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Total Levels of Some Heavy Metals in Cassava Tuber from Eleme Local Government Area of Rivers State, Nigeria

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Abstract

Cassava tuber obtained from four towns in Eleme Local Government Area were analyzed for Fe, Zn, Cu, Cd, Ni, Pb, Mn and Mg using Perking Elmer AAnalyst 200 model. All the eight metals analyzed were detected as follows: The highest concentration of Fe was obtained from cassava tuber from Onne with a value of 28.80 mg/kg; the level of Zn was highest in cassava tuber from Eteo with a value of 6.59 mg/kg; the level of Cu was highest in cassava tuber from Onne with a value of 1.23 mg/kg; Cd was highest in cassava tuber from Eteo, with a value of 6.89 mg/kg; the highest value of Ni occurred in cassava tuber from Eteo with a value of 5.67 mg/kg; the highest concentration of Pb occurred in cassava tuber from Ebubu with a value of 2.44 mg/kg; the level of Mn was highest in cassava tuber from Eteo with a value of 14.55 mg/kg and the highest concentration of Mg occurred in cassava tuber from Eleme with a value of 36.60 mg/kg. Pearson correlation matrix (PCM) for metal – metal concentrations in cassava tuber samples revealed that there were strong positive correlations between Fe and Cu (0.61) , Zn and Cd (0.78), and Ni and Cd (0.86). Other metals which showed positive correlations were: Fe and Zn (0.50), Pb and Zn (0.42), Ni and Zn (0.54), Pb and Zn (0.06), Pb and Cu (0.23), Pb and Cd (0.15), Mg and Cd (0.08), Ni and Mn (0.22), Mn and Ni (0.43), Mg and Mn (0.18). This indicates that these metals had a common source. A near – perfect negative correlation (R = - 0.99) existed between Mn and Pb, Ni and Cu (- 0.98) and Mg and Zn (- 0.98).

Keywords: Heavy metals, Levels, Cassava tuber.

Introduction

Heavy metal contamination and pollution of the environment is one very serious problem associated with the industrial revolution. Heavy metals are toxic whether in elemental form or combined form[1].

Continuous exposure to heavy metals even at low concentrations is harmful to human health[2]. One of the important natural components of the earth´s crust is heavy metals. Heavy metals cannot be degraded or destroyed. The routes of exposure of human bodies to heavy metals include food, drinking water and air. Oil-polluted soils suffer increase in chromium, lead, cadmium and nickel [3]. Some heavy metals are trace elements which are essential to humans eg. Fe and Zn, since they play important role in the body metabolical activities, but they can produce toxic effects when their intake is excessively elevated [4, 5]. The bio-accumulation of heavy metals makes them dangerous. The increase in the concentration of a chemical in a biological organism over time, compared to the concentration of the chemical in the environment is referred to as bio-accumulation. The rate of accumulation of compounds in living things is faster than the rate at which they are broken down (metabolized) or excreted. Cd and Cu are metals which are reported to be extremely poisonous and cause environmental hazards.

Effects of heavy metals on living things including humans have regularly been reviewed by international bodies such as World Health Organization[6]. Heavy metals also accumulate in crop plants. This is often of great concern because of its potential for food contamination through the soil - root interface[7]. Kidney and bone damage are associated with Cd exposure. Cd is a potential human carcinogen causing lung cancer[8]. Electrolyte imbalance, nausea, anaemia and lethargy are some effects of the toxicity of Zn due to excessive intake[9].

Data on food consumption which should be accurate and adequate are however invaluable for estimating the adequacy of intakes of essential nutrients and assessing exposure risks from intake of toxic non – essential elements. Such data are not readily available in many less developed countries[10,11]. An important aspect of environmental pollution studies involve trace metal analysis[12,13] and the consequence of trace metals in foods such as tubers. These have been of considerable interest because of their toxic effects which are important in human beings[14]. Therefore the aim of this research is to determine the levels of heavy metals (such as Fe, Zn, Cu, Cd, Ni, Pb, Mn and Mg) in cassava tuber, which is the staple food in the Niger Delta area of Nigeria.

