©NIJSES
Publications

Open Access
ONLINE ISSN: 2992-5819
PRINT ISSN: 2992-6149

NEWPORT INTERNATIONAL JOURNAL OF SCIENTIFIC AND EXPERIMENTAL SCIENCES (NIJSES)

Volume 4 Issue 1 2023

https://doi.org/10.59298/NIJSES/2023/10.8.1000

Quantifying Bioaccumulation Factors of Food Cultivars in the Vicinity of Coal Mining: A Study in Ngwo, Akwuke, and Udi Communities, Enugu State, Nigeria

[1]Uhama Kingsley Chukwuka*, [2]Aneke Chinwe Jacinta, [1]Akpata Ebere Immaculata and [3]Nwaigbo Olive Chika

[1]Department of Biochemistry, Faculty of Applied Natural Sciences, Enugu State University of Science and Technology, (ESUT), Nigeria.
[2]Department of Applied Microbiology and Brewery Faculty of Applied Natural Sciences, Enugu State University of Science and Technology.
[3]Enugu State University of Science, Nigeria.
Email: kingsley.uhama@esut.edu.ng
Phone: +2348065665045

ABSTRACT

Heavy metal contamination resulting from coal mining activities poses a substantial threat to both environmental stability and human health. This study delves into the bioaccumulation factors of various food cultivars within the coal mining regions of Ngwo, Akwuke, and Udi Communities in Enugu State, Nigeria. Heavy metals, including lead, cadmium, nickel, manganese, and chromium, have been recognized as significant contaminants responsible for various detrimental health effects. The presence of these metals in the environment, particularly in soil, water, and subsequently in food crops, leads to indirect human exposure through the food chain, thereby triggering several health risks. This research focuses on assessing the levels of heavy metal bioaccumulation in food cultivars and their potential implications for human health. Samples of leafy vegetables and tubers were collected from different locations within the communities and processed following recommended methods. The digestion process involved the use of concentrated acids and subsequent analysis through Atomic Absorption Spectrophotometry (AAS) to quantify the concentration of heavy metals. Bioaccumulation factors (BAF) were determined by establishing the ratio of metal concentrations in the plants to those in water. Results indicated significant variations in bioaccumulation factors among different cultivars and study sites. For instance, the bioaccumulation of manganese and chromium in pumpkin from Akwuke was notably higher compared to Udi and Ngwo, while lead and cadmium levels were significantly higher in Udi. Similar trends were observed in scent leaf and cassava samples, suggesting differential metal accumulation based on cultivar type and geographical location. The findings underscore the concerning levels of heavy metal bioaccumulation, especially high cadmium accumulation in certain food cultivars, posing potential health hazards to communities reliant on these crops. This study emphasizes the critical need for effective environmental management strategies and water treatment practices in these regions to mitigate health risks associated with heavy metal exposure through food consumption.

Keywords: Heavy metals, Bioaccumulation factors, Food cultivars, Coal mining, Environmental health, Nigeria.

Open Access
ONLINE ISSN: 2992-5819
PRINT ISSN: 2992-6149

INTRODUCTION

Heavy metal pollution poses a great potential threat to the environment and human health. Coal as source of fuel and one of natural endowment has constituted a repository of heavy metal to the environment. Heavy metal contaminate the soil, water and thus enter the food chain in these manner, humans are indirectly exposed to heavy metals through food chain.Several studies have shown that heavy metals such as lead, cadmium, nickel, manganese and chromium amongst others are responsible for certain diseases [1]. In general heavy metals are systemic toxins with specific neutrotoxic, nephrotoxic, fetotoxic and tetratogenic effect [1]. Heavy metals can directly influence behaviour by impairing mental and neurological function, influencing neurotransmitter production and utilization and altering numerous metabolic processes. Systems in which toxic metal elements can induce impairment and dysfunction include the blood and cardiovascular, eliminative pathways (colon, liver, kidney, skin), endocrine (hormonal), energy production pathways, enzymatic, gastrointestinal, immune, nervous (central and peripheral), reproductive and urinary that have lethal effects on man and animals [1].Diseases associated with the heavy metal toxicity include, pulmonary, abdominal pain, chronic bronchitis, kidney disease, pulmonary edema (accumulation of fluid in the lungs), cancer of the lungs and nasal sinus ulcers, convulsion, liver damage and even death [1].Heavy metals get into the environments: water, soil and food cultivars through activities like intense agriculture, power generation, industrial discharges seepages and municipal landfills, septic tank effluents etc. Many authors have reported high levels of heavy metals ions in the soil and groundwater in different areas of Nigeria [2]

Aim of the Study

This research work is aimed at assessing the bioaccumulation factors of Food Cultivars in the Coal miningenvironment of Ngwo, Akwuke and UdiCommunities of Enugu State, Nigeria.

