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Heavy Metals in Vegetables Collected from Selected Farms in Funtua and Katsina Cities, Katsina State, Nigeria

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Abstract- The frequent use of industrial and domestic wastewaters for irrigation on vegetable gardens is a public health concern in Nigeria. Atomic Absorption Spectrophotometry was used to determine the concentration of heavy metals cadmium (Cd)) chromium (Cr) (copper (Cu), iron (Fe) manganese (Mn) zinc (Zn), lead (Pb) and in five different vegetables viz; (Bitter-leaf), Cabbage, Cucumber, Lettuce and Spinach collected from selected farm areas of Katsina and Funtua Cities, Katsina state. The results reveal that all the heavy metals were detected in all the vegetables from the various sites. Most of the concentrations are below the World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) safe limit of 0.1 mg/kg, 0.1 mg/kg, 40 mg/kg, 1.3 mg/kg, 1.5 mg/kg, 6.61 mg/kg, 3 mg/kg, 60 mg/kg for cadmium (Cd), cobalt (Co) (Cu), chromium (Cr), iron (Fe), lead (Pb) and zinc (Zn), respectively in the vegetables. However the concentration of cobalt in spinach and lead in cabbage from Katsina are above the WHO and FAO safe limits. There is a significant differences in the concentration of Cd in the vegetables from the sampling sites ($P<0.05$), while there is no significant difference in the concentration of Cr, Co, Cu, Fe, Mn, Pb, Zn in the vegetables from the sampling sites ($P>0.05$). If the practice of treating the soils in the irrigation gardens with contaminated waters is not controlled, it may lead to health hazard on the part of consumers of the vegetables on the long term. Continuous monitoring, control and necessary policy decisions should be taken so as to limit and ultimately prevent these avoidable problems.

Keywords- *Gardens, Heavy Metals, Irrigation, Vegetables*

I. INTRODUCTION

In Zimbabwe, Nyamangara and Mzezewa (1999) implicated land disposal of sewage and industrial effluents as the chief source of heavy metal enrichment of pasturelands and agricultural fields. Barrow and Webber (1972), Pike et al. (1975) pointed out the dangers of repeatedly treating soils with metallurgical slag because of the possible build up of elements to toxic concentrations. Juste (1974) observed that the spreading of some organic wastes (town refuse, domestic and industrial effluents etc) might contribute to increased levels of nonessential metals in soil, which could cause poor plant growth. The uptake of metals from the soil depends on different factors such as their solubility, soil pH, plant growth stages, fertilizer and soil (Sharma et al., 2006; Ismail et al., 2005). Plant species have various ways of removing and accumulating heavy metals, hence there are reports indicating that some species may accumulate specific heavy metals, causing a serious risk to human health when plant-based food stuff are consumed (Wenzel and Jackwer, 1999). Vegetables are edible plants which store up food reserves in their roots, stems, leaves and fruits. They play an important role in maintaining general good health due to the presence of mineral elements such as calcium, iron, sulphur, potassium and vitamins such as vitamins A, B, and C. These substances help to build bone, teeth and protect the body from diseases. They also regulate body processes on which vitality and good health depend. Leafy vegetables are widely used for culinary purposes. They are used to increase the quality of soup and for dietary purposes (Sobukola et al., 2007). They contain cellulose and form roughage which helps the bowel to function regularly in the elimination of unwanted matter from the body. They also contain 70-75% water which is essential to the body system. They are very important protective foods, useful for the maintenance of health, prevention and treatment of various diseases (D'Mello,2003). Waste water irrigation is known to contribute significantly to the heavy metal contents of soils (Mapanda et al., 2005). Irrigation is the artificial addition of water to soils in order to meet plants' needs to overcome drought limitations and improve the crops' yields. However, other factors such as soil and water quality and management practices are also important. Vegetables constitute important part of the human diet since they contain carbohydrates, proteins, vitamins, minerals as well as trace elements. Elevated concentration of heavy metal can negatively affect human being. Heavy metals are not easily biodegradable and consequently can be accumulated in human vital organs leading to unwanted side effect (Sathawara N.G et al., 2004). This situation causes varying degrees of illnesses based on acute and chronic exposures. Wastewater irrigation is known to contribute significantly to the heavy metal contents of soils (Mapanda et al., 2005; Devkota and Schmidt, 2000). A vast majority of the vegetables consumed in Katsina state are produced through irrigation, and the water used by the farmers is mostly waste water from gutters and other waste water outlets. There is therefore the need for periodic monitoring of these vegetables for the presence of heavy metals. Results obtained from this study will reveal if the vegetables consumed by the inhabitants of Katsina state are contaminated or not when compared with world health organization safe limits and standards.

