HEALTH RISK ASSESSMENT OF HEAVY METAL CONTAMINATION OF CASSAVA GROWN IN A CEMENT PRODUCTION AREA.

Makanjuola, J.O.[1] and *Aderinboye, O.E.[2]
[1&2] Science Laboratory Technology department, Federal polytechnic Ilaro, Ogun state.
Corresponding Author: Email: Oluwaseyi.aderinboye@federalpolyilaro.edu.ng
Phone number: 08077917699

ABSTRACT
Limestone mining and the manufacture of cement are examples of industrial activities that pollute the environment and cement production is a known source of heavy metals such as Cd, Cr, Cu, Pb and Zn. The aim of this study was to analyse cassava grown around a cement production area for heavy metal presence in order to determine the associated health risk in consumption. To achieve this, a Flame atomic absorption spectrophotometer was used to analyse cassava samples taken from three different locations around the cement factory for Ni, Cd, Cu, Pb and Zn. The metal concentrations were used to estimate the potential health risks; Daily Intake of Metal (DIM), Health Risk Index (HRI), Target Hazard Quotient (THQ) and Hazard Index (HI). The metal concentrations in the cassava samples ranged from 0.0464 mgkg^{-1} to 0.705 mgkg$^{-1.}$, with Zn having the highest concentration and Cu the least. The DIM calculated showed that the metals all had daily intake values below the standards given by regulatory bodies while the HRI,THQ and HI gave values less than the threshold of one indicating there may be no health risk associated with consuming cassava from these locations.

1. Introduction

Heavy metals are a potent environmental problem because of their inability to biodegrade which leads to their persistence in the environment. Some of these metals in small quantities can be beneficial (Zn, Fe, Cu) and toxic at high concentration while others (e.g. Cd , Pb) do not have any beneficial effect for both plants and animals. Although a lot of these metals occur naturally in the earth's crust, industrialization and urbanization increase their availability in the environment. Contamination of food crops by metals can come from the soil on which it grows or atmospheric deposition, all of which are as a result of anthropogenic activities such as mining operations, rapid urbanization, waste disposal, pollution from vehicle exhausts and industrial activities (Khan, Cao, Zheng, Huang & Zhu, 2008).

Limestone mining and the manufacture of cement are examples of industrial activities that pollute the environment. Cement production is a known source of heavy metals such as Cd, Cr, Cu, Pb and Zn (Olowoyo, Mugivhisa&Busa, 2015; Ujoh& Alhassan, 2014) . The effect and amount of heavy metal-containing dust emitted by a cement factory is largely dependent on the technology used by the factory to reduce contamination of the environment (Olowoyo et al., 2015). These metals can become adhered to particles and move from different environmental media into soils, water bodiesand biota. Humans can then be affected via, drinking water, plants, skin absorption and inhalation (Schuhmacher, Domingo &Garreta, 2004).

The concentration and accumulation of heavy metals in edible plants is of great public concern because of its potential impact on public health. Intake of heavy metal rich foods as been linked to the depletion of essential minerals in the body which has been implicated in the rise in stomach cancers, fertility issues in women, reduced functions of the immune systems and impaired psycho-social faculties (Ahmad et al., 2016). Chronic exposure to cadmium for example has been implicated in kidney malfunctions and an increased occurrence of cancer of the prostrate (Mojolagbe, Yusuf &Duru, 2014).

Cassavawas chosen for this study because it is highly cultivated and consumed in the Yewa South local government area of Ogun state, Nigeria. Cassava is processed mainly as either garri or fufu and then consumed.
The aim of this study was to analysecassava grown around a cement production area for heavy metal presence in order to determine the associated health risk in consumption.

2.0 Methods

Study area

Samples were collected in Ibese, Ilaro Ogun State where a cement factory is located. Ibese is located in Egbado (Yewa North Local Government) of Ogun State, Southwest Nigeria. It lies on latitude 6° 58' 0'' N and longitude 3°,2'3''E. The inhabitants are mostly farmers and traders.

