

# Heavy metals in the urban soils and vegetables in Jos metropolis, Nigeria: Implications on children's health

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**Abstract:** The act of scavenging for food on harvested farms, metal substance in waste dumps and playing football games are common among children in the Jos metropolis, north central Nigeria. The aftermath of these activities (eating with unwashed hands, inhalation of dust during playing and transportation activities within the metropolis and consumption of vegetables may expose children to the constituent heavy metals. The aim of this study was to determine concentration of heavy metals in the urban soils and their levels in vegetables grown and consumed by residents of Jos Metropolis, with the view to drawing inferences on probable health implications on children who are the vulnerable group in the society. An assessment of the level of contamination or accumulation of the heavy metals in the soils was carried out using an index of geo-accumulation (Igeo) and the transfer factor (TF) from soil to vegetables and its health risk index (HRI) were calculated. Geochemical results obtained from the analysis soil samples (from the playgrounds, stream sediments, farm soils and soil dump) and vegetables samples show that the soils in the playground are generally enriched in  $Al_2O_3$  and  $Fe_2O_3$  (10.99 and 10.21 wt% respectively). The heavy metals content of the soils are elevated (Co, Cr, Pb and Zn; 146, 66, 268 and 219 ppm respectively). Most of the heavy metals (As, Co, Cr, Cu, Ni, Pb and Zn) in the playgrounds display  $I_{geo} < 1$  suggesting that the playgrounds are safe and pose no risk to the health of children who play on it. All the variety of vegetables display different metal absorption capabilities with Cu being the highest ( $TF = 3 - 6$ ). The intake of Zn and Pb into these vegetables are minimal. The calculated HRI for Pb, Zn and Cu are  $< 1$  suggesting that the consumption of these vegetables is safe and pose no potential human health risks.

**Keywords:** Heavy Metals, Urban Soils, Children's Health, Vegetables, Jos Metropolis

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## 1. Introduction

In the Jos metropolis, relicts of abandoned tin mines and tin ore processing sites abound in the area. Mill tailings from the processing of the tin ore (often associated with Pb-ZnS ores) are disposed indiscriminately in the Jos metropolis. Also, population growth and urbanization have contributed immensely to heavy metal contents in urban soils. Children are often seen playing on these soils thereby exposing them to heavy metal health risks. Heavy metals could get into the human body system through inhalation, hand-to-mouth contact or through the food chain pathways. Vegetable crops grown on such heavy metals contaminated soils could consequently be contaminated by these metals and may pose a threat to human health when such vegetables are consumed. Thus, the pathways for human exposure to such heavy metals contaminated soils through the food chain and human are of

