



# **Determination of Radiation Exposure and Heavy Metals Concentration in Agricultural Research Farm Federal Polytechnic Ile-Oluji and Environs**

**G. O. Awoleye<sup>1\*</sup>, O. Olatunji<sup>2\*</sup> and O. J. Agunbiade<sup>3</sup>**

<sup>1</sup>*Department of Statistics, School of Applied Sciences, Federal Polytechnic Ile-Oluji, Nigeria.*

<sup>2</sup>*School of Geography, Geology and Environment, Keele University, United Kingdom.*

<sup>3</sup>*Department of Science Laboratory Technology, Federal Polytechnic Ile-Oluji, Nigeria.*

## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/IJECC/2021/v11i830464

### Editor(s):

(1) Dr. Fang Xiang, University of International and Business Economics, China.

### Reviewers:

(1) Sérgio Thode Filho, Federal Institute of Education, Science, and Technology of Rio de Janeiro, Brazil.

(2) Austin SOKPUWU, Ignatius Ajuru University of Education, Nigeria.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/74905>

**Original Research Article**

**Received 18 July 2021**

**Accepted 28 September 2021**

**Published 29 September 2021**

## **ABSTRACT**

Exposure level of radiation and heavy metal concentration were examined in Agricultural research farm, Federal Polytechnic Ile-Oluji and environs using a gamma scout survey meter and Atomic Absorption Spectroscopy respectively. The exposure level was determined by placing a survey meter 1 m above the soil level in each sampling point. The mean value of exposure level was  $0.5113 \mu\text{Sv hr}^{-1}$  which was higher than the recommended limit of  $0.11 \mu\text{Sv hr}^{-1}$  [1]. For the heavy metal values, there is a general increase in the concentration from Zn metal to Pb in the order Zn>Fe>Cu>Cr>Cd>As>Pb. The highest concentration of heavy metals was recorded for Zn while Pb metal has the lowest heavy metal concentration for the soil samples. In the plant samples however, the trend of heavy metals is as Cu>Zn>Fe>Cr>Cd>As>Pb. The highest concentration of the metals is recorded for Cu metal while Pb has the lowest value. Concentrations of Cd, Cr, Zn and Fe were all above permissible levels in plant materials while only Pb and As have lower values than the safety limit. The transfer factor from soil to plant is greater than 0.5 in some of the areas indicating a high risk through the food chain to man. Similarly, most of the metals have transfer factors greater than 0.2 which is also an indication of contamination of the Cassava plant in the study area.

\*Corresponding author: E-mail: [gabawoleye@fedpolel.edu.ng](mailto:gabawoleye@fedpolel.edu.ng), [o.olatunji@keele.ac.uk](mailto:o.olatunji@keele.ac.uk);

**Keywords:** Exposure level; heavy metals; concentration; transfer factor.

## 1. INTRODUCTION

The earth is radioactive due to natural sources and activities of man in the environment. There is a Continuous bombardment of man and his environment by these (radionuclide) ionizing radiations [2]. Human beings have always been exposed to natural background radiation. The natural background radiation has two components: one originating from extra-terrestrial sources such as cosmic rays and the other from terrestrial sources which derive essentially from the Earth's strata. However, there are certain locations in the world where external exposure from natural sources may substantially exceed the normal variability range. Some of our technological endeavors like burning of coal for electrical power generation, reduction and use of phosphate fertilizer, operation of nuclearpower reactors and application of radioisotopes in medicine, agriculture and industry mayalso contribute to the radiation level of the environment. It is therefore expedient to know that soil, which nourishes the terrestrial ecosystem, plays a major role in the human food chain and thus in causing radiation exposure.

Trace element or heavy metal concentration in different environmental media especially in soil is increasingly becoming an issues of global concern. Agricultural soil contamination with heavy metals through the repeated use of untreated or poorly treated waste water and application of chemical fertilizer and pesticides are most of the severe ecological problem in

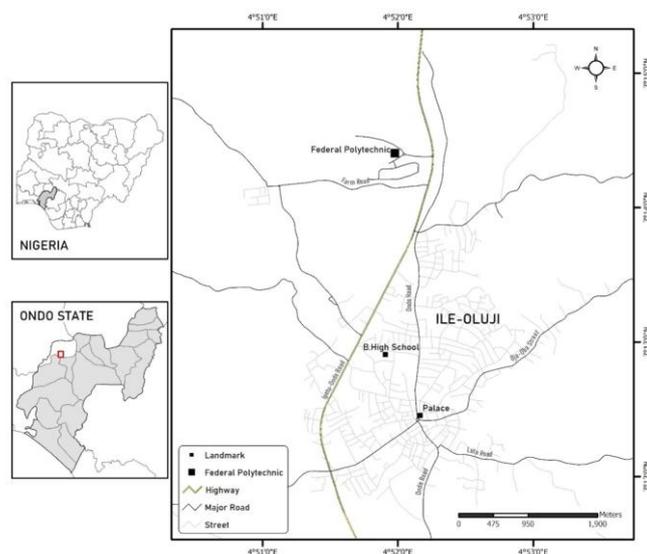
Nigeria [3]. Heavy metals are dangerous because they tend to bio accumulate. They can enter the groundwater through industrial and consumer wastes, landfills or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes and rivers [4,5,6].

Hence, the issue of environmental degradation and pollution in the 21st century is of global concern, because of its health impact and implications. The quest for agriculture development and in the Southwestern States of Nigeria had led to various forms of activities that tend to perturb the fragile ecological, biophysical systems and the socio-economic structures of the area, It is therefore important to assess the level of trace element and radioactivity content with Its radiological health impact through transfer mechanism in agricultural research farm, Federal Polytechnic Ile-Oluji.

