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Assessment Of Some Heavy Metals On Lettuce (Lactuca Sativa L.) Grown Along Badagry Expressway, Lagos, Nigeria

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Abstract:
Vegetables grown at environmentally contaminated sites in Lagos could take up and accumulate metals at concentrations that are toxic to human health. This study was conducted to analyze the heavy metal in a selected vegetable (Garden Lettuce) in Lagos, Nigeria. Recently matured plant samples of Garden Lettuce (Lactuca sativa L.) from roadside farm, Badagry Expressway, Lagos, Nigeria were assessed using Atomic Absorption Spectrophotometer and underwent pressurized digestion with HCL, H_2S0_4 and HNO_3 to determine the heavy metals. Three composite samples on each bed at each distance were used. The distances were 5m, 10m and15m.The concentration of heavy metals which include, Cu, Zn, Fe, Cr, Cd, and Pb, were determined using Analyst Perkin-Elmer 300 Atomic Absorption Spectroscopy (AAS). The mean concentration for each heavy metal in the samples were obtained and compared with the permissible levels set by the FAO and WHO. The results of this analysis revealed that Fe showed the highest concentrations in the stem (14.681±11.621mg/kg), second to Zn in the leaf (0.062±0.047mg/kg) while Cr shows the lowest levels (0.001±0.000mg/kg) in the whole plant organ .When compared with standards, heavy metal levels were found to be within safe limit.
Metal uptake differences by parts of the plant (Lactuca sativa L.) is attributed to plant differences in tolerance to heavy metals. The intake of all the six metals constitutes less than 100% of the TMDI (Theoretical Maximum Daily Intake) at present and hence, health risk is minimal. But with the increase in vegetable consumption by man, the situation could worsen in the future.

***Keywords**: Lactuca sativa L, Heavy metals, Bioaccumulation, soil*

1.Introduction

The tradition of growing vegetables within and at the edges of cities is very old. It should be realized that most of these cultivated lands are contaminated with heavy metals contributed mainly through vehicular emissions, pesticides and fertilizers, industrial effluents and other anthropogenic activities (Halweil and Nierenberg, 2007). These contaminated soils have resulted in the growth of contaminated vegetables. Heavy metals in soils reduce the yield of vegetables because of disturbing the metabolic processes of plants (Ogbodo *et al.,* 2010). Singh *et al.,* (2010) 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. It was also concluded that Cd and Pb were of more concern than Cu and Zn.

Vegetables, especially those of leafy vegetables grown in heavy metals contaminated soils, accumulate higher amounts of metals than those grown in uncontaminated soils because of the fact that they absorb these metals through their leaves (Muhammad *et al.*, 2008). Atayese *et al.* (2009) investigated heavy metal contamination of Amaranthus grown along major highways in Lagos, Nigeria. Ladipo and Doherty (2011) studied heavy metal levels in vegetables from selected markets in Lagos, Nigeria. Vegetables accumulate heavy metals in their edible and non-edible parts. Intake of vegetables is an important path of heavy metal toxicity to human being.

Absorption capacity of heavy metals depends upon the nature of vegetables and some of them have a greater potential to accumulate higher concentrations of heavy metals than others (Akan *et al.*, 2009).

Most tropical countries have vegetation containing a diversity of leafy vegetables such as spinach, amaranth, lettuce that serve as indispensable constituents of the human diet. The use of green leafy vegetables for the preparation of soups cuts across different cultures in Nigeria and other parts of West Africa (Ladipo and Doherty, 2011; Akan *et al.*, 2009).

Lettuce and radish were found to be more responsible than other vegetables for the accumulation of heavy metals in humans through the edible portion (Itanna, 2002). The consumption of lettuce has become very popular in most urban centers in the southeastern Nigeria.

Based on persistent nature and cumulative behavior as well as the probability of potential toxicity effects of heavy metals as a result of consumption of leafy vegetables, there is need to test and analyze these food items to ensure that the levels of these trace elements meet the agreed international requirements. It was in this regard that Lettuce (*Lactuca* *sativa* L.) which is one of the vegetables grown for commercial purposes at Fin-Niger bus-stop on Badagry Expressway in Lagos was screened to assess the levels of Cr, Cu, Cd, Pb, Zn and Fe in it.

