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SPECIATION OF THE HEAVY METALS CONCENTRATION IN CASSAVA ROOTS (MANIHOT SPP. FAMILY EUPHORBIACEAE) CULTIVATED IN OKPAI OIL AND GAS BEARING COMMUNITY, DELTA NIGERIA.

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Abstract

Industrial activities of oil exploration and exploitation have been consistently associated with environment degradation thus violating the environmental quality. This study was an ex-post facto research that investigated the content of heavy metals in cassava roots in Okpai

oil bearing community for their sustainability for human and animal consumption and for export. Okpai community was mapped into sample units corresponding to the 5 quarters, Oluchi, Obeze, Umuagulu, Ashaka and Obodoyibo. Each units was further mapped into 5 research cells using the villages farm locations and cassava roots samples of 4-5 cm in length were obtained from 5 sampling spots in each cell bulked and composites drawn. The analytical standard adopted was WHO 2018 and the instrument of determination deployed was Agilent ICP-MS Mass Hunter Software version 5.7 and the mean results obtained were as follow; Pb, 0.05±0.00 mg/kg, Cd, 0.05±0.02, Mn, 0.06±0.02, Co, 0.02±0.00 and Cr, 0.06±0.02. The mean results were further subjected to test of significance deploying SPSS IBM model 29 at 0.05 level of significance and the p-value was 0.048 thus rejecting H0. The study concluded that the heavy metals concentration in cassava roots in Okpai were higher than WHO 2018 maximum permissible concentration for heavy metals in food and thus recommended that cassava production should be discontinued in the interim. Oil company in Okpai should be made to adopt world best practices in their operations; decontamination remediation and restoration should be commissioned forthwith to restore the environment to its hitherto pristine status so as to attain improved environmental quality.

Keywords: *Oil exploitation, heavy metals, Bioaccumullation, Biomagnification, cassava root, Environmental quality.*

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Introduction

Environmental quality and sanctity is constantly violated by man in course of his developmental activities through the expulsion of multiplicity of toxicants and one of such toxics substances is heavy metals. Heavy metals are a group of metallic chemical elements having relatively high atomic weights and high density (Jone 2020; Davidson 2021; Betrand, 2024). They are metals with densities of more than $5g/cm^3$ (Benson, 2023, Terry, 2024), a group of naturally occurring elements that are metallic and sometimes metalloids with densities higher than water and with high molecular weights (Thomas, 2019, Joseph, 2020, Kent, 2021). Any metallic element that is poisonous at very low concentration with proportionally high density (Maximillian, 2018, Tedwell, 2019) and are non-biodegradable in natural environment (Benjamin, 2020, Leonard, 2021) and that can sometimess be categorized as essential and toxic metal (Joseph, 2023, John, 2024). Heavy metals refers traditionally to metallic elements with atomic weights of between 63.5 and 200.6 and with density of more than $4.5g/cm^3$ found in earthcrust in water and atmosphere (Abdel-Daim *et al*., 2015; Abolaji *et al*., 2020, Aboihassan, 2015, Ogwu *et al*., 2021).

Heavy metals contamination is a global phenomena that is attaining crises point (Ogwu *et al*., 2020, Adetegha *et al*., 2015, Adeyemi *et al*., 2017, Aljaiwas *et al*., 2017, Alkaraz-Contrerus *et al*., 2016) and whose sources in the environment are naturally through weathering of rocks, volcanic eruption (Alhusaini *et al*., 2019, Atmeer *et al*., 2019, Azeh *et al*., 2019), forest fire (Ogwu *et al*., 2022, Baha *et al*., 2017, Banerjee, 2020). Anthropogenic sources of heavy metals are varied and include industrial processes; smelting, mining, manufacturing (Barhoma 2018, Batool *et al*, 2019, Erboga *et al*., 2016, Elshazly *et al*., 2015), agricultural practices;; pesticides, fertilizers (Friberg *et al*., 2019, Elblehi *et al*., 2019, Donrado *et al*., 2020, Beng *et al*., 2016), through the extraction and combustion of fossil fuels; oil and gas (Chen *et al*., 2018, Coetzee *et al*., 2020, Cao *et al*., 2016).