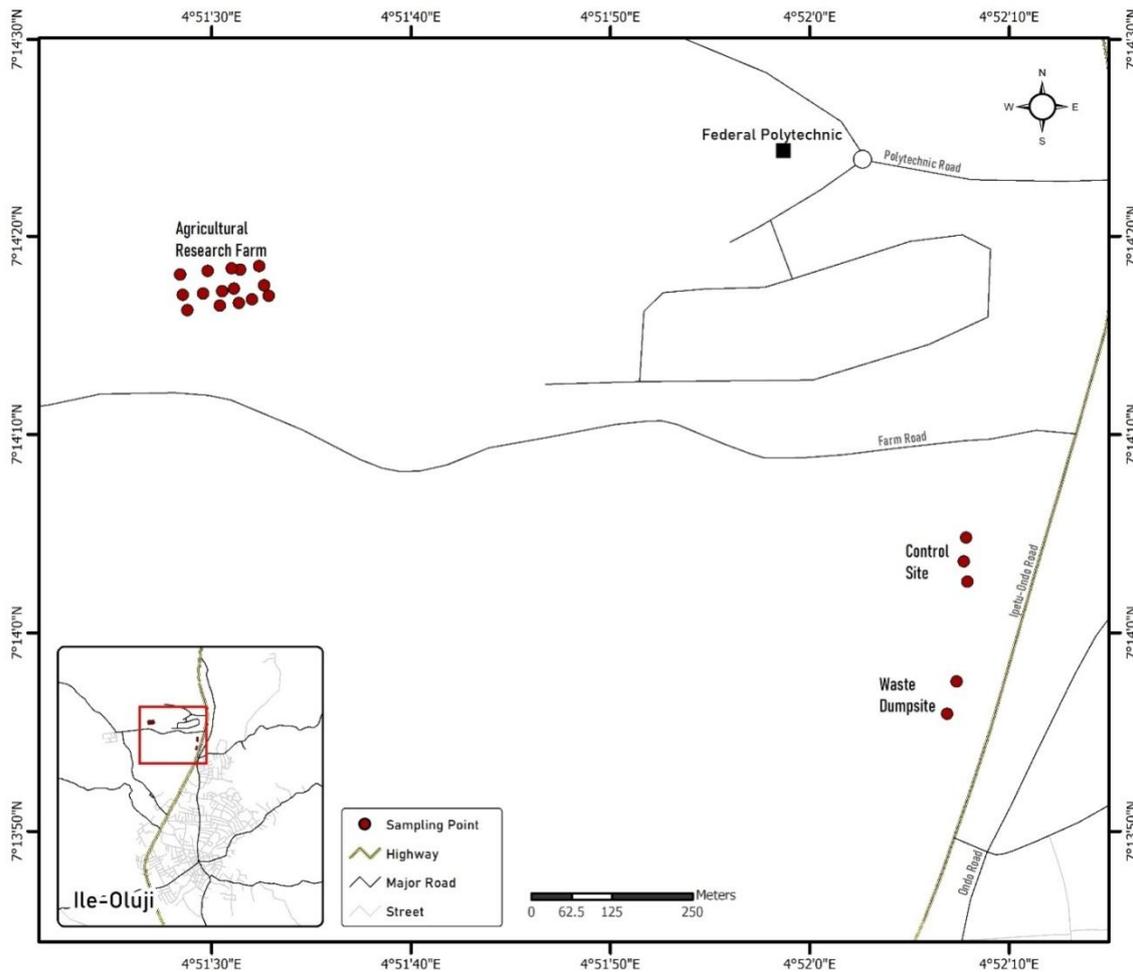
## 2. MATERIALS AND METHODS

### 2.1 Study Area

Ile-Oluji is the headquarter of Ile-Oluji/Okeigbo Local Government, Ondo State, Nigeria and lies between Longitudes 6°40' N and 7°14' N, and Latitudes 4°38' E and 4°53' E. It has an area of 698 km<sup>2</sup> and a population of 172,870 as at the 2006 census. Federal Polytechnic is located within the axis of Ipejuljesha express way, which lies within 7°14'0"N - 7°14'50"N and 4°51'0"E - 4°52'10"E covering a land area of 1.53 km<sup>2</sup>.



**Fig. 1. Map of Ile-Oluji, Ondo State where federal polytechnic is located**



**Fig. 2. Agricultural research farm where samples are collected**

### 3. METHODOLOGY

For the exposure level, an in-situ approach of measurement was preferred and adopted, this was to enable samples maintain their original characteristics. The Gamma-Scout survey meter is a health and safety instrument that measures alpha, beta, gamma and x-ray. Measurements were carried out with Gamma-Scout radiation detector with Serial Number: 038439 as a dose meter (cumulative radiation), It was placed 1 m above the soil level point for about five minutes, an average measurement was recorded for exposure rate (radiation dose level). On the other hand for the trace elements and heavy metals, a total of 20 samples of soil and Cassava plant were collected in an undisturbed area in the vicinity of site. Hand trowel was used to collect the soil and packed into a polytene bag labelled appropriately. Soil samples were oven dried in 105°C sieved and weight.

All chemicals used are of analytical grade. 5ml concentrated HF and 20ml HNO<sub>3</sub> were carefully added to the seized soil. The beaker was gently shaken to allow the sample dissolve in the acid mixture and then heated in the fume hood until the sample was digested. After about an hour, heating was removed and the beaker allowed to cool, this was filtered and the filtrate made up to mark in a 25ml std flask, on the other hand, plant dried and seized were weighed into a Teflon beaker. 20ml of freshly prepared aqua-regia (HCl : HNO<sub>3</sub> (3:1)) was added, this were then each heated to near dryness, heating was removed and allowed to cool, 20ml distilled water was then added and heated again for about 3-5 minutes, this was then allowed to cool and filtered, the filtrate was also made up to mark in a 25ml flask. All the digested samples were refrigerated pending metal determination by Atomic Absorption Spectrophotometer (AAS).

