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Determination of the Contamination Levels of Cadmium, Lead, Arsenic and Mercury in the Vegetables from Old Mining Site of Jos Plateau, Nigeria

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Abstract: **Levels of heavy metals: cadmium (Cd), lead (Pb), arsenic (As) and mercury (Hg) were investigated in the vegetables (carrots and tomatoes) planted on farms near the old mining sites in Jos, Plateau State. The vegetables were planted and harvested during the two seasons, dry and raining seasons of 2014. Atomic absorption spectrometry was used for the analyses. The results showed that concentrations of most of the metals were above the Food and Agriculture Organization/World Health Organization (FAO/WHO) maximum permissible limit. Cadmium (Cd) concentration ranged from 0.01–0.45mg/kg, lead (Pb) concentrations ranged from 0.01– 0.43mg/kg, arsenic (As) concentrations ranged from 0.02 -1.20mg/kg lastly, mercury (Hg) concentrations ranged from 0.01 – 0.39mg/kg. The concentrations of the metals followed the order of Cd< Pb < As < Hg. It was observed that the uptake of metals by tomatoes was higher than carrots' uptake.**

Keywords: **heavy metals, vegetables, atomic absorption spectrometry, FAO/WHO maximum permissible limit.**

I. INTRODUCTION

A lot of tin mining activities started on the Plateau during the pre-colonial era. The mining history dates back to 1904 when tin was discovered on the Plateau. This tin mining left a lot of over burdens and mining ponds. Settlements are found around these mining ponds which contain untreated mining waste waters throughout the year [1]. Many of these settlers are farmers, who use this water from the mining ponds for irrigation farming of vegetables which after harvest are transported to every part of country for consumption.

Mining is the process of excavating heavy volume of overburdened materials or natural minerals from the earth surface for various applications [2]. In most cases, this process results to the release of metals unto the surface, thereby contaminating the environment such as the waterway and the soil [3], [4]. The World Health Organization (WHO) reported that the environment got highly contaminated through the activities of the small scale, artisanal or surface mining, as these processes produce lot of tailings, which contained metals that could be released into the environment be it through the wind or waterways or land [5]. The mining, processing, smelting/refining activities of mineral resources led to the contamination of agricultural soils and crops within and around the vicinity of mining site as a result of tailings and waste water [6]. Apart from contaminating the soil, crops and water, the health of the populace is also being jeopardized because of the chemicals being used during the processes. Various types of chemical reagents are being used at the mining sites. Types of chemical used depend on so many factors, such as the processing method, type of ores being considered etc. Some of the chemical reagents include: Sodium Silicate, Hydrochloric acid, Carbon tetra- chloride and several others [7].

There is a global concern over the effect of technological advancement on the environment, due to the impact industrial pollution is making on the environment. Many developed countries have imposed some legislation to maintain sustainable environment. These legislations are enforced by specialized institutions such as European Economic Community (EEC), United State Bureau of Statistics, U.S Mission to the European Union and many others [8]. Heavy metals such as cadmium, lead, mercury arsenic etc contamination cannot be under estimated as they cause serious health problems such as loss of vision, hearing, mental retardation, all forms of cancer and even death. Studies in China, South Korea, USA, etc have shown that vegetables are often contaminated with these heavy metals, thereby contaminating the food chain [9].

It was reported that vegetables are shrubs / herbaceous annular perennials plants consumed by both animals and man. They can be eaten raw or cooked. They can either be underground such as carrots, potatoes, onions, etc or they could be above the ground such as tomatoes, cabbage, chili etc. Eating diet rich in vegetables reduced the risk of heart diseases, heart attack, stroke, bone loss, constipation etc. Vegetables were reported to be low in fat and calories but rich in fiber, vitamins, folate (folic acid) and minerals [10], [11]. Tomatoes were reported to be rich in lycopene, the red carotenoid pigment and phytonutrient. Lycopene was an antioxidatant which helped in the elimination of damaging free radicals in the body tissues, thereby reducing the chances of getting cancer (prostate cancer). It also reduced the risks of cardiovascular diseases [12]. Carrots cleansed the intestine and remineralized the body. Carrots had diuretic, antidiarrheal and antianemic abilities. It helped the human body to maintain the acid- alkaline system and was very good for the human sight. Carrot tea was recommended for bladder and kidney ailment, dropsy and gout diseases [13].

