# Proximate and heavy metals composition of Plantain (*Musa paradisiaca* L.) fruits harvested from some solid waste dumps in Uyo Metropolis, Nigeria

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***Abstract—*** *Plantain thrives well in waste dumpsites. These wastes usually contaminate the soil with heavy metals which become absorbed by the plants. The risk of heavy metal toxicity in humans is an issue of serious concern globally. Proximate composition of plantain fruits harvested from three randomly selected waste dumpsites in Uyo metropolis, Nigeria were determined using AOAC standard analytical techniques while their heavy metals (Pb, Cr, Ni, Cu, Co, Cd and As) concentrations and that of their rhizosphere soil were analysed with Unicam Atomic Absorption Spectrophotometer. Proximate analyses results revealed that carbohydrate content was higher in the fruits harvested from the control uncontaminated soil sites (91.61%) than in the fruits harvested from dumpsite soils (87.23%; 87.89%; 88.00%). Dumpsite soils had higher heavy metals concentrations than the control soil. Lead (Pb) was the highest occurring heavy metal in all the dumpsite soils. Fruits harvested from the dumpsite soils had higher heavy metals concentrations than those from the control soil. Pb was the only heavy metal whose concentration in the plantain fruits was higher than the WHO/FAO permissible limit. This work has established that the selected dumpsite soils have been contaminated with heavy metals which have been absorbed by the plantain cultivated there. Cultivation and consumption of plantain from these dumpsite soils should be discouraged.*

***Keywords— Dumpsites soils, Heavy metals, Plantain fruits, Proximate composition.***

## I. INTRODUCTION

Plantain (*Musa paradisiaca* L.) is a tree-like herb belonging to the Musaceae family. With its high starchy fruits, plantain fruit serves as a staple crop in most parts of the tropics including Nigeria. Plantain fruits have high fibre contents which make it a diet for lowering of blood cholesterol and relieving of constipation thereby putting colon cancer at bay (Okareh, 2015). Plantain has a high demand for organic matter and thrives luxuriantly in waste dumpsites where they produce healthy bunches of fruits.

Solid waste dumpsites are common features in most urban cities in Nigeria as much waste is generated by their teeming human population. Due to scarcity of arable lands in the urban areas, plantain is cultivated in strategic locations where all sorts of solid waste materials are dumped. Leachates from these dumpsites contribute heavy metals to the soil (Ukpong *et al.*, 2013) which according to Ideria *et al*. (2010) constitute the commonest occurring group of solid waste dumpsite soil contaminants. Plantain growing in such dumpsites absorbs these heavy metals along with other nutrients and accumulates them in its fruits. Studies have revealed higher levels of heavy metals such as lead, cadmium, nickel, cobalt, arsenic and chromium in waste dumpsite soils than in soil some distances away from them (Ukpong *et al*., 2013; Amos-Tautua *et al.*, 2014; Olufunmilayo *et al.*, 2014, Tanee and Eshalomi-Mario, 2015). Higher concentrations of these heavy metals have also been detected in fruits and vegetables harvested from waste dumpsites (Imasuen Omorogieva, 2013; Cortez and Ching, 2014; Tanee and Eshalomi-Mario, 2015).

Heavy metals according to Kibria *et al*. (2010) are elements with an atomic weight greater than 20 and are characterised by similar atomic electronic configurations in the outer orbitals. They are mostly harmful chemicals as they are usually persistent, toxic and bio-accumulative in the environment while some of them are also endocrine disrupting as well as carcinogenic (Kibria *et al.* 2016a; Kibria *et al.* 2016b). Some heavy metals such as iron, nickel, zinc, copper are known to be essential and beneficial for the growth and development of plants and animals including humans at low concentrations (Cortez and Ching, 2014; Tanee and Eshalomi-Mario, 2015; Balkhair and Ashraf, 2016). Other heavy metals such as lead, cadmium and mercury are highly toxic even at low concentrations (Cortez and Ching, 2014).

