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BIOACCUMULATION OF HEAVY METALS AND HEALTH RISK ASSESSMENT AFTER THE CONSUMPTION OF SOME VEGETABLES GROWN ALONG RIVERS JAKARA AND GETSI IN ALBINO RATS

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ABSTRACT

Cabbage and lettuce were collected from three locations each along the irrigation farms of Rivers Jakara and Getsi. Domestic and industrial waste are freely discharge into these rivers. Thirty Nine Albino Rats were divided into Thirteen (13) groups where Animals in groups 1-12 were fed with diet containing 10% cabbage or lettuce. The 13th group were fed with normal diet. After 90 days, the Animals were sacrificed, blood and organs were collected. Fe had the highest level in the blood and significantly different from the control in all the groups. The level of other essential heavy metals is in the following order of decreasing concentration, Fe> Zn > Cu > Cr > Mn > Co while Pb has the highest concentration and in the following order of decreasing concentration Pb > As > Cd > Ni > Hg. A significant decrease in weight of the heart, kidney and pancreas was observed and a significance difference in the organ/body weight coefficient was observed in the Liver (group 3, 4 and 11) Kidney (group 5, 6 and 7) and Pancreas (group 1, 3 and 9). The bioaccumulation index (BAI) shows that eight (8), Seven (7) and Six (6) of the elements analyzed accumulates in the Liver and the Pancreas, Kidney and Heart respectively. Liver accumulated more Cadmium, Lead and Nickel while Pancreas accumulated Nickel, Manganese and Cobalt. Consumption of these vegetables led to reduction in organ weight, increase blood levels and bioaccumulation of some heavy metals in vital organs of albino rats

Keywords: Heavy Metals, Organ/Body weight Coefficient, Bioaccumulation Index, Albino Rats

INTRODUCTION

Heavy metals are elements with metallic properties and an atomic number >20, atomic weight between 63.545 and 200.5g/cm^3 Density and a specific gravity greater than 4 (Mbong *et al*., 2014; Tangahu *et al.*, 2011). Heavy metals are ubiquitous environmental contaminants found in soil, water and air, they are persistent, can easily contaminate the food chain and causes serious problems to consumers including humans (Ali *et al.*, 2019). The menace of food heavy metals contamination is a threat to public health and it is increasingly becoming a global problem (Abdullahi *et al.*, 2021).

Accelerated population growth, industrialization and poor waste management and environmental pollution control poses a grave challenge to food and environmental safety in many developing countries including Nigeria (Abdullahi and Mohammed, 2020; Christopher *et al.*, 2017). Vigorous industrialization and the incessant release of effluents accounts for the continuous accumulation of Heavy Metals in the environment (Danjuma and Abdulkadir, 2018). Breach of environmental regulations and failure of environmental regulatory agencies to actively enforce environmental protection laws contributed immensely to the poor quality of soil and surface water in Nigeria (Ighalo and Adeniyi, 2020). Soil and water bodies in Kano are under threat due to the Heavy Metals contamination commonly sourced from industrial wastes and agrochemicals. Shawai *et al.*, (2019), was of the view that Rivers in Kano are not fit for human consumption and agricultural activities due to Heavy Metals contamination from untreated industrial effluents. Excessive and indiscriminate use of agricultural inputs also contributed to soil contamination along Jakara River (Abdulkadir *et al.*, 2013). Consumption of vegetables grown in contaminated soils is the major route for Heavy Metals contamination in humans (Habu *et al.*, 2021). The findings by Bichi and Bello, 2013 that the Concentration of Cr, Cu, Cd, Zn, Co, Fe, Pb, and Mn in tomatoes, onions and pepper produce in the Kano exceeded FAO limits was alarming while Mohammed and Inuwa (2017) cautioned the use of medicinal plant grown within Kano metropolis due to high pollution index. Abdullahi and Mohammed (2020) and Habu *et al.*, (2021) reported that the food products from the Jakara river can be carcinogenic. Despite the foreseeing danger, Government is very reluctant to take measures that will prevent people from getting contamination through consumption of the foods produced along the river (Sanda *et al.*, 2016).