2.Materials And Methods

STUDY AREA: The study was carried out at Amuwo-Odofin Local Government Area (Fin-Niger bus-stop) in the city of Lagos, located in the South Western Nigeria. The climate of the region is tropical with two distinct seasons, that is, dry and rainy. The dry season (November to April) is associated with high temperature during the day ranging from a minimum of 30^{O} to a maximum of 33^{O}C. Rainy season starts in May and continues till end of October. During the rainy season, the temperature varies from minimum of 24^{O}C to a maximum of 32^{O}C.

Lagos is one of the most densely populated cities of Nigeria. There are several industrial estate located at the peripheral of the city. Heavy traffic on narrow roads leading to frequent traffic congestion is of common occurrence within the city. The soil is from sedimentary rock formation (Atayese *et al*., 2009). The common vegetables planted are spring onions, lettuce, fluted pumpkin, celosia, jute and cabbage.

SAMPLING PROCEDURES: Specifically, the site was located at Fin-Niger bus-stop along Badagry expressway. Samples were collected in February 2011. Samples of soil were taken at a distance of 5m, 10m and 15m from the major road. Soil was sampled at 0-10m depth and then packed into three labeled polythene bags and taken to the research Laboratory while ensuring that there were no other sources of contamination at the site of investigation. Each soil sample was air-dried and all clods and crumbs were removed for obtaining mixed uniform soil by sampling. Soils were sieved through a 2mm sieve to remove coarse particles before sub-sampling for chemical analysis.

2.Pre-Treatment

Washing of samples: The collected vegetable samples were washed with distilled water to remove dust particles. The samples were then cut to separate the roots, stems and leaves using a knife.

Drying of samples**:** Different parts (roots, stems and leaves) of vegetables were air-dried and then placed in a dehydrator at 80°C for 2-3 days and then dried in an oven at 100 °C.

Grinding of samples**:** Dried samples of different parts of vegetables were grounded into a fine powder (80 mesh) using a commercial blender (TSK- WestPoint, France) and stored in polyethylene bags, until used for acid digestion.

The soil samples were air-dried , sieving and about (5.0 gm) of the most fine dried grains were digested with a mixture of conc. H_2O_2, HCl and HNO_3 as the method described in APHA ,1998 and preserved in a refrigerator till analysis.

Analyzed for heavy metal contents; Chromium (Cr), Copper (Cu), Cadmium (Cd), Iron (Fe), Zinc (Zn) and Lead (Pb).

Similarly, samples of *Lactuca sativa* L. were collected at same distances (5m, 10m and 15m) from the roadside. The plant samples were then packed into three different labeled polythene bags and taken to the laboratory.

2.Determination Of Heavy Metal Content In The Soil

A sample of 5.0g of air-dried ground soil was transferred to 25ml conical flask; 5ml of concentration H_2SO_4 was added followed by 25ml of concentrated HNO_3 acid and 5ml of concentrated HCL. The contents of the tube were heated at 200^OC for 1hr in a fuming hood and then cooled to room temperature. After cooling, 20ml of distilled water was added and the mixture was filtered to complete the digestion.

Finally, the mixture was transferred to a 50ml volumetric flask, filled to the mark and let to settle for at least 15 hours. The filtrate was analyzed for total Cr, Fe, Cu, Pb, Zn and Cd by Atomic Absorption Spectrometer (Analyst Perkin-Elmer 300).

3.Determination Of Heavy Metal Content In Plants

The whole plant was divided into roots, leaves and stem. The sample were weighed to determine the fresh weight and then dried in an oven at 60^OC for 48hours. The dry samples were grounded into a fine powder using commercial blender (TSK- WestPoint, France). Resulting powder was packed for analysis of metals Cr, Fe, Cu, Pb, Zn and Cd. Approximately, 5g of the powder was put to a 25ml conical flask: 5ml of concentrated H_2SO_4 was added followed by 25ml of concentrated HNO_3 and 5ml of concentrated HCL. The contents of the tube were heated at 200^OC for 1 hour in a fuming hood and then cooled to room temperature. Then 20ml of distilled was added and the mixture was filtered using filter paper to complete the digestion of organic matter.

