed and Khamis, 2012). When vegetables are cultivated on contaminated soils, they tend to take up heavy metals in quantities large enough to cause health problems to their consumers (Sprynskyy *et al*., 2007). The absorption of heavy metals by plants is one of the main routes of entrance into the food chain (Jorda *et al*., 2006). Uptake of heavy metals by plants and subsequent accumulation along the food chain is a potential threat to animal and human health (Sprynskyy *et al*., 2007).

Heavy metals are potentially toxic. Their accumulations in plants depend upon plant species. Plant uptake or soil to plant transfer factors could be used to evaluate the efficiency of different plants in absorbing metals (Khan *et al*., 2008). The phytotoxicity for plants may lead to chlorosis, weak plant growth and yield depression. Also there may be reduction in nutrient uptake; disorders in plant metabolism and reduced ability to fixate molecular nitrogen in leguminous plants (Gray et al., 1999). The samples used in this study were obtained from farmlands in Kudan Local Government Area of Kaduna state. Gas emissions from the exhaust of traffic plying that road could probably be the route through which heavy metals infiltrate the soil. The aim of this work was to determine the potential hazard of consuming *Allium cepa* (onion) cultivated on farmlands along Hunkuyi-Zaria road Kaduna State, Nigeria.

2. Experimental

2.1 Sampling site

The research was conducted on the irrigated *Allium cepa* (onion) obtained from farms along Hunkuyi-Zaria road. The study area is located in Kudan Local Government Area of Kaduna State Nigeria, covering an area extending between latitude 11°06´N and 11°22´N and longitude 7°25´E and 7°55´E (Figure1). The sampling sites were some farmlands located along Hunkuyi-Zaria road as shown in figure 2.

2.2 Collection, preservation and preparation of sample

Samples were collected twice in the year 2012 from three different farms: 1, 2 and 3. The first round of sampling was carried out in March towards the end of the dry season while the second round was in September at the peak of the rainy season. Fresh matured *Allium cepa* (onion) was randomly handpicked from farms: 1, 2 and 3 each during dry and wet seasons.

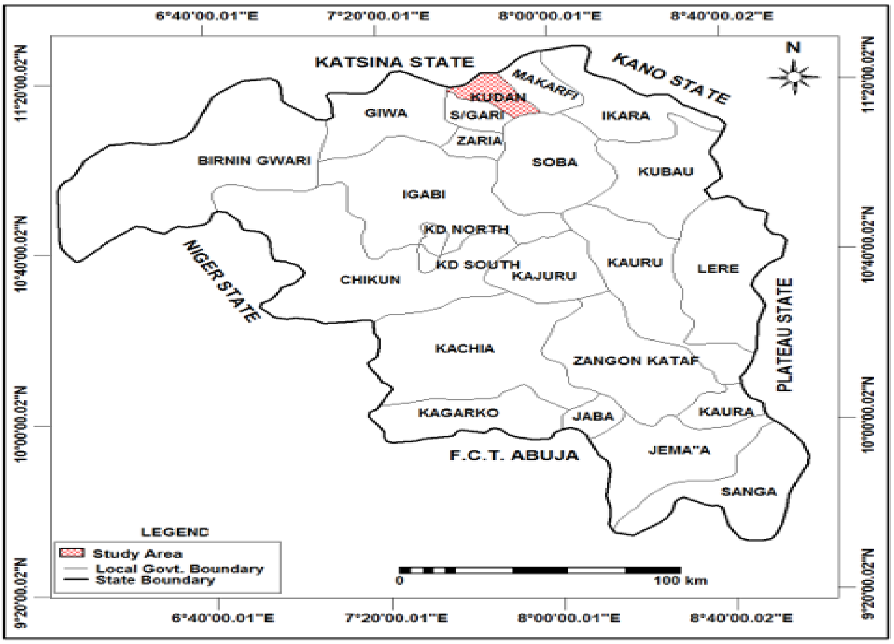

Figure 1: Map of Kaduna state showing Kudan Local Government Area.

