Innovations

Quantification of Heavy Metals and Metalloid in Cassava Roots (manihotesculentacrantz; Family: Euphorbiaceae) grown in Oil Bearing Communities of the Niger Delta

[1]Ogwu, C, [2]Ukpene, A. O., [3]Ekpe, I. N. & [4]Umukoro B. O. J., [5]Onuelu J. E.

[1,3&4]Department of Environmental Management & Toxicology, Delta State University of Science & Technology, Ozoro
[2]Department of Biological Sciences, University of Delta, Agbor
[5]Department of Pharmacology, Delta State University, Abraka

Corresponding author: **Ogwu, C,**

Abstract
This study is an ex-port facto research that investigated the heavy metals concentrations in cassava roots harvested in the Niger Delta oil bearing communities. The study answered 4 research questions and tested a hypothesis. To accomplish these, 5 states out of 9 Niger Delta states were randomly selected and anoil producing community also randomly selected from each state. Cassava roots samples were randomly collected from 5 farms in 5 villages/quarters of the oil producing communities. The analytical standard adopted for this study is EPA 201650 and the instrument of determination deployed is Analytic Jena's NOVAA 800AAS. The grand mean results of the metals investigated were: Cd; 0.06±0.00, Cr, 0.06±0.01 mg/kg, As, 0.06±0.01 mg/kg, and Co, 0.07 ±0.01 mg/kg, and Pb 0.06±0.01 mg/kg. The grand mean result of the metals determined were subjected to test of significance deploying ANOVA using SPSS model 29 at 0.05 level of significance. The p-valuewas 0.48 thus rejecting H_0. The study concludes that the heavy metals in the cassava tubers are higher than the critical threshold recommended by WHO thus the cassava roots and products are not healthy for human consumption. They are also not fit for export. It recommends that the impacted areas should be remediated and the monitoring agencies advised to increase their surveillance for the oil extracting companies to comply and adopt world best practices in their activities.

Keywords: *Oil exploitation, heavy metals, cassava roots, bioaccumulation, human health*

Introduction

Cassava was has its origin in America and was brought into Africa by the Portuguese in 1558 where it has become staple food and mainstay economic source of the rural economies. Cassava is a traditional food in Nigeria, Ghana, Togo, Republic of Benin and Central Africa Republic (Ogwu, *2021*, Singh *et al*., 2012, Singh *et al*., 2015). It is also consumed as staple food in Thailand, China, Indonesia and Panama (Shah *et al*., 2013; Ogwu*et al*, 2022b, Sangwan*et al*., 2014). Cassava is very rich in vitamin and low in sugar (Rasaq*et al*., 2015, Ogwu*et al*., 2021b, Panda *et al*., 2013). It repairs damaged kidneys and protects the liver against cancer

(Ogunlesi*et al*., 2017, Ogwu*et al*, 2021a, Nwinnewii and Neeka, 2017). Cassava is used as composite in bread and cakes in confectionary and as a sweetener in drug manufacturing (Ogwu*et al*., 2020, Moradi*et al*., 2013, Mee-Young *et al*., 2013). It also found use as glue, in plyboards manufacturing and in alcohol production (Ogwu*et al*., 2021a, Luo*et al*., 2012, Khan *et al*., 2008). Cassava is useful in making of wall paper, starch production and in canned fruits (Kacholi&Sabu, 2018, Ogwu*et al*., 2022a, Idodo-Umeh&Ogbeibu, 2010). The peelingsand pellets are valuable in livestock nutrition (Ogwu*et al*.,2023c, Hind *et al*., 2014, Foju-Mensah *et al*., 2017, Hajar*et al*., 2014).

