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# TRANSLOCATION CONCEPT OF HEAVY METALS IN PLANTAIN CONSUMPTION CHAIN OF CRUDE OIL IMPACTED COMMUNITY IN BAYELSA STATE NIGERIA

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**Key words:** Heavy metals, Imiringi, Bioaccumulation, Plantain, Vitreous humour, Serum.

**ABSTRACT**

This study was conducted to assess the concentrations of some Heavy Metals (HM) and their translocation capacity in the various milieus of plantain cultivation-consumption chain using a rabbit as an animal model. Twelve male albino rabbits divided into control and treatment groups constituted the sample size. Both groups were fed with normal rabbit meal void of detectable HM, except for the treatment that plantain harvested from Imiringi Bayelsa State was included. Heavy metals (Cr, Pb, Cd, As, Hg) concentrations were estimated using AAS in soil, plantain, and serum, and vitreous of the groups. Data analysis was carried out using Student-tests on the SPSS version 22 package. Cadmium, chromium, arsenic, and mercury concentrations were significantly increased ($p<0.05$) in plantain cultivated soil when compared to the plantain. The concentrations of vitreous cadmium and lead were significantly elevated ($p<0.05$) in the treatment group when compared to the control group, whereas vitreous chromium was vice versa. Similarly, serum cadmium and chromium significantly decreased ($p<0.05$) in the treatment group when compared to the control group, whereas serum lead concentration increased. The study has shown that heavy metals have the preponderances of bioaccumulation and translocation in studied body fluids.

## INTRODUCTION

Crude oil is a composite of hydrocarbons that when distilled result in numerous products used for domestic and industrial activities. Products of refined crude oil include diesel, gasoline, heating oil, jet fuel, kerosene, and other products called petrochemicals. The process of crude oil exploration and exploitation result in the evacuation of countless toxic and no-toxic substances to the environment. These substances undergo a couple of reactions that are deleterious to humans, fauna, and flora. One of such toxic substances released from crude oil and gas exploration is heavy metals. Fossil fuel exploration and exploitation are known to be a major source of generation and release of heavy metals into the environment (Manisalidis, et al., 2020).

The term heavy metals refer to any metallic chemical element that has a relatively high density and is toxic at low concentrations. Heavy metals employed for this study include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), and lead (Pb). The negative impacts of heavy metals could be stratified into a human, ecological, evolutionary, nutritional, and environmental (Goyer, 1990; Christoforidis, et al., 2009).

Plantain is one of the most important crops of tropical plants. It belongs to the family Musaceae and the genus Musa rich in minerals and vitamins (Fagbohun, et al., 2010). Food consumption surveys in Nigeria identified plantain among the major starchy staples (Odenigbo, et al., 2012; Okeke, et al., 2008; Ogechi, et al., 2007). Being the major staple food in Bayelsa State, plantain is used in the preparation of varieties of local cuisines such as bole, kekefieya, and a lot more.

Exposure of food crops such as plantain to heavy metal contamination could pose a potential health risk to humans because these metals can "bio-accumulate and translocate". Reports from previous research have shown that compounds accumulate in

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living things any time they are taken up and stored faster than they are broken (metabolized) or excreted. Excessive accumulation of heavy metals from petroleum and other related human activities has been documented in soils and constitutes major environmental and human health problems (Hazrat, et al., 2019). Heavy metals have been found in food crops and are a potential health hazard to man through dietary intake (Obiajunwa, 2001). Uptake of heavy metals increases in plants grown in polluted areas and high levels of accumulation in common garden vegetables and plantain have been reported(Agoro, et al.,2022; Cortez, et al., 2014).

The routes and subsequent bioaccumulation of heavy metals occur in various organs of plants and consequently humans. In animals or humans, the transportation of xenobiotics is via the lymphatic or the hepatic system before accessing the circulatory system. Blood is the major fluid that facilitates the transportation of xenobiotics to the storage organs. Another fluid that performs a similar function is the vitreous humour. These fluids are pivotal in the study of transportation of xenobiotics and its toxicological effects(Agoro, et al., 2019; Agoro, et al., 2020).

Documented works of literature on bioaccumulation and translocation of heavy metals at the point of cultivation of plantain in a crude oil exposed community to consumption is lacking. The need to interrogate all facets as it relates to heavy metals translocation capacity and the impact on humans is apt, especially with the growing idiopathic causes of diseases. This study was therefore designed to trace heavy metal bioaccumulation and translocation from the point of cultivation to that of systemic assimilation using blood and vitreous samples of a rabbit as a model.

