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Health Risk Evaluation of Heavy Metals via Consumption of Contaminated Vegetable in Bekwara, Cross River State, Nigeria

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Abstract: *The average concentration of heavy metals namely; Hg, Ni, Pb, and Zn in edible vegetables and soil in Bekwara Urban Area of Cross River State were determined using flame Atomic Absorption Spectrometer (AAS). The Target Hazard Quotient (THQ) was also calculated based on the concentration of the metals in the vegetables to assess the possible health risk associated with the consumption of the vegetables. The eight vegetables considered together with the soil samples where they were planted include: Amarathus spp., Corchorus olitorius, Murraya koenigii, Ocimium grattissimum, Solanum melongena, Talinum triangulare, Telfaira occidentalis and Vernonia amygdalina. The results show that the mean concentration of Ni, Pb, and Zn in mgkg^{-1}in the soil was 0.003-0.010, (0.007-0.033) and (0.522-1.415) respectively in the rainy season, and (0.003-0.011), (0.005-0.029), (0.520-1081) respectively in dry season. The mean concentration of Ni, Pb, and Zn accumulated by the vegetables in mgkg^{-1} was in the range 0.001-0.009, 0.002-0.014and 0.047-0.110 respectively in rainy season and 0.001-0.008, 0.001-0.010 and 0.043- 0.101 respectively in dry season. Hg was a string variable as its concentration was not detected in the soil or vegetables. The Target Quotient (THQ) values of Ni, Pb, and Zn for all the vegetables were less than 1 indicating that there is no health risk associated with the consumption of the vegetables for now. The results also reveal that there is some level of heavy metals contamination of the area and the vegetables though very low and within the permissible limits of WHO. There is no significant difference between the results of the rainy and dry season showing that the source of the metals is not from air pollution sources or irrigation water but from indiscriminate disposal of waste.*

Keywords*: Health risk, Evaluation, Heavy metals, Consumption, Contaminated vegetables.*

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I. Introduction

Heavy metal is a term which is often broadly applied to include other potentially toxic elements even if they do not meet the strict chemical definition. (Hardy et al., 2008). It refers to metals which has a specific gravity of 5.0 and above, and is usually poisonous. Wikipedia free encyclopedia describes a heavy metal as a member of a loosely defined subset of elements that exhibits metallic properties. It mainly includes the transition metals, some metalloids lanthanides and actinides. Many different definitions have been proposed fpr heavy metals based on density, atomic number or atomic weight, chemical properties or toxicity. However, these metals or metalloids are the major contaminants of the ecosystem, polluting the soil, rivers, seas and plants, food crops through accumulation from the soil. This affects the quality and safety of food as well as the health of animals and humans that depend on plants for food.

According to Lenntech (2014), the effects of long term exposure to and or accumulation of high dose of heavy metals by humans include the following: Cadmium causes bone defects (Osteoporosis) renal dysfunction and lung cancer, chromium causes ulceration, kidney, liver, nerve, tissue and circulatory damages. Excess mercury causes tremors, gingivitis, psychological changes and brain damage. Lead causes foetus, brain, kidney, nervous system damages and low intelligent quotient (IQ) in children. Nickel can cause heart, liver damage and skin irritation, while copper causes anaemia, Wilson's disease (liver and kidney damage) etc. The need to avoid the contamination of food by these metals and ensure food safety has become a major concern of the society worldwide. This according to Dmello (2008), have attracted the attention of researcher to the risk associated with the consumption of contaminants (pesticides, heavy metals and toxins) in food. Several researchers have evaluated the health risk associated with the consumption of food or vegetables contaminated with heavy metals like Zhuang et. Al. (2009), Harmanescu et.al. (2011), Chandorka and Deota (2013), Mahmood and Mailk (2014) among others.

The source of heavy metals in the environment varies from place to place depending on the kind of anthropogenic activities carried out and the waste management and disposal method use in those places. Activities like construction, industrial waste, vehicular emission, solid mineral exploration, pesticides and fertilizer application, indiscriminate disposal of waste containing heavy metals etc. are the common sources of these metals. Zhou et al. (1994) have reported that phosphate fertilizers are one of the main sources of heavy metals pollution in the soil. Some of these metals are used for many things. For instance, Lead (Pb) is used as stabilizer in paints, pigments, batteries or accumulators etc., Mercury (Hg) is also used in making batteries, lamps, thermometers etc., Nickel (Ni) is also used in batteries and as a catalyst in some organic reactions, while Zinc is used in alloy, electroplating of iron against corrosion, just to mention a few. Thus, the disposal of these products as waste indiscriminately after use pollutes the soil and water environment for plants, animals and humans.

