International Journal of Biological Sciences and Applications
2015; 2(6): 76-85
Published online November 30, 2015 (http://www.aascit.org/journal/ijbsa)
ISSN: 2375-3811

American Association for Science and Technology

Keywords
River Galma,
Effluent,
Onion Bulbs,
Metals,
Toxicological Risk

Received: October 7, 2015
Revised: October 30, 2015
Accepted: November 1, 2015

Toxicity Potential of *Allium cepa L.* as a Bioindicator of Heavy Metal Pollution Status of River Galma Basin Around Dakace Industrial Layout, Zaria, Nigeria

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Citation
Udiba U. U., Anyanwu Stella, Gauje Balli, Dawaki S. I., Oddy-Obi I. C., Agboun T. D. T. Toxicity Potential of *Allium cepa L.* as a Bioindicator of Heavy Metal Pollution Status of River Galma Basin Around Dakace Industrial Layout, Zaria, Nigeria. *International Journal of Biological Sciences and Applications*. Vol. 2, No. 6, 2015, pp. 76-85.

Abstract
River Galma is the main drainage channel in Zaria, Nigeria. Effluents from Dakace industrial layout are discharged through drains and canal that empties into the river and the basin is a booming agricultural area. Concentrations of lead, chromium, nickel and manganese were investigated in onion (*Allium cepa L.*) bulbs cultivated along the river basin around Dakace industrial area using Shimadzu atomic absorption spectrophotometer (model AA-6800, Japan) after wet digestion. The overall mean concentrations of the metals were: 1.11±0.8 mg/kg for Lead, 1.51±0.9 mg/kg for chromium, 3.28±1.76 mg/kg for nickel and 1.68±2.72 mg/kg for manganese. Lead and chromium concentrations were found to be above WHO/FAO permissible levels. Average values of Estimated Daily Intakes (EDI) were higher compared to Recommended Daily Intakes (RDI) and Upper Tolerable Daily Intakes (UL) for the metals. Target Hazard Quotient (THQ) computed to estimate the risk to human health pose by each metal were within the safe limit of unity, lead (Pb) being the only exception. Hazard Index (HI) used to evaluate the potential risk to human health due to the combined effect of the four heavy metals was 2.83. The relative contributions of Pd, Cr, Ni, and Mn to the aggregated risk were 64.18%, 0.21%, 33.33% and 2.41% respectively. Consumption of onion bulbs from the study area thus poses a serious toxicological risk. The study concludes that uptake and subsequent accumulation of these metals in onions bulbs which is a measure of the degree of bioavailability of the toxic metals in the growth media indicates that River Galma basin is polluted.

1. Introduction

Urbanization and industrialization have contributed immensely to the large scale pollution currently observed in most Nigerian cities notably those swarming with industries viz., Lagos, Ibadan, Kano and Kaduna (Ekiye and Luo 2010). There are no incentives for implementing pollution reduction measures. Wastes are disposed indiscriminately especially from small and medium scale industries. The insufficient information available on pollution matters also poses a serious hindrance to pollution management directly or remotely. Thus, in addition to treatment of wastewater before disposal, appraisal of water resources and agricultural lands could offer proficient information to indicate areas of major concern. This would prove useful in detection of imminent threats to inhabitants and environmental health (Ekiye and Luo, 2010).

Rapid industrialization and urbanization with insufficient environmental monitoring and planning have actually lead to the discharge of industrial waste and sewage into rivers and lakes which in turn have lead to gradual pollution of our water resources. Many times such wastewater is drained to the agricultural land where they are used for irrigating crops including vegetables. Many farmers in areas closer to urban localities are often compelled to use waste water to irrigate their crops, due to absence of better alternatives (Ghimire, 1994). Polluted effluent has been found to be rich not only in organic matter and nutrients but also in heavy metals that eventually reach the soil of agricultural area (Smith *et al.*, 1996). The uncontrolled input of heavy metals in soils is an undesirable one because once in the soil, they are generally very difficult to remove (Smith *et al.,* 1996). Subsequent problems may be toxicity to the plant growing on the contaminated soil and uptake by the plants resulting in high metals levels in plant tissues which may leads to food chain contamination (Ward *et al.*, 1995). Heavy metal contamination in agricultural soils from wastewater irrigation is therefore of earnest concern due to its implications on human health. Accumulation of heavy metals by plants may depend on a number of factors such as: plant species, age of plant, soil chemistry and the chemical form of the metal discharged.

The total concentration of a given metal in soil provides a useful and easier way of stating clearly, pollution due to the metal. Studies have shown that this method of evaluation is not good enough in predicting the toxicity of the metal pollutant (Yusuf, 2006). The chemical form of the metal is of great importance in determining its potential bioavailability and remobilization from the soil to the other components of the ecosystem such as water, plants and animals when physic-conditions are favourable. Generally, ecological exposure to a metallic pollutant occurs when the metal reaches an organism and is in the form that is bioavailable. The lower the bioavailability the lower the risk posed by the metal. In the absence of bioavailability, there is no exposure and the metal in question will essentially pose no risk to the organism (Suter, 1993). In this study uptake and subsequent accumulation of lead, chromium, nickel and manganese in onions (*Allium cepa L.*) bulbs was used as a measure of the degree of bioavailability of the toxic metals in River Galma basin bearing in mind however, that the degree of bioavailability differs among species and can change under different environmental conditions. The study also assessed the toxicity potential of the food and spice crop.