Heavy metals are non-biodegradable and persistent environmental contaminants which may be deposited on the surfaces and then be absorbed into the tissues of the vegetables. Plants took up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from contaminated soils [14].

The aim of the research work is to determine the levels of contamination of cadmium, lead, arsenic and mercury in vegetables planted at the old mining sites.

II. MATERIALS AND METHODS

Study site:

Samples were collected from four farms namely: Farm A, (Danjuma farm, Hollaza settlement near F.G.C, Jos in Jos North L.G.A,) Farm B (Gurum Village near Mistaali) and Farm C at Tsaya (Village both in Bassa L.G.A.) while the control samples were collected from West Africa Milk Company (WAMCO) farm (Vom, Jos South L.G.A).

Sampling:

Two samples were obtained from each site namely: Tomatoes (a fruit vegetable), Carrot (a root vegetable). Planting and harvesting of the vegetables were done during the dry and raining seasons of 2014. Whole plant samples of *Lycopersicum esculentum* (tomato) and *Daucus carrota* (Carrot) were collected.

Sample Treatment:

The vegetable samples were washed, separated, cut and air-dried. The dried samples were ashed at 550^{o}C using Carbolite muffle furnace and stored in air tight covered plastic containers for elemental analyses. One gram (1g) of the ashed plant sample was digested with 40 ml of aqua regia (a mixture of 3 parts concentrated HCl to 1 part concentrated HNO_3) on a hot plate in the fume cupboard, until the digested sample dried and baked. The baked sample was re dissolved with 10ml 1 : 1 HCl. To the hot solution, 30 ml of distilled water was then added and filtered through a Whatman number 41 filter paper into a 100 ml standard volumetric flask and the solution was made up to the mark with deionized water. All the reagents used were of standard analytical grade. Cadmium, lead, arsenic and mercury concentrations were determined in the plant samples using a SOLAAR ice 3000AA01122804v1.30 Atomic Absorption Spectrophotometer (AAS).

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TABLE 1 : CONCENTRATION OF METALS (mg/kg)

		Cadmium (Cd)		Lead (Pb)		Mercury (Hg)		Arsenic (As)	
		RAINING SEASON	DRY SEASON	RAINING SEASON	DRY SEASON	RAINING SEASON	DRY SEASON	RAINING SEASON	DRY SEASON
FARM IDENTITY	CONTROLLED CARROT	0.16±0.02		0.01±0.01		0.20±0.02		BDL	
	FARM A 2014	0.45±0.02	0.03±0.02	0.18±0.01	0.08±0.03	BDL	0.13±0.03	0.14±0.03	0.21±0.05
	FARM B 2014	0.01±0.01	BDL	0.28±0.02	BDL	0.08±0.02	0.19±0.05	0.05±0.06	0.99±0.08
	FARM C 2014	0.02±0.01	BDL	0.01±0.01	BDL	0.07±0.03	0.14±0.04	BDL	1.20±0.01
	CONTROLLED TOMATOES	0.18±0.01		0.05±0.01		0.29±0.01		BDL	
	FARM A 2014	BDL	0.08±0.002	BDL	0.07±0.02	0.01±0.	0.23±0.07	0.86±0.10	0.12±0.05
	FARM B 2014	0.35±0.01	BDL	0.31±0.04	BDL	BDL	0.28±0.10	0.27±0.05	0.91
	FARM C 2014	0.68±0.03	0.23±0.01	0.03±0.01	0.10±0.07	BDL	0.10±0.05	0.18±0.02	0.14±0.02

BDL: BELOW DETECTION LIMIT

III. RESULTS AND DISCUSSION

Results:

The Concentrations of Cd, Pb, Hg and As are presented on Table 1.

