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# HEAVY METALS CONTENT OF FOOD CROPS GROWN IN OIL EXPLORATION AREAS OF RIVERS STATE

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**ABSTRACT**
The concentrations of heavy metals in some common food crops (cassava tubers and plantain fruits) harvested from farms located in oil exploration areas (Eleme, Ogoni, and Okrika, all in Rivers State, Nigeria) and non-oil exploration areas (Ugwusimon and Nkwuba, all in Ebonyi State) were investigated in this study. The selected heavy metals were Zn, Cd, Pb, Fe, Cu, Cr, Hg, Co, Ni and Mn. Heavy metals were analyzed using Atomic Absorption spectrophotometer. Some physicochemical characteristics and heavy metal concentrations in soil samples from the test locations were also analyzed. The results for Total Organic Carbon (%) for Eleme, Ogoni, Okrika, Ugwusimon and Nkwuba were: 1.67±0.0, 2.13±0.0, 1.86±0.0, 0.33±0.0 and 0.29±0.0, respectively. The results for total PAH (Mg/Kg) content showed highest value of 10.30±0.10 in Ogoni (oil exploration area) while a lowest value of 2.13±0.0 was recorded in Nkwuba (non-oil exploration area). From the results of the physicochemical parameters, the soil samples from oil exploration areas had higher values than those of non-oil exploration areas. Results obtained showed that the concentration of the heavy metals analyzed (Zn, Cd, Pb, Fe, Cu, Cr, Co and Mn) in food crops from oil exploration locations were found to be relatively higher than those from non-oil producing areas. The concentration of lead (Mg/Kg) was significantly higher ($P<0.05$), (0.99±0.0, 0.83±0.0) in cassava and plantain, respectively, from oil-exploration areas than non-oil exploration areas (0.1±0.00, 0.1±0.0). These soils therefore constitute a major health risk to the local population. These findings are indicative of potential health hazards faced by the indigenous population who feed on these crops.

**KEY WORDS:** Polyaromatic Hydrocarbon, Cassava Tubers, Plantain Fruits and Heavy Metals.

## INTRODUCTION

The Niger Delta Region, the world's largest wetland accounts for 7.5 percent of the total landmass of Nigeria (Nwuche and Ugorji, 2010). With an estimated population of about 22 million, the region's oil resources account for 90 percent of the nation's export earnings. The region also houses over 600 oil fields, 5284 on and off-shore oil wells, 10 export terminals, 272 flow stations, 4 refineries and a Liquefied Natural Gas (LNG) project, with an estimated oil reserve of 30 billion barrels (Lubeck *et al.,* 2007). Petroleum activities have brought prosperity, better living conditions and general economic development to Nigeria (Evoh, 2002; Okpara, 2004). Unfortunately, the Niger Delta Region has witnessed massive oil-based environmental degradation and soil fertility loss (Akwiwu *et al.,* 2002; Nwuche and Ugorji, 2010), agricultural decline (Otitoloju and Udosen, 2004; Duru, 2005) oil spillage and gas flare (Ezebuiro, 2004), fisheries decline and depletion of biodiversity (Daniel-Kalio and Braide, 2004, Ikelegbe 2004). Oil spills have also been observed to cause the death of plants (Ufot *et al.,* 2003; Osuji and Ezebuiro, 2006), and have been linked with blood contamination of people working at impacted sites (Mckelvey *et al.,* 2007). One of the greatest problems associated with oil pollution is the constant exposure to high concentration of heavy metals from oil (Osuji *et al.,* 2004; Nkwocha and Duru 2010). Several studies in China, South Korea and USA have shown that heavy metals from mining activities widely contaminated nearby sources of drinking water (Zhang and Li, 1987; Beaumont *et al.,* 2008), food crops (Satarung and Moore, 2004), and drastically affected the health of vulnerable population including children (; Martha *et al.,* 2001; Fielder *et al.,* 2003). It has also been widely documented that the consumption of food crops contaminated with heavy metals may lead to serious systemic health problems in the body of the affected persons (Jarup and Alfven,2004; Griggs, 2004). Heavy metal contamination of agricultural soils and crops in the vicinity of mining areas has been regarded as a major environmental concern (Luo *et al.,* 2003; Liu *et al.,* 2005a; Costa, 2006; Kalili *et al.,* 2011). Based on the above information, there is therefore a dire need for research concerning heavy metals in soils and food crops in oil-producing areas and their impact. It is in view of this that this research was undertaken to find out the levels of heavy metal concentrations (Pb, Zn, Cr, Cu, Co, Ni, Mn, Hg, Fe and Cd) in soils impacted with petroleum and non-petroleum activities in relation to accumulation of heavy metals in cassava tubers and plantain fruits obtained from both soils and highlight the effects of consuming such contaminated tubers and fruits.

