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LEAD, CADMIUM, CHROMIUM AND MANGANESE CONTAMINATION OF FOOD CROPS FROM POST-REMEDIATED LEAD-POLLUTED GOLD MINING AREA (DARETA) OF ZAMFARA STATE, NIGERIA.

Odey, Michael Oko[*1,2]; Udiba, Udiba Ugumanim[3]; Iwara, IwaraArikpo[1];Eze Azubuike[1]; Nneoyi-Egbe, Francesca Ada[1]; Edet, Effiong Asanga[4]; Godfrey, Obinna Chukwuemeka[1]; Takim, Burch Ndifon[5]; Eteng, Mbeh Ubanga[1] and Uboh, Friday Effiong[1]

[1]Department of Biochemistry, Faculty of Basic Medical Sciences, University of Calabar, Nigeria.

[2]Department of Biochemistry, Faculty of Medicine and Pharmaceutical Sciences, Kampala International University, Tanzania.

[3]Department of Zoology and Environmental Biology, Faculty of Biological Sciences, University of Calabar, Nigeria.

[4]Department of Biochemistry, Arthur Jarvis University, Cross River State, Nigeria.

[5]Department of Chemistry, Cross River College of Education, Akamkpa, Cross River State, Nigeria.

***Corresponding author email address:** mymikeodey@yahoo.com; phone number: +2348034180445

Abstract

This study assessed the post-remediation status, heavy metal bioaccumulation, and bio-toxicity of edible plants from Dareta village, Zamfara State, Nigeria. Plant samples; Bean (*Phaseolus coccineus*), *Maize (Zea mays)*, Carrot *(Daucus carota)*, Okra (*Hibiscus esculentus)*,andTapasa (*Senna obtusifolia*) were collected and used for this study. The heavy metal concentrations were assessed using Atomic Absorption Spectrophotometer (Model AA-6800, Japan) after wet digestion, while method validation was achieved using standard reference materials, such as animal blood coded IAEA-A-13, and Lichens coded IAEA-336. Assessment of lead, cadmium, chromium, and manganese levels in edible plants was carried out to assess the pollution situation of the environment for three years post-remediation. The mean lead content of edible crops assessed was above the Joint Food and Agricultural Organization/World Health Organization (FAO/WHO) standards of 0.2mg Kg^{-1} and the European Union (EU) standards of 0.3mg kg^{-1}. The mean Cadmium contents of Beans and Maize, were above the FAO/WHO limit, while those of Okra, Tapassa, and Carrot, were within the limit. Apart from the Chromium content of Beans that was above the FAO/WHO limit of 2.3mg Kg^{-1}, all others were within the limit. The Manganese levels of all the plants were significantly higher ($P<0.05$) than the FAO/WHO limit of 0.5mg Kg^{-}

[1]. Consumption of food crops under study from Dareta is therefore generally unsafe, and poses serious toxicological risks.

Keywords: Toxicity assessment; Edible crops; Heavy metals status; Post-remediation; Lead pollution.

1.0 Introduction

Pollution of the air, water, and especially land is a major global problem today, with far-reaching consequences. Anthropogenic and natural processes have resulted in the pollution of the environment with harmful substances. These substances are readily carried through food chains. The supply of safe food and feed products to humans and animals respectively is crucial to reduce the exposure of humans to toxic substances, and also to safeguard the health and welfare of animals (Udiba et al., 2013). Among environmental pollutants and toxicants, heavy metals affect cellular activities and are potentially deleterious, especially due to bio-accumulation along the food chain (Kafeel et al., 2013). Heavy metals can be bioaccumulated and biomagnified along the food chains, which can invariably be passed to humans (McCauley, 2009; Ajorlo et al., 2010). The extent of heavy metal accumulation and bio-magnification is dependent on the plant and plant part, as different parts of the same plant can sequester the same or different metals at different concentrations. Since metal concentrations in foods may consistently bio-magnify along the food chains, animals with higher trophic levels may accumulate more pollutants than they are contained in their foods (Hays and Swenson, 2015).

Whereas some metals, such as sodium and potassium are excreted easily, hence pose no toxicity threat to the body, others have extremely low excretion rate, which results in the accumulation of some minerals, metals, and metalloids, in biological tissues, which may become toxic at certain high levels (McCauley, 2009; Ogundiran et al., 2012). Food chain accumulation and bio-magnification is a major entry routes for metals into the body. Therefore, monitoring heavy metals in contaminated soil, foodstuff, and water is of paramount concern.