MATERIALS AND METHOD

Sample collection

Food cultivars; leafy vegetables and tubers were collected from three different location (Akwuke,Udiand Ngwo)in three different Local Government Area in Enugu State, with the consent of the owners of the farm, and the tubers were also collected from their storage bans with the consent of the farmers.

Sample preparation

Preparation of plant samples: the sample preparation technique for plants involves steps like, washing, drying, grinding, and storage. The plant samples were prepared according to the method recommended by [3] and [4]. The plant sample were washed with water and air dried firstly and then in an oven at 70-80^{0C} until a constant dry weight was attained. The dried samples were ground in wooden mortar to make a fine powder. The finely ground samples were passed through 0.5mm nylon mesh sieve and packed in the air tight polythene bags to prevent the absorption of water from the humid environments.

DIGESTION OF SAMPLES

Digestion of food cultivars

Exactly 1g of the ground sample was weighed into a breaker. 10cm^3 of 1:1 dilution of the concentrated HNO_3 and water was mixed and then covered with a watch glass. The solution was placed on a hot plate to reflux for 10 to 15 minutes without boiling. The beaker was allowed to cool and then 2cm^3 of distilled water and 3cm^3 of 30% H_2O_2 were added, cover with watch glass and placed over a hot plate. After the effervescence had subsided, the solution was removed and cooled .HCl(5cm^3) and 10cm^3 of distilled water were added and then heated for another 15minutes without boiling. The solution was when transferred to 100cm^3 beaker and made up to mark using deionized water and taken for AAS determination of lead, chromium, Nickel, cadmium and manganese.

Principles of AAS: Atomic Absorption Spectrophotometer working principle is based on the sample being aspirated into the flame and atomized when the AAS light beam is directed through the flame into the monochrometor, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metal have their own characteristic absorption wave length, a source lamp composed of that element is used in making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed is proportional to the concentration of the element in the sample.

DETERMINATION OF BIOACCUMULATION FACTOR

Bioaccumulation of metals in different samples were quantified by a bioaccumulated factor (BAF), which is the ratio of a particular metal concentration in the plants to the concentration of that metal in water [5]

$$BAF = \frac{concentration\ of\ metal\ in\ palnt}{concentration\ of\ metal\ \ in\ water}$$

Open Access
ONLINE ISSN: 2992-5819
PRINT ISSN: 2992-6149

RESULTS

COMPARISON OF BIOACCUMULATION FACTOR OF HEAVY METALS IN PUMPKIN FROM THE STUDY SITES

Result of bioaccumulation factor in pumpkin from coal mining communities in Enugu State showed that the bioaccumulation factor for Mn and Cr levels in pumpkin from Akwuke were significantly higher ($p<0.05$) when compared to Udi and Ngwo, while that of Pb and Cd in Udi was significantly highest ($p<0.05$) followed by Ngwo and Akwuke . Ni level were below detectable level in pumpkin from all the communities (Table 1).

Table 1:Comparison of bioaccumulation factor of heavy metals from study sites in pumpkin

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	1.87 ± 0.02^{b}	1.57 ± 0.01^{c}	1.98 ± 0.06^{a}
Cr	0.00 ± 0.01^{c}	0.10 ± 0.01^{b}	1.22 ± 0.01^{a}
Pb	1.26 ± 0.01^{a}	1.25 ± 0.01^{b}	0.75 ± 0.01^{c}
Cd	6.33 ± 0.58^{a}	2.00 ± 1.00^{b}	1.07 ± 0.01^{b}
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at $P<0.05$

COMPARISON OF BIOACCUMULATION FACTOR OF HEAVY METALS IN SCENT LEAF FROM THE STUDY SITES

The result of bioaccumulation factor in scent leaf from coal mining communities in Enugu State showed that the bioaccumulation factor for Mn, Cr and Pb levels in cassava from Ngwo were significantly higher ($p<0.05$) when compared to Udi and Akwuke, while that of Cd in Udi and Ngwo did not differ significantly ($p<0.05$), but is higher than that of Akwuke. Ni were below detectable level in scent leaf from all the communities (Table 1).

Table 2: Comparison of bioaccumulation factor of heavymetal in scent leaf from site

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at $P<0.05$

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	1.13 ± 0.01^{b}	1.15 ± 0.01^{a}	1.05 ± 0.01^{c}
Cr	0.00 ± 0.01^{a}	0.50 ± 0.57^{a}	0.00 ± 0.01^{a}
Pb	0.89 ± 0.01^{c}	1.43 ± 0.15^{a}	1.14 ± 0.01^{b}
Cd	1.33 ± 0.58^{a}	1.33 ± 0.58^{a}	0.04 ± 0.01^{b}
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}

COMPARISON OF BIOACCUMULATION FACTOR OF HEAVY METALS IN CASSAVA FROM THE STUDY SITES

Result of bioaccumulation factor in cassava from coal mining communities in Enugu State showed that the bioaccumulation factor for Mn ,Cr and Pb levels in cassava from Ngwo were significantly higher ($p<0.05$) when compared to Udi and Akwuke, while that of Cd in Udi was significantly highest ($p<0.05$) followed by Ngwo and Akwuke . Ni level were below detectable level in cassava from all the communities (Table 3).