## MATERIALS & METHODS

Cassava tubers, Plantain fruits, and Soil samples from study locations.

**Source**: All samples were gotten from Eleme, Ogoni, Okrika (Rivers State- Oil producing areas) Nkwuba and Ugwusimon (Ebonyi State- Non oil producing areas).

**Sample collection**

The samples used in the analysis of this project were cassava tubers and plantain fruits collected from five different communities: Eleme, Ogoni, Okirika, (all in Rivers State), Ugwusimon, and Nkwuba (all in Ebonyi State). The cassava tubers and plantain fruits were peeled and cut into smaller pieces and air-dried. The dried pieces were grinded into powder form.

**Soil:** Random soil samples were collected from each of the test locations into clean polythene bags and kept in a cooler.

Soil samples were homogenized with clean glass rod and oven-dried at $85^0$C to constant weight. Any lump present was broken up with a clean glass rod in order to expose the inside for proper drying and all plant materials were removed. The oven dried soil sample were thoroughly ground into powdery form and sieved through 650um stainless sieve.

**Analysis of sample**

The dishes were cleaned, dried and ignited and covered at $500^0$C for 30 minutes in the furnace to inactivate or kill all persisting microbes. The dishes were cooled and covered in desiccators. They were weighed until a constant weight was obtained. 3g of each sample was then accurately weighed into the dish. This was burnt slightly, opening the cover for escape of gases at $500^0$C. This was checked periodically until complete ashing was obtained.

**Extraction and analysis of heavy metal in soil**

Ten grams of the sieved dry soil was weighed into acid-washed 250ml polythene extraction bottles and 100 mL of extraction solution (0.05 M HCL and 0.0125 M $HNO_3$was added and shaken for 1hr on a mechanical shaker. The solution was filtered through Whatman filter paper. Blank samples were prepared using the same procedure with deionised water instead of the soil.

Analysis of Cd, Zn, Cu, Pb, Mn, Co, Ni, Cr, Fe and Hg was carried out with GBC Avanta atomic absorption spectrophotometer.

**Extraction and analysis of heavy metals in plantain fruits and cassava tubers**

The plantain and cassava samples were brought out of the refrigerator and kept in clean polythene bags and allowed to attain room temperature. The epicarps and mesocarps of plantain piliferous layers and cortex of cassava were cut into pieces and oven dried at $85^0$C to constant weight. The dried samples were ground into powdery form and labeled. One gram of each ground sample was weighed into 100 ml beaker. Five milliliter concentrated nitric acid and 2 ml perchloric acid were added and heated in a fume cupboard to almost dryness. Then, 10 ml of deionised water was added and the solution was properly stirred and filtered with Whatman filter paper. Blank samples were prepared in the same procedure with deionised instead of plantain or cassava sample. The filtrate of each sample was aspirated into the flame of AAS along with standard solution.

## RESULTS

**Physicochemical parameters of soil samples**

The results of the physicochemical properties of soil samples from test locations: Eleme, Ogoni and Okrika (Rivers State), Ugwusimon, and Nkwuba (Ebonyi State) are presented in Table 1. The physicochemical parameters analyzed in the soil samples include Total Organic Carbon, Water Holding Capacity, Total Nitrogen, pH, Available Phosphorus, and PAH.

Total Organic Carbon was lowest in Nkwuba (non oil-producing area) 0.29± 0.0 % and highest in Ogoni (oil-producing area) 2.126± 0.0 %. The water holding capacity of the soil samples varied significantly from each other with soil from Ogoni (oil-producing area) having the highest value (64±0.1 %) while soil from Ugwusimon had the lowest value (20.3±0.2 %). There was no significant difference ($P<0.05$) in pH of Ogoni and Okrika (oil-producing areas) but each was significantly lower than the level of 7.74± 0.0 in Ugwusimon (non oil-producing area). Available phosphorus of soil samples varied significantly from each other with soil from Ogoni (oil-producing area) having the highest value (78.75± 0.0 mg/kg) while Ugwusimon (non oil-producing area) had the lowest value (10.57± 0.0mg/kg). Total Nitrogen of soil samples varied significantly from each other with soil from Ugwusimon (non-oil producing area) having the highest value (2.632± 0.0 %) while Eleme (oil-producing area) had the lowest value (0.147± 0.0%). PAH of soil samples varied significantly from each other with soil from Okrika (oil-producing area) having the highest value (12.602± 0.0 mg/kg) while Nkwuba (non oil-producing area) had the lowest value (2.130± 0.0mg/kg).