The US-EPA report generalizes that consumption of a regular diet containing 2-8 mg of lead per kilogram of body weight per day, for a long time will cause death and disabilitiesin most animals (Udiba et al., 2013). Lead (Pb) and Cadmium (Cd) are considered major environmental pollutants because they are easily bioaccumulated and bio-magnified along the food chains, and are of no significant biological functions. They rather produce an array of deleterious effects in both animals and man when exposed, with consequent undesirable biochemical and physiological changes. Plasma and hormonal changes with abnormal liver functions have been reported in food animals, such as cows exposed to Lead and Cadmium in industrial areas (Yebpella et al., 2011). Some biologically essential elements such as Chromium (Cr) and Manganese (Mn), though necessary for life, at a trace amount, and are particularly involved in some metabolic processes, could be toxic if ingested in higher-than-normal amount. The concentration of a particular metal may affect those of others in animal tissues; a higher lead level, for instance, interferes with the normal absorption of copper and Zinc (Micheal et al., 2017). The anthropogenic sources of heavy metals, especially in the soil are primarily a result of mining, smelting, and aerosol deposition, agriculture as well as industries (Silva et al., 2013). Mining and smelting of ores have thus increased the extent, occurrence, and prevalence of toxic elements due to dust emissions, mine tailing, and wastewater (Kafeel et al., 2013).

In general, the soil-to-plant transfer of metals is small. However, in soils containing an increased amount of a given metal, such metal can be taken up in a much more elevated amount. The movement of heavy metals from soil to plant is determined by many factors, which include, soil properties, plant species, and metals bioavailability for uptake in the soil-plant system (De-Matos et al., 2001). The movement and availability of metals in plants depend on the chemistry of such metals. Most metals taken up by plants, especially on land are stored in their roots. There is some evidence that plant leaf may also take up lead (and this lead can be translocated to other plant parts). Some species of plants can accumulate elevated levels of lead. Lead is relatively unavailable to plants in a neural to alkaline soil environment (Udiba et al., 2014).

Dareta village in Zamfara state is highly influenced by metal pollution sourced from mining activities. Although there had been a long history of unauthorized gold mining in Zamfara, little or no scientific evaluation was undertaken to ascertain the severity of contamination and by implication the pollution status of the environment until the Lead pollution crisis of 2010 in which over 10,000 people were estimated to have been affected (UNEP/OCHA, 2010; UNICEF, 2010). The primary source of this pollution crisis was traced and confirmed to be due to environmental exposure to Lead from the processing of lead-rich gold ore mined by artisans for gold extraction. Gold processing includes grinding of the gold-rich ore/rocks into fine particles in a mill, with mills scattered around the villages, resulting in the dispersal of Lead dust.

Studies during the remediation exercise implicated a few other metals of little or no bio-importance. This study is focused on the evaluation of Lead, Cadmium, Chromium, and Manganese levels in tubers, cereals, and vegetables commonly used as food for men and livestock in Dareta village. The implications of the findings to public health are fully discussed.

2.0 MATERIALS AND METHODS

2.1 Description of sampling sites

This study was carried out to assess the heavy metals levels in crops that are harvested and sold in the farm sites and markets in Dareta village of Anka local government area of Zamfara state, North-western Nigeria. Dareta village (the study area) is located on 12°06′30″ N and 5°56′00″ E with a total area of about 2,746 sq km and a total human population of about 142, 280, of which about 20% are children below the age of five years, at the time of this study(Odey et al., 2022). Dareta is populated majorly by Hausa and Fulani tribes. Not until recently, before the discovery of gold deposits, the major occupation of Dareta was farming. Recently, small-scale artisanal mining activities employed a large percentage of this population, especially the youths. Apart from Dareta, other major villages where the lead poison crisis of 2010 occurred include, Abare, Tungan Daji, Sunke, Tungar guru, Duza, and Bagega (UNICEF, 2010) (Figure 1).

