Heavy Metal Contents of Cassava Leaves (*Manihot esculenta*) obtained from Andoni Local Government Area of Rivers State

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Abstract: The concentrations of selected heavy metals in cassava leaves obtained from Andoni Local Government Area of Rivers State were determined using atomic absorption spectrophotometer (AAS) and compared with the soils on which they Cassava grows. The result obtained showed a high level of heavy metals in the order Zn > Pb > Hg in cassava leaves when compared with heavy metal detected in the different soils on which they grow. For all the farms, the soil plant transfer values were in the order Pb> Zn> Hg. This shows that among the three metals studied, lead was the easiest to migrate followed by zinc and then, mercury. This trend signifies that plant absorbs a higher concentration of lead from the soil in which it grows when compared to other metals present while Hg is the least absorbed metal. It was observed that the lead content in cassava leaves was above World Health Organization (WHO)/Food and Agricultural Organization (FAO) safe limit.
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Introduction

Cassava (*Manihot esculenta*) is a perennial crop native to tropical America (Allen 1994; Olsen and Schaal, 2001). The plant is characterized by palmate lobed leaves; inconspicuous flowers and a large, starchy, tuberous root with a tough papery brown bark and white to yellow flesh, (New World Encyclopedia, 2008). It is one of the most perishable tuber crops with a high postharvest loss (Diasolua *et al*., 2003). Anatomically, cassava root is not a tuberous root, but a true root, which cannot be used for vegetative propagation.

The mature cassava storage root has three distinct tissues: bark (periderm), peel (cortex) and parenchyma. The parenchyma, which is the edible portion of the fresh root, comprises approximately 85% of the total weight, consisting of the xylem vessels radially distributed in a matrix of starch containing cells (Wheatley and Chuze, 2013). Consequently, cassava is of lower nutritional value than cereals, legumes, and even some other root and tuber crops such as yams (Charles *et al*., 2005). Cassava root contains significant amount of iron, phosphorus, calcium and vitamin C, but is a poor source of proteins.

Heavy metals

Heavy metals are defined as those elements in the periodic table with atomic numbers greater than 20 or with densities greater than 5g/cm3. Heavy metals without doubt, are important constituents of plants and animals, when present only in small amount. Some micronutrient elements may also be toxic to both animals and plants at high concentrations. For instance, copper (Cu), chromium (Cr), fluorine (F), molybdenum (Mo), nickel (Ni), selenium (Se) or zinc (Zn). Other trace elements such as arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) are toxic even at small concentrations (Divrikli *et al*., 2006). Heavy metals, being persistent and non-biodegradable, can neither be removed by normal cropping nor easily leached by rain water (Khadeeja *et al*., 2013). They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops. For this reason, the knowledge of metal plant interactions is also important for the safety of the environment (Divrikli *et al*., 2006). The contamination of soils with heavy metals or micronutrients in phytotoxic concentrations generates adverse effects not only on plants but also poses risks to human health (Murugesan *et al*., 2008).

Afterwards, the consumption of contaminated vegetables constitutes an important route of heavy metal exposure to animals and humans (Sajjad *et al*., 2009; Tsafe *et al*. 2012). Abandoned waste dumpsites have been used extensively as fertile grounds for cultivating vegetables, though research has indicated that the vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils (Cobb et al., 2000; Benson and Ebong, 2005).

The main environmental burden with heavy metals is that they are non- degradable and most of them have toxic effect on living organisms when they are above the maximum permissible limit or concentration level either in water, soil or food substances (Hong *et al.* 2014). Heavy metals can accumulate in soil at lethal level due to long term application of waste-water. The contamination of vegetables with heavy metals as a result of the contamination of the soil and atmosphere creates a threat to the quality and safety of these vegetables (El-Fadel *et al.* 1997).

Heavy metal contamination levels in agricultural soil are of major significance because of the potential to accumulate in soil for a long period of time (Iweghue *et al.*, 2013). High concentration of heavy metal ions in soil environment may pose a significant risk to the quality of soils, plants, natural waters and human health (Wu and Zhang, 2010). Excessive accumulation of heavy metals in agricultural soils may result not only in soil contamination but also negatively affect food quality and human health. Evidence of heavy metal contamination pollution of agricultural soils and uptake of the heavy metals in vegetables and fruits in Romania and Brazil were reported by Lacatusu (2008) and Guerra *et al.* (2012).