Nigeria is an oil based economy with oil and gas contributing 80 percent to its gross domestic product (GDP) and 90 percent of its foreign earning (Nigeria Bureau of Statistics (NBS), 2014, Ruwani, 2025, Oteriba, 2025) and Delta State is currently maintaining the lead as the highest oil producing state in Nigeria (NBS, 2025, Ruwani 2025) with 100 barrels per day production output (NBS, 2025). Okpai produces 183.4 cubic feet of gas and 1.8 million barrels of oil per day (NBS 2025, Oteriba, 2025, Ruwani, 2025) and plays host to the largest gas plant in West Africa (Nigeria National Petroleum Company Plc, 2025, NBS 2024).

Bioavailability, bioaccumulation and biomanification of oil is usually through equipment failure, tank wash, ballast water, pipeline rupture (Ogwu *et al*., 2022, Chen *et al*., 2018), bunkering, pipeline vandalism (Gong *et al*., 2021, Cao *et al*., 2016) through particulates from gas flare (Kaushal *et al*., 2019, Hayat *et al*., 2018, Jiao *et al*., 2019, He *et al*., 2019, Guuvala *et al*., 2019, Gworek *et al*., 2020), Petroleum oil is composed of carbon, hydrogen oxygen and variable heavy metals (SU *et al* 2016, Tanaka *et al* 2017) (Goodarzi *et al*., 2017, Gong *et al*., 2021, Karbowska 2016, Ituang *et al*., 2019). Human exposure and ingestion of heavy metals contaminated foods result in renal failure osteoporosis (Kulka, 2016, Lentini *et al*., 2017, Li *et al*., 2016, Li *et al*., 2015, Mitra, 2021), cancers, (Naz & Balzo, 2017, Ommati *et al*., 2019, Mohamed *et al*., 2017), hormone function disruption (Loh *et al*., 2016, Patel & Lao, 2015, Mohajeri *et al*., 2017), reproductive health issues, neurological disorder (Rahaman *et al*., 2021, Su *et al*., 2016, Fudjarwo *et al*., 2017, Uter *et al*., 2018, Tanaka *et al*., 2017, Sunet *et al*., 2017).

The focus of this study was the analysis of the cassava roots cultivated in Okpai oil bearing community for the content of the heavy metals as concomitant effects of oil exploitation on environmental quality. The heavy metals investigated were, lead (Pb), cadmium (Cd), Manganese (Mn), Cobalt (Co) and Chromium (Cr).

The study was guided by objectives as to:

1. determine the concentration of Pb, Cd, Mn, Co and Cr in cassava roots harvested in Okpai Oil bearing community
2. ascertain if the concentrations of the heavy metals in the cassava roots are within the Maximum Permissible Concentrations (MPC) of the heavy metals in foods espoused by World Health Organization (WHO) 2018.
3. establish if the roots are healthy for human consumption?
4. find out if the cassava roots in okapi are fit for formulation of animal feeds?
5. validate the export potentials of cassava roots cultivated in okpai considering Codex Alimentarius 1963 conditions for produce export commission.

The hypothesis that guided the study was;

H_0: there is no significant difference in the concentrations of the heavy metals in cassava roots harvested in Okpai oil bearing community and WHO 2018 MPC for the heavy metals in foods.

Area of Study

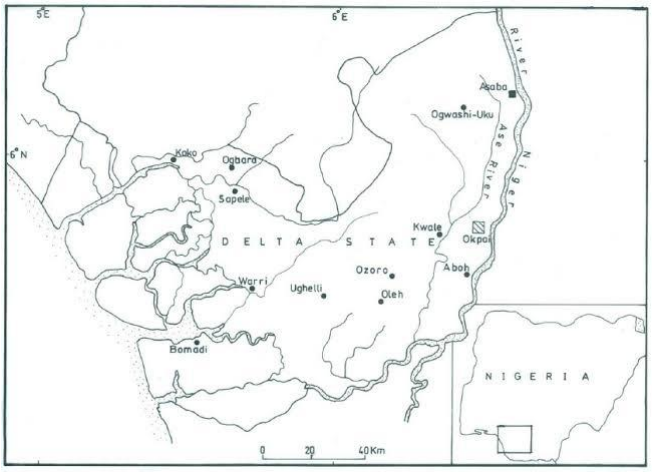


Figure 1: Map of the study location showing Okpai

Okpai community in Ndokwa East Local Government Area Delta State Nigeria lying between geographical coordinates of 5.7230°N and 6.59900E, has a population of 14000 people (National Population Commission estimate 2006), It is a wetland linear settlement along the coast of River Niger distributry. The people of Okpai are mainly farmers and fishermen, others are artisans, petty traders while some are civil servants teaching in public primary and secondary schools. A few work in the oil company, mainly as janitors, messengers and security guards. The environment is the recipients of the effluents generated by the oil company in course of oil explotation and flaring of the associated gas.