**TABLE 1.** Mean concentration ± S.D of physicochemical parameters of soil samples

| Parameters | Eleme | Ogoni | Okrika | Ugwusimon | Nkwuba |
|---|---|---|---|---|---|
| Total organic carbon (%) | $1.697\pm0.0^a$ | $2.126\pm0.0^b$ | $1.860\pm0.0^c$ | $0.33\pm0.0^e$ | $0.29\pm0.0^e$ |
| Water holding capacity (%) | $35\pm0.3^e$ | $64\pm0.1^b$ | $40.5\pm0.8^c$ | $20.3\pm0.2^d$ | $30.0\pm0.2^a$ |
| Total nitrogen (%) | $0.147\pm0.0^a$ | $0.184\pm0.0^b$ | $0.167\pm0.0^c$ | $2.632\pm0.0^d$ | $1.020\pm0.0^e$ |
| **pH** | $6.30\pm0.1^a$ | $6.10\pm0.1^b$ | $6.20\pm0.0^b$ | $7.74\pm0.0^a$ | $7.04\pm0.0^e$ |
| Available phosphorus (mg/kg) | $18.59\pm0.0^a$ | $78.75\pm0.0^b$ | $25.70\pm0.2^c$ | $10.57\pm0.0^d$ | $14.10\pm0.1^e$ |
| Pah (mg/kg) | $7.470\pm0.0^a$ | $10.304\pm0.1^b$ | $12.602\pm0.0^c$ | $2.626\pm0.2^d$ | $2.130\pm0.0^e$ |

Values are mean ±standard deviation of triplicate determinations.

Values in the same row bearing the same superscript letters are not significantly different at 5% level.

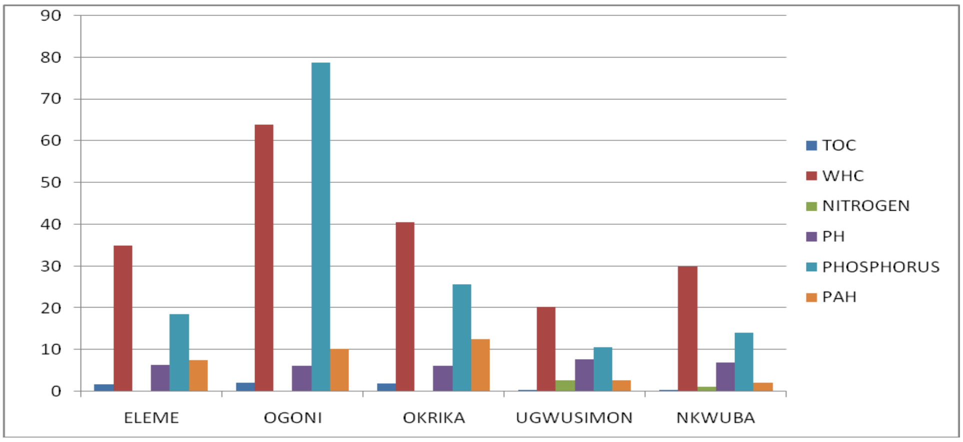


**FIGURE 1:** A bar chart showing the mean concentrations of physicochemical parameters of soils from different locations

**Mean concentrations of the Heavy Metals ± S.D in the soil samples.**

The results of the mean concentrations of the Heavy Metals ± S.D in the soil samples from test locations: Eleme, Ogoni and Okrika (Rivers State), Ugwusimon, and Nkwuba (Ebonyi State) are presented in Table 2. The Heavy metals analyzed in the soil samples include Zinc, Iron, Copper, Lead, Chromium, Cadmium, Cobalt, Manganese, Mercury and Nickel. Zn in soil samples varied significantly from each other. There was no significant difference ($P<0.05$) in Fe levels of Ugwusimon and Nkwuba (non-oil producing areas), but each was significantly lower than the level of 5245±4.9Mg/Kg in Okrika (oil producing area). Cu of soil samples varied significantly from each other with Cu from Eleme having the highest value (5.20± 0.0Mg/Kg) while Ugwusimon (non-oil producing area) had the lowest value (1.22± 0.0Mg/Kg). There was no significant difference ($P<0.05$) in Pb levels of Ugwusimon and Nkwuba (non-oil producing areas) but each was significantly lower than the level of 0.51± 0.0 and 0.32± 0.0 (Mg/Kg) for Eleme and Okrika, respectively (oil producing areas). Hg and Ni were below detectable limits in all the soil samples.

