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RESEARCH ARTICLE

HEAVY METALS ACCUMULATION IN IRRIGATED SOIL ON LETTUCE PRODUCTION (*LACTUCA SATIVA*) IN GOMBE STATE, NIGERIA

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ABSTRACT

The study was conducted in Gombe State, Nigeria. The objective of the study was to determine the concentration and distribution of heavy metals inirrigated soil as it affect Lettuce (Lactuca sativa) production in Gombe state. Three zones that make up the state namely Gombe North, Gombe Central and Gombe South were used for the study. From each zone three locations were selected, plant (Lettuce) samples and soil samples were collected randomly from the locations and air dried in a room, sieved, grinded and digested as describe by USEPA (1996) and analysed in standard laboratory. The result showed that plant (Lettuce) heavy metals concentration were in descending order of Fe>Zn>Cu>Pb>Cd>Cr>Ni>As, and ranged as follows (Fe.4.31^b – 7.15^amgkg^{-1}),(Zn 3.40^b – 7.97^amgkg^{-1}), (Cu 2.19^b – 2.76^a), (Pb 0.80^b – 2.46^a mgkg^{-1}), (Cd 0.22^b – 0.45^amgkg^{-1}), (Cr 0.17^b – 0.30^a mgkg^{-1}), (Ni 0.10^b – 0.45^amgkg^{-1}) and (As0.06^b – 0.10^amgkg^{-1}) across the zones. All the concentration of heavy metals in lettuce plant was within the permissible limit of food standard committee and WHO. The result from the study suggested that significant difference existed in heavy metal concentration in lettuce plant analysed which might be due, partly, to the geology of the soil and anthropogenic activities of the communities. Though the concentration in the plant (lettuce) was low, there is tendency of accumulation in future. Regular monitoring of heavy metals in plant was suggested to avoid excessive build up in future and further research on other crops grown in the study areas was also recommended.

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INTRODUCTION

Deteroration of the general environment has focused an increased global interest. In this respect, contamination of agricultural soil with heavy metal has always been seriously a critical challenge in the scientific environment (Faruk *et al.*, 2006) due to their cumulative behaviour and toxicity;however, they have a strongly hazardous effect not only on crop plat but also on human health (Das *et al.,* 1997). Even metal that are substantial to plant growth like copper (Cu), Magnesium (Mn) Molybdeun (Mo) and Zinc (Zn) can be toxic at high concentration in the soil, which ends up in food series. Some element not know to be essential to plant growth, such as Arsenic (As), Selenium (Sn), Barium (Ba) Cadmium (Cd), Chromium (Cn) Lead (Pb), and Nicked (Ni) also are toxic at high concentration or under certain environmental condition in soil. Heavy metals are metallic element that are present in both natural and contaminated environment in natural environment, they occur at low concentration, However in contaminated environment, the concentration of element are high (Hitschison, 1980), Anthropogenic activities like mining, smelting operation, domestic, industrial, farming activities such as the use of fertilizer, traffic emission municipal waste industrial effluent, have dramatically generated and increase in the production of one form of pollution or the other and subject to the menace in the environment (Wagajyoti *et al.*, 2010; Chibueke and Obioma, 2014 and Nriagu, 1990). However heavy metals (e.g Pb, Cd, Mn, Ni, cd) are associated with continued irrigation of agricultural land with domestic and industrial waste which causes accumulation in the soil and vegetable (Ibrahim *et al.*, 2014). However heavy metals get