Statement of the Problem

One of the world's most significant problems is pollution in which a lot of the inhabitants of the world suffer health problems due to daily contacts with industrial, (effluents, sewage, oil spillage, (etc), agricultural and atmospheric pollutants. In Nigeria and other parts of the world, industrial wastes and effluents are released at random on the soil, into inland waterways, rivers, along road sides or in the surrounding area of industry without any treatment or proper management.

These pollutants pollute productive soils, natural water systems as well as ground water. Heavy metals are extremely persistent in the environment and accumulate to toxic level. Cassava leaves are also eaten in some communities especially Ebukuma, Andoni, Rivers State, South-South, Nigeria after extensive boiling. The contamination of cassava leaves with heavy metals as a result of the contamination of the soil and atmosphere creates a threat to the quality and safety of the crop, hence the need for this project work. Studies on heavy metal concentration in cassava leaves have been done, but none has been done on cassava leaves from Ebukuma soil.

The present work reports on variations in three heavy metal concentration in cassava leaves (lead, mercury and zinc) growns in three different locations in Ebukuma. There are yet no reported physicochemical studies of cassava leaves grown in Ebukuma community in Andoni Local government Area of Rivers State, Nigeria. Therefore this study is aimed at determining the levels of three heavy metal (lead, mercury and zinc) in the soil and cassava leaves samples obtained from Ebukuma community in Andoni Local government Area of Rivers State, Nigeria. The general objectives of the study are to:

i. Analyze the three selected heavy metals: lead, mercury and zinc concentration levels in cassava leaves obtained from three different locations in Ebukuma in order to ascertain the food quality and safety of the cassava leaves consumed by the people of Ebuku.

ii. Compare the concentration levels obtained with set standards and to procure the present quality status as baseline data for future periodic monitoring of the rate of consumption of the cassava leaves in this area.

iii. Determine the concentration levels of these heavy metals in the soil where the cassava leaves obtained from the three farms located in the study area.

iv. Compare the levels of concentration of heavy metals in the soil and cassava leaves obtained from the three farms located in the study area with each other and with the standard.

v. Suggest the possible measures to manage the contamination to ensure safety to humans and animals.

Study Area

The three farms chosen for this project work are located in C.S.S Ebukuma, Ebukurna Health Centre and New Road in Ebukuma in Andoni LGA of Rivers State, Nigeria. Ebukuma is located on Latitude 4° N and Longitude 7° E with a population of 222,262, based on 2006 population census (Figure 3.1 The people in the study locations are into fishing activities and sustenance farming with the use of fertilizers to enhance the soil fertility.

Heavy Metals

Heavy metals are generally referred to as those metals which possess a specific density of more than 5g/cm3 and adversely affect the environment and living organisms (Jãrup, 2003). A heavy metal is said to be toxic when its concentration in the plant and animal exceeds a certain threshold (the dose that makes the effect). Some elements, called trace elements or micronutrients, have essential functions in plant and animal cells. This has been shown for Co, Cu, Fe, Mn, Mo, Ni and Zn. Only when the internal concentration exceeds a certain threshold do they demonstrate toxic effects, and then they are commonly termed "heavy metals" (Klaus-J 2010).

Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons (Jaishankar *et al.*, 2013). Heavy metals are one of the important types of contaminants that can be found on the surface and in the tissues of fresh vegetables. Heavy metals rank high amongst the major contaminants of leafy vegetables

(Mapanda *et al*., 2005). Zheijazkov and Neilson (1996) found that the concentrations of heavy metals in vegetables per unit dry matter generally follow the order: leaves> fresh fruits> seeds.

The prolonged human consumption of unsafe concentrations of heavy metals in foodstuffs may lead to the disruption' of numerous biological and biochemical processes in the human body. Vegetables, especially leafy vegetables grown in heavy metal-contaminated soils, accumulate higher amounts of metals than do those grown in uncontaminated soils because they absorb these metals through their leaves (Al Jassir *et al*., 2005).

Heavy Metal Poisoning

Heavy metals can contaminate the general environment through many routes. Because of their stability, they may penetrate environmental compartments, in some cases, many years after the initial deposition pollution of the soil and water systems may also arise from the weathering of disposed product (Nordberg *et al*., 2005). Heavy metal accumulations in plant and soil from natural and artificial sources and subsequent consequences represent important environmental pollution problems. Food safety issues and potential adverse health risks make this one of the most serious environmental concerns (Cui *et al*., 2004). Some heavy metals like copper, zinc, manganese, cobalt and molybdenum act as micronutrients for the growth of animals and human beings when present in trace quantities, whereas others such as cadmium, arsenic and chromium acts as carcinogens (Trichopoulos *et al*., 1997).