Sample collection

Cassava tubers(*Manihot esculenta*) were collected in Ibese, Ogun State with consideration of where people were likely to pick for consumption. The Cassava samples were labeled D-F and collected as follows; Sample D (Cassava) was collected at the cement factory, Sample E (Cassava) was collected at Dangote estate , 400 meters away from the cement factory and Sample F (Cassava) was collected at Balogun, Ibese 2km away from the cement factory.

Sample preparation

Collected samples were washed using de-ionized water to remove dirt and impurities. The cuticle of the cassava was removed with a stainless steel knife and the edible part was cut into smaller pieces. Samples were air-dried for three weeks to remove moisture. The dried samples were pulverized using an electric blender.

Heavy metals analysis

The pulverized samples were then dissolved in 5ml of 6M Nitric acid and then filtered using whatman 42 filter paper. The filtrate was quantitatively transferred into 50ml standard flask. The determination of the following heavy metals- Ni, Pb, Zn, Cu and Cd- was carried out using Flame Atomic Absorption Spectrophotometer (FAAS) at the following wavelengths respectively; 232.0nm, 217nm, 213.9 nm, 324.8 nm and 228.8 nm.

Health risk assessement (Non-cancer health risk assessment)

For the evaluation of the potential health risk associated with consuming Cassava, the Daily Intake of Metal (DIM), Health risk index (HRI), Target Hazard Quotient (THQ) were calculated using equations 1,2, 3 and 4.

Daily intake of metals

Daily intake of metals (DIM) was calculated as reported by Sajjad et al. (2009)

$DIM=C_{metal}D_{food\ intake}/B_{averageweight}$ …… (1)

$C_{metal}$is the concentration of metals

$D_{food\ intake}$ daily intake of cassava

$B_{averageweight}$ Average body weight.

For adults, the average daily cassava intake used was 0.350kg/person/day (Orisakwe,Ozoani, Nwaogazie&Ezejiofor, 2019)

Average body mass used is 65kg

Health risk index (HRI)

The ratio of the DIM to the reference dose (R_fD) gives us the health risk index.

$HRI= DIM/R_fD$-------(2)

If this value is greater than 1, then it indicates high health risk to consumers through dietary intake.

Target Hazard Quotient (THQ)

This is a non-cancer risk characterization of pollutants effect over a lifetime and it is calculated as follows;

$THQ=10^{-3}\ \{E_FE_DF_{IR}C/R_fDB_{averageweight}T_A\}$ --------(3)

$R_f$dvalues for Ni, Cu, Pb, Cd, and Zn are0.02, 0.04, 0.004, 0.001, and 0.30 (mg/kg)respectively (USEPA IRIS, 2006). E_F is exposure frequency (365 days year^{-1}),E_D is the exposure duration (70 years),equivalent to the average lifetime , F_{IR} is the food ingestion rate (kgperson^{-1} day^{-1}), C is the metalconcentration in food (mg /kg) , and $T_A$is the average exposure time for noncarcinogens (365 days year^{-1}).

Hazard Index (HI)

Thisis used to estimate the total chronic toxicity of a number of metals based on the addition of doses.

$HI=\sum HQ1+HQ2+\ldots\ldots.+HQn$ ---------- (4)

Statistical analysis was carried out using the SPSS software and Microsoft Excel 2010

3.0 Results and Discussion

Table 1: Heavy metal concentration (mgkg^{-1}) of cassava samples from different locations.

Sample	Ni	Pb	Cu	Cd	Zn
D	0.1109±0.0090	0.4649±0.0009	0.1407 ±0.0007	BDL	0.2591±0.0031
E	0.1538±0.0000	0.5583±0.0023	BDL	BDL	0.7051±0.0000
F	0.2299±0.0009	0.584±0.0040	0.0464±0.0004	BDL	0.4128±0.0008

Concentrations in mean±SD. BDL: Below detection limit of instrument

Potential human health risk assessment of the heavy metals

Table 2: Daily intake of metal (mg^{-1}person day^{-1}) of Cassava in the three different sampling areas.