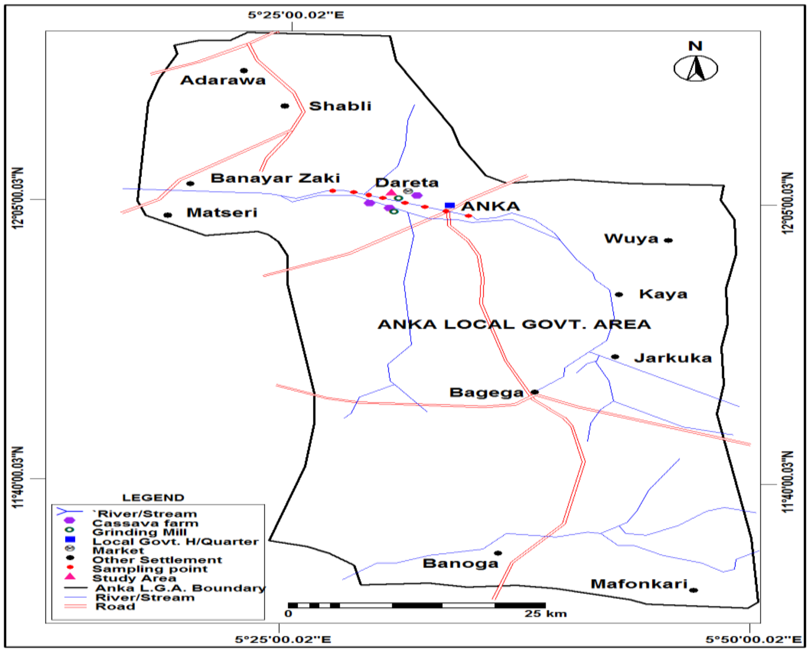

Figure 1. Anka Local Government Area showing Dareta; the study area with the sampling points
Source: Adapted and modified from administrative map of Zamfara state (2016)

2.2 Sample collection and processing

Crop samples (*Phaseolus coccineus*, *Zeamayss*, *Daucus carota*, *Hibiscus esculentus*, and *Senna obtusifolia*) were purchased from the farmers at Hausa Fulani stream where all farmers stopover on the way from their farms to processing their farm produce. This was to ensure that all the samples were from the study area. At the Hausa Fulani stream, the vegetables are washed and tied into bundles for sale by the farmers. The root crops are washed to remove adhered soil. Preliminary processing of some of the grains also takes place here. Wholesale marketers meet the farmers at this mini market (Hausa Fulani stream) to buy at cheaper prices before transporting the goods to the main market. Samples were purchased and stored in labeled polyethylene bags and transported to the laboratory. The samples from the control area (Zaria; which is subject to the same soil (sandy-loamy), and environmental conditions, but has no gold mining activities) were purchased directly from farmers in Sabon Garry (a local settlement and non-mining community), due to a lack of access to farms in this area. These were also properly packaged, labeled, and transported to the laboratory. Sampling was carried out every Monday for four weeks. One cup each of *Phaseolus coccineus*, *Zeamayss*, One-hundred-naira (Nigeria Local Currency) worth each *Daucus carota*, *Hibiscus esculentus* (Measured with a local scale), and one-hundred-naira worth bundle of *Senna obtusifolia* was purchased from five different farmers. Five samples of each crop were purchased on every sampling day. Twenty samples of each crop were therefore purchased for the study. A total of one hundred samples were used for the study of the five crops under consideration.

Daucus carota, *Hibiscus esculentus, and Senna obtusifolia*were thoroughly washed, cut in pieces, air dried under a shed, pulverized separately and passed through a 1mm sieve. *Phaseolus coccineus*, and *Zeamayss*were also air dried and subjected to similar conditions. The digestion of the samples (1g each) was done using 20ml of concentrated nitric acid, perchloric acid, and hydrofluoric acid in the ratio of 3: 1:1 at 80 – 90^{o}C on a laboratory hot plate according to (Awofolu, 2005; Odey et al., 2022). The digest was filtered separately in a 50mL volumetric flask and made up to the 50mL mark with distilled de-ionized water. Heavy metal contents of the digests were determined using Atomic Absorption Spectrophotometer (Model AA-6800, Japan).

2.3 Analytical quality assurance

The reliability and accuracy of the obtained result was established by adequate suitable precautionary and quality assurance protocols. To avoid cross-contamination, samples were handled with utmost care. All the glassware and other apparatus used were thoroughly cleaned. Distilled de-ionized water and reagents of analytical grades [perchloric acid and hydrofluoric acid (British Drug House, England), and nitric acid (Riedel-DeHaan, Germany)] were used throughout sample processing and analysis. For the evaluation of trustworthiness of analytical procedures, and method adopted for metal determination, each batch of the sample was run with blank and combined standards, to detect background contamination and also monitor consistency between batches(Udiba et al., 2022). The validation of the analyzed results was done by analyzing standard reference materials (Lichens coded IAEA-A-13), using the same procedure. Thereafter, the certified reference values and the analyzed values of the heavy metals were compared to establish the reliability of the method.

3 Results

Result of the standard reference material (Lichens IAEA -A-13) used to evaluate the correctness of the analytical method used in this study revealed that the analyzed and certified reference values were within the same range (Table 1). This suggests that the method adopted for this was reliability.