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accumulated with time in soil and plant due towaste water irrigation (Lakeshwari and Chandrappa, 2006). Soil to plant transfer of heavy metal is the major path way of human exposure to metal contamination. Vegetables take up heavy metals and accumulate them in their edible and non edible part in quantities high enough to cause clinical problems to human beings and animals (Lakeshwari and Chandrappa, 2006). The bioavailability of a metal of a particular type on a species of plants is referred to as transfer factor (TF). This however, is dependent on different factor such as the soil pH and the nature of plant itself. A convenient way for qualifying the relative difference of bioavailability of metal to plant is the transfer coefficient. The higher transfer coefficient of heavy metal indicates the stronger accumulation of the respective metal by vegetable (Smith *et al.,* 1996; Alloway, 1995 and Sonayeri *et al.,* 2009). The tradition of growing vegetable within and at edges of cities is very old (Smith *et al.,* 1996). It should be realised that most of these cultrate soils are contaminated with heavy metals contributed through vehicular emissions, fertilizer, industrial effluent and other anthropogenic activities. These contaminated soils have resulted in the growth of contaminated vegetable, (Alloway, 1995; Sonayeri *et al.,* 2009). It was reveal that soil, irrigation water and some vegetable in the urban sites are usually contaminated by metals. Heavy metal not only affects the nutrient value of vegetables but also affect the health of human beings and therefore the safe limit of these heavy metals should be lowered regularly in vegetable, a responsibility saddled onto national and international regulations authority (Mohammed and Ahmed, 2006). Mostly the concentration of heavy metals is higher in soils than vegetables grown (Davis and White, 1981) but the contaminationdiffer from area to area as the application of fertilizer and other human activities differed but most are from geologic and anthropogenic activities. Agricultural pollution is one of the most investigated subjects by research at present time. Most of applied fertilizer, pesticide, industrial and municipal waste water, in the name of adding nutrient to replenish crop has become sources of heavy metals in soil (USEPA, 1996). Unlike other pollutants that are visible, heavy metals may accumulate in vegetable crop to toxic level to human and ecosystem. The measures of the fluxes of heavy metal pollutant from soil to plant can aid in knowing the distribution and concentration in the irrigated farm land. There is need, therefore, to determine the presence of heavy metal in the agricultural crop (e.g lettuce) in the environment.

Statement of the Problem

Agricultural pollution is one of the most investigated subjects by research at present time. Most of the applied fertilizers, pesticides, industrial and municipal waste water, in the name of improving crop production has become sources of heavy metals in soil. Unlike other pollutants that are visible, heavy metals may accumulate in vegetable crop to toxic level and thus to human and ecosystem. The measures of the fluxes of heavy metal pollutant from soil to plant can aid in knowing the distribution and concentration in the irrigated farm land.

Objective of the Study

To determine the presence and concentration of heavy metal in the agricultural crop (e.g. lettuce) in the environment.

Accumulation

Heavy metal accumulation in agricultural soil is potentially hazardous to human and livestock health, excessive accumulation also present the risk of elevated heavy metal uptake by crops which could affect food quality and safety (Omolaye, 2009), stated that heavy metals are of interest due to their abundance in the environment, which has increased considerably as a result of human activities. Their fate in polluted soils is a subject of study because of the direct potential toxicity to biota and the indirect threat to human health via the contamination of soils and accumulation in food crops (Martinez and Motto, 2000). Heavy metals are dangerous because they tend to bioaccumulate, .High concentration of heavy metals have negative influence on living organism, likewise the concentration of some heavy metal (Lead) Pb, Cadmium (Cd), Zinc (Zn). All concentration of heavy metals in the soil and grasses varies yearly depends on the places and need to be monitor every yea. Heavy metal pollution of soil enhances plant uptake causing accumulation in plant tissues. In environments with high nutrient levels, metal uptake can be inhibited because of complex formation between nutrient and metal ions. Therefore, a better understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in water and soil on plant systems seems to be a particularly important issue (Sharma *et al*., 2008). Accumulation of heavy metals can also cause a considerable detrimental effect on soil ecosystems, environment and human health due to their mobilities and solubilities which determine their speciation (Kebata-Pendias, 1992). The soil to plant transfer factor is one of the important parameters used to estimate the possible accumulation of toxic elements, especially radionuclides through food ingestion. Different studies have indicated that crops grown on soils contaminated with heavy metals have higher concentrations of heavy metals than those grown on uncontaminated soil (Nabulu, 2008). Heavy metals accumulating in soil directly or through plants indirectly enter food chains, thus endangering herbivores, indirectly carnivores and not least the top consumer humans (Kadar, 1995). Compounds accumulate in living organisms any time they are taken up faster than they are broken down (metabolized) or excreted Metals such as lead, arsenic, cadmium, copper, zinc, nickel, and mercury are continuously being added to our soils through various agricultural activities such as agrochemical usage and long-term application of urban sewage sludge in agricultural soils, industrial activities such as waste disposal, waste incineration and vehicle exhausts, together with anthropogenic sources. All these sources cause accumulation of metals and metalloids in our agricultural soils and pose threat to food safety issues and potential health risks due to soil to plant transfer of metals (Khan, 2005).