## MATERIALS AND METHODS

### Study Location

Soil and plantain used for the study were collected from Imiringi town. Imiringi is one of the major communities in Bayelsa State exposed to heavy oil and gas exploration and exploitation for over a half-century (Figure 1). It is located in Ogbia Local Government Area of Bayelsa State Nigeria. The animal breeding and laboratory analysis were carried out in the Biochemistry Department of Federal University Otuoke, and the Eni-yimini Laboratories LTD respectively.

### Research Design and Sample Size

Mead's resource equation was utilized for the calculation of the sample size (Kirkwood, et al., 2010). A total of twelve rabbits divided equally into control and treatment groups were used for the study. Except for the powdered unripe plantain sourced from Imiringi that was restricted to the treatments, other meals were given equally to both groups unhindered. Excluding two weeks of acclimatization, the animals were exposed to the above-stated regimes consecutively for three months before anesthesia and subsequent mechanical sacrifices. The rabbits were intoxicated with chloroform before the sacrifices.

### Selection Criteria

Rabbits used were healthy and active as confirmed and approved by a veterinary doctor. Rabbits showing signs and symptoms of illness were excluded. The research employed only male albino rabbits of age range between seven to eight months and weight brackets of 1.8-2 kg. Lysed blood samples and turbid vitreous humours were precluded. Soil and plantain samples were harvested from central locations in Imiringi town into appropriate collectibles. The locations were twenty meters apart.

### Ethical Approval

The ethical clearance was obtained from the Directorate of Research and Quality Assurance (DR&QA) of the Federal University Otuoke. The Animal Welfare Act of 1985 of the United States of America for research and Institutional Animal Care and Use Committee (IACUC) protocols were stringently followed.

### Collection of Samples

**Vitreous humour and blood:** Vitreous humour samples were collected by the method of Coe, whereas that of blood by the method of Ness (Coe, 1989; Ness, 1999). Both samples were collected into plain containers and centrifuged at 2000 rpm for ten minutes at 25°C. The supernatants were subsequently separated and used for the biochemical analysis.

**Soil:** 20 g of soil sample was collected into a plain clean plastic container with a tight lid from the ten locations of 20 meters apart in Imiringi town. The samples were consequently transported to the laboratory for heavy metal analysis. All the processes involved in the collection were strictly void of contamination.

**Plantain:** The plantains used were all harvested from Imiringi and of the same specie as indicated by the university botanist. Ten bunches of plantains of one kilogram each were harvested from ten locations as indicated in the soil collection. Plantains were peeled, sun-dried, and, grinded, and then collected into a clean plastic container for laboratory analysis. Aseptic methods were strictly followed to avoid contamination during the processing and collection stages (WHO, 1996).

**Laboratory procedure:** Vitreous humour and serum samples with a total volume of 1.2 L each were thawed at room temperature and each sample was treated separately. A volume of 300 µL of samples was added to 300 µL of HNO3 and 100 µL of H2O2. Sample decomposition was then carried out in a water bath at 80°c for 30 mins. After digestion/decomposition, samples were diluted to 10 µL with deionized water. Similarly, 2 g of soil or plantain samples were weighed and digested with aqua-riga for 1 hr. The samples were allowed to cool and filtered into a 50ml volumetric flask after digestion was completed. The digest from all the prepared matrices was then analysed using Varian Spectra A100 Atomic Absorption Spectroscopy (AAS) for Pb, Cd, Cr, Hg, and As.

**Statistics:** Data were analysed with the Statistical Package for Social Science (SPSS) program version 22 (SPSS inc., Chicago, IL, USA) and Microsoft excel. Student t-tests and One-way ANOVA (Post Hoc-LSD) were used in comparing the means of the various groups depending on the number of groups. Data were presented as Mean ± Standard Deviation (SD). The level of significance was pegged at less than or equal to 0.05.

## RESULTS AND DISCUSSION

Table 1 is an overview of the heavy metal concentrations in the various matrices used. World Health Organization (WHO) permissible limits for heavy metals in plants and soil were used as a baseline compared to that of Imiringi town. Cadmium concentration in Imiringi town was higher than the acceptable limit as shown in Table 2. Mean comparison of the heavy metal concentrations between soil and plantain samples exhibited a significant increase in concentrations of cadmium, chromium, arsenic, and mercury in soil samples when compared to that of plantain (Table 3). The mean concentrations of vitreous cadmium and lead were higher in the treatment group of rabbits fed with plantain when compared to the control; whereas chromium concentration was lower (Table 4). Serum cadmium and chromium were higher in the control group when compared with the treatment, on the contrary, serum lead was lower (Table 5). Figure 1 is a presentation of the location of the study location located in Imiringi in Ogbia Local Government Area of Bayelsa State, Nigeria.