## 4. RESULTS AND DISCUSSION

**Table 1. Radiation exposure level measurement in study area using gamma scout**

Sampling Point	GPS description Latitude	Longitude	Exposure Level $\mu\text{sv}/\text{Hr}$
P1	N07°14.283'	E004°51.548'	0.500
P2	N07°14.280'	E004°51.534'	0.468
P3	N07°14.277'	E004°51.523'	0.562
P4	N07°14.275'	E004°51.507'	0.625
P5	N07°14.271'	E004°51.480'	0.375
P6	N07°14.284'	E004°51.476'	0.250
P7	N07°14.285'	E004°51.493'	0.312
P8	N07°14.287'	E004°51.509'	0.437
P9	N07°14.289'	E004°51.591'	0.625
P10	N07°14.292'	E004°51.544'	0.656
P11	N07°14.308'	E004°51.540'	0.375
P12	N07°14.305'	E004°51.524'	0.406
P13	N07°14.306'	E004°51.517'	0.562
P14	N07°14.304'	E004°51.497'	0.375
P15	N07°14.301'	E004°51.474'	0.312
P16	N07°14.080'	E004°52.131'	0.562
P17	N07°14.060'	E004°52.129'	0.812
P18	N07°14.043'	E004°52.132'	0.625
P19	N07°13.932'	E004°52.115'	0.825
P20	N07°13.959'	E004°52.123'	0.562
		Mean value	0.5113

**Table 2. % Recovery of metals from spiked water samples**

Metals	Zn	Cd	Cr	Cu	Pb	Mn	As
% Recovery	89.8	88.4	91.3	96.4	85.1	90.6	77.9

The results of the in-situ survey are presented in Tables 1 for the exposure level of radiation in the Agricultural research farm and its environs. The exposure level ranging between 0.25 to 0.83  $\mu\text{Sv hr}^{-1}$  with an average of 0.511  $\mu\text{Sv hr}^{-1}$  in the study area. It is easily noticed that the average values of the exposure rate in study area (Agricultural Research farm and its environs) are higher than recommended limit of 0.11  $\mu\text{Sv hr}^{-1}$  [1]. The overall average results obtained in the sampling site were lower when compared with the obtained value elsewhere like China and India that has an exposure level of 30  $\mu\text{Sv hr}^{-1}$  [1]. Though the high level of exposure rate in the study area could have been associated with the combination value of all the environmental media which include soil, plants and the air. It was discovered that the sampling site is about 500 m to an open dumping site which burning of wastes are done regularly. Another fact to note is cosmic radiation exposure contribute to a quarter of total background radiation exposure in an environment. Therefore the value estimated for the exposure level in the sampling site could

have been contribution of both the anthropogenic and natural exposure to radiation.

The results of the spiking experiment shows the percentage recoveries of metals (Table 2) ranged from 77.9% for As to 96.4% for Cu. These recoveries are observed to be within reasonable range. This confirms the quality of the analytical procedure employed for the study.

### 4.1 Heavy Metals in Soil Samples

The levels of heavy metals analyzed in soils samples collected from the Agriculture research Farm are as represented in Table 2. A total of seven heavy metals were analysed in the collected soil samples. Observably, there is a general increase in the concentration from Zn metal to Pb in the order Zn>Fe>Cu>Cr>Cd>As>Pb. The highest concentration of heavy metals was recorded for Zn (Fig 3) while Pb metal has the lowest heavy metal concentration. In the plant samples however (Table 4), the trend of heavy metals is

as Cu>Zn>Fe>Cr>Cd>As>Pb. The highest concentration of the metals is recorded for Cu metal while Pb has the lowest value (Fig 4). Cu is an essential element that is needed in soils for well-being and normal growth of plants. Its presence in soils has been known to have a positive effect on farm yield, hence, its use as fertilizer and management of farm diseases. A Copper-deficient soil affects the metabolic processes of photosynthesis and respiration of plants such as rice, it often results in poor growth, delayed flowering and sterility and is only corrected by adding fertilizers enriched with Cu and incorporating them into the soils. The concentration of Cu metal in the studied Farm soils ranged from  $14.40 \pm 0.0006$  mg/kg -  $9.60 \pm 0.0008$  mg/kg. In all the samples studied, these concentrations are well higher than the recommended range of 0.6 – 6.0mg/kg safe limit by the Food and Agricultural Organization and World Health Organisation codex Standards for contaminant and Toxins in foods [7]. The high concentration recorded might be due to regular incorporation of Cu-enriched fertilizers into the farm soils, not necessarily because the soil is deficient of the metal but also to manage some farm diseases. Of all Cassava plant samples

collected from the soil, only one (1), sample point 17 recorded a higher concentration ( $4.150 \pm 0.0009$ mg/l) of Cu metal than the recommended 4.0mg/kg as safe for the metal in plant materials [7]. Though Cu is an essential heavy metal needed by plants animals and even microorganisms for various metabolic processes, high concentration of the metal is undesirable as it becomes toxic to humans as a result of its high affinity for metals in certain groups that causes diseases like epilepsy and melanoma [8].

Chromium (Cr) is another micronutrient required by soils for germination, growth, yield, and several physiological processes. The United States Environmental protection Agency [9] has recommended a safe limit of 11.00mg/kg for the metal in soils for farming. This limit is clearly higher than the levels of the metal recorded in all studied samples. Cr concentration ranged from  $2.40 \pm 0.0009$  mg/kg in sample point 13 to  $3.20 \pm 0.0006$  mg/kg in sample point 6 and 18. Cr metal may enter the soil through weathering of Chromium –containing rocks, as impurities from usage of farm chemicals as well as other anthropogenic sources such as direct discharge [10].

