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# BIOACCUMMULATION AND HEALTH RISK ASSESSMENT OF SOME POTENTIALLY TOXIC ELEMENTS IN CROPS FROM FARMS ROUND GRANITE QUARRY SITES IN IBADAN SOUTHWESTERN NIGERIA

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## ABSTRACT

Potentially toxic elements (PTEs) in food crops have significant apprehension in the environment because of their impending human health risks. This study thus assessed PTEs concentrations in soils and crops from farmlands around quarry sites, quantifies their level of uptake by the crops and their potential health risks to human. Collection of Soil and crop (*Dioscorea alata*, *Colocasia esculenta* and *Manihot esculenta* ) samples were done and analysed for Fe, Mn, Pb, Zn, Cu, Cr, Co, Ni and Cd using suitable instrumentation methods Data were evaluated using accumulation factor (AF), calculated daily intakes (CDI), target hazard quotent (THQ) and hazard index (HI). Farmlands soils that are closer to studied sites had higher PTEs concentrations than those that are farther away. Mean PTEs concentrations in the crops were in the order of *Dioscorea alata* > *Colocasia esculenta* > *Manihot esculenta*. Mean values of AF are less than one indicating low potential PTEs accumulation in the crops. The mean CDI in mg/kg/day of PTEs in crops for children and adults were 0.0001 - 0.060 while THQ values are in order Pb> Mn>Cu> Cd>Ni> Co>Fe >Zn>Cr. Hazard index (HI) is greater than one in all the crops from the farmlands closer to quarry sites, indicating risk upon consumption. Thus, necessary remediation methods should be taken to reduce the effect of these PTEs on the environment.

**KEYWORDS:** Contamination, consumption, food crops, heavy metals, human health risks,

## INTRODUCTION

Potentially toxic elements (PTEs) concentrations in soil are on continuous increase due to agricultural activities (fertilizers, pesticides), waste generation and poor disposal, mining activities and industrialization (Ekpo et al., 2012; Akintola, 2014). Most of these HMs are indispensable for living when in minute attendance but can be noxious and dangerous to plants, human and animal with high concentrations (Oves et al., 2012). Human contact with HMs from food, air and through skin has been reported by different researchers (Chang et al., 2014; Khan et al., 2014; Akintola et al., 2019). Food crops cultivated on contaminated farmlands may be at risk due to high concentrations of HMs resulting from accumulation of these HMs from the soil into the root of the crops and transfer them into their different parts (Akintola et al., 2020). The availability of these metals in soils and in plants can become dangerous to animal or human through consumption.

Quarrying, an open pit or surface mining is used for divulging the minerals deposits underneath the earth surface. It requires an exhaustive blasting, and abstraction of rock, soil and vegetation to get to below the earth surface, where large mineral ores are deposited
(Angela et al., 2016). All through these processes, some toxic substances are released into the environment as wilds which may pollute the soil, plants, water and can become harmful and toxic to human. Aside these, they can also cause wildlife and biodiversity loss, contamination of air, loss of soil nutrients, land degradation, reduction in agricultural activities and injurious to human health among others (Adepoju, 2002). This study thus assessed concentrations of heavy metals in soils and crops from farmlands around the quarry sites, quantifies their level of uptake by the crops and their potential health risks to human.

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## MATERIALS AND METHODS

### Study area description

The two quarry sites (Ratcon and NSCE) are located within Oluyole local Government area in Ibadan, Southwestern Nigeria (Figure 1). The study locations are within latitude (7°12' to7° 21' N) and longitude (3°48'E to 3°54'E). Both Ratcon and NSCE produce granite aggregates, lumps and dust through blasting and crushing. Farming activities are found around the area. Urbanization is evolving towards the area. The climate of the area falls between the humid and tropic with a mean annual rainfall of about 1270mm and average temperature of 32 ºC. Drainage pattern of the area is dendritic. Geologically, the area is among the Crystalline Basement Complex of southwestern Nigeria consisting of igneous and metamorphic rocks forming part of the African crystalline shield (Akintola *et al.,* 2022). The rocks are banded gneiss with few intrusions of granite, quartizites and other porphyritic rocks.