Table1. Results of analysis of reference material (Lichens IAEA-A-13) compared to the certified reference value (mg kg^{-1}).

Elements (Mg Kg^{-1})	Pb	Cd	Cr	Mn
Analyzedvalues	5.27	0.15	4.64	1.26
Reference values	4.2-5.5	0.1-2.34	4.30-5.00	1.00-1.5

Table 2. Comparative lead, cadmium, chromium and manganese levels (mg Kg^{-1}) from Dareta, Zaria, and WHO/FAO standards

Crops	Lead (Pb)			Cadmium (Cd)			Chromium (Cr)			Magnesium (Mn)		
	Dareta	**Zaria**	**WHO /FAO**	**Dareta**	**Zaria**	**WHO/ FAO**	**Dareta**	**Zaria**	**WHO/ FAO**	**Dareta**	**Zaria**	**WHO/ FAO**
Beans	10.15±3.41	1.00±0.29	0.2	0.10±0.01	0.30±0.02	0.05	4.09±0.68	0.30±0.02	2.3	1.21±0.16	0.67±0.04	0.5
Maize	8.98±1.32	1.27±0.38	5.0	0.35±0.07	0.27±0.03	0.2	1.19±0.66	0.27±0.03	2.3	1.54±0.17	0.45±0.02	0.5
Okra	7.18±1.32	1.11±0.23	5.0	0.10±0.02	0.90±0.02	0.2	0.54±0.18	0.90±0.02	2.3	1.85±0.11	0.63±0.18	0.5
Tapasa	14.63±3.49	2.27±1.00	0.3	0.40±0.02	0.50±0.02	0.2	1.22±0.28	0.50±0.02	2.3	20.38±0.40	0.78±0.02	0.5
Carrot	8.91±1.94	1.45±0.24	5.0	0.17±0.08	0.80±0.02	0.2	1.09±0.02	0.17±0.08	2.3	30.82±0.97	1.17±0.19	0.5
Millet	6.20±2.08	-	0.2	0.15±0.05	-	0.2	0.27±0.08	-	2.3	1.70±0.39	-	0.5

-Sample not available

N/B: There is no Nigerian standard for these metals in edible crops

The Lead concentration (mg kg^{-1}) in edible plants from Dareta and the control area, in comparison with the FAO 2007 permissible standards is presented in Table 2 and Figures 2 & 3. The Pb content of beans (*Phaseolus coccineusL.*), (Figure 2) was 10.15±3.41 for Dareta, and 1.00±0.29 for Zaria (the control area). These were both higher than the permissible FAO/WHO value of 0.2, with that of Dareta being significant (P<0.05). That of maize (*Zea mays*), (Figure 2) was 8.98±1.32 for Dareta and 1.27±0.38 for Zaria. That of Dareta was higher than the FAO/WHO permissible value of 5, while the one from Zaria was lower. The changes were not significant (P>0.05).

For okra, (Figure 3), the Pb level was 7.18±1.32 for Dareta and was non-significantly higher (P>0.05) than the FAO/WHO limit of 5. The value from Zaria was lower, 1.11±0.23. The Pb content of Tapassa (*Senna obtusifolia*) (Figure 3), was 14.63±3.49 for Dareta, 2.27±1.00 for Zaria. Both were higher significantly (P<0.05) than the FAO/WHO permissible value of 0.3 for leafy vegetables. That of carrot (*Daucus carota*) (Figure 3), was 8.91±1.94 for Dareta, and 1.45±0.24 for Zaria. The Dareta value was higher than the FAO/WHO value of 5, while that of Zaria was lower. These changes were not significant. The Pb level in Millet (Figure 3) from Dareta was 6.20±2.08 and was higher significantly (P<0.05) compare to FAO value of 0.2.

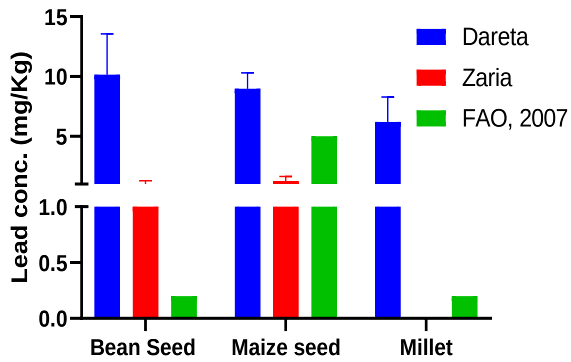

Figure 2: Mean Lead concentrations of Beans, Maize and Millet from Dareta and Zaria

