ASSESSMENT OF HEAVY METALS CONTAMINATION IN VEGETABLES AND ITS GROWING SOIL IN SELECTED AREAS OF OFFA LOCAL GOVERNMENT

Ibitomi O.O, Abubakar A.A, Ibietan E.O, Olaniyi S.S

Department of Science Laboratory Technology, Federal Polytechnic Offa, Kwara State.

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Abstract: Vegetables are the principal source of nutrients and play a crucial role in maintaining sound health. But, vegetables are being contaminated by various types of unwanted substances which is becoming an alarming issue nowadays. Intake of contaminated vegetables may cause several diseases and hamper normal physiological functions. Therefore, the main purpose of this study is to establish a database about the contamination status of heavy metals in popular vegetables and their growing soil in selected areas of Offa Local Government. The concentrations of heavy metals in growing soils from the two selected areas were found to be within the permissible limit but the concentration of Pb, Cr, and Zn in vegetable were higher than the safe limit recognized by joint FAO/WHO. Therefore, the consumption of these vegetables is a matter of concern and regular monitoring is strongly recommended.

Keywords: Heavy metals; Soil; Vegetables; Contamination.

Introduction

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations, examples of heavy metals include: Cadmium (Cd), Cobalt (Co), Chromium (Cr), Zinc (Zn), and Lead (Pb). The environment has been severely polluted by these heavy metals, this has compromised the ability of the environment to promote life and render its natural values. Heavy metals are known to be naturally occurring compounds, but environmental pollutions and pollutants originating from human activities introduce them in large quantities in different environmental compartments (Masindi *et al., 2018).* This leads to the environment's ability to foster life being reduced as human, animal, and plant health become threatened, which occurs due to bioaccumulation of heavy metals in the food chains as a result of their non-degradable property. Among all the pollutants, heavy metals have received a paramount attention to environmental chemists due to their toxic nature, heavy metals are usually present in trace amounts in natural waters but many of them are toxic even at very low concentrations (Herawati *et al.,* 2000).

Heavy metals such as Cadmium (Cd), Cobalt (Co), Chromium (Cr), Zinc (Zn), and Lead (Pb) are highly toxic even in minor quantity. Increasing quantity of heavy metals in our resources is currently an area of great concern, especially since a large number of industries are discharging their metal containing effluents into fresh water without any adequate treatment *(*Salomons *et al., 2001).* Heavy metals become toxic when they are not metabolised by the body and accumulate in the soft tissues. They may enter the human body through food, water, air or absorption through the skin when they come in contact with humans in agriculture, manufacturing, pharmaceutical, industrial or residential settings. Industrial exposure accounts for a common route of exposure for adults while ingestion is the most common route of exposure in children. Natural and human activities are contaminating the environment and its resources, they are discharging more than what the environment can handle *(*Herawati *et al., 2000).*

There are many sources of heavy metals in soils including *(*Reichman *et al., 2002)*: Natural e.g. soil parent material, volcanic eruptions, marine aerosols, and forest fires; Agricultural e.g. fertilizers, sewage sludges, pesticides and irrigation water; Energy and fuel production e.g. emissions from power stations; Mining and smelting e.g. tailing, smelting, refining and transportation; Automobiles e.g. combustion of petroleum fuels; Urban/industrial complexes e.g. incineration of wastes and waste disposal; and , Recycling operations e.g. melting of scrap. The occurrence of heavy metals in soils, both natural and polluted, has been the subject of a number of studies *(*Caussy *et al., 1992; Cui et al., 2004).*

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While metal contamination is widespread, the occurrence of heavy metals in agricultural soils is a major concern. When heavy metals are taken up by plants, heavy metals may enter the food chain in significant amounts. Hence, people could be at risk of adverse health effects from consuming vegetables grown in such soils containing elevated metal concentrations. Therefore, heavy metals contamination is becoming a serious issue of concern around the world as it has gained momentum due to the increase in the use and processing of heavy metals during various activities to meet the needs of the rapidly growing population. Soil, water and air are the major environmental components which are affected by heavy metals pollution. The presence of heavy metals in the environment leads to a number of adverse impacts. Such impacts affect all spheres of the environment. Until these impacts are dealt with, health and mortality problems will become rapidly increased, as well as the disturbance of food chains. Table 1 summarizes the health impacts of heavy metals.