Heavy metals are important environmental pollutants in oil producing and oil servicing areas of the world. Eleme Local Government Area of Rivers State, in the Niger Delta Zone, in

Nigeria has over five hundred companies which mainly are oil producing, oil servicing, drilling, chemical and construction companies. The wastes generated from these companies e.g. oil drilling and agricultural activities such as use of agrochemicals in crop production, waste dumps in landfills are common sources of heavy metal contamination and some or all of these could be responsible for the exceptionally high concentrations of some of the heavy metals found in the cassava tuber analysed from various sampling locations in Eleme Local Government Area.

Description of Study Area: Eleme Local Government of Rivers State Nigeria is located on Latitude 5.08333 and Longitude 6.65 with an altitude of 224. This is part of the Niger Delta in the South-South Zone of Nigeria. The Eleme people occupy a territory which expands across approximately 140 square kilometres. The neighbouring Local Government Areas surrounding Eleme Local Government Area are Obio-Akpor and Oyigbo in the North, Okrika and Ogubolo in the South, Tai in the East and Okrika and Port Harcourt in the West. Crops cultivated by Eleme people include yam, cassava, oil palm fruit, fluted pumpkin and bitter leaf. There is a heavy concentration of industries in Eleme. Some of these industries are: two major refineries, a foremost fertilizer plant in West Africa a sea port, with so many other companies in Onne like, Panapina, Intels, Dangote cement, P and O, Federal Lighter Terminal, Federal Ocean Terminal, WACT, etc. The wastes generated by these industries have negatively affected the quality of water, soil air and the general environment of the area. Crude oil was discovered in the Niger Delta in 1958 and since then the Eleme territory has become home to both oil refineries and fertilizer industries. The Eleme territory has about 100 oil wells currently in use. Some of the environmental effects of the mining of oil on the status of the Niger Delta area are increasing acid rain and reduction of soil, water and air qualities.

Materials and Methods

Collection and Preparation of Sample: Sampling was carried out between October and December, 2014.Cassava tuber from Ebubu, Eteo, Eleme and Onne towns in Eleme Local Government Area of Rivers State, were peeled and washed thoroughly with water, rinsed with deionised water to remove air-borne impurities, sliced, sun-dried for about 10 days and oven-dried at 70 ºC for 24 hours to remove moisture. The samples were then packaged in black air-tight polythene bags until further analysis.

Determination of Total Metal Concentration in the Samples: Acid Digestion: 2 g of each ground sample was weighed into a beaker, digested with 10 ml conc. HNO_3, 8 ml conc. HCl and 2 ml perchloric acids that made up 20 ml acid digestion mixture. The mixture was left in the fume cupboard overnight in order to achieve optimum digestion of the samples. The digests were warmed on a hot plate the following day, diluted with de-ionized water and filtered through a Whatman No. 1 filter paper. The filtrates were made up to 50 ml mark in a volumetric flask with the de-ionized water. The samples were analysed (Elemental analysis) using Perkin Elmer Atomic Absorption Spectrophotometer Analyst 200 in accordance with standard methods[15,16].

Atomic Absorption Analysis: The digested samples were sent to Eleme Petrochemicals Limited Laboratory Eleme Rivers State and analyzed for metals using Perkin Elmer Atomic Absorption Spectrophotometer Analyst 200.The instruments used for the AAS included hollow cathode lamps, for Fe, Zn, Cd, Cu, Pb, Ni, Mn, and Mg filament; flame or electrically heated furnace or carbon rod, monochromator, photomultiplier, recorder, analytical balance (Libror AEG)

Reagents and Salts Used: The chemicals used were of Analytical Reagent Grade. They included: Iron (II) sulphate heptahydrate, $FeSO_4.7H_2O$; Zinc (II) sulphate heptahydrate, $ZnSO_4.7H_2O$; Cadmium sulphate, $CdSO_4$; Copper (II) sulphate pentahydrate, $CuSO_4.5H_2O$; Lead oxide, PbO; Nickel (II) nitrate, $Ni(NO_3)_2.6H_2O$. Maganese sulphate, $MnSO_4.H_2O$; Magnesium chloride hexahydrate, $MgCl_2.6H_2O$.