Heavy metals are non-biodegradable and persistent and are known to cause deleterious effects on animal and human health. Both acute and prolonged exposures to heavy metals cause various diseases (Javed and Usmani, 2015). The ideal sources of pollution to the Rivers Jakara and Getsi are sewage, industrial waste and agricultural inputs (Mustapha and Aris, 2011). Wastewater irrigation, agrochemicals and atmospheric deposit stock up the soil around the rivers with dangerous levels of Heavy Metals (Dawaki *et al.*, 2015). The practice of using urban wastes as compost by urban farmers in Kano (Lewcock, 1995) can be an additional source of Heavy Metals to the agricultural soil.

Virtually all heavy metals are toxic in sufficient quantities. Because of their concentrations in the environment, Lead, mercury, and arsenic are of particular interest. Entering our bodies by way of food, drinking water, and air, metals produce toxicity by forming complexes with cellular compounds containing sulfur, oxygen, or nitrogen. The complexes inactivate enzyme systems or modify critical protein structures leading to cellular dysfunction and death. The most commonly affected organ systems include central nervous, gastrointestinal (GI), cardiovascular, hematopoietic, renal, and peripheral nervous systems. The nature and severity varies with the heavy metal involved, its exposure level, chemical and valence state (organic versus inorganic), mode of exposure (acute versus chronic) and the age of individual. This research was aimed to assess the bioaccumulation of some heavy metals in some vital organs of Albino Rats after consumption of cabbage and lettuce grown along Rivers Jakara and Getsi.

MATERIALS AND METHODS

SAMPLE COLLECTION AND PREPARATION

This study was conducted in Late 2019 to early 2020 in Kano State Nigeria located between Latitude 12° 00'N and Longitude 8° 30' E in the North West Zone of Nigeria with an area of 20,131Km^2 and estimated Population of 20 Million People. The Vegetable samples were collected between Latitude 12° 027'N to 12° 638'N and Longitude 8° 527' E and 8° 563' E

Animals

Albino rats were purchased from the Department of Physiology, Bayero University, Kano. The experiment was performed on both male and female albino rats weighing approximately 250 g. Animals were housed under standard controlled conditions (temperature 25 ± 3 ◦C, relative humidity of 35% to 50%, 12-h light-dark cycle) and allowed free access to standard rat chow and drinking water during the experiment.

Study Design and Experimental Procedure

Following two weeks of acclimatization, rats were randomly divided into 13 groups: one control group and twelve experimental groups. Both the experimental and Control groups comprised of three (3) animals. The experimental groups were fed with meals containing 10% of either Cabbage or Lettuce separately for a period of 90 days. The control group were fed with water and standard rat chow. Animals were sacrificed after treatment. The animal groupings were as follows;

Group (1) Animals fed with Cabbage collected from Zungeru Road along River Jakara
Group (2) Animals fed with Cabbage collected from Airport by Immigration Training School along River Jakara
Group (3) Animals fed with Cabbage collected from P. R. P. along River Jakara
Group (4) Animals fed with Cabbage collected from Gama by Tudun Wada along River Getsi
Group (5) Animals fed with Cabbage collected from Gayawa along River Getsi
Group (6) Animals fed with Cabbage collected from Getsi by Jakara Confluence along River Getsi
Group (7) Animals fed with Lettuce collected from Zungeru Road along River Jakara
Group (8) Animals fed with Lettuce collected from Airport by Immigration Training School along River Jakara
Group (9) Animals fed with Lettuce collected from P. R. P. along River Jakara
Group (10) Animals fed with Lettuce collected from Gama by Tudun Wada along River Getsi
Group (11) Animals fed with Lettuce collected from Gayawa along River Getsi
Group (12) Animals fed with Lettuce collected from Getsi By Jakara Confluence along River Getsi
Group (13) Control Group

Blood and Tissue Preparations

After Ninety (90) days, the animals were sacrificed, Blood samples were collected, an aliquot of blood was wet digested for toxic metals analysis. Organ systems were examined, the livers, kidneys, Hearts and Pancreas were removed and separated into two parts. One tissue sample was immediately frozen at $-20^{\circ C}$ for toxic metals analysis.

