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EVALUATION OF TOXIC HEAVY METALS AND MINERAL ELEMENTS UPTAKE BY LEAFY VEGETABLES CULTIVATED WITH SOIL SAMPLES OF RIVER GINZO IRRIGATION SITES, KATSINA, KATSINA STATE, NIGERIA

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ABSTRACT

The present study is aimed at determining the levels of toxic heavy metals (Cadmium, Chromium, Lead and Zinc) and mineral elements (Potassium, Sodium, Magnesium and Calcium) in parts of spinach and cabbage collected at Kofar Marusa, Kofar Durbi and Kofar Sauri irrigation areas located along Ginzo River, Katsina, Katsina State, Nigeria. A total of 40 samples were analysed for the presence of toxic heavy metals and mineral elements using Atomic Absorption Spectrophotometry. Concentration of chromium, lead and zinc in leaves of cabbage we found to be within the permissible limits except cadmium (0.40ppm and 0.39ppm) that exceeded the 0.2ppm WHO/FAO, 1984 permissible limit in leaves of Kofar Marusa and Kofar Durbi samples. In roots of cabbage, cadmium level exceeded the standard. Concentration of elements in head of cabbage is within the permissible, except cadmium in all samples. In leaves, stems and roots of spinach, cadmium showed exceeded level and have highest values of 0.50±0.01ppm, 0.59±0.0ppm and 069±0.01ppm all obtained in Kofar Marusa samples. The findings showed that Ginzo River is suitable for agricultural purpose. Level of cadmium in soil, water, roots, stems and leaves have exceeded the permissible limit while concentration of chromium, lead and zinc in all samples is similar with set standards.

Keywords: Toxic Heavy Metals, Pollution, Wastewater, Irrigation, Atomic Absorption Spectrophotometry, Mineral Elements, Ginzo River

INTRODUCTION

Heavy metals are those elements with density above 5mg ml^{-1} (Jarup, 2003) such as cadmium, Chromium, Lead, Vanadium etc. Some of these elements like iron have a physiological functioning human body in the formation of heamoglobin and cytochromes. Heavy metals such as cadmium, Lead and Mercury that are emitted from industrial facilities causes air, water and land pollution after been deposited in these media and get accumulated in food chain. In plants and even at low concentration, heavy metals are greatly toxic (Girigisu et al 2020). In humans, exposure to lead causes developmental and neurobehavioral effects in unborn babies, infants and children and also causes elevation in blood pressure. Most of these are caused environmental negative effects on humans and the environment by heavy metals is caused as a result of industrialization and technological development that demands an improved quality of life (WHO, 2007[b]).

World Health Organization (WHO) estimates that about a quarter of the diseases facing mankind have environmental pollution agents (Kimani, 2007). Heavy metals are pollutant of the environment

It is well known that high industrial and traffic activities contribute high levels of heavy metals to the environments. Plants grown around such areas are likely to absorb these metals either from the soil through the roots or from atmospheric contaminants through the leaves (Fifield and Haina, 1997).

The soil contamination by heavy metals can be transferred to food and ultimately to consumers. For instance, plants accumulate heavy metals from contaminated soil without physical changes or visible indication, which could cause a potential risk for humans and animals (Osma *et al.*, 2006). The present study has the aim of determining some selected heavy metals and mineral elements as well as their concentrations in leaves stem ad roots of spinach and cabbage cultivated using soils from irrigation sites along River Ginzo, K atsina, Katsina State

MATERIALS AND METHODS

Description of Study area

The study area is located in Katsina urban area (Figure 1) lies on Latitude 12 59 7.9116 N Longitude 7 37 1.7184 E with a total land area of about 3,370km^2. The climate of the area has a single mode of rainfall pattern which is received between the Months of May and September with annual average of 700mm (Maiwada, 2017). Ruma and Shiekh (2010) reported high temperature in most part of the year with maximum day temperature of about 38^oC or higher in the Months of March, April and May. The maximum day temperature of about 22^oC or a bit lower in the Months of December and January.

Based on the National Population Commission (NPC) estimate of 2022, the study area has a population of 9 million. The population has been increasing since due to the migration of people from all over the country especially the trouble North Eastern part because of insecurity and the neighboring nations especially Niger Republic (Ladan, 2014). This increase the magnitude of the channel modification of the study site.