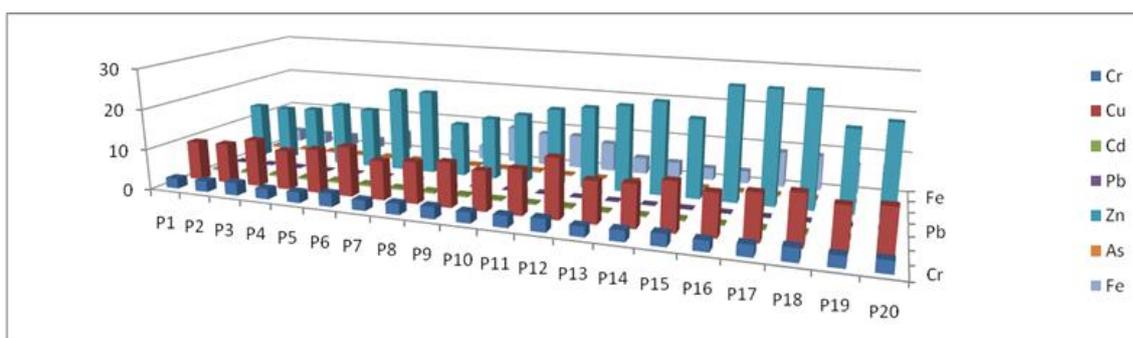


Fig. 3. Variation of heavy metals in soil samples from the farm area

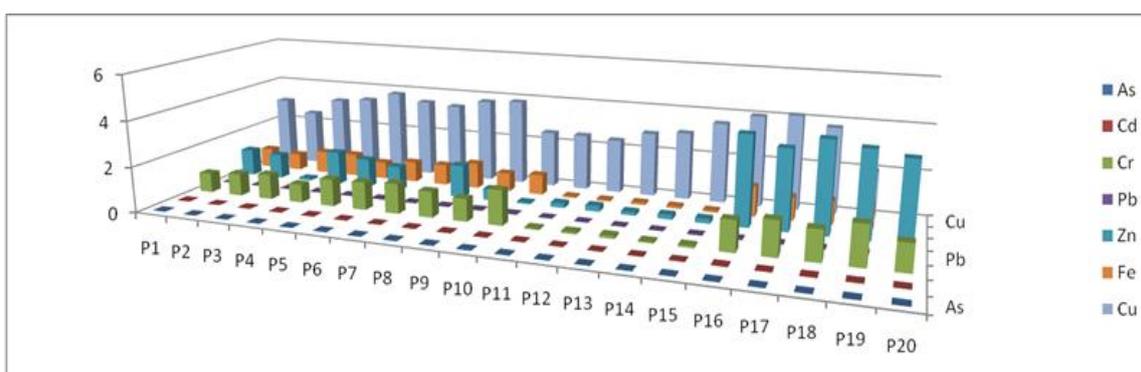


Fig. 4. Variation of heavy metals in plant (cassava) samples from the farm area

Cr metal, amongst others such as Pb, Co, Cd, As, Cu, Mo, Ni, Zn, Hg, Se and V, is implicated by the United States Environmental protection Agency and the Weinberg Group, in a report by the Fertilizer Institute as a contaminant found in Agricultural Fertilizers [11]. All fears relating to high level of this metal in soil for agricultural purpose is however allayed as all soil samples collected from the Agricultural research Farm contained Cr lower than recommended limits. Cr in its hexavalent state is very mobile and moves freely through the soil where it may be absorbed by plant for onward consumption by man and animal [12,13] In the cassava plant studied in the farm area, Cr metal ranged from  $0.060 \pm 0.0001$  mg/kg in sample point 11 and 14 to  $1.710 \pm 0.0006$  mg/kg in point 19. The highest value recorded is higher than the 1.30mg/kg safe limit [7]. Apart from having a negative effect on plant growth, high concentration of the metal can alter the germination process and affects the growth of parts of the plant. The toxicity of Cr is dependent on the oxidation state in the environment. While Cr (III) is less mobile and less toxic, Cr (VI) is highly mobile and highly soluble with its high oxidation states and is considered the most toxic [14]. More studies will have to be done in the study area to ascertain the specie of the Cr in both the soil and plant sample.

Concentration of Cd metal in soils from the farm ranged from  $0.240 \pm 0.0007$  mg/kg in sample points 13 and 20 to  $0.57 \pm 0.0007$  mg/kg in sample point 3. Almost 30% of the samples collected contained concentrations of Cd equal to or higher than the recommended 0.48mg/kg safe limit by the United States Environmental Protection Agency [11]. This might not be unconnected to usage of farm chemicals such as fertilizers, herbicides as well as anthropogenic sources. High concentration of Cd metal in soils particularly has harmful effects on biological activity of soil and also negatively impairs plant metabolism [15]. In humans, Cd is a known Carcinogen, it also causes other important health conditions such ascardiovascular, neurological, renal and reproductive [16]. In all the cassava plant collected for the study, samples collected from points 3 ( $0.020 \pm 0.0010$ mg/kg), 16  $0.024 \pm 0.0007$  mg/kg), 17 ( $0.022 \pm 0.0008$  mg/kg), 18 ( $0.029 \pm 0.0012$  mg/kg) and 19 ( $0.022 \pm 0.0011$  mg/kg) respectively, has values greater than or equal to safe limit of 0.02 mg/kg recommended for Cd metal in plant material as revealed by the (WHO, 2006). This high concentration in some of the sampling points is undesirable as cassava is

used in the production of cassava flower which is a common food in the area and Nigeria as a whole. This high concentration will aid in accumulation of the metal in man and animals in the area.

Pb is another non-essential heavy metal whose presence in soils is of no particular advantage, one of the most important heavy metal contaminants in soils [17]. In soils, it is highly stable and toxic to human, plants and animals [18]. Important sources of Pb in soils for farming are atmospheric deposition from industrial emissions; sewage sludge as well as livestock manures [19]. Farm soils could also be contaminated with Pb through mine tailings, application of fertilizers as well as usage of pesticides and herbicides in farming. Concentration of Pb metal in the studied soil samples ranged from  $0.05 \pm 0.0003$  mg/kg in sample points 8, 9, 12 and 14 to  $0.15 \pm 0.0006$  mg/kg in sample point 6. These values are clearly below the safe range of (1.0 – 7.0) mg/kg limit for the metal in soil for farming by the Food and Agricultural Organization and World Health Organization codex Standards for contaminant and Toxins in foods [7]. This is an indication of proper management and assessment of farm chemicals and waste waters used for irrigation in the Agricultural research Farm [20,21] In the studied plant samples collected from the farm area (Table 3), similarly, the concentration of Pb metal recorded in the plant sample from the grown on the soil in the studied area is also observably lower than the safe limit [7]. The highest concentration of  $0.020 \pm 0.0004$  mg/kg recorded in plant sample from point 13 is much lower than the 0.03mg/kg safe limit of the metal in plant materials. This also agrees well with the reason for the low amount of the metal in respective soil samples and removes the fear of hazards in humans from consumption of the non-essential heavy metal.