Lastly, the mixture was transferred to a 50ml volumetric flask filled to mark and let to settle for at least 15hours. The resultant supernatant was analyzed for total Cr, Fe, Cu, Pb, Zn and Cd by Atomic Absorption Spectrometer (Analyst Perkin -Elmer 300)

Statistical analysis: Three samples (leaves, stems and roots) of each Lettuce sample assayed and analyzed individually in triplicate. Data were reported as mean ± SD. One way analysis of variance (ANOVA) was used to determine significant difference between groups, considering a level of significance of less than 5% (p<0.05) by using SPSS Version 17 Statistical Software.

4.Results

The results showed that Cr has the same value in all the plant organs (0.001±0.000mg/kg). With regards to distance, Cr is highest at 15m with mean value of 0.003±0.004mg/kg and lowest at 10m with mean value of 0.001±0.000mg/kg.

Cu is highest in the root with mean value of 0.051±0.019mg/kg and lowest in the leaf with mean value of 0.015±0.002mg/kg. As with distance, Cu is highest at 5m with mean value of 0.037±0.020mg/kg and lowest at 15m with mean value of 0.027±0.017mg/kg

Cadmium is highest in the root with the mean value of 0.006±0.003mg/kg and lowest in the stem with mean value of 0.002±0.002mg/kg. As regards distance, Cd is highest at 10m with mean value 0.009±0.010mg/kg and lowest at 15m with 0.004±0.004mg/kg

Lead is highest in the root with mean value of 0.043±0.029 mg/kg and lowest in the leaf with the mean value of 0.010±0.007mg/kg. As with distance, Pb is highest at 5m with the mean value 0.042±0.029mg/kg and lowest at 15m with mean value of 0.005±0.003mg/kg.

Iron (Fe) is highest in the stem with mean value of 14.681±11.621mg/kg and lowest in the root with the mean value of 6.267±1.034mg/kg.

As regards distance, Fe is highest at 5m with mean value of 38.564±34.741mg/kg and lowest at 10m with mean value of 3.920±2.074mg/kg.

Zinc (Zn) is highest in the leaf with mean value of 0.062±0.047mg/kg and lowest in the stem with the mean value of 0.058±0.080mg/kg.

As with distance, Zn is highest at 10m with the mean value of 0.068±0.043mg/kg and lowest at 15m with mean value of 0.043±0.073mg/kg.

5.Discussion

The Cadmium plant content is more concentrated in the root (0.006±0.003mg/kg) followed by the leaf (0.004±0.004mg/kg) then the stem (0.002±0.002mg/kg) which has the lowest accumulation of the metal (Table 1). The content of Cadmium reported in this study is generally lower than the WHO/FAO (2001) safe limit which is 0.2mg/kg. However it is statistically significant at ($P<0.05$).

Cadmium content is found highest (0.009±0.010mg/kg) at distance 10metres from the major road and the lowest at 15m (0.004±0.004mg/kg) from the roadside. As regards distance, the level of Cd is statistically not significant i.e. ($P>0.05$), P= 0.159. This could infer that the level of Cd in the plant and soil has nothing to do with distance. There has been report that cadmium is a highly mobile metal, easily absorbed by the plants through root surface and moves to wood tissue and transfers to upper parts of plants. Itanna (2002) and Muhammad *et al.*, (2008) reported that there is a direct relation between the levels of presence of Cadmium in the root zone and its absorption by plant. Thus in this study, soil Cd concentration is higher than plant Cd concentration.

Zinc content is highest in the leaf (0.062±0.047mg/kg) and lowest in the stem (0.058±0.080mg/kg). The Zinc content is lower than the WHO/FAO (2001) safe limit of 99.40mg/kg. However, ANOVA result showed that this value is statistically significant as P> 0.05, as P = 0.992.

Among all heavy metals, Zinc is the least toxic and an essential element in human diet as it is required to maintain the functioning of the immune system. Zinc deficiency in the diet may be highly detrimental to human health than too much Zinc in the diet. The recommended dietary allowance for Zinc is 15mg/day for men and 12mg/day for Women (Ogunlesi *et al*, 2002). Vegetables that growing on heavy metal contaminated soils can accumulate high concentrations of Zinc to cause serious health risk to consumers. During this study, Zn soil content was found to be highest at 10m with the mean value of (0.068±0.043mg/kg) and lowest at 15m (0.043±0.073mg/kg). The Analysis of Variance shows that it is statistically insignificant as P> 0.05 as P = 0.486.

