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Chronic Kidney Disease Associated with Consumption of Vegetables Cultivated on Contaminated Soil in Gashua, Yobe State – Nigeria

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Abstract

This study aimed to use atomic absorption spectrophotometry (AAS) to determine the levels of concentration of heavy metals: lead (Pb), chromium (Cr), and cadmium (Cd) uptake by two vegetables (onion and salad) cultivated in three contaminated areas along Gada River, Gashua. Samples were collected from different cultivation land, Mashangwari, Garden, Gada right and Gada left. The results showed that the average concentration of Cd is 0.1179 mg kg^{-1} and 0.1267 mg kg^{-1}, Cr is 0.8575 mg kg$^{-1,}$ and 0.8265 mg kg^{-1}, and Pb is 0.1771 mg kg^{-1} and 1.3314 mg kg^{-1} in onion and salad samples respectively. The average concentration of cadmium (Cd) and lead (Pb) detected in onion and salad samples from the study area exceeded the acceptable limits of 0.2 mg kg^{-1} for Cd and 0.3 mg kg^{-1} for Pb for edible vegetable recommended by FAO/WHO. The average value of Cr concentration detected was below the permissible limit (2.3 mg kg^{-1}) recommended by FAO/WHO. Therefore, consumers of onion and salad cultivated in some areas in the Gashua community were likely to be liable to Cd and Pb toxicity. The research indicates that vegetables planted during the irrigation period are polluted by Cd and Pb. These heavy metals have health hazard risks and consumption of the vegetables might be a likely cause of Kidney disease.

Keywords — *Heavy, metals, contamination, kidney, vegetables.*

I. INTRODUCTION

Heavy metals pollute the soil-plant environment through anthropogenic sources which include mining, smelting, waste disposal, urban effluent, vehicle exhausts, sewage sludge, pesticides, and fertilizer application. Vegetables become imperative as it is the most cultivated and consumed in Gashua community and are very important in the human diet because of the presence of vitamins and minerals salts. They contain water, calcium, iron, sulfur, and potash [1]. They act as neutralizing agents for acidic substances forming during digestion [2]. Therefore they are very useful for the maintenance of health as a preventive treatment of various diseases [3]. But the quality of vegetables changes due to the presence of heavy metals [4]. Heavy metals can be found generally at trace levels in soil and vegetation. Even in low concentrations in the soil-water system, they persist for a longer time in soil from where they enter into the food chain through plant uptake. Their toxicity has an inhibitory effect on plant growth, enzymatic activity, stoma function, photosynthesis activity, and accumulation of other nutrient elements, and also damages the root system [5,6]. Heavy metals may enter the human body through the consumption of vegetables grown in heavy metal contaminated soil. However, it exceeds certain limits [7].

The intake of heavy metals through vegetable consumption is a problem that has been reported globally. It is receiving increasing attention not only from governments but also from the public, who are becoming increasingly concerned about the possible health risks associated with the higher concentrations of heavy metals found in the human food chain. It is estimated that nearly half of the mean ingestion of heavy metals is of plant origin [8-10]. Ingestion of large amounts of heavy metals could result in various illnesses and toxicities due to the disruption of several biochemical processes within the human body. Thus, the bioaccumulation of heavy metals in vegetables and fruits could pose a direct threat to human health [11].

Heavy metals such as cadmium, copper, lead, nickel, and zinc can cause deleterious health effects in human and higher animals which include mental lapse, kidney failure, and central nervous system disorder. For example, cadmium (*Cd*) is highly toxic for both plants and animals. The study conducted by WHO (1989) estimated the amount of *Cd* ingested by a man from terrestrial foods grown in contaminated soil contains a high level (about 98%) of *Cd* [12]. This is because the compounds of *Cd* are more soluble than other heavy metals and therefore rendering it more available for plant absorption where these could accumulate in edible plant parts. Chronic exposure to *Cd* can have harmful effects such as lung cancer, bone fractures, kidney dysfunction, and hypertension [13-15].

Lead (*Pb*) is a widespread heavy present in soils, plants, and waters. It is mostly present in the top layer of soil due to the deposition from air containing smoke from vehicles. The *Pb* is released from mining, industrial and agricultural chemicals. Research showed that about 7% of the lead in the soil contaminates the vegetation growing in the environment [7,16]. International Agency for Research on Cancer publication has shown that the *Pb* compound has no known beneficial effect on man, its chronic exposure retard growth in children, cause plumbism, anemia, nephropathy, gastrointestinal colic, and central nervous system symptoms [14,15].