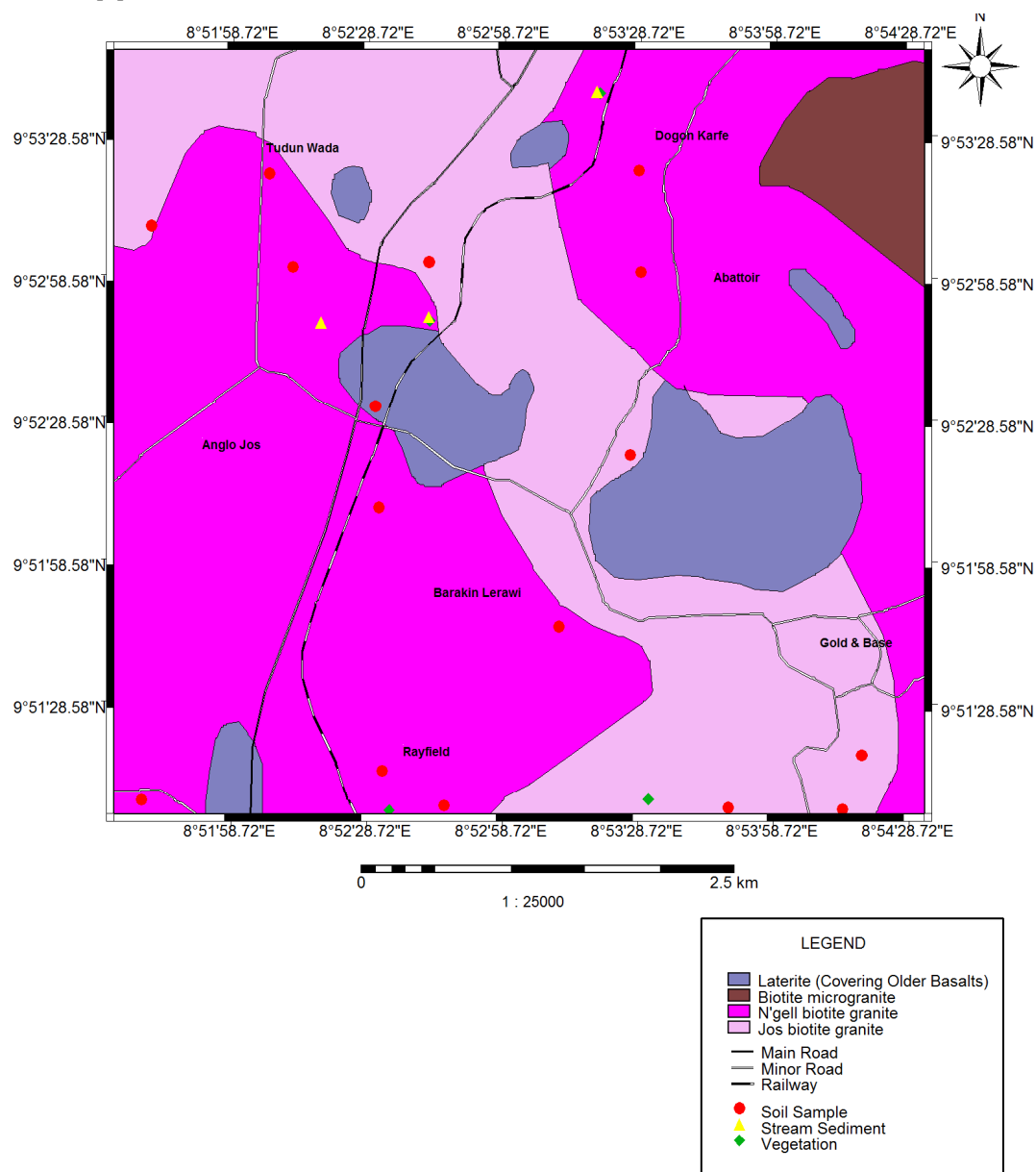
great concern in this study. The Jos area is predominantly granitic consisting mainly of the Younger granites ring complexes which have been overlain by basaltic volcanic rocks. The volcanic have been decomposed to laterite (Fig.1).

The presence of heavy metals such as Pb, Ni, Cd, Cu, Cr, Zn, Co and As in soils have the potential to contaminate vegetables grown on them. Vegetables constitute essential diet component by contributing protein, vitamin, iron, calcium and other nutrients, which are usually in short supply [1]. According to [2] metal accumulation in vegetables may pose a direct threat to human health. Heavy metal pollution can arise from many sources but most commonly from the purification of metals, for example the smelting of copper and the preparation of nuclear fuels. Hence, human over exposure from environmental concentrations of heavy metals occur naturally or by human activities such as industrial pollution [3]; [4]. Mining, manufacturing and the use of

chemicals can result in heavy metal contamination of urban and agricultural soils.

[5] reported low risk for lead-induced health effects in children. Heavy metals have been reported to reside mainly in the clay components of the soil where they are immobile leading to vary metal content in the soils of old playgrounds [6] ; [7] demonstrated that Pb-contaminated soil contributed to the lead burden of urban children and that abatement of Pb contaminated soil around homes results in a modest decline in blood lead levels. [8] established that children exhibit a

steep rise in blood Pb at soil Pb <100ug g<sup>-1</sup> and empirically, a safe soil Pb for most children is around 80ug g<sup>-1</sup>. They found out that Soil Pb is a useful diagnostic tool and curtailing it may complement primary Pb prevention for children. [9] indicated that urban soils in parks and public amenity in Hong Kong have elevated concentrations of Cd, Cu, Pb and Zn. The parks with high concentrations are located in old urban commercial districts and industrial areas, indicating that the major contamination sources in these soils are traffic emissions and industrial activities.