A critical study of table 3 shows Arsenic contamination of Farm soils in the Agricultural research Farm, area in four sampling points 1, 8, 10 and 19 with concentration values  $0.51 \pm 0.0002$  mg/kg,  $0.42 \pm 0.0003$  mg/kg,  $0.51 \pm 0.0003$  mg/kg and  $0.42 \pm 0.0003$  mg/kg respectively. These recorded values are higher than the recommended 0.39mg/kg limit for the metal in soils for farming (FAO/WHO, 1996). This high value of As metal may enter the soil through burning and incineration of As-containing metals. The lower values in other sample points however, is an indication that the metal is not

evenly, distributed in all the farm area, the affected sampling points might be closer and more exposed to anthropogenic routes for the metal on the soil. Danger of As contamination is particularly heightened by the fact that the metal cannot be destroyed, it changes form through reaction with oxygen or other molecules. In the soil, it is acted upon by soil bacteria. Generally, in plant materials, As metal is non-essential for growth, nevertheless, it bio accumulates and becomes toxic to man and animals above certain trace level. The values recorded for the concentration of the metal in cassava plant studied ranged from  $0.001 \pm 0.0001$  mg/kg in sample points 11 and 14 to  $0.010 \pm 0.0002$  mg/kg and  $0.010 \pm 0.0003$  mg/kg in sample points 1 and 8 respectively. These values are all lower than the recommended 0.10mg/kg for the metal by the Food and Agricultural Organizations [7].

Zn is one heavy metal that is required by plant, animal, humans and even aquatic organisms in various amounts for different metabolic processes. In plants, the formation of Chlorophyll, some carbohydrates are made possible by Zinc. It also helps in concerting starches to sugar helping plants to grow during cold conditions. In soils, the metal is a major micronutrient required for soil enrichment needed for plant growth. Through anthropogenic action it is added to soil through discharges from smelter, wastes, and tailings from mining operations [22]. Extensive application of farm chemicals including fertilizers is also a major source of Zn in the soil. In the studied farm area, concentration of Zn metal in the soil samples collected are all below the 50mg/kg limit by the Food and Agricultural Organization/World Health Organization (FAO/WHO 2013) codex general standards for contaminants and toxins in foods (FAO/WHO, 2013). It ranged from  $13.300 \pm 0.0004$  mg/kg in point 8 to  $28.100 \pm 0.0003$  mg/kg in point 18. The low values recorded does not necessarily indicate absence of contamination sources but might rather be due to the immobility of the metal in soil as plant roots have to grow to meet the metal in the depth of the soil. However, in the cassava plant collected for the study, more than 50% has their concentrations higher than the 0.6 mg/kg safe limit [7]. The highest value was recorded in sample collected from point 18 with  $4.000 \pm 0.0008$  mg/kg while point 10 has the lowest value recorded with  $0.065 \pm 0.0010$  mg/kg. Though Zn is needed for plant development, it is required in small amount and high values results in growth inhibition and a reduction in biomass production. High zinc content in food samples is

not recommended for pregnant and breast feeding women.

In the soil, Fe plays an important role in plant development through adequate soil micronutrient enrichment. It helps in metabolic processes such as respiration and photosynthesis and also helps the plant in chlorophyll production. Concentration of Fe recorded in all the soil samples collected was much lower than the recommended limit of 15.00 mg/kg [7]. The highest value recorded was  $9.300 \pm 0.0008$  mg/kg in sample point 9 while sample point 4 presented the lowest Fe level in the soil samples with  $2.500 \pm 0.0007$  mg/kg. In the plant (Cassava) sample however, the lowest concentration recorded was  $0.050 \pm 0.0002$  mg/kg in sample point 11 and apart from samples collected in points 12, 13, 14 and 15, all other sample points recorded higher values of the essential metal than the 0.3 mg/kg safe limit for the metal in plant samples. The high concentration of the metal recorded is undesirable as it may have a toxic effect on the plant that may results into weakening of the plant. These high values recorded in the plant samples is an indication of bioaccumulation of the metal and may be as a result of a low pH in the soil. Since the Fe is absorbed from the soil and increase in soil pH becomes necessary through the application of K, P and Mg fertilizers as well as lime addition in order to increase the pH of the soil.

#### 4.2 Soil-plant Transfer Factor

The transfer factor from soil to plant (enrichment factor) is used in assessing the importance of the impact of heavy metals in soils. It reveals the extent of contamination of the soil by comparing levels of heavy metals in studied samples with a reference material. It is also an important way of determining the contribution of anthropogenic sources to the heavy metal level of the soil [23,24]. The coefficient depends on the properties of both the soil and plant. The coefficient is calculated as a ratio of heavy metal in plant to total heavy metal in soil [25] and is calculated as the ratio of concentration of heavy metals in plant to that of the soil;

$S-P Tf = \text{Conc of heavy metals in plant} / \text{Concn of heavy metals in soil}$

The Plant transfer factor is used to measure the exposure of humans to hazardous metals through the food chain. When the factor is high, it's an indication of high translocation in plants