In the data issued by the Agency for Toxic Substances and Disease Registry (ATSDR), and WHO Chromium (*Cr*) is classified as carcinogenic to human beings [17-19] and sufficiently high exposure to *Cr* would result in potential harm to human through its toxic, genotoxic and carcinogenic effects [20-24]. This study, investigate the level of uptake of heavy metals (*Cr*, *Pb*, and *Cd*) in vegetable leaves and stem and assess their negative influence on vegetables grown in the Gashua community.

II. MATERIAL AND METHODS

A. Sample collection, preparation, and analyses

The equipment and instruments used in this study were all calibrated to check their status before and in the middle of the experiments. Apparatus such as volumetric flasks, measuring cylinder, and digestion flasks were thoroughly washed with detergents and tap water and then rinsed with deionized water. All Glasswares were cleaned with 10% concentrated Nitric acid (HNO_3) to clear out any heavy metal on their surfaces and then rinsed with distilled-deionized water. The digestion tubes were soaked with 1% (w/v) potassium dichromate in 98% (v/v) H_2SO_4 and the volumetric flasks in 10% (v/v) HNO_3 for 24 hours followed by rinsing with deionized water and then dried in the oven and kept in dust-free place until analysis began. Before each use, the apparatus was soaked and rinsed in deionized water.

B. *Sample Pre-Treatment/Digestion*

The samples were allowed to dry using a hot oven (Model 30GC lab oven) and then ground into fine powder by using a porcelain mortar and pestle. As much as 100 *mg* of each sample was weighed in to thoroughly clean plastic container (microwave tube) and 6ml of 65% HNO_3 and 2 *ml* of hydrogen peroxide 3:1 was added and allowed and to stand for a while.

The plastic container (microwave tube) was then covered and placed into a microwave digester (Master 40 serial No: 40G106M) and digested. The digestion was carried out at a temperature of (120 °*C*) for 30 *mins* and then ramped at 20 °*C* per min to 180 °*C* and hold for 10 *mins*. The digestion was followed by cooling to room temperature in the microwave. The potential presence of heavy metal in a chemical used in digestion was determined. Blanks were used simultaneously in each batch of the analysis to authenticate the analytical quality. The digested samples were diluted with deionized water to a total volume of 25 *ml*.

C. Preparation of 1000 mg/Litre stock AAS standard solution for selected heavy metals (such as Pb, Cr and Cd, and other metals)

The determination of a given metal concentration in the experimental solution was based on its respective calibration curve. In plotting the calibration curves for lead, cadmium, and chromium, a stock solution of each metal ion of (1000 *ppm*) was prepared by dissolving; 1.5980 *g* of $Pb(NO_3)_2$, 2.1032 *g* of $Cd(NO_3)_2$ (and other metals to get exactly 1.0 *g* of the desired metal in 100 *mL* of solution) in deionized water and then diluting to 1 liter in a volumetric flask.

D. Determination of metal content by AAS

Calibration curves were prepared to determine the concentration of the metals in the sample solution. The instrument was calibrated using a series of working standards. The working standard solutions of each metal were prepared from standard solutions of their respective metals and their absorbances were taken using the AAS. The calibration curve for each metal ion to be analyzed was prepared by plotting the absorbance as a function of metal ion standard concentration. The concentration of the metal ions present in the sample was determined by reading their absorbance using AAS (Buck scientific model 210GP) and comparing it on the respective standard calibration curve. Three replicate determinations were carried out on each sample. The metals were determined by absorption/concentration mode and the instrument readout was recorded for each solution manually. The same analytical procedure was employed for the determination of elements in digested blank solutions and the spiked samples.