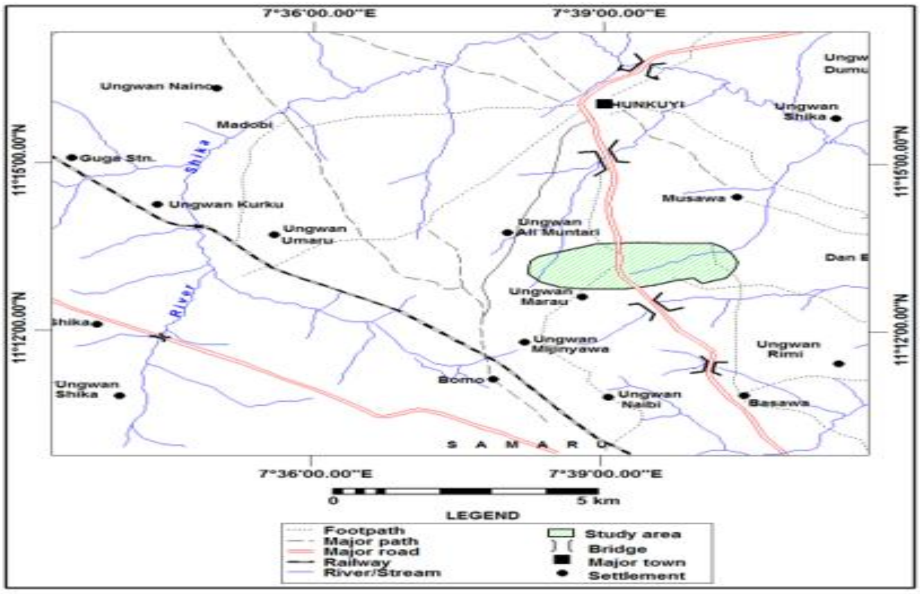

Figure 2: Map of Kudan Local Government area showing the sampling site

All the washed samples were dried in an oven at 80°C. Exactly 2g of each of the cooled grounded sample was weighed out into a Kjeadahl flask mixed with $20cm^3$ of concentrated perchloric acid and concentrated nitric acid in the ratio 1: 4 by volume respectively and left to stand overnight. Thereafter, the flask was heated at 70°C for about 40 min; the temperature was increased to 120°C for about 20 min. The mixture turned black after a while. The digestion was completed when the solution became clear and the appearance of white fumes. The digest was diluted with $20cm^3$ of distilled water and boiled for 15 min. This was allowed to cool, transferred into 100 cm^3 volumetric flasks and diluted to the calibrated of the volumetric flask with distilled water. The sample solution was filtered through a filter paper into a screw capped polyethylene bottle (Erwin and lvo, 1992; Larry and Morgan, 1986).

2.3 Statistical Analysis

Data collected were subjected to statistical test of significance using Independent t-test, and Pearson products moment correlation coefficient. According to Addo *et al.*, (2012) equation (2), estimated daily metal intake from onion was determined as shown below;

$$\mathbf{EDI = C_{metal} \times DAC \times C_{factor} / (Bw)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where C_{metal} (mg/kg) is the concentration of heavy metals in the contaminated sample; DAC (kg/day) represents the daily average consumption of onion; C_{factor} is the conversion factor = 0.085. BW is the body weight.

Target Hazard Quotient (THQ) was computed using equation (3).

$$THQ = [W_{plant}] \times [M_{plant}] / RfD \times Bo …………… (3)$$

Where $[W_{plant}]$ is the daily intake of vegetables (kg per day of fresh weight), $[M_{plant}]$ is the concentration of metal in the vegetable (mg kg^{-1}). RfD is the oral reference dose for the metal (mg/kg body weight per day), and Bw is the human body mass (kg).

3. Results

3.1 Concentration of metals in the edible *Allium cepa (onion)* tissues

The mean concentrations of Copper, Lead, Cadmium, Zinc and Chromium in samples of edible *Allium cepa* tissues from the three established sampling stations of the two seasons are presented Figure 3 below.