Sample	Ni	Pb	Cu	Cd	Zn
D	$7.3 x 10^{-4}$	$2.5 x 10^{-3}$	$7.6 x 10^{-4}$	NE	$1.4 x 10^{-3}$
E	$8.3 x 10^{-4}$	$3.0 x 10^{-3}$	NE	NE	$3.7 x 10^{-3}$
F	$1.2 x 10^{-3}$	$3.0 x 10^{-3}$	$2.5 x 10^{-4}$	NE	$2.2 x 10^{-3}$

NE: Not estimated

Table 3: Calculated values of the HRI and THQ of the heavy metals analysed.

Samples	Heavy Metals Present									
	Ni		Pb		Cu		Cd		Zn	
	HRI	THQ	HRI	THQ	HRI	THQ	HRI	THQ	HRI	THQ
D	0.0365	0.0026	0.625	0.044	0.019	0.0013	NC	NC	0.005	0.0003
E	0.0415	0.0029	0.750	0.053	NC	NC	NC	NC	0.012	0.0009
F	0.060	0.0043	0.750	0.053	0.0006	0.0004	NC	NC	0.007	0.0005

NC: Not calculated

Table 4: Hazard index values for the heavy metals analysed for

Sample	Hazard Index (HI)
D	0.048
E	0.069
F	0.065

Table 5: WHO/FAO maximum tolerable levels for Cu,Ni,Cd,Pb and Zn. (FDA, 2019; WHO/FAO, 2011; WHO 1996)

Metal	PMTDI (bw 65kg)
Cu	32
Cd	1.63
Zn	19.5
Pb	0.013
Ni	39

PMTDI: Provisional Maximum Tolerable Daily Intake. Bw: Body weight.

Table 1 shows the concentrations of Ni, Pb, Cu, and Zn at different distances from the cement manufacturing company. The concentrations of the metals analysed for except Cd varied from 0.046 to 0.705 mgkg^{-1}. The highest level of Zn (0.705 mgkg^{-1}) which was the highest metal concentration obtained was from sample E (400m from the cement factory). This is not farfetched as Ogunbileje et al. (2013) reported in their study that cement dust is a major contributor of Zn to the environment. Sample D (at the cement factory) had the lowest concentrations in all the metals analysed for except Cu where it had the highest concentration (0.1407 $mgkg^{-1}$) while Sample F (2km from the cement factory) had the highest concentrations for Ni and Pb. Cadmium concentrations were below the limit of the instrument used and was reported as BDL.

The daily intake of the heavy metals (DIM) for adults via the consumption of cassava from the different locations wascalculated and shown in table 2. The DIM ranged from 3.7×10^{-3} to 8.4×10^{-3} with Zn having the highest DIM and Ni having the lowest both from sample E. None of the metals exceeded the maximum levels provided by different regulatory bodies as shown in table 5.

The Target hazard quotient (THQ) and Health risk index (HRI) are reported in table 3. No metal had results greater than the threshold value of 1 but Pb in all samples had the highest THQ AND HRI values. The hazard indices calculated for all the metals as seen in table 4 were all less than the threshold value of 1. The THQ and HI indicate that there may be no metal related health risk associated with the consumption of cassava from these locations during the duration of a person’s lifetime. This is in line with a similar study carried out by Olayinka, Adedeji, Oresanya and Alabi-Thompson (2016) who reported HI and THQ values of less than 1 for cassava tubers around the cement factory in Ibese.

Although the estimated HRI assessment of Pb from all the cassava samples gave values below 1, there were still values as high 0.750. It can be inferred from this that there is a possibility of risk from an accumulation of Pb if Pb is present in order food items consumed.This is important to note because lead has been found to target systems such as the reproductive, renal, hematopoietic and central nervous systems (Assi, Hezmee, Haron, Sabri &Rajion, 2016).