Table 1.1: Impacts of heavy metals on the environment (García-Niño et al., 2014).

HEAVY METALS	HEALTH IMPACT
As (Arsenic)	Skin, Lungs, Brain, Kidneys, Liver, Metabolism, Cardiovascular, Immunological, Endocrine
Cd (Cadmium)	Bones, Liver, Kidneys, Lungs, Testes, Brains, Immunological, Cardiovascular
Cr (Chromium)	Skin, Lungs, Kidneys, Pancreas, Testes, Gastrointestinal, Reproductive.
Hg (Mercury	Brain, Lungs Kidneys, Liver, Immunological, Cardiovascular, Endocrine, Reproductive.
Cu (Copper)	Liver, Brain, Kidneys, Cornea, Gastrointestinal, Lungs, Immunological, Hematological.
Pb (Lead)	Bones, Liver, Kidneys, Brain, Lungs, Spleen, Immunological, Haematological, Cardiovascular, Reproductive

It has been shown that accumulation of heavy metals in the kidney and liver of humans may occur after prolonged exposure to unsafe concentrations of heavy metals through foodstuffs. Pregnant women or very young children are more vulnerable to heavy metal toxicity. Some of the other important effects of heavy metal poisoning are neurological disorders, central nervous system destruction, and cancers of various body organs. They may cause disruption of several biochemical processes, leading to cardiovascular, nervous, kidneys and bone diseases. Also, there are some reports showing low birth weight and severe mental retardation of newborn children where during pregnancy mother exposed to toxic amounts of a heavy metal through direct or indirect consumption of vegetables. *(*Kumar *et al.,* 2007*; Sharma et al.,* 2008*).*

Vegetables are vital to Nigeria people's diet, and in particular provide the well-known nutrients to maintain normal physiological functions and among the most daily consume food stuff. This fact shows the importance of evaluating the safety of vegetables in aspect of heavy metal contamination. The prolonged application of large amount of fertilizers and pesticides has resulted in heavy metal accumulation in vegetable gardens, vegetables take up heavy metals and accumulate them in their edible and non-edible parts at quantities high enough to cause clinical problems to both animals and human beings. Exposure to heavy metals by the consumption of contaminated vegetables and its toxicity is a serious concern, as an example; the consumption of contaminated food can seriously deplete some

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essential nutrients in the body causing a decrease of immunological defenses, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Lacatusu *et al.,* 2005).

This study work on the presence of heavy metals using Atomic Absorption Spectroscopy in different vegetables such as Jute mallow (*Cochorus Olitorus*) and Africa spinach (*Amaranthus hybridus)* composite samples collected randomly from two (2) different study locations from Offa Local Government Area, screened the measured heavy metals on physiology, and nutrient reduction associated with impact on humans.

Materials and Methods

Apparatus and instruments

Properly cleaned polyethylene bags were used for soil and vegetable samples collection. A Milestone Microwave was used for digestion of vegetable and soil samples, while Drying Oven was employed to dry the soil and vegetable samples. Analytical balance was employed to weigh the processed samples, and measuring cylinders, pipette, and micropipette were used to measure different volumes of sample solutions, acid reagents and metal standard solutions. The digested samples were filtered with Whatman No. 42 filter paper and the digestion processes were performed in a laboratory fume hood. The Atomic Absorption Spectrometer was used for the determination of target metals in vegetable and soil samples considered in this study.

Chemicals and reagents

All reagents and chemicals used in this study were analytical grade. Double distilled water was used for all preparation and dilution purposes of solutions throughout the experimental procedures. Chemicals such as HNO_3 (69%), ammonium acetate (≥98%), sodium acetate (≥99%), KCl (≥99%), HAc (≥99%), $MgCl_2$ (≥99%), $NH_4OH.HCl$ (98%), H_2SO_4 (98%) and H_2O (30%) and HCl (37%) were used during sample digestion procedures. Stock standard solutions of 1000 ppm were prepared from their corresponding salts for the selected heavy metals (Co, Zn, Cr, Pb and Cd). Standard buffer solutions of pH = 4, 7 and 9 were used for pH meter calibration and KCl was used for conductivity meter calibration.