**Table 3. Concentration (mg/kg) of heavy metals in soil**

Soil/Metal	Cr	Cu	Cd	Pb	Zn	As	Fe
P1	2.50 ± 0.0005	9.70 ± 0.0005	0.45 ± 0.0010	0.10 ± 0.0003	13.800± 0.0004	0.51±0.0002	3.100±0.0008
P2	2.70 ± 0.0002	9.90 ± 0.0010	0.48 ± 0.0005	0.10 ± 0.0010	13.700± 0.0004	0.24±0.0003	2.800±0.0008
P3	3.10 ± 0.0008	11.60 ± 0.0006	0.57 ± 0.0007	0.125 ± 0.0004	14.100± 0.0002	0.36±0.0004	3.000±0.0003
P4	2.50 ± 0.0006	9.70 ± 0.0007	0.48 ± 0.0009	0.075 ± 0.0006	15.900± 0.0009	0.30±0.0004	2.500±0.0007
P5	2.60 ± 0.0002	10.80 ± 0.0006	0.54 ± 0.0008	0.10 ± 0.0009	15.200± 0.0005	0.27±0.0002	5.100±0.0009
P6	3.20 ± 0.0006	12.20 ± 0.0007	0.54 ± 0.0010	0.15 ± 0.0006	21.000± 0.0005	0.24±0.0002	5.000±0.0009
P7	2.50 ± 0.0003	9.60 ± 0.0008	0.42 ± 0.0004	0.075 ± 0.0007	21.100± 0.0011	0.30±0.0002	4.100±0.0010
P8	2.70 ± 0.0006	10.10 ± 0.0007	0.48 ± 0.0007	0.05 ± 0.0008	13.300± 0.0004	0.42±0.0003	3.500±0.0005
P9	2.90 ± 0.0002	10.90 ± 0.0006	0.45 ± 0.0009	0.05 ± 0.0003	15.500± 0.0004	0.36±0.0002	9.300±0.0008
P10	2.60 ± 0.0004	9.70 ± 0.0005	0.30 ± 0.0009	0.075 ± 0.0004	17.100± 0.0008	0.51±0.0003	8.400±0.0008
P11	2.80 ± 0.0004	11.00 ± 0.0008	0.27 ± 0.0006	0.10 ± 0.0006	19.200± 0.0009	0.24±0.0001	8.500±0.0011
P12	3.10 ± 0.0008	14.40 ± 0.0006	0.39 ± 0.0007	0.05 ± 0.0001	20.300± 0.0002	0.21±0.0001	7.200±0.0011
P13	2.40 ± 0.0009	10.00 ± 0.0005	0.24 ± 0.0008	0.075 ± 0.0004	21.400± 0.0009	0.30±0.0002	4.100±0.0009
P14	2.60 ± 0.0004	10.20 ± 0.0011	0.27 ± 0.0008	0.05 ± 0.0008	23.000± 0.0004	0.33±0.0002	3.700±0.0006
P15	2.90 ± 0.0005	11.70 ± 0.0010	0.39 ± 0.0009	0.075 ± 0.0003	19.500± 0.0003	0.27±0.0003	3.000±0.0007
P16	2.50 ± 0.0003	10.10 ± 0.0010	0.30 ± 0.0007	0.075 ± 0.0001	27.900± 0.0003	0.27±0.0002	3.100±0.0007
P17	2.70 ± 0.0002	11.00 ± 0.0006	0.36 ± 0.0007	0.10 ± 0.0005	27.800± 0.0006	0.36±0.0002	8.800±0.0010
P18	3.20 ± 0.0007	11.90 ± 0.0008	0.48 ± 0.0009	0.10 ± 0.0005	28.100± 0.0003	0.33±0.0002	8.600±0.0005
P19	2.60 ± 0.0007	10.20 ± 0.0006	0.27 ± 0.0006	0.125 ± 0.0006	20.000± 0.0003	0.42±0.0003	7.100±0.0009
P20	2.80 ± 0.0002	10.90 ± 0.0008	0.24 ± 0.0007	0.10 ± 0.0003	22.100± 0.0003	0.30±0.0003	7.000±0.0008
MAL	*11.00	**0.6 – 6.0	*0.48	**1.00-7.00	**50.00	**0.39.00	***15.00

\* US EPA, 2002, \*\*FAO/WHO codex general standards for contaminants and toxins in foods (1996), \*\*\* WHO, 2000

**Table 4. Concentration (mg/kg) of heavy metals in plant samples**

Plant/Metal	As	Cd	Cr	Pb	Zn	Fe	Cu
P1	0.010± 0.0002	0.013± 0.0012	0.870±0.0005	0.010±0.0002	1.200±0.0016	0.880±0.0015	3.050±0.0006
P2	0.003 ± 0.0002	0.012 ± 0.0011	0.990± .0006	0.011±0.0002	1.100±0.0011	0.750±0.0015	2.500±0.0006
P3	0.008 ± 0.0002	0.020 ± 0.0010	1.110± .0007	0.009±0.0003	0.095±0.0017	1.000±0.0013	3.250±0.0007
P4	0.004 ± 0.0001	0.017 ± 0.0013	0.810±0.0007	0.017±0.0003	1.500±0.0020	1.010±0.0020	3.400±0.0008
P5	0.003 ± 0.0002	0.019 ± 0.0017	1.200± .0007	0.017±0.0004	1.300±0.0015	0.760±0.0022	3.800±0.0011
P6	0.004 ± 0.0002	0.013± 0.0009	1.230±0.0004	0.019±0.0005	1.100±0.0014	0.920±0.0018	3.500±0.0012
P7	0.006 ± 0.0002	0.010 ± 0.0009	1.320±0.0004	0.013±0.0006	0.095±0.0017	0.930±0.0015	3.400±0.0008
P8	0.010 ± 0.0003	0.014 ± 0.0013	1.140±0.0009	0.016±0.0002	1.450±0.0012	1.150±0.0018	3.750±0.0008
P9	0.008 ± 0.0001	0.018 ± 0.0013	0.990± .0008	0.019±0.0002	0.500±0.0013	0.830±0.0012	3.850±0.0009
P10	0.006 ± 0.0002	0.014 ± 0.0016	1.530±0.0008	0.010±0.0003	0.065±0.0010	0.900±0.0010	2.500±0.0006
P11	0.001 ± 0.0001	0.004 ± 0.0003	0.060±0.0001	0.003±0.0004	0.200±0.0003	0.050±0.0002	2.500±0.0006
P12	0.002 ± 0.0001	0.003 ± 0.0002	0.090±0.0002	0.004±0.0005	0.250±0.0003	0.060±0.0003	2.400±0.0003
P13	0.002 ± 0.0001	0.003 ± 0.0002	0.120±0.0002	0.002±0.0003	0.150±0.0002	0.100±0.0003	2.850±0.0006
P14	0.001 ± 0.0001	0.005 ± 0.0003	0.060±0.0001	0.002±0.0003	0.200±0.0004	0.100±0.0002	3.000±0.0007
P15	0.003 ± 0.0001	0.005 ± 0.0003	0.090±0.0001	0.003±0.0004	0.200±0.0005	0.080±0.0004	3.550±0.0007
P16	0.005 ± 0.0001	0.024 ± 0.0007	1.320±0.0005	0.020±0.0004	3.950± .0010	1.320±0.0019	4.000±0.0010
P17	0.006 ± 0.0002	0.022 ± 0.0008	1.500± 0.0007	0.022±0.0005	3.500±0.0010	1.030±0.0016	4.150±0.0009
P18	0.004 ± 0.0001	0.029 ± 0.0012	1.320± 0.0007	0.021±0.0003	4.000±0.0008	1.040±0.0015	3.750±0.0008
P19	0.007 ± 0.0002	0.022 ± 0.0011	1.710± 0.0006	0.018±0.0002	3.750±0.0009	1.000±0.0020	2.000±0.0005
P20	0.004 ± 0.0001	0.019 ± 0.0007	1.170± 0.0008	0.011±0.0003	3.500±0.0010	1.130±0.0022	2.050±0.0003
MAL	0.10*	***0.02	**1.50	0.03*	0.60***	****0.30	4.0*