The world cassava processing market stood at 311.5 million metric tonnes in 2022 (Food and Agricultural Organisation, 2023, World Food Programme, 2023). Nigeria is the world greatest producer of cassava with production volume of 60.1 million metric tonnes (Ogwu*et al*., 2023a, Adezugo, 2023, Ozah, 2023). Cassava is Nigeria rural economy mainstay with 9.085736 hectares of land being put into its cultivation annually (IKuemonisa, 2020, Aduda, 2021, Ogagu, 2021). The region for cassava production in Nigeria is the Niger Delta which also doubles asNigeria oil belt (Ogwu*et al*., 2022a, Ogwu*et al*., 2022b). Oil exploitation is associated with oil spills which degrades the environment and hults its ecosystem services (Ogwu et al., 2022a, Ogwu et al., 2023a, Ogwuet a., 2023c). Nigeria recorded 822 oil spills cases between 2020 and 2021 with 28,0003 barrels of oil spilled to terrestrial and aquatic environment (Friend of the Earth, 2022, Nigeria Environmental Society, 2022, National Oil Spills Detection and Response Agency (NOSDRA), 2023). Oil iscomposed of hydrogen, carbon, nitrogen, sulphur, oxygen and varying percentage of varying heavy metals (Atshana&Atshana, 2012, Aworegba2015, United States Environmental Protection Agency, 2015)

Bioavailability of heavy metals in the soil environment results in bioaccumulation and biomagnification of the metals in crops grown in the environment (Ogwu*et al*, 2023a, Ogwu*et al*., 2023b, Bamgboye, 2020). Consumption of heavy metals contaminated foods is associated with health complications such as renal failure, lung, nose and throat cancers, cardiovascular problems, memory loss amongst others (Bike *et al*., 2015, Benson *et al*., 2015, Ali *et al*., 2013, Ahmad &Ashraff, 2011).

The focus of this study is the determination of the heavy metals content of cassava roots grown in the Niger Delta oil bearing regions of Nigeria. The heavy metals investigated are Cd, Cr, As, Pb and Co.

The study was guided by research questions as;

- What are the concentrations of Cd, Cr, As, Pb and Co in cassava roots grown in the Niger Delta?
- Are the concentrations of Cd, Cr, As, Pb, and Co in the cassava roots within the World Health Organisation(2014) Maximum Permissible Concentrations (MPC) for heavy metals in foods?
- are cassava roots produced in the Niger Delta healthy for human consumption?
- Can the cassava produced in the region be exported to international markets considering Codex Alimentarius standard for agricultural produce export?

The study was guided by a hypothesis as;

Ho: there is no significant difference between the heavy metals concentrations in the cassava roots grown in the Niger Delta and WHO Maximum Permissible Concentrations for heavy metals in food crops and produces.