Vegetables exercise important role in meeting the food requirements of people world-wide, because they are a very important source of various essential components of food (Ogle *et al.*, 2001; Mukerji, 2004). They are sources of vitamins, minerals, and fibers in abundance and also have beneficial anti-oxidative effects. Vegetables are also potential source of essential nutrients which constitutes functional food components thereby providing protein, iron and calcium which have noticeable health effects (Arai, 2002). However, intakes of heavy metal-contaminated vegetables have the possibility of posing risk to the human health. This is because, heavy metals have the ability to accumulate in living organisms and at elevated levels they can be toxic. It has been reported that prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of the metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (Trichopoulos,1997; Jarup, 2003).

Allium plants are known as a source of many different sulphuric compounds, which have similar metabolic pathway with phytochelatins and cysteine as a basic precursor of phytochelatin, thiosulfinate and sulphoxide synthesis (Block *et al*., 1992; Lancaster and Shaw 1989; Murasugi *et al.*, 1981). Also, several Allium species are food and spice crops hence knowledge on their heavy metal uptake as well as evaluation of the potential risks in the food chains should be of a major concern. Jiang *et al*., 2001 reported hyperaccumulation of cadmium by hydroponically cultivated *Allium sativum.* Onions and garlics are staple ingredients in cooking and their health benefits have been touted from centuries. Onions have been used in folk medicine for the relief of coughs, colds and catarrh, especially asthma, but more recently some of their curative properties have been attributed to a compound called allyl propyl disulphide, which is thought to have a similar effect to insulin in balancing blood sugar levels (Jo-Lewin, 2015). Onions prefer loose, well-drained soils that are high in fertility, slightly acidic, adequately irrigated and exposed to full sunlight.

2. Materials and Methods

2.1. Sampling Area

Zaria, a city in Kaduna State, Northern Nigeria is located at latitude 11º3'N and longitude 7º40'E. The city is about 128 km South- East of Kano and 64 km North-East of Kaduna, the State capital (Nnaji et al., 2011). River Galma is the main drainage channel in Zaria since other rivers and streams discharge into it. The river is located at the southeastern part of Zaria and its source is the Jos Plateau. The Zaria dam is located on River Galma (Nnaji et al 2007). Dakace industrial area habours a number of wet industries such as oil mills, packaging, food and beverages industries. Effluents from these industries are discharged through drains and canal that empties into the River. The Galma river basin is a booming agricultural area. Crops are planted on both sides of the river bank throughout the year. The river is a major source of water supply to a number of communities located along its course. It is used for irrigation, fishing, bathing and even drinking. The river carries water throughout the year with its peak discharge in the month of July or August and least discharge in March or April (Thorp, 1970). The geology of the study area is basement of complex rock composed mainly of fine grain gneisses and migmatite with some coarse-grained granite outcrop in few places. The gneisses are moderately to weakly floated, primarily made up of quartz and oligoclase, depth of weathering is regular but thorough, the depth ranges from 10 meters to deep pocket, occasionally extending to about 60 meter. Due to poor conservation and land use practice like extensive vegetation clearance for agricultural and urban development purposes, intensive grazing, livestock tracks and human foot paths criss-crossing the area, overland flow, rilling and gullying have become the dominant mode of rain water disposal from the landscape.(Ologe, 1971; Bello, 1973; and Iguisi, 1996). The catchment area lies in the natural vegetation zone known as the Northern Guinea Savannah. Unfortunately, this characteristic vegetation cover is hardly preserved due to urbanization and other anthropogenic activities and poor management practices, like cultivation, intensive grazing, fuel wood harvesting and annual bush burning (Ologe, 1971).

Rainfed agriculture and irrigation are the two major forms of agricultural activities practice in the Galma catchment. The rainfed agriculture is a rainy season activity which takes place on the upland fields.