Mercury and lead are associated with the development of abnormalities in children (Gibb and Chen, 1989). Long term intake of cadmium causes renal, prostate and ovarian cancers (Hariwig, 1998). Generally, at the biochemical levels, the toxic effects caused by excess concentrations of heavy metals include competition for sites with essential metabolites, replacement of essential ions, reactions with —SH groups, damage to cell membranes and reactions with the phosphates groups (Okoronkwo *et al*., 2005).

Routes of Heavy Metal Exposure

Heavy metals enter the human body mainly through two routes which are inhalation and ingestion. Ingestion is the main route of exposure to these elements in human population (Turkdogän *et al*., 2003). Absorption through the skin is another route of exposure when the metals come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure accounts for a common route of exposure for adults (Ngan, 2006). Ingestion is the most common route of exposure in children. Children may acquire toxic levels from the normal hand-to-mouth activity with contaminated soil or by actually eating objects that are not food (Dupler, 2001). Less common routes of exposure are during a radiological procedure, from inappropriate dosing or monitoring during intravenous nutrition and from broken thermometers (Smith et al., 1997).

Classifications of Heavy Metal Exposure

Exposure to toxic heavy metals is generally classified as acute (two weeks or less); intermediate (15-354 days); and chronic (more than 365 days). Heavy metals are not easily biodegradable and so they can accumulate in vital human organs. Chronic low level intakes of heavy metals have adverse effects on human beings and other anima1s due to the fact that there is no effective mechanism for their elimination from the body (Bahemuka and Mubofu, 1999). Metals such as lead, mercury, cadmium and copper are cumulative poisons. These metals cause environmental hazards and are reported to be exceptionally toxic (Ellen et al., 1990). Chronic toxicity results from repeated or continuous exposure, leading to an accumulation of the toxic substance in the body. Chronic exposure may result from contaminated food, air, water, or dust; living near a hazardous waste site; spending time in areas with deteriorating lead paint; maternal transfer in the womb; or from participating in hobbies that use lead paint or solder. Chronic exposure may occur in either at home or workplace. Symptoms of chronic toxicity are often similar to many common conditions and may not be readily recognized (WHO, 1998; Dupler, 2001).

Mechanism of Action of Heavy Metals

The heavy metal ions form complexes with proteins, in which carboxylic acid (-COOH), amine (—NH2), and thiol (—SH) groups are involved. These modified biological molecules lose their ability to function properly and result in the malfunctioning or death of the cells. When metals bind to these groups, they inactivate important enzyme systems, or affect protein structure, which is linked to the catalytic properties of enzymes. This type of toxin may also cause the formation of radicals, dangerous chemicals that cause the oxidation of biological molecules (Neal and Guilarte, 2012).

Heavy Metals Contamination of Soils

The heavy metals essentially become contaminants in the soil environments, because:

i. Their rates of generation via man-made cycles are more rapid relative to natural ones; they become transferred from mines to random environmental locations where higher potentials of direct exposure occur;

ii. The concentrations of the metals in discarded products are relatively high compared to those in the receiving environment; and

iii. The chemical form (species) in which a metal is found in the receiving environmental system may render it more bioavailable (D 'Amore *et al*., 2005).

A simple mass balance of the heavy metals in the soil can be expressed as:

M_{total} = (Mp + Ma + Mf + Mag + Mow + Mip) — (Mcr + M1)

Where, M= heavy metal, "p" is the parent material, "a" is the atmospheric deposition, "f" is the fertilizer sources, "ag" are the agrochemical sources, "ow" are the organic waste sources, "ip" are inorganic pollutants, "cr" is crop removal, and "1" is the losses by leaching, volatilization, and so forth (Alloway, 1995; Lombi and Gerzabek, 1998).

Heavy Metal Contamination of Cassava Leaves

Cassava leaves are much richer in proteins than the roots (Chijindu and Boateng, 2008). Although the leaves contain far less methionine than the roots, the levels of all other essential amino acids exceed the FAO's recommended reference protein intake. Cassava-leaf protein is claimed to be superior to soybean protein (Adegbola, 1977). Large proportions of these nutrients have been reported to be lost during processing. Supplementation of Cassava products such as leaf-meal with methionine or any other of the nutrients it lacks serves to improve its biological value significantly and has been widely practiced in industry for the processing of food for human consumption and animal feeds (Adegbola, 1977).