4. Conclusion

This study aimed at assessing the potential health risk of consuming cassava gotten from farms around a cement manufacturing company in Ibese, Ogun state. The study revealed that the concentrations of metals in the raw cassava analysed were below stipulated standards. The health risk assessments (DIM, HRI, THQ and HI) showed that there may be no associated potential health risk from the metals analysed. However, Lead stood out as having a significantly higher THQ value which could pose harm when other lead rich foods are consumed alongside.

References

Ahmad, k., Ashfaq, A., Khan, Z., Ashraf, M., Akram, N., Yasmin, S., et al. (2016). Health risk assessment of heavy metals and metalloids via dietary intake of a potential vegetable (Coriandrum sativum L.) grown in contaminated water irrigated agricultural sites of Sargodha, Pakistan,. *Human and Ecological Risk Assessment: An International Journal,* , 1-15.

Assi, M. A., Hezmee, M. N., Haron, A. W., Sabri, M. Y., & Rajion, M. A. (2016). The detrimental effect of lead on animal and human health. *Vertinary world, 9* (6), 660-671.

Khan, S., Cao, Q., Zheng, Y., Huang, Y., & Zhu, Y. (2008). 1.Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental Pollution, 152*, 686-692.

Majolagbe, O. A., Yusuf, K. A., & Duru, A. E. (2014). Trace Metals Characterization in Environmental Media: A Case Study of Cement Production. Area Ewekoro, Southwest, Nigeria. *American Journal of Environmental Protection., 3* (2), 83-89.

Ogunbileje, J. O., Sadagoparamanujam, V. M., Anetor, J. I., Farombi, E. O., Okorodudu, O. A., & Akinosun, O. M. (2013). Lead, mercury, cadmium, chromium, nickel, copper, zinc, calcium, iron, manganese and chromium (VI) levels in Nigeria and United States of America cement dust. *Chemosphere, 90*, 2743–2749.

Olayinka, O. O., Adedeji, H. A., Oresanya, O. O., & Alabi-Thompson, F. (2016). Environmental and Health Impact of Cement Factory Production in Ibese, Ogun state, Nigeria. *Applied Environmental Research, 38* (2), 93-110.

Olowoyo, J., Mugivhisa, L., & Busa, N. (2015). Trace Metals in Soil and Plants around a Cement Factory in Pretoria, south Africa. *Pol. J. Environ. Stud, 24* (5), 2087-2093.

Orisakwe, O. E., Ozoani, H. A., Nwaogazie, I. L., & Ezejiofor, A. N. (2019). Probabilistic health risk assessment of heavy metals in honey, Manihot esculenta,andVernonia amygdalina consumed in Enugu State, Nigeria. *Environ Monit Assess, 191*, 1-14.

Sajjad, K., Robina, F., Shagufta, S., Mohammed, A., & Maria, S. (2009). Health risk assessment of heavy metals for population via consumption of vegetables. *World applied sciences journals., 6* (12), 1602-1606.

Schuhmacher, M., Domingo, J., & Garreta, J. (2004). Pollutants emitted by a cement plant: health risks for the population living in the neighborhood. *Environmental Research, 95*, 198-206.

Ujoh, F., & Alhassan.M. (2014). Oxides and Heavy Metals Concentration around a Cement Plant at Yandev, Central Nigeria. *International Journal of Plant & Soil Science, 3* (6), 777-789.

US EPA IRIS. (2006). *United States, Environmental Protection Agency, Integrated Risk Information System.* Retrieved September 20, 2019, from United States, Environmental Protection Agency: http://www.epa.gov/iris/substS.

US FDA. (2019). *Lead in Food, Foodwares, and Dietary Supplements*. Retrieved September 25, 2019, from US FDA: https://www.fda.gov/food/metals/lead-food-foodwares-and-dietary-supplements#collapseFour

WHO. (1996). *World Health Organisation.* Retrieved September 20, 2019, from http://www.who.int/nutrition/publications/micronutrients/9241561734/en/

WHO/FAO. (2011). *CODEX Alimentarius Commison.* Retrieved September 20, 2019, from FAO: http://www.fao.org/tempref/codex/Meetings/CCCF/CCCF5/cf05_INF.pdf