Estimation of Heavy Metals

Heavy metals, namely Zn, Cu, Cr, Fe, Pb, Cd, As, Ni, Co, Mn and Hg were assessed in the Blood, Liver, Heart, Kidney and Pancreas of Albino rats. Dried tissue (1g) and serum were digested in analytical grade HNO_3:$HClO_4$ (4:1). After digestion the samples volume were raised up to the mark (100ml), mixed thoroughly and used for the estimation of heavy metals using Atomic Absorption Spectrophotometer, Perkin Elmer, Model, Pinnancle 900H (Javed and Usmani,2015). Instrument calibration standards were made by diluting the standard (1000 ppm) supplied by Wako Pure Chemical Industry Ltd., Japan. Analytical blanks were run in the same way as the samples and concentrations were determined using standard solutions prepared in the same acid matrix.

Organ Weight and Organ/Body Weight Coefficients

39 rats were weighed and sacrificed. Organs, including the heart, liver, kidney, and Pancreas were obtained immediately. Organ weight and organ/body weight coefficients were calculated subsequently.

Bioaccumulation Index (BAI)

Bioaccumulation Index (BAI), which is the relative increase in the concentration of a given element in the organism to its initial concentration after the experiment. BAI was calculated using the following formula;

$$BAI = \frac{C_{\text{in organ after experiment}} - C_{\text{in organ before experiment}}}{C_{\text{in organ before experiment}}}$$

Where BAI is the Bioaccumulation index; $C_{in\ organism\ after\ experiment}$ is the concentration of a given element in Dry Weight (DW) of organ after the experiment (mass unit); and $C_{in\ organism\ before\ experiment}$ is the concentration of a given element in DW of organism biomass before the experiment (mass unit). A BAI value above 1 denotes Bioaccumulation (Proc *et al.*, 2021). In this work, element in DW of control group wwre used as $C_{in\ organ\ before\ experiment}$.

Statistics

Statistical analysis was performed using one-way ANOVA followed by LSD-t test to compare experimental treatments by SPSS 20.0 software package (SPSS Inc., Chicago, IL, USA). Data were presented as means ± standard deviation (SD). A *p*-value less than or equal to 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Individuals are usually exposed to a mixture of heavy metals either through contaminated air, food or water. Consumption of multi heavy metals contaminated food may result in severe damage to vital tissues and organs. Industrialization, environmental pollution and poor waste management distress food and environmental safety in Kano (Abdullahi *et al.*, 2021). The present study attempt to evaluate the extent of bioaccumulation of heavy metals in some vital organs of adult albino rats after being fed with cabbage and lettuce grown along Rivers Jakara and Getsi.

The results of analysis of heavy metal content in the blood of albino rats fed with meals containing 10% cabbage or lettuce grown along Rivers Jakara and Getsi were presented in Table 1. The result shows that consumption of such meals led to the significance increase in the concentration of all the heavy metals analyzed. A significant difference was observed in the essential elements Fe, Zn, Cu, Co, Mn and Cr when compared with the controlwhile major variations were also recorded in the toxic element Pb, Cd, Ni, Hg and As. Fe has the highest concentration in all the elements analyzed with 1383.98mg/L in Group 1 while the lowest was found in group 5. The haemoglobin content of blood and the large distribution of Welders, auto mechanic and other metal processing industries around Kofar Ruwa and Kwakawaci axis could account for the highest concentration of Fe, Zn and Cu in Animals groups fed with Vegetables from Zungeru and Airport Road sites along River Jakara while the battery recycling plants, paint, foam and wood processing factories in the Bompai and Gama against to which River Getsi passes through could be responsible for the higher levels of Pb, Cd, As, Co and Ni in groups fed with vegetables collected from sites along River Getsi most especially lettuce collected from Gama and Getsi axis.The average levels of the Heavy metals is in the following order of decreasing concentration, Fe > Zn > Cr > Cu > Pb >Cd >As > Mn > Co > Ni > Hg.