Bekwara is one the Local Government Area of Cross River State with a population of about 90 thousand people. Its urban town Abuochiche is quite a busy area with traffic due to the passage of the major highway from the State to Northern Nigeria and other roads to neighboring towns. There are small and medium scale enterprises, business shops, skill workers like mechanics, electricians who work with metals and electrical gadgets. Besides the people engage in subsistence and commercial agriculture, growing rice, yams, groundnuts, cassava etc. using fertilizers and herbicides. They also practice rotational waste-dumpsite at their premises (backyards) and plant vegetables, food crops in old dumpsites in order to tap compost manure for good yields, yet waste is indiscriminately dumped on this site, without sorting. Therefore, the presence of heavy metals pollution of the environment is inevitable. It is in view of this and the need to ascertain the vegetable (food) quality and the health implication of consuming vegetables grown in the area that necessitated this study. Also, to find out whether there is heavy metal contamination of the area, and is within the WHO/FAO permissible limits or is posing a health risk or not.

II. Materials And Methods

Sampling and sample pre-treatment: forty soil samples and vegetables were collected randomly at different locations within Bekwara urban area and the closest neighborhood. The soil samples were collected at the root level of the vegetables at the depth of the 12 to 15 cm, and at the same time the edible vegetables were collected and wrapped separately with identification labels before taking them to the laboratory.

The edible vegetables considered for this study in area which were planted in each of the forty soil samples include: *Amaranthus spp* (Green vegetable), *Corchorus olitorius* (Ewedu), *Murraya koenigii* (Curry leaf), *Ocimium gratissimum* (Scent leaf), *Solanum melongena* (eggplant leaf), *Telfairia occidentalis* (Pumpkin), *Talinum triangulare* (Water leaf), and *Vernonia amygdalina* (Bitter leaf). They are commonly used for food and medicinal purposes in the area. The samples were collected and analyzed between January and March for the dry season and between July and September for the rainy season.

The vegetable samples were washed with distilled water and oven-dried at 80-85^{O}c for about 2 hours. Each dried sample was milled into powder, sieved with 0.3mm sieve and stored in a labeled plastic jar with cap. The soil sample was also oven-dried, ground into find powder and homogenized with pestle and mortar sieve and stored in labeled plastic jars separately.

Digestion of samples: vegetable samples were digested in a fume cupboard following the procedure reported by Sobukola, et al. (2010) thus: 1.0 g of each sample was placed in a beaker and 20 cm^3 of concentrated (HCl), $10cm^3$ of concentrated HNO_3 and $5cm^3$ of H_2SO_4 were added. After volatiles were removed, the beaker was heated in a fume cupboard for about 30minutes. The digested sample was removed and allowed to cool. De-ionized water was added to the digest and made up to $100cm^3$ in a volumetric flask. The solution was stirred and filtered to obtain the supernatant liquid ready for heavy metals analysis. Similarly, the soil samples were digested following the procedure of Akan et al. (2010) thus: 2.0g of each soil sample powder was weighed into an acid washed beaker. $20cm^3$ of aqua region (mixtures of HCl and HNO_3, in the ratio 3:1) was added to the sample in the beaker. The beaker was covered with a clean dry watch glass and heated at 90^{0}C for about 2 hours, the beaker was removed, allowed to cool, washed together with the watch glass using de-ionized water into a volumetric flask and made-up to $100cm^3$ solution. The solution was filtered and supernatant liquid solution was used for heavy metal analysis.

Element analysis: The soil and vegetable samples were analyzed for Hg, Ni, Pb and Zn using Flame Atomic Absorption Spectrometer (AAS) at the following wavelengths. Hg(253.7nm), Ni(232.0nm), Pb(283.3nm), and Zn(213.1nm).