Study Area

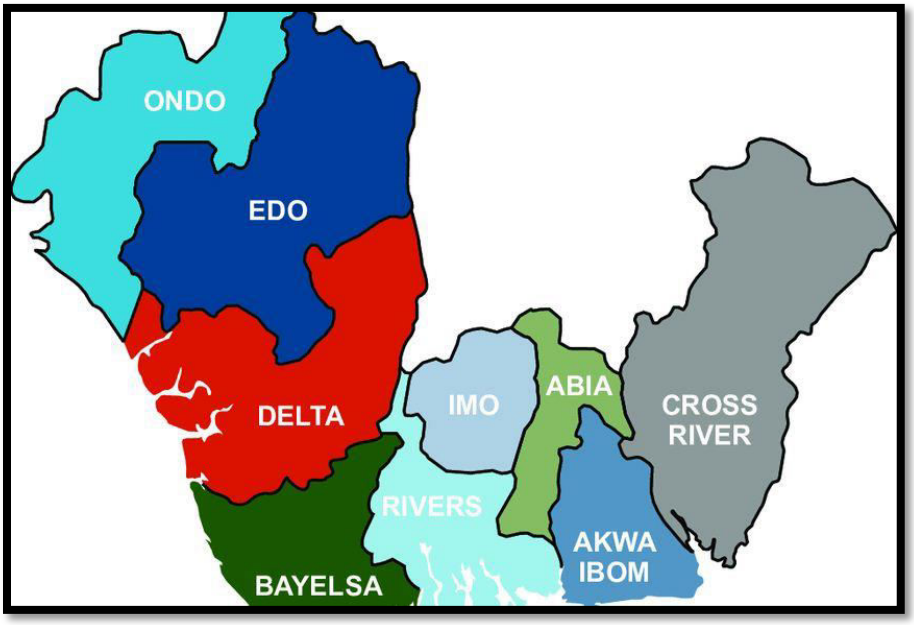


Figure 1: Map of Niger Delta
Source: Oladeinde (2021)

Niger Delta is the delta of the River Niger in Nigeria. It covers nine states of southern Nigeria and it is located at the Gulf of Guinea within geographical coordinates of latitude 3° and 4°N and longitude 4° and 8°Ewith an area of 70000km^2 (7.5% of Nigeria land mass), separating the Bight of Bonny from the Bight of Benin.
The Niger Delta is the hydrocarbon zone of Nigeria whose inhabitants are mainly agrarians producing yams, cocoyam, vegetables, maize plantain and cassava in commercial scale.

Materials and Methods

5 out of the 9 states that make up Niger Delta region were randomly selected to make the study states. These were Delta, Bayelsa, Rivers, Akwa-Ibom and Imo state.
From each of the 5 states, an oil producing community was randomly selected for samples collection and the communities selected were; Delta state; Okpai oil producing community, Bayelsa state; Sagbama, Rivers State; Ogoni oil producing community, Akwa-Ibomstate; Eketoil producing community and Imo State; Oguta oil producing community.
From each of the oil producing communities, 5 agrarian quarters/villages were randomly selected for samples collection and these wereOkpai in Delta state and the villages were samples were collected were, Oluchi Okpai-Ashaka, Obi-eze, ObodoOyibo, OkpaiAnieze;SagbamaBayelsa state and the selected villages were Abuku, Angalabiri, Asamabiri, Anibeze and Ebendebiri,Ogoni(River state) and the villages randomly selected were Babbe, Gokana, Ken-Khana, Eleme and Toi.Eket (Akwa-Ibom state) and the villages/quarters were Samples were collected wereIkot-Abasi, Esiturua, AfaraAtai, Edet-Urua, and Ebanawhile in Imo state the oil producing community is Oguta and the quarters sampled were Batu, AmaOzua, Enigbo,Obegwu and Ogwunna.

From each of the villages, moderate cassava root sizes were collected from 5 spots in 5 farms with the assistance of the villager in each quarter/village. The samples collected from farms were then bulked and composite collected in each case were well labelled and stored for analysis.

Sample Preparation

The cassava roots were washed with clean water to remove the associated dirt. They were later washed with doubled distilled water and again with deionized water. The barks of the cassava roots were then peeled with stainless scapels and knives and then washed again with double distilled water. The edible part left were then diced with stainless knives into small cubes and were later oven dried with Agilent G2545a Hybridization oven for 12 hours to achieve a constant weight. The dried roots were then milled into powder with high quality Agilent laboratory blender/homogenizer.

Digestion of Cassava Root Samples

2.0g of each of the cassava samples from each village from the varying oil producing communities were weighted out into digestion vessels that have been thoroughly washed with 65 percent nitric acid (HNO_3) and 40 percent hydrogen peroxide (H_2O_2) together with one ml of hydrochloric acid (HCl).