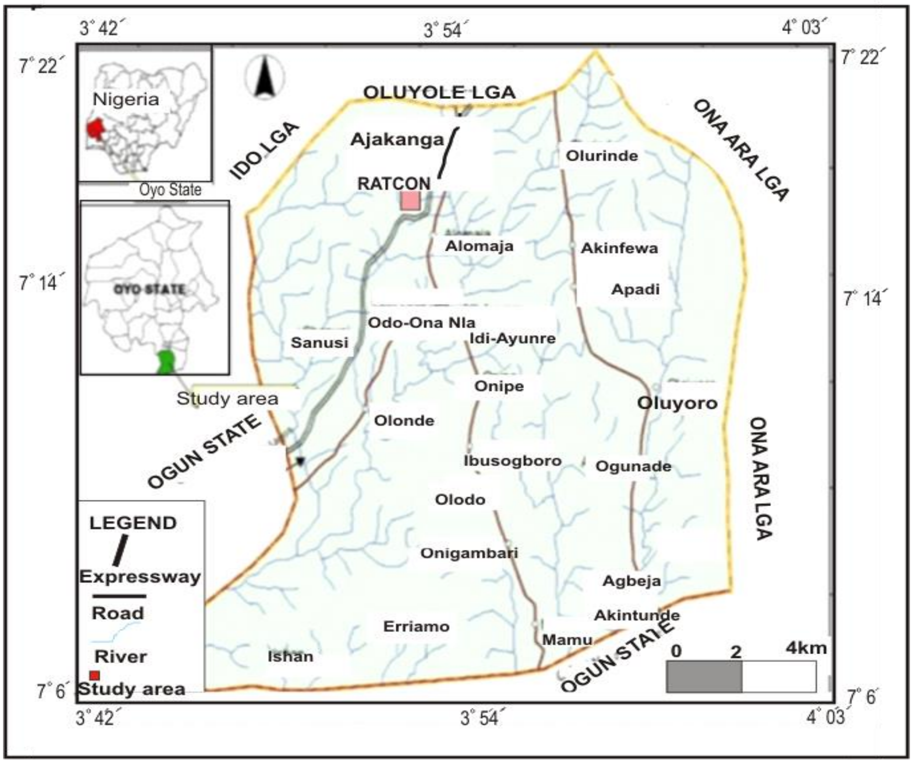


**Figure 1: Location map of the study area modified after Akintola et al (2022)**

### Sample collection, preparation and analysis

Six different farmlands were randomly located and selected for this study around the two quarry sites. The farmlands were located at distances 50m, 150m, 250m, 500m and 700m from the study area while control farmland was sited at 7km from the quarry sites. Ten soil samples at the depth of 0.15m were collected from each selected farmlands making a sum of 60 soil samples. The farmlands were designated as follows: FLD 1 (50 m), FLD 2 (150 m), FLD 3 (250 m), FLD 4 (500 m), FLD 5 (700m) and CFLD (7km). FLD is farmlands while CFLD is control farmland. At each farm lands, five different plant species were identified. The identified tuber crops at each sampling points were collected and labelled accordingly. Crop samples collected for this study are *Colocasia esculenta* (cocoa yam), *Manihot esculenta* (Cassava) and *Dioscorea alata* (yam).

Soil samples were air-dried, ground, sieved and packed in a well labelled sealed envelope for laboratory analysis. Tuber crops were also oven-dried at 70 °C to constant weight, ground, sieved with a 0.15-mm sieve and packaged for heavy metal analysis.

The analyses of the soils and tuber crops were done by measuring 1.0 g each of the sieved samples ( soils and tuber crops) and digested in a 20ml acid mixture of $HNO_3$, $H_2SO_4$ and $HClO_4$ in the ratio of 5v:1v:1v for about 8h at 80 °C. The digested mixtures were filtered with WHATMAN qualitative filter paper. The filtrate was later diluted with 50ml deionised water in a glass container. Determination of Fe, Cu, Zn, Pb, Mn, Co, Cr, Ni and Cd were done using atomic absorption spectrophotometer (AAS, MEDTECH). The procedures were repeated for all the samples.

Appropriate superior measures and precautions were carried out in order to have reliable results. All the reagents used were standard grade and the analyses were done in triplicate to ensure accurate readings. The Average readings were recorded for data analysis.

**Data analysis**

Data were analysed using SPSS using SPSS version 15 for windows. One-way analysis of variance (ANOVA) was used to compare the mean values of the determined parameters in soils and tuber crops from the different farmlands in the study area. Accumulation factor (AF) was used for assessment of bioaccumulation of PTES from soil to the tuber crops while calculated daily intake of PTEs (CDI); target hazard quotient (THQ) and Hazard index (HI) were used for health risk assessment of PTEs on human in the study area.

The accumulation factor (AF) as calculated from equation 1 is given by Baker (1991).

$$AF = \frac{CPTEsC}{CPTEsS} \ldots. \qquad Equation\ 1$$

Where

CHMIC is the concentration of PTEs in crops (mg/kg)

CHMIS is the concentration of PTEs in soils (mg/kg)

The calculated daily intake of PTEs (CDI) as evaluated in Equation 2 is given by Okereke et al., (2016)

$$CDI = \frac{CPTEs\ x\ ADI\ x\ Cf}{ABW} \ldots. \qquad Equation\ 2$$

Where CPTEs is the concentration of PTEs in the crops (mg/kg), ADI is the average daily intake of plants for adults and children, Cf is the conversion factor and ABW is average body weight. The values are presented in Table 1.

The target hazard quotient (THQ) was evaluated using the equation 3 (Ohiagu et al., 2020).

$$THQ = \frac{CDI}{ORD} \ldots. \qquad Equation\ 3$$

Where CDI is the calculated daily intake of PTEs in the crops and ORD is the oral reference dose (Table 1). Hazard index (HI) was used for assessment of PTEs in the crops. This is done by summing all the calculated THQ values of the PTEs

$$HI = THQfe + THQCu + THQZn + THQCo + THQ\ Mn + THQNi + THQPb + THQCr + THQCd \qquad 4$$

Table 1

| PTEs | Ofd USEPA (2007) and WHO (1996) | Average daily intakes (ADI) kg/person/day | Average body weight (kg) (ABW) | Conversion factor (Rattan *et al* (2005) |
|---|---|---|---|---|
| **Fe** | **0.07** | **0.345 (Adult)** | **55.90 (adult)** | **0.085** |
| **Cu** | **0.04** | **0.232( Children** | **32.70 (children)** | |
| **Zn** | **0.30** | | | |
| **Pb** | **0.02** | | | |
| **Mn** | **0.014** | | | |
| **Co** | **0.02** | | | |
| **Cr** | **1.50** | | | |
| **Ni** | **0.02** | | | |
| **Cd** | **0.001** | | | |