Sampling Site

Soil and plant samples were collected from 2 sites within Offa Town, Kwara State, (Figure 1), Afelele Area Offa and Along Offa erin-ile road, beside NEPA office, Offa, Kwara State. The following vegetables are considered for heavy metals investigation: Jute Mallow (*Cochorus Olitorus*) and Africa spinach (*Amaranthus hybridus).* The sites were commercial vegetables farms/gardens.

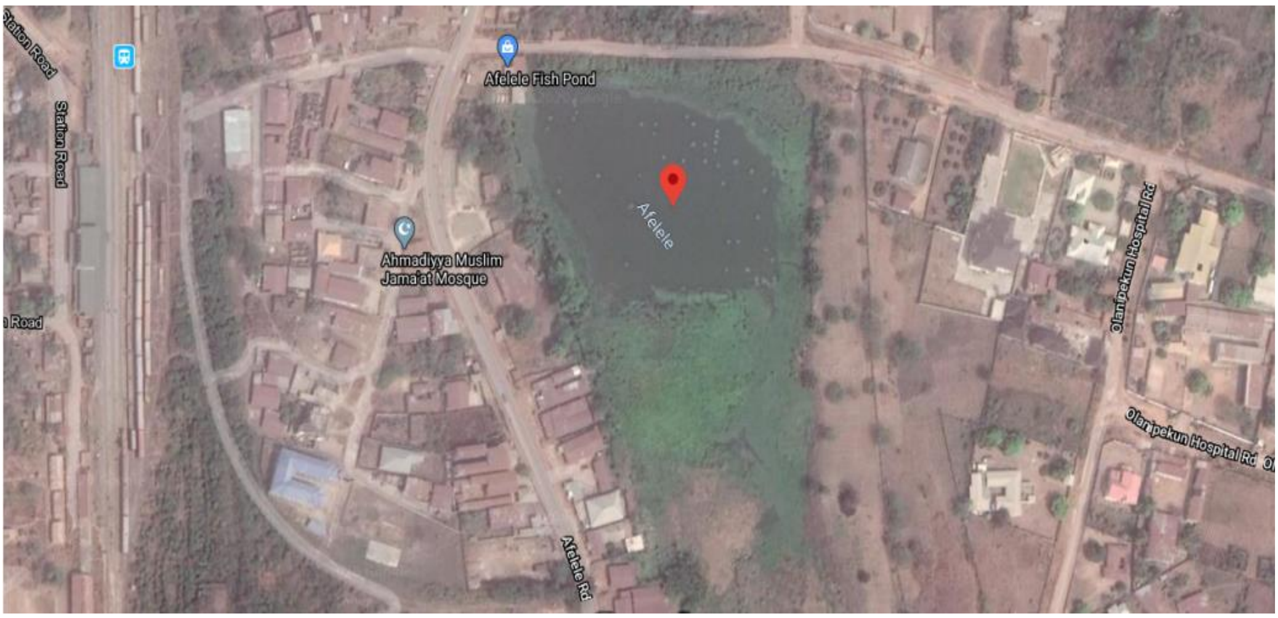

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Figure 1. Afelele Site Offa, Map Location (www.googlemap.com)

Vegetables sample collection and preparation

The edible part of vegetable samples Jute Mallow (*Cochorus Olitorus*) and Africa spinach (*Amaranthus hybridus)* were collected into a pre-cleaned and sterilized separate polyethylene bags. The vegetable samples were directly collected from privately owned farmlands with the consent of the owners (farmers). About 1 Kg of each (Jute Mallow and Africa Spinach) were separately collected from five randomly selected subsampling sites and pooled together to form a composite sample.

The bruised or rotten portions were manually removed and the remaining samples were carefully packed and immediately transported to the Federal Polytechnic Offa, Science Laboratory Technology, Research Laboratory, Kwara State, for further processing and analysis. The vegetable samples were washed with tap water and distilled water in laboratory to remove adsorbed dust and particulate matters and then cut and chopped into small pieces using plastic knife in order to facilitate drying. Subsequently, the samples were air-dried for five days and further dried in hot air oven at 50–60°C for 24 hrs., to remove moisture and maintain constant mass. The dried samples were grounded into powder using acid washed laboratory mortar and pestle and then sieved using 2 mm mesh size sieve. The sieved samples were finally stored in polyethylene bags and kept in desiccators until digestion analysis.