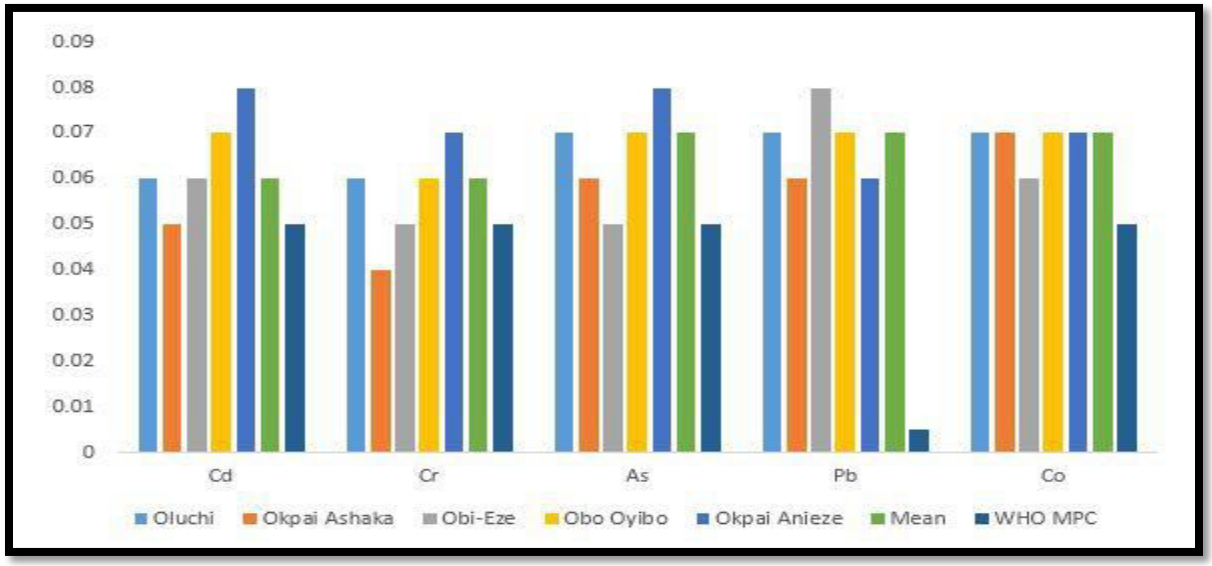
The samples in the digestion vessels tightly sealed are placed in steam bath at 60°C for 1 hour 30 minutes until digestion is completed indicated by the appearance of clear colour of the digests. 20 ml of water was added and heated for another half an hour and the vessels then removed from the digester and the digests allowed to cool for two hours (2hrs). Water was added to mark and the digests allowed to cool further at room temperature. The digests were later transferred into 50 ml volumetric flask and water added to 50 ml mark. The digests were filtered using Merck Germany filter into plastic sample bottles of 50 ml. The metals, Cd, Cr, As, Pb and Co were determined using Analytic Jena's NOVAA 800 Atomic Adsorption Spectrophotometer (AAS).

Results

The results of the analysis of the heavy metals in cassava roots from oil bearing communities of the Niger Delta are as in Figures 2-6 while the grand mean results of the heavy metals is as in Figure 7.