**Fig 1.** Geological Map of the Study Area

It has also been reported that Pb is the major pollutant of concern in the central region of the city of Prague, Czech Republic, where exposure assessment for children as the most sensitive population based on soil ingestion pathway was carried out [10].

An investigation on found elevated level of Pb in soils around the vicinity of a battery factory in Ibadan, Nigeria,

shows elevated Pb levels in soils with an average level of about 2000 mg kg<sup>-1</sup> of Pb, Zn, Cu, Cr, Ni and Cd close to the fence of the battery factory, but decline gradually to about 50 mg kg<sup>-1</sup> some 750 m away [11]. Soil Pb level around a primary school located about 50 m from the factory was as high as 1450 mg kg<sup>-1</sup>. Vegetable crops grown on these soils were equally elevated in Pb. Similar study by [12] revealed

that heavy metals contamination of edible vegetables at Itam road construction site in Uyo metropolis which may impact negatively on human health of humans of residents.

A recent study on a near-by Pb-Zn mining community few kilometers away from Jos, show that Pb and other potentially harmful elements (PHEs) discharged from the mining activity have contributed significantly to the enrichment of these elements in the surrounding environment, including the natural water bodies and are disposed to subsequent entry into the human body through the food chain. Men and children who constitute a large percentage of the mining workforce are the most vulnerable groups to exposure to these PHEs. In the developing world, activities of children which may involve scavenging and playing exposed them to some of these media which may host some of the potentially harmful elements, thereby making them vulnerable. Such activities are commonly seen in schools, mining areas, vegetable farms and along stream channels in the Jos metropolis. The aim of this study is to determine the potential health risks posed by the exposure of children to urban playground soils, soil dumps, stream channel sediments and consumption of vegetables grown along the stream channels.

## 2. Materials and Methods

### 2.1. Sampling and Sample Preparations

Two different representative sample media (soils and vegetables) were carried out. The vegetable samples which included spinach, okro, tomatoes and lettuce were collected from three gardens. Soil samples were collected using hand trowel from the ground surfaces (< 10cm depth), gardens and dump sites, in polythene sample bags in order to maintain their moisture (Fig 1)

The soil samples were air dried for about 24 hours in an oven at a temperature of 25 °C. The samples were then sieved with a 200 mesh size. Precautions were taken to avoid contamination by properly cleaning the sieve using distilled water and later methylated spirit. The vegetable samples were thoroughly washed with distilled water to remove all adhered particles. Samples were cut into small pieces, air dried in an oven for 24 hours and finally dried with hot air oven at 90 °C for 3 hours. The vegetable samples were ground into fine powder using agate pestle and mortar.

### 2.2. Sample Digestion

Both the pulverized vegetable and soil samples were shipped to the Acme Analytical Laboratories (Vancouver) Ltd in Canada for the geochemical analysis. 100 mg of the powdered soil sample was weighed into a Teflon crucible and dissolved in aqua regia (HCl-HNO<sub>3</sub> (3:2) after 6 hours of heating the solution was allowed to dry on a hot-plate (250°C). After the crucible containing the sample was allowed to cool, 2ml of 2M HCl was added and was topped with de-ionised water to about ¾ full and warmed on a hot-plate for not more than 15mins. The crucible and sample solution was removed from the hot-plate and allowed to

finally cool. The content was diluted to 100 ml and filtered into a flat bottomed flask. For the vegetable samples, 500 mg of the sample powder was weighed and digested in the same manner as the soil sample.

### 2.3. Analytical Method

Heavy metals analysis of both the soils and vegetable samples were done using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). 0.25g each of the soil or vegetables samples was digested in aqua regia at 200°C on a hot plate sand bath for two hours. The solution was diluted and analysed by ICP-OES Perkin Elmer OPTIMA 2000 DV. International certified reference materials USGS GXR -1, GXR -2, GXR-4 and GXR-6 were analyzed at the beginning and at the end of each batch of samples. The instrument was calibrated prior to the introduction of sample by measuring in-house standards and blank solutions. The quality of the analysis was controlled through the analysis of samples of known compositions along with the unknowns. Internal control standards were analyzed for every ten samples and a duplicate is run for the samples.

