DISTRIBUTION AND CONCENTRATION OF HEAVY METALS IN SOME VEGETABLES AND SOIL FROM VEGETABLE FARMS OF ANGWAN WAZIRI, AKWANGA, NASARAWA STATE , NIGERIA

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Abstract
The concentration of heavy metals in five vegetables comprising of leaves and fruits from vegetable farms in Agwan Waziri, Akwanga were studied. Leaf samples of spinach, Garden egg and fruit samples of tomatoes, cucumber and water melon as well as soil samples were collected from the farms and analyzed for Cd,Cu,Pb,Zn,Fe and Ni using atomic absorption spectrophotometric method. The heavy metals in vegetable ranged to1.76ugg^{-1}mean levels of 0.01, 0.04, 8.30, 13.05,7.53,24.75 and 1.48, 1.76ugg-^{1} for Cd,Cu,Pb,Zn,Fe and Ni respectively while the soil had the mean metal levels of 0.05, 4.25, 0.55, 25.25, 60.05 and 1.70ugg^{-1} for Cd,Cu,Pb,Zn,Fe and Ni respectively. In all, values for these metals in both the vegetables and soil generally indicate the presence of metals analyzed in vegetable samples that might have been taken up from the soil. However, all the values are within the permissible limits set by world regulatory bodies for food, FAO/WHO,EC/CODEX. Hence the consumption of these plant base food substances will not likely pose any danger to the consumers.

Keywords*:* Agwan Waziri, Concentration, Heavy metals, Soil, Vegetables

Pollution of the environment with heavy metals, even at low concentrations, and their long term cumulative health risks are part of the major health worries globally (Oluyemi, Fenyit, Oyekunle & Ogunfowokan, 2008, Opaluwa and Umar, 2010). For instance, bioaccumulation of Pb in human body interferes with the functioning of mitochondria, thereby impairing respiration, and also causes constipation, swelling of the brain, paralysis and eventual death (Chang, 1998). Humans affect the natural geological and biological redistribution of heavy metals released to the environment (Charlerati, Wan & Li. 1980). Such alterations often affect the heavy metals' toxicity by allowing it to bio-accumulate in plants and animals, bio-concentrates in food chain, or attack specific organs of the body (Charlerati et al, 1980).

Though through precipitation of ion exchange, heavy metals and their compounds enters into the soil, mud and most times, heavy metal pollutants can localize and lay dormant. Unlike organic pollutant, they do not decay and thus pose a different kind of challenge for remediation and therefore calls for thorough researches on them. A well documented environmental disaster associated with heavy metals is the Minamater disease caused by mercury (De Benzo and Fernandez, 2000).

An important source of heavy metals is liquid waste from metals galvanization, the tanning industry and other industries; sludge from sewage treatment plants, as well as municipal waste. Large quantities of some heavy metals such as Cd and Hg enter the soil and subsequently ground water and food chains through the extensive use of certain agrochemical (Environmental Protection Heritage Council, EPHC, 2003). These chemicals include phosphorous-based fertilizers and certain pesticides especially those designed to protect cereals from fungal infections.

In most developing countries, environmental pollution is at its peak because of the indiscriminate dumping of domestic wastes and refuse into water bodies and where not available, agricultural farmlands are used as the sites for dumping. These wastes often contain heavy metals in various forms and at different contamination levels. Some of these heavy metals are As, Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni, and Zn which end up in the soil as the sink when they are leached from the dumpsite (Oluyemi, Feyit, Oyekunle & Ogunfowokan, 2008).

The use of dumpsites as farm land is a common practice in urban and sub urban centers in some developing countries of which Nigeria is not an exception. This is due to the fact that decayed and composted wastes enhance the fertility of the soil (Ogunyemi, Awodoyin & Opadeji, 2003). Some heavy metals like As,Cd,Hg,Pb are particularly hazardous to plants, animals and humans (Alloway and Ayres, 1997). Vegetables grown in polluted environment, waste dump sites and landfills irrigated with polluted water are potential sources of trace heavy metals in plant-based food substances because it could eventually lead to bio-accumulation and bio-concentration of these heavy metals in the tissues of plants.

Vegetable uptake of metals is one of the major pathways soil metals enter into food chain and are subsequently bio-accumulated to high concentrations causing serious risks to human health when contaminated plant-based food stuffs are consumed (Daniel, Nimyel & Damiang, 2006). The health risks depend on the chemical composition of the waste materials, its physical characteristics, the vegetables cultivated and the consumption rate (Khariah, Zalita, & Amina,1984). Generally, higher concentrations of trace metals are found in leafy vegetables and roots crops than other types of vegetables (Environmental Protection Heritage Council, EPHC, 2003).