Contamination of foods by heavy metals has become a challenge for producers and consumers. The main sources of heavy metals to crops are their growth media (soil, air, and nutrient solutions) from which these heavy metals are taken up by the roots or foliage (Lokeshwari and Chandrappa, 2006). The toxic and detrimental impacts of heavy metals become apparent only when long-term consumption of contaminated cassava leaves occurs. Regular monitoring of heavy metals in cassava and other food items should be performed in order to prevent excessive build up of these heavy metals in the human food chain (Khanna and Khanna, 2011).

Vegetables constitute important functional food components by contributing protein, vitamins, iron, calcium and other nutrients which have marked health effects (Aral, 2002). There is an inherent tendency of plants to take up toxic substances including heavy metals that are subsequently transferred along the food chain (Singh *et al*., 2010) and as such, heavy metal contamination in vegetables cannot be underestimated as food stuffs are important components of human diet. Heavy metal contamination of the food items is one of the most important aspects of food quality assurance (Khan *et al*., 2008). Cassava leaves can take up and accumulate heavy metals in quantities high enough to cause clinical problems to humans (Alam *et al*., 2003). Daily metal intake estimate does not take into account the possible metabolic ejection of the metals but can easily tell the possible ingestion rate of a particular metal. Cassava leaves grown on heavy metal contaminated soils accumulate higher amounts of metals than those grown in uncontaminated soils because of the fact that they absorb these metals through their roots (Sharma *et al*., 2007, Marshall *et al.,* 2007). Heavy metals are persistent in the environment and are subject to bioaccumulation in food chains.

They are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops (Mapanda *et al*., 2005). Excessive accumulation of these heavy metals in agricultural soils, resulting in elevated heavy metal uptake by food crops, are of great concern because of their potential health risk to man and animal (Zelles *et al*., 1994). They are also an important part of human and animal diet because they are a source of nutrients.

Zinc (Zn)

Zinc is a bluish-white, metallic element with atomic number 30, atomic weight of 65,38 glmol and density of 7.13 g!cm3. Trace amounts (<0.05 mg/L) of zinc is present in most natural waters. Zinc may be present in higher levels in irrigation areas due to the use of galvanized iron, copper and brass in plumbing fixtures and for water storage (Zelles *et al*, 1994). A higher concentration of zinc (5-30 mg/L) is aesthetically objectionable in drinking water due to a milky appearance and a greasy film in boiling (Dehlin *et al.,* 1997).

A concentration of zinc higher than 5rng/L causes a bitter astringent taste and opalescence in alkaline waters (Akbar *et al*, 2006, Ayodele and Oluyomi, 2011). Zinc, if associated with lead and cadmium, may indicate deterioration of galvanized iron and dezincification of brass pipes (Luilo and Othman, 2006; Onder *et al*., 2007). Among all heavy metals, zinc is the least toxic and an essential element in human diet as it is required to maintain the functioning of the immune system. The deficiency of Zn may be more fatal to human health than the excess of it (Saplakogelu and Iscan, 1997,' Hartwig, 1998). In human, high levels of zinc cause acute effects such as vomiting and gastrointestinal irritation (nausea, cramps, diarrhea), weakness, anorexia, anemia, diminished growth, loss of hair, lowered food utilization, changes in the levels of liver and serum enzymes, morphological and enzymatic changes in the brain, and histological and functional changes in the kidney. Chronic elevated intake of Zn could also result to impaired Cu uptake in humans.

This implies that some of the effects of Zn may be secondary to impaired copper utilization (Turan *et al*., 2011; Shaflq *et al* 2012; Verma *et al*. 2013). Zinc is an essential nutrient in humans and animals and is necessary for the function of a large number of metallo-enzymes. These enzymes include alcohol dehydrogenase, alkaline phosphatase, carbonic anhydrase, leucine aminopeptidase, superoxide dismutase, and deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) polymerase. An acute oral dose of zinc may cause symptoms such as tachycardia, vascular shock, dyspeptic nausea, vomiting, diarrhea, pancreatitis and damage of hepatic parenchyma (Salgueiro *et al*., 2000).