### 2.4. Determination of Index of Geo-Accumulation (Igeo)

The Index of geo-accumulation (Igeo) has been used widely to evaluate the degree of metal contamination in different environments [13]; [14]; [15]. It is expressed as:

$$I_{geo} = \log_2 (C_m / 1.5 \times B_m)$$

Where  $C_m$  = Measured concentration

$B_m$  = Background concentration of metal;

1.5 = A constant to account for fluctuation in the content of a given substances in the environments.

The geo-accumulation index, consist of seven grades (0 to 6) based on the increasing numerical value of the index and ranges from unpolluted to extremely polluted. The standard Igeo values are presented below:

$I_{geo}$ Value	Grade	Classification
$\leq 0$	0	Unpolluted
0-1	1	Unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	Moderately polluted to strongly polluted
3-4	4	Strongly polluted
4-5	5	Strongly polluted to extremely polluted
>6	6	Extremely polluted

### 2.5. Determination of oral Intake of Metals from Soil through Vegetables

The Daily consumption of metals (DIM) is expressed as; the daily vegetable consumption x mean vegetable metal concentrations (mg/day, fresh weight) (Cui et al., (2004). The required amount of vegetables in man's daily diet as recommended by WHO guidelines [15], is 300-350g per person. In this study however, we have estimated 61.5g/day of vegetable consumed by Nigerians since Africans generally eat less of vegetables. We have also assumed an average human weight of 65kg for and average adult.

## 2.6. Determination of Transfer Factor (TF)

The transfer factor (TF) of metals from soil to vegetables was calculated using the formula of [16] as follows:

$$TF = C_{\text{vegetable}}/C_{\text{soil}}$$

Where  $C_{\text{vegetable}}$  and  $C_{\text{soil}}$  represent the concentrations of the toxic metal in the vegetable and soil respectively.

## 2.7. Determination of Health Risk Index (HRI)

The health risk index provides an indication of health risk

level due to exposure to toxic metals. The estimated potential health risk to humans through the ingestion of vegetables was calculated using the United States Environmental Protection Agency (EPA, 1989) hazard quotient where

$$HRI = (DIM) \times (C_{\text{metal}})/RD \times Bo$$

Where DIM is the daily intake of metal through the vegetables (kg/day) (see formula above), ( $C_{\text{metal}}$ ) is the concentration of in the vegetable (mg/kg), RD is the oral reference dose for the metal (mg/kg of body weight/day) and Bo is the human body weight (kg).

**Table 1.** Chemical Compositions of Major Oxides (wt%) and some Trace Elements (ppm) in the Study Area

COORDINATES	AREA	SOURCE	Al <sub>2</sub> O <sub>3</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub>	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	As	Cd
90 59.46N 80 52.44	Hwolshe	Playground	2.46	0.06	4.15	BDL	0.07	0.03	7	BDL
90 52.16N 80 52.13	Anglo Jos	Playground	2.29	0.03	0.87	BDL	1.35	0.15	BDL	0.4
90 51.76N 80 51.69	Kufan	Playground	2.02	0.27	3.01	0.03	0.54	0.2	BDL	BDL
90 51.60N 80 52.29	Zarmaganda	Playground	1.93	0.41	2.19	0.02	0.34	0.16	BDL	BDL
90 51.33N 80 52.03	Zarmaganda	Playground	5.91	0.11	7.15	0.02	0.19	0.04	6	BDL
90 51.59N 80 54.09	Ray Field	Playground	10.99	0.43	10.21	0.07	0.83	0.19	11	BDL
90 51.79N 80 53.60	Yingi	Playground	4.49	0.49	4.48	0.03	0.55	0.05	6	BDL
90 52.05N 80 53.28	Namoa	Playground	8.24	0.2	7.38	0.12	0.7	0.07	BDL	BDL
90 53.05N 80 53.20	Giring	Playground	3.51	0.63	5.36	0.07	0.3	0.07	6	BDL
90 53.34N 80 53.23	Abattoir	Playground	0.98	1.29	0.73	BDL	0.13	0.03	BDL	BDL
90 53.35N 80 51.10	Hwolshe	Playground	4.53	0.08	1.69	0.03	2.63	0.24	BDL	BDL
90 53.27N 80 52.05	Hwolshe	Playground	8.03	0.07	2.1	0.08	4.34	0.23	BDL	BDL
90 53.03N 80 52.35	Polytechnic	Playground	6.42	0.22	4.09	0.05	0.9	0.34	7	BDL
90 51.60N 80 52.27	Zarmaganda Church	Farm	7.82	0.22	4.09	0.05	0.9	0.34	BDL	BDL
90 51.50N 80 52.29	Zarmaganda Bridge	Farm	6.78	0.27	3.92	0.12	1.07	0.09	BDL	BDL
90 58.47N 80 52.78	Sec. Junction	Stream	3.46	0.07	3.49	0.03	0.81	0.27	BDL	BDL
90 53.27N 80 51.85	Tudun Wada	Stream	6.9	0.08	2.67	0.03	2.8	0.54	BDL	BDL
90 58.47N 80 52.78	NNPC	Stream	7.61	0.38	3.33	0.07	2.82	0.39	BDL	BDL
90 50.86N 80 53.39	Favwei Ray Field	Dump	0.84	0.42	3.59	0.05	0.39	0.09	BDL	BDL
90 51.09N 80 54.09	Favwei Junction	Road	10.99	0.43	10.21	0.07	0.83	0.19	11	BDL