The issue of heavy metals contamination of soil and subsequent uptake and accumulation in food crops is fast becoming a major health concern as their presence pose serious health hazards to plants, animals and humans (Rim-Rukeh, 2012). The danger posed by the presence of heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb) and nickel (Ni) is as a result of their bioaccumulation in the environment with time (Helmenstine, 2014). Prolonged intake of heavy metals contaminated food is implicated with cancer, nervous system disorders, cardiovascular diseases, renal problems, destruction of liver, lungs and kidneys. The risk involved in consuming crops harvested from waste dumpsites calls for serious investigation into the concentration of heavy metals in such food items. This research was therefore carried out to investigate the heavy metals (Pb, Cr, Ni, Cu, Co, Cd and As) concentrations of both the dumpsite soils and their plantain fruits as well as the possible effect on the proximate composition of such fruits. Findings from this work are expected to give growers of plantain on dumpsite soils insight as to the risk of heavy metals accumulation in the fruits and the consequent health hazards to their consumers.

## II. MATERIALS AND METHODS

**Sampling Site**

Three dumpsites cultivated with plantain bearing mature unripe bunches of fruits located within Uyo metropolis were randomly selected. Fruits for control were harvested from another location without any waste dumpsite within the same metropolis. The geographical coordinates of Uyo is 5° 3' 0" North and 7° 56' 0" (maplandia.com, 2016). The experimental sites as determined using a Global positioning system (GPS) to geo-reference the sampling positions were respectively designated as: Site A located between latitude 5°1'56.935"N and longitude 7°55'46.714"E; Site B located between latitude 5°1'21.640"N and longitude 7°54'47.592"E; Site C located between latitude 5°0'35.8812"N and longitude 7°55'5.4048"E and the Control site located between latitude 4°59'7.224"N and longitude 7°55'11.244"E.

**Collection of Plant and Soil Samples.**

Rhizosphere soil samples were collected in triplicates from each site at 15-20 cm rooting zone using soil auger. The plantain fruits were also collected in triplicates from plants whose rhizosphere soil samples were collected. The soil and plant samples were appropriately labeled and taken to the laboratory for proximate and heavy metal analyses.

**Preparation of the plantain fruit samples.**

Each batch of fruits from each dumpsite was separately washed with distilled water and peeled. They were then cut into thin slices and air dried at room temperature before being transferred to an oven (Gallenkamp) to dry at 80°C. The dried slices were then ground into powder using an electric blender (Model: GND-280 AUTOSHARP) and stored in an airtight container until when needed for analysis.

**Proximate composition analysis of plantain fruits**

The proximate nutrient composition of the plantain fruits was determined using the standard methods of analysis of Association of Official Analytical Chemists (AOAC, 2000) for moisture, dry matter, crude protein, lipid, ash and fibre. Moisture content was determined by drying in a (Gallenkamp) oven at 105°C to constant dry weight and then calculating the percentage difference between the initial and final weights. The crude protein of the samples was determined using micro-Kjeldahl method. Percentage lipid content was determined using petroleum ether (B.P. 60°C - 80°C) extraction by reflux Soxhlet method and the percentage oil calculated as:

$$\%\ \text{Oil} = \frac{\text{Weight of oil} \times 100}{\text{Weight of dry sample}}$$

Ash content was determined by dry ashing in a muffle furnace at 550°C until grayish white ash was obtained and calculating the percentage difference between the sample initial weight and the ash weight. Crude fibre was determined using acid-base digestion with 1.25% $H_2SO_4$ (w/v) and 1.25% NaOH (w/v) solutions. Carbohydrate content was obtained following Onwuka (2005) method as the difference:

% Carbohydrate = 100 - (% crude protein + % crude fibre + % ash + % crude fat).

**Determination of heavy metals contents in the plant samples**

The powdered plant samples were ashed in a muffle furnace and digested after the procedure of Adefemi *et al.* (2012). 2g of each ashed plant sample was digested in 15ml of $HNO_3$ at 80ºC until a transparent solution was obtained. The solution was allowed to cool and then filtered through Whatman filter paper (no. 42) into 100ml volumetric flask and made to mark with distilled water. Each filtrate was stored in separately labeled sample bottle ready for the determination of Pb, Cr, Ni, Cu, Co, Cd, As and Fe concentrations using Unicam 939 atomic absorption spectrophotometer (AAS). The AAS was calibrated with appropriate standard solutions for each element and the samples filtrate were aspirated in turns into it to determine the heavy metals concentration.