Table 1: Heavy Metals content in blood of Albino Rats fed with meals containing either 10% of Cabbage or Lettuce (n=39)

	CABBAGE						LETTUCE						CONTROL
Group	1	2	3	4	5	6	7	8	9	10	11	12	13
Zn**(mg/L)**	537.40 ±39.02	543.45 ±105.72 ^{a}	440.64 ±95.20	434.38 ±45.46	409.03 ±74.07	478.40 ±49.50	473.43 ±71.5 ^{a}	456.2±98.3 ^{a}	568.61±30.3 ^{a}	448.66±72.9 ^{a}	518.66±120.7 ^{a}	426.13±130.3 ^{a}	144.52±152.7^{a}
C**(mg/L)** u	220.4±33.69 ^{b}	233.28 ±13.8 ^{b}	212.61 ±29.0 ^{b}	129.10 ±23.34 ^{b}	117.09 ±4.6	123.29 ±9.5 ^{b}	155.01 ±20.3 ^{b}	154.63±20.09 ^{b}	124.35±9.6 ^{b}	132.43±15.7 ^{b}	154.81±14.5 ^{b}	279.4±18.2 ^{b}	103.03±15.01^{b}
Cr**(mg/L)**	165.86 ±33.0^{c}	130.97 ±15.1 ^{c}	92.47±14.5	112.58 ±15.6 ^{c}	99.84±33.6	89.73±11.7	280.31 ±60.0	215.57±33.29 ^{c}	216.19±44.3 ^{c}	233.28±30.02 ^{c}	335.12±25.2 ^{c}	458.75±30.2 ^{c}	88.10±10.12 ^{c}
Fe**(mg/L)**	1383.98±90.7 ^{d}	1249.91±88.18 ^{d}	777.28 ±96.9 ^{d}	815.81 ±70.01 ^{d}	333.64 ±46.48 ^{d}	445.52 ±62.0 ^{d}	527.38 ±77. ^{d}	853.82±136.1 ^{d}	1071.181±95.5 ^{d}	1063.12 ±138.6 ^{d}	1226.49 ±150.76 ^{d}	1196.80 ±161.03 ^{d}	339.54±266.9 ^{d}
Pb**(mg/L)**	61.38±6.7^{e}	20.84±5.21 ^{e}	32.78±5.88 ^{e}	27.84±6.2 ^{e}	31.96±5.27 ^{e}	29.66±11.6 ^{e}	20.80±5.3 ^{e}	29.50±7.5 ^{e}	69.78±4.22 ^{e}	73.53±7.06 ^{e}	124.60±12.31 ^{e}	87.73±10.71 ^{e}	4.56±2.03 ^{e}
Cd**(mg/L)**	8.26±1.4^{f}	5.27±1.3	7.22±2.0 ^{f}	7.28±2.4 ^{f}	6.96±1.6 ^{f}	6.99±2.4 ^{f}	5.17±1.1	6.28±1.3	6.37±1.5 ^{f}	8.49±2.5 ^{f}	9.62±1.6 ^{f}	9.90±1.9 ^{f}	3.05±0.8 ^{f}
As**(mg/L)**	20.91±4.55^{g}	25.80±4.01 ^{g}	29.06±6.57 ^{g}	11.77±3.53	29.18±7.90 ^{g}	10.91±3.66	30.16±5.39 ^{g}	37.91±6.94 ^{g}	29.54±4.84 ^{g}	43.27±7.01 ^{g}	51.82±11.0 ^{g}	58.88±6.53 ^{g}	6.76±2.55 ^{g}
Ni**(mg/L)**	3.33±1.52	4.19±0.98 ^{h}	3.74±0.45	4.90±1.21 ^{h}	3.27±1.35	5.24±1.16 ^{h}	8.07±1.00 ^{h}	5.37±1.51 ^{h}	5.34±0.65 ^{h}	4.73±2.05 ^{h}	3.71±1.30 ^{h}	5.37±0.65 ^{h}	1.83±0.20 ^{h}
Co**(mg/L)**	4.24±1.08^{j}	5.66±0.35 ^{j}	5.03±1.00 ^{j}	7.76±0.78 ^{j}	7.27±0.30 ^{j}	5.85±0.59 ^{j}	4.47±0.50 ^{j}	3.57±0.52 ^{j}	8.06±1.32 ^{j}	7.16±1.03 ^{j}	9.37±1.51 ^{j}	8.11±2.36 ^{j}	1.77±0.62 ^{j}
Mn**(mg/L)**	12.24±2.04^{k}	8.39±0.53 ^{k}	8.07±1.00 ^{k}	11.14±3.01 ^{k}	9.37±1.51 ^{k}	8.44±0.45 ^{k}	8.68±3.05 ^{k}	8.68±3.05 ^{k}	14.20±2.04 ^{k}	14.56±3.12 ^{k}	13.95±4.56 ^{k}	18.51±6.06 ^{k}	6.07±3.12 ^{k}
Hg**(mg/L)**	0.99±0.11^{m}	1.10±0.21 ^{m}	1.02±0.51 ^{m}	0.91±0.06 ^{m}	0.94±0.50 ^{m}	0.91±0.38 ^{m}	0.70±0.45 ^{m}	1.15±0.20 ^{m}	1.18±0.44 ^{m}	1.07±0.31 ^{m}	1.18±0.31 ^{m}	1.06±0.42 ^{m}	0.00 ^{m}