Soil sample collection and preparation

Soil samples (about 1 Kg) were collected into a clean polyethylene bags from the same sites where the vegetable samples were collected (for each vegetable type separately) with the consent of the farmers at 0–20 cm depth using a steeliness steel spoon and pooled together to form composite sample. The collected, carefully packed and labeled soil samples were then transported to the Federal Polytechnic Offa, Science Laboratory Technology, Research Laboratory, Kwara State, for pretreatment and analysis. In laboratory, the soil samples were air dried in a dry and dust free place at room temperature (25°C) for 5 days, followed by an oven dry until constant weights were attained. The samples were then ground with a mortar and pestle to pass through a 2 mm sieve and homogenized. The dried, sieved, and homogenized soil samples were finally stored in polyethylene bags and kept in desiccators until digestion analysis.

Optimization of digestion procedures for soil and vegetable samples

To select an optimum condition for digestion procedure, parameters like digestion time, reagent volume and digestion temperature were optimized by varying one parameter at a time while keeping the others constant. The

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optimum conditions were selected based on clarity of digests, minimum reagent volume consumption, minimum digestion time, simplicity and minimum and optimal temperature required to complete digestion of samples. Accordingly, a representative sample for both soil and vegetable were taken separately and digestion procedures were followed under controlled condition by varying one parameter while keeping others constant. From the optimization procedures, an acid volume of 9 mL of HNO_3 and 3 mL HCl at digestion time of 45 minutes, and digestion temperature W and 180°C, respectively, were found to be the optimal condition to digest 2g of each soil and vegetable samples.

Digestion procedures for vegetable samples.

The samples were washed with distilled water to eliminate air-borne pollutants. Leafy stalks were removed according to the common household practices. Excess moisture was removed by drying samples on the sheet of paper. The samples were then sliced, weighed and oven dried at 60 °C to a constant weight. Each oven-dried sample was ground in a mortar to pass through a 60-mesh sieve. Each determination was carried out by accurately weighing a sample of 2 g of a ground sample in a crucible before placing it in a muffle furnace and ashed at 450 ^oC for 12 h. The ash was then digested with 5 ml of 20% (v/v) analar HCl (Perkin-Elmer 1982). The residue was then filtered into a 50 ml volumetric flask using Whatman filter paper No. 41, and the solution was made to the mark with deionised water. AAS was used for the determination of the heavy metals. Each sample solution was run in duplicate to ensure the repeatability of the obtained results. The same procedure was followed for each sample and the appropriate dilution factors were used in the calculation

Digestion procedures for soil samples.

A 2 g of dried and homogenized soil samples were similarly transferred in to microwave digestion vessel in triplicate. In each of this vessel, 9 mL of 10 M HNO_3 and 3 mL 10 M HCl were added and the samples were digested at 180°C for 45 mins. The clear solutions obtained were then filtered out through Whatman No. 42 filter paper to a 50 mL volumetric flask and finally diluted to the mark with 2% HNO_3 following procedure reported by with slight modification as per the optimized conditions. The heavy metals of interest were then assayed by Atomic Absorption Spectroscopy (AOAC 1995).

The concentrations of Cadmium (Cd), Cobalt (Co), Chromium (Cr), Zinc (Zn), and Lead (Pb) in the vegetables and their growing soil samples were determined by using Atomic Absorption Spectroscopy after properly calibrating the instrument using calibration blank and five working calibration standard solutions of each metals to analyzed. All the calibration procedures were evaluated based on their corresponding correlation coefficients (r) of the calibration curves which were found to be ≥ 0.998.

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Results and Discussion

Results

Poor environmental management, sewage and industrial wastewater regularly utilized as water system for the production of vegetables and different products especially in the rural regions. The table 1 presents the metal contamination in wastewater irrigated soil, concentration of heavy metals analyzed for soil samples under African spinach and Jute mellow cultivation from two selected area of Offa farmland and the maximum permissible concentration by FAO/WHO .