## RESULTS AND DISCUSSION

### *Concentration of PTEs in soils*

Mean concentrations of PTEs in soils from the six farmlands including the control are shown in Table 1. Respective values of Fe and Mn in the soils from the farmlands were: FLD 1 (22156.22 ±2.56, 822.90±0.99 mg/kg), FLD 2 (19267.01±1.43, 692.12±0.52mg/kg), FLD 3 (17200.41±1.01, 610.10±0.45mg/kg), FLD 4 (16681.09 ±0.99, 581.20±0.21 mg/kg), FLD 5 (16100.21±0.71, 498.10±0.16mg/kg) and CFLD (15614.13±0.59, 792.10±0.10mg/kg). Also, Zn, Cu, Pb and Co concentrations in the soils from the studied six farmlands were FLD 1 (65.10±0.90 , 56.86±0.52, 30.68±0.27 and 30.12 ±0.18 mg/kg), FLD 2 ( 55.26±0.56, 45.21±0.33, 26.56 ±0.19and 24.09±0.12 mg/kg), FLD 3( 45.08±0.38, 32.68±0.26, 21.86±0.14 and18.16±0.11mg/kg), FLD 4 (38.10 ±0.29, 20.05±0.19, 18.11±0.11 and15.09 ±0.09 mg/kg), FLD 5 ( 37.56±0.21, 18.22±0.10, 12.40±0.08 and 12.11±0.05mg/kg) and CFLD (25.10±0.16, 16.01±0.05, 12.22±0.02 and 12.06 ±0.02mg/kg). The values of Cr, Ni, Cd and As in the soils were FLD 1 (22.65±0.09 , 19.10±0.05, 0.45±0.03 and 0.31±0.01mg/kg), FLD 2 (

18.16 ±0.03, 17.29±0.02, 0.35±0.002 and 0.25±0.001 mg/kg), FLD 3 ( 16.22±0.02, 15.81±0.01, 0.31±0.001 and 0.21±0.001mg/kg), FLD 4 (14.21±0.005, 14.01±0.003, 0.25 ±0.02 and 0.18±0.02 mg/kg), FLD 5 ( 12.56±0.004, 11.01±0.002, 0.18±0.001 and 0.16±0.001 mg/kg) and CFLD (8.10±0.002, 7.20±0.002, 0.15±0.001 and 0.09 ±0.001mg/kg).

It was observed that the concentrations of PTEs in soil reduced as the farmlands are farther away from the quarry sites. Mean concentrations of PTEs in soil from FLD 1 (50 m from the quarry sites) recorded the highest values while those from CFLD (control farmland, about 7km from the quarry sites) had the lowest values with the exception of Mn. Furthermore, PTEs concentrations in soils are in order of Fe > Mn >Zn >Cu >Pb >Co >Cr >Ni> Cd>AS.

Significant differences at P≤ 0.05 were observed in the concentrations of PTEs in soils from the six farmlands. Concentrations of PTEs in soils were greater than what was obtainable from limestone quarry site in Oluyole Local Government Area, Oyo State, Nigeria (Etim and Adie, 2012) and within the recommended values given by FAO/WHO (2011) with the exception of Fe at some locations. Reduction in the concentrations of the heavy metals with distance from quarry sites may be ascribed to the anthropogenic effects on the soils due to exhaustive blasting and abstraction of rock that releases noxious substances into the environmental as well as long time effect and excessive application of fertilizers on the soils due to agricultural activities in the area.

**Table 2: Mean concentrations of PTEs in soils from farmlands around the Quarry sites**

| PTEs ***(mg/kg)*** | ***Farmlands*** | | | | | | |
|---|---|---|---|---|---|---|---|
| | ***FLD1*** | ***FLD2*** | ***FLD3*** | ***FLD4*** | ***FLD5*** | ***CFLD ( control)*** | ***Recommended Levels (FAO/WHO, 2011, * Vecera, 1999)*** |
| **Fe** | **22156.22 ±2.56** | **19267.01±1.43** | **17200.41± 1.01** | **16681.09± 0.99** | **16100.21± 0.71** | **15614.13± 0.59** | **100-700*** |
| **Zn** | **65.10±0.90** | **55.26±0.56** | **45.08±0.38** | **38.10 ±0.29** | **37.56±0.21** | **25.10±0.16** | **300** |
| **Cu** | **56.86±0.52** | **45.21±0.33** | **32.68±0.26** | **20.05±0.19** | **18.22±0.10** | **16.01±0.05** | **100** |
| **Pb** | **5230.68±0.27** | **26.56 ±0.19** | **21.86±0.14** | **18.11±0.11** | **12.40±0.08** | **12.22±0.02** | **100** |
| **Mn** | **822.90±0.99** | **692.12±0.52** | **610.10 ±0.45** | **581.20±0.21** | **498.10±0.16** | **792.10±0.10** | **500** |
| **Co** | **30.12 ±0.18** | **24.09±0.12** | **18.16±0.11** | **15.09 ±0.09** | **12.11±0.05** | **12.06 ±0.02** | **50** |
| **Ni** | **19.10±0.05** | **17.29±0.02** | **15.81±0.01** | **14.01±0.003** | **11.01±0.002** | **7.20±0.002,** | **50** |
| **Cr** | **22.65±0.09** | **18.16 ±0.03** | **16.22±0.02** | **14.21±0.005** | **12.56±0.004** | **8.10±0.002,** | **100** |
| **Cd** | **0.45±0.03** | **0.35±0.002** | **0.31±0.001** | **0.25 ±0.02** | **0.18±0.001** | **0.15±0.001** | **3** |
| **As** | **0.31±0.01** | **0.25±0.001** | **0.21±0.001** | **0.18±0.02** | **0.16±0.001** | **0.09 ±0.001** | **20** |

Values within the same column are significantly different from each other at P≤0.05. FLD –farmland; CFLD- control farmland

***Concentrations of PTEs in crops***

Respective mean concentrations of PTEs for *Colocasia esculenta, Manihot esculenta* and *Dioscorea alata* from the six farmlands (FLD) were Fe (18.22±0.08- 81.22±1.01; 12.09 ±0.05- 73.01±0.87; 22.11±0.15- 98.22±1.11), Zn (0.99±0.02 - 21.02±0.01; 0.52±0.01 - 10.99±0.01; 2.99±0.02 - 38.12±0.04), Cu ( 2.11±0.01 - 19.10±0.04; 1.52±0.01 - 12.11±0.01; 4.09±0.01 - 32.09±0.02); Pb ( 0.56 ±0.01- 14.54±0.03; 0.21±0.01 - 8.01±0.01; 1.69±0.02 - 27.11±0.01); Mn (1.01±0.01 - 15.81±0.05; 0.43±0.03 - 8.01±0.02; 2.67±0.01 - 25.09±0.06); Co ( 0.61±0.02 - 2.99±0.02; 0.31±0.01 - 1.06±0.05; 0.76±0.02 - 3.67±0.04); Cr (0.71±0.01 - 4.51±0.01; 0.41±0.01 - 1.99±0.01; 1.11±0.01 - 6.09±0.03); Ni ( 0.25±0.02 - 3.14±0.03; 0.16±0.01 - 1.28±0.02; 0.78±0.02 - 5.11±0.01 ) and Cd (0.08±0.01 - 0.25±0.01; 0.04±0.01 - 0.16±0.02; 0.09±0.01 - 0.30±0.01) in mg/kg (Table 3). However, concentration of As was not detected in the sampled crops.