**Table 1.** Continue

COORDINATES	AREA	SOURCE	Co	Cr	Ni	Pb	Cu	Sb	Sc	Ti	Zn
90 59.46N 80 52.44	Hwolshe	Playground	BDL	44	BDL	10	5	BDL	3	0.05	10
90 52.16N 80 52.13	Anglo Jos	Playground	BDL	8	BDL	9	3	BDL	<1	0.03	16
90 51.76N 80 51.69	Kufan	Playground	BDL	20	2	32	5	BDL	1	0.12	66
90 51.60N 80 52.29	Zarmaganda	Playground	BDL	28	BDL	10	3	BDL	1	0.04	21
90 51.33N 80 52.03	Zarmaganda	Playground	BDL	112	7	41	14	BDL	5	0.14	35
90 51.59N 80 54.09	Ray Field	Playground	BDL	171	12	36	11	BDL	7	0.39	43
90 51.79N 80 53.60	Yingi	Playground	BDL	62	5	12	6	BDL	2	0.1	38
90 52.05N 80 53.28	Namoa	Playground	6	91	20	26	16	BDL	7	0.36	32
90 53.05N 80 53.20	Giring	Playground	2	23	12	19	9	BDL	2	0.1	68
90 53.34N 80 53.23	Abattoir	Playground	7	7	2	57	7	BDL	<1	0.03	12
90 53.35N 80 51.10	Hwolshe	Playground	BDL	12	2	20	4	BDL	3	0.18	36
90 53.27N 80 52.05	Hwolshe	Playground	BDL	10	4	24	2	BDL	2	0.15	53
90 53.03N 80 52.35	Polytechnic	Playground	BDL	48	10	25	7	BDL	3	0.91	42
90 51.60N 80 52.27	Zarmaganda Church	Farm	146	66	11	268	13	BDL	5	0.37	219
90 51.50N 80 52.29	Zarmaganda Bridge	Farm	3	43	11	52	12	BDL	4	0.38	62
90 58.47N 80 52.78	Sec. Junction	Stream	4	28	5	24	6	BDL	2	0.07	59
90 53.27N 80 51.85	Tudun Wada	Stream	BDL	51	8	24	9	BDL	2	0.12	59
90 58.47N 80 52.78	NNPC	Stream	3	37	9	30	10	BDL	3	0.12	11
90 50.86N 80 53.39	Favwei Ray Field	Dump	BDL	41	7	21	7	BDL	2	0.14	43
90 51.09N 80 54.09	Favwei Junction	Road	BDL	43	4	30	7	BDL	4	0.09	38

BDL= Below Detection Limit

**Table 2.** CHEMICAL Composition of some commonly consumed Vegetables in some Farms in the Study Area (The major elements are in weight% and Trace elements in ppm).