Table 1: Concentration of heavy metals (mg kg^{-1}) in vegetables growing soil

		Concentration(mg/kg)				
S/N	**Sample ID**	**Pb**	**Cr**	**Cd**	**Zn**	**Co**
1	ASGA1	6.5	2.5	ND	112.00	7.50
2	ASGA2	6.5	4.0	ND	40.50	3.50
3	JMGA1	11.0	1.5	ND	27.50	1.00
4	JMGA2	63.0	6.0	ND	27.00	5.00
5	FAO/WHO	100	100	3	300	50

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Vegetables are an essential part of human diet and assume an essential part in the human nourishment since the start of human life. However, as it may, the edible portion of vegetables shifts and relies on the convention and particular vegetables to be consumed. The examined vegetables showed different concentration for every metal taken under study. Their concentrations were compared to know if it crossed the safe limits as set by WHO/FAO, as given in Table 2.

Table 2: Concentration of heavy metals (mg kg^{-1}) in vegetables samples

		Concentration(mg/kg)				
S/N	**Sample ID**	**Pb**	**Cr**	**Cd**	**Zn**	**Co**
1	ASA1	10.0	12.5	ND	97.00	ND
2	ASA2	4.0	8.0	ND	74.50	0.50
3	JMA1	21.5	9.5	ND	37.50	ND
4	JMA2	19.0	8.5	ND	35.50	ND
5	FAO/WHO	0.30	0.1	0.10	100	50

Soil-vegetable transfer coefficients

The transfer coefficient quantifies the relative differences in bioavailability of metals to plants and is a function of both soil and plant properties. The coefficient is calculated by dividing the concentration of a metal in a vegetable crop by the total metal concentration in the soil. Higher transfer coefficient represents relatively poor retention in soils or greater efficiency of plants to absorb metals. Low coefficient demonstrates the strong sorption of metals to the soil colloids *(Coutate TP 1992)*. Soil-to-plant transfer is one of the key components of human exposure to metals through food chain. Transfer Factor (TF) or Plant Concentration Factor (PCF) is a parameter used to describe the transfer of trace elements from soil to plant body and it is also is a function of both soil and vegetables properties. The transfer coefficient was calculated by dividing the concentration of heavy metals in vegetables by the total heavy metal concentration in the soil 2. *(Kachenko and Singh, 2006).*

$$TF = \frac{C_{plant}}{C_{soil}} \qquad 1$$

Where,
C_{plant} : metal concentration in vegetable tissue, mg kg^{-1}
C_{soil} : metal concentration in soil, mg kg^{-1}.

Table 3: Transfer factors of heavy metal from selected area in offa soils into the vegetable samples.

Sample ID	**Pb**	**Cr**	**Cd**	**Zn**	**Co**
Africa Spinach Vegetable and Soil from A1	1.538	5.000	-	0.866	-
Africa Spinach Vegetable and Soil from A2	0.615	2.000	-	1.840	0.143
Jute Mallow Vegetable and Soil from A1	1.955	6.333	-	1.364	-
Jute Mallow Vegetable and soil from A2	0.302	1.417	-	1.315	-

Sample Description

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Table 4: Description of the studied vegetables growing soil in selected area of offa.

S/No.	Soil	Sampling Site	Sample ID
1	Africa Spinach Growing Soil	A1	ASGA1
2	Africa Spinach Growing Soil	A2	ASGA2
3	Jute Mallow Growing Soil	A1	JMGA1
4	Jute Mallow Growing Soil	A2	JMGA2

A1= Along Offa-erin ille road, beside NEPA office, Offa. A2= Beside Afelele River Offa Kwara State.

Table 5: Description of the studied vegetables cultivated in selected area of offa.

S/No.	Local Name	Scientific Name	Sampling Site	Sample ID	Vegetable Type
1	Africa Spinach Vegetable	*Amaranthus hybridus*	A1	ASA1	LEAFY
2	Africa Spinach Vegetable	*Amaranthus hybridus*	A2	ASA2	LEAFY
3	Jute Mallow Vegetable	*Cochorus Olitorus*	A1	JMA1	LEAFY
4	Jute Mallow Vegetable	*Cochorus Olitorus*	A2	JMA2	LEAFY

A1= Along Offa-erin ille road, beside NEPA office, Offa. A2= Beside Afelele River Offa Kwara State.