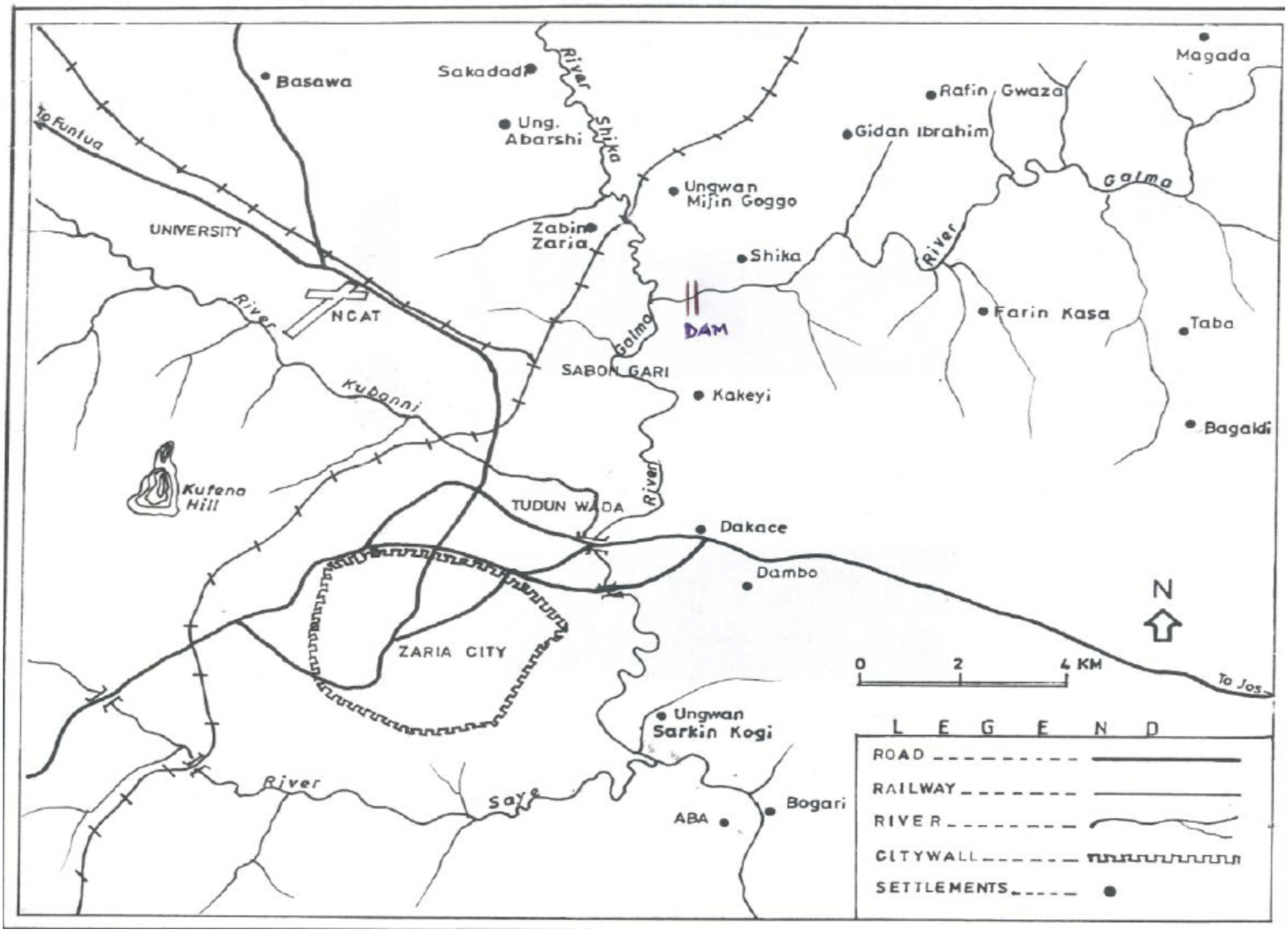

Fig. 1. *Zaria showing Rivers and Settlements (Nnaji et al., 2007).*

2.2. Collection, Preservation and Preparation Samples

Procedure for sample collection, preservation and preparation was adopted from Abida (2009). Four sampling stations were established along Galma River basin around Dakace industrial layout after identifying effluent discharge points (point sources) from the industries. Sampling station A was 500 meters upstream of the industrial layout (control). Sampling station B was at the first identified point source in industrial layout. Sampling station C was after the second and third identified effluent discharge points about 200 meters from sampling station B. Sampling station D was 200 meters from sampling station C. Matured Onions bulbs were harvested from three different points in farms around each of the four established sampling stations. The harvested crops were stored in black polythene bags and transported to the environmental laboratory of National Research Institute for Chemical Technology (NARICT), Zaria, Nigeria. The onions bulbs from each sampling station were thoroughly washed so as to remove all adhered soil, cut into pieces and air dried for 5 days in the laboratory. The dried samples were pulverized, passed through 1 mm sieve and digested. The digestion of 1 g was carried out using 5 ml of concentrated nitric acid according to Awofolu (2005).

2.3. Sample Analysis

Metal concentration in the digests was determined by Atomic Absorption Spectrophotometry, using shemadzu Atomic Absorption Spectrophotometer (model AA-6800, Japan) equipped with Zeaman background correction and graphite furnace at National Research Institute for Chemical Technology (NARICT), Zaria-Nigeria. The calibration curve was prepared by running different concentrations of standard solutions. The instrument was set to zero by running the respective reagent blanks. Average values of three replicates were taken for each determination and were subjected to statistical analysis

2.4. Analytical Quality Assurance

In order to check the reliability of the analytical methods employed for metal determination, one blank and combine standards were run with every batch to detect background contamination and monitor consistency between batches. The result of the analysis was validated by digesting and analyzing Standard Reference Materials, Lichen coded IAEA-336 following the same procedure. The analyzed values and the certified reference values of the elements determined were compared to ascertain the reliability of the analytical method employed. The reagent used for sample preservation and digestion, viz. nitric acid, perchloric acid and hydrofluoric acid (Riedel-deHaën, Germany), were of analytical grade.

2.5. Statistical Analysis

Data collected were subjected to statistical test of significance using the Analysis of Variance (ANOVA) test to assess significant variation in metal levels across the three sampling points within the study area. Independent t-test was used to compare metal levels between the study area and the control. Pearson products moment correlation coefficient was used to determine the level of association between metals in the study. The three statistical analyses (ANOVA, t- test and correlation) were done by SPSS software 17.0 for windows.

The estimated daily metals intake from onions bulbs in this study was determined according to Addo *et al*., (2012) following equation (1)

$$EDI = \frac{CHM \times DAC}{BW} \quad (1)$$

Where CHM (mg/kg, on fresh weight basis) is the concentration of heavy metals in contaminated onions bulb; DAC represents the daily average consumption of onions; and BW is the body weight. The DAC (400g) for this study was taken from Sharma *et al*., (2009) as 400g. An adult's average body weight of 70kg was used for the EDI evaluation.