II. METHODOLOGY

Katsina is a city in Nigeria. Its area is 52 sq mi 142 km^2. The city's population is 318,459. Katsina is located at 12.5139° N, 7.6114° E. Funtua city is a local government area in Katsina state, Northern Nigeria. It has an area of 448 km^2 and a population of 225,571 (at the 2006 census) and 420,110 according to 2012 estimate. Funtua has a conducive weather condition as it lies on the latitude and longitude 11° 32′ N and 7° 19′ E respectively.

A. Sample Collection and Analysis

The vegetables analyzed include spinach, cucumber, cabbage, lettuce and bitter leaf. The vegetables were washed with distilled water to remove dust particles and then cut to separate the root, stems and leaves using a knife. The leaves and soil were air-dried and then oven-dried at 65oC. Dried vegetable samples were ground into a fine powder using a commercial blender (TSK WestPoint, France) and stored in polyethylene bags until they were used for digestion. 2g of each vegetable was weighed into a digestion flask and treated with 9ml of an acid mixture made up of concentrated nitric acid (HNO_3), hydrochloric acid (HCl) and sulphuric acid (H_2SO_4). A blank sample was prepared by applying 9ml of concentrated HNO_3, HCl and H_2S0_4 into an empty digestion flask. The samples were mixed and heated for 30 minutes on an electric hot plate at 80-90oC at which they were brought to boil and a clean solution was obtained. After cooling, the solution was filtered with whatman No. 4 filter paper and then transferred quantitatively to a 100ml volumetric flask by adding 50ml of de-ionized water. The solution was then preserved in a universal bottle for further analysis. All reagents used were of analytical grade and the Atomic Absorption Spectrophotometer (AAS, Perkin Elmer model 2130) was used to determine the heavy metals {Copper (Cu), Cobalt (co) Zinc (Zn), Lead (Pb) Cadmium (Cd), Chromium (Cr), and Manganese (Mn)} in the digested solution.

B. Data Management and Analysis

All analysis was performed in triplicates. Results were expressed by means of ±SD. Statistical significance was established using T test ($p < 0.05$) using software SPSS 23.0.

III. RESULTS AND DISCUSSION

Vegetables are known to accumulate heavy metals either from waste water or dump site (Arora et al ., 2008). The concentrations of Cd, Co, Cu, Cr, Fe, Mn, Pb and Zn from the two sampling cities are shown in Table 1 and their means in Figure 1.

TABLE I. RESULT OF HEAVY METALS CONCENTRATIONS OF VEGETABLES FROM KATSINA AND FUNTUA CITIES

Sampling Sites					Metals (mg/kg)			
	Cd	Co	Cu	Cr	Fe	Mn	Pb	Zn
					Bitter leaf			
Katsina	0.0119	0.1656	0.0037	0.1347	0.1128	0.0144	0.0031	0.0028
Funtua	0.0147	0.2053	0.0018	0.3406	0.0205	0.0223	0.1178	0.0003
Mean	0.18545	0.00275	0.23765	0.06665	0.01835	0.06045	0.00155	0.00155
STD	0.01985	0.00095	0.10295	0.04615	0.00395	0.05735	0.00125	0.00125
					Cabbage			
Katsina	0.0108	0.0612	0.0044	0.1327	0.1247	0.0048	0.3481	0.0004
Funtua	0.0129	0.2097	0.0019	0.0726	0.0256	0.037	0.2439	0.0021
Mean	0.13545	0.00315	0.10265	0.07515	0.0209	0.296	0.00125	0.00125
STD	0.07425	0.00125	0.03005	0.04955	0.0161	0.0521	0.00085	0.00085
					Cucumber			
Katsina	0.0113	0.1524	0.0086	0.0301	0.094	0.0314	0.2522	0.0034
Funtua	0.0122	0.1964	0.0015	0.0431	0.0496	0.0061	0.1449	0.0034
Mean	0.1744	0.00505	0.0366	0.0718	0.01875	0.19855	0.0034	0.0034
STD	0.022	0.00355	0.0065	0.0222	0.01265	0.05365	0	0
					Lettuce			
Katsina	0.0102	0.208	0.9951	0.0732	0.053	0.0218	0.1011	0.0006
Funtua	0.0127	0.1386	0.0014	0.0484	0.0496	0.0013	0.2501	0.0054
Mean	0.1733	0.49825	0.0608	0.0513	0.01155	0.1756	0.003	0.003
STD	0.0347	0.49685	0.0124	0.0017	0.01025	0.0745	0.0024	0.0024
					Spinach			
Katsina	0.0116	0.224	0.0015	0.0013	0.0116	0.0116	0.1115	0.0062
Funtua	0.0147	0.2179	0.0014	0.0052	0.0256	0.0124	0.1563	0.0065
Mean	0.22095	0.00145	0.00325	0.0186	0.012	0.1339	0.00635	0.00635
STD	0.00305	0.00005	0.00195	0.007	0.0004	0.0224	0.00015	0.00015
WHO/FAO STDS	0.1	0.1	40	1.3	150	6.61	0.3	60