Discussion

Cadmium (Cd):

Cadmium (Cd) is non-essential and has no advantageous part in plants, animals and people and has no nutritious capacity, as they are exceptionally toxic. Cd and micronutrients have solid cooperation in gastrointestinal assimilation. Fe and Zn are the most critical micronutrients associated with these interactions. This retention includes intestinal Fe transporters. Women and children have higher body Cd than men in light of the fact that their Fe necessities are more noteworthy than men. Therefore satisfactory sustenance is imperative for youthful youngsters and pregnant ladies in the prior stages to have ideal improvement and growth. The concentration of Cd in the two selected vegetables with their growing soil is lower than the detection limit. This shows that both area selected or under study are not contaminated with Cd as its concentration is lower that maximum permissible limit 0.10 mg/kg and 3.00 mg/kg set by FAO/ WHO for vegetables and Soil (Table 5 and 6).

Chromium (Cr):

The level of Cr was in of range 1.5 mg/kg to 6.0 mg/kg for selected vegetables soil and 8.0 mg/kg to 12.5 mg/kg for vegetables sample in selected areas of offa. Cr maximum concentration 12.5 mg/kg which was recorded in african spinach from A1 site and lowest 1.5 mg/kg was seen in jute mallow growing soil from site A1 as shown in Table 1 and 2. The vegetables in the present study showed the maximum level of heavy metals that might be linked with the high absorption rates of leafy vegetables having a large surface area. Concentration in african spinach exceeds standard limit 0.1 mg/kg set by FAO/WHO. Africa spinach from site A1 is followed by Jute mallow with the concentration 12.5 mg/kg and 9.5 mg/kg respectively, while their growing soils still below the permissible limit of 100 mg/kg by FAO/WHO for soil in which jute mallow growing soil has the highest value of 6.0 mg/kg followed by african spinach 2.5 mg/kg. However all the vegetables in terms of Cr concentration exceeds the allowed limit 0.1 mg/kg by FAO/ WHO.

Lead (Pb):

The concentration of lead (Pb) in vegetables samples was found in toxic level. Which were varied from 4.0 mg/kg to 21.5 mg/kg. The highest lead content was found in jute mallow (21.5 mg/kg) from site A1 while in africa spinach it was lowest in concentration (4.0 mg/kg). According to the standard limit of lead for vegetables by FAO/WHO it is 0.3 mg/kg. It is found from Table 6 that in all vegetables, lead concentration is more than permitted level, so they are not suitable for consumption. In the study area lead concentration that was found in the vegetables growing soil

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are below the allowed concentration for soil by FAO/WHO (100 mg/kg) in which jute mallow growing from A2 has the highest lead concentration of 63 mg/kg while african spinach growing soils from site A1 and A2 has the lowest concentration of 6.5mg/kg. The of high concentration of lead stems from human activities such as waste water irrigation, solid waste disposal and sludge applications, solid waste combustion, agrochemicals and vehicular exhausted. The lead in fuels can contribute to the air pollution. It is highly unlikely that in that region, the traffic is so voluminous that the air pollution could convert to soil pollution in short term. Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible change in their appearance or yield. In many plants lead accumulation can exceed several hundred times the threshold of maximum level permissible for human. The introduction of lead into the food chain may affect human health and may cause disruption of the biosynthesis of hemoglobin and anemia, rise in blood pressure, kidney damage, miscarriages and subtle abortions, disruption of nervous systems and brain damage.

Zinc (Zn):

Zn is additionally one of the micronutrient basically needed for normal plant development, however just a little amount of these components is required particularly Zn (25-150 mg/kg). Zn is the slightest lethal and a basic component in human eating regimen as it is required to keep up the working of the immune defense. Zn lack in the eating routine might be exceedingly negative to human health than an excess of Zn in the eating diet. The Zn content was measured in range of 35.5 mg/kg to 97.00 mg/kg (Table 6) for vegetables and 27.00 mg/kg to 112.00 mg/kg for vegetables growing soils. Zn maximum concentration 97 mg/kg for vegetable in african spinach from site A1 which is very close to the permissible limit set my FAO/WHO (100mg/kg) for vegetables and maximum value recorded for growing soil was 112.00 mg/kg from african spinach growing soil from site A1, this concentrations for soil has not exceed standard limit 300 mg/kg. However all the vegetables in terms of Zn concentration did not exceed the safe limit of FAO/WHO. Regular consumption of these two vegetables from the two sites may assist in preventing the adverse effect of Zn deficiency which results in retarded growth and delayed sexual maturation because of its role in nucleic acid metabolism and protein synthesis.