Table 1: Elements with their wavelength

S/No	Element	Wavelength (*nm*)	Slit (*nm*)
1	Lead	283.2	0.7
2	Chromium	357.9	0.7
3	Cadmium	228.8	0.7

Table 2: The concentration of cadmium (Cd), lead (Pb), and Chromium (Cr) in their first absorption

S/No	*Concentration (µg/mL)*	*1st absorption*		
		Cd	***Cr***	***Pb***
1	0	0.002150	0.00125	0.010512
2	1	0.025810	0.24530	0.024243
3	2.5	0.064551	0.60271	0.061455
4	5	0.130040	1.22040	0.122215
5	10	0.256880	2.32640	0.242520
6	15	0.390220	3.58621	0.312445
7	20	0.498580	4.65281	0.484890
8	25	0.651230	4.88540	0.612450

Table 3: Regression data for the calibration plots

Heavy Metals	***Cd***	***Cr***	***Pb***
Regression Equation	$y = 0.025x + 0.000$	$y = 0.209x + 0.134$	$y = 0.023x + 0.000$
Coefficient of Determination	$R^2 = 0.999$	$R^2 = 0.982$	$R^2 = 0.992$
Correlation Coefficient	0.999	0.991	0.996

III. RESULTS AND CONCLUSIONS

The average concentration of heavy metals in vegetables (Onions and Salad) collected at irrigation farm sites are shown in table 4 and 5. The concentration of Cadmium (Cd), Chromium (Cr), and Lead (Pb) were found present in onion and salad samples collected at all locations. Table 4 showed the concentration of cadmium (Cd), lead (Pb), and Chromium (Cr) in onion samples. The concentration of *Cd* varied from in Garden 0.0307 $mg\ kg^{-1}$ to 0.1685 $mg\ kg^{-1}$ in Mashangwari with an average 0.1179 $mg\ kg^{-1}$. The concentration of *Cr* detected in the onion sample is minimum (-0.0402 $mg\ kg^{-1}$) in Garden and the highest concentration of *Cr* (1.7841 $mg\ kg^{-1}$) was detected in Gada (left). Table 4 showed the concentration of *Pb* varied from 0.0661 $mg\ kg^{-1}$ in Garden to 0.1771 $mg\ kg^{-1}$ in Gada (left), with an average of 0.1018 $mg\ kg^{-1}$.

Table 4: The concentration of cadmium (Cd), lead (Pb), and Chromium (Cr) in onion samples from four locations

S/No	**Onion**	**Concentration ($mg\ kg^{-1}$)**		
		Cd	***Cr***	***Pb***
1	Mashangwari	0.1685	0.0091	0.0734
2	Garden	0.0307	-0.0402	0.0661
3	Gada (right)	0.1167	1.6767	0.0907
4	Gada (left)	0.1561	1.7841	0.1771
Average		0.1179	0.8575	0.1771

Table 5: The concentration of cadmium (Cd), lead (Pb), and Chromium (Cr) in salad samples from four locations

S/No	**Salad**	**Concentration ($mg\ kg^{-1}$)**		
		Cd	***Cr***	***Pb***
1	Mashangwari	0.0542	0.0034	0.1249
2	Garden	0.1202	-0.2242	0.1182
3	Gada (right)	0.2735	1.7435	0.0641
4	Gada (left)	0.0590	1.7832	5.0187
Average		0.1267	0.8265	1.3314

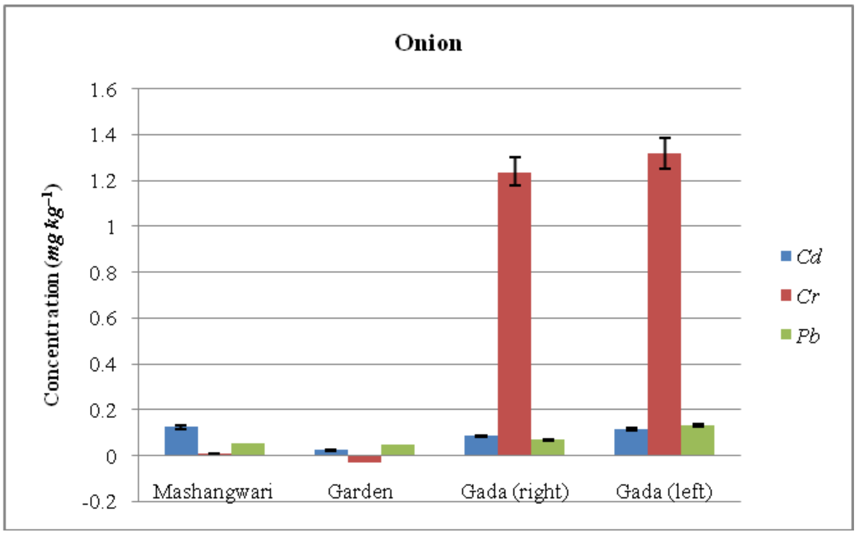

Figure 1: The concentration of cadmium (Cd), lead (Pb), and Chromium (Cr) in onion samples from four locations