COORDINATES	AREA	VEGETABLE	Al <sub>2</sub> O <sub>3</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub>	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	As	Cd	Co
90 53.46N 80 52.78	Sec. Junction	Okro	BDL	0.22	0.1	0.5	3.41	0.22	0.1	0.09	0.08
90 53.46N 80 52.78	Sec. Junction	Spinach	0.06	2.94	0.08	1	8.09	0.02	BDL	0.32	0.32
90 51.60N 80 52.27	Zarmaganda Church	Lettuce	0.08	1.69	0.07	0.77	7.91	0.4	BDL	0.61	0.19
90 51.60N 80 52.27	Zarmaganda Church	Unripe Tomato	BDL	0.99	0.01	0.25	4.51	0.05	BDL	0.1	0.09
90 50.95N 80 52.98	Zarmaganda Bridge	Ripe Tomato	BDL	0.11	0.01	0.33	5.5	0.15	BDL	0.32	0.07

**Table 2. Continue**

COORDINATES	AREA	VEGETABLE	Al <sub>2</sub> O <sub>3</sub>	Cr	Ni	Pb	Cu	Sb	Sc	Ti (WT%)	Zn
90 53.46N 80 52.78	Sec. Junction	Okro	BDL	1.4	0.9	0.29	15.2	0.04	0	12	49.8
90 53.46N 80 52.78	Sec. Junction	Spinach	0.06	1.7	1	1.71	9.83	0.04	0.2	23	164.2
90 51.60N 80 52.27	Zarmaganda Church	Lettuce	0.08	1.5	1.4	2.59	15.9	0.08	0.2	28	168.1
90 51.60N 80 52.27	Zarmaganda Church	Unripe Tomato	BDL	1.4	0.4	0.16	6.46	0.02	0.2	13	34.8
90 50.95N 80 52.98	Zarmaganda Bridge	Ripe Tomato	BDL	1.4	0.5	0.11	11.7	0.03	0.3	21	29.6

**Table 3.** The estimated Daily metal intake and Hazard Quotient (HRI) through the intake of vegetables.

Transfer Factor	Okro	Spinach	Lettuce	Ripe tomato	RD mg/day
Pb	0.007	0.045	0.068	0.002	0.245 (Yeasmin, 2013)
Zn	0.351	1.172	1.200	0.212	15.00 <sup>“”</sup>
Cu	6.08	3.36	6.36	4.68	2.0-3.0 <sup>“”</sup>
Daily Intake of metal (mg/day)					
Pb	0.002	0.015	0.0242	0.001	
Zn	0.0169	0.0558	0.057	0.010	
Cu	0.012	0.008	0.013	0.009	
Health Risk Index					
Pb	0.008	0.061	0.098	0.004	
Zn	0.0011	0.0037	0.0038	0.0006	
Cu	0.0048	0.0032	0.0052	0.0036	

### 3. Results and Discussion

#### 3.1. Major Oxides and Heavy Metals

##### 3.1.1. Soil and Sediment Samples

Table 1 shows the result of geochemical analysis of soil samples in the study area for major oxides (wt/%) and heavy metals (ppm). In almost all the different sample locations, CaO, MgO, and Na<sub>2</sub>O contents are <1% in the soils. This is expected of soils derived from a mostly granitic parent host rocks. However, Al<sub>2</sub>O<sub>3</sub> display higher content (0.98-10.99 wt%) in playground soils, the soils from the farms have Al<sub>2</sub>O<sub>3</sub> of 6.78 and 7.82 respectively); the stream sediments have 3.46, 6.90 and 7.61, the road side soil has 10.99 wt% and the lowest Al<sub>2</sub>O<sub>3</sub> were obtained in the soil dump. The highest values of 10.99 were obtained in the RayField playground and at the Fawvei Junction; all in RayField area (see Table 1). The concentrations of Fe<sub>2</sub>O<sub>3</sub> are also high (from 0.73-10.21 wt%) in all locations with the highest of 10.21 wt% at the Ray Field playground) attributed to the lateritic altered basaltic cover. Higher values of Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub> from both stream sediments and farm soils may be the result input from wastes that are being emptied into the streams, whose waters are also used to irrigate the farms. Only the playground soil at Anglo Jos records a Cd value of 0.4ppm. Only the stream sediments and soils from the Zarmaganda area has As of 7.0 ppm with highest value of 11.0 ppm at the playground at Ray Field and the Fawvei Junction road side soils. The soil from the Zarmaganda

Church Farm records the highest values of Co, Zn and Pb with 146 ppm, 219ppm and 268 ppm respectively, but virtually absent in 70% of the playground soils.