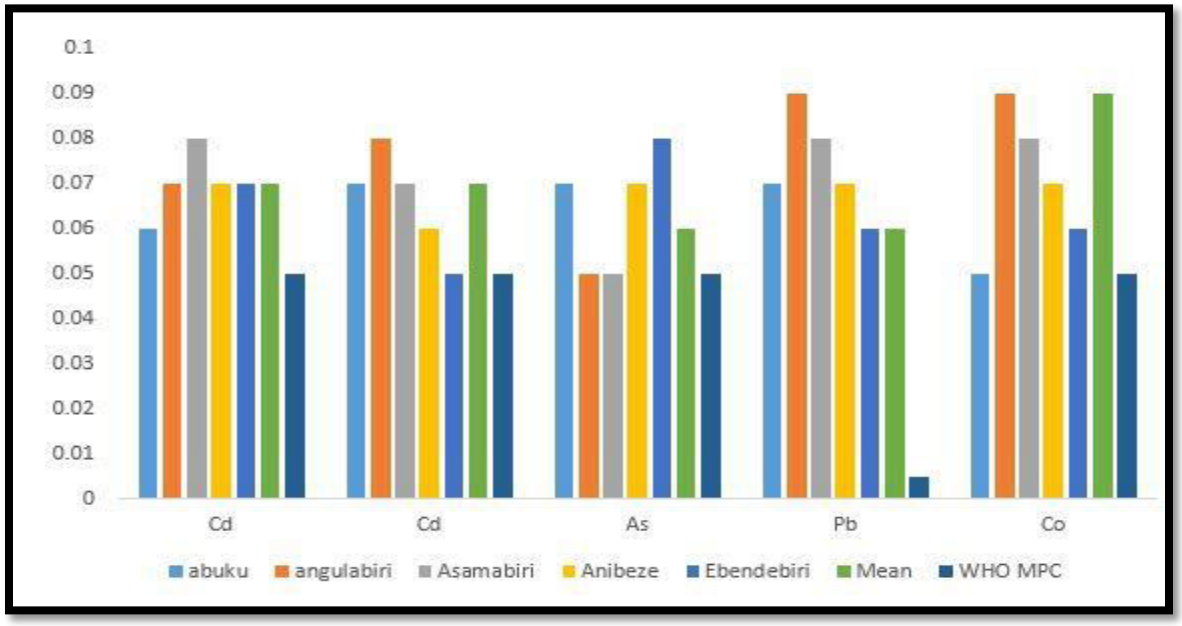
The results of the heavy metals in cassava roots in Okpaioil bearing community Delta state are as in Figure 2.

Figure 2: results of the heavy metals content in cassava roots in Okpai and WHO MPC in mg/kg.



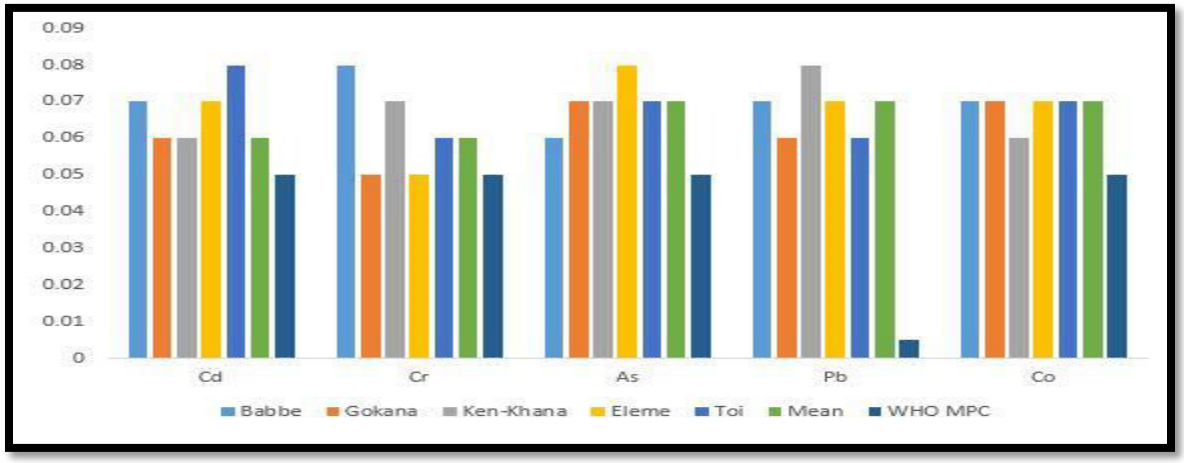
The results of the heavy metals in cassava roots in Sagbama oil producing communities Bayelsa state are as in Figure 3.