Calculations: The Target Hazard quotient which is the ration of the body intake does of a pollutant to the reference dose was calculated thus:

$$\text{THQ} = \frac{DIV\ x\ Cm}{RfD\ x\ B}$$

Where DIV is the daily intake of vegetable in (kg/day), Cm is the concentration of pollutant (heavy metal) in the vegetable in $mgKg^{-1}$, B is the average body weight of human in kg and R_fD is the oral reference dose which is generally accepted and it is the permissible oral dose fixed by the US-EPA. Note: B is assumed by US-EPA to be 70 kg for adult males and 60 kg for adult females. For this study, 65kg (the average of 70 kg and 60 kg) for all adults was used while the DIV was assumed to be 100 g (0.1kg/day) per day. In some countries or places, up to 150 or 200 g per day has been assumed especially for vegetarians. From the formula, THQ is a dimensionless parameter or ratio. According to US-EPA through IRIS (2003), if THQ is less than 1 (THQ<1), it shows that there is no potential health risk associated with the pollutant. But if THQ>1, there is a health risk associated with the pollutant (heavy metal) at that moment. The R_fD for Cr, Ni, Pb and Zn from IRIS (2003) are 0.603, 0.01, 0.0035 and 0.0300mgkg^{-1} respectively.

Statistical analysis: The data collected were analyzed using SPSS version 2.0. The data were also expressed in term of descriptive statistics and figures were presented with mean values of triplicates. The significance test was computed using pair sample T-test at P<0.05 for dry and rainy seasons data.

III. Results

The mean concentration of heavy metals in mgkg^{-1} in the vegetables and in Bekwara in the rainy and dry seasons are presented in Tables1 and 2 respectively, Target Hazard Quotient (THQ)are presented in Tables 3 and 4 respectively.

Table1: Mean concentration of heavy metals in vegetables and soil in Bekwara during the rainy season in mgkg^{-1} (dry weight).

Vegetables	Hg	Ni	Pb	Zn
***Amaranthus spp*.**	ND	0.005±0.004	0.007±0.004	0.069±0.021
Soil	ND	0.08±0.003	0.021±0.010	0.759±0.189
Corchorus olitorius	ND	0.006±0.004	0.013±0.003	0.047±0.018
Soil	ND	0.010±0.004	0.023±0.010	0.522±0.079
Murraya koeningii	ND	0.008±0.003	0.004±0.002	0.059±0.021
Soil	ND	0.012±0.003	0.012±0.007	0.617±0.0116
Ocimium gratissimum	ND	0.001±0.001	0.014±0.002	0.095±0.017
Soil	ND	0.003±0.001	0.033±0.022	0.570±0.130
Solanum melongena	ND	0.007±0.005	0.008±0.003	0.097±0.030
Soil	ND	0.012±0.007	0.012±0.007	1.415±0.436
Talinum triangulare	ND	0.005±0.004	0.006±0.004	0.110±0.033
Soil	ND	0.009±0.006	0.019±0.007	0.605±0.081
Telfaira occidentalis	ND	ND	0.004±0.003	0.112±0.075
Soil	ND	ND	0.016±0.008	0.826±0.024
Vernonia amygdalina	ND	0.004±0.006	0.002±0.001	0.103±0.070
Soil	ND	0.009±0.006	0.007±0.004	0.784±0.176

Note: ND means not detected values reported in meant SD format, N=3

Table 2: Mean concentration of heavy metals in vegetables and soil in Bekwara in dry season in mgkg^{-1} (dry weight).

Vegetables	Hg	Ni	Pb	Zn
Amaranthus spp.	ND	0.003±0.002	0.004±0.003	0.063±0.014
Soil	ND	0.009±0.002	0.006±0.004	0.730±0.149
Corchorus Olitorius	ND	0.006±0.002	0.008±0.002	0.043±0.016
Soil	ND	0.008±0.002	0.014±0.004	0.520±0.050
Murraya koeningii	ND	0.007±0.002	0.003±0.001	0.054±0.017
Soil	ND	0.011±0.005	0.011±0.004	0.610±0.121
Ocimium gratissimum	ND	0.001±0.001	0.010±0.002	0.088±0.018
Soil	ND	0.003±0.001	0.029±0.003	0.559±0.108
Solanum melongena	ND	0.006±0.003	0.005±0.003	0.086±0.015
Soil	ND	0.008±0.004	0.018±0.005	1.081±0.058
Talinum triangulare	ND	0.003±0.001	0.005±0.002	0.093±0.052
Soil	ND	0.007±0.004	0.016±0.005	0.598±0.062

Telfaira occidentalis	ND	ND	0.005±0.002	0.092±0.018
Soil	ND	ND	0.014±0.005	0.836±0.018
Vernonia amygdalina	ND	0.003±0.001	0.001±0.001	0.101±0.048
Soil	ND	0.007±0.003	0.005±0.003	0.760±0.166

Note: ND = not detected, values reported in mean ±SD format with N=3

Table 3: Target Hazard Quotients (THQ) of heavy metals in Bekwara in the rainy season