\*FAO/WHO, 1993; FAO/WHO, 2013, \*\*WHO, 1998, \*\*\*Nworu et al, 2018

**Table 5. Transfer factor for heavy metals in studied soil samples**

	<b>Cr</b>	<b>Cu</b>	<b>Cd</b>	<b>Pb</b>	<b>Zn</b>	<b>As</b>	<b>Fe</b>
P1	0.348	0.314	0.028	0.1	0.086	0.019	0.283
P2	0.366	0.252	0.025	0.11	0.08	0.012	0.267
P3	0.358	0.28	0.035	0.072	0.006	0.022	0.333
P4	0.324	0.35	0.035	0.226	0.094	0.013	0.404
P5	0.461	0.351	0.035	0.17	0.085	0.011	0.149
P6	0.384	0.286	0.024	0.126	0.052	0.016	0.184
P7	0.528	0.354	0.023	0.173	0.004	0.02	0.226
P8	0.422	0.371	0.029	0.32	0.109	0.023	0.328
P9	0.341	0.353	0.04	0.38	0.032	0.022	0.089
P10	0.588	0.257	0.046	0.133	0.003	0.011	0.107
P11	0.021	0.227	0.014	0.03	0.01	0.004	0.005
P12	0.029	0.166	0.007	0.08	0.012	0.009	0.008
P13	0.05	0.285	0.012	0.026	0.007	0.006	0.024
P14	0.023	0.294	0.018	0.04	0.008	0.003	0.027
P15	0.031	0.303	0.012	0.04	0.01	0.011	0.026
P16	0.528	0.396	0.08	0.266	0.141	0.018	0.425
P17	0.555	0.377	0.061	0.22	0.125	0.016	0.117
P18	0.412	0.315	0.06	0.21	0.142	0.012	0.121
P19	0.657	0.196	0.081	0.144	0.185	0.016	0.14
P20	0.417	0.188	0.079	0.11	0.158	0.013	0.161

and that the metal is poorly retained by the soil. Table 3 reveals the calculated PTF of the heavy metals for the studied area. The TF values ranged from Cr (0.05 – 0.657), Cu (0.166-0.396), Cd (0.004-0.081), Pb (0.030-0.266), Zn (0.004-0.185), As (0.003-0.023) and Fe (0.005- 0.425). A transfer factor of 0.1 shows the metals in the plant tissues are being excluded while a factor of greater than (>0.2) indicates contamination of the plant by the metals [26]. If the transfer factor is greater than 0.5, the plant have a greater anthropogenic contamination by heavy metals [27]. In the Agricultural research farm studied area, even though the concentrations of Cr metal in the soil studied are below recommended safety limits, the transfer factor from soil to plant is greater than 0.5 in some of the areas indicating a high risk through the food chain to man. Similarly, most of the metals have transfer factors greater than 0.2 which is also an indication of contamination of the Cassava plant in the area.

## 5. CONCLUSION AND RECOMMENDATION

Summarily, the results (Tables 3, 4) revealed that the concentrations of heavy metals in soil samples collected in the Federal Polytechnic Agricultural research studied area contains elevated levels of Cu, As and non-essential Cd while Cr, Pb, Zn and Fe occurs below safety levels. In the plant sample collected for analysis,

grown on soils in the area, concentrations of Cd, Cr, Zn and Fe were all above permissible levels in plant materials while only Pb and As have lower values than the safety limit. Regrettably, while the concentration of Zn was low in the soil, its values found in Cassava plant grown on the soil clearly exceeded the limit; this is an indication of hyper accumulation of the metal by the plant. Similarly, non-essential Cd also recorded the same high values in both the soil and plant showing contamination of the farm land from anthropogenic sources. Generally, the high levels of other heavy metals (Cr, Fe, As) in both the soil and plant is also a pointer to the fact that overuse of farm chemicals as well as contamination from other sources is high and needs to be discouraged. This much is well supported by the calculations of the soil-plant transfer factor. The values obtained clearly indicted the plant grown on the soil in the farm area in the transfer of these harmful heavy metals to man through the food chain bearing in mind that these metals are bio accumulated in man and other organisms.

However, since the dangers exhibited by these metals depends on their form in the environment due to their different oxidation states [3], a knowledge of the specie of the metals present in the Cassava plant as well as the soil in the farm area might be important to be able to further clarify their transfer from the soil to plant and hence, the level of their hazard, therefore, a

speciation study of the soils and plant is recommended.