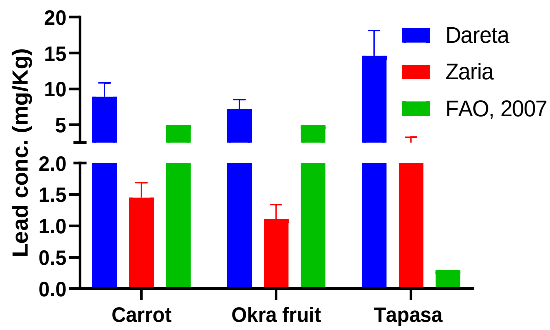

Figure 3: Mean Lead concentrations of Carrot, Okra fruit and Tapasa from Dareta and Zaria

The results of the Cadmium concentration (mg kg^{-1}) of edible plants are presented in Table 2 and Figures 4 & 5. The Cd concentration in beans (*Phaseolus coccineus*L.) (Figure 4), was 0.10±0.01 for Dareta, and 0.30±0.02 for Zaria (the control area). These were both higher than the allowable FAO/WHO value of 0.05. These increases were however not significant (P>0.05). The Cd status of maize (*Zea mays*), (Figure 4) was 0.35±0.07 for Dareta and 0.27±0.03 for Zaria. Both were insignificantly higher (P>0.05) than the FAO/WHO permissible value of 0.2. The Cd concentration in millet from Dareta was 0.15±0.05 and was lower than the permissible limit of 0.2.

The Cd level in Okra, (Figure 5) was 0.10±0.02 for Dareta and 0.90±0.02 for Zaria. Both were insignificantly lower (P>0.05) than the FAO/WHO limit of 0.2. The Cd content of Tapassa (*Senna obtusifolia*) (Figure 5) was 0.40±0.02 for Dareta and 0.50±0.02 for Zaria. Both were also lower than the FAO/WHO permissible value of 0.2 for leafy vegetables. That of carrot (*Daucus carota*), (Figure 5), was 0.17±0.08 for Dareta and 0.80±0.02 for Zaria. Both were also within the FAO/WHO permissible value of 0.2.

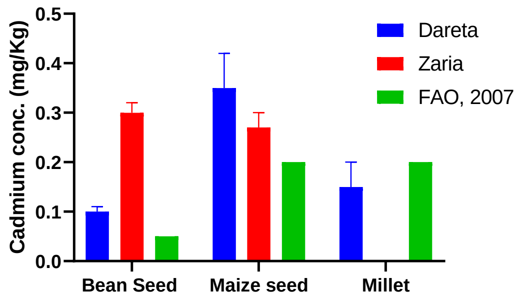

Figure 4: Mean Cadmium concentrations of Beans, Maize and Millet from Dareta and Zaria

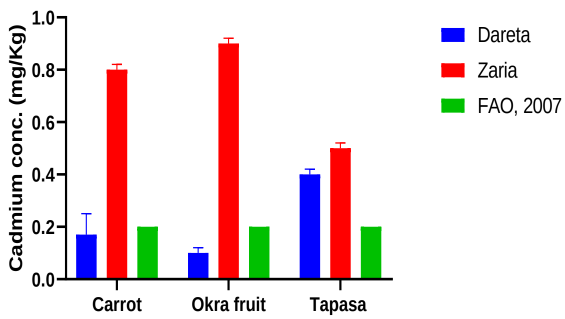

Figure 5: Mean Cadmium concentrations of Carrot, Okra fruit and Tapasa from Dareta and Zaria

The results of the Chromium (Cr) concentration (mg kg^{-1}) of edible plants from Dareta village, and the controls (from Zaria) are presented in Table 2 and Figures 6 & 7. The Cr content for beans (*Phaseolus coccineus* L.) (Figure 6) was 4.09±0.68 for Dareta, and 0.30±0.02 for Zaria. The Dareta value was higher than the FAO/WHO permissible value of 2.3, while that of Zaria was lower. However, the changes were not significant (P>0.05). The Cr status of maize (*Zeamayss*) (Figure 6) was 1.19±0.66 for Dareta and 0.27±0.03 for Zaria. Both were non-significantly lower (P>0.05) than the FAO/WHO permissible value of 2.3. The level of Cr in millet (Figure 6), was 0.27±0.08 and was lower than the FAO permissible limit of 2.3.