Discussion:

The result showed that cadmium (Cd) had mean concentration of 0.24mg/kg in carrots of farm A, 0.005mg/kg in carrots of farm B and 0.01mg/kg in carrots of farm C. The maximum permissible limit for cadmium is 0.10mg/kg [15], as such only carrots from farm A with such cadmium may be unsafe for human consumption. The mean concentrations of lead (Pb) for carrots from farm A was 0.13mg/kg, 0.14mg/kg for carrots from farm B and 0.005mg/kg for carrots from farm C. Carrots from all the farms were safe for human consumption as their concentrations were below the maximum permissible limit, 0.30mg/kg [15]. Average mercury (Hg) concentrations in carrots from farm A was 0.065mg/kg, 0.14mg/kg was the average concentration of mercury (Hg) in carrots from farm B and farm C had 0.11mg/kg was the average concentration in carrots from farm C. The maximum permissible limit is 0.03mg/kg [15], based on this, no carrot was safe for human consumption. Arsenic (As) was high in most of the carrots, farm A had a mean concentration of 0.18mg/kg, farm B carrots had 0.52mg/kg and carrots from farm C had 0.60mg/kg. The maximum permissible limit is 0.43mg/kg, based on these carrots from farms B and C were unsafe for human consumption. Considering the individual and total metal concentrations in the carrots from all the farms, farm C had the least concentration of metals followed by farm A and finally farm B.

Mean concentrations of cadmium (Cd) in tomatoes was 0.004mg/kg of farm A, 0.18mg/kg in farm B's tomatoes and farm C tomatoes had 0.46mg/kg. The maximum permissible limit is 0.10mg/kg, thus it could be seen that only tomatoes from farm A with values lower than the maximum permissible limit could be recommended for human consumption. Average lead (Pb) concentrations in tomatoes from farm A was 0.04mg/kg, 0.16mg/kg was found in tomatoes of farm B and farm C had 0.07mg/kg. The maximum permissible limit is 0.30mg/kg. Based on this result, tomatoes from all the farms were safe for human consumption. The average mercury (Hg) concentrations in tomatoes from farm A was 0.12mg/kg, 0.14mg/kg was found in the tomatoes of farm B and tomatoes from farm C had 0.005mg/kg. Maximum permissible limit is 0.03mg/kg. Only tomatoes from farm C were safe for human consumption. Mercury is more toxic than the other studied metals and causes more serious health related problems such as mental retardation, loss of vision, hearing and even death. This could have gotten into the plants through the use of pesticides and herbicides. Mercury was higher than the Maximum Permissible Level values in almost all the samples.

This agreed with the research studies carried out in Pakistan and Saudi Arabia where it was reported that the mercury concentration in food and foodstuff in Sindh, Pakistan and vegetables, cereals and fruits in Saudi Arabia respectively exceeded the permissible levels reported by the WHO of 0.03mg/kg [16], [17].

The average concentration arsenic (As) in tomatoes of farm A was 0.49mg/kg, 0.59mg/kg was found in farm B and 0.16mg/kg was found in the tomatoes of farm C. The maximum permissible limit is 0.43mg/kg. Only tomatoes from farm C were safe for human consumption .

The results of this study showed that most of the vegetables up took arsenic; this observed result was similar to the results obtained in Southern Turkey [18] on a research study carried out on heavy metal concentration on edible parts of some cultivated plants and medical samples. High arsenic concentrations observed may be due to the usage of arsenic containing chemicals such as pesticides and herbicides (calcium arsenate, cupper acetoarsenate and lead hydrogen arsenate). It was reported that these were used in pig and poultry feeds [19]. Which in turn introduce arsenic into the soil and plants as chicken dug is used as fertilizers.

From the results, tomatoes from farm C was the safest for human consumption followed by farm A and finally farm B. The results showed that concentrations of most of the metals were higher tham the FAO/WHO maximum permissible limit in the vegetables. This corresponded to the results obtained in a research study on the levels of As, Cd, Cr, Hg and Pb in soils and some vegetables which showed that the mean concentration of metals in the analysed sample fell above the maximum permissible limit and standard value [20].

It can also be seen that metal concentrations of tomatoes are higher than that of carrots, Tomatoes up take of metals seemed higher than carrots. This may be due to plant's selectivity of absorption of metals, in the research studies on assessment of cadmium and lead in soils and tomatoes in farmlands of Kaduna, it was also observed that tomatoes uptake of cadmium was higher than carrots' uptake [21].

IV. CONCLUSION

Based on the results obtained from this research work, only carrots and tomatoes from farm C were relatively safe for human consumption. Lead concentrations in almost all the samples were lower than the maximum permissible limit; as such lead poisoning as a result of these vegetables may be rare.

V. RECOMMENDATION

Further studies are recommended, the soil - plant transfer factor may be considered.

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