The primary source of Zinc in the area could be the attrition of motor vehicle rubber tyres exacerbated by poor road surface, waste combustion or steel processing.

The level of Lead in this study is found highest in the root (0.043±0.029g/kg) and lowest in the leaf (0.010±0.007mg/kg). All these values are small when compared to the WHO/FAO (2001) safe limit of 0.3mg/kg. This result is statistically significant P< 0.05. Pb soil content is highest at 5m (0.042±0.029mg/kg) and lowest at 15m (0.005±0.003mg/kg). The ANOVA shows that it is statistically significant P<0.05 as P= 0.001.

One likely source of the Pb contamination on the vegetables could be as a result of acid-lead batteries as waste dump in the drainage around the site which is subsequently used to irrigate the farmland. This may also be responsible for high level of lead in the vegetable site.

Lead is a serious cumulative body poison which enters into the body system through air, water and food and cannot be removed by washing fruits and vegetables (Itanna, 2002). The high levels of Lead in some plants may probably be attributed to pollutants in irrigation water, farm soil or due to pollution from the highways traffic (Ladipo and Doherty, 2011). Lead pollution has been shown to be commensurate with population/vehicular density. One possible explanation for this situation is that the Pb uptake can be promoted by the pH of soil and the levels of organic matter. Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human consumption (Muhammad *et al.*, 2008). The introduction of Pb into the food chain may affect human health and thus, studies concerning Pb accumulation in vegetables have increasing importance. The study shows that the plant Pb content is more than the soil Pb content.

The metal chromium was equally distributed in all plant organs with mean value of 0.001±0.000mg/kg. This value is lower than the WHO/FAO (1999) safe limit of 1.30mg/kg. The ANOVA shows that it is significant in terms of statistics.

The Cr soil content is highest at 15m (0.003±0.004mg/kg) and lowest at 10m (0.001±0.000mg/kg). The ANOVA shows that it is not significant $P = 0.221$ ($P > 0.05$)

The soil content (0.004±0.004mg/kg) was found to be higher than plant content.

Sharma *et al.*, (2006) studied the heavy metal contents in different vegetables grown in the lands irrigated by wastewater and noted the concentration of Cr to be with in the safe limits. However, it was noted that chromium concentrations in all the cases were under permissible limits (1.30 mg /kg WHO).

The Cu plant concentration is highest in the root (0.051±0.019mg/kg) and lowest in the leaf (0.015±0.002mg/kg). This value is less than the WHO/FAO safe limit of 73.00. The ANOVA result shows that it is statistically significant. $P < 0.05$ as $P = 0.000$

The Cu soil content is highest at 5m with mean value of 0.037±0.020mg/kg and lowest at 15m with mean value of 0.027±0.017mg/kg. The AVOVA shows that it is not significant as $P = 0.412$ ($P > 0.05$).

The copper levels found in vegetables were within safe limits in all samples. Muhammad *et al.*, (2008) studied the response of three vegetables to Cu toxicity and found that Cu levels in both root and shoot increased, but root Cu concentration increased more sharply than shoot with increasing Cu levels in growth media. Cu mainly accumulated in roots while a small fraction (10%) of absorbed Cu was transported to shoot. Moshen and Moshen, (2008) found that Cu concentration in the shoots was significantly influenced by Cu concentration in soil and increased markedly with an increase in the soil Cu concentration. The possible deficiency in plant tops is due to its preferential accumulation in the roots (Itanna, 2002). Plant Cu concentration is higher than soil Cu concentration.

Iron plant content is highest in the stem with mean value of 14.681±11.621mg/kg and lowest in the root with the mean value of 6.267±1.034mg/kg. This is far lower than the WHO/FAO safe limit of 425.00. The ANOVA data also shows that the value is statistically significant as $P<0.05$ ($P=0.039$).

As regards distance, Fe soil content is highest at 5m with mean value of 38.564±34.741mg/kg and lowest at 10m with mean value of 3.920±2.074mg/kg. The ANOVA shows that the value is statistically significant as $P<0.05$ ($P=0.000$).