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Materials and Methods

Ethical consideration

The cassava roots were sampled from farms in the agrarian oil-bearing community after permissions were sought from village heads and the farm owners. No approval was sought from the State or Federal Government as cassava is not on prohibition list and it was not endangered.

Sampling

This study was carried out within a period of 6 months, January to June, 2025. Cassava roots samples were collected with the help of research assistants one each from the 5 quarters that make up Okpai research grid. These are Oluchi, Obeze, Umuagulu, Okpai Ashaka and Okpai Obodoyibo. The quaters were mapped out into 5 research cells and cassava roots measuring 4-5 cm were collected from 5 spots in in five different farm in its cell, and these were bulked and composites the drawn were washed with clean water and rinsed with doubled distilled water and the peels removed using stainless steel scalpel. The cassava roots were dehydrated with Agilent 6890/9890 GC oven stroudsat at 105°C for 24 hours and homogenized using Agilent technologies homogenizer 7550 Exapro blender. 10g of the samples from each cell were drawn rapped with aluminum foil paper giving a total of 25 samples from each cells and a total of 125 samples from the grid for analysis.

Sample Analysis

The analytical method adopted was WHO 2008.8 (2018) as described in (Li *et al* 2016 Hayat *et al* 2018) 5g of the samples were measured out into laboratory beakers and digested with perchloric acid and nitric acid at 1:1 ratio and the mixtures were then heated at 200°C for 1½hrs using Agilent door oven 3250 model. The digest were allowed to cool for 2 hour and the concentration of the metals were determined using Agilent inductively Coupled Plasma Mass Specrometry (ICP-MS) Mass Hunter Software version 5.7 as described in Mabro UK *et al*., 2017, Reczek, 2017, Zhou *et al*., 2021).

Quality Assurance

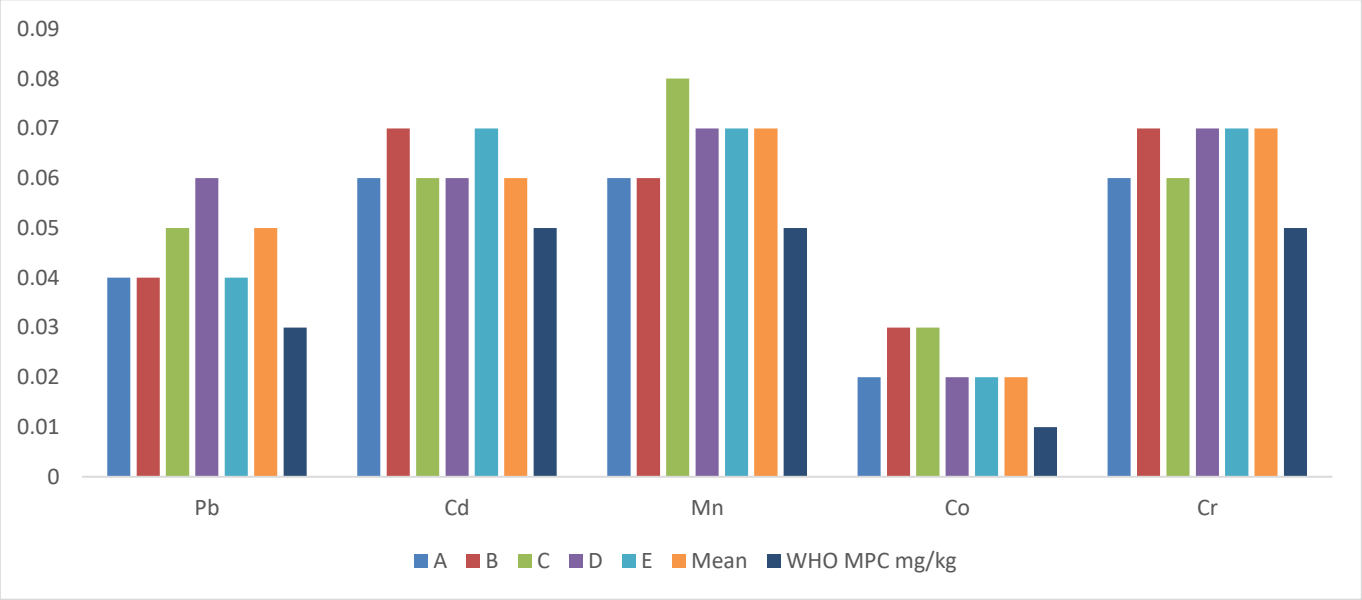
Reagents used for this study were of high quality and the equipment were of proven standards being products from organization with enviable track records. The beakers were soaked in nitric acid for 2 hours and washed in potassium permanganate and rinsed in deionized water. Occurrence were checked with International Atomic Energy CRM407 Reference Material. The result of ICP/MS was very satisfactory and gave an accurate reading of the metals to certified grade of 99-100%.