**Table 1.** Overview of some heavy metal concentrations in studied matrices.

| Metals | Vitreous control | Serum control | Vitreous treatment | Serum treatment | Soil | Plantain |
|---|---|---|---|---|---|---|
| Cadmium mg/L | 0.0020 ± 0.0007 | 0.0021 ± 0.0008 | 0.0362 ± 0.0016 | 0.0012 ± 0.0001 | 3.5039 ± 0.5701 | 0.8348 ± 0.1214 |
| Chromium mg/L | 0.0020 ± 0.0010 | 0.6282 ± 0.1166 | -0.0800 ± 0.0071 | 0.0014 ± 0.0055 | 1.9158 ± 0.0859 | 0.5748 ± 0.9940 |
| Arsenic mg/L | -0.1600 ± 0.0158 | -0.4359 ± 0.0758 | -0.5798 ± 0.0819 | -0.9271 ± 0.0500 | 1.4348 ± 0.1053 | 0.2770 ± 0.1054 |
| Lead mg/L | 0.0020 ± 0.0007 | 0.0248 ± 0.0048 | 0.0989 ± 0.0146 | 0.0468 ± 0.0072 | 0.4424 ± 0.0408 | 0.5157 ± 0.0660 |
| Mercury mg/L | -0.2106 ± 0.0681 | -0.1486 ± 0.0070 | -0.1486 ± 0.0070 | -0.1659 ± 0.0137 | 1.4348 ± 0.1053 | 0.2770 ± 0.1054 |

**Table 2.** World Health Organization (WHO) permissible limits for heavy metals in plant and soil comparable to Imiringi mean concentrations.

| Metals | WHO acceptable limits (Soil) | Soil (Imiringi) | WHO acceptable limits (Plant) | Plantain (Imiringi) |
|---|---|---|---|---|
| Cadmium mg/kg | 0.8 | 3.5 | 0.02 | 0.83 |
| Chromium mg/kg | 100 | 1.92 | 1.3 | 0.57 |
| Arsenic mg/kg | 5 | 1.44 | 1.46 | 0.28 |
| Lead mg/kg | 85 | 0.44 | 2 | 0.51 |
| Mercury mg/kg | 2.00 | 1.43 | 0.02 | 0.28 |

**Table 3.** Comparison of some heavy metal concentrations between soil and plantain sourced from Imiringi.

| Metals | Soil | Plantain | t-test | p-value |
|---|---|---|---|---|
| Cadmium mg/L | 3.5039 ± 0.5701 | 0.8348 ± 0.1214 | 10.228 | 0 |
| Chromium mg/L | 1.9158 ± 0.0859 | 0.5748 ± 0.9940 | 22.589 | 0 |
| Arsenic mg/L | 1.4348 ± 0.1053 | 0.2770 ± 0.1054 | 22.589 | 0 |
| Lead mg/L | 0.4424 ± 0.0408 | 0.5157 ± 0.0660 | -2.11 | 0.068 |
| Mercury mg/L | 1.4348 ± 0.1053 | 0.2770 ± 0.1054 | 114.799 | 0 |

**Table 4.** Comparison of some heavy metal concentrations between vitreous of control and treatment.

| Metals | Vitreous control | Vitreous treatment | t-test | p-value |
|---|---|---|---|---|
| Cadmium mg/L | 0.0020 ± 0.0007 | 0.0362 ± 0.0016 | -44.536 | 0 |
| Chromium mg/L | 0.0020 ± 0.0010 | -0.0800 ± 0.0071 | 25.675 | 0 |
| Arsenic mg/L | >0.0001 | >0.0001 | | |
| Lead mg/L | 0.0020 ± 0.0007 | 0.0989 ± 0.0146 | -14.796 | 0 |
| Mercury mg/L | >0.0001 | >0.0001 | | |