An estimate of the potential hazard to human health (Target Hazard Quotient- THQ) through consumption of onions grown along River Galma basin around Dakace industrial area was computed using equation (2).

$$\text{THQ} = \frac{(Div)\times Cmetal}{RfD \times Bo} \quad (2)$$

Where *(Div)* is the daily intake of vegetables (kg per day), (Cmetal) is the concentration of metal in the vegetable (mg kg–1), RfD is the oral reference dose for the metal (mg kg–1 of body weight per day), and Bo is the human body mass (kg). RfD is an estimate of a daily oral exposure for the human population, which does not cause deleterious effects during a lifetime. The methodology for estimation of target hazard quotients (THQ) was adopted from *USEPA Region III Risk-Based Concentration Table, January–June 1996 cited in Q*uerra *et al*., (2012). Values of RfD for Cr (1.5 mg kg–1 per day), Ni (0.02 mg kg–1 per day) and Mn (0.14 mgkg-1) were taken from Integrated Risk Information System (US EPA, 2010). The value of RfD for Pb (0.0035 mg kg–1 per day) was taken from WHO (1993). The average Bo was taken as 70 kg for adults (WHO, 1993).

The hazard index (HI) was computed as the sum of the Target Hazard Quotients of the heavy metals under study (US EPA, 1989, Querra *et al*., 2012) as described in Equation (3)

$$\text{HI} = \Sigma\ \text{THQ} = \text{THQ}_{Pb} + \text{THQ}_{Cr} + \text{THQ}_{Ni} + \text{THQ}_{Mn} \quad (3)$$

3. Results

To evaluate the accuracy and precision of the analytical procedure employed, standard reference material of Lichen coded IAEA - 336 was analyzed in like manner to our samples. The analyzed values and the certified reference values of the elements determined were very close (Table 1), suggesting the reliability of the method employed.

Table 1. *Results of analysis of reference material (Lichen IAEA -336) compared to the certified reference value (mg/kg).*

Element (mg/kg)	Pb	Cd	Cu	Mn	Ni
A Value	5.25	0.140	4.00	55.78	1.20
R value	4.2-5.5	0.1-2.34	3.1- 4.1	56-70	1.00 – 1.40

A Value = Analyzed value R Value = Reference value.

Results obtained from the determination of lead, chromium, manganese and nickel content of onions bulbs (*Allium cepa L.)* from the four established sampling stations are presented in Table 2. while the spatial distribution of the Average metal concentrations of onions bulbs across the different sampling stations in the study area is shown in Figure 2, 3, 4, and 5.

Result obtained from the determination of metal content of onion bulbs across the different sampling points along River Galma Basin, Zaria and the control River Kubanni basin, Zaria, Nigeria (Table 2, Figure 2) indicates that the order of detection of lead in onion bulbs along River Galma basin was; Sampling Station 3 > Sampling Station 2 > Sampling Station 1. The concentration ranged from 0.78 mg/kg – 1.54 mg/kg. The lowest concentration (0.78 mg/kg) was recorded in Sampling Station 1 in the month of November and the highest concentration (1.54 mg/kg) in Sampling Station 3 in January. The mean lead levels of onion bulbs from River Galma basin increased with increasing distance downstream throughout the sampling period. Statistical analysis shows that the difference in lead levels of onions bulbs across the sampling stations were not statistically significant (ANOVA, $p > 0.05$). The overall mean lead levels of onions bulbs from River Galma basin (Study area) was found to be 1.11±0.8 mg/kg while the average lead level of onions bulbs from River Kubanni basin (control) was 0.53±06 mg/kg. The difference in lead levels of onions bulbs between the study area and the control was found to be statistically significant ($P < 0.05$), with the average lead levels of onion bulbs from the study area being significantly higher than the control.

Table 2. *Metal Contents of onions bulbs from River Galma Basin around Dakace Industrial Area, Zaria, Nigeria (mg/kg).*

Element	Sampling Month	Sampling Station 1	Sampling Station 2	Sampling Station 3	River Kubanni (Control)
Lead	Nov.	0.78	0.99	1.08	0.48
	Dec.	0.97	1.11	1.31	0.55
	Jan.	1.01	1.17	1.54	0.58
	Mean ± SD	0.92±0.12	1.09±0.09	1.31±0.23	0.54±0.05
Chromium	Nov.	0.92	1.21	1.22	0.54
	Dec.	1.26	1.28	1.28	0.68
	Jan.	1.91	1.98	2.56	0.74
	Mean ± SD	1.36±0.50	1.49±0.43	1.69±0.76	0.65±
Nickel	Nov.	1.78	2.41	2.12	0.31
	Dec.	2.64	3.21	3.21	0.38
	Jan.	2.97	4.11	7.03	0.41
	Mean ± SD	2.46±0.61	3.24±0.49	4.12±1.62	0.37±0.12
Manganese	Nov.	1.01	2.83	0.23	0.44
	Dec.	1.21	1.98	0.24	0.54
	Jan.	1.71	2.83	3.04	0.68
	Mean ± SD	1.31±0.36	2.55±0.49	1.17±1.62	0.55±0.12