**Determination of heavy metals contents in the soil samples.**

Determination of heavy metals concentration of the soil samples was carried out using the method of Cortez and Ching (2014). Each soil sample was oven-dried at 105°C, ground with mortar and pestle and sieved through a 2 mm sieve. About 0.5 g of each sample was weighed into a porcelain crucible and ignited at 450°C in a furnace to destroy organic matter, then digested twice with 10 ml of a mixture of 1:1 mixture of concentrated $HNO_3$ and HF in a 100 ml polyprylene beaker and placed over a water bath for evaporation till dryness. The residue was dissolved in 20 ml of 2M $HNO_3$ and diluted to mark in 100 ml volumetric flask. The digest was then used for heavy metals (Pb, Cr, Ni, Cu, Co, Cd and As) concentrations determination using Unicam 939 model of atomic absorption spectrophotometer (AAS).

Heavy metals concentration data from the soil and fruits were used in calculating the accumulation factor as the ratio of heavy metal concentration in the plantain fruit to the heavy metal concentration in their corresponding rhizosphere soil for samples from each site (Li *et al.*, 2012):

$$AF = \frac{\text{Heavy metal concentration in the food crops edible parts}}{\text{Heavy metal concentration in the soil}}$$

All data generated in triplicates were subjected to analysis of variance using SPSS for windows version 19. Means were separated using Duncan's multiple range test.

## III. RESULTS

The proximate composition of plantain fruits harvested from the different dumpsites in Uyo metropolis under investigation and that of the control is as presented in Table 1. Carbohydrate (91.61%) content was significantly (P = 0.05) higher in control site fruits than in dumpsites fruits. Crude protein on the other hand was significantly (P = 0.05) lowest (3.76%) in control site fruits. Crude lipid was significantly higher (1.10%) in fruits from dumpsite A than other sites.

*Table.1: Proximate composition of plantain fruits (%)*

| Parameters | Site A | Site B | Site C | Control |
|---|---|---|---|---|
| Moisture content | *51.28b | 53.27a | 54.00a | 51.00b |
| Dry matter | 48.72a | 46.73a | 46.00a | 49.00a |
| Crude protein | 7.88a | 7.77a | 7.69a | 3.76b |
| Crude fat | 1.10a | 0.070c | 0.88b | 0.93a |
| Crude fibre | 0.30a | 0.22b | 0.26ab | 3.04a |
| Ash content | 3.50a | 3.30a | 2.28b | 3.04a |
| Carbohydrate | 87.23b | 88.00b | 87.89b | 91.61a |

*Means of three replicates. Mean within each row followed by different letters are significantly different at P = 0.05 according to Duncan's multiple range test.

Dumpsite soil heavy metals analyses as presented in Table 2 showed that the control site soil had significantly (P = 0.05) lower heavy metal contents for Pb, Cr, Ni, Co, and Cd and significantly (P = 0.05) higher Cu and As contents than the dumpsite soils. The highest Cr, Ni, Co and Cd contents were recorded from dumpsite A while the highest Pb content was from dumpsite B.

*Table.2: Concentration of heavy metals in Dumpsite Soil samples (mg/kg) compared with WHO/FAO certified standards.*

| Heavy Metal | Site A | Site B | Site C | Control | §WHO/FAO |
|---|---|---|---|---|---|
| Pb | *18.29b | 21.18a | 20.32a | 5.56c | 100.00 |
| Cr | 10.56a | 9.89a | 8.54b | 5.88c | 100.00 |
| Ni | 7.05a | 6.64b | 6.16c | 6.06c | 50.00 |
| Cu | 2.34b | 2.21b | 1.65c | 5.11a | 10.00 |

*http://dx.doi.org/10.22161/ijeab/2.4.23* *ISSN: 2456-1878*

| | | | | | |
|---|---|---|---|---|---|
| Co | 1.42a | 1.38a | 1.29b | 0.20c | 50.00 |
| Cd | 1.55a | 1.51a | 1.46a | 1.20b | 3.00 |
| As | <0.01b | <0.01b | <0.02b | <0.05a | 20.00 |

*Means of three replicates. Mean within each row followed by different letters are significantly different at P = 0.05 according to Duncan's multiple range test. §Maximum allowable limits of heavy metal in soils as defined by WHO and FAO. (Chiroma *et al*., 2014).

Concentration of heavy metals in fruits was significantly (P = 0.05) lower in samples from the control site than fruits from dumpsite soils (Table 3).