**TABLE 2**: Mean concentration of the metals ± S.D in the soil samples

| Heavy metals (mg/kg) | Eleme | Ogoni | Okrika | Ugwusimon | Nkwuba |
|---|---|---|---|---|---|
| Zinc | $2.31\pm0.0^{a}$ | $1.67\pm0.0^{b}$ | $1.43\pm0.0^{c}$ | $8.24\pm0.0^{d}$ | $6.32\pm0.1^{e}$ |
| Iron | $4167.2\pm13.8^{a}$ | $2640.4\pm1.1^{b}$ | $5245\pm4.9^{c}$ | $14.40\pm0.1^{d}$ | $15.10\pm0.1^{d}$ |
| Copper | $5.20\pm0.0^{a}$ | $3.31\pm0.0^{b}$ | $4.15\pm0.0^{c}$ | $1.22\pm0.0^{d}$ | $2.30\pm0.0^{e}$ |
| Lead | $0.51\pm0.0^{a}$ | $0.19\pm0.0^{b}$ | $0.32\pm0.0^{c}$ | $0.0\pm0.0^{e}$ | $0.13\pm0.0^{e}$ |
| Chromium | $9.16\pm0.0^{b}$ | $7.56\pm0.0^{c}$ | $4.26\pm0.0^{d}$ | BDL | BDL |
| Cadmium | $0.22\pm0.0^{a}$ | $0.13\pm0.0^{b}$ | $0.11\pm0.0^{b}$ | BDL | BDL |
| Cobalt | $1.38\pm0.0^{a}$ | $0.63\pm0.0^{b}$ | $1.10\pm0.1^{c}$ | $0.2\pm0.0^{e}$ | $0.18\pm0.0^{e}$ |
| Manganese | $46.28\pm0.1^{b}$ | $30.85\pm0.1^{c}$ | $40.02\pm0.0^{d}$ | $2.46\pm0.0^{e}$ | $1.96\pm0.0^{a}$ |
| Mercury | BDL | BDL | BDL | BDL | BDL |
| Nickel | BDL | BDL | BDL | BDL | BDL |

Values are mean ±standard deviation of triplicate determinations.
Values in the same row bearing the same superscript letters are not significantly different at 5% level.