Concentrations of PTEs were considerably higher in Dioscorea *alata* than *Colocasia esculenta* and *Manihot esculenta* at P≤ 0.05. Also, HMs concentrations reduced with distances from the quarry sites. Several researchers have reported that food crops grown in contaminated soils may affect human health when taken (Okereke *et al.,* 2016; Akande and Ajayi, 2017; Peters *et al.,* 2018; Ohiagu *et al.*, 2020). Concentrations of Fe in studied food tuber crops (*Colocasia esculenta, Manihot esculenta* and *Dioscorea alata*) from farmland 1 and 2 were higher that the permissible levels recommended by FAO/WHO (2011).

Concentrations of Cu were also found higher than the recommended permissible levels in crops from farmland 1. Likewise, Pb concentrations were found higher than the permissible limits in food crops with the exception of those from FLD 5 for *Manihot esculenta* and control farmland for *Colocasia esculenta* and *Manihot esculenta.* The results indicate that the food crops have the potential to uptake some of these studied heavy metals from the soils. Generally, the significant high concentrations of heavy metals recorded in *Dioscorea alata* is attributed to its potential to bioaccumulate most of these metals in its roots. Concentrations of HMs recorded in the three crops from this study were higher than those recorded by previous researchers (Padhan *et al*, 2018, Peters *et al,* 2018; Ohiagu *et al,* 2020).

**Bioaccumulation of PTEs in Crops**

Ranged mean values of accumulation factor (AF) for PTEs in Colocasia esculenta, Manihot esculenta and Dioscorea alata from the farmlands were Fe (0.001- 0.004; 0.001- 0.003; 0.001- 0.004) , Zn (0.04 – 0.32; 0.10 – 0.17; 0.12 – 0.58), Cu (0.13 – 0.34; 0.02 – 0.21; 0.28 – 0.56), Pb ( 0.05 – 0.47; 0.02 – 0.26; 0.14 – 0.88), Mn (0.01 – 0.02; 0.001 – 0.010; 0.003 – 0.30), Co ( 0.08 – 0.10; 0.03 - 0.04; 0.06 - 0.12), Cr (0.09 - 0.20; 0.05 - 0.09; 0.14 - 0.27), Ni ( 0.03 - 0.17; 0.02 - 0.07; 0.11 - 0.28 ) and Cd (0.53 - 0.56; 0.27 - 0.36; 0.60 - 0.67) as shown in Table 4. There was significant difference in AF values at P≤ 0.05 in the six farmlands. The values of AF for heavy metals in the three crops were less than one and this can be ascribed to low potential of these crops to take up these metals to their roots from the soils.

**Health Risk Assessment of the PTEs in the crops**

The trends of calculated daily intakes (CDIs) from the three crops were Fe >Zn>Cu >Pb>Mn>Cr>Co>Ni>Cd (Table 5 and 6). The CDIs of heavy metals from the three crops are 0.001- 0.052 and 0.001 -0.060 in mg/kg/day for adults and children respectively. The results showed that crops from farmland nearer to the sites have higher values of CDIs than those that are farther. *Dioscorea alata* has highest CDIs than *Colocasia esculenta* and *Manihot esculenta* both in adults and children. The CDIs are lower than the tolerable daily intake given by WHO (1996) and USEPA (2007). Target hazard quotient (THQ) and Hazard index (HI) of PTEs in crops from the six farmlands are presented in Table 6 and 7 for adult and children respectively. Values of THQ of PTEs in the three crops from the six farmland were *Colocasia esculenta* (0.001-1.91), *Manihot esculenta* (0.001-1.70) and *Dioscorea alata* (0.001-3.01) for adult while THQ values of PTEs in children are *Colocasia esculenta* (0.001-2.03), *Manihot esculenta* (0.001-1.28) and *Dioscorea alata* (0.001- 4.05). These values were found higher in children than the adult. Also, the values were higher in Dioscorea *alata* than the other crops. Furthermore, the values were higher in crops from farmland closer to the quarry sites while the farmland used as control recorded the lower values of THQ in adults and children. The trend of THQ values for both adult and children are Pb> Mn>Cu> Cd>Ni> Co>Fe >Zn>Cr. Values of THQ of studied PTEs in the crops with the exception of Pb are less than 1 indicating no adverse health no effects. THQ of Pb greater than 1 in crops from farmland 1 and others as shown in Table 7 and 8 for adult and children indicates probable adverse health effects (Qing et al., 2015).