Results

The results of the analysis for the heavy metals in cassava roots in Okpai community were as in Figures 2 – 6 and the comparative mean results in Figure 7.

Figure 2. The results of the heavy metals content of cassava roots in Oluchi were as in Figure 2.

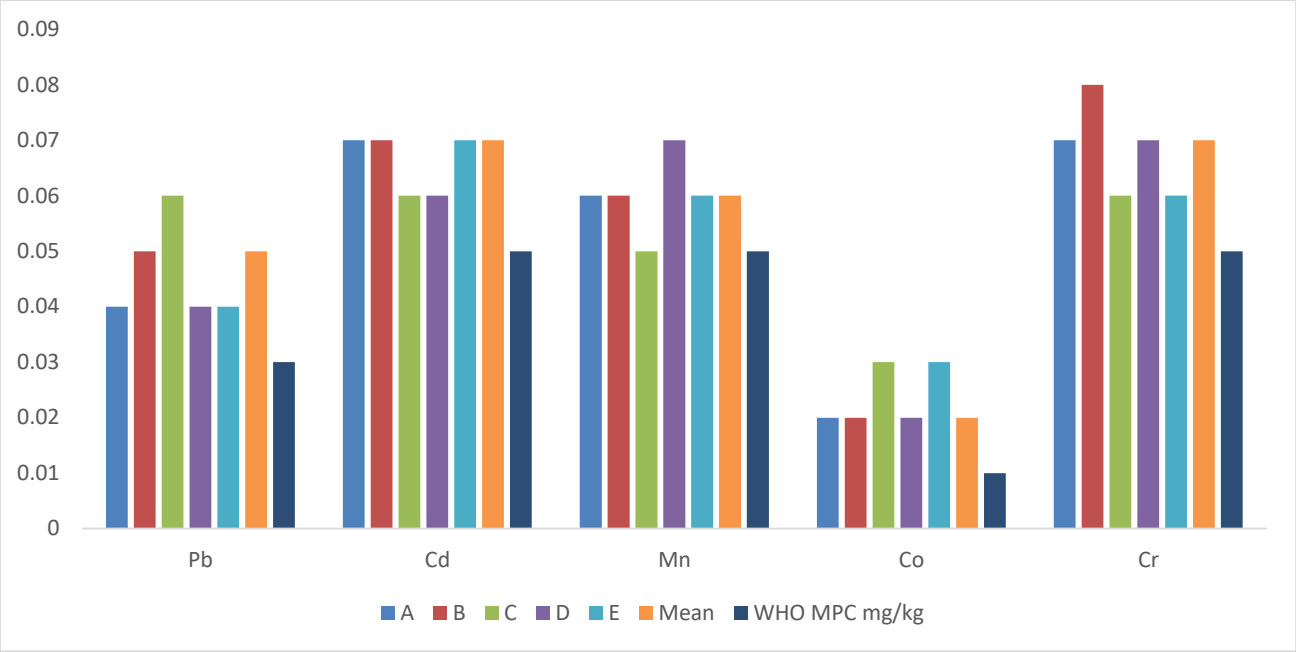
Figure 2: results of the heavy metals in the cassava roots in Oluchi and WHO 2018 MPC for the heavy metals in food in mg/kg.



The results of the concentration of heavy metals in the cassava roots in Obeze were as in Figure 3.