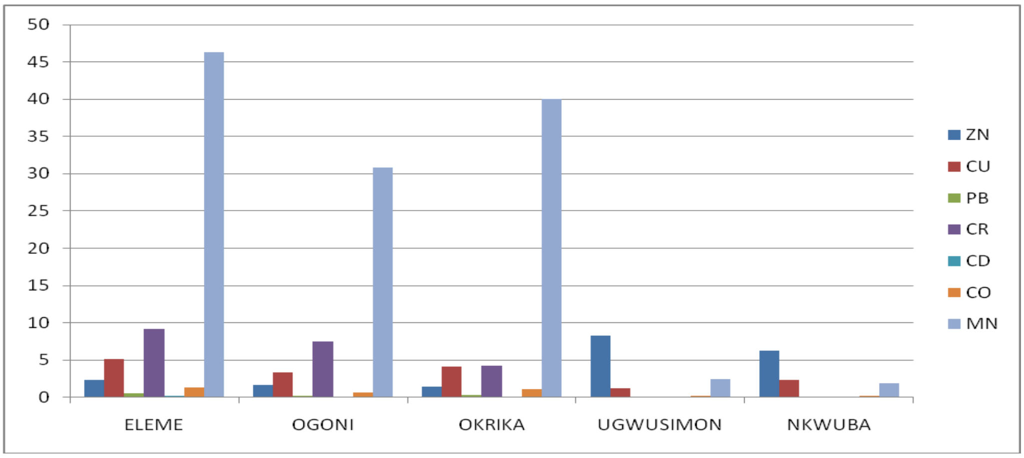


**FIGURE 2:** A bar chart showing the mean concentrations of heavy metals in the soil from different locations

**Mean concentrations of the Heavy Metals ± S.D in the Cassava samples**

The results of the mean concentrations of the Heavy Metals ± S.D in the cassava samples from test locations: Eleme, Ogoni and Okrika (Rivers State), Ugwusimon, and Nkwuba (Ebonyi State) are presented in Table 3. The Heavy metals analyzed in the cassava samples include Zinc, Iron, Copper, Lead, Chromium, Cadmium, Cobalt, Manganese, Mercury and Nickel. There was no significant difference ($P<0.05$) in the Cd levels of cassava from Eleme and Ogoni (oil-producing areas), but each was significantly higher than the value of 0.05± 0.0 and -0.01± 0.0 Mg/Kg in Ugwusimon and Nkwuba, respectively, (non-oil producing areas). Mn levels in cassava samples varied significantly from each other. Mn was lowest in cassava from Nkwuba with 4.86± 0.0 Mg/Kg and highest in Eleme (20.54± 0.0Mg/Kg). Co levels varied significantly from each other in cassava smples form Eleme, Ogoni and Okrika (oil producing areas) with that of Ogoni having the highest level (1.0± 0.0 Mg/Kg). Meanwhile there was no significant difference in Co levels of cassava from Ugwusimon and Nkwuba (non-oil producing areas) with Co level from Nkwuba having the lowest value (0.09± 0.0Mg/Kg). There was no significant difference ($P<0.05$) in the Cu levels of cassava from Ogoni and Okrika (oil-producing areas), but each was significantly higher than the value of 0.95± 0.0 Mg/Kg in cassava from Ugwusimon (non-oil producing areas).

Hg and Ni were below detectable limits in all the cassava samples.

**TABLE 3:** mean concentrations of the metals ± S.D in the cassava samples

| Heavy metals(mg/kg) | Eleme | Ogoni | Okrika | Ugwusimon | Nkwuba |
|---|---|---|---|---|---|
| CD | $0.10\pm 0.0^{a}$ | $0.14 \pm 0.0^{a}$ | $0.85\pm 0.0^{b}$ | $0.05\pm 0.0^{c}$ | $-0.01\pm 0.0^{d}$ |
| ZN | $6.22\pm 0.0^{a}$ | $4.25\pm 0.1^{b}$ | $4.87\pm 0.0^{c}$ | $6.31\pm 0.1^{a}$ | $8.18\pm 0.1^{d}$ |
| PB | $0.99\pm 0.0^{a}$ | $0.81\pm 0.0^{b}$ | $0.10\pm 0.0^{c}$ | $0.60\pm 0.0^{d}$ | $0.76\pm 0.0^{e}$ |
| CU | $3.08\pm 0.2^{a}$ | $2.86\pm 0.1^{ba}$ | $2.65\pm 0.0^{ba}$ | $0.95\pm 0.0^{d}$ | $1.14\pm 0.1^{d}$ |
| FE | $8.50\pm 0.3^{b}$ | $9.65\pm 0.2^{a}$ | $8.56\pm 0.1^{b}$ | $4.23\pm 0.0^{c}$ | $3.61\pm 0.1^{d}$ |
| CO | $0.96\pm 0.0^{a}$ | $1.00\pm 0.0^{b}$ | $0.82\pm 0.0^{c}$ | $0.10\pm 0.0^{d}$ | $0.09\pm 0.0^{d}$ |
| MN | $20.54\pm 0.0^{a}$ | $10.30\pm 0.0^{b}$ | $12.11\pm 0.2^{c}$ | $5.24\pm 0.0^{d}$ | $4.86\pm 0.0^{e}$ |
| CR | $0.58\pm 0.1^{a}$ | $0.78\pm 0.0^{b}$ | $0.70\pm 0.0^{ab}$ | $0.003\pm 0.0^{c}$ | $0.005\pm 0.0^{c}$ |
| NI | BDL | BDL | BDL | BDL | BDL |
| HG | BDL | BDL | BDL | BDL | BDL |

Values are mean ±standard deviation of triplicate determinations.
Values in the same row bearing the same superscript letters are not significantly different at 5% level.