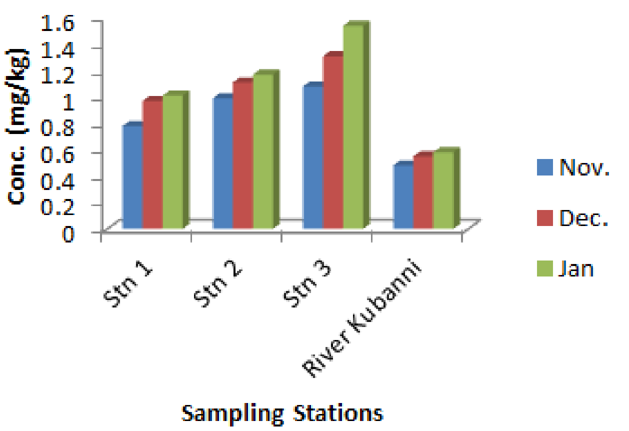

Fig. 2. *Spatial distributions of lead concentration in edible tissues of Allium cepa L across sampling stations.*

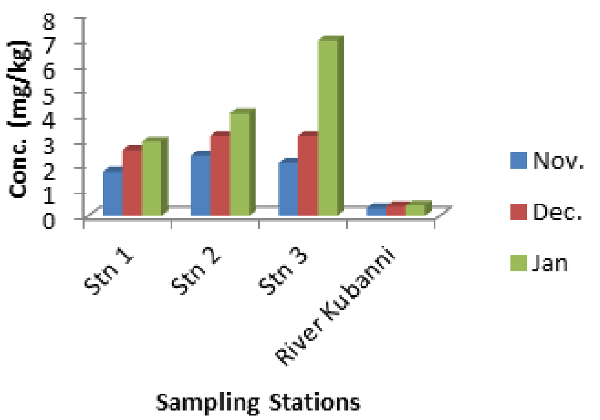

Fig. 4. *Spatial distributions of Nickel concentration in edible tissues of Allium cepa L across sampling stations.*

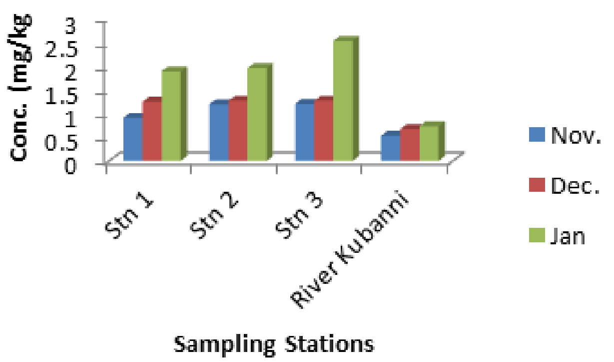

Fig. 3. *Spatial distributions of Chromium concentration in edible tissues of Allium cepa L across sampling stations.*

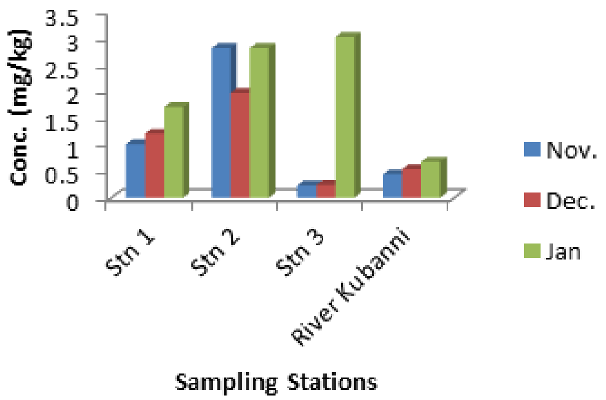

Fig. 5. *Spatial distributions of Manganese concentration in edible tissues of Allium cepa L across sampling statio.*

Table 2 shows that chromium concentration followed the order: Sampling Station 3 > Sampling Station 2 > Sampling Station 1. The concentration ranged between 0.92 mg/kg – 2.56 mg/kg. The lowest concentration (0.92 mg/kg) was recorded in Sampling Station 1 in the month of November and the highest concentration (2.56 mg/kg) in Sampling Station 3 in January. The mean chromium levels of onion bulbs from River Galma basin also increased with increasing distance downstream throughout the sampling period. Statistical analysis shows that the difference in chromium levels in onion bulbs across the sampling stations were not statistically significant (ANOVA, $p > 0.05$). The overall mean chromium levels of onion bulbs from River Galma basin (Study area) was found to be 1.51±0.9 mg/kg while the average chromium level of onion bulbs from River Kubanni basin (control) was 0.65±06 mg/kg. The difference in chromium levels in onion bulbs between the study area and the control was found to be statistically significant ($P < 0.05$), with the average chromium levels of onion bulbs from the study area being significantly higher than the control.

Nickel concentrations obtained from the determination of metal content of onion bulbs from the different sampling points along River Galma Basin, Zaria and the control River Kubanni basin, Zaria, Nigeria (Table 2, Figure 4) followed the trend: Sampling Station 3 > Sampling Station 2 > Sampling Station 1. The concentration ranged between 1.78 mg/kg – 7.03 mg/kg. The lowest concentration (1.73 mg/kg) was recorded in Sampling Station 1 in the month of November and the highest concentration (7.03 mg/kg) in Sampling Station 3 in January. The mean nickel levels of onion bulbs from River Galma basin also increased with increasing distance downstream throughout the sampling period. Statistical analysis shows that the difference in nickel levels of edible onions tissues from the sampling stations were not statistically significant (ANOVA, $p > 0.05$). The overall mean nickel levels of onion bulbs from River Galma basin (Study area) was found to be 3.28±1.76 mg/kg while the average nickel level of edible onions tissues from River Kubanni basin (control) was 0.37±01 mg/kg. The difference in nickel levels of onion bulbs between the study area and the control was found to be statistically significant ($P < 0.05$), with the average nickel levels of onion bulbs from the study area being significantly higher than the control.