Vegetables	Hg	Ni	Pb	Zn
Amarathus spp	Nil	0.0004	0.0031	0.0004
Corchorus olitorius	Nil	0.0005	0.0057	0.002
Murraya koenigii	Nil	0.0006	0.0018	0.0003
Ocimium grattissimium	Nil	0.0001	0.0062	0.0005
Solanum melongena	Nil	0.0005	0.0035	0.0005
Talinium triangulare	Nil	0.0004	0.0026	0.0006
Telfaira occidentalis	Nil	Nil	0.0018	0.0006
Vernonia amygdalina	Nil	0.0003	0.0009	0.0006

Note: Hg was not detected and so has Nil for THQ.

Table 4: Target Hazard Quotients (THQ) of heavy metals in Bekwara in the dry season

Vegetables	Hg	Ni	Pb	Zn
Amarathus spp	Nil	0.0002	0.0018	0.0003
Corchorus olitorius	Nil	0.0005	0.0035	0.0002
Murraya koenigii	Nil	0.0005	0.0013	0.0003
Ocimium grattissimium	Nil	0.0001	0.0044	0.0005
Solanum melongena	Nil	0.0005	0.0022	0.0004
Talinium triangulare	Nil	0.0002	0.0022	0.0005
Telfaira occidentalis	Nil	Nil	0.0022	0.0005
Vernonia amygdalina	Nil	0.0002	0.0004	0.0005

IV. Discussion

The results in Tables 1 and 2 revealed that there is some level of heavy metals contamination in the study area especially Ni, Pb and Zn. Hg was not detected in the soil or the vegetable samples, indicating that its concentration in the soil is still insignificant to be available for the vegetables to accumulate. Therefore, Hg is a string variable in the data. From the results, the highest amount of Ni accumulated was 0.008 $mgkg^{-1}$ and 0.007$mgkg^{-1}$ by *Murraya koenigii* for rainy and dry season respectively at the soil level of 0.012 and 0.011 for rainy and dry season respectively.

The lowest was 0.001$mgkg^{-1}$ by *Ocimium gratissimum*for both seasons. The highest values of Pb accumulated was 0.014 at the soil level of 0.033$mgkg^{-1}$ in rainy seasons by *Ocimium gratissimum*and 0.010 at the soil level of 0.029$mgkg^{-1}$ in dry season, whereas its lowest values accumulated was 0.002 at the soil level of 0.007 in the rainy season and 0.001 at the soil level of 0.005 in the dry season by *Vernoniaamygdalina*. The highest value of Zn accumulated was 0.110 at the soil level of 0.605 in the rainy season by *Talinum triangulare* and 0.101 at the soil level of 0.760 in the dry season by *Vernonia amygdalina*, whereas its lowest values accumulated was 0.047 at the soil level of 0.522 in the rainy season and 0.043 at the soil level of 0.520 in the dry season both by *Corchorus olitorius.*The average concentration of the metals in the vegetables and the soil was in the order Zn>Pb>Ni>Hg.

These results indicate that there is no significant difference between the metals concentration both in the soil and in the vegetables for both seasons, suggesting that the source of the pollution metals may not be from air pollution sources like vehicular emissions or irrigation water sources used during the dry season. Rather, their sources could be from other anthropogenic sources like indiscriminate disposal of waste containing heavy metals, industrial sewage, leachate from auto mechanic workshops or quarrying sites which are transported to the vegetable gardens during rainy season erosion. However, the amounts of the metals in the soil are still low and the amounts accumulated by the edible vegetable in the area are still within the permissible limit of FAO/WHO which is 0.1 $mgkg^{-1}$.

The availability of heavy metals in the soil for plants depends on many factors like PH, soil texture or porosity among others. Earlier research in the area by Free Library (2014) reported the soil is quite acidic and porous. It has been proved by several researchers that as the soil PH decreases, the solubility of cationic forms of metals in the soil solution increases and thus they become readily available for plants to accumulate (Gray et al., 1998, Salam and Helmke, 1998, Chlopecka et al., 1996, Single et al., 1995).

The results in Tables 3 and 4 showed the Target Hazard Quotients (THQ) of the heavy metals in the edible vegetables in the study area for the rainy and dry seasons respectively. The results indicate that the THQ values for Ni, Pb, and Zn which were detected in the vegetables were far less than 1 for all the vegetables in the season. This implies that the heavy metals concentration in the vegetables is not posing any risk and there is no potential health risk associated with their consumption at the moment. According to US-EPA/IRIS (2003), it is only THQ values greater than 1 that indicates there is potential health risk associated with the consumption of food or vegetables contaminated with a certain pollutant or heavy metal. Based on this, the THQ values agreed with the fact that the mean concentrations of these heavy metals in the vegetables are still low and are within the permissible limits of FAO/WHO.