*Table.3: Concentration of heavy metals in Dumpsite Fruits samples (mg/kg) compared with certified standards.*

| Metal | Site A | Site B | Site C | Control | §WHO/FAO |
|---|---|---|---|---|---|
| Pb | *8.67a | 8.52a | 7.63b | 1.13c | 0.30 |
| Cr | 7.44a | 7.33a | 6.59b | 2.23 | - |
| Ni | 3.36a | 2.85b | 2.66b | 1.14c | 67.00 |
| Cu | 5.26a | 3.66b | 2.44c | 0.02d | 73.00 |
| Co | 1.36a | 1.28a | 1.25a | ND | 50.00 |
| Cd | 0.32a | 0.29a | 0.22b | ND | 0.10 |
| As | < 0.02a | < 0.02a | < 0.02a | ND | - |

•Means of three replicate. Mean within each row followed by different letters are significantly different at p=0.05 according to Duncan's Multiple range test. §Maximum allowable limits of heavy metal in plant as defined by WHO and FAO (Chiroma *et al*., 2014).

Accumulation factor calculations (Table 4) showed the highest values for Cu (2.25) in dumpsite A, followed by As (2.00) in dumpsites A and B. Accumulation factor was generally low in the control site fruits for all heavy metals than those from the dumpsites.

*Table.4: Accumulation Factor of heavy metals in the experimental sites*

| Heavy Metal | Site A | Site B | Site C | Control |
|---|---|---|---|---|
| Pb | *0.47a | 0.40bc | 0.38c | 0.20d |
| Cr | 0.70c | 0.74ab | 0.77a | 0.38d |
| Ni | 0.48a | 0.43b | 0.43b | 0.19c |
| Cu | 2.25a | 1.66b | 1.48b | 0.01c |
| Co | 0.96a | 0.93a | 0.97a | 0.00b |
| Cd | 0.21a | 0.19ab | 0.15b | 0.00c |
| As | 2.00a | 2.00a | 1.00b | 0.00c |

*Means of three replicates. Mean within each row followed by different letters are significantly different at P= 0.05 according to Duncan's multiple range test.

## IV. DISCUSSION

The proximate composition (% dry matter) of plantain fruits from both the waste dump and control soils differed from what has been reported by some earlier workers for crude protein (5.09-5.18%), fats (0.47-0.62%) and ash (2.03-2.33%) while carbohydrate content was however similar to some of the results (Odenigbo *et al.*, 2013). However, related work by Oko *et al.* (2015), gave lower carbohydrate contents (70.88 - 81.18%) than ours, also fibre and ash contents were higher in our control samples (3.04% and 3.04%) than what were obtained by them (0.19 – 0.16% and 0.55 – 2.53%) respectively. The variation in the nutrient composition of our results as compared to those of other workers could probably have been due to the differences in their growth environment, soil properties, varietal differences and even the prevailing climate. (Koyuncu *et al*., 2014; Zou *et al.*, 2015). Carbohydrate and fibre contents were significantly highest in the control soil fruit samples. Unripe plantain fruits are known to be high in carbohydrate contents (Makanjuola *et al*., 2013). Carbohydrates are energy yielding food nutrients. Thus plantain fruits harvested from uncontaminated soil will supply enough energy to the consumer. Dietary fibre such as contained in unripe plantain fruits has been implicated with such health benefits as reducing blood cholesterol, slowing the rate of glucose absorption, improving the sensitivity of the body to insulin, relieving constipation and preventing the incidence of colon cancer (Okareh *et al., 2015;* Oko *et al.*, 2015).

With the exception of Cu and As, all the other heavy metals investigated showed significantly higher concentrations in the dumpsite soil samples than in the control. The heavy metals concentrations in the dumpsite soil samples were lower for Cd, Cu, and Pb than the mean obtained by Olufunmilayo *et al*. (2014) which ranged from 2.25 - 2.58; 2.58 - 3.30 and 60.00 - 91.67 mg/kg respectively. The concentrations of Co and Ni were however higher in our results than theirs which ranged between 0.42 - 0.72 mg/kg and 1.91 - 2.91 mg/kg respectively but our cobalt concentration was far lower than the values obtained by Awokunmi *et al.* (2010) which was 105 – 810 mg/kg. Heavy metals concentrations in any soil is known to be related to the biogeochemical cycles resulting from the anthropogenic activities such as agricultural, industrial and domestic wastes disposal (Olufunmilayo *et al*., 2014). The highest concentrations of Cr, Ni, Co and Cd were detected in soil samples from dumpsite A which is an age long dumpsite fed with various kinds of wastes from a popular Uyo urban market. The occurrence of these heavy metals in the soil makes them available for absorption by the plants roots (Okoronkwo *et al.,* 2015).