Table 3:Comparison of bioaccumulation factor of heavy metal in cassava from study site

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	0.29 ± 0.02^{b}	0.46 ± 0.01^{a}	0.31 ± 0.01^{b}
Cr	0.00 ± 0.01^{c}	0.67 ± 0.01^{a}	0.22 ± 0.01^{b}
Pb	1.30 ± 0.01^{b}	2.10 ± 0.10^{a}	1.08 ± 0.01^{c}
Cd	6.00 ± 1.00^{a}	1.00 ± 1.00^{b}	0.07 ± 0.01^{b}
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at $P<0.05$

COMPARISON OF BIOACCUMULATION FACTOR OF HEAVY METAL IN YAM FROM STUDY SITES

Result of bioaccumulation factor in yam from coal mining communities in Enugu State showed that bioaccumulation factor for Cr and Pb levels in yam from Ngwo were significantly higher ($p<0.0.5$) when compared to Udi and Akwuke , whilen that of Mn in Akwuke was significantly higher ($p<0.05$) compared to that of Ngwo and Udi . Cd level in Udi was significantly highest ($p<0.05$) followed by Ngwo and Akwuke.Ni level were below detectable level in yam from all the communities (Table 4).

Table 4: Comparison of bioaccumulation factor in yam from study sites.

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	0.08 ± 0.01^{c}	0.26 ± 0.01^{b}	0.29 ± 0.01^{a}
Cr	0.00 ± 0.01^{c}	2.83 ± 0.01^{a}	0.78 ± 0.01^{b}
Pb	1.26 ± 0.01^{a}	1.33 ± 0.58^{a}	1.04 ± 0.01^{a}
Cd	8.67 ± 0.58^{a}	2.00 ± 1.00^{b}	0.04 ± 0.01^{c}
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at $P<0.05$

DISCUSSION

The bioaccumulation factor of heavy metals in food cultivars from the studied areas followed the same trend as the transfer factor. The leafy vegetables showed high level of heavy metal bioaccumulation factor. Among the heavy metals, cadimium (Cd) was highly bioaccumulated in all samples from all locations than any other heavy metals. The preponderance of Cd in the food cultivars especially from udi with the highest bioaccumulation factor Cd may impose health threat to the community that depends on these food cultivars for food. However [6] asserted that bioaccumulation factor in food chain may be highly dangerous to human health.

CONCLUSION

The bioaccumulation of these heavy metals as determined by bioaccumulation factor indicated high level of Cd accumulation in the food cultivars, especially pumpkin leaf. Continuous consumption of water from these communities without adequate water treatment may expose the inhibitants to dangers.

REFERENCES

1. Hughes, W.W (1996) Essentials of environmental toxicology. The effects of environmental hazardous substances on human health. Loma, Lind California. Tay and Francais Publishers Pp 3887-95
2. Ibeto, C.N and Okoye C.O.B. (2010). High levels of heavy metals in blood of the urban population in Nigeria. *Research Journal of Environmental Sciences.* **4**(4):371-382
3. Jones J.B. plant tissue Analysis. For Micronutients. Soil Sci. 68,pp 75-79.
4. Amma, M.K. (1990). Plant ad soil analysis. Rubber research institute, Rubber Board, kottayam-686009, keral, India
5. Sinha *etal.*, 2008, comparative growth response of two varieties of vigna radiate l. (var PDM 54 and var.Nm 1) grown on different tannery sludge applications: effects of treated wastewater and ground water used for irrigation.
6. Turkdogan, M.K., Kilical, f., Kara, Tuncer,I., and Uygan,I. (2003). Heavy metals in soil, vegetables and fruit in endomic upper gastrointestinal cancer region of turkey. Environ.Toxicol. Pharmacool; 13(3)175-179

CITE AS: Uhama Kingsley Chukwuka, Aneke Chinwe Jacinta, Akpata Ebere Immaculata and Nwaigbo Olive Chika (2023). Quantifying Bioaccumulation Factors of Food Cultivars in the Vicinity of Coal Mining: A Study in Ngwo, Akwuke, and Udi Communities, Enugu State, Nigeria. NEWPORT INTERNATIONAL JOURNAL OF SCIENTIFIC AND EXPERIMENTAL SCIENCES (NIJSES) 4(1):53-56. https://doi.org/10.59298/NIJSES/2023/10.8.1000