Figure 3: results of the heavy metals content in cassava roots in Sagbama oil producing community and WHO MPC in mg/kg



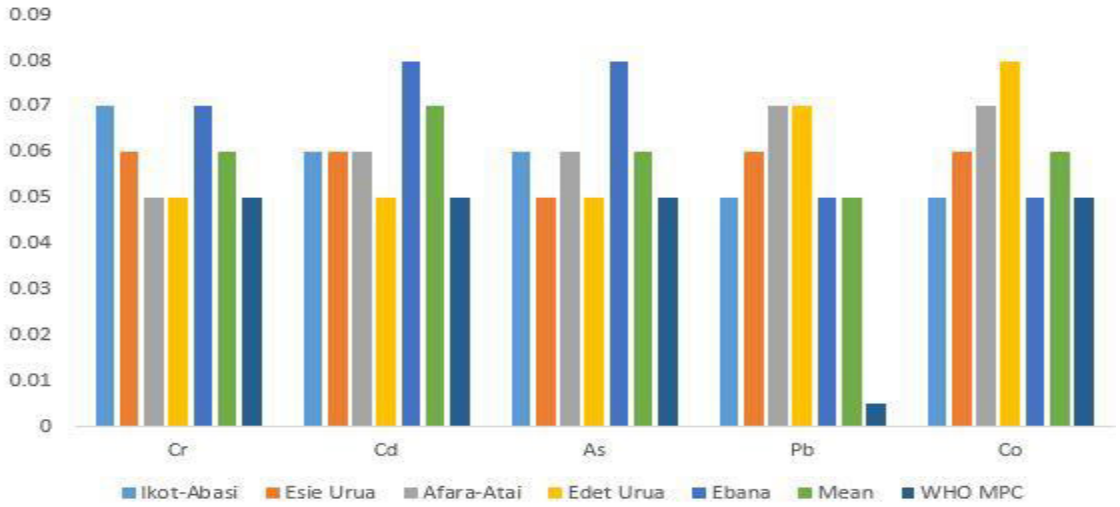
The results of the heavy metals content in cassava roots in Ogoni oil bearing community River state are as in Figure 4.

Figure 4: results of the heavy metals in cassava roots in Ogoni oil bearing community and WHO MPC in mg/kg



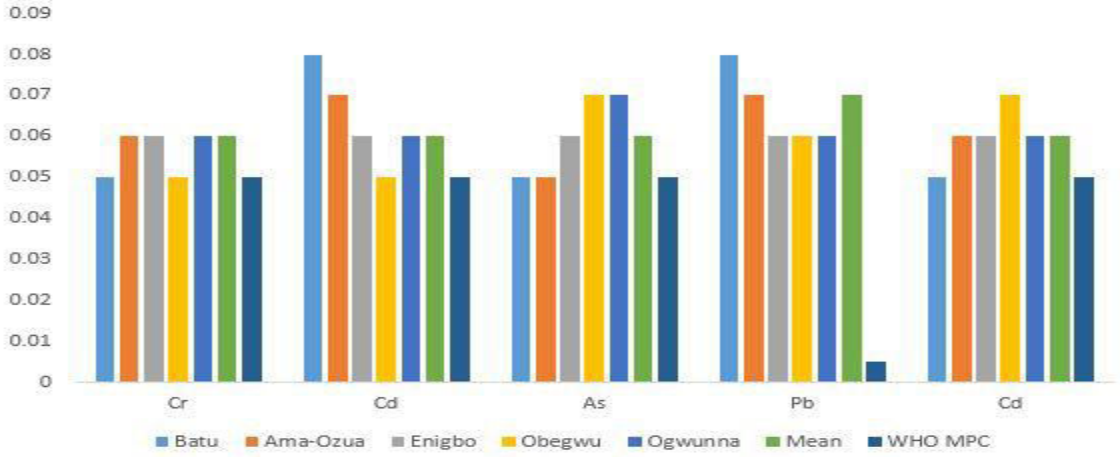
The results of the heavy metals in cassava roots harvested in Eket oil bearing community Akwa-Ibom state are as in Figure 5.

Figure 5: results of the heavy metals content of cassava roots in Eket oil bearing communities and WHO MPC in mg/kg.