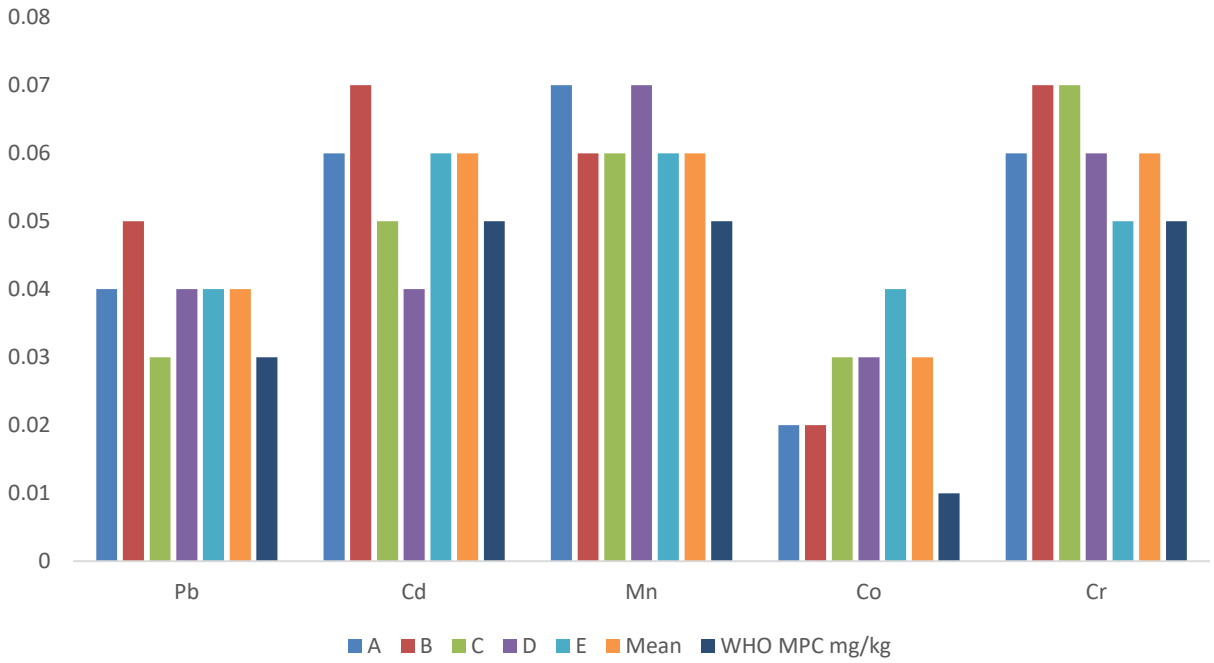
Figure 3: results of the heavy metals in cassava roots in Obeze and WHO 2018 MPC for heavy metals in food in mg/kg.

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The results of the heavy metals in cassava roots from Umuaqulu were as in Figure 4.