This is the most abundant metal in this study. It was found that heavy metals accumulated more in roots and leaves than those in other parts because both are the entry points of heavy metals from soils and air. Elevated Fe content in plants could be due to Fe effluents from metal industries which enter the farmland. Some injured leaves have been witnessed and on some plants, necrotic spots were observed. This is usually attributed to Fe toxicity. Chlorosis of leaves has also been observed in some plants due to metal toxicity.

Respectively in the present study many soil factors such as pH, organic matter, nitrogen bioavailability, soil moisture and temperature have interacted-impact on uptake. Source of contamination which includes: tire wear, motor oil, grease, brake emissions, corrosion of galvanized parts, fuel burning, batteries etc. There is a cumulative effect on sustained intake of heavy metals, as they are not easily removed from the body. Many rural and urban low-income families in Nigeria consume large quantities of vegetables on a daily basis and this exposes them to the health risks associated with heavy metals ingestion.

6.Conclusion

The results from this study suggested that significant differences existed in the elemental concentrations among the vegetables analyzed that might be in due part to the Geological status of the area under investigation and the ability of plants and their specific parts to accumulate metals as well.

To avoid entrance of metals into the food chain, municipal or industrial wastes should not be drained into rivers and farmlands without prior treatment. Apart from treating the discharge that enters into the farms, it is also imperative to utilize measures to clean-up the already contaminated substrates.

		Leaf	Stem	root	soil
Cr	Mean	0.001±0.000	0.001±0.000	0.001±0.000	0.004±0.004
Cu	Mean	0.015±0.002	0.037±0.018	0.051±0.019	0.021±0.005
Cd	Mean	0.004±0.004	0.002±0.002	0.006±0.003	0.013±0.010
Pb	Mean	0.010±0.007	0.024±0.032	0.043±0.029	0.009±0.001
Fe	Mean	12.873±11.585	14.681±11.62	6.267±1.034	37.284±42.657
Zn	Mean	0.062±0.047	0.058±0.080	0.061±0.042	0.054±0.057

Table 1: showed the mean values of heavy metal content present in Lactuca sativa plant and soil and how it varies with distance from the major road

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Distance		Cr	cu	Cd	Pb	Fe	Zn
5m	Mean	0.002±0.001	0.037±0.020	0.005±0.003	0.042±0.029	38.564±34.741	0.066±0.049
10m	Mean	0.001±0.000	0.029±0.021	0.009±0.010	0.017±0.020	3.920±2.074	0.068±0.043
15m	Mean	0.003±0.004	0.027±0.017	0.004±0.004	0.005±0.003	10.843±4.761	0.043±0.073

Table 2: Mean concentration of heavy metals in soil and with varying distance from the roadside farm along Badagry Expressway, Lagos, Nigeria