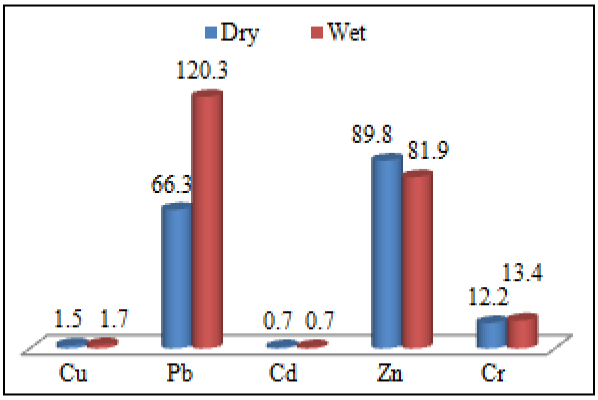

Figure 3: Seasonal concentration of (mg/kg) of *Allium cepa* (onion)

3.2 Estimated daily intake

Table 1: Estimated daily metal intake (mg/kg bw. /day) across the farms during dry season

Element	Copper	Lead	Cadmium	Zinc	Chromium
Farm 1	0.00063	0.0054	0.00019	0.047	0.0087
Farm 2	0.00068	0.023	0.00054	0.0054	0.0054
Farm 3	0.00083	0.64	0.00034	0.0037	0.0037
Average	0.00071	0.031	0.00036	0.019	0.0059
RDI(mg/ day)	0.900	0.00	0.00	11 (8)	0.003-1.5

Figures in brackets indicate the Recommended Daily Intake (RDI) for females

Table 2: Estimated daily metal intake (mg/kg b.w. /day) across the farms during wet season

Element	Copper	Lead	Cadmium	Zinc	Chromium
Farm 1	0.00097	0.051	0.00019	0.042	0.0087
Farm 2	0.0011	0.053	0.00053	0.031	0.011
Farm 3	0.00043	0.072	0.00034	0.046	0.0067
Average	0.00083	0.059	0.00035	0.040	0.0088
RDI(mg/ day)	0.900	0.00	0.00	11.0(8.0)	0.003-1.5

Figure in brackets indicate the Recommended Daily Intake (RDI) for females

Table 3: Target hazard quotient (thq) of metals in the onion during dry season

Element	Copper	Lead	Cadmium	Zinc	Chromium
Farm 1	0.19	18.12	2.29	1.89	0.0678
Farm 2	0.20	92.90	6.29	1.50	0.0426
Farm 3	0.24	213.55	4.00	1.79	0.0289
Average	0.21	108.19	4.19	1.71	0.046

Table 4: Target hazard quotient (thq) of metals in the onion during wet season

Element	Copper	Lead	Cadmium	Zinc	Chromium
Farm 1	0.29	171.76	2.29	1.66	0.07
Farm 2	3.14	176.33	6.29	1.23	0.08
Farm 3	0.13	241.31	4.00	1.79	0.05
Average	2.04	196.46	4.19	1.56	0.07

4. Discussion

4.1 Concentration of metals in the edible *Allium cepa (onion)* tissues

The concentration of metals in the sample (Figure 1) were significantly high above the value recommended by Food and Agriculture Organization/World Health Organization, FAO/WHO (2001) except for Cu and Zn which were below the maximum recommended limit of 73.3 and 99.4 mg/kg respectively. In general, the extent of Pb, Cd and Cr contamination in the vegetable crops are of great concern as this may pose health risk to man (WHO, 2001). High concentration of metals observed in the sample could be as a result of high traffic density along that road (Udiba et al, 2015). This is in agreement with the results of Abechi *et al*., (2010) and Ibrahim and Jaal (2013).

On the other hand, there were reductions in the metal levels (except for Pb and Cr) in the sample collected during rainy season as shown in Figure 1. This could be consequently, the effect in the use of irrigation water or increase in water volume which reduces the concentrations of the metals available for plant uptake. Also, it could be as result of leaching away of some parts of the metals accumulated in the soil resulting in the reduction of the quantity of the metals available to plant in the soil (Lawal and Audu 2011). Hence, negative value recorded for the percentage loss of metal in rainy season samples over the dry season (Figure 1) samples could be attributed to the possibility of runoffs from the surrounding land containing metal salts being washed into the farmlands (Gray *et al.*, 1999; Lawal and Audu, 2011).