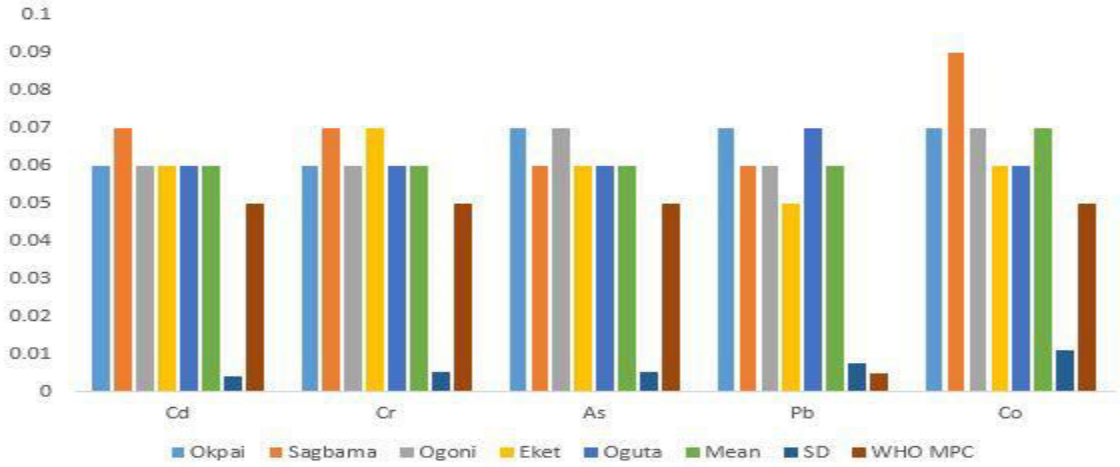
The results of the heavy metals content of cassava roots grown in Oguta oil producing community Imo state are as in Figure 6.

Figure 6: results of the heavy metals in cassava roots harvested in Oguta and WHO MPC in mg/kg.



The grand mean of the heavy metals measured in 5 oil producing communities in 5 Niger Delta states are as in Figure 7.

Figure 7: grand mean results of the heavy metals in cassava roots harvested in Niger Delta oil producing states and WHO MPC in mg/kg.



The grand means of the heavy metals in cassava roots in the Niger Delta oil producing communities of Nigeria were further subjected to test of significance deploying special package for social sciences (SPSS) model 29 at 0.05 level of significance The p value was 0.48, thus rejecting H_0.

Discussion

The analyses of the cassava roots harvested from Niger Delta oil bearing communities presented varying concentrations of the heavy metals investigated.

The mean concentrations of Cd the analyses revealed is 0.06 mg/kg in OKpaiOgoni, Eket and Oguta to 0.07 mg/kg in Sagbama. The deviation from the critical point established by WHO of 0.05 mg/kg is as a result of input of Pb by anthropogenic sources. High content of Pb in cassava was reported in (Yar*et al*., 2001, Wang *et al*., 2005). The presence of Pb above the recommended level in human system results in health complications

such as cancer of the lungs, sinus and liver (Verma*et al*., 2013), bone degeneration, memory loss and death (Ogwu*et al*., 2023d).

The analysis of the cassava roots cultivated in oil producing communities of the Niger Delta for Cr showed varying results ranging from 0.06mg/kg in Okpai, Ogoni and Oguta to 0.07 mg/kg in Sagbama and Eket with a grand mean of 0.06 mg/kg. The WHO MPC for Cr is 0.05 mg/kg. The elevated content of Cr in the cassava roots is attributable to the impact of oil exploitation in the communities.Increased content of Cr in cassava was in the reports present in (Uwah*et al*., 2009, Singh *et al*., 2010). Ingestion of Cr in human system causes varying health problems such as dermatitis and cancer of the lungs (Sharma *et al*., 2010, Sharma *et al*., 2008, Ogwu*et al*., 2023c).