Results were presented as means ± SD; One-way ANOVA and LSD-t test were used; * $p < 0.05$, (Rats fed either 10% Cabbage or Lettuce compared with the control group); values sharing same superscript along the same column are significantly different from the control

The result of measurement of organ weight in Albino Rats fed with Cabbage and Lettuce collected from River Jakara and Getsi were presented in Table 2. Consumption of meals containing 10% cabbage or lettuce grown along Rivers Jakara and Getsi resulted in significance decrease in organ weight of the Heart in all the groups with significance difference observed in group (2, 3, 4, 5, 9, 10 and 12) that cut across both animals fed with Cabbage and Lettuce while the weight of Kidney was found to be significantly decrease when compared with the control in three (1, 4, and 5) and two (7 and 11) groups that were fed with Cabbage and lettuce respectively. Pancreas also shows significant decrease except in four (2, 5, 7, and 12) groups.

Table 2: Effect of consuming Cabbage and Lettuce grown along Rivers Jakara and Getsi on Organ Weight of Albino Rats n=39)

Type of Vegetable	CABBAGE						LETTUCE						CONTROL
Group/ Organ	1	2	3	4	5	6	7	8	9	10	11	12	**13**
Liver(g)	4.27± 0.34	3.84± 1.80	3.56± 0.44	3.33± 0.16	2.98± 0.50	4.47± 1.00	4.28± 0.22	4.27± 0.89	3.35± 0.36	3.22± 0.75	3.77± 0.32	3.58± 1.54	4.21± 0.65^{a}
Heart(g)	0.38± 0.05	0.35± 0.04^{b}	0.30± 0.02^{b}	0.26± 0.03^{b}	0.26± 0.02^{b}	0.37± 0.02	0.41± 0.04	0.38± 0.03	0.32± 0.03^{b}	0.28± 0.02^{b}	0.36± 0.04	0.29± 0.03^{b}	0.42± 0.04^{b}
Kidney(g)	0.59± 0.03^{c}	0.69± 0.01	0.70± 0.02	0.61± 0.05^{c}	0.55± 0.02^{c}	0.69± 0.03	0.82±0 .05^{c}	0.79± 0.04	0.73± 0.04	0.72± 0.03	0.84± 0.03^{c}	0.74± 0.05	0.74± 0.06^{c}
Pancreas(g)	0.37± 0.03^{d}	0.54± 0.05	0.77± 0.08^{d}	0.43± 0.06^{d}	0.53± 0.07	0.45± 0.03^{d}	0.56±0 .03	0.46± 0.03^{d}	0.78± 0.06^{d}	0.38± 0.07^{d}	0.49± 0.04^{d}	0.54± 0.05	0.57± 0.03^{d}

Results were presented as means ± SD; One-way ANOVA and LSD-t test were used; * $p < 0.05$, vs. the control group (Rats fed either 10% Cabbage or Lettuce compared with the control group); values sharing same superscript along the same column are significantly different from the control

However, none of the groups shows significance difference from the control in the weight of the liver. The consumption of the vegetables showed a reduction in organ weight in many groups with few showing increase in weight which could be associated with hypotrophy of the internal organs that are related to the cumulative and sorption capacity of the metals (Lopotych *et al.*, 2020) except the liver that has shown a capacity to regenerate. It was also discovered that heavy metals specifically cadmium and lead have a toxic effect on a number of organs and systems in the body of animals. They can easily connect to the thiol group of Apoproteins and thus change the activity of Antioxidant, Microsomal and other enzymatic system and affect the exchange of Macro and micronutrients (Sobolev *et a.l*, 2019). The observed reduction in the weight of the vital organs could be due to the combine effects of these heavy metals which agree with the findings by Milena *et al*, 2019 and Vandjiguiba *et al.*, 2016after feeding rats with Cadmium and Lead and then a mixture of the two.