The chief significance of vegetables is their supply of considerable amounts of vitamins and minerals which the body requires. The darker the green leaves of plants, the more, they received sunlight and more likely to metabolize and have large proportions of nutrients, hence the darker the vegetable, the greater the nutrients value (Ojeka and Achi, 2005).

Fruits and vegetables are also very important sources of natural antioxidants. Antioxidants are substances that interrupt the process of oxidation reactions. The natural antioxidants constitute an important component of fruits and vegetables in human diets. The distribution of these constituents varies and depends on the pigments produced by the plant species and the plant family where they belong. If the biological properties of antioxidant are taken into consideration, a diet enriched with fruits and vegetables is expected to reduce the possibility of life limited diseases like cancer, diabetes, hypertension, etc. (Adelakun, 2004).

Vegetable farm in this part of Akwanga supplies the major vegetables needs of people in the town and its envious. In view of the importance of vegetables and the health risks associated with high concentrations of heavy metals in plant based food (vegetable), there is a need for this type of work to ascertain the level of heavy metals in vegetable grown in this area and to know if any danger will be posed if they are consumed.

Materials and Methods

Sample Collection and Preparation

Sampling was done on vegetable farms in A/Waziri, Akwanga. The vegetable samples were leaves of spinach, and garden egg while the fruit vegetable samples were tomatoes, cucumber and water melon. Samplings were done between July and September, 2015, on all the vegetable farms and on each farm, it was done randomly. The same kinds of vegetable were mixed to give a representative fraction of the vegetable (Opaluwa and Umar, 2010). The vegetable harvested were washed with water and rinsed with distilled water in order to remove soil particles, shredded and sun dried. The dried samples were pounded in an agate mortar with pestle and the ground samples sieved through 200um mesh size and stored in polythene bags awaiting analysis (Ceirwyn, 1985). Soil samples were collected from the farms from point where the vegetables were uprooted to the depth of about 5-10cm (Awofolu, Mbolekwa, Mtshmla & Fatoki 2010). The samples were sun dried, ground in an agate mortar with pestle, sieved through 200um mesh size and stored in polythene bags awaiting analysis.

The ground samples of vegetable 1. 0g each were weighed into conical flask and 10.0ml of concentrated HNO_3 and 5.0ml of per-chloric acid added, the mixture was swirled and were digested on a hot plates at 80^0C in the fume cupboard until the digest were clear, digested volumetric flasks, cooled and made up to the mark with de-ionized water (Daniel et al., 2006). 5.0g of the soil sample was weighed into 150cm conical flask, digested using 15.0ml nitric acid 2.0ml perchloric acid and placed on hot plate for3h (Atolaye,Aremu, Shagye&Pennap, 2006). On cooling, the digest was filtered into 100.0ml volumetric flask and made up to the mark and ready for analysis.

Mineral Analysis

The digested solutions were analyzed for Cd, Cu, Pb, Zn, Fe and Ni using Atomic Absorption spectrophotometer, (AAS). All chemicals used are of analytical grade.

Results and Discussion

The mean levels of six heavy metals determined in the soil and five different types of vegetables that were grow on vegetable farms in AgwanWaziri, Akwangaare shown in Table 1. For metal levels in vegetables, it was discovered that iron and zinc had higher concentrations in Garden egg leaves and spinach followed by cucumber and then the fruit vegetables that is, tomatoes, cucumber and water melon. These results agree with the report of Opaluwa and Umar, (2010) that the leafy vegetables accumulate these metals more than fruit vegetables. For cadmium in vegetables studies, the level ranged from 0.01-0.04ug/g. For copper the range was from 0.09 3.08ug/g, lead levels in vegetables ranged from 0.03- 0.06ug/g, for zinc it was from 8.30-13.05ug/g, for iron the range was 7.53- 24.75ug/g. The levels of metals in the soil were 0.05,4.25,0.58,25.95,65.05 and 1.09ugg-1 for Cd, Cu, Pb,Zn,Fe and Ni, respectively. The levels of Cd Pb, Zn, in the analysed samples in this report are lower than the values reported for spinach and pumpkin leaves grown along major highways in Eastern Nigeria reported by Alinnor, (2008). However, the values reported for Cd Pb, Cu,Zn Cu and Ni in our report are comparable to the values reported for the same metals in vegetables and soil from an irrigated farmland in South Africa (Awofolu et al., 2010).