## ACKNOWLEDGEMENTS

The authors express their thanks to the Tertiary Education Trust Fund (TETFUND) Institution Based Research for the keen interest sponsoring the research project. As this research work is sponsored by the Tertiary Education Trust Fund (TETFUND) Institution Based Research (IBR).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. International Atomic Energy Agency. Radiation protection and the management of radioactive waste in the oil and gas industry, training course series No. 40. IAEA, Vienna; 2000.
2. John AF, Zordan M. Predicting radium availability and uptake from soil properties. *Chemosphere*. 2001;69:664–674.
3. Abolanle AS, John AO, Oyekunle OS, Ojo OW, Makinde TT, Nkambule B Mamba. heavy metal speciation, microbial study and physicochemical properties of some groundwaters: A case study. *Chemistry Africa*. 2020;3:211–226.
4. Afzal Shah, Abdul Niaz, Nazeef Ullah, Ali Rehman, Muhammad Akhlaq, Muhammad Zakir, Muhammad Suleman Khan. Comparative study of heavy metals in soil and selected medicinal plants. *Journal of Chemistry*. 2013;5A.
5. Nick C Oforka, Leo C Osuji, Uche I Onwuachu. Assessment of heavy metal pollution in muscles and internal organs of chickens raised in Rivers State, Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)*. 2012;3 (3):406-411.
6. Nworu JS, Ogbolu BO, Nwachukwu SO, Izomor RN, Oghonyon EI. Heavy Metal concentrations in yam and cassava tubers from enyigba lead-zinc mining site in South Eastern Nigeria. *Journal of Applied Chemistry*. 2018;11(10 Ver. I):39-43.
7. Codex general standard for contaminants and toxins in foods,” Joint FAO/WHO joint food standards programme, Codex Alimentarius commission, Rome, Italy; 2013.
8. Lima AJB, Cardoso MG, Guerreiro MC, Pimentel FA. Using activated carbon to remove copper from sugar cane spirit. *Química Nova*. 2006;29(2):247-250.
9. United States Environmental Protection Agency (US EPA). Supplemental guidance for developing soil screening levels for superfund sites. Office of Solid Waste and Emergency Response, Washington, D.C; 2002. Available:<http://www.epa.gov/superfund/health/conmedia/soil/index.htm>
10. Gonçalves Jr AC, Luchese EB, Lenzi E. Evaluation of phytoavailability of the cadmium, lead and chromium in soybean cultivated in the Latossolo vermelho escuro, treated with commercial fertilizers. *Química Nova*. 2000;23(2):173-177.
11. USEPA – United States Environmental Protection Agency. Zinc fertilizers made from recycled hazardous secondary materials. Washington: USEPA; 2002.
12. Kumral E. Speciation of chromium in waters via sol–gel preconcentration prior to atomic spectrometric determination. Doctorate Thesis. The Graduate School of Engineering and Sciences of Izmir Institute of Technology; 2007.
13. Frois SR, Grassi MT, Fernandes TC, Barreto RAS, Abate G. Preconcentration of Cr (III) and speciation analysis of chromium employing montmorillonite saturated with potassium ions. *Química Nova*. 2011;34(3):462-467.
14. Helena Oliveira. Chromium as an environmental pollutant: Insights on induced plant toxicity. *Journal of Botany*. 2012;1-9.
15. Paoliello MMB, Chasin AAM. Ecotoxicology of lead and its compounds. Salvador: CRA; 2001.
16. Rahman MA, Hasegawa H, Lim PR. Bioaccumulation, biotransformation and trophic transfer of arsenic in the aquatic food chain. *Environmental Research*. 2012;116(1):118-135.
17. Attanayake CP, Hettiarachchi GM, Harms A, Presley D, Martin S, Pierzynski GM. Field evaluations on soil plant transfer of lead from an urban garden soil. *J. Environ. Qual*. 2014;43:475–487.
18. Brady JE, Humiston GE. General chemistry. 2th ed. Rio de Janeiro: Livros Técnicos e Científicos; 2016.
19. Nicola FD, Maisto G, Alfani A. Assessment of nutritional status and trace element contamination of holm oak woodlands

- through analyses of leaves and surrounding soils. *Sci. Total Environ.* 2003;311:191-203.
20. Fodor L, Szabo L. Study of heavy metal leaching in the soil proceedings of the thirteenth international soil conservation organisation (ISCO) conference – brisbane. *Conserving Soil and Water for Society: Sharing Solutions.* 2004;216:1-4.
  21. Mensah E, Amoah P, Abaidoo RC, Drechsel P. Environmental concerns of peri-urban vegetable production: Case studies from Kumasi and Accra P. Drechsel, D. Kunze (Eds.), (2001) *Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa*, IWMI/FAO/CABI: Wallingford. 2001;55-68.
  22. Makinde OW, Oluyemi EA, Olabanji OI, Eludoyin AO, Tubosun IA, Ogundele KT. A particle induced x-ray emission (PIXE) analysis heavy metals in soil and plantain (*Musa paradisiaca*) leave at an Artisanal gold mining settlements in Southwestern Nigeria. *Open Journal of Ecology.* 2019;9(6):200-208.
  23. Gallagher DL, Johnston KM, Dietrich AM. Fate and transport of copper-based crop protectants in plasticulture runoff and the impact of sedimentation as a best management practice. *Water Resaerch.* 2000;35(12):2984–2994.
  24. Hess R, Schmid B. Zinc supplement overdose can cause toxic effects. *Journal of Peadratric Heamatology/Oncology.* 2002;24:582-584.
  25. David SK, Minati S. Levels and health risk assessment of heavy metals in soil, water, and vegetables of dares salaam, Tanzania. *Journal of Chemistry.* 2018;1-10.
  26. Mahfuza S, Sultana YN, Jolly S, Yeasmin A, Islam S, Safi M. Transfer of heavy metals and radionuclides from soil to vegetables and plants in Bangladesh in book: *Soil remediation and plants publisher.* Academic press editors; 2015.
  27. Nataša M, Rukie A, Ljubomir Š, Lidija M, Zoran S. transfer factor as indicator of heavy metals content in plants. *Fresenius Environmental Bulletin.* 2015;24(11c).

© 2021 Awoloye et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle4.com/review-history/74905>