The result of organ/ bodyweight coefficients were presented in Table 3. The result shows that consumption of meals containing 10% cabbage or lettuce grown along Rivers Jakara and Getsi has no effect on Heart's organ/body weight coefficient showing difference in only one of the experimental group while three groups were found to be statistically different from the control in the Liver, Kidney and the Pancreas. This suggests that the general hypotrophy of the internal organs has also affected the body weight of the experimental group which causes many groups to have comparable coefficient with the control. A mechanism proposed by Lazic *et al.*, 2020 suggests that the heavy metals contained in the vegetables may cause damage to the organs which makes the animal ill, which then lead to a reduction in body weight while it was observed that the Liver, Kidney and Heart are positively correlated with the body weight (Lumamba *et al.*, 2018).

Table 3: Effect of Consuming Cabbage and Lettuce grown along Rivers Jakara and Getsi on organ/Body Weight Coefficient of Albino Rats (n=39)

Type of Vegetable	CABBAGE						LETTUCE						CONTROL
Group/ Organ	1	2	3	4	5	6	7	8	9	10	11	12	**13**
LIVER	0.93±0 .23	0.93±0 .19	0.81±0 .30^{a}	0.83±0 .18^{a}	0.96±0 .33	0.94±0. 29	1.15±0 .51	1.01±0 .47	0.90±0 .33	0.91±0 .17	0.67±0 .22^{a}	0.90±0 .38	0.95±0. 26^{a}
HEART	0.08±0 .03	0.08±0 .02	0.07±0 .02	0.07±0 .01	0.09±0 .03	0.08±0. 02	0.11±0 .03	0.09±0 .02	0.08±0 .01	0.07±0 .02	0.06±0 .01	0.09±0 .03	0.08±0. 03^{b}
KIDNEY	0.13±0 .04	0.18±0 .02	0.18±0 .06	0.18±0 .04	0.23±0 .08^{c}	0.20±0. 06^{c}	0.22±0 .08^{c}	0.18±0 .05	0.18±0 .04	0.17±0 .06	0.13±0 .03	0.15±0 .05	0.15±0. 04^{c}
PANCREAS	0.07±0 .02^{d}	0.11±0 .03	0.19±0 .06^{d}	0.09±0 .02	0.13±0 .06	0.14±0. 05	0.14±0 .03	0.14±0 .02	0.20±0 .07^{d}	0.12±0 .05	0.13±0 .04	0.10±0 .04	0.11±0. 03^{d}

Results were presented as means ± SD; One-way ANOVA and LSD-t test were used; * $p < 0.05$, vs. the control group (Rats fed either 10% Cabbage or Lettuce compared with the control group); values sharing same superscript along the same column are significantly different from the control

Bioaccumulation Index (BAI) of Heavy Metals in Liver, Heart, Kidney and Pancreas of Albino Rats fed with meals containing either 10% of Cabbage or Lettuce

The result of bioaccumulation index (BAI) in Liver of Albino rats fed with meals containing 10% of either cabbage or lettuce collected from farms along River Jakara and Getsi were presented in Table 4.

Table 4: Bioaccumulation index of some Heavy metals in the Liver of Albino rats feds with meals containing 10% Cabbage or Lettuce

Heavy metal/Location	Zn	Cu	Cr	Fe	Pb	Cd	As	Ni	Co	Mn
River Jakara Cabbage	0.20	6.48	5.0	1.86	35.64	21.66	4.51	1.77	0.93	-0.67
River Getsi Cabbage	2.85	2.38	7.27	8.21	6.54	19.83	2.04	2.50	0.30	0.78
River Jakara Lettuce	0.50	0.30	11.36	2.98	18.75	3.33	7.90	2.00	0.80	1.03
River Getsi Lettuce	3.09	1.95	9.18	11.09	2.25	2.67	3.49	3.97	2.17	1.62

Results are present as bioaccumulation index calculated by comparing with level of heavy metal in mg/Kg in Liver of control rats

The result shows a varying degree of bioaccumulation with Pb and Cd presenting the highest accumulation especially in group fed with Cabbage collected from River Jakara. These was followed by Fe, Cr, Cu and As also showing some level of bioaccumulation while Zn, Mn and Co shows from non to a very low level bioaccumulation in all the groups.