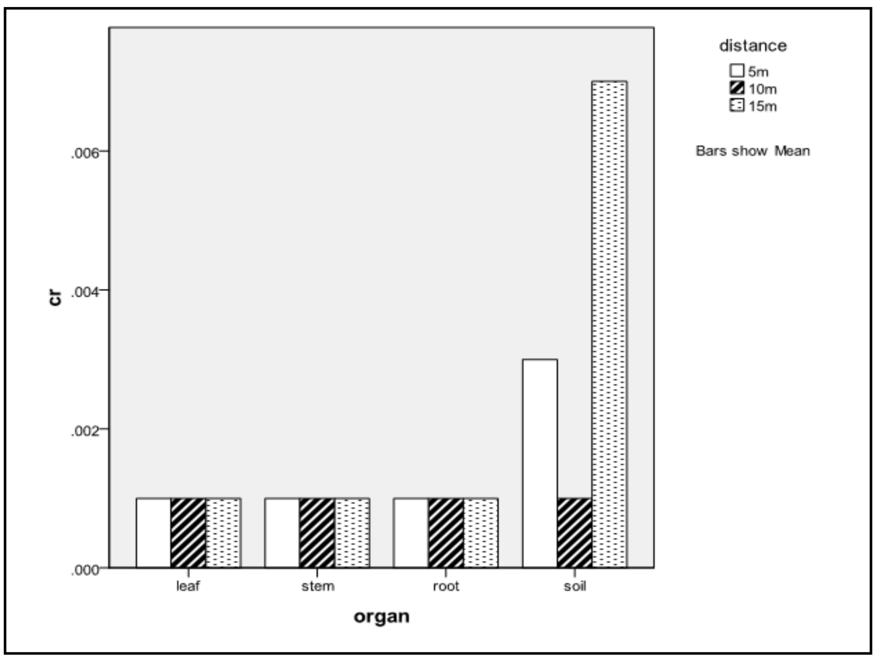

Figure 1: Chart showing Chromium in plant organ and soil with varying distance

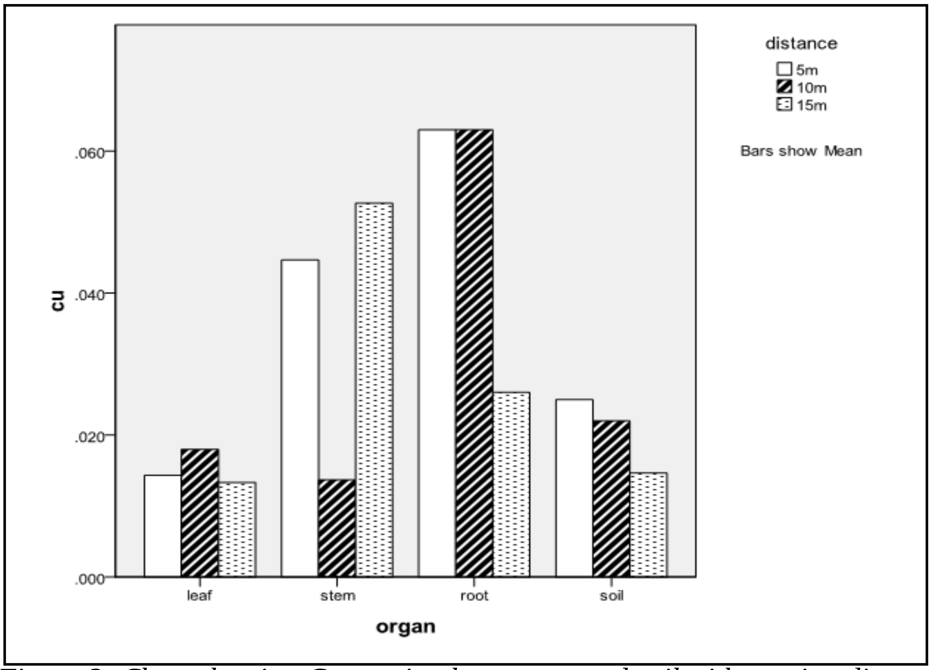

Figure 2: Chart showing Copper in plant organ and soil with varying distance

