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Health Risk Assessment of Heavy Metals (Cr, Ni, Pb & Zn) Contamination of Edible Vegetables in Ogoja Urban Area of Cross River State

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Abstract— **The mean concentration of Cr, Ni, Pb and Zn in edible vegetables grown in Ogoja Urban area of Cross River State was determined both in the vegetables and the soil. The Target Harzard Quotient (THQ) was also calculated to assess the possible health risk associated with the consumption of the vegetables. To achieve this, samples of eight vegetables namely: Amaranthus spp, Corchorus olitoruis, Murraya koenigii, Ocininum grattissimum, Solanum melongena, Talinum triangulare, Telfairia occidentalis and Vernonia amygdalina were collected together with the soil samples where they were planted during the rainy and dry seasons of the year. They were digested and analyzed for mean metal concentration using Atomic Absorption Spectrometer (AAS). The results show that the mean concentration range of Cr and Zn in the soil was 0.004-0.016 mgkg-1 and .329 – 1.077mgkg-1 respectively in dry season, and 0.004-0.018 mgkg-1 and 0.333 – 1.265 mgkg-1 respectively in rainy season. The mean concentration of Cr and Zn accumulated by the vegetables ranged from 0.002 – 0.008mgkg-1 and 0.015 – 0.083 mgkg-1 respectively in dry season, and 0.003 – 0.008 mgkg-1 and 0.017 – 0.087 migkg-1 respectively in rainy season. Ni and Pb were string variables as their concentration was not detected both in the soil and in the vegetables. The Target Harzard Quotient (THQ) values of Cr and Zn for all the vegetables were less than 1 indicating there is no health risk associated with the consumption of the vegetables at the moment. The results also reveal that there is some level of heavy metal (Cr and Zn) contamination in the area and the vegetables, though very low, and within the permissible limits of World Health Organisation (WHO). There is no significant difference between the results of the dry and rainy season, indicating the source of contamination of not necessary from air pollution source or irrigation water but from indiscriminate disposal of waste (anthropogenic sources). The government and relevant agencies should monitor and evaluate the environment in this aspect and create awareness for public health.**

Index Terms— **Edible Vegetables: Health risk assessment, Heavy metals contamination, Ogoja urban area.**

I. Introduction

A heavy metal is a general collective term which applies to the group of metals and metalloids with an atomic density greater than 4 gcm^{-3}. Although it is a loosely defined term, it is widely recognized and related to the wide spread contaminants of land and fresh water ecosystems [1]. Wikipedia free online encyclopedia also described a heavy metal as a member of a loosely defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloids lanthanides and actinides. Several different definitions have been advocated for heavy metals based on density, atomic number or weight, chemical properties or toxicity. Besides heavy metals have become popular as major pollutants or contaminants of the environment and due to their large number, and serious health challenges they pose to humans, animals and plants. Food safety has also become a major issue all over the world is it has significant effect on the health of man and animals. Dmello have stated that increasing demands for food and its safety has drawn the attention of researchers to the risks associated with consumption of contaminants (pesticides, heavy metals and toxins) in vegetables [2]. According to Khair, heavy metals are the major contaminants of our food. This is due to the fact that significant level of toxic chemical elements are frequently released into the seas, rivers, lakes and irrigation channels from industrial wastes and other anthropogenic sources [3]. Plants accumulate these heavy metals (toxicants) from contaminated soil and water. Man and animals get affected or contaminated by accumulating these metals through the consumption of contaminated plants or vegetables cultivated in contaminated soils. In order to ensure food safety for mankind and animals, several researches on heavy metal contamination have been carried out in different part of the world by scholars like Kumar in India, Kananke in Sri Lanka, Alberto in Mexico, Michein in Romania, Raphael in Makurdi, Nigeria etc[4,5,6,7,8]. Raphael have also stated that the consumption of contaminated vegetables constitutes and important route of animals and human exposure [8]. Some of the effects of heavy metals on human health according to Lenntech include ulceration, kidney, liver, nerve, tissue and circulatory damages due to toxic levels of chromium, heart, liver damages and skin irritation is caused by high doses of Nickel. Low intelligence Quotient (IQ) in children, nervous system, brain and fetus damages is caused by high level of lead, excess zinc levels in humans also causes several physiological disorders in body systems while high doses cadmium cause bone defects, renal dysfunction and lung cancer [10].