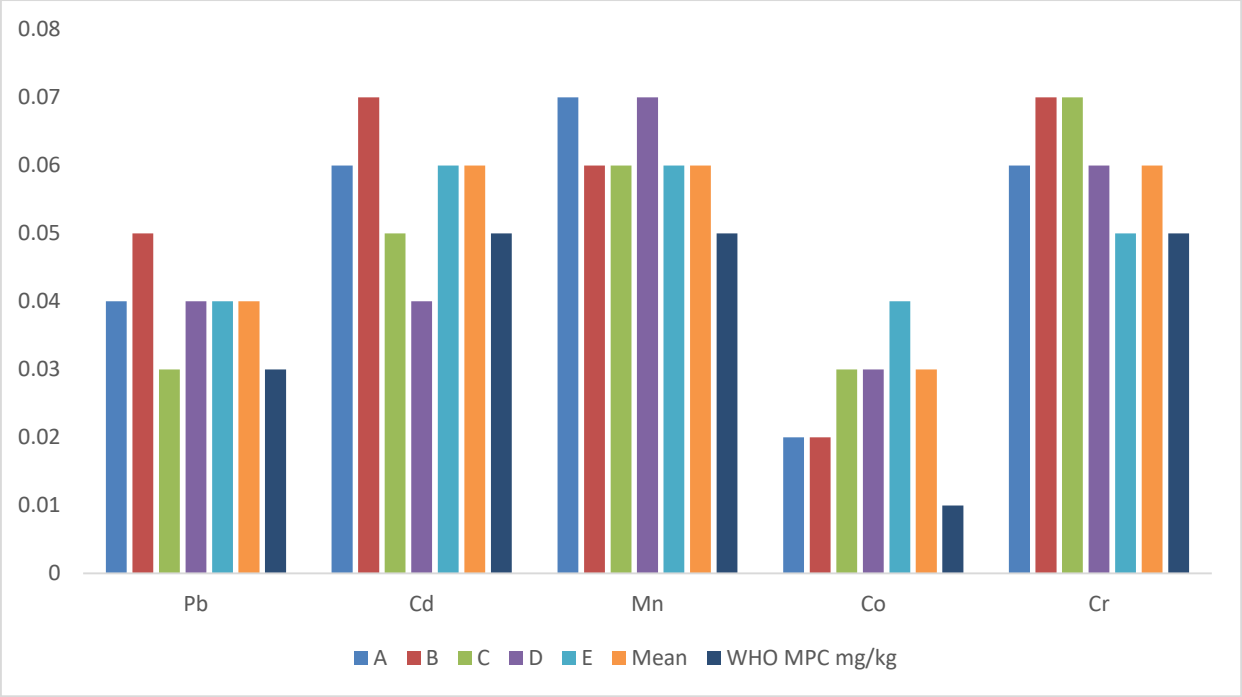
Figure 4: results of the heavy metals in cassava roots in Umuagulu and WHO 2018 MPC for heavy metals in foods in mg/kg.



Results of the heavy metals in cassava roots in Okpai-Ashaka were as in Figure 5.

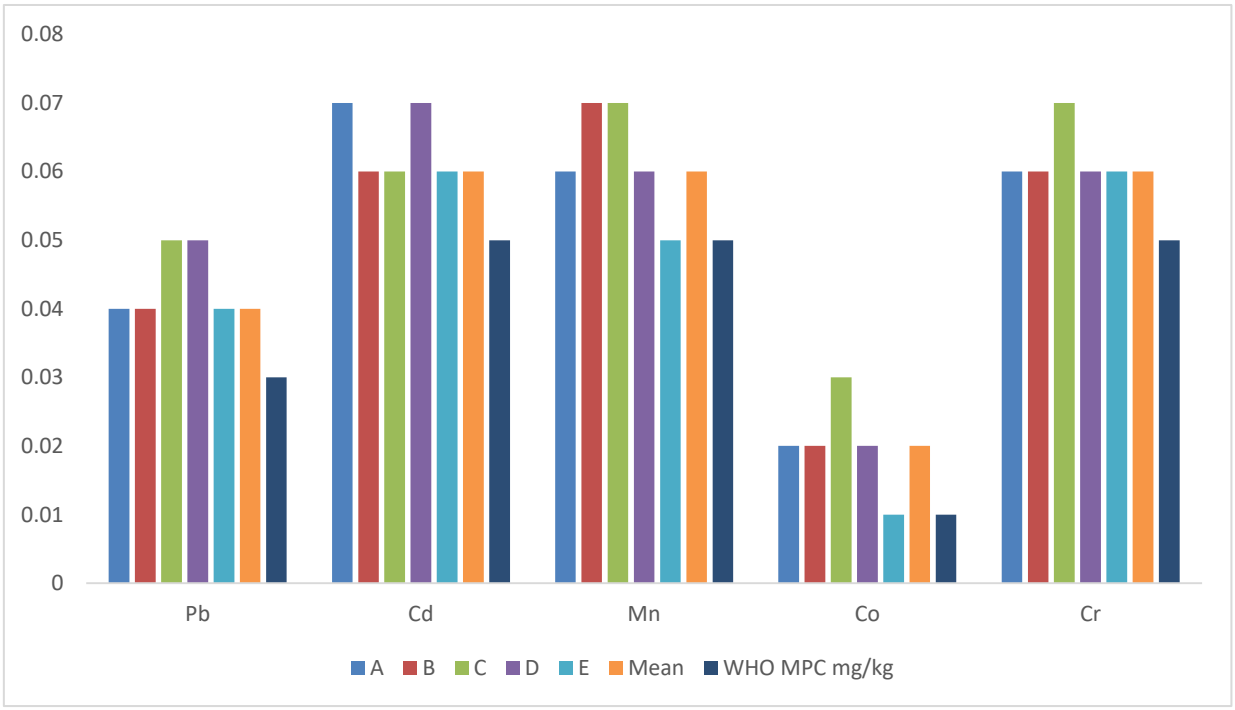
Figure 5: results of the heavy metals in cassava roots in Okpai Ashaka and WHO 2018 MPC for heavy metals in foods in mg/kg.