When high levels of zinc are ingested inhibition of copper absorption through interaction with metallothionein at the brush border of the intestinal lumen occurs. Both copper and zinc appear to bind to the same metallothionein protein; however, copper has a higher affinity for metallothionein than zinc and displaces zinc from metallothionein protein. Copper complexed with metallothionein is retained in the mucosal cell, relatively unavailable for transfer to plasma, and is excreted in the feces when the mucosal cells are sloughed off. Thus, an excess of zinc can result in a decreased availability of dietary copper, and the development of copper deficiency (Gyorffy and Chan, 1992). On the other hand, zinc deficiency has been associated with dermatitis, anorexia, growth retardation, poor wound healing, hypogonadism with impaired reproductive capacity, impaired immune function, and depressed mental function; increased incidence of congenital malformations in infants has also been associated with zinc deficiency in the mothers (Sandstead, 1981).

Lead (Pb)

Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. Lead is a well-known neurotoxin. Impairment of neurodevelopment in children is the most critical effect. Exposure in uterus, during breastfeeding and in early childhood may all be responsible for the effects. Lead accumulates in the skeleton and its mobilization from bones during pregnancy and lactation causes exposure to fetuses and breastfed infants (ATSDR, 2007).

In many plants, lead accumulation can exceed several hundred times the threshold of maximum level permissible for human (Wierzbicka, 1995). Plants grown in lead- contaminated soils accumulate low levels of lead in the edible portions of the plant from adherence of dusts and translocation into the tissues (Finster *et al*., 2004). It has been suggested that lead on a cellular and molecular level may permit or enhance carcinogenic events involved in DNA damage, DNA repair, and regulation of tumors suppressor and promoter genes (Silbergeld, 2003). Also, in humans, exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing foetus and infants being more sensitive than the adult. It causes nausea, vomiting and other gastrointestinal effects in adults, but more serious impacts of central nervous system dysfunction and intelligence quotient (IQ) deficits occur in children. I-ugh level of exposure may result in acute and chronic lead toxicity (Rehman *et al*, 2013).

Mercury (Hg)

Mercury is a ubiquitous environmental toxin that produces a wide range of adverse health effects in humans (Guzzi and La Porta, 2008). The most common natural forms of mercury found in the environment are metallic mercury, mercuric sulfide (cinnabar ore, mercuric chloride, and methyl mercury). Each of them has its own profile of toxicity (ATSDR, 1999). Methyl mercury is of particular concern because it can build up in certain edible freshwater and saltwater fish and marine mammals to levels that are many times greater than levels in the surrounding water.

Metallic and inorganic mercury enters the air from mining deposits of ores that contain mercury, from the emissions of coal fired power plants, from burning municipal and medical waste, from the production of cement, and from uncontrolled releases in factories that use mercury. Metallic mercury is a liquid at room temperature, but some of the metal will evaporate into the air and can be carried long distances. In air, the mercury vapour can be changed into other forms of mercury, and can be further transported to water or soil in rain or snow (Wiwanitkit, 2009).

Inorganic mercury may also enter water or soil from the weathering of rocks that contain mercury, from factories or water treatment facilities that release water contaminated with mercury, and from incineration of municipal garbage that contains mercury (for example, in thermometers, electrical switches, or batteries that have been thrown away (Balshaw *et al*., 2007). Mercury can enter and accumulate in the food chain. The form of mercury that accumulates in the food chain is methyl mercury (Baishaw *et al*., 2007, Wiwanitkit, 2009). Symptoms of mercury poisoning include permanent damage to the brain and kidneys, personality changes (irritability, shyness, and nervousness), tremors, changes in vision, deafness, muscle in coordination, loss of sensation, and difficulties with memory (ATSDR, 1999).

Materials and Methods

Collection of Cassava leaves Samples and Treatment

Cassava leaves (Manihot esculenta) were collected from three farms located in C.S.S Ebukurna, Ebukuma Health Centre and New Road in Ebukuma, Andoni LGA of Rivers State, Nigeria in July, 2018. Fresh cassava leaves were randomly collected from two spots (30 meters apart) on each of the farms. Each cassava leaf samples were divided into three portions for composite replicate analyses (Alinnor, 2004; lyaka, 2007). The leaves samples were washed with tap water to remove soil particles and dust and then rinsed with distilled water.

They were sliced using knife to aid drying at room temperature. The samples were air dried on white tiles for two days in the laboratory and then oven-dried at 60° C for five days to constant weight. The dried samples were crushed and finely ground using porcelain mortar and pestle to pass a 250mm mesh sieve. Thereafter, each of the processed powder was subjected to acid digestion (Alinnor, 2004; lyaka, 2007) and the concentrations of the heavy metals, Pb and Zn in the solutions were determined using atomic absorption spectrophotometer equipped with air-acetylene burner.