Therefore, the need to investigate heavy metal contamination of vegetables in areas where such research has not been carried out is very necessary for public health and awareness. In view of this, heavy metals (Cr, Ni, Pb and Zn) concentration in edible vegetables cultivated in Ogoja town were studied and the Target Hazard Quotient calculated to ascertain whether there is any health risk associated with the continuous consumption of these vegetables or not.

Ogoja is one of the oldest Local Government Areas with its headquarters town in Igoli extending to Monaya, Abakpa and

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it environs. As an urban area with many government agencies, like banks, tertiary institutions, small and medium scale enterprises etc., the population of the inhabitants is high compared to other parts of the Local Government Area due to rural-urban migration. This makes it to have a reasonable amount of vehicular traffic and auto mechanic workshops, coupled with the fact that it is major a link from the state capital to Northern Nigeria. Thus, the release of wastes containing heavy metals into the environment is inevitable. Besides the people in their culture like most Africans practice rotational waste dumpsites within their backyards or premises. Edible vegetables are often planted in old waste dumpsites in order to tap the compost manure for good yields and harvest. However, wastes are usually dumped indiscriminately in these dumpsites, which include metal objects and scraps. With the undulating nature of the area, hills and plains in the area, it is possible that leachates or metal wastes from workshops and industries can be transported during excessive rainfall and deposited in some nearby farm lands. All these factors can possibly make heavy metals available to plants and vegetables depending on the concentration in the soil. Therefore, there is need to study the quality of vegetables consumed by the population in terms their heavy metals content.

II. MATERIALS AND METHODS

A.Sampling and sample pre-treatment: forty soil samples and vegetables were collected randomly at different locations within Ogoja urban area and the closest neighborhood. The soil samples were collected at the root level of the vegetables at the depth of about 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 forth soil samples include: *Amaranthus spp* (Green vegetables), *Corchorus olitorius* (Ewedu), *Murraya koeningii* (Curry leaf), *Ocimium grattissimum* (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 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 ground into powder, sieved with 0.3mm sieve and stored in a labeled plastic jar with cap. The soil sampled was also oven–dried, ground into find powder and homogenized with pestle and mortar, sieved and stored in labeled plastic jars separately.

B. **Digestion of samples:** vegetable samples were digested following the procedure of Sobukola [11] thus: 1.0$_{g}$ of each sample was placed in a beaker and 20cm^3 of concentrated (HCI), 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 30 minutes. 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 [12] thus: 2.0g of each soil sample powder was weighed into an acid washed beaker. 20cm^3 of aqua regia (mixture 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% 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.

C.Element analysis: the soil and vegetable samples were analyzed for Cr, Ni, Pb and Zn using the210 VGP Buck scientific model Atomic Absorption Spectrometer (AAS) at the following wavelengths.

Cr (357.0nm), Ni (232.0nm), Pb (283.3nm) and Zn (213.1nm).

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

$THQ = \frac{DIV \times \mathrm{Cm}}{\mathrm{RfD} \times \mathrm{B}}$ 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 RfD 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 70kg for adult males and 60kg for adult females. For this study, the average of 70kg and to kg) for all adults, while the DIV was assumed to be 100g (0.1kg/day) per day. In some countries or places, up to 150 or 200g per day has been assumed especially for vegetarians. From the formula, THQ is a dimensionless parameter or ratio. According to IRIS, if THQ is less than 1 (THQ<1), it shows that there is no potential health risk associated with the pollutant [13]. But if THQ>1, there is a health risk associated with the pollutant (heavy metal) at that moment. The RfD for Cr, Ni, Pb and Zn from IRIS are 0.03, 0.01, 0.0035 and 0.300 mgkg^{-1} respectively.