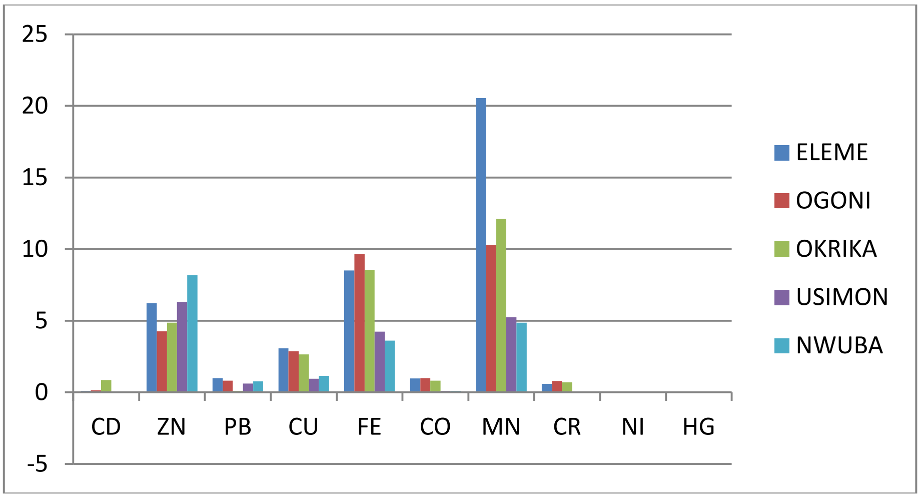


**FIGURE 3:** A bar chart showing the mean concentrations of heavy metals in the cassava samples from different locations

**Mean concentrations of the Heavy Metals ± S.D in the Plantain Fruits samples**

The results of the mean concentrations of the Heavy Metals ± S.D in the Plantain Fruits samples from test locations: Eleme, Ogoni and Okrika (Rivers State), Ugwusimon, and Nkwuba (Ebonyi State) are presented in Table 4. The Heavy metals analyzed in the Plantain Fruits samples include Zinc, Iron, Copper, Lead, Chromium, Cadmium, Cobalt, Manganese, Mercury and Nickel. There was no significant difference ($P<0.05$) in the Cd levels of plantain from Eleme and Ogoni (oil-producing areas), but each was significantly higher than the values of -0.01± 0.0 Mg/Kg and 0.01± 0.0 Mg/Kg in cassava from Nkwuba and Ugwusimon, respectively (non-oil producing areas).

There was no significant difference ($P<0.05$) in the Zn levels of plantain from Eleme, Ogoni and Okrika (oil-producing areas).Zn was lowest in plantain from Okrika (4.63± 0.0 Mg/Kg). Plantain from Nkwuba (non-oil producing areas) recorded the highest Zn value (10.26± 0.0 Mg/Kg). Cu levels varied significantly from each other in all the plantain test samples with that of Eleme (oil producing area) having the highest level (2.67± 0.0 Mg/Kg). Fe levels varied significantly from each other in

all the plantain test samples. Nkwuba (non-oil producing area) recorded the lowest level (3.15± 0.1 Mg/Kg).
Mn levels varied significantly from each other in all the plantain test samples. Ugwusimon (non-oil producing area) recorded the lowest value (3.64± 0.0 Mg/Kg). While Eleme (oil producing area) had the highest value (15.84± 0.0 Mg/Kg).
Hg and Ni were below detectable limits in all the cassava samples.

**TABLE 4**: mean concentrations of the metals ± S.D in the plantain fruits samples

| Heavy metals(mg/kg) | Eleme | Ogoni | Okrika | Ugwusimon | Nkwuba |
|---|---|---|---|---|---|
| CD | $0.10\pm 0.0^{e}$ | $0.11\pm 0.0^{e}$ | $0.70\pm 0.0^{b}$ | $0.01\pm 0.0^{a}$ | $-0.01\pm 0.0^{a}$ |
| ZN | $5.51\pm 0.8^{a}$ | $5.20\pm 0.2^{a}$ | $4.63\pm 0.0^{a}$ | $7.28\pm 0.1^{b}$ | $10.26\pm 0.0^{c}$ |
| PB | $0.83\pm 0.0^{a}$ | $0.62\pm 0.0^{b}$ | $0.09\pm 0.0^{a}$ | $0.52\pm 0.0^{c}$ | $0.80\pm 0.0^{d}$ |
| CU | $2.67\pm 0.0^{a}$ | $2.25\pm 0.1^{b}$ | $1.83\pm 0.0^{c}$ | $0.30\pm 0.0^{d}$ | $1.02\pm 0.0^{e}$ |
| FE | $6.62\pm 0.0^{a}$ | $10.20\pm 0.1^{b}$ | $7.80\pm 0.1^{c}$ | $4.15\pm 0.0^{d}$ | $3.15\pm 0.1^{e}$ |
| CO | $0.86\pm 0.0^{a}$ | $0.98\pm 0.0^{b}$ | $0.92\pm 0.0^{c}$ | $0.07\pm 0.0^{d}$ | $0.09\pm 0.0^{d}$ |
| MN | $15.84\pm 0.0^{a}$ | $12.68\pm 0.0^{b}$ | $6.39\pm 0.1^{c}$ | $3.64\pm 0.0^{d}$ | $4.35\pm 0.0^{e}$ |
| CR | $0.54\pm 0.1^{a}$ | $0.67\pm 0.0^{a}$ | $0.66\pm 0.0^{a}$ | $0.003\pm 0.0^{c}$ | $0.004\pm 0.0^{c}$ |
| NI | BDL | BDL | BDL | BDL | BDL |
| HG | BDL | BDL | BDL | BDL | BDL |

Values are mean ±standard deviation of triplicate determinations.
Values in the same row bearing the same superscript letters are not significantly different at 5% level.