**Table 5.** Comparison of some heavy metal concentrations between serum of control and treatment.

| Metals | Serum control | Serum treatment | t-test | p-value |
|---|---|---|---|---|
| Cadmium mg/L | 0.0021 ± 0.0008 | 0.0012 ± 0.0001 | 2.663 | 0.029 |
| Chromium mg/L | 0.6282 ± 0.1166 | 0.0014 ± 0.0055 | 12.024 | 0 |
| Arsenic mg/L | >0.0001 | >0.0001 | | |
| Lead mg/L | 0.0248 ± 0.0048 | 0.0468 ± 0.0072 | -5.665 | 0 |
| Mercury mg/L | >0.0001 | >0.0001 | | |

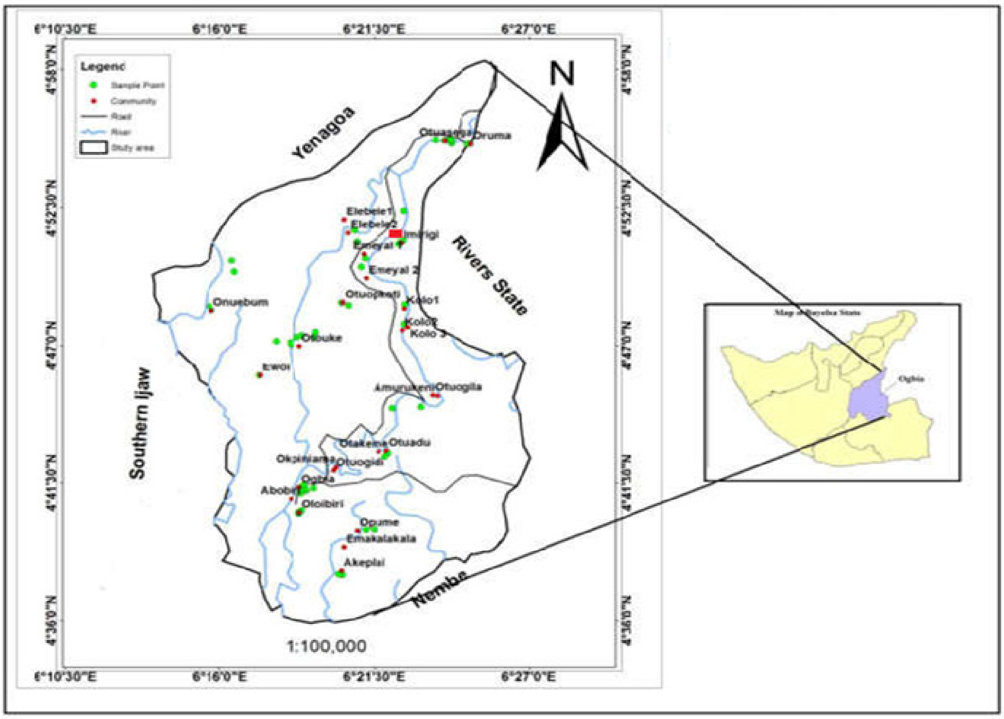


**Fig. 1.** Map of Ogbia local government, showing the community location Imiringi. Note: (▬) – Imiringi, (▬) – Other communities.

The aim of this study was anchored on evaluating the preponderances of bioaccumulation and translocation of heavy metals in a cultivation-consumption chain using plantain and rabbit as a model in a crude oil exposed niche. The findings are crystal clear of the possibility of the Imiringi community located in Bayelsa State Nigeria sitting on heavy metals contaminated footrests as shown in Table 1. This is based on the premise of the observance of some heavy metals from the cultivation to the consumption chain of plantain by rabbits. Adjunct to this submission is the presence of some heavy metals above the maximum acceptable limits by WHO, coupled with the possibility of further bioaccumulation and exposure. Below are the scientific standpoints to the above submissions.

The mean concentrations of cadmium in soil and plants were higher in Imiringi than the maximum acceptable limits by WHO (Table 2). Similarly, mercury concentration in plantain was higher than the acceptable limits. In comparison to heavy metal concentrations between soil and plantain, the study established that the concentrations of cadmium, chromium, arsenic, and mercury were significantly higher in soil samples when compared to that of plantain (Table 3). The higher concentration indicated in this study is in line with common scientific reasoning of a reservoir being more concentrated than an offshoot. Plantain derives its nutrients and other ancillary substances from the soil. The presence of a lower concentration of cadmium, chromium, arsenic, and mercury in plantain as compared to soil is poof of transference and bio-accumulative capacity of heavy metals in plantain derivable from the soil. This is indicative that heavy metals are transmissible in the environment through absorption from soil and adsorption from the environment. The presence of some of the heavy metals in the soil and plantain could be attributed to oil exploration and gas flaring. Nigerian crude oil has been shown to have relatively high concentrations of Pb, Hg, Ar, and Cd with other heavy metals also present in varying proportions depending on the source (Ifenkwe, et al., 2018).