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

III. RESULTS

The concentration of Cr, Ni, Pb and Zn in the soil and the eight vegetables both for the rainy and dry seasons are presented in Tables 1 and 2 respectively, while their Target Hazard Quotients (THQ) are in Tables 3 and 4 respectively

Table 1: Mean heavy metal concentrations (mgkg^{-1} dry weight) in soil and vegetables during the rainy season in Ogoja.

Vegetable	Cr	Ni	Pb	Zn
Amaranthus spp	0.003 ± 0.001	ND	ND	0.017 ± 0.003
Soil	0.007 ± 0.003	ND	ND	1.265 ± 0.260
Corchorus olitorius	0.005 ± 0.002	ND	ND	0.025 ± 0.003
Soil	0.008 ± 0.004	ND	ND	0.433 ± 0.023
Murraya koenigii	0.006 ± 0.003	ND	ND	0.027 ± 0.002
Soil	0.012 ± 0.004	ND	ND	0.529 ± 0.085
Ocimium grattissinum	0.007 ± 0.003	ND	ND	0.043 ± 0.004
Soil	0.018 ± 0.003	ND	ND	0.333 ± 0.024
Solanum melongena	0.001 ± 0.002	ND	ND	0.069 ±0.004
Soil	0.004 ± 0.001	ND	ND	1.132 ± 0.207
Talinum triangulare	0.008 ± 0.003	ND	ND	0.087 ±0.005
Soil	0.012 ± 0.002	ND	ND	0.980 ± 0.073
Telfaira occidentalis	0.005 ± 0.002	ND	ND	0.075 ± 0.003
Soil	0.010 ± 0.004	ND	ND	0.439 ± 0.004
Vernoina amygdalua	0.003 ± 0.002	ND	ND	0.037 ± 0.004
Soil	0.005 ± 0.002	ND	ND	0.611 ± 0.317

Note: ND = Not delected

Table2: Mean heavy metal concentrations (mgkg^{-1} dry weight) in soil and vegetables during dry season in Ogoja.

Vegetables	Cr	Ni	Pb	Zn
Amaranthus spp	0.003 ± 0.002	ND	ND	0.015 ± 0.003
Soil	0.006 ± 0.004	ND	ND	0.562 ± 0.078
Corchorus olitorius	0.004 ± 0.002	ND	ND	0.023 ± 0.004
Soil	0.008 ± 0.004	ND	ND	0.423 ± 0.021
Murraya Koenigii	0.006 ± 0.004	ND	ND	0.024 ± 0.001
Soil	0.010 ± 0.003	ND	ND	0.499 ± 0.070
Ocimium grattissmum	0.008 ± 0.002	ND	ND	0.025 ± 0.003
Soil	0.016 ± 0.002	ND	ND	0.329 ± 0.025
Solanum melongena	0.002 ± 0.001	ND	ND	0.049 ±0.030
Soil	0.004 ± 0.001	ND	ND	1.077 ± 0.079
Talinum triangulare	0.007 ± 0.003	ND	ND	0.083 ±0.007
Soil	0.011 ± 0.003	ND	ND	0.920 ± 0.101
Telfaira occidentalis	0.003 ± 0.001	ND	ND	0.054 ± 0.001
Soil	0.009 ± 0.004	ND	ND	0.426 ± 0.024
Vernonia amygdalina	0.002 ± 0.001	ND	ND	0.035 ± 0.009
Soil	0.005 ± 0.002	ND	ND	0.598 ± 0.067

Note: ND = Not delected

Tables3: Target Hazard Quotients (THQ) of Heavy metals in Edible vegetables in Ogoja in Rainy Season.