**Table 3: Mean concentrations of PTEs in crops from farmlands around the Quarry sites**

| Farmland | Plants | PTEs in mg/kg | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Cu | Zn | Pb | Mn | Co | Cr | Ni | Cd | As |
| FLD 1 | *Colocasia esculenta* | 81.22±1.01 | 19.10±0.04 | 21.02±0.01 | 14.54±0.03 | 15.81±0.05 | 2.99±0.02 | 4.51±0.01 | 3.14±0.03 | 0.25±0.01 | ND |
| | *Manihot esculenta* | 73.01±0.87 | 12.11±0.01 | 10.99±0.01 | 8.01±0.01 | 8.01±0.02 | 1.06±0.01 | 1.99±0.04 | 1.28±0.02 | 0.16±0.01 | ND |
| | *Dioscorea alata* | 98.22±1.11 | 32.09±0.02 | 38.12±0.04 | 27.11±0.01 | 25.09±0.06 | 3.67±0.04 | 6.09±0.03 | 5.11±0.01 | 0.30±0.01 | ND |
| FLD 2 | *Colocasia esculenta* | 78.09±0.92 | 15.05±0.01 | 15.67±0.02 | 10.89±0.01 | 12.34±0.01 | 2.25±0.02 | 2.34±0.01 | 1.89±0.05 | 0.21±0.02 | ND |
| | *Manihot esculenta* | 67.27±0.67 | 9.21±0.01 | 8.22±0.04 | 4.08±0.01 | 6.21±0.02 | 1.01±0.01 | 1.21±0.02 | 0.98±0.03 | 0.12±0.01 | ND |
| | *Dioscorea alata* | 91.68±0.95 | 25.71±0.05 | 35.03±0.03 | 18.98±0.02 | 20.11±0.04 | 2.89±0.05 | 3.67±0.01 | 3.56±0.02 | 0.28±0.01 | ND |
| FLD 3 | *Colocasia esculenta* | 42.91±0.51 | 12.08±0.02 | 12.09±0.02 | 7.67±0.01 | 8.99±0.01 | 1.67±0.01 | 1.98±0.01 | 0.78±0.02 | 0.18±0.01 | ND |
| | *Manihot esculenta* | 34.09±0.21 | 6.01±0.01 | 5.03±0.01 | 2.35±0.03 | 4.21±0.01 | 0.67±0.01 | 0.78±0.02 | 0.41±0.02 | 0.10±0.02 | ND |
| | *Dioscorea alata* | 51.21±0.65 | 21.67±0.03 | 24.56±0.05 | 12.56±0.05 | 15.78±0.02 | 1.87±0.01 | 2.81±0.02 | 2.11±0.01 | 0.23±0.01 | ND |
| FLD 4 | *Colocasia esculenta* | 30.67±0.32 | 10.06±0.04 | 6.35±0.01 | 3.29±0.02 | 5.67±0.04 | 1.21±0.02 | 1.11±0.01 | 0.39±0.02 | 0.15±0.01 | ND |
| | *Manihot esculenta* | 21.01±0.12 | 3.45±0.01 | 2.09±0.01 | 1.18±0.01 | 2.86±0.01 | 0.49±0.01 | 0.56±0.02 | 0.21±0.01 | 0.09±0.01 | ND |
| | *Dioscorea alata* | 38.11±0.28 | 18.48±0.02 | 10.11±0.02 | 7.99±0.02 | 8.11±0.01 | 1.01±0.03 | 1.99±0.01 | 1.21±0.05 | 0.19±0.01 | ND |
| FLD 5 | *Colocasia esculenta* | 23.22±0.11 | 6.09±0.01 | 2.51±0.01 | 1.21±0.01 | 3.01±0.02 | 0.68±0.02 | 0.86±0.01 | 0.31±0.02 | 0.10±0.01 | ND |
| | *Manihot esculenta* | 16.11±0.09 | 2.87±0.01 | 1.45±0.01 | 0.78±0.01 | 1.99±0.03 | 0.32±0.01 | 0.48±0.02 | 0.19±0.01 | 0.06±0.01 | ND |
| | *Dioscorea alata* | 29.99±0.15 | 10.38±0.02 | 6.79±0.02 | 4.88±0.01 | 5.21±0.01 | 0.88±0.05 | 1.21±0.01 | 0.99±0.02 | 0.14±0.01 | ND |
| CFLD | *Colocasia esculenta* | 18.22±0.08 | 2.11±0.01 | 0.99±0.01 | 0.56±0.02 | 1.01±0.01 | 0.61±0.02 | 0.71±0.01 | 0.25±0.02 | 0.08±0.01 | ND |
| | *Manihot esculenta* | 12.09±0.05 | 1.52±0.01 | 0.52±0.01 | 0.21±0.01 | 0.43±0.03 | 0.31±0.01 | 0.41±0.01 | 0.16±0.01 | 0.04±0.01 | ND |
| | *Dioscorea alata* | 22.11±0.05 | 4.09±0.01 | 2.99±0.02 | 1.69±0.02 | 2.67±0.02 | 0.76±0.04 | 1.11±0.01 | 0.78±0.01 | 0.09±0.01 | ND |
| FAO/WHO(2011) | | 46 | 10 | 60 | 2 | 200 | 50 | 1 | 10 | 1 | |

Values within the same column are significantly different from each other at $P \leq 0.05$
FLD –farmland
CFLD- control farmland
ND –Not detected