The level of Cr in Carrot (*Daucus carota*), (Figure 7) was 1.09±0.02 for Dareta and 0.17±0.08 for Zaria. These were also non-significantly lower (P>0.05) compared to the FAO/WHO limit of 2.3. That of okra (*Hibiscus esculentus*), (Figure 7), was 0.54±0.18 for Dareta, and 0.90±0.02 for Zaria. They were both lower than the FAO/WHO permissible limit of 2.3, with that of Zaria (the control) being significant (P<0.05). The Cr content of Tapassa (*Senna obtusifolia*), (Figure 7), was 1.22±0.28 for Dareta, and 0.50±0.02 for Zaria. Both were lower than the FAO/WHO permissible value of 2.3 for leafy vegetables, with that of Zaria being significant (P<0.05).

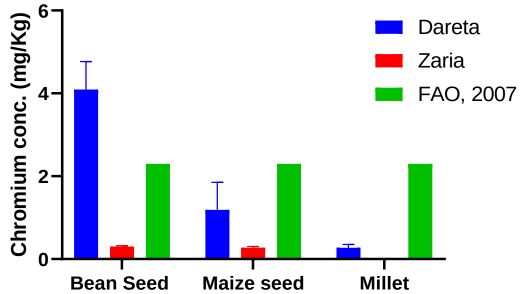

Figure 6: Mean Chromium concentrations of Beans, Maize and Millet from Dareta and Zaria

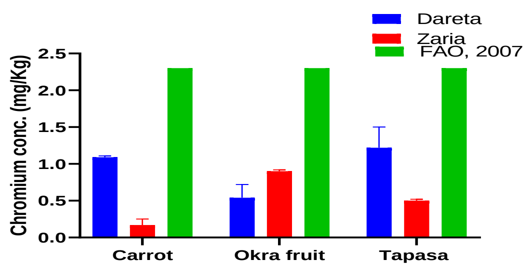

Figure 7: Mean Chromium concentrations of Carrot, Okra fruit and Tapasa from Dareta and Zaria

The Mn concentrations (mg kg^{-1}) of edible plants from Dareta and the control area are presented in Table 2 and Figures 8 & 9. The value of Mn in beans (*Phaseolus coccineus* L.) (Figure 8), was 1.21±0.16 for Dareta, and 0.67±0.04 for Zaria (the control area). The values were higher than the FAO/WHO permissible value of 0.5mg Kg^{-1}, though the increases were not significant (P>0.05). That of maize (*Zea mays*), (Figure 8), was 1.54±0.17 for Dareta, and 0.45±0.02 for Zaria. The Dareta value was higher than the FAO/WHO permissible value of 0.5, while that of Zaria was lower. The Mn concentration of millet from Dareta was 1.70±0.39 and was higher than the permissible limit of 0.5.

For okra (*Hibiscus esculentus*), (Figure 9), the Mn level was 1.85±0.11 for Dareta and 0.63±0.18 for Zaria. These were higher compared to FAO/WHO permissible limit of 0.5. That of Tapassa (*Senna obtusifolia*), (Figure 9) was 20.38±3.40 for Dareta and 0.78±0.02 for Zaria. The Dareta and Zaria values were both higher than the FAO/WHO value of 0.5, with the Dareta value being significant (P<0.05). The Mn content of carrot (*Daucus carota*) (Figure 9) was 30.82±3.97 for Dareta, and 1.17±0.19 for Zaria. Both were also higher than the FAO/WHO permissible value of 0.5 for root crops, with that of Dareta being significant (P <0.05).

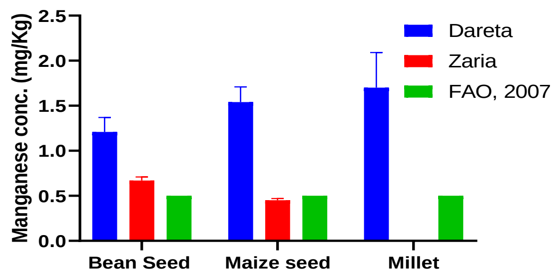

Figure 8: Mean Manganese concentrations of Beans, Maize and Millet from Dareta and Zaria

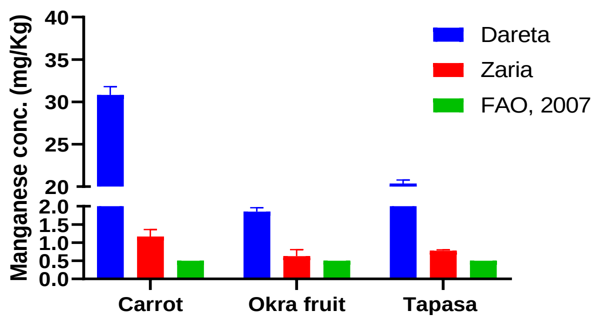

Figure 9: Mean Manganese concentrations of Carrot, Okra fruit and Tapasa from Dareta and Zaria