Effect of heavy metals on humans

Heavy metals have been known to have harmful effect to the body systems upon ingestion over time and in much quantity. Arsenic can cause cancer, nausea, vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of “pins and needles” in hands and feet. Long-term low level exposure can cause a darkening of the skin and the appearance of small “corns” or “warts” on the palms, soles, torso and death from much intake (Scragg, 2006). Cadmium and cadmium compounds are carcinogens. Much intake irritates the stomach, leading to vomiting and diarrhea. Long-term exposure to lower levels leads to a buildup in the kidneys and possible kidney disease, lung damage, and fragile bones (Campbell, 2006). Breathing high levels of Chromium can cause irritation to the lining of the nose; nose ulcers; cancer and breathing problems, such as asthma, cough, shortness of breath, or wheezing. Skin contact can cause skin ulcers. Over time, it could damage the liver, kidney circulatory and nerve tissues, as well cause skin irritation (Smith *et al.,* 1996). Lead is carcinogenic, affecting every system of the body. It reduces the functioning of the nervous system; weakness in fingers, wrists, or ankles; small increases in blood pressure; and anemia. High intake can damage the brain and kidneys and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High level exposure in men can damage the organs responsible for sperm production (Simeonov *et al.,* 2010). Zinc (Zn) can interrupt soil activities, as it negatively influences the activity of microorganisms and earthworms, thus retarding the breakdown of organic matter. It pollutes the water bodies and magnify fishes in the foodchain (Greany, 2005; Hardy *et al.,* 2008).

Soils contaminated with cupper poses both direct and indirect threats: direct, through negative effects of metals on crop growth and yield, and indirect, by entering the human food chain with a potentially negative impact on human health. Even a reduction of crop yield by a few percent could lead to a significant long-term loss in production and income (Greany, 2003). Nickel is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded (Khodadout *et al.,* 2004). Iron causes conjuctivis, choroiditis and retinitis if it contacts and remains in the tissue (Basta *et al.,* 2005).

Sampling and Sampling preparation

Plant sampling

Gombe state comprises three senatorial zone, namely Gombe north, Gombe central and Gombe south. In each zone, three Local governments were randomly selected within the study area. Plant samples were collected from the locations. The samples collected were washed thrice with distilled water and oven dried at 80^0c for 72 hours before chemically analysing the samples. The dried samples were grinded using motor and pestle, it was then sieved with a 0.5mm mesh to obtain a fine powder. The sieved samples were then labelled and stored for laboratory analysis. This procedure was replicated thrice. Similar method was used by (Dean, 2013).

Procedure for Heavy Metals Determination

5g of each of the plant (lettuce) was placed in 100ml beaker. 15ml of HNO_3; H_2SO_4 and HCL mixture (5:1:1) of tri-acid were added and the content heated and digested gently at low heat on digestion block machine for about 2 hours at 80 – 100^0c until transparent or colourless solution was obtained. After cooling, the digested sample was filtered using Whatman filter paper (No. 42). It was then transferred to a 100ml volumetric flask and made to mark with distilled water. The digested sample transferred into plastic 100ml bottle for the heavy metals determination using A.A.S. machine ,buck scientific VGP model 210 (USEPA, 1996) at their respective wavelengths. For the plant, USEPA (1996) method was used for digestion. Though not a total digestion technique (Chen *et al.,* 2014) it was found a very strong acid digestion method that dissolved almost all elements that were environmentally available.

Transfer Factor (TF)

Metal concentrations in the extract at soils and vegetable were calculated on the basis of dry weight ($mgkg^{-1}$). TF was calculated as follows (Cui *et'al,* 2004)

$$TF \quad = C\frac{C(vegetable)}{C(Soil)}$$

Where C (vegetable)= Metal concentration in vegetable (mg/kg^{-1}).
C(Soil) = Metal concentration in Soil (Mg/kg^{-1})(Cui *et'al,* 2004)

Statistical Analysis

The data were reported as mean, standard error and coefficient of variability (Cv %). One way analysis of variance (ANOVA) was used to determine significant difference between groups at level of significance of 5% (P = 0.05) using SPSS (USDA, 2000)