**Table 4: Mean values of accumulation factors (AF) of PTEs in the studied crops**

| Farmland | Plants | PTEs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Cu | Zn | Pb | Mn | Co | Cr | Ni | Cd |
| FLD 1 | *Colocasia esculenta* | 0.004 | 0.34 | 0.32 | 0.47 | 0.02 | 0.10 | 0.20 | 0.17 | 0.56 |
| | *Manihot esculenta* | 0.003 | 0.21 | 0.17 | 0.26 | 0.10 | 0.04 | 0.09 | 0.07 | 0.36 |
| | *Dioscorea alata* | 0.004 | 0.56 | 0.58 | 0.88 | 0.03 | 0.12 | 0.27 | 0.28 | 0.67 |
| FLD 2 | *Colocasia esculenta* | 0.004 | 0.33 | 0.28 | 0.41 | 0.02 | 0.09 | 0.13 | 0.11 | 0.60 |
| | *Manihot esculenta* | 0.003 | 0.20 | 0.15 | 0.15 | 0.01 | 0.04 | 0.07 | 0.06 | 0.34 |
| | *Dioscorea alata* | 0.005 | 0.57 | 0.61 | 0.71 | 0.03 | 0.12 | 0.20 | 0.21 | 0.80 |
| FLD 3 | *Colocasia esculenta* | 0.002 | 0.38 | 0.27 | 0.35 | 0.01 | 0.09 | 0.12 | 0.05 | 0.58 |
| | *Manihot esculenta* | 0.002 | 0.19 | 0.11 | 0.12 | 0.01 | 0.04 | 0.05 | 0.03 | 0.32 |
| | *Dioscorea alata* | 0.003 | 0.68 | 0.54 | 0.55 | 0.03 | 0.10 | 0.81 | 0.13 | 0.74 |
| FLD 4 | *Colocasia esculenta* | 0.002 | 0.50 | 0.17 | 0.18 | 0.01 | 0.08 | 0.08 | 0.03 | 0.60 |
| | *Manihot esculenta* | 0.001 | 0.17 | 0.05 | 0.07 | 0.01 | 0.03 | 0.04 | 0.02 | 0.36 |
| | *Dioscorea alata* | 0.002 | 0.95 | 0.08 | 0.44 | 0.01 | 0.07 | 0.14 | 0.09 | 0.76 |
| FLD 5 | *Colocasia esculenta* | 0.001 | 0.33 | 0.07 | 0.10 | 0.01 | 0.05 | 0.07 | 0.03 | 0.55 |
| | *Manihot esculenta* | 0.001 | 0.16 | 0.04 | 0.06 | 0.004 | 0.03 | 0.04 | 0.02 | 0.33 |
| | *Dioscorea alata* | 0.002 | 0.59 | 0.18 | 0.39 | 0.010 | 0.07 | 0.10 | 0.09 | 0.77 |
| CFLD | *Colocasia esculenta* | 0.001 | 0.13 | 0.04 | 0.05 | 0.001 | 0.08 | 0.09 | 0.03 | 0.53 |
| | *Manihot esculenta* | 0.001 | 0.09 | 0.02 | 0.02 | 0.001 | 0.03 | 0.05 | 0.02 | 0.27 |
| | *Dioscorea alata* | 0.001 | 0.28 | 0.12 | 0.14 | 0.003 | 0.06 | 0.14 | 0.11 | 0.60 |

FLD –farmland; CFLD- control farmland

**Table 5: Calculated daily intakes (CDI) of PTEs in studied crops for adults in mg/kg/day.**

| Farmland | Plants | PTEs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Cu | Zn | Pb | Mn | Co | Cr | Ni | Cd |
| FLD 1 | *Colocasia esculenta* | 0.043 | 0.009 | 0.011 | 0.008 | 0.009 | 0.003 | 0.003 | 0.002 | 0.0002 |
| | *Manihot esculenta* | 0.043 | 0.007 | 0.006 | 0.007 | 0.004 | 0.001 | 0.020 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.052 | 0.017 | 0.021 | 0.015 | 0.010 | 0.002 | 0.003 | 0.003 | 0.0002 |
| FLD 2 | *Colocasia esculenta* | 0.041 | 0.008 | 0.009 | 0.005 | 0.007 | 0.002 | 0.002 | 0.001 | 0.0001 |
| | *Manihot esculenta* | 0.036 | 0.005 | 0.005 | 0.003 | 0.003 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.048 | 0.014 | 0.019 | 0.011 | 0.011 | 0.002 | 0.003 | 0.002 | 0.0002 |
| FLD 3 | *Colocasia esculenta* | 0.022 | 0.006 | 0.006 | 0.004 | 0.005 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Manihot esculenta* | 0.018 | 0.003 | 0.003 | 0.002 | 0.003 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.027 | 0.011 | 0.014 | 0.007 | 0.009 | 0.001 | 0.002 | 0.002 | 0.0001 |
| FLD 4 | *Colocasia esculenta* | 0.016 | 0.001 | 0.004 | 0.002 | 0.004 | 0.001 | 0.001 | 0.0003 | 0.0001 |
| | *Manihot esculenta* | 0.011 | 0.003 | 0.001 | 0.007 | 0.002 | 0.003 | 0.003 | 0.0001 | 0.0001 |
| | *Dioscorea alata* | 0.024 | 0.011 | 0.005 | 0.004 | 0.004 | 0.001 | 0.001 | 0.001 | 0.0001 |
| FLD 5 | *Colocasia esculenta* | 0.012 | 0.003 | 0.002 | 0.001 | 0.001 | 0.0001 | 0.001 | 0.0002 | 0.0001 |
| | *Manihot esculenta* | 0.009 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 | 0.0001 |
| | *Dioscorea alata* | 0.016 | 0.006 | 0.004 | 0.003 | 0.003 | 0.001 | 0.001 | 0.0001 | 0.0001 |
| CFLD | *Colocasia esculenta* | 0.012 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.0002 | 0.0001 |
| | *Manihot esculenta* | 0.006 | 0.001 | 0.001 | 0.0001 | 0.0003 | 0.0002 | 0.0003 | 0.0001 | 0.0001 |
| | *Dioscorea alata* | 0.012 | 0.003 | 0.002 | 0.001 | 0.002 | 0.0004 | 0.0006 | 0.001 | 0.0001 |
| Tolerable daily intake* | | 0. 70 | 0.500 | 0.300 | 0.004 | 0.014 | 0.023 | 1.500 | 0.020 | 0.0001 |

* USEPA (2007), WHO (1996)