Manganese concentration (Table 2, Figure 5) of onion bulbs from the study area followed the sequence: Sampling Station 2 > Sampling Station 3 > Sampling Station 1. The concentration ranged between 0.23 mg/kg – 3.04 mg/kg. The lowest concentration (0.23 mg/kg) was recorded in Sampling Station 3 in the month of November and the highest concentration (3.04 mg/kg) in Sampling Station 3 in January. Statistical analysis shows that the difference in manganese content of onion bulbs across the sampling stations was not statistically significant (ANOVA, $p > 0.05$). The overall mean manganese levels of onion bulbs from River Galma basin (Study area) was found to be 1.68±2.72 mg/kg while the average manganese level of onion bulbs from River Kubanni basin (control) was 0.55±03 mg/kg. The difference in manganese levels of onion bulbs between the study area and the control was found to be statistically significant ($P < 0.05$), with the average manganese levels of onion bulbs from the study area being significantly higher than the control.

The spatial distribution of the Average metal concentration of onion bulbs from the different sampling points in the study area (Figure 6) shows that the trend of occurrence of the heavy metals in the study area was nickel > manganese > chromium > Lead. Positive correlation was observed between lead and chromium ($r = 0.733$), lead and nickel ($r = 0.879$), and between lead and manganese ($r = 0.292$). Positive correlation was also observed between chromium and manganese ($r = 0.625$), chromium and nickel ($r = 0.900$), and between nickel and manganese ($r = 0.596$). Only the correlations between lead and chromium, lead and nickel, and between chromium and nickel were statistically significant at 99% confidence level.

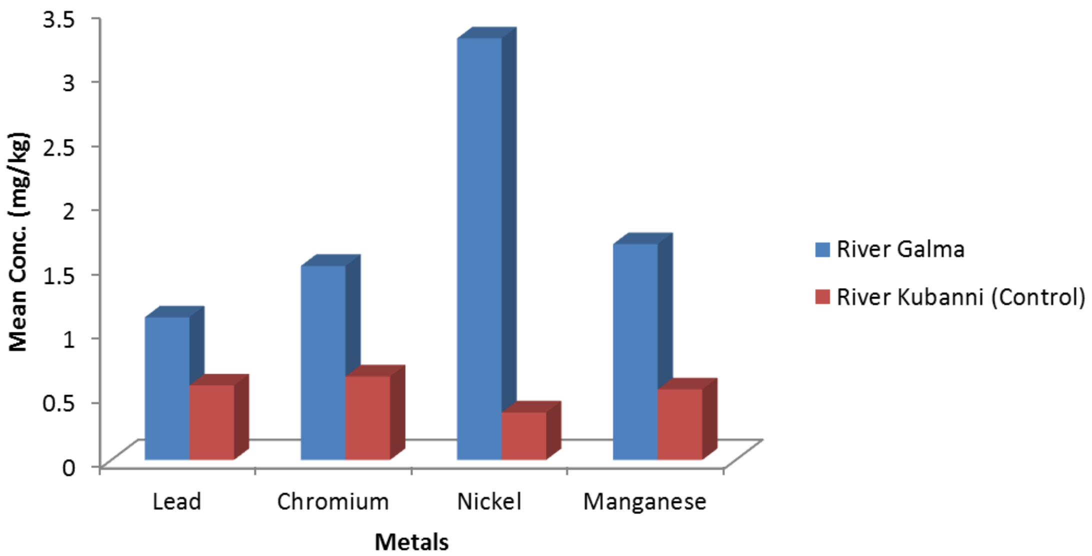

Fig. 6. *Spatial distribution of the Average metal concentrations of onion bulbs across the different sampling points in the study area.*

The estimated daily metal intake expressed as per unit body weight (mg/kg b.w. /day) calculated for onions bulbs from each of the three sampling station and the control is presented in table 3.

Table 3. *Estimated daily metal intake (mg/kg b.w. /day) across sampling locations.*

Element	Lead	Chromium	Nickel	Manganese
Sampling Station 1	5.26	7.77	14.06	7.49
Sampling Station 2	6.23	8.51	18.51	14.57
Sampling Station 3	7.49	9.66	23.54	6.69
Average	6.33	8.65	18.70	9.58
River Kubanni (control)	3.09	3.71	2.11	3.14
UL(mg/ day)	0.240	130µg/day	3-7	11.00
RDI(mg/ day)	0.00	0.003-1.5	0.500	2.3(1.8)

Figures in brackets () indicate the RDI for females

Table 3 revealed that the estimated daily metal intake from the consumption of onion bulbs from River Galma Basin around Dakace industrial area ranged from: 5.26 to 7.49 for lead, 7.77 to 9.66 for chromium, 14.06 to 23.44 for nickel and 6.69 to 14.57 for manganese.

The Target Hazard Quotient computed for the metals under study as presented in Table 4 revealed a range of 1.50 – 2.14, 0.005 – 0.006, 0.70 – 1.18, and 0.048 – 0.104 for lead, chromium, nickel and manganese respectively.