Results and Discussion

Total Heavy Metal Levels in Cassava Tuber obtained from Various Sampling Locations: The total heavy metal levels obtained for cassava tuber samples from different sampling locations is presented in figure 1. The results show that the total concentration of Fe in cassava tuber obtained from different sampling locations ranged from 12.08 ± 18.27 mg/kg to 28.80 ± 18.27 mg/kg. These values are lower than that obtained in a previous study[17] and also lower than the prescribed minimum acceptable level[19].

The Food and Drug Administration (FDA) has prescribed a Minimum Acceptable Level (MAL) of 60mg/kg for iron in cassava tuber and cassava meals and a Maximum Tolerable Limit (MTL) of 90 mg/kg[19]. The deficiency of iron in cassava tuber is of great concern because iron is a very important metal for physiological activity being a component of haemoglobin, amongst other functions. Therefore the human body requires iron in relatively higher amounts compared to other essential trace metals for proper physiological functions. Iron deficiency in a staple crop like cassava may not only result in pernicious anaemia but may lead to increased lead toxicity. The deficiency of iron leads to an increase in the absorption of lead which is highly toxic (neuro toxic) to the body. Individuals who are iron deficient can absorb up to seven times more lead, as the body responds to iron deficiency by dispatching increasing amounts of the iron transporter, DMT 1 (Divalent Metal Transporter 1) into the gut. Unfortunately DMT 1 can carry eight metals including lead and will transport lead if iron is unavailable[20]. This fact is a concern considering the high lead concentration and relatively low iron levels observed across the cassava samples.

The total concentration of Zn in cassava tuber obtained from different sampling locations ranged from 3.20 ± 4.99 mg/kg 6.59 ± 4.99 mg/kg. The levels of Zn obtained in this work is lower than that reported in a previous study[17] but higher than that reported in another similar study[18]. Zn is an important trace metal because of its vital role as an enzyme co-factor and its presence may impair lead toxicity as lead exposure may be minimised in the presence of zinc.

The total concentration of Cu in cassava tuber obtained from different sampling locations ranged from 0.87± 0.99 mg/kg to 1.23 ± 0.99 mg/kg in cassava tuber samples in Onne. The concentration of copper in cassava tuber samples from the various locations is lower than that reported in a previous study[17], but higher when compared with the level reported by another similar study[18]. Cu is highly toxic. Abdominal pains, diarrhoea, vomiting and metallic taste in the mouth is some of the symptoms of Cu toxicity. Cirrhosis and other liver conditions can also be caused by ingestion of Cu compounds.

The total concentration of Cd in cassava tuber obtained from different sampling locations ranged from 2.62 ± 5.22 mg/kg to 6.89 ± 5.22 mg/kg in cassava tuber. Cadmium concentration across the various samples of cassava tuber from the various locations is very significant. The values obtained are higher than that of a previous research work[17]. Cadmium is highly toxic and of no biological use. Cadmium accumulates in the kidney of man and can cause malfunction. Exposure to cadmium can be fatal. The total concentration of Ni in cassava tuber obtained from different sampling locations ranged from 3.88 ± 4.86 mg/kg to 4.11 ± 4.86 mg/kg to 5.67 ± 4.86 mg/kg.

The total concentration of Pb in cassava tuber obtained from different sampling locations ranged from 0.70 ± 1.36 mg/kg to 2.44 ± 1.36 mg/kg. The total concentration of lead across the cassava tuber samples from the various locations though small is of great concern. The value obtained is higher than the result obtained in a previous study[21] but lower than that of another related study[17]. The total lead concentration obtained in this work is much higher than the Maximum Tolerable Level[19], which is set at 0.2 mg/kg. Nervous system disorders, anaemia, decreased haemoglobin synthesis, cardiovascular disease, and disorder in bone metabolism, renal function and reproduction have been associated with lead.