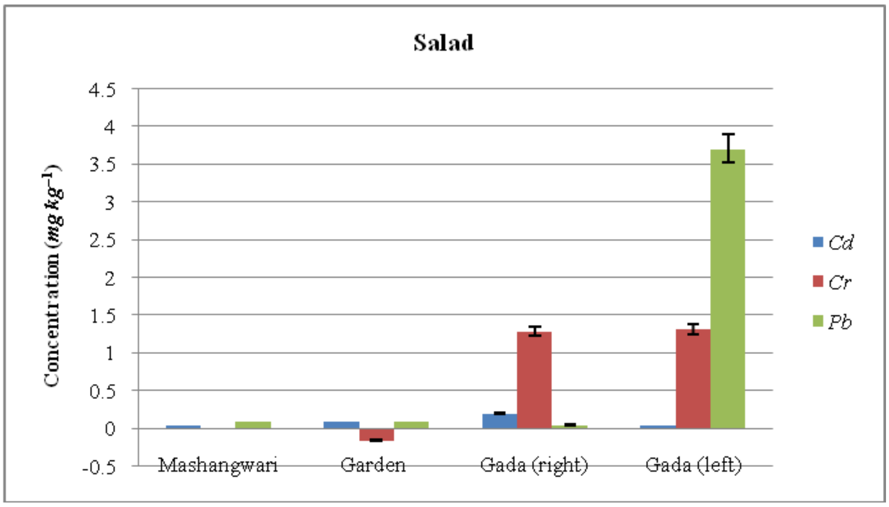

Figure 2: The concentration of cadmium (Cd), lead (Pb), and Chromium (Cr) in salad samples from four locations

Table 5 showed the concentration of cadmium (*Cd*), lead (*Pb*), and Chromium (*Cr*) in salad samples. The maximum concentration of *Cd* (0.2735 $mg\ kg^{-1}$) was detected in Gada (left) and the minimum concentration of *Cd* is 0.0542 $mg\ kg^{-1}$ found in Mashangwari. Cadmium has an average concentration of 0.1267 $mg\ kg^{-1}$ in all the salad samples. The concentration of *Cr* in salad samples varied from -0.2242 $mg\ kg^{-1}$ in Garden to 1.7832 $mg\ kg^{-1}$ in Gada (left). The average concentration of *Cr* in the salad samples was 0.8265 $mg\ kg^{-1}$. Lead (*Pb*) showed the lowest concentration of 0.0641 $mg\ kg^{-1}$ in salad samples at Gada (right) and significantly the highest concentration of 5.0187 $mg\ kg^{-1}$ in Gada (left). The average concentration of *Pb* in salad samples was 1.3314 $mg\ kg^{-1}$. This study reveals the presence of heavy metals (Cd, Cr, Pb) in onion and salad cultivated in some areas in the Gashua community.

The average concentration of *Cd* (0.1179 $mg\ kg^{-1}$ and 0.1267 $mg\ kg^{-1}$) *Cr* (0.8575 $mg\ kg^{-1}$ and 0.8265 $mg\ kg^{-1}$) and *Pb* (0.1771 $mg\ kg^{-1}$ and 1.3314 $mg\ kg^{-1}$) in onion and salad sample respectively.

IV. CONCLUSIONS

Cadmium (*Cd*) and lead (*Pb*) detected in onion and salad samples from the study area showed that the average value exceeded the acceptable limits of 0.2 $mg\ kg^{-1}$ for *Cd* and 0.3 $mg\ kg^{-1}$ for *Pb*) for edible vegetable recommended by FAO/WHO (2013). The average value of *Cr* concentration detected was below the permissible limit (2.3 $mg\ kg^{-1}$) recommended by FAO/WHO (2013) [25,26]. Therefore, consumers of onion and salad cultivated in some areas in the Gashua community were likely to be liable to *Cd* and *Pb* toxicity. The research indicates that vegetables planted during the irrigation period are polluted by *Cd* and *Pb*. These heavy metals have health hazard risks and consumption of the vegetables might be a likely cause of Kidney disease.

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