From the independent t-test analysis of the metal concentrations between the two seasons, the difference in Cu, Pb, Zn, Cd and Cr levels of *Allium cepa* between dry and wet season was not statistically significant ($p>0.05$). According to the Pearson products moment correlation coefficient, analysis on the metal concentrations of the sample to establish the relationships among the metal concentrations, positive Correlation was observed between Cu and Cd ($r=0.239$); Cu and Zn ($r =0.600$); Pb and Cd ($r= 0.239$); Cd and Cr ($r= 0.598$); Cd and Zn($r=0.429$). The positive correlation observed between these elements indicates that increase in one elemental content of edible *Allium cepa* tissues brings about increase in the other and vice versa. It also shows that the same source is responsible for their presence at the concentrations determined.

On the other hand, negative correlation was observed between Cu and Pb ($r= -0.029$); Pd and Zn ($r= -0.314$); Pb and Cr ($r= -0.598$). There was no correlation between Cd and Zn. Negative correlation observed among the identified heavy metals showed increase in one metal contained in

Allium cepa tissues which invariably, showed decrease in another metal.

4.2 Estimated Daily Intake (EDI)

The estimated daily intake (EDI) of heavy metals is widely used to describe safe levels of metallic intake through food consumed (Mohammed and Khamis, 2012). Also, it combines data on the levels ofheavy metals in foodstuff with quantities of food consumed on the daily basis (Jorda *et al.*, 2006). In this study, the average seasonal daily copper, lead cadmium, zinc and chromium intake for people living in Hunkuyi Zaria and its environs through the consumption of *Allium cepa* cultivated along Hunkuyi road were estimated and compared with the recommended daily intakes/or allowances (RDI) as shown in tables 1 and 2 respectively. The average values of the estimated daily intake for lead and cadmium were 0.031 and 0.00036 mg/ day in dry season. These were above the value for RDI 0.00 for Pb and Cd. Likewise, during wet season, the estimated daily intake for lead and cadmium were 0.059 and 0.00035 mg/ day. They were also higher than the recommended daily intake. Copper, zinc and chromium values were below the RDI values for both seasons as shown in Table 1 and 2.

4.3 Target Hazard Quotients (THQ)

THQ is the ratio between exposure and the reference oral dose (RfD). If the THQ is less than one, there is no obvious risk. THQ-based risk assessment method indeed provides an indication of the risk level due to exposure to pollutants (Udiba et al, 2015). The average THQs for Pb, Cd, and Zn across the study area were all above 1.00 for both wet and dry seasons. While THQ for Cr was less than 1.00 for both seasons. THQ for Cu was less than 1.00 and above 1.00 during dry and wet season respectively. See Tables 3 and 4 results respectively. THQ-based risk assessment in this study thus indicates that, the consumption of *Allium cepa* from the study area poses serious toxicological risk with respect to lead intoxication irrespective of the season (WHO, 2001).

5. Conclusion

Alliumcepa planted in farmlands neighboring busy roads has been found to contain heavy metals in both dry and rainy seasons. The concentration of heavy metals presence in analyzed *Allium cepa* exceeded the standard permissible limit recommended by WHO. This implies that there is danger of growing vegetable crops on farmlands nearby the road. This could also be applicable to other major roads. This is because of release of pollutants from moving vehicles which will settle on land and will eventually be absorbed by the soil. Also, use of inorganic or chemical fertilizers on farmlands to enrich the soil nutrients would increase the level of heavy metal concentrations. This is in agreement with elevated levels of Pb, Cr and Cd in *Allium cepa* obtained in this study which is above the recommended standard limits. The study showed that abundant concentration of heavy metals especially Pb, Cr and Cd could be directly related to the amount in the environment. Consumption of contaminated *Allium cepa* may lead to severe health implications in the body. Thus, from the results of this investigation, it could be concluded that in the vicinity of the farmlands by Hunkuyi - Zaria road, the uptake of these heavy metals by the vegetable crops may increase especially during dry season. Further research is required to assess other sources of these heavy metals as well as situate mitigating measures to reduce these contaminants to the barest minimum.

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