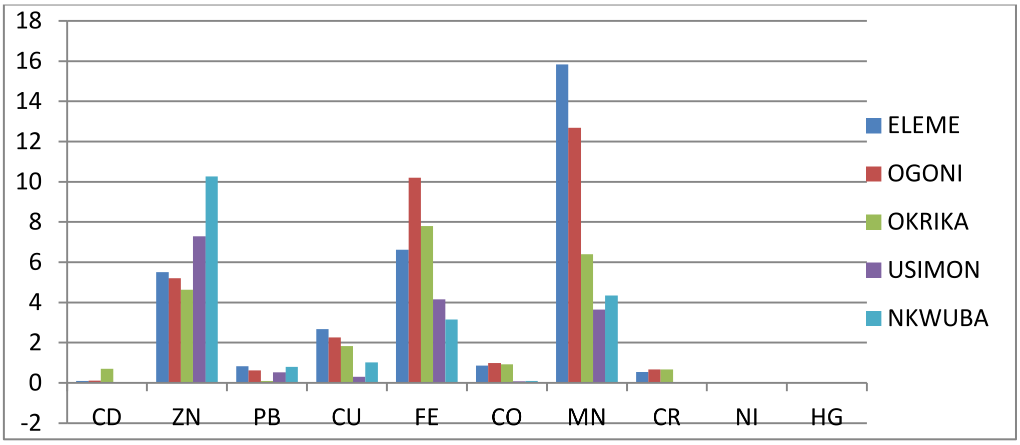


**FIGURE 4:** A bar chart showing the mean concentrations of heavy metals in the plantain fruits samples from different locations

## DISCUSSION

Heavy metals are chemical elements mostly with density greater than 4g/cm$^3$ found in some soils, rocks and water interrestrial and freshwater ecosystems. Their presence is determined by anthropogenic activity, rock types present, and industrial waste discharge in the area. They occur in typical background concentrations in these ecosystems.
However anthropogenic releases and industrial waste discharge can lead to higher concentrations of these metals relative to their normal background values. When this occurs, heavy metals are considered serious pollutants because of toxicity, persistence and nondegradable conditions in the environment, thereby constituting threat to human beings and other forms of biological life (Tam and Wong, 2000;Yuan *et al*., 2004; Nwuche and Ugoji, 2008; Aina *et al*.,2009; Mohiuddin *et al*., 2010). Heavy metal pollution refers to cases where the quantities of these elements in soils are higher than the maximum allowable concentrations, and this is potentially harmful to biological life at such locations. As noted by Gazso (2001), heavy metals come from a variety of sources but human economic activities such as coal and metal ore mining, chemical manufacturing, petroleum mining and refining, electric power generation, melting and metal refining, metal plating and to some extent domestic sewage are principally responsible. As observed by Begun *et al*., 2009), large quantities of pollutants have continuously been introduced into ecosystems as a consequence of urbanization and industrial processes. Metals are persistent pollutants that can be biomagnified in the food chains, becoming an integral part of life and thus increasingly dangerous to human beings and wildlife. Zinc, Cadmium, Lead, Cobalt, Copper, Iron, Manganese, Chromium, Nickel and Mercury levels were investigated. The result showed that cadmium in cassava from Okrika (oil producing area) (0.1±0.0-0.85±0.0mg/kg) was significantly higher than cadmium levels in cassava from Ebonyi State (non-oil producing areas) which were below detectable levels. Chronic cadmium exposures result in kidney damage, bone deformities, and cardiovascular problems (Goyer and Clarkson, 2001). Human diseases have resulted from consumption of cadmium contaminated foods (Kobayashi, 1978; Nogawa *et al.*, 1987). The threat that heavy metals pose to human and animal health is aggravated by their low environmental mobility, even under high precipitations, and their long term persistence in the environment (Mench *et al*., 1994; Chirenje *et*