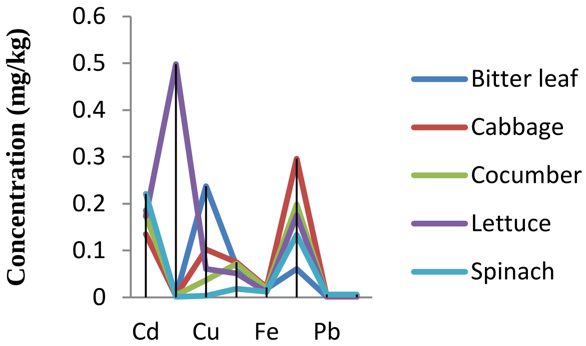

Figure 1. Mean concentrations of heavy metals in vegtables from katsina and funtua

A. Heavy Metals Concentration Across all the Vegetables .

Various sources of environmental contamination have been implicated for the presence of cadmium in foods. Differing values have been previously reported in leafy vegetables which include 0.090mg/kg for flutted pumpkin by Sobukola et al. (2010) and 0.049mg/kg by Muhammad et al. (2008) for lettuce. In this study, Cadmium was detected at low concentrations of 0.0102 – 0.0147mg/kg in vegetables purchased from Funtua in spinach and Katsina in Lettuce. This is below the FAO/WHO safe limit of 0.1mg/kg for cadmium consumption in vegetables. The order of increasing of concentration of Cd is as follows: Katsina:lettuce<cabbage<cucumber<spinach<biterleaf.Funtua: cucumber<lettuce<cabbage<bitterleaf<spinach. Cobalt shows highest concentration of 0.224 mg/kg in spinach from Katsina and lowest concentration of 0.0612 mg/kg in cabbage from Katsina. With the exception of spinach from Katsina, all the samples are above the FAO/WHO safe limits of 0.1 mg/kg. The order of increasing of concentration of Co is as follows: Katsina: cabbage<cucumber<bitterleaf<lettuce<spinach.Funtua:lettuce< cucumber<bitterleaf<cabbage<spinach. The concentration of copper ranged from 0.014 mg/kg in spinach from Funtua to 0.9951 mg/kg in lettuce from Katsina. All the results obtained are below the FAO/WHO safe limits of 40 mg/kg. This is higher than the findings of Divrikli et al. (2006) and Ozcan (2004) who reported Copper concentrations of 0.02mg/kg and 0.0081mg/kg, respectively for Indian Basil. The order of increasing of concentration of Cu is as follows: Katsina: spinach<bitterleaf<cabbage<cucumber<lettuce.Funtua:spinach <lettuce<cucumber<bitterleaf<cabbage.The concentration range for Cr was found to be 0.013 to 0.3406 mg/kg with the highest concentration recorded in Funtua spinach and the lowest in the spinach from Katsina. All the results obtained are below WHO/FAO safe limits. The order of increasing of concentration of Cr is as follows: Katsina: spinach<cucumber<lettuce<cabbage<bitterleaf.Funtua:spinach <cucumber<lettuce<cabbage<bitterleaf. Interestingly all the vegetables show similar trend in the accumulation Cr across all the sampling locations. Fe concentration ranged from 0.0116 mg/kg from Katsina in spinach to 0.1247 mg/kg in the cabbage from Katsina. All the vegetables are considered safe, as the Fe concentration of below the WHO/FAO safe limits of 150 mg/kg. The order of increasing of concentration of Cr is as follows: Katsina: bitterleaf<spinach<cabbage<lettuce<cucumber.Funtua:bitterleaf<spinach<cabbage<lettuce<cucumber. Maximum concentration of Mn of 0.037 mg/kg was found in cabbage from Katsina and the lowest concentration of 0.0013 mg/kg was found in lettuce from Funtua. All the results obtained are below WHO/FAO safe limits. The order of increasing of concentration of Mn is as follows: Katsina: cabbage<spinach<bitterleaf<lettuce<cucumber. Funtua: lettuce<cucumber<spinach<bitterleaf. Lead, a nonessential toxic metal showed highest concentration of 0.3481 mg/kg in cabbage sampled from Katsina and lowest concentration of 0.0031 mg/kg bitter leaf from Katsina. The concentration of lead is above the WHO/FAO safe limits