Many heavy metals are environmentally stable and non-biodegradable, toxic to living beings, plants, and animals (Vijaya, et al., 2010). Plants are known to bioaccumulate heavy metals from soil or atmosphere of which plantain is included. Several studies on metals bioaccumulation in plants from cultivation sources have been previously reported (Nkwocha, et al., 2011; Okoye, et al., 2014; Mohammed, et al., 2015; Ogunkunle, et al., 2016).

In a similar vein, the mean concentrations of vitreous cadmium and lead were higher in the treatment group of rabbits fed with plantain when compared to the control; whereas the vitreous concentration of chromium was lower (Table 4). Furthermore, serum cadmium and chromium were lower in the treatments when compared to the controls, whereas lead was higher (Table 5). The presence of some of these heavy metals in serum and vitreous of rabbits fed with the plantain sourced from Imiringi is an expository of the possibility of translocation or transference of heavy metals from one matrix to another.

The translocation of heavy metals from dieting to humans or animals as posited in this study is an indication of potential systemic disruptions. Systemic disruptions are known fallout of heavy metal intoxication either acute or chronic. This is attributable to the ease of absorption through ingestion of food and water, and inhalation ( Ferner, 2001). Also, heavy metals are known to be a floodgate to countless systemic disorders and diseases. These disruptions could be exemplified using lead and cadmium. Lead has a negative influence on both children and adults (Simeonova, et al., 2010). Notably serious systemic disruptions of lead toxicity include teratogenic effect, inhibition of the synthesis of haemoglobin, and damage to the kidneys, joints, reproductive systems, cardiovascular system, Central Nervous System (CNS), and Peripheral Nervous System (PNS) (Ogwuegbu, et al., 2003; Lenntech, 2004; Udedi, 2003). Small quantities of Cd cause adverse changes in the arteries of the human kidney and instigate high blood pressure and kidney damage (Mebrahtu, et al., 2011).

The above systemic disruptions resulting from bioaccumulation and translocation of heavy metals fit the stance of this study that the Imiringi community located in Bayelsa State Nigeria is possibly sitting on heavy metals contaminated footrest. The presence of some of these metals in the production and consumption chain is worrisome and calls for action to halt a long-term effect. Incidence of heavy metals in milieus related to humans as presented in this study calls for further interrogation and investigation especially using a human model to consolidate and validate the posture of this study.

## CONCLUSION

This study has affirmed the sequential bioaccumulation and translocation of some heavy metals in three distinct compartmental milieus-soil, plantain, and rabbits. The concentration of cadmium was higher in both soil and plantain than the acceptable limits as posited by WHO. Similarly, other heavy metals observed in soil and plantains have the preponderance of escalating above the maximum limit set by WHO if not controlled. Furthermore, cadmium and lead were detected significantly in the serum and vitreous of rabbits upon consumption of plantain harvested from Imiringi soil. The presence of these metals in the serum and vitreous is an indication of a potential floodgate of arrays of diseases and disorders. These alterations and disruptions are proofs of the vulnerability of the ecosystem and living beings of Imiringi to long-term heavy metal intoxication.

## RECOMMENDATIONS

The presence of heavy metals in the cultivation and consumption chain has the preponderances of bio accumulating to toxic levels if unrestrained. This can be averted by eliminating gas flaring and oil exploitation processes that are inimical to the survival of the environment. Government should as matter of urgency see to instituting international standards in environmental management and remediation. Also, the postures of this study call for further investigation and probes for the sole purpose of validation and consolidation of the concept we proposed as “Floodgates of Potential Heavy Metal Intoxication”.

## AUTHOR’S CONTRIBUTION

All authors contributed to the conception and design of the work. Conception and design, interpretation of the results, and revisions performed by E.S. Agoro. J.T. Johnson performed data acquisition and analysis, and literature searches and gathering. All authors read and gave final approval of the manuscript and are accountable for the originality of the work.

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## ETHICAL APPROVAL

The study protocol was approved by the Directorate of Research and Quality Assurance of the Federal University Otuoke, Bayelsa State, Nigeria. The ethical principles for medical research involving animal subjects as outlined in the Helsinki declaration in 1975 and subsequent revisions were strictly adhered to in the course of this study.

## DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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