RESULTS AND DISCUSSION

Table 1 shows the mean metals concentrations of Zinc (Zn), Copper (Cu), Iron (Fe), Cadmium (Cd), lead (Pb), Chromium (Cr), Nickel (Ni) and Arsenic (As) of lettuce at the three senatorial zones. According to the results Gombe central had significantly (P=0.05) different values of some metals studied (Zn, Cu & Fe) than the other zones. Each metal has the mean of; Zn (5.28), Cu (2.47) Fe (7.65), Cd (0.34), pb (1.43), Cr (0.23), Ni (0.12) and As (0.07). Zn, Fe and Pb were highly variable with a Cv % percent of 45.27, 47.32, and 62.89 respectively; while Cd, Cr, Ni and As were moderately variability each having a Cv % of 34.76%, 29.37%, 22.05% and 31.49% respectively. Only Cu recorded a low variation across the zones (Cv % = 11.54%). The order of level of heavy metals in lettuce vegetable was Fe > Zn > Cu > Pb > Cd > Cr > Ni > As. Heavy metal content by plants can be affected by several factors including metal concentration in soils, soil pH, cation exchange capacity, organic matter content, types and varieties of plants and plant age. It is generally accepted that the metal concentration in soil is the dominant factor (Adriano, 1986). Heavy metal availability can also be directly affected by plant itself (Zhang *et al*., 2009). In the present study, it was observed that the concentration of Pb in lettuce was higher than the Cd. In general, vegetable studied from different areas had a concentration of Pb higher than that of Cd (Dei'rezen and Aksoy, 2004). The lettuce Pb and Cd concentrations was found to be higher than the maxmimum limit by FAO/WHO(2001), but lower than the values reported by Singh and Kumar (2004) who reported that the values of Pb and Cd content in spinach ranged between 1.7 and 7.0 as 2.0 and 7.1 $mgkg^{-1}$respectively. The Cr concentration found in the study areas were lower than FAO/WHO(2001) limits, but in agreement with the ranged given by Wagajyoti *et.al* (2010) who found Cr concentration in five leafy vegetables ranging between 0.89 to 1.08 $mgkg^{-1}$. Singh and Kumar in (2004) concluded that soil irrigation water and some vegetables from peri-urban sites are significantly contaminated by the heavy metals i.e Cu, Cd, Pb, and Zn. Heavy metals not only affect the nutritive value of vegetables but also affects the health of human beings. Different vegetables had different ability and capacity in accumulating different metals. Some plants are hyper-accumulators (e.g cabbage) while others are mono-accumulators. Xiong, (1998) and Benzarti *et.al* (2008) showed that the concentrations of Cd in alfalfa, lettuce, radish and *T. caerulescens* increased with increases in dose of Cd in soil. Kwadon, Cr concentration registered the lowest value (0.22). We can also observe that the means of Akko lettuce Ni and As concentrations are higher than the mean concentration in the other locations. The lettuce heavy metals concentration at the Gombe south zone (Table 4) shows Kaltungo and Billiri lettuce heavy metals concentrations of Zn, Fe, Pb, Cr, Ni and As did not differed statistically but had recorded lower mean

Table 1. Heavy metal concentration in lettuce at three senatorial zones of Gombe state $Mgkg^{-1}$

Location	Zn	Cu	Fe	Cd [Mgkg-1]	Pb	Cr	Ni	As
Gombe North	4.47b	2.19b	7.15b	0.22b	0.80b	0.17b	0.11b	0.06b
Gombe Central	7.97a	2.76a	11.50a	0.36a	2.46a	0.30a	0.45a	0.10a
Gombe South	3.40b	2.46b	4.31b	0.45a	1.03b	0.21b	0.10b	0.06b
Mean	5.28	2.47	7.65	0.34	1.43	0.23	0.12	0.07
SE	0.80	0.10	1.21	0.04	0.30	0.02	0.01	0.01
Cv %	45.27	11.54	47.32	34.76	62.89	29.37	22.05	31.49

Table 2. Heavy metals Concentration in lettuce at the Gombe north senatorial zone