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The results of the heavy metals in the cassava roots in Okpai-Obodoyibo were as in Figure 6.

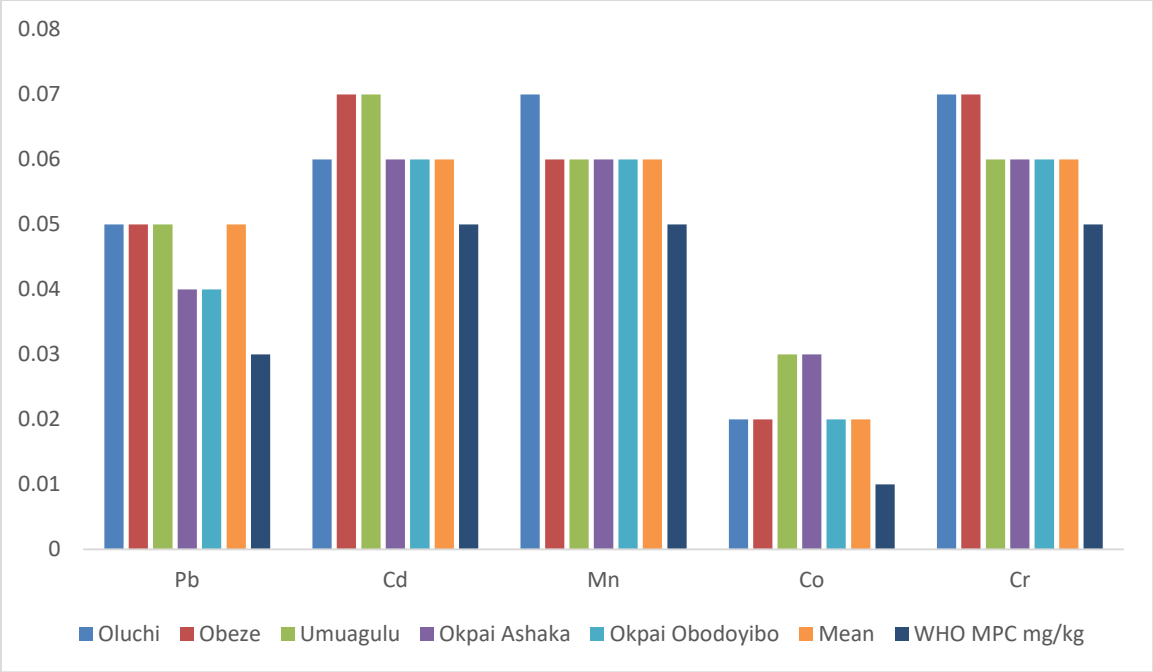
Figure 6: results of the heavy metals in cassava roots in Okpai-Obodoyibo and the WHO 2018 MPC for heavy metals in food in mg/kg.



The comparative mean of the concentrations of the heavy metals in cassava roots cultivated in Okpai oil bearing community were as in Figure 7.

Figure 7: Comparative mean results of the heavy metals in cassava roots in Okpai oil bearing community and WHO MPC for heavy metals in food in mg/kg.

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The mean results of the heavy metals in cassava roots in okapi oil bearing community were subjected to the test of significance using Statistical Package for the Social Sciences(SPSS) IBM model 29 at 0.05 level of significance and the P value was 0.048 thus rejecting Ho.

Discussion of Findings

This study evidenced varying concentrations of heavy metals in Okpai oil bearing community. The concentration of lead (Pb) the results revealed range from 0.034 mg/kg in Okpai-Ashaka and Obodoyibo to 0.05 mg/kg in Oluchi, Obeze and Umuagulu as against 0.03 mg/kg MPC stipulated by WHO 2018. The high concentration of pb in the cassava roots is oil activity related.High concentrations of Pb in crops harvested in oil-bearing areas was in (Zhen *et al* 2017, Ogwu *et al*., 2022; Ogwu *et al*., 2021, Zhang *et al*., 2020). Health implications arising from human exposure to Pb include high blood pressure, kidney damage (Zambel *et al*., 2016, Yumito *et al*., 2017).