Table 4. *Target Hazard Quotient (THQ) of metals in Onion bulbs from River Galma Basin.*

Element	Lead	Chromium	Nickel	Manganese
Sampling Station 1	1.50	0.005	0.70	0.053
Sampling Station 2	1.78	0.006	0.93	0.104
Sampling Station 3	2.14	0.006	1.18	0.048
Average	1.81	0.006	0.94	0.068
River Kubanni (control)	0.88	0.002	0.11	0.026

4. Discussion of Results

Lead, chromium, nickel and manganese content of onion bulbs across sampling stations in the study area followed the order: sampling station 3 > sampling station 2 > sampling station 1 except for manganese that was higher at sampling station 2 than sampling station 3. The order of these metals in soil and water used for irrigation were reported to follow the same sequence (Udiba et al., 2014a; Udiba et al., 2014b; Udiba et al., 2015), suggesting uptake of the metals from the soil and water may be responsible for their presence at the concentration determined. Metal uptake by plants generally increases as the soil metal content increases. The lowest concentration of each metal in the study was recorded in the month of November and the highest concentration in January. This observation could be explained on the basis of the water used for irrigation. The volume of River Galma used for irrigation was observed to decrease as the dry season progressed. The concentration of the contaminants in the water increases as the volume decreases. The use of this highly contaminated water for irrigation resulted to higher uptake by the plant. Metal content of edible onions tissues from River Galma (study area) was found to be higher than those from River Kubanni (control). The observation also followed the order of the metals concentrations in soil and water indicting that crop grown in areas with less input of metals from anthropogenic sources accumulates lower amounts of the contaminants. The soil and water chemistry as well as the specie and age of plants also play significant roles in the uptake of metals by plants. Occurrence of the heavy metals under study in onions bulbs followed the order: nickel > manganese > chromium > Lead. The significant ($p < 0.01$) positive correlations observed between lead and chromium ($r = 0.733$), lead and nickel ($r = 0.879$) and between chromium and nickel ($r = 0.900$) indicates that increase in lead concentration of onions bulbs is associated with increase in chromium and nickel concentrations and that increase in chromium concentration is also associated with increase in nickel concentration suggesting that same source is responsible for the presence of these metals at the. concentrations determined in the crop.

The overall mean lead concentration (1.11± 0.8 mg/kg) of onions bulbs from River Galma basin was found to be higher than the FAO/WHO safe limit of 0.3 mg/kg for edible vegetables. Consumption of onions cultivated along River Galma basin thus pose significant risk with respect to lead intoxication. A higher range (5.870-7.537 mg/kg) was reported for onions grown on irrigated soil (Abdullahi *et al.*, 2009) and a mean value of 11.30 mg/kg for onion grown with waste water in Meerut City Region (Deepak and Skukia, 2013). Lead is one of the limited classes of element that can be described as purely toxic. Most other elements though toxic at high concentration are actually required nutrients at lower levels (Udiba *et al*., 2012 a). There is no exposure level below which lead appear to be safe. Lead is number 2 in the Agency for Toxic Substances and Disease Registry (ATSDR) Top 20 list, and account for most of the cases of pediatric heavy metal poisoning. It interferes with the normal development of a child's brain and nervous system, therefore children are at greater risk of lead toxicity. The effect on peripheral nervous system on the other hand, is more pronounced in adults. Lead absorption constitutes serious risk to public health. It induces reduced cognitive development and intellectual performance in children, increased blood pressure, and cardiovascular diseases in adult as well as liver and kidney dysfunction (Udiba *et al*., 2012a).

The overall mean chromium concentration (1.52±0.9 mg/kg) of onions bulbs from the study area was found to be over three times the WHO/FAO safe limit of 0.5 mg/kg for edible vegetable. Results of this study thus show that onions cultivated in the study area is not safe for human consumption. Abdullahi *et al.,* (2009) reported a range of 3.870-7.860 mg/kg for onion grown on irrigated soils. A mean value of 11.82 mg/kg was also reported in onion grown wit waste water in Meerut City Region (Deepak and Skukia, 2013). Both values were higher when compared to the result from the present study. Chromium is a toxic human carcinogen that causes or increases the rate of cancer; ingestion of high concentration often results in lung function and blood system problems, gastrointestinal burns, hemorrhage, generalized oedema, pulmonary oedema, liver damage and kidney damage. Symptoms are diarrhea, abdominal pain, indigestion and vomiting. Death may be the result of pulmonary or cardiac arrest. Skin contact causes a number of skin problems including rashes and sores (Udiba *et al.,* 2012b).

The nickel content of 3.28±1.76 mg/kg in the onions bulbs was found to be lower when compared with the WHO/FAO safe limit of 67 mg/kg. The range of concentration in the study area (1.73 mg/kg 7.03 mg/kg) was found to be higher than 0.430-0.950 mg/kg reported for irrigated onion in Markurdi Benue State, Nigeria (Odoh *et al,* 2011). Small amount of nickel is needed by the human body to produce red blood cells, however, when the concentration exceeds a certain threshold, can cause decreased body weight, heart and liver damage, thyroid disease, cancer and skin irritation (Udiba *et al.,* 2012b). Other toxic effects of nickel observed following chronic exposure including bronchitis, emplysema, reduced vital capacity and asthma.