The result of bioaccumulation index (BAI) in Heart of Albino rats fed with meals containing 10% of either cabbage or lettuce collected from farms along River Jakara and Getsi were presented in Table 5.

Table 5: Bioaccumulation index of some Heavy metals in the Heart of Albino rats feds with meals containing 10% Cabbage or Lettuce

Heavy metal/Location	Zn	Cu	Cr	Fe	Pb	Cd	As	Ni	Co	Mn
River Jakara Cabbage	**0.52**	**0.97**	**2.37**	**0.78**	**8.57**	**14.44**	**5.94**	**2.56**	**4.19**	**0.18**
River Getsi Cabbage	**0.73**	**0.46**	**3.84**	**0.71**	**9.35**	**5.00**	**5.24**	**4.00**	**5.25**	**2.05**
River Jakara Lettuce	**1.09**	**2.18**	**1.67**	**0.65**	**18.54**	**7.44**	**8.47**	**5.00**	**4.57**	**-1.00**
River Getsi Lettuce	**0.69**	**1.00**	**3.35**	**0.46**	**9.35**	**7.75**	**4.47**	**4.89**	**5.00**	**1.89**

Results are present as bioaccumulation index calculated by comparing with level of heavy metal in mg/Kg in Heart of control rats

The result shows a high degree of bioaccumulation of heavy metals analyzed in the heart with Pb, Cd and As having the highest accumulation especially in group fed with cabbage and lettuce collected from River Jakara. These were followed by Cr, Ni and Co also showing moderate bioaccumulation while Zn, Mn and Fe shows bioaccumulation index ranging from non to a very low level bioaccumulation in all the groups.

The result of bioaccumulation index (BAI) in the Kidney of Albino rats fed with meals containing 10% of either cabbage or lettuce collected from farms along River Jakara and Getsi were presented in Table 6.

The result shows a high level of bioaccumulation of Ni in the Kidney in group fed with lettuce collected from River Getsi which was followed by a moderate bioaccumulation of Cu, Co, Mn, Pb, Cd and Cr while Zn, Fe and As shows index ranging from non to a very low level bioaccumulation in all the groups.

Table 6: Bioaccumulation index of some Heavy metals in the Kidney of Albino rats feds with meals containing 10% Cabbage or Lettuce

Heavy metal/Location	Zn	Cu	Cr	Fe	Pb	Cd	As	Ni	Co	Mn
River Jakara Cabbage	**0.68**	**2.95**	**3.00**	**0.12**	**3.05**	**3.65**	**1.95**	**4.75**	**7.00**	**0.21**
River Getsi Cabbage	**0.92**	**4.36**	**4.00**	**0.27**	**2.27**	**2.4**	**0.98**	**6.75**	**11.86**	**4.96**
River Jakara Lettuce	**0.26**	**8.06**	**2.63**	**0.24**	**2.35**	**3.65**	**1.30**	**9.50**	**1.29**	**6.04**
River Getsi Lettuce	**0.72**	**7.37**	**3.77**	**0.62**	**2.45**	**3.30**	**0.88**	**26.25**	**9.00**	**6.50**

Results are present as bioaccumulation index calculated by comparing with level of heavy metal in mg/Kg in Kidney of control rats

The result of bioaccumulation index (BAI) in the Pancreas of Albino rats fed with meals containing 10% of either cabbage or lettuce collected from farms along River Jakara and Getsi were presented in Table 7.

Table 7: Bioaccumulation index of some Heavy metals in the Pancreas of Albino rats feds with meals containing 10% Cabbage or Lettuce

Heavy metal/Location	Zn	Cu	Cr	Fe	Pb	Cd	As	Ni	Co	Mn
River Jakara Cabbage	0.11	3.49	1.52	3.93	2.29	0.57	0.99	0.11	0.19	0.72
River Getsi Cabbage	0.93	2.23	3.91	4.46	2.14	0.10	0.43	0.12	0.70	2.06
River Jakara Lettuce	0.44	4.22	1.71	3.45	9.54	0.41	1.18	0.44	0.91	0.71
River Getsi Lettuce	1.40	6.94	2.61	6.81	2.59	0.21	0.46	1.41	3.02	2.41