Collection and Preparation of Soil Samples

The soil samples were collected from three farms located in C.S.S Ebukurna, Ebukuma Health Centre and New Road in Ebukuma, Andoni LGA of Rivers State, Nigeria in July, 2018, air dried for 48 hours, ground and sieved using 0.5 mm mesh size sieve to have uniform particle size. Each sample was labelled and stored in a dry plastic container that had been pre-cleaned with concentrated nitric acid prior to analysis with Atomic Absorption Spectrophotometer (AAS).

Laboratory Equipments and Reagents

Atomic absorption spectrophotometer, vortex mixer and cuvettes, 100ml volumetric flask, whatmann filter paper, beakers, funnel, zinc, lead and mercury kits, oven, white tiles, porcelain mortar and pestle, nitric acid, hydrochloric acid, distilled water and cellophane bags.

Acid Digestion of the Samples

A measured weight (2 g) of the processed cassava leaves sample was digested in 12 ml of aqua regia HNO_3/ HC1 (1:3) on a hot plate for 3 hours at 110°C until the brown fumes disappeared. Heating was then continued until the brown fumes turned to white. 20ml of distilled water was added and heated until a colourless solution was obtained. The solution was allowed to cool and filtered into a standard volumetric flask (100 ml) through a Whatman No. 42 filter paper and the volume was made to the mark with distilled water (Alinnor, 2004; lyaka, 2007). The concentrations of the heavy metals (Zn, Hg and Pb) in the cassava leaves samples were determined using atomic absorption spectrophotometer (AAS).

Heavy Metals Determination Procedure

Two hundred ml of water sample was measured into a conical flask. 10 mL of concentrated nitric acid was added followed by digestion of the solution until the volume reduced to below 25 mL. The solution was made up to 25 mL with distilled water in a volumetric flask. Atomic absorption spectrophotometer (AAS) of the GBC Avanta ver 2.02 scientific model was used for the heavy metals determination. It was first of all standardized using standard solutions and then the samples now in small sample cells were placed in the AAS. The metal concentrations in the soil and cassava leaves samples were measured and recorded. Lead, zinc, and mercury were determined using this procedure.

(R) Calculation: Heavy metals (mg/L) = CF

R= AAS reading (Sample concentration - Blank concentration)

C.F = Concentration factor (8)

For zinc, 10 times dilution was made for samples from C.S.S Ebukuma farm before determination.

Therefore concentration of zinc in the soil and cassava leaves samples is given by:

$$Zn\ (mg/L) = \frac{(DxR)}{C\ F}$$

Where:

D = Dilution factor (10)

R = AAS reading

C.F = Concentration factor (8)

Plant Concentration Factor (PCF)

Plant concentration factor (PCF) was computed using the following equation (Liang *et al*., 2011).

$$PCF = \frac{Cplant}{C\ Soil}$$

Where Cplant = metal concentrations in plant

Csoil = metal concentrations in soils

Results And Discussion

The result of the analysis of the levels of the heavy metals found in the soil samples obtained from the three farms are presented in Table 1 while the result of the analysis of the levels of the heavy metals found in the samples of Cassava leaves are presented in Table 2. Also, the plant concentration factor for the analysis is presented in Table 3.

Table 1: Mean concentrations of heavy metals (Zn, Pb and Hg) of soil samples obtained from three farms in Ebukuma Town, Andoni Local Government Area, Rivers State.

Sample	Mineral (mg/kg)		
	Zn	Pb	Hg
Farm 1	84.60	18.42	ND
Farm 2	117.93	10.74	<0.01
Farm 3	110.35	26.23	<0.01

Table 2: Mean concentrations of heavy metals (Zn, Pb and Hg) of cassava leaves samples obtained from three farms in Ebukuma Town, Andoni Local Government Area, Rivers State.