4 Discussion

Lead concentrations of beans and maize grains in this study were found to be above (JECFA, 2007) and (CEC, 2007) safe limits. Bean (*Phaseolus coccineusL*) is a major food crop in sub-Saharan Africa. The seeds are a major source of secondary or plant proteins for man and feed for farm animals. A Pb mean value of 0.19±0.05 was reported for beans grown around the derelict Udege Mines of Nasarawa State, Nigeria (Aremu et al., 2010). A range of 0.01 - 0.04 was reported for grains of cowpea, cultivated in soil polluted with spent engine oil, in Owerri, Imo State, Nigeria (Ogbuehi et al., 2011). A report by (Silva et al., 2013) gave a range of 0.67 – 1.06mg/kg for bean grains from soil that has been amended with tannery sludge compost for three consecutive years. Maize (*Zea mays)*, is one of the most important cereals with the widest geographical spread in terms of production and utilization among the cereals in Nigeria. A Lead concentration range of 0.31-0.45µg g^{-1} was reported for maize corn dried long high ways in selected states of northern part of Nigeria (Adebayo andRapheal, 2011; Udiba et al, 2022). A mean value of 0.03mg kg^{-1} has been reported for maize grains in Lagos and Ogun state, and 0.05mg kg^{-1} for Oyo state in 2004 (Nwude et al., 2010). A Pb mean value of 52±2.3mmg kg^{-1} was recorded for farms irrigated with wastewater for over thirty (30) years and 8.4±0.1mgkg^{-1} for farms never irrigated with wastewater in Harare, Zimbabwe (Masona et al., 2011; Odey et al., 2022). Findings from this study revealed that the Pb contents of maize grains, beans, carrots, and okra fruits from farms in Dareta village were higher than the Pb contents of those from the control area

(Basawa village, Zaria). The observed significantly higher Pb level in these crops from Dareta compared to Zaria (the control area) is indicative of increased level of Pb due to the illegal artisanal mining activities. The significant variation in Pb levels in these crops may be due to differences in soil Pb levels, the chemical form of lead present, soil chemistry, specie of crop, and stage of maturity of the crop. Metal uptake is dependent on the concentration and mobility of such metal in the growth medium and plant species in question (Ngole, 2011). Lead concentration (mg kg^{-1}) of *Senna obtusifolia* (Tapassa) was significantly higher than the Cordex general standards and the EU maximum level for Pb in leafy vegetables. The concentration of Pb in *Senna obtusifolia* leaf was equally higher compared to the available reported toxicity level of 1.00mgPb/day for human, as reported by (Abah et al., 2013). Ingestion of *Senna obtusifolia* leaves from Dareta thus poses a high risk to Pb poisoning. The increased Pb level of *Senna obtusifolia* may also be attributed to the fact that over 45% of Pb in Dareta farm and pasture soils is in the mobile phase and is readily available for translocation from soil to plants (Bano, 2012). Annanel al., (2013) reported a higher lead level in leaf than stem and root of *Sennaobtusifolia.* This could be indicative of higher sequestration of toxic metals in leaf, a pointer to the fact that leaf may be the major storage organ for lead in *Sennaobtusifolia*.

Plants that have high translocation factor (TF) values are considered suitable for phytoextraction. Phytoextraction generally requires translocation of heavy metals in easily harvestable plant parts i.e. shoots (Ghosh and Singh, 2005; Yoon et al, 2006). Translocation factor, bio-concentration factor, and bioaccumulation values >1are used to evaluate the potential of plant type for phytoextraction and phytostabilization(Ghosh and Singh, 2005). The normal and phytotoxic concentrations of Pb were reported by (Levy et al., 1999), which were 0.5–10 and 30–300mg/ kg respectively. *Sennaobtusifolia* in this study indicated Pb concentration which is much more than the normal, but is within the phytotoxic concentrations. These show that the plant may be tolerant to this metal. The observed significantly higher Pb concentrations in *Senna obtusifolia* leaves from Dareta village compared to that from Zaria may be due mining and processing of Pb-rich gold ore by artisans in Dareta.