The analysis of the cassava roots from Okpai for the contents of Cd showed the concentrations to be between 0.6 mg/kg in Oluchi, Ashaka, and Obodoyibo to 0.07 mg/kg in Obeze and Umuaguluu. WHO MPC for Cd in food is 0.05 mg/kg. The high content of Cd is anthropogenic. Similar results were reported in (Yang *et al*., 2020, Xiong *et al*., 2020). Cd has been fingered in immunological research to be associated with bone damage, respiratory problems and increased risks of cancer (Wagas *et al*., 2015, Wang *et al*., 2018, Ogwu *et al*., 2021).

Cassava roots in Okpai oil bearing community analyses presented the concentrations of Mn to be between 0.06 mg/kg in Obeze, Umuagulu, Ashaka and Obodoyibo to 0.07 mg/kg in Oluchi as against 0.05 mg/kg Maximum Permissible Concentration espoused by WHO 2018. The increased content of Mn is predicated on oil exploitation and spillages and gas flares into the environment. This report is a corroboration of the reports of (Benvenga *et al*., 2020, Shattacharya, 2018, Ogwu *et al*., 2020). Epidemiological studies have implicated Mn in varying health problems ranging from Manganism, a neurological disorder symptoms similar to Parkinson disease; tremours, muscle stiffness and impaired movement (Camps *et al*., 2020, Bronca *et al*., 2018), reproductive problems, respiratory problems and developmental problems in children (Bayat *et al*., 2015, Ali *et al*., 2020).

Analysing cassava roots for the concentration of Co revealed that the concentration range between 0.02 mg/kg in Oluchi, Obeze and Obodoybo to 0.03 mg/kg in Umuagulu and Ashaka. The maximum allowable concentration of Co in food as established by WHO 2018 is 0.01 mg/kg. This increased content of Co in the cassava root in Okpai is the concomitant effect of oil mining in the environment. This result is a confirmation of the reports in (Al-javian *et al*., fang *et al*., 2014, Ogwu et la., 2021). Human exposure to Co results in health complications such as impaired lung functions, and asthma (Bong *et al*., 2016, Gervas *et al*., 2016, Genchi *et al*., 2016).

The analysis of cassava roots in Okpai for the Cr contamination status showed that the concentration of Cr is between 0.06 mg/kg in Umuagulu, Ashaka and Obodoyibo to 0.07 mg/kg in Oluchi and Obeze WHO 2018 MPC for Cr is 0.05 mg/kg. This high content of Cr is attributable to the oil mining activities in the environment. A comparable result of high concentration of Cr in oil and gas bearing area was in (Garza-Lombo *et al* 2019, Gargauni *et al*., 2018, He *et al*., 2019, Ogwu *et al*., 2020). Health complications arising from human exposure to Cr include gastrointestinal problems, cancer of the bone and lungs (Gegazy & Fouad, 2014, Gumpta *et al*., 2016, hasanein et la., 2019, Hassanein *et al*., 2016)

Conclusion

The effect of oil exploration on environmental quality is well documented in literature but the effect of oil exploitation on the environment of Okpai remain scanty and sometimes unavailable and that underscored this study.

The study mean results of Pb, 0.05±01mg/kg, Cd, 0.06±0.10; Mn, 0.06±0.02, Co, 0.02±0.01 and Cr, 0.06±0.02, revealed that the content of the metals investigated in cassava root in Okpai were higher than World Health Organisatoin maximum permissible concentration 2018 and thus they are contaminated with heavy metals. The produce are therefore not suitable for human consumption and not suitable for compounding animal feeds. They are also not fit for export because they have failed Codex Allimentarius 1963 commission standards for international trade

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on agricultural produce. Against this backdrop, the study recommends that production and consumption of cassava roots in the study area should halt forthwith, oil companies operating in Okpai should be mandated to adopt the world best practices in their operations, decontamination remediation and restoration of the environment should be carried out on the environment, Nigeria Environmental Standards, Regulation and Enforcement Agency (NESREA) should be on top of their surveillance mandate so as to protect the environment from further degradation through oil activities so as to ensure environmental quality.

Declaration

We declare that this study is an original work of the researchers. It has never been submitted, reviewed or published by

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