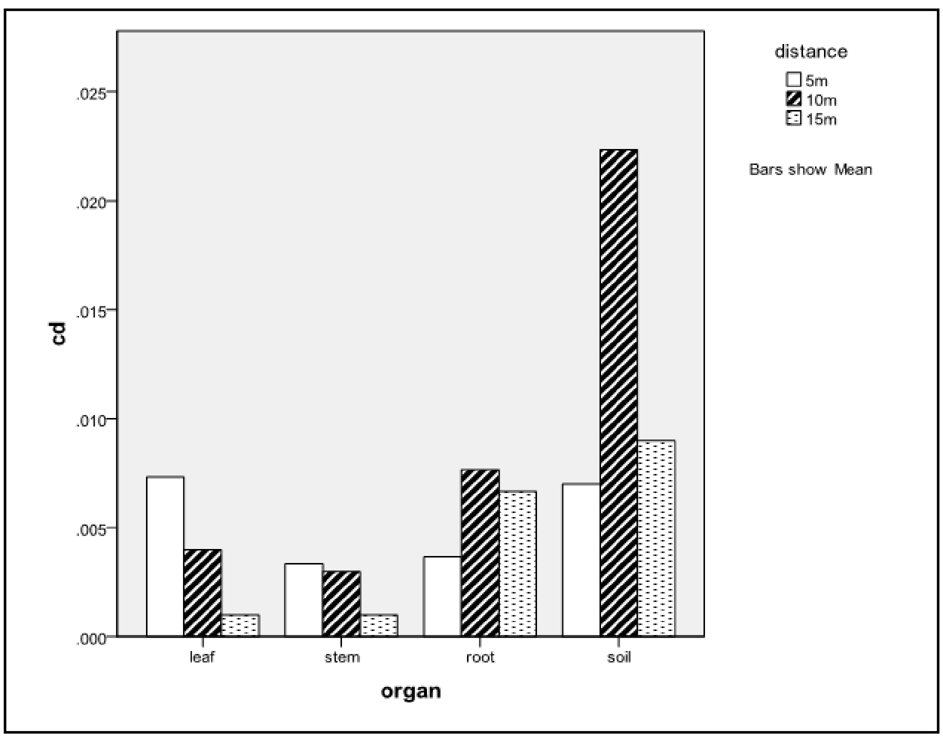

Figure 3: Chart showing Cadmium in plant organ and soil with varying distance

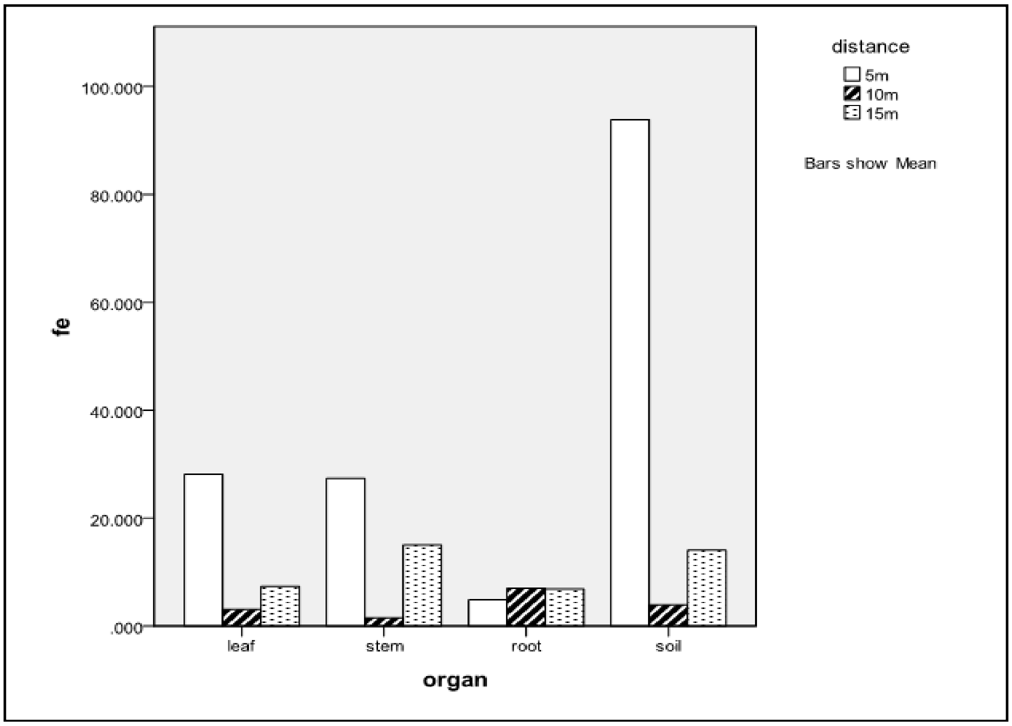

Figure 4: Chart showing Iron in plant organ and soil with varying distance

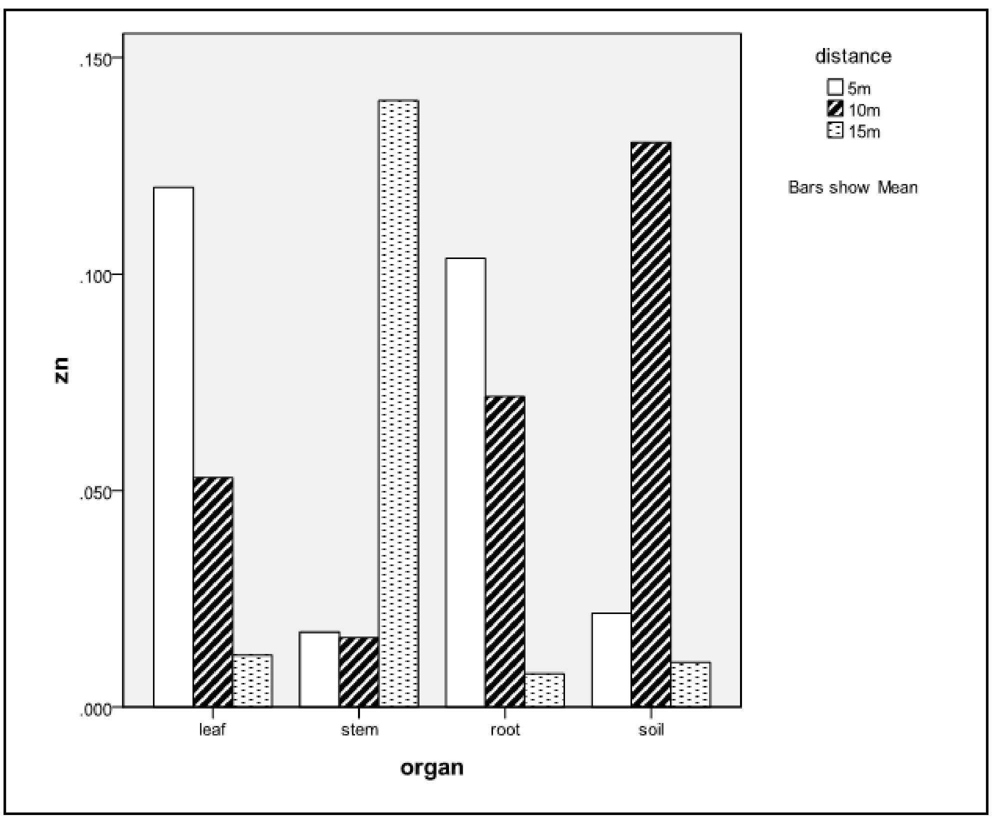