Heavy metals concentrations in plantain fruits varied markedly between those harvested from dumpsites and those from the control site. All the dumpsite fruits had significantly (P=0.05) higher heavy metals contents than those from the control site. Our results for Pb, Cr, Ni, Cd and As were however lower than what were obtained by Imasuen and Omorogieva (2013) 10.69; 37.71; 9.18; 21.90 and 13.20 mg/kg respectively for plantain fruits harvested from different types of polluted soils. Although with the exception of Pb in fruit samples from dumpsites B and C, the concentrations of all the other heavy metals in fruit samples were below the WHO/FAO maximum allowable limit. It is however worthy of note that their continuous consumption can lead to bioaccumulation resulting in lethal concentrations in the body. Lead is known to be very toxic even at very low concentrations (Okorononkwo *et al.,* 2005). It is a deadly carcinogen and is associated with renal tumour, cardiovascular, kidney, nervous, circulatory, skeletal and reproductive systems damages (Kibria, 2016). Cr is known to be both mutagenic and carcinogenic (Podsiki, 2008), causing asthma and shortness of breath as well as liver and kidneys damage with long term exposure. Ni is also a human carcinogen and constitutes a health hazard at high doses causing cancer of the nose, larynx, lungs and that of the prostrate, respiratory failure, birth defects and heart disorders (Kibria, 2016). Cu is considered as an essential trace element for humans, but at elevated concentrations such as result from bioaccumulation, it can cause cirrhosis of the liver and results in death in extreme cases (Nolan, 2003; Kibria, 2016). Co occurs as heavy metal in the plant or animal bodies without being bio-magnified up in the food chain due to the fact that a vast quantity of it ingested is passed out of the body unabsorbed (Lenntech, 2014). However, when a high concentration of Co is taken health effects such as nausea and vomiting, vision problems, heart and pulmonary problems and thyroid damage usually result (Lenntech, 2014). Cd is a toxic heavy metal even at low concentrations and is also considered a carcinogen causing bronchitis, emphysema and alveolitis (Kabata-Pendias, 2011). Arsenic is a deadly heavy metal which is considered a human carcinogen even at extremely low levels of exposure (ATSDR, 1999) with various other clinico-pathological conditions such as cardiovascular and peripheral vascular disease, developmental anomalies, neurologic and neurobehavioural disorders, diabetes, hearing loss, portal fibrosis, hematologic disorders (anemia, leukopenia and eosinophilia) carcinoma, nausea, vomiting, abdominal pain, muscle cramps and diarrhoea when taken in high concentrations (ATSDR,2000; Abdul *et al.,* 2015).

The accumulation factor (AF) calculations showed values greater than 1 for Cu in fruit samples from all the dumpsites while this was the case for As only for fruit samples from dumpsites A and B. Heavy metals are capable of moving from the soil to the edible parts of the food crop (Li *et al.,* 2012). Our results showed that the accumulation factor varied with the heavy metals thus agreeing with the findings of Adefemi *et al.,* (2012). Cu had the highest accumulation factor except in samples from the control site while Cd had the lowest. Those heavy metals with high AF point to the fact that much consumption of the plantain fruits from those dumpsites with time may result in some health problems.

## V. CONCLUSIONS

The concentrations of Pb, Cr, Ni, Co and Cd were higher in all the dumpsite soils than in the control soil. Plantain fruits from dumpsite soils accumulated higher heavy metal concentrations than those from the control soil. In the three dumpsite soils investigated, Pb concentration was highest followed by Cr, while Cu and Ni followed in that order in site A and B. In site C, Ni was however, higher in concentration than Cu. The presence of these heavy metals in the dumpsite soils and their accumulation in the plantain fruits harvested from there is sounding a cautionary note as to the health risk involved in continual cultivation and consumption of plantain fruits from these dumpsites. Proper and safer methods should be adopted by the Uyo municipal government to evacuate and dispose these wastes away from the immediate human settlement while at the same time creating awareness and discouraging the people from cultivating on waste dumpsite soils.

## VI. ACKNOWLEGMENT

The authors are grateful to the laboratory staff of Soil Science Department, University of Uyo for their technical assistance.

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