Laboratory analysis of cassava tubers grown in oil bearing communities of the Niger Delta for the As showed that the concentration is between 0.06 mg/kg in Oguta, Eket and Sagbama to 0.07 mg/kg in Ogoni and Okpai with grand mean of 0.06 mg/kg, while the WHO MPC for As is 0.05 mg/kg. The high content of As noticed in the roots is as a result of As being bioavailable in the soil as a result of oil exploration and extraction in the region. Similar reports of high content of As in roots and tubers were in (Shafiq*et al*., 2012, Ogwu*et al*., 2023a, Opeluwa*et al*., 2012). Effects of As in man include poor cognitive development, skin lessions and cardiovascular diseases (Osuocha*et al*., 2014, Olalade&Ologundudu, 2007, Mohammed & Folorunsho, 2015), infant mortality, reduction in sperm motility in male (Mbong*et al*., 2013, Okeshwari&Chandrappa, 2006).

Analyses of cassava roots grown in the Niger Delta oil bearing communities for the content of Pb revealed the concentrations of Pb to be between 0.05 mg/kg in Eket to 0.07 mg/kg in Okpai with a grand mean of 0.06 mg/kg. WHO MPC for Pb is 0.005 mg/kg. This increased Pb concentration in the cassava roots in the region is traceable to the impact of oil exploitation and spillage into the environments. This report of high content of Pb in Cassava roots is in agreement with the reports in (Lokeshappa*et al*., 2012, Khan *et al*., 2031, Kabata-Pamidlas&Pendias, 2011). The effects of ingestion of Pb contaminated foods include intellectual disability, convulsion and coma (John *et al*., 2009, Fassir*et al*., 2005). It also attacks the central nervous system and may leave the survivor with low intellectual capability (Jacob, 2010, Chiroma, 2003).

Analysis of cassava roots grown in the Niger Delta for the Co content also showed varying mean concnetrations ranging from 0.6 mg/kg in Eket and Oguta to 0.09 mg/kg in Sagbama with a ground mean of 0.07 mg/g. The WHO MPC for Co is 0.05 mg/kg. The high content of Co in the cassava rootsis the concomitant effect of input of Co into the environment through oil activities. High content of Co inroots grown in industrial areas was in the reports of (Amusan*et al*., 2003, Adu*et al*., 2012, Adelasoye, 2014). The effects of Co in man include visual loss, hearing loss, heart diseases (Abegunde, 2015) weakness, fatigue, and peripheral neuropathy (Gideon & Josephine, 2008).

Conclusion and Recommendations

Oil is Nigeria economic mainstay contributing 85 percent of Gross Domestic Product (GDP) and 95 percent of foreign exchange earning. Oil exploration and explitation activities most often especially in the third world countries such as Nigeria leave the environment of operation highly degraded through incessant oil spillages. Crude oil is a complex compound containing hydrogen, carbon and oxygen and varying percentage of heavy metals and metalloids that bioaccumulate in crops in the soil and in aquatic organisms in marine environment.

The analysis of the cassava roots grown in the Niger Delta oil bearing communities revealed that the heavy metals investigated have bioaccumulated in the edible roots making them unhealthy for human consumption. Consequent upon the results of the analyses, the study recommend thus:

- Cassava roots grown in the soil bearing communities of the Niger Delta are unfit for human consumption due to heavy metals contamination.
- The cassava are also not suitable for export because of their failure to scale Codex Alimentorius conditions for export of agricultural produce.

- The impacted environment should be remediated.
- The Agencies charged with monitoring oil production environment: National Environmental Standards Regulation and Enforcement Agency (NESREA) and National Oil Spills Detection and Response Agency (NOSDRA) are enjoined to step up their surveillance on the oil companies in the Niger Delta for compliance to set standards.

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Corresponding email ***chukwudiogwu008@yahoo.com***