The overall mean manganese level of onions bulbs (1.68±2.72 mg/kg) from River Galma was found to be far lower than the safe limit of 200 mg/kg WHO/FAO set standards. The concentration in the study (0.23 mg/kg-3.04 mg/kg) was lower when compared with the result of 2.010-7.800ug/u reported from irrigated onions farm from Markurdi Benue State, Nigeria (Odoh, et al, 2011). It could be concluded that the manganese in onions in the study area pose no serious risk when consumed since it is far lower than the permissible limit. Manganese toxicity may result in multiple neurological problems (Keen et al, 2001). The effects of early exposure may not appear until many years later. In its worst form, manganese toxicity can result in a permanent neurological disorder with symptoms similar to those of Parkinson's disease, including tremors, difficulty in walking and facial muscle spasms (udiba *et al*., 2012b).

The significant positive correlation observed between lead and chromium, lead and nickel, and between chromium and nickel indicates that as the concentration of lead in onions bulbs increases the concentrations of chromium and nickel also increases suggesting that same source is responsible for the presence of these metals at the concentrations determined.

4.1. Estimated Daily Intake (EDI)

In order to assess the health risk of any pollutant, it is absolutely necessary to estimate the level of exposure. One very significant aspect of such estimation is by the evaluation of the daily intake. The estimated daily intake (EDI) of heavy metals is widely used to describe safe levels of metallic intake through food consumed (Querra et al., 2012; Lanre-Iyanda and Adekunle, 2012). It also combines data on the levels of heavy metals in foodstuff with quantities of food consumed on the daily basis (Querra et al., 2012). The EDI thus depend on both the metal concentration in edible portion of the food crops and the amount of the food crop consumed. In this study, the approximate daily lead, chromium, nickel and manganese intake for people living in Zaria and its environs through the consumption of onion cultivated along River Galma basin around Dakace industrial area estimated were compared with the recommended daily intakes/or allowances and the upper tolerable daily intakes for the metals (UL) (Table 3). Tolerable Daily Intake (TDI) is an estimate of the amount of elements in air, food or drinking water that can be taken in daily over a lifetime without appreciable health risk. The average values of the estimated daily intake for lead, chromium, nickel and manganese were above the recommended daily intakes for the metals (Table 3). The average values of the estimated daily intake for metals under study were also found to be above the upper tolerable daily intakes for the metals (UL) (Table 3). The estimated daily metal intake computed in this study were expressed per kilogram body weight (mg/kg b.w. /day) so that for an average adult of 70kg body weight, the average value of EDI of say manganese is equivalent to 9.58 multiplied by 70 which is equal to 670.6 mg per day. The results obtained from the estimation of daily intake (EDI) of lead, chromium, nickel and manganese in the study clearly implies that the perennial intake of onions bulbs harvested from Dakace industrial layout is likely to induce serious adverse health effects.

4.2. Target Hazard Quotients (THQ)

Risk to human health by the intake of metal-contaminated onions was also characterized using Target Hazard Quotient (THQ). THQ is the ratio between exposure and the reference oral dose (RfD). When the ratio is lower than one (1), there is no obvious risk. THQ-based risk assessment method indeed provides an indication of the risk level due to exposure to pollutants (Chary et al., 2008 cited in Querra et al., 2012). THQ method employed in this study considered only exposure to the selected heavy metals through consumption of onions bulbs, without taking into account other exposure routes like dermal contact, soil ingestion, and other factors such as the presence of agrochemicals and herbicide molecules. The average THQs for individual metals across the study area were all below 1.00 lead (Pb) being the only exception. Table three shows that the THQ for lead across the three sampling stations were all above 1.00 with the highest value recorded at sampling station three. THQ for nickel at sampling station 3 was also found to be above 1.00. THQ-based risk assessment in this study thus indicates that, the consumption of onion bulbs from the study area poses serious toxicological risk with respect to lead intoxication. Sampling station 3 was also indicted with respect to nickel intoxication.

4.3. Hazard Index (HI)

To evaluate the potential risk to human health through more than one heavy metal, the hazard index (HI) has been developed (US EPA, 1989 cited in Querra *et al*., 2012). It assumes that the magnitude of the adverse effect will be proportional to the sum of multiple metal exposures. It also assumes similar working mechanisms that linearly affect the target organ (Querra *et al*., 2012). There is serious concern for potential health effects when the Hazard Index is greater than

1. Even though there was no apparent risk when each metal was analyzed individually, the potential risk could be multiplied when considering all metals are considered together. The hazard index for a typical adult of body weight 70 kg considered in this study was found to be 2.83. The relative contributions of Pd, Cr, Ni, and Mn to the aggregated risk were 64.18 %, 0.21 %, 33.33 % and 2.41 % respectively. Consumption of onion bulbs from the study area therefore poses serious course for concern.

5. Conclusion

The contamination and deterioration of Nigerian urban environment especially in our growing cities is a course for serious concern. Large scale pollution has resulted in undue levels of toxic chemicals in our food, water and soil. The result of this study indicates that onions cultivated along River Galma basin round Dakace industrial area has lead and chromium concentrations above WHO/FAO standards for consumed vegetables. The average values of the estimated daily metal intake were all above recommended daily intakes and upper tolerable daily intakes for the metals. The average THQs for individual metals across the study area were all below 1.00, lead (Pb) being the only exception. THQ for lead across the three sampling stations were all above 1.00. Nickel was however indicted at sampling station 3. The hazard index for a typical adult of body weight 70 kg computed was found to be 2.83. The relative contributions of Pd, Cr, Ni, and Mn to the aggregated risk were 64.18%, 0.21%, 33.33 % and 2.41% respectively. It was therefore concluded that consumption of onion bulbs from the study area poses serious toxicological risk.

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