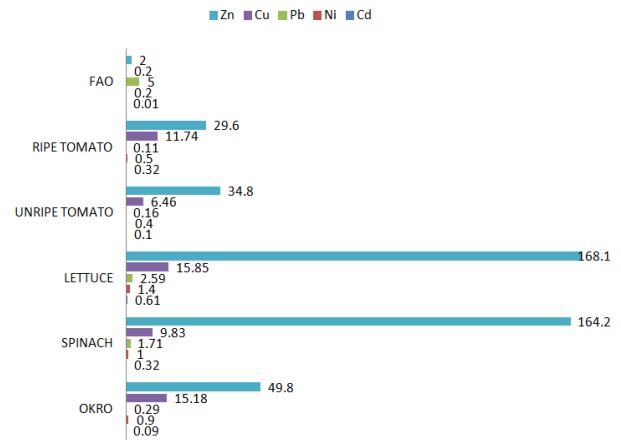
##### 3.1.2. Vegetable Samples

The concentration of the major oxide (Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub>) in the soils from the farms appear to be virtually absent in vegetables collected from these farms. There is no variation in the content of both MgO and Na<sub>2</sub>O in the soils and those in the vegetables. However, K<sub>2</sub>O which appear very low in the farm soils are quite much in all the vegetables with higher values of 7.9 and 8.09 wt% in both Lettuce and spinach. This probably indicates higher absorption of this oxide by the leafy vegetables relative to the other oxides. Also, the trace element Cd and Sb which appear virtually absent in the soils are present in all the vegetables in concentration ranging from 0.09 in Okro to 0.61 ppm in lettuce and 0.02 in unripe tomato to 0.08 ppm in lettuce. The high values of Cu and Zn in the vegetables (lettuce: 168.1 ppm and spinach: 164.2 ppm) point to their high absorption capabilities for these metals. Despite the high values of Pb in the farm soils, concentrations in the vegetables are quite low, indicating little absorption of Pb in the vegetables. As is virtually absent in all the vegetables except in okro with value of 0.1 ppm. Ni ranges from 0.4 in ripe tomato to 1.4 ppm in lettuce. Compared to recommended metal levels in vegetables by the Food and Agricultural Organization Standard (FAO), Cd, Ni, Cu, and Zn values in the vegetables are far above the recommended limits. The vegetables

display transfer factor of  $<1$  for Pb, indicating that these vegetable have low absorption capability for Pb (Table 3). On the contrary however, only spinach and lettuce had a TF for Zn  $>1$  (1.17-1.2), while okro and ripe tomato have TF  $<1$ . All the vegetables show very high TF values for Cu in decreasing order lettuce (6.36)  $>$  okro (6.08)  $>$  ripe tomato (4.68)  $>$  spinach (3.36), suggesting a very high retention capacity of these vegetables for Cu.

The calculated indices of geo-accumulation (Igeo) are presented in Table 4. Almost all the heavy metals in all the sample locations (playgrounds, stream soils, dump soils, roadside soil) display Igeo  $<1$ , signifying that these areas are generally uncontaminated by them. However, the soils from the roadside at Favwei Junction, Ray Field and Bethel School RayField are moderately contaminated by As (Igeo = 1.12-1.23). The playground at NMC quarters Anglo- Jos is very highly contaminated with Cd (Igeo  $>5$ ), this is not surprising since the area is located near the Nasco group of companies where untreated effluents are released into the stream channels. There is a recorded high Igeo (Igeo  $>4$ ) for Pb from

the soil at the vegetable garden by Shepherd House Church Zarmaganda, indicating that the area is highly to very highly contaminated with Pb.