Cobalt (Co):

Cobalt particles are deposition in the upper and lower respiratory tract when ingested, where they can be retained or absorbed into the blood after dissolution or mechanically transferred to the gastrointestinal tract by mucociliary action and swallowing. Approximately 50% of the cobalt that enters the gastrointestinal tract will be absorbed. Cobalt absorption is increased among individuals who are iron deficient. Water-soluble forms are better absorbed than insoluble forms. Cobalt is essential as a component of vitamin B_{12}; therefore, it is found in most tissues and lower in liver and lungs. Urinary excretion increases with time following inhalation exposure. Particle size affects elimination of inhaled cobalt, since more cobalt is mechanically cleared to the gastrointestinal tract when particles are larger. Faecal elimination is the primary route of excretion following oral exposure in humans. In present study no concentration was detected in all the vegetable samples except for African spinach from site A2 which has 0.5mg/kg concentration, while all the vegetables soil from different areas of Offa are below the permissible limit set by the FAO/WHO which is 50mg/kg this might be associated with no or low anthropogenic activities including the burning of fossil fuels, sewage sludge, phosphate fertilizers, mining and smelting of cobalt ores, processing of cobalt alloys, and industries that use or process cobalt compounds that can cause cobalt contamination in the selected area

Transfer factor (TF)

In this study, the TF of different heavy metal from soil to vegetable are presented in Table 7. Higher transfer factors reflect relatively poor retention in soils or greater efficiency of vegetables to absorbs metals. Low transfer factor reflects the strong sorption of metals to the soil colloids *(Wierzbicka M 1995)*. The TF value ranges were: Pb 0.302-1.955, Cr 1.417 - 6.333, Zn 0.866 - 1.364 and Co 0.00- 0.143 and the trend of TF for heavy metal in vegetable samples studied were in order: Cr>Pb>Zn>Co>Cd. The mobility of metals from soil to plants is a function of the physical and chemical properties of the soil and of vegetable species, and is altered by innumerable environmental and human factors *(Alloway BJ and Ayres CD 1997)*. The highest TF value was found 6.333 and 1.955 for Cr and Pb. These might be due to higher mobility of these heavy metals with a natural occurrence in soil and the low retention of them in the soil than other toxic cations . According to the soil to plant transfer factor (TF) calculated for tested metals and leafy vegetables, it can be concluded that Pb and Cr was high accumulator among the investigated

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metals. However, the higher concentrations of these heavy metals are due to the waste water irrigation, solid waste disposal and sludge applications, solid waste combustion, agrochemicals and vehicular exhausted.

Conclusion

This study has established a database about the contamination status of heavy metals in popular vegetables and their growing soil in selected areas of Offa Local Government, Kwara State. Although the concentration of heavy metals in soil was found to be within the permissible limit but the concentration of Pb, Cr, and Zn in vegetable were higher than the safe limit recognized by joint FAO/WHO. So, the soil in these areas is quite safe for cultivation and also the vegetables are safe for eating. But dietary intake of these vegetables result in long term low level body accumulation of heavy metals and the detrimental impact becomes apparent only after several years of exposure. Thus this study area is one of the more vegetable growing areas in Offa. So regular monitoring of these toxic heavy metals in soil, in vegetables and other food materials is essential to prevent excessive build-up in the food chain. The higher concentration of heavy metal in vegetables might be due to anthropogenic activities like deposition from vehicle emission, excessive use of wastewater, fertilizer, pesticides in agricultural fields and dependent on their respective transfer factor between the vegetables and their growing soil. Hence, awareness should be given to the farmers of the area regarding the serious consequences of using contaminated wastewater for irrigation purpose and selective use of fertilizers and pesticides.

Recommendation

It is recommended that the study of heavy metals in environmental components in the proposed area of Offa areas should be repeated at least two times in every year to know either any changes in contamination levels are occurring or not. The remediation of the contamination of soil and vegetables is necessary not only to preserve soil and vegetables but also to safeguard ecosystem.

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