Sample	Mineral (mg/kg)		
	Zn	Pb	Hg
Farm 1	2.67	1.67	ND
Farm 2	3.30	0.83	ND
Farm 3	2.91	0.98	ND

Table 3 Plant Concentration Factor of the cassava leaves samples relative to their soil sources

Sample	Mineral (mg/kg)		
	Zn	Pb	Hg
Farm 1	0.030	0.090	-
Farm 2	0.028	0.080	-
Farm 3	0.026	0.040	-

Farm 1 = C.S.S Ebukuma School Farmland
Farm 2= Ebukuma Health. Centre Farmland
Farm 3 = New Road Farmland

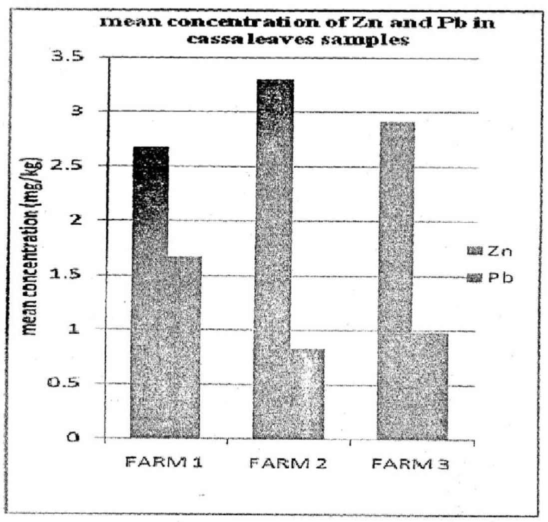

Figure 4: Bioaccumulation of heavy metals in the cassava leaves samples obtained from the three Farms located in Ebukuma Town, Andoni L.G.A, Rivers State.

Generally, crops cannot grow normally and flourish in polluted soil. Yet if some crops manage to grow, depending on the level of contamination, then those crops would be poisonous enough in short-run or long-run to cause serious health defects in consumers. From the results obtained for Zn in the cassava leaves sample, Farm 2 had lower concentrations of (2.67mg/kg) than those samples from Farms 1 and 3 while the cassava leaves sample in Farm 1 had highest concentrations of (3.30mg/kg) as shown in Table 2. More so, the results obtained for Zn in the soil sample from Farm 2 had highest concentrations of (1 17.93mg/kg) than those samples from Farms land 3 while the concentration level of Pb in soil sample from Farm 3 had highest concentrations of (26.23 mg/kg) as shown in Table 1. Meanwhile, mercury was not detected in all the samples analyzed.

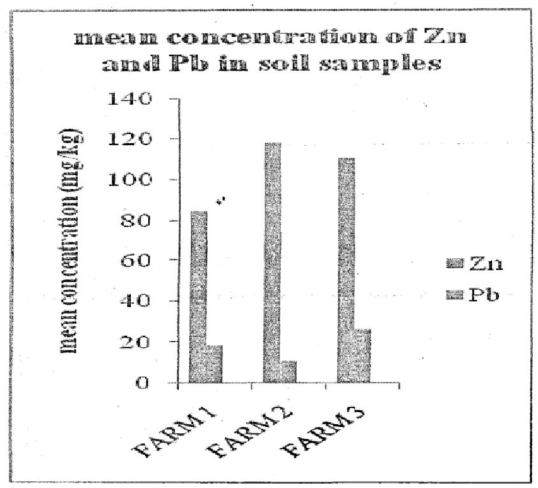

Figure 5: Bioaccunrnlation of heavy metals in the Soil samples obtained from the three Farms located in Ebukuma Town, Andoni L.G.A, Rivers State.

All the cassava leaves samples that were analyzed for Zn were below the acceptable limit of 60 mg/kg. Zn levels were from 2.67mg/kg to 3.30 mg/kg. High levels of Zn in soil inhibit many plant metabolic functions; result in retarded growth and cause senescence, Zinc toxicity in plants limited the growth of both root and shoot (Choi *et al.*, 1996). The Zn concentrations in all the soil samples exceed the permissible limits of 60 mg/kg. (WHO/FAO, 2007). Whereas, the Zn concentrations in all the cassava leaves samples were lower than the permissible limits of 60 mg/kg. Zn concentrations lower than the permissible limits of WHO/FAO (2007) have been reported for bitter leaf, water leaf and cabbage (Sobukola *et al.*, 2010) although with a technique different from the one used in this present research.