The total concentration of Mn in cassava tuber obtained from different sampling locations ranged from 5.95 ± 11.48 mg/kg to 14.55 ± 11.48 mg/kg. Manganese toxicity is evidenced in the central nervous system, progressive disorder of the extra-pyramidal system which is similar to Parkinson's disease. The total concentration of Mg in cassava tuber samples ranged from 36.10 ± 37.44 mg/kg to 0 37.60 ± 37.44 mg/kg. These values are very close to the Food and Drug Administration (FDA) Minimum Acceptable Level (MAL) for magnesium. Hundreds of chemical reactions, including proper functioning of the nerves and muscles, maintaining regular heartbeat etc. are aided by Mg. Mg toxicity causes various gastrointestinal symptoms eg. difficulty in breathing, and low blood pressure.

One – way Anova showed (Table-2) significant differences in the mean concentrations of Fe, Zn, Cd, and Mn cassava tuber samples. However, Anova reveals similar values in the mean concentrations of Cu, Ni, Pb, and Mg in cassava tuber samples.

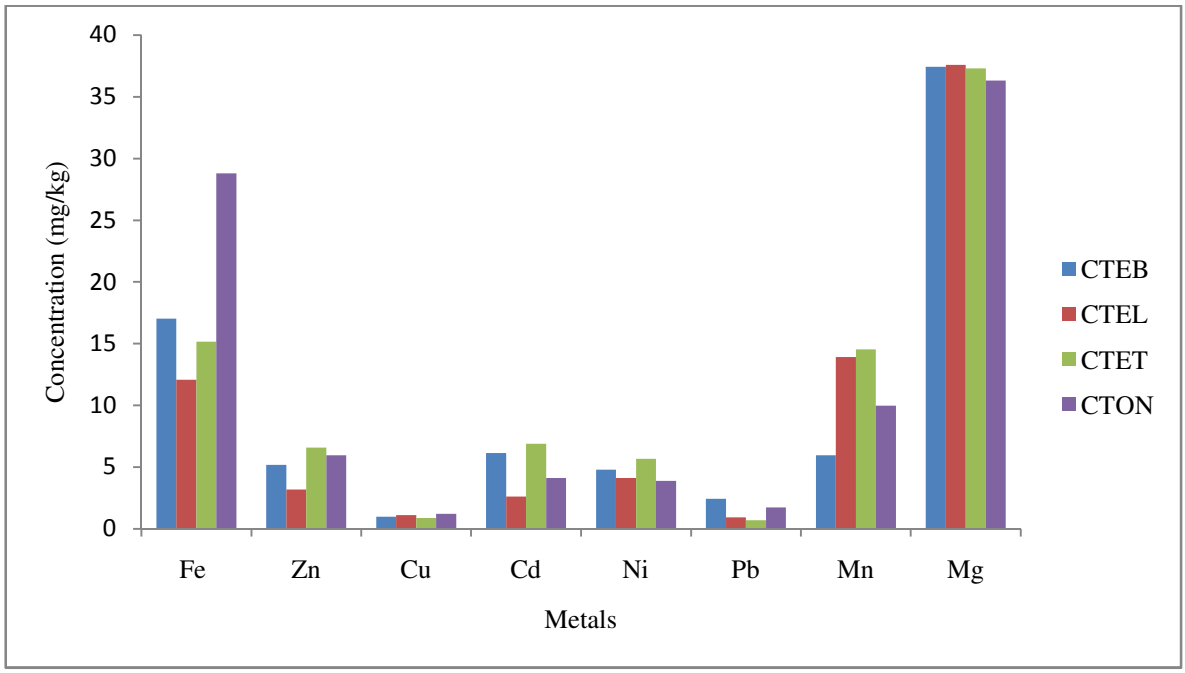

Figure-1
Total Heavy Metal Levels in Cassava Tuber Samples from different Sampling Locations