FLD –farmland; CFLD- control farmland

**Table 6: Calculated daily intakes (CDI) of PTEs in crops for children in mg/kg/day**

| Farmland | Plants | PTEs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Cu | Zn | Pb | Mn | Co | Cr | Ni | Cd |
| FLD 1 | *Colocasia esculenta* | 0.048 | 0.012 | 0.013 | 0.010 | 0.010 | 0.002 | 0.003 | 0.003 | 0.0002 |
| | *Manihot esculenta* | 0.044 | 0.008 | 0.007 | 0.005 | 0.005 | 0.001 | 0.002 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.060 | 0.020 | 0.023 | 0.016 | 0.015 | 0.003 | 0.005 | 0.003 | 0.0002 |
| FLD 2 | *Colocasia esculenta* | 0.048 | 0.009 | 0.010 | 0.007 | 0.008 | 0.002 | 0.002 | 0.001 | 0.0002 |
| | *Manihot esculenta* | 0.041 | 0.006 | 0.005 | 0.003 | 0.003 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.056 | 0.016 | 0.021 | 0.012 | 0.012 | 0.002 | 0.003 | 0.003 | 0.0002 |
| FLD 3 | *Colocasia esculenta* | 0.026 | 0.008 | 0.008 | 0.005 | 0.006 | 0.002 | 0.001 | 0.001 | 0.0001 |
| | *Manihot esculenta* | 0.020 | 0.003 | 0.003 | 0.002 | 0.003 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.031 | 0.001 | 0.002 | 0.008 | 0.001 | 0.001 | 0.002 | 0.002 | 0.0002 |
| FLD 4 | *Colocasia esculenta* | 0.019 | 0.005 | 0.004 | 0.003 | 0.004 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Manihot esculenta* | 0.013 | 0.003 | 0.002 | 0.006 | 0.002 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.023 | 0.012 | 0.006 | 0.005 | 0.005 | 0.001 | 0.001 | 0.001 | 0.0001 |
| FLD 5 | *Colocasia esculenta* | 0.015 | 0.003 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Manihot esculenta* | 0.010 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.019 | 0.006 | 0.005 | 0.003 | 0.003 | 0.001 | 0.001 | 0.001 | 0.0001 |
| CFLD | *Colocasia esculenta* | 0.011 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Manihot esculenta* | 0.011 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 |
| | *Dioscorea alata* | 0.014 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.0001 |
| Tolerable daily intake* | | 0. 70 | 0.040 | 0.300 | 0.0036 | 0.014 | 0.023 | 1.500 | 0.020 | 0.0001 |

* USEPA (2007), WHO (1996)
FLD –farmland; CFLD- control farmland

**Table 7: Target Hazard Index (THQ) and Hazard index (HI) of PTEs in the studied crops for adults**

| Farmland | Plants | THQ of PTEs | | | | | | | | | Hazard index (HI) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Cu | Zn | Pb | Mn | Co | Cr | Ni | Cd | |
| FLD 1 | *Colocasia esculenta* | 0.060 | 0.23 | 0.037 | 1.91 | 0.61 | 0.085 | 0.002 | 0.09 | 0.13 | 2.85 |
| | *Manihot esculenta* | 0.055 | 0.17 | 0.020 | 1.70 | 0.30 | 0.034 | 0.001 | 0.03 | 0.08 | 2.39 |
| | *Dioscorea alata* | 0.074 | 0.43 | 0.068 | 3.61 | 0.73 | 0.085 | 0.002 | 0.12 | 0.16 | 5.28 |
| FLD 2 | *Colocasia esculenta* | 0.055 | 0.19 | 0.028 | 1.28 | 0.49 | 0.085 | 0.001 | 0.04 | 0.11 | 2.28 |
| | *Manihot esculenta* | 0.043 | 0.13 | 0.017 | 0.63 | 0.24 | 0.034 | 0.001 | 0.02 | 0.06 | 1.18 |
| | *Dioscorea alata* | 0.069 | 0.34 | 0.062 | 2.55 | 0.72 | 0.085 | 0.002 | 0.09 | 0.15 | 4.07 |
| FLD 3 | *Colocasia esculenta* | 0.031 | 0.17 | 0.022 | 1.06 | 0.36 | 0.042 | 0.001 | 0.02 | 0.09 | 1.80 |
| | *Manihot esculenta* | 0.026 | 0.09 | 0.001 | 0.43 | 0.38 | 0.021 | 0.001 | 0.01 | 0.05 | 1.01 |
| | *Dioscorea alata* | 0.038 | 0.28 | 0.045 | 1.70 | 0.61 | 0.042 | 0.001 | 0.09 | 0.12 | 2.92 |
| FLD 4 | *Colocasia esculenta* | 0.023 | 0.01 | 0.011 | 0.43 | 0.24 | 0.026 | 0.001 | 0.01 | 0.08 | 0.83 |
| | *Manihot esculenta* | 0.016 | 0.06 | 0.003 | 0.21 | 0.12 | 0.013 | 0.001 | 0.01 | 0.05 | 0.48 |
| | *Dioscorea alata* | 0.029 | 0.26 | 0.002 | 1.06 | 0.30 | 0.030 | 0.001 | 0.03 | 0.10 | 1.81 |
| FLD 5 | *Colocasia esculenta* | 0.017 | 0.09 | 0.008 | 0.21 | 0.06 | 0.017 | 0.001 | 0.01 | 0.05 | 0.46 |
| | *Manihot esculenta* | 0.012 | 0.05 | 0.003 | 0.06 | 0.04 | 0.009 | 0.001 | 0.01 | 0.03 | 0.21 |
| | *Dioscorea alata* | 0.023 | 0.12 | 0.011 | 0.64 | 0.18 | 0.026 | 0.001 | 0.03 | 0.08 | 1.11 |
| CFLD | *Colocasia esculenta* | 0.014 | 0.02 | 0.003 | 0.06 | 0.04 | 0.017 | 0.001 | 0.01 | 0.04 | 0.14 |
| | *Manihot esculenta* | 0.009 | 0.02 | 0.003 | 0.02 | 0.02 | 0.018 | 0.001 | 0.01 | 0.03 | 0.13 |
| | *Dioscorea alata* | 0.017 | 0.12 | 0.003 | 0.21 | 0.12 | 0.021 | 0.001 | 0.02 | 0.05 | 0.56 |