Results are present as bioaccumulation index calculated by comparing with level of heavy metal in mg/Kg in Pancreas of control rats

The result shows a high level of bioaccumulation of Pb in group fed with lettuce collected from River Jakara and Fe in group fed with lettuce collected from River Getsi and was followed by a moderate bioaccumulation of Cu, Cr and also Fe while Zn, As, Ni, Co and Mn shows bioaccumulation index ranging from non to a very low level bioaccumulation in all the groups

Fe was found to be lower in the Heart and Kidney but high in the Pancreas. The Pancreas have a high expression of metal transporters and a low antioxidant that create a weak antioxidant defense system which makes the pancreas extremely sensitive to the effects of heavy metals (Khan and Awan, 2014). The reported antagonistic effects of trace essential elements like Fe with their antioxidants properties could counter the oxidative stress caused by toxic heavy metals (Edwards *et al.*, 2016). The toxic elements Pb was found to be higher in all the four (4) organs with highest accumulation in Liver and Heart which could be due to Pb-Zn interactions that lead to displacement of Zn and a phenomenon where organisms possesses the ability to regulate the intake and excretion of trace elements and the maintenance of internal homeostasis. Researchers have also identified that Cu binding proteins like CTR1 were a necessary mechanism for Cu uptake and transport, and ATP7B in hepatocytes was vital to help mammals excrete excess Cu. In human bodies, proteins like ZIP4 and ZnT1 mediate dietary Zn uptake and distribution in the organism. Regulation of Zn excretion is mainly through the gastrointestinal tract. Zn is excreted in the feces through food consumption, and fecal Zn also derives from pancreatic and biliary secretion into the intestine which explained the low bioaccumulation of Zn (Sloup *et al.*, 2018). The result further shows that Cd was also found to accumulate more in the Liver and Heart than Kidney and Pancreas while Zn and Fe do not accumulate in the kidney. The Liver and heart exhibited a moderate capacity to regulate the accumulation of some heavy metals like Zn, Cu, Co and Mn and a reduced capacity to regulate the accumulation of Pb and Cd when compared with the Pancreas that has shown an efficient mechanism to regulate the bioaccumulation of the heavy metals except Fe, Pb and Cu. The result further showed that Pb, Cr and Cu were the only elements that accumulates in all the four organs assessed while Fe and Zn accumulates more in the liver and Pancreas. The level of Fe in the liver could also be due to the hemoglobin content of the blood.

Essential elements such as Fe, Cr, Mn, Ni, Cu, and Zn normally accumulates only in one or a few organs; by contrast, detrimental heavy metals like Cd and Pb could deposit in almost all organs. As a consequence, to maintain normal physiological functions, organisms have developed an effective biological mechanism to consume and excrete obligatory trace elements, but they lack a feasible approach to eliminate detrimental heavy metals like Cd, Hg or Pb. Primary targets that cadmium is toxic includes the kidneys in addition to lungs and bone (ATSDR, 2012). Cadmium is also known as a potent carcinogenic which affects the kidney, lung, pancreas, and prostate. The accumulation of Cd in Liver and kidneys could be due to transmission from other tissues, release from hemoglobin during hemolysis or liberating metallothionein from red cells as it is known to have a strong association with the protein. Cadmium has been associated with the promotion of apoptosis, oxidative stress, methylation of DNA, and DNA damage (Azeh, *et al.*, 2019).

CONCLUSION

The consumption of Heavy Metals contaminated foods poses a great risk to the Health and wellbeing of Animals and Humans. Heavy Metals contaminated vegetables from Rivers Jakara and Getsi could be a risk to dwellers of Kano Metropolis being the major market of the vegetables. The consumption of cabbage and lettuce grown along Rivers Jakara and Getsi led to elevation of heavy metal levels in the blood and reduction in the weight of the Heart, Kidney and the Pancreas and has no effect on the organ/ body weight coefficient of the Heart. The heavy metals content of the vital organs analyzed shows a varied pattern of bioaccumulation with the toxic elements Pb and Cd presenting a highest bioaccumulation index in Liver and Heart while Fe showed its highest bioaccumulation index in the pancreas and Ni in the Kidneys.

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