V. Conclusion

The results of this study have revealed that Bekwara urban area is contaminated with some heavy metals especially Ni, Pb and Zn at a very low concentration at the moment. Edible vegetables in the area have also accumulated some of these heavy metals though at a concentration that is still within the permissible limit of WHO and there is no health risk associated with the consumption of the vegetables for now. The source of these metals could be from anthropogenic activities like indiscriminate disposal of waste containing some of these heavy metals among others. One can therefore recommend that the relevant government agencies should monitor and evaluate the environment regularly at an interval of 5 to 10years and advise the public accordingly. Also, other heavy metals not considered in this study can be considered for further study.

References

[1]. Akan, J. C., Abdulahaman, F. I. Sodipo, O. A. & Lange, A. G.(2010). Physiochemical parameters in the soil and vegetable samples from Gongulon agricultural sites Maiduguri Borno State, Nigeria.*Journal of American science (12): 78-88*

[2]. Chandorka, S. &Deota, P. (2013). Heavy metals content of foods and health risk assessment in the study population of Vadodara. *Current world environment* 8(2). Available from http://www.civejournal.org/?p=4762

[3]. Chlopecka, A., Bacon, J. R., Wilson, M. J. and Kay, J. (1996). Forms of Cadmium, lead and zinc in contaminated soils in south-west Poland. *Journal of Environmental Quality.25:69-79*

[4]. Dmello,J.P.F.(2003). *Food safety contaminants and toxins.* Walling Food, Oxon, U.K., Cambridge M.A, (AB) Publishing.

[5]. Free Library (2014). *Mineralogy and geochemical properties of some upland soils from different sedimentary formations in south-eastern Nigeria.*www.thefreelibrary.com (accessed July, 2015).

[6]. Gray, C. W., Mclaren, R. G., Roberts, A. H. &Condron, L.M.(1998). Sorption and desorption of Cadmium from some New Zealand soils: Effect of PH and contact time. *Australian Journal of soil research 36: 199-216.*

[7]. Hardy, D. H. Myers, J. & Strokes (2008). *Heavy metals in North Carolina soils: occurrence and significance.* North Carolina, USA. Agronomy Division, Dept. of Agriculture and consumer service.

[8]. Harmanescu, M. Alda, L. M., Bordean, D. M., Gogoasa, I. &Gergen, I. (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study. Banat country, Romania. *Chemistry Central Journal5: 64.*doi: 18: 1186/1752-153x-5-640.

[9]. IRIS (2003). Integrated Risk Information System- database. US Environmental Protection Agency (US-EPA).

[10]. Lenntech (1998-2014). *Effect of some heavy metals.*www.sciencedaily.com (accessed 22nd July 2014).

[11]. Mahmood, A. I. & Malik, N. R. (2014). Human health risk assessment of heavy metals via consumption of contaminated vegetables collectd from different irrigation source in Lahore, Pakistan. *Arabian Journal of Chemistry 7(1): 91-99.*

[12]. Salam, A. K. &Helmke, P. A. (1998). The PH dependence of free ionic activities and total dissolved concentrations of copper and cadmium in soil. *Geoderma 83: 281-291*

[13]. Signh, B. R., Naiwai, R. P., Jeng, A. S. &Ahmas, A. (1995). Crop uptake and extractability of Cadmium in soils naturally high in metals at different PH levels. *Communication of soil science and plant analysis 26:2133-2142.*

[14]. Sobukola, O. P., Adeniran, O. P., Odedara, A. A. &Kaijihausa, O. E. (2010). Heavy metals level of some fruit and leafy vegetables from selected markets in Lagos, Nigeria. *African Journal of food science 4(2):389-393.*

[15]. Zhou, Q., Wu, Y. &Xiong, X.(1994). Compound pollution of Cd and Zn and its ecological effect on rice plant. *China J. Applied Ecology 5:428-441.*

[16]. Zhuang, P. Mcbride, M. B., Xia, H., Li, N. & Li, Z.(2009). Health risk from heavy metals via consumption of food crops in the vicinity if Daboashan mine, South China. *Science of the total environment 40(5):1551-1561.*

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