**Table 8: Target Hazard Index (THQ) and Hazard index (HI) of PTEs in the studied crops children**

| Farmland | Plants | THQ of Heavy metals | | | | | | | | | Hazard index (HI) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fe | Cu | Zn | Pb | Mn | Co | Cr | Ni | Cd | |
| FLD 1 | *Colocasia esculenta* | 0.068 | 0.30 | 0.04 | 2.30 | 0.73 | 0.09 | 0.002 | 0.13 | 0.15 | 3.81 |
| | *Manihot esculenta* | 0.063 | 0.19 | 0.02 | 1.28 | 0.36 | 0.04 | 0.001 | 0.04 | 0.09 | 2.08 |
| | *Dioscorea alata* | 0.078 | 0.49 | 0.08 | 4.05 | 1.09 | 0.13 | 0.002 | 0.13 | 0.18 | 6.28 |
| FLD 2 | *Colocasia esculenta* | 0.069 | 0.23 | 0.03 | 1.70 | 0.54 | 0.09 | 0.001 | 0.04 | 0.13 | 2.83 |
| | *Manihot esculenta* | 0.058 | 0.15 | 0.02 | 0.64 | 0.24 | 0.04 | 0.001 | 0.03 | 0.09 | 1.30 |
| | *Dioscorea alata* | 0.076 | 0.40 | 0.07 | 2.98 | 0.85 | 0.09 | 0.002 | 0.12 | 0.17 | 4.76 |
| FLD 3 | *Colocasia esculenta* | 0.037 | 0.20 | 0.03 | 1.28 | 0.43 | 0.09 | 0.001 | 0.03 | 0.11 | 2.23 |
| | *Manihot esculenta* | 0.029 | 0.09 | 0.01 | 0.43 | 0.18 | 0.02 | 0.001 | 0.10 | 0.06 | 0.92 |
| | *Dioscorea alata* | 0.043 | 0.34 | 0.05 | 1.91 | 0.73 | 0.04 | 0.001 | 0.09 | 0.14 | 3.34 |
| FLD 4 | *Colocasia esculenta* | 0.026 | 0.15 | 0.01 | 0.64 | 0.63 | 0.03 | 0.001 | 0.02 | 0.09 | 1.60 |
| | *Manihot esculenta* | 0.018 | 0.06 | 0.01 | 0.15 | 0.12 | 0.02 | 0.001 | 0.01 | 0.05 | 0.44 |
| | *Dioscorea alata* | 0.033 | 0.30 | 0.02 | 1.28 | 0.36 | 0.02 | 0.001 | 0.04 | 0.12 | 2.08 |
| FLD 5 | *Colocasia esculenta* | 0.020 | 0.09 | 0.05 | 0.21 | 0.12 | 0.02 | 0.001 | 0.01 | 0.06 | 0.23 |
| | *Manihot esculenta* | 0.014 | 0.04 | 0.01 | 0.06 | 0.05 | 0.01 | 0.001 | 0.01 | 0.03 | 0.31 |
| | *Dioscorea alata* | 0.026 | 0.15 | 0.01 | 0.91 | 0.24 | 0.02 | 0.001 | 0.03 | 0.09 | 1.45 |
| CFLD | *Colocasia esculenta* | 0.016 | 0.04 | 0.01 | 0.09 | 0.05 | 0.02 | 0.001 | 0.01 | 0.05 | 0.29 |
| | *Manihot esculenta* | 0.015 | 0.04 | 0.01 | 0.021 | 0.06 | 0.01 | 0.001 | 0.01 | 0.03 | 0.20 |
| | *Dioscorea alata* | 0.020 | 0.09 | 0.01 | 0.43 | 0.12 | 0.02 | 0.001 | 0.03 | 0.05 | 0.77 |

Values of HI of PTEs for adult (Table 7) were *Colocasia esculenta* (0.14-2.81), *Manihot esculenta* (0.13-2.39) and *Dioscorea alata* (0.56-5.28) while HI values of PTEs in children (Table 8) are *Colocasia esculenta* (0.29-3.81), *Manihot esculenta* (0.20-2.08) and *Dioscorea alata* (0.77- 6.28). The HI values for adult were greater than 1 in the three studied crops from FLD 1, 2 and 3 while Dioscorea *alata* has HI values greater than 1 in FLD 4 and FLD 5. Also, HI values of PTEs for children were greater than 1 in the three crops from FLD 1 and 2. *Manihot esculenta* and *Dioscorea alata* have HI values greater than 1 in FLD 3and 4 while *Dioscorea alata* has HI values less than 1 in FLD 5. The HI values <1 indicates that the crops is safe for human consumption from the studied PTEs whereas HI >1 indicate that the consumption of these crops is not safe for human health (Qing et al., 2015).

Food chain has been recognised mainly as the aisle for human contact to potentially toxic elements (PTEs) from different contamination sources, mostly from soil to plant to man (Ibe *et al.,* 2017). It has also been pointed out by Peters *et al.* (2018) that Pb, Cu, Mn and Cd could be of risk to human health due to their bioaccumulation over a period of time and through continuous consumption of the crops that contain these elements.

Thus, consumption of these crops from the studied area over time may be dangerous to the health of both the adult and children than consume them.

## CONCLUSION

Assessments of potentially toxic elements (PTEs) in soils and crops from farmland soils around the quarry sites have been studied. Soils from farmland, closer to the quarry sites had higher concentrations of PTEs than those that were farther away. Accumulation factor (less than one) indicated low uptake of these elements by *Colocasia esculenta, Manihot esculenta* and *Dioscorea alata*. Daily intakes of some of the PTEs in the studied crops were higher than the tolerable permissible daily intake values for both the adult and children. Health risk index indicated that the consumption of these crops is not safe for human health. This study has shown the impact of the quarry sites on the surrounding environment, thus farming in the area should be discouraged and appropriate remedial measures such as tree planting should be adopted for sustainable environment.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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