In comparison to the FAO/WHO limits, the Cd concentrations in *Phaseolus coccineus*and *Zea mays* were higher, while those of *Hibiscus esculentus* and *Daucus carota* were lower.A mean Cd value of 49±1.1mg kg^{-1} was recorded for farms irrigated with wastewater for over thirty (30) years and 8.4±0.1mgkg^{-1} for farms never irrigated with wastewater in Harare, Zimbabwe (Masona et al., 2011). A mean Cd value of 0.14±0.06 was reported for beans grown around the derelict Udege Mines of Nasarawa State, Nigeria (Aremu et al., 2010). A range of 0.01 - 0.04 was reported for grains of cowpea, cultivated in soil polluted with spoilt engine oil in Owerri, Imo state, Nigeria (Ogbuehi et al., 2011). It has been reported a range of 0.67–1.06mg kg^{-1} for bean grains from soil amended with tannery sludge compost for three consecutive years(Silva et al., 2013). On the contrary, Cd contents of okra and carrot from Dareta were lower than(JECFA,

2007) limits of 0.2mg Kg^{-1} and (CEC, 2006) safe limits of 0.30mg kg^{-1}. Consuming carrots and okra from Dareta, therefore, does not pose a serious Cd-related toxicological risk. A range of 0.40 - 2.10mg kg^{-1} with mean value of 1.05mg kg^{-1} was reported for carrots from the Baia Mare area, North-Western Romania (Miclean ET AL., 2000). Mean values of 7.35mg kg^{-1}, 3.13mg kg^{-1}, and 0.19mg kg^{-1} were recorded for okra fruits irrigated with sewage water, sewage plus tube well water, and tube well water respectively (Lone ET AL., 2003).

The Cd concentration of *Senna obtusifolia* leaf was significantly low (0.07mg Kg^{-1}) compared to FAO/WHO permissible limit of 0.2mg Kg^{-1}. Though Cd has no beneficial biochemical role, its concentration of this sort poses no serious toxicity threat with the consumption of this vegetable. This finding did not agree with (Yoon et al., 2006), which showed that Cd always co-accumulates with Pb. This is because *Senna obtusifolia* has a very high Pb accumulation potential, which is significantly higher than the FAO/WHO permissible limit, but not Cd. Also, the disparity may be due to the physiology of the plant or there was a low mobile Cd component in the Pb polluted environment.

The Cr contents of maize grains, beans, and carrots from farms in Dareta village were higher than the controls, while that of okra was lower. The observed increase in Cr concentration in crops from Dareta compared to Zaria (the control area) is an indication of the presence of Cr in the Pb-rich ore excavated due to the mining activities. The variation in Cr concentrations of each crop across the different farms studied may be due to differences in soil Cr concentrations, the chemistry of Cr present, soil chemistry, specie of crop, and stage of maturity of the crop. Metal translocation is dependent the concentration of the metal, speciation, and mobility in the environment and the type of plant concerned (Ngole, 2011).

The Cr concentration in *Phaseolus coccineus*(beans) was higher than the WHO/FAO value, while those of *Zeamayss, Daucus carota, and Hibiscus esculentus* were lower. This implies that maize grains and beans from Dareta village have no potential to pose significant health risks for Cr toxicity, to both livestock and humans. This is because of the low to insignificantly increased levels of this metal in these crops, compared to the FAO/WHO permissible limits. They may be good sources of Cr, as Cr is essential in trace amounts. However, regular monitoring of heavy metals in the maize and beans grown in Dareta farms is necessary to avoid over-accumulation by plants and subsequent intoxication when these plants are consumed. The Cr concentration of *Senna obtusifolia* from the study area was less than the FAO/WHO permissible level. The low concentration of Cr in *Senna obtusifolia* is indicative of the fact that the plant either has low Cr uptake ability from the soil, or there is a low presence of mobile Cr in the soil.

The manganese concentrations of *Phaseolus coccineus, Zeamayss, Daucus carota, and Hibiscus esculentus* were all higher than those from the control area. In comparison to the FAO/WHO permissible limit, they were also significantly higher. This is indicative of the fact that the plant either has a high Mn uptake ability from the soil, or there is a high presence of mobile Mn in the soil, accompanying Pb-rich ore. The Mn concentration of *Senna obtusifolia* from Dareta was significantly higher than the

FAO/WHO permissible limit. This increase is a possible indication that the plant either has a high Mn uptake ability from the soil, or there is a high presence of mobile Mn in the soil, accompanying Pb-rich ore.

5 Conclusions

The finding of this assessment implies that maize grains and beans from Dareta village have the potential to pose significant health risks for Pb and Cd intoxication to both livestock and humans. Also, the consumption of vegetables like *Senna obtusifolia*, Okra, and carrot from the study area is susceptive to Pb and Cd intoxication, as these plants have shown to have the ability to sequester these metals above the limits permissible by food regulatory agencies. Regular monitoring of these heavy metals in edible crops cultivated in Dareta farms is therefore necessary as ingestion of heavy metals via contaminated foods may lead to various deleterious effects.

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