Table-1
Descriptive Statistics of Total Metal Concentration (mg/kg) of Heavy Metals in Cassava Tuber from Eleme Local Government Area in Rivers State

	Fe	Zn	Cu	Cd	Ni	Pb	Mn	Mg
Mean	18.27	4.99	0.99	5.22	4.86	1.36	11.48	37.44
Standard Error	1.44	0.98	0.07	1.32	0.45	0.55	2.77	0.09
Standard Deviation	3.00	1.70	0.13	2.28	0.78	0.95	4.80	0.15044437.30
Minimum	12.08	3.20	0.87	2.62	4.11	0.70	5.95	37.30
Maximum	28.80	6.59	1.12	6.89	5.67	2.44	14.55	37.60

Table-2
One – Way Anova Analysis of Total Heavy Metal Concentration (mg/kg) of Heavy Metals in Cassava Tuber obtained from Different Sampling Locations in Eleme Local Government Area. Anova: Single Factor
Summary

Groups	Count	Sum	Average	Variance
Fe	4	73.07	18.2675	53.46889
Zn	4	20.93	5.2325	2.168625
Cu	4	4.21	1.0525	0.024425
Cd	4	19.76	4.94	3.771267
Ni	4	18.45	4.6125	0.646292
Pb	4	5.81	1.4525	0.632358
Mn	4	44.42	11.105	15.88863
Mg	4	148.64	37.16	0.3362

Anova

Sources of variation	Ss	Df	Ms	F	p-value	F crit
Between groups	4143.548	7	591.9355	61.55039	8.65E-14	2.422629
Within groups	230.81 01	24	9.617086			
Total	4374.358	31				

Table-3
Pearson Correlation Matrix between Heavy Metal Concentrations in Cassava Tuber Samples

	Fe	Zn	Cu	Cd	Ni	Pb	Mn	Mg
Fe	1							
Zn	0.498	1						
Cu	0.611	-0.366	1					
Cd	-0.045	0.780	-0.807	1				
Ni	-0.460	0.539	-0.976	0.864	1			
Pb	0.423	0.056	0.245	0.149	-0.296	1		
Mn	-0.384	-0.091	-0.168	-0.219	0.221	-0.997	1	
Mg	-0.978	-0.522	-0.602	0.083	0.427	-0.226	0.185	1

The Pearson correlation matrix (PCM) provides a measure of ascertaining through statistics the association/correlation of one parameter with another. Pearson correlation matrix (PCM) Table-3, for metal – metal concentrations in cassava tuber samples revealed that there were strong positive correlation between Fe and Cu (0.61), Zn and Cd (0.78), and Ni and Cd (0.86). Other metals which showed positive correlations were: Fe and Zn (0.50), Pb and Zn (0.42), Ni and Zn (0.54), Pb and Zn (0.06), Pb and Cu (0.23), Pb and Cd (0.15), Mg and Cd (0.08), Ni and Mn (0.22), Mn and Ni (0.43), Mg and Mn (0.18). This indicates that these metals had a common source. Near – perfect negative correlations, (R = - 0.99) existed between Mn and Pb; Ni and Cu (- 0.98) and Mg and Zn (- 0.98), some others also exhibited lesser negative correlations. This indicates that the sources of these metals were varied.

Conclusion

The concentrations of Pb, Ni, and Cd in cassava tuber and cassava meals in Eleme Local Government Area exceeded by far the Maximum Tolerable Levels set by WHO, 2011 and FDA, 2013. These are potentially hazardous heavy metals to the consumer. The deleterious effects of these metals are grave and have long term consequences on the health of individual and the general populace who consumes the food crop. It is therefore recommended that the inhabitants of this area should not consume these foods in large quantities so as to avoid the accumulation of heavy metals excessively in the body and to prevent future health hazards.