Location	Zn	Cu	Fe	Cd	Pb [Mgkg-1]	Cr	Ni	As
Dukku	5.26a	2.75a	8.88a	0.21b	0.93a	0.18	0.11a	0.06
Kwami	3.87b	1.28b	5.26a	0.18b	0.84a	0.16	0.09ab	0.06
Funakaye	4.29b	2.54a	7.30a	0.27a	0.63b	0.18	0.12a	0.05
Mean	4.47	2.19	7.15	0.22	0.80	0.17	0.11	0.06
SE	0.24	0.27	0.60	0.02	0.05	0.01	0.01	0.01
Cv %	16.02	36.30	25.39	20.83	19.24	6.66	14.32	10.19

Table 3. Concentration of heavy metals in lettuce at Gombe central senatorial zone

Location	Zn	Cu	Fe	Cd	Pb [Mgkg-1]	Cr	Ni	As
Akko	8.25a	3.21a	11.25b	0.31b	1.35b	0.31b	0.18a	0.12a
Kwadon	9.38a	2.88a	10.10b	0.42a	2.30b	0.22b	0.13b	0.09b
Dadin Kowa	6.21b	2.18b	13.15a	0.36b	3.73a	0.38a	0.15b	0.08b
Mean	7.95	2.76	11.50	0.36	2.46	0.30	0.15	0.10
SET	0.54	0.18	0.51	0.02	0.40	0.03	0.01	0.01
Cv %	20.22	19.08	13.39	15.16	48.70	26.44	16.41	21.53

Table 4. Lettuce heavy metals concentration at Gombe South senatorial zone

Location	Zn	Cu	Fe	Cd	Pb [Mgkg-1]	Cr	Ni	As
Kaltungo	1.52b	3.78a	0.09a	0.44b	0.06b	0.04b	0.04b	0.02b
Billiri	1.34b	0.75b	4.23b	0.14c	0.93b	0.08b	0.06b	0.04b
Balanga	7.34a	2.85a	8.61a	0.76a	2.11a	0.52a	0.21a	0.12a
Mean	3.40	2.46	4.31	0.45	1.03	0.21	0.10	0.06
SE	1.14	0.02	1.42	0.10	0.34	0.09	0.03	0.02
Cv %	100.39	63.10	98.85	69.42	99.57	124.84	89.92	88.19

Table 2 indicated a significant difference at 0.05 between the mean values of metal concentrations in lettuce at Gombe North senatorial zones. Statistical analysis shows that Dukku location recorded the highest mean content of Zn (5.26). Kwami and Funakaye gave 3.87 and 4.29 respectively with the variability of 16.02. Cd ranged between 0.18-0.27 $^{-1}$(mean = 0.22 $^{-1}$) which show a moderate variation (Cv % = 20.83%). Dukku and Kwami did not differ significantly but had lower Cd than Funakaye. Table 3 showed that the pattern of heavy metals concentration in Gombe central zone. The content of Zn and Cu metals did not vary statistically at Akko and Kwadon locations, but mean of Zn and Cu content are significantly higher than Dadin-Kowa. From the table we can observe that Akko and kwadon recorded almost the same Fe and Pb concentration whereas Dadinkowa location recorded lower concentrations than the other locations studied. The lettuce Cd concentration found at Kwadon was statistically higher than that of Dadin Kowa. Cr ranged between 0.22 $mgkg^{-1}$to 0.38 $mgkg^{-1}$with a mean of 0.30 $mgkg^{-1}$and a Cv % of moderate variability (26.44%). Dadinkowa and Akko location recorded (0.33), (0.31) Cr concentration respectively, whereas in concentration than Balanga with a Cv % percentage of Zn (100.39), Fe (98.85), Pb (99.57), Cr (124.84), Ni (89.92) and As (88.19). Pattern of Cu metal concentration was highly variable (Cv % = 63.10%). Kaltungo and Balanga lettuce Cu content (3.78) and (2.85 $mgkg^{-1}$) are statistically the same and significantly higher than Billiri (0.75). Balanga recorded significantly higher Cd content (0.76) than Kaltungo (0.44) whereas Billiri location recorded the lowest Cd content (0.14) with a coefficient of variability of 69.42%.