**Fig 2.** Compositions of heavy metals in the vegetables compared to the FAO Standards

**Table 4.** Index of geoaccumulation (Igeo) of selected heavy metals in the soil samples.

Sample ID	As	Cd	Co	Cr	Cu	Ni	Pb	Zn
Stream sediment	0.00	0.00	0.04	0.06	0.02	0.13	0.39	0.17
Playground	0.78	0.00	0.00	0.09	0.02	0.00	0.16	0.03
Playground	0.00	5.35	0.00	0.02	0.01	0.00	0.14	0.05
Playground	0.00	0.00	0.00	0.04	0.020	0.05	0.51	0.19
Vegetable garden	0.78	0.00	1.33	0.19	0.05	0.03	4.30	0.63
Playground	0.00	0.00	0.00	0.06	0.01	0.00	0.16	0.06
Playground	0.67	0.00	0.00	0.23	0.06	0.02	0.66	0.10
Vegetable garden	0.00	0.00	0.03	0.09	0.05	0.03	0.84	0.18
Dumpsite	0.00	0.00	0.00	0.12	0.03	0.02	0.34	0.12
Road side	1.12	0.00	0.00	0.09	0.03	0.01	0.48	0.11
Playground	1.23	0.00	0.00	0.34	0.04	0.03	0.42	0.12
Playground	0.67	0.00	0.00	0.12	0.02	0.01	0.19	0.11
Playground	0.00	0.00	0.54	0.18	0.06	0.05	0.42	0.09
Playground	0.67	0.00	0.02	0.05	0.04	0.03	0.31	0.19
Playground	0.00	0.00	0.64	0.01	0.03	0.01	0.92	0.03
Playground	0.00	0.00	0.00	0.02	0.02	0.01	0.32	0.10
Playground	0.00	0.00	0.00	0.02	0.01	0.01	0.39	0.15
Stream sediment	0.00	0.00	0.00	0.15	0.04	0.02	0.39	0.17
Playground	0.00	0.00	0.00	0.10	0.32	0.03	0.40	0.12
Stream sediment	0.00	0.00	0.03	0.11	0.04	0.02	0.48	0.32

### 3.2. Health Risk Posed by Consumption of the Vegetables and Soils to Children

Children are known for their playful nature. The younger ones put in just anything into their mouths. By these, they are highly exposed to intake of toxic substances into their system and associated health risk. The lack of control over where children go and where they play is a big problem around the Jos metropolis. The act of scavenging by children for food (tomatoes, lettuce, carrots, garden eggs etc) on harvested farms and for metal substances in open wastes disposal sites increases the chances of being exposing them to these toxic heavy metals already recorded in the soils and the vegetables in the study area. From Igeo calculations, all the soils from the different playgrounds could be considered uncontaminated to moderately contaminated. The calculated Health Risk Index (HRI) for Pb, Zn and Cu is  $<1$  in all the

vegetables and therefore are considered safe. However, the HRI for Pb in the leafy vegetables (spinach and lettuce 0.061 and 0.098 respectively) are relatively higher. However, the prolonged exposure of children to heavy metals through inhalation, hand-to-mouth ingestion and through ingestion of food stuffs (which has the capacity to accumulate more metals into its tissues) may lead to serious human health consequences.

Exposure to Pb is most serious for young children because they absorb Pb more easily than adults. Children with high levels of lead in their bodies can suffer from damage brain and nervous system, behavior and learning problem (such as hyperactivity), Slowed growth, Hearing problems, [17]. Zinc is an element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell, slow wound healing and

skin sores. Zinc shortages can even cause birth defects. Zinc can be a danger to unborn and newborn children especially when their mothers have absorbed large concentrations of zinc the children may be exposed to it through blood or milk of their mothers.

## 4. Conclusion

A fallout of this study is that the urban soils in the Jos metropolis are generally uncontaminated to moderately contaminated in heavy metals (As, Cd, Pb, Cu, Zn) resulting mainly from one or many anthropogenic activities (industries, waste disposal, and mining activities). This notwithstanding, the long time direct exposure of children to the heavy metals contaminated soils may constitute serious health risks because of children's vulnerability.

Among the vegetables grown on these heavy metals contaminated soils, the fruit vegetables (ripe tomato and okro) are generally less contaminated by the heavy metals than the leafy vegetables (Spinach and lettuce). All the vegetables however display very high capacity for the accumulation of Cu. The calculated Health risk index for the heavy metals in all the vegetables are less than 1 suggesting that they are generally safe for human consumption and pose no health risks. Despite this, the prolong consumption of such vegetables over time may constitute some human health danger and therefore should be consumed with caution. The playground used by children should be detoxified to reduce the risks of heavy metal related human health problems.

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