Heavy Metal	*Amaranthus spp*	*Corchonus olitorius*	*Murraya koenigii*	*Ocimum grattissimum*	*Solanum melongena*	*Talinum triangulare*	*Telfaira occidentalis*	*Vemonia amygdalina*
Cr	0.0015	0.0026	0.0031	0.0036	0.0005	0.0041	0.0026	0.0015
Ni	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Pb	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Zn	0.0087	0.0128	0.0139	0.0221	0.0354	0.0446	0.0385	0.0190

Table4: Target Hazard Quotient (THQ) of Heavy metals in edible vegetables in Ogoja in Dry Season.

Heavy Metal	*Amaranthus Spp*	*Corchonus olitorius*	*Murraya koenigii*	*Ocimum grattissimum*	*Solanum melonga*	*Talinum triangulare*	*Telfaira occidentalis*	*Vernonia amygdalina*
Cr	0.0015	0.0021	0.0031	0.0041	0.0010	0.0036	0.0015	0.0010
Ni	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Pb	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Zn	0.0077	0.0118	0.0123	0.0128	0.0251	0.0426	0.0277	0.0180

IV. DISCUSSION

The results in Tables 1 and 2 revealed that there is some level of heavy metal concentration in the study area, especially Cr and Zn. Ni and Pb were not detected in soil or the vegetables. It might be that their concentration in the soil is still insignificant to be available for the vegetables. Thus, Ni and Pb are string variables in the data. For Cr and Zn, the data revealed that there is no significant difference between their concentration both in the soil and in the vegetables for both seasons, suggesting that the source of these metals may not be from air pollution sources like vehicular emissions or irrigation water sources used during the dry season. Rather, the source may be from other anthropogenic sources like indiscriminate disposal of waste containing metals industrial sewage, leachates from auto mechanic workshops, which are transported to the vegetable gardens during rainy season erosion. Besides, vegetables planted in old waste dumpsites for compost manure may accumulate metals if they are present in soil. However, the amount of Cr and Zn
were still within the permissible limits of FAO/WHO which is 0.1mgkg-1.

The bioaccumulation of these metals by vegetables depends on the amount of the pollutant (metal) in the soil, its chemical form and soil pH which determines its availability for the vegetable. Shuman and Kiekens have stated earlier that Zn availability to plants in the soil depend on its chemical form in the soil and the dynamic equilibrium among its different forms or fractions in the soil [14], [15].

McBride has also observed that increased in soil concentrations of heavy metals increases the crop or vegetable uptake [16]. This accounts for why there are some slight variations in the mean concentrations of metals in vegetables from place to place in the study area.

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 season respectively. The results reveal that THQ values for Cr and Zn which were detected in the vegetables were far less than 1 for all the vegetables. This implies that the heavy metals concentration in the vegetables is not posing any risk and there is no potential health risk associated with the consumption of the vegetables at the moment. The results were the same for both the rainy season and the dry season.

According to IRIS, it is only THQ values greater than 1 indicates there is potential health risk associated with the consumption of food or vegetables contaminated with a certain pollutant or heavy metal [13]. Based on this, THQ agrees with the fact that the mean concentrations of these heavy metals in the vegetables and soil are still low and are within the permissible limits of FAO/WHO.

CONCLUSION

The results of this study have revealed that Ogoja town and its environs are contaminated with some heavy metals especially Cr and Zn even though the concentration is still very low. Edible vegetables in the area have also accumulated some these heavy metals, and the amount accumulated is directly proportional to the amount in the soil where they are planted. The mean concentration of Cr and Zn are still within the permissible limits of WHO which are 0.1mgkg-1 and 0.3 respectively. There is no significant difference between the mean concentrations of heavy metals in the rainy season and that of the dry season, indicating that their source is from anthropogenic activities especially indiscriminate disposal of waste containing some of these metals and not from air pollution sources. Therefore, one can recommend that, there is need for relevant government agencies to monitor and evaluate the environment regularly and advise the public accordingly on the dangers associated with indiscriminate disposal of waste and resultant contamination of food and vegetables planted in the environment for consumption.

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