Heavy metals from soils to vegetables in the studied zones

Table 5. Transfer factors (TF) of the heavy metals from soils to vegetable collected at the three senatorial zones

Vegetable	Zn	Cu	Fe	Cd	Pb	Cr	Ni	As
Lettuce 1	0.34	0.36	0.26	0.46	0.15	0.47	0.52	0.26
Lettuce 2	0.57	0.48	0.55	0.56	0.77	0.94	0.65	0.56
Lettuce 3	0.45	0.68	0.33	0.83	0.39	0.72	0.50	0.38

Source: (field work, 2014). The number 1, 2 and 3 indicate the zone where the lettuce was collected
1= Gombe North Senatorial zone
2.= Gombe Central Senatorial Zone
3. = Gombe South Senatorial Zone

Transfer factors (tf) of the heavy metals from soil to vegetable

The results in table 2 revealed that all the metals studied had a transfer factor less than 1. The value obtained were ranged from 0.34 to 0.57 (mean =) Zn, 0.36 to 0.68 (mean = 0.52) Cu, 0.26 to 0.55 (mean = 0.41) Fe, 0.46 to 0.83 (mean = 0.65) Cd, 0.15 to 0.77 (mean = 0.46) pb, 0.47 to 0.94 (mean = 0.71) Cr, 0.52 to 0.65 (mean = 0.59) Ni and 0.26 to 0.56 (mean = 0.41) respectively. The highest ratios were observed for Zn, Fe, pb, Cr, Ni and As in lettuce grown at the Gombe central senatorial zone, while Cu and Cd at the Gombe south senatorial zone recorded the highest value. The ability of a metal species to migrate from soil into plant root is referred to as transfer factor (TF). The factors are based on the roots uptake of the metal and discount the foliar absorption of atmospheric metal deposited. (Lokeshwari and Chandrappa, 2006; Awode, *et al*., 2008). The transfer factors (TF) of the heavy metals from soils to lettuce in this study are presented in Table 2 The highest value (tF) was observed for Cd (0.83) at Gombe south senatorial zone site while the lowest was in pb (0.15) at Gombe North senatorial zone site. According to Sajjad, *et al*. (2009) if the transfer factor of a metal is greater than 0.50, the plant will have a greater chance of the metal contamination by anthropogenic activities. This indicates that the concentrations of heavy metals in the plants are low but, there is a change of its to be contaminated. The results indicated that about 95% of the metals studied at Gombe north senate zone have TF of <0.5>, at the Gombe central senate zone the metal had about 95% > 0.5 TF and > 50% of the metals had TF above 0.5 respectively.

The higher value of TF suggests poor retention of metals in soil and one or more translocation in vegetables. Because the metal with high. TF are easily transferred from soil to the edible parts of vegetables than ones with low TF. The higher uptake of heavy metals in leafy vegetables may be due to higher transpiration rate to maintain the growth and moisture content of these plants. The preset results agrees with the finding made by (Zhang *et al.,* 2009) in food crops in the vicinity at Dabaoshan nine, South China where by Bioaccumulation factors for heavy metals were significantly higher for leafy than non-leafy vegetables. In heavy metals polluted soils some plants species are able to accumulate fairly large amounts of heavy metals without showing stress, which represents a potential risk for animals and human health because at transmission in food chain (Oliver, 1997). Many people could be at risk of adverse health effect from consuming common vegetables grown in contaminated soils.

Conclusion

1. The result from this study suggested that significant difference existed in the heavy metals concentration in plant (lettuce), analyses that might in due part to the soil formation, anthropogenic activities and the ability of lettuce plant to accumulate metal as well.
2. The present result revealed that among the heavy metal studied Pb and Cd were above the toxicity level in lettuce.
3. On the other hand, the transfer factor (TF) of all metals studies was below the risk level except for Gombe central that recorded 95% over 0.5 TF, but there is chance for the vegetable to be contaminated with metal heavy (TF) >0.5 by further anthropogenic activities.

Recommendation

1. It is therefore suggested that regular monitoring of heavy metals in plants is essential in order to prevent excessive build up of these metal in the human food charm.
2. It is recommended that further research to be conducted on different plants grown within the study zones in order to obtain more specific information about the status of plant species in accumulation and distribution of the heavy metals.
3. It is suggested also that good management of anthropogenic activities by state ministry of environment be encouraged in order to reduce accumulation of metals by such activities.

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