Zn is the least toxic and an essential element in human diet as it is required to maintain the functioning of the immune system. Zn deficiency in the diet may be highly detrimental to human health than too much Zn in the diet. The recommended dietary allowance for Zn is 15 mg/day for men and 12 mg/day for women ATSDR, 2007). But high concentration of Zn in vegetables may cause vomiting, renal damage, cramps, etc (ATSDR, 2007). Zn is an essential trace element for humans; it is vital for many biological functions and plays a crucial role in more than 300 enzymes in the human body. Zn is needed for growth and it plays a vital role in fertility. In males, Zn protects the prostate gland from infection (prostatic disorders) and ultimate enlargement (prostatic hypertrophy). Zn deficiency in the body is worse than its toxicity. The results also show that Pb concentration for cassava leaves was highest in Farm I (1.67mg/kg) and lowest in Farm 2 (0.83mg/kg). Similarly, Pb concentration for soil samples was highest in Farm 3 (26.23mg/kg) and lowest in Farm 2 (10.74mg/kg). These values exceeded WHO maximum acceptable limit of 0.1mg/kg. Therefore, there is possible risk of lead poisoning from cassava leaves harvested from these farmlands, and it is well established that exposure to high levels of lead may cause kidney damage leading to renal failure (Laura *et al.,* 2009, Colgan, 2003).

Such concentration of lead in cassava leaves and other trace heavy metals in general will particularly affect vulnerable populations including children (Wang *et al*., 2006, Canfield *et a.,* 2003) and all exposed adults (Saraiva *et al*., 2007). Lead is considered a potential carcinogen and is associated with etiology of a number of diseases especially cardiovascular diseases. In addition comparative bioaccumulations of the heavy metals among the soil samples and the cassava leaves samples obtained from the three different farms are displayed in Figures 4 - 54. The plant concentration factor (Table 3) which is also called plant transfer ratio values obtained in this study are almost in the same range with those reported by Osakwe (2009), Liang et al. (2011) and Opaluwa et al. (2012).

For all the farms, the soil plant transfer values were in the order Pb> Zn> Hg. This shows that among the three metals studied lead is easiest to migrate. This trend signifies that plant absorbs a higher concentration of lead from the soil compared to other metals while Hg in the least absorbed. Abedemi, (2013) similarly reported that Pb had highest value of plant transfer ratio among all the metals in his study and also more easily available for plant uptake. Higher transfer coefficients reflect high soil contents or greater potentials of plants to absorb metals and bioaccumulate into tissues (Abah *et al*., 2012). However, low transfer coefficients have been reported to indicate strong absorption of the metals to soil colloids (Kachenko *et al.,* 2006). When transfer factor is less than one, it may be a probability that soil is the main source of metal bioaccuinulation in plants.

However, it is more revealing that, when the value is higher than one, the total concentrations of metals in soil do not necessary correspond to the metal bioavailability in plants. The bioavailability of heavy metals depends on a number of physicochemical properties such as pH, organic matter contents, cation exchange capacity, redox potential, soil texture and clay contents (Mwegoha and Kihampa, 2010). Soil electrolyte plays an important role in the process of heavy metal transfer, and influences transformation ability of heavy metals.

Conclusion and Recommendations

The concentrations of heavy metals in the cassava leaves obtained from different farms in Ebukuma (C.S.S Ebukuma farm, Ebukuma Health Centre farm and New Road farm) axes have been studied in comparison with the soils on which they grow. The cassava leaves are used as food for the inhabitants of the study area and this study has revealed high accumulation of some heavy metals by this edible leaf from the area of study which is also experiencing pollution activities.

The concentration of lead in cassava leaves and soil samples were significantly higher in Farms 1 and 3 respectively than the WHO maximum acceptable limit for food and this calls for serious health concern as when heavy metals are bioaccumulated in human organs and tissues, various diseases and disorders manifest, if they are not properly controlled. Generally, the concentrations of the metals in the soil samples are in the decreasing order, Zn>Pb>Hg. The cassava leaves samples show the same trend of metal concentrations. In addition, the transfer factors of the cassava leaves samples are less pronounced than those of the soil samples. This suggests that the absorption and retention of metals by the tissues are very low. In other words, bioaccumulation of metals in plants is, sometimes, dependent on their bioavailability in the soil.

Recommendations

From the results of the analysis, it is recommended as follows:

i. Farmlands should be located far away from oil polluted area to minimize health risks associated with heavy metals poisoning.

ii. Farmers and, the people of Ebukuma should be sensitized of the dangers of planting in such polluted areas.

iii. Other methods of analysis of metals in soil and cassava leaves should be adopted for the same soil and cassava leaves samples;

iv. The consummers of these leafy vegetables should be screened for any incident of heavy metal contamination in the food chain; and the cassava leaves studied in this research work could be applied for phytoremediation of polluted soils.

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