of 0.3 mg/kg in cabbage and cucumber sampled from Katsina. There are other concentrations that are also close to the WHO/FAO safe limits in most of the vegetables sampled. The elevated levels of Pb in certain leafy vegetables may also occur due to contaminants in irrigation water, soil or industrial and vehicular emission as lead occurs in the fuel as anti-knocking (Mebale A.A et al ., 2014).The traffic is so voluminous around the study sites that the air pollution could convert to soil pollution in short term. The introduction of lead into the food chain may affect human health and may cause disruption of the biosynthesis of hemoglobin and anemia, rise in blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous systems and brain damage. Thus studies concerning lead accumulation in vegetables have increased important. The order of increasing of concentration of Pb is as follows: Katsina: bitter leaf<lettuce<spinach<cucumber<cabbage. Font: bitter leaf<cucumber<spinach<cabbage<lettuce. Finally the results indicated the mean concentration range of Zn to be 0.0065 to 0.0003 mg/Kg with the highest concentration found in Funtua spinach onions and the lowest in bitter leaf from Funtua. However, the highest value obtained is still below the WHO/FAO safe limit of Zn (50 mg/Kg) in fresh vegetables. The results obtained in this study are comparable with some literature values of similar studies reported previously (Onianwa et al., 2001; Erwin and Ivo, 1992; Pennington et al., 1995). The order of increasing of concentration of Pb is as follows: cabbage<lettuce<bitter leaf<cucumber<spinach. Funtua: bitterleaf<cabbage<cucumber<lettucee<spinach.

B. Statistical Analysis

The P values for the heavy metals were shown in Table 2. There is a significant differences in the concentration of Cd in the vegetables from the sampling sites ($P<0.05$), while there is no significant difference in the concentration of Cr, Co, Cu, Fe, Mn, Pb, Zn in the vegetables from the sampling sites. This could be attributed to the similarities of the activities and topography of the sampling sites. This made the null hypothesis made from this study acceptable.

TABLE II. P-VALUES FOR THE HEAVY METALS SAMPLED IN VEGETABLES FROM KATSINA AND FUNTUA CITIES

Metals	Cd	Co	Cr	Cu	Fe	Mn	Pb	Zn
P value	0.0085	0.5773	0.5453	0.9106	0.1241	0.9889	0.9638	0.8324

IV. CONCLUSION

The findings fron this study further confirms the increased danger of growing vegetables on filth irrigated with contaminated industrial and domestic wastewaters. However, the levels of the metals in most of the vegetables are currently within the WHO/ safe demarcation line limts.But lead is found in all the vegetables with some concentrations such as in cabbage and cucumber. If the practice of treating the soils in the irrigation gardens with contaminated waters is not controlled, it may lead to health hazard on the part of consumers of the vegetables on the long term. Therefore, there is the need to continually monitor, control and take necessary policy decisiveness so as to limit and ultimately prevent these avoidable problems. In any case, meanwhile, farmers from the study regions are therefore urged to utilize well or borehole water for water irrigation in their gardens rather than defiled streams.

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