Table 1: Mean Metal Levels (ugg-1) in Vegetables Grown in Agwan Waziri, Akwanga, Nigeria

Metals	**Spinach**	**Tomatoes**	W/melo	**C/ber**	**G/egg**	**Mean**	**S.D**	**Cv%**	**Soil**
Cd	0.04	0.01	0.03	0.01	0.04	0.03	0.01	37.37	0.05
Cu	1.01	3.08	0.09	2.57	2.05	1.76	0.20	39.02	4.25
Pb	0.06	0.03	0.05	0.03	0.04	0.04	0.01	9.99	0.55
Zn	13.05	8.30	9.30	8.5	10.45	9.92	1.07	10.49	25.25
Fe	14.85	9.70	.7.00	7.53	24.75	13.62	1.28	29.96	60.05
Ni	1.63	1.76	1.50	1.58	1.48	1.59	0.02	2.25	1.70

S.D: Standard Deviation
C.V: Coefficient of Variation

The levels of metals in the vegetables are within the normal range for metals in plant leaves and much lower than the toxic levels, and are also within the permissible limit set by the various regulatory bodies (Tables 2 and 3).

The metals levels in the soil are higher than those in vegetables except for nickel. Nickel concentration increasing with depth showing the tendency of Ni increasing from surface irrespective of drainage (Opaluwa and Umar, 2010), therefore, the low level of nickel at the surface soil could be because Ni is being leached from topsoil layer by percolating rain water and by depletion arising from plant uptake and erosion (Adekenya, 1998).

Plants are known to take up and accumulate trace metals from contaminated soil (Singh, 2001) hence detection in vegetable samples was not surprising. When the levels of metals in the different vegetables were compared, the highest variability was found in Cu (39.09%) while Ni was the least varied (2.25%). The order of variation in descending order was Cu>Cd>Fe.Zn>Pb>Ni.

Table 2: Normal and Phytotoxic Level (ugg^{-1}) of Metals Found in Plant Leaves

Metal	Normal	Toxicity
Cd	0.1-2.4	5-30
Cu	5-20	20-100
Pb	5-10	30-300
Zn	1-400	100-400
Fe	40-500	-
Ni	0.02-5	10-100

Source: Opaluwa and Umar, 2010.

Table 3: Guidelines for Metals in Foods and Vegetables

Metal	**Normal range**	**NAFDAC**	**EC/CODEX**	**FAO/WHO**
Cd	<2.4	-	0.2	1
Cu	2.5	20	-	30
Pb	0.5-30	2	0.3	2
Zn	20-100	50	<50	60
Fe	40-500	-	-	48
Ni	0.02-50	-	-	-

Codex Alimantarius Commission, NAFDAC, FAO/WHO, 2003

Table 4 which shown the bio-concentration factors in the various vegetables revealed that Ni had the highest values in the vegetables ranging from 0.91in garden egg to 1.12in tomatoes and the lowest bio-concentration values was found in Pb ranging from 0.03 in tomatoes and cucumber to 0.10 in spinach. The high bio-amplification of Ni in this study, suggests that the vegetables have good uptake mechanism of Ni than the others. The rate of bio-accumulation of heavy metals by plants depends on their levels in the soils and the ability of these plants to store them after the uptake (Daniel, et al, 2006). Cd, Cu, Pb, Zn, and Fe had bio-concentration factors less than 1.0 while Ni had more than 1.0. However, these are consistent with the biological magnification hypothesis (Aremu and Inajoh, 2007)

Table 4: Bio-concentration Factor of Metals in Vegetable Grown in AgwanWaziri,Akwanga, Nigeria

Metals	Spinach	Tomatoes	Cucumber	Water melon	Garden egg
Cd	0.41	0.20	0.27	0.21	0.41
Cu	0.01	0.33	0.15	0.30	0.17
Pb	0.01	0.03	0.05	0.03	0.04
Zn	0.15	0.02	0.05	0.03	0.08
Fe	0.09	0.20	0.03	0.08	0.13
Ni	1.03	1.12	0.93	1.00	0.91

Source; Opaluwa and Umar, 2010

Table 5: The Average Percentage Recoveries of Metal Standard added to Pre-digested Vegetables, Soil and Sediment Samples

Metals	Vegetable	Soil
Cadmium	79±4.3	77±2.7
Copper	88±5.5	87± 3.6
Lead	80±5.1	78±1.1
Iron	82±8.1	80±4.3
Zinc	85±5.3	81±2.0
Nickel	88±4.7	83±3.7

Values are ± MD (Mean deviation) of three determinations

Conclusion

The study revealed the presence of metals analysed in all the vegetables and soil samples, an indication of uptake of these metals from the soil, since the levels of the metals in the soil are higher those in the vegetable except Ni.

However, the levels of these metals in vegetables are within the normal range for metals in plant leaves and much lower than the toxic levels and are also within the permissible limit set by the various regulatory bodies. Hence consumption of these vegetables should not be of concern for now but there might be a need for periodic assessment.

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