*al*.,2004). The average biological half-life of Cd, another accumulation poison similar to lead, has been estimated to be about 18years (Forstner, 1995). Two possible reasons for cadmium being below detectable levels in Ebonyi State may be ascribed to low occurrence of Cd in soil. The first is that the aggregate of Cd levels in the soil was below detectable levels. The other explanation is the mobility of Cd through the soil layers. Cadmium tends to be more mobile in soil systems than many other heavy metals (Alloway, 1995). The result showed that cadmium in plantain from oil producing areas (Okrika, Ogoni and Eleme) were higher than cadmium levels in plantain from Nkwuba and Ugwusimon (non-oil producing areas). This may suggest that the populations feeding on plantain from these oil-producing areas are at higher risk of cadmium toxicity than those feeding on plantain from Ebonyi State. The accumulation in the system may lead to acute cadmium poisoning which includes high blood pressure, kidney damage, destruction of testicular tissue and destruction of red blood cells (Goyer and Cherian, 1992).Chronic cadmium exposures result in kidney damage, bone deformities, and cardiovascular problems (Goyer and Clarkson, 2001).

In pregnant women, normal dietary level exposure of cadmium may cause teratogenic and mutagenic effects on the foetus (Macrae *et al.*, 1993). The level of lead ranges from 0.99mg/L in Eleme, 0.6mg/L in Ugwusimon, 0.76mg/L in Nkwuba, 0.8mg/L in Ogoni, and 0.12mg/L in Okirika. These were relatively high when compared with WHO standard of 0.1mg for lead except for Okirika (0.1mg/L) which is close to the WHO standard. Lead (Pb) is the most common environmental contaminant found in soils. Unlike other metals, Pb has no biological role, and is potentially toxic to microorganisms (Sobolev and Begonia, 2008). Its excessive accumulation in living organisms is always detrimental. Thus, Pb exposure can cause seizures, mental retardation, and behavioral disorders inhuman beings. Hence, people of Eleme, Ugwusimon, Nkwuba and Ogoni are at risk of lead toxicity from underground water and crops cultivated in the area. Reasons for elevated Pb levels in soil are basically anthropogenic. Due to past uses of lead in industrial processes and consumer products (for example paint, gasoline, diesel, other petrochemicals, accumulators), urban soils often contain high lead concentrations, up to 1840 mg.kg-1 or more (Curtis and Smith, 2002). High concentration of lead can cause harmful effects in humans like vomiting, kidney damage and neurological effect in children (Sobolev and Begonia, 2008). *Garri* from cassava and plantain are common food consumed daily by Nigerians in large quantities. Therefore, lead concentrations could be cumulative and can easily cross the placenta and damage the foetal brain in pregnant women and may also cause development of autoimmunity, such as rheumatoid arthritis, diseases of kidneys, nervous system and circulatory system (Casarett and Doull, 1996). The populations most affected by consumption of contaminated farm products are pregnant women and young children (LeCoultre, 2001). Soils contaminated with lead have been reported to decrease the growth and yield of plants (Balba *et al.*, 1991). For zinc concentration in cassava, Eleme had 6.22mg/L, Ugwusiomon 6.31mg/L, Nkwuba 8.18mg/L, Ogoni 4.26mg/L and Okirika 4.86mg/L. These are relatively lower than the WHO standard of 15mg. However, zinc concentration of plantain, in Eleme had 5.51mg/L, Ugwusiomon 7.28mg/L, Nkwuba 10.26mg/L, Ogoni 5.20mg/L and Okirika 4.63mg/L. These are relatively lower than the WHO standard of 15mg. Zn is essential to plants and animals in very low concentrations by serving as components of enzymes, structural proteins, pigments and also helping to maintain the ionic balance of cells (Kosolapov *et al.*, 2004). These and other trace elements are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders. Mercury and Nickel were below detection levels in all cassava and plantain from both oil-producing and non-oil producing areas. This indicates non-assumption and contamination from anthropogenic source.

Heavy metals have been found in cassava and plantain and this has a potential health hazards to man through the dietary pathway in Nigeria (Obiajunwa *et al.*, 2001). Uptake of heavy metals is increased in plants that are grown in areas with increased soil concentrations of heavy metals (LeCoultre, 2001). This study has revealed high concentration of heavy metals especially lead in cassavas and plantain from different locations where oil exploration activities are carried out in Rivers State compared to non-oil exploration sites in Ebonyi State and WHO standard. These findings are indicative of industrial pollution which is detrimental to health.

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