References

1. Manahan S.E. (1993). Fundamentals of Environmental Chemistry. Lewis Publishers: Michigan, 745.

2. Wyatt R.E., Doane Fimbres C., Romo L., Mendez R.O. and Grijana M. (1998). Incidence of Heavy Metal Contamination in Water Supplies in Northern Mexico. *Environmental Research*, 114 – 119.

3. Essoka P.A., Ubogu A.E. and Uzu L (2006). An overview of oil pollution and heavy metal concentration in Warri area, Nigeria. Mgt. *Environ Quality International Journal*, 17(2), 209 – 215.

4. Mendil D., Tuzen M., Yazici K. and Soylak M. (2005). Heavy metals in lichens from roadsides in an industrial zone in Trabzon. *Bulletin of Environmental Contamination and Toxicology*, 74(1), 190-194.

5. Narin I., Tuzen M., Sari H. and Soylak M. (2005). Heavy metal content of potato and corn chips from Turkey. *Bull. Environ. Contam. Toxicol*., 74, 1072-1077.

6. WHO (2011). Guidelines for drinking water quality. 4th edn. WHO press Geneva, 564.

7. WHO, Europe (2007). Health risks of heavy metals from long-range transboundary air pollution. World Health Organization Regional.

8. Onianwa P.C, Lawal J.A, Ogunkeye A.A and Orejimi B.M. (2000). Cadmium and nickel composition of some Nigerian foods. *Journal of Food Analysis,* 13, 961-969.

9. Fairweather-Tait S.J. (1988). Zinc in human nutrition. *Nutrition Research Review*, 1, 23-37.

10. Burk C.M., and Pao M.E. (1980). Analysis of food composition survey data for developing countries. Rome: Food and Agriculture Organisation of the United Nations.

11. Bruce A. and Bergstrom L. (1983). User requirements for food data bases and applications in nutritional research. *Food and Nutrition Bulletin*, 5, 24-29.

12. Solecki J. and Chibowski S. (2000). Examination of trace amounts of some heavy metals in bottom sediments of selected lakes of South Eastern Poland. *Polish J. Environ. Stud.*, 9, 203.

13. Czarrnowska F. and Milewska A. (2000). The content of heavy metals in an indicator plant (*Taraxacumofficinale*) in Warsaw. *Polish J. Environ. Stud.*, 9, 125.

14. Asaolu S.S. (1995). Lead content of vegetables and tomatoes at Erekesan Market, Ado-Ekiti. *Pak. J. Sci. Ind. Res.*, 38, 399.

15. Allen S.E., Grinshaw H.M., Parkinson and Quarmby C., (1974). Chemical Methods of Analysing Ecological Material. Sci. Pub. London, 525.

16. Christian G.D. (1980). Analytical Chemistry. John Willey and ONS Inc. New York, 3rd ed., 400-415.

17. Kalagbor I.A., Dighi N.K. and James R. (2015). Levels of some heavy metals in cassava and plantain from farmlands in Kaani and Kpean in Khana Local Government Area of Rivers State. *J. Appl. Sci. Environ. Manage,*. 19(2), 219-222.

18. Santos E.E., Laura D.C. and Porto C.L. (2004). Assessment of daily intake of trace elements due to consumption of foodstuffs by inhabitants of Rio de Janeiro City. *Sci. Total Environ*, 327(1-3), 69-79.

19. Food and Drug Administration (FDA). (2013). Summary of Current Food Standards (Annex J.). Minimum Requirements for analysis of finished products. 1–21.

20. Lead Action News (2010). The Journal of the LEAD (Lead Education and Abatement Design) Group Inc. Lead Action News, 10(2), 1-3.

21. Orisakwe O.E., Nduka J.K., Amadi C.N., Dike D.O. and Bede O. (2012). Heavy Metals Health Risk Assessment for population via consumption of food crops in Owerri, South Eastern Nigeria. *Chemistry Central Journal.*, 6(77),5–12.