Figure 5: Chart showing Zinc in plant organ and soil with varying distance

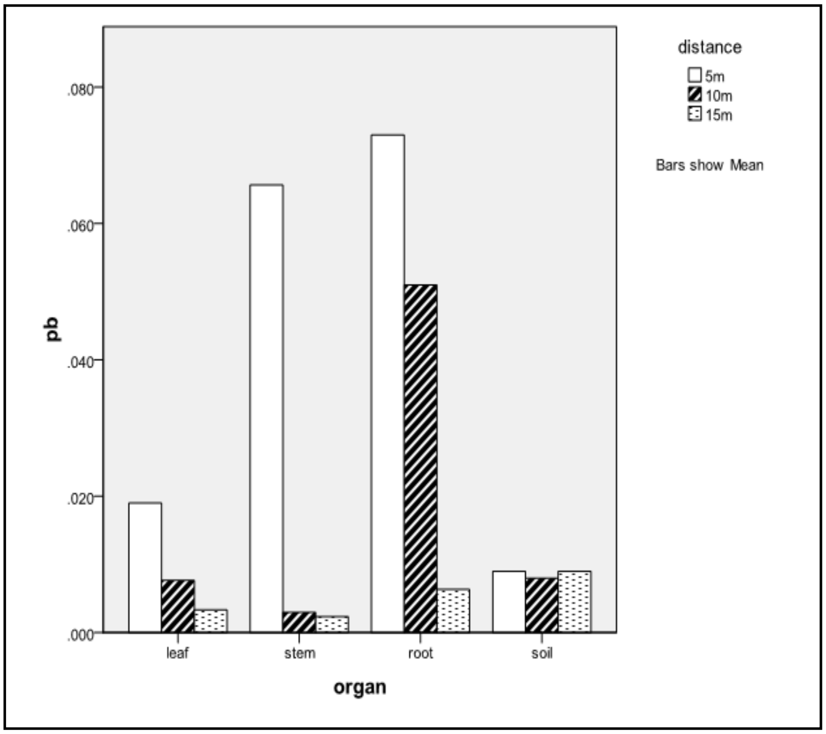

Figure 6: Chart showing Lead in plant organ and soil with varying distance

7.Reference

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