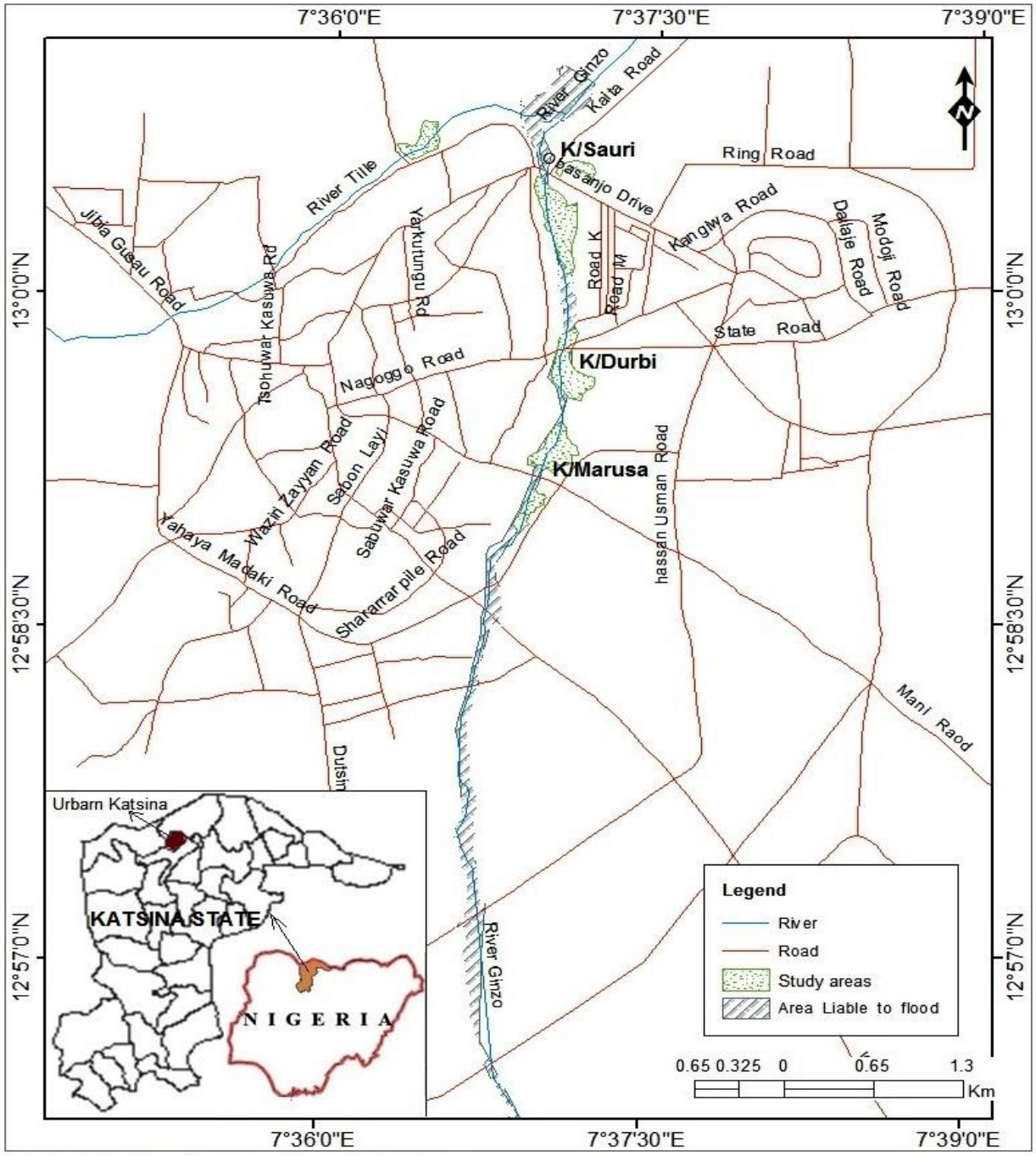

Figure 1: Map of Urban Katsina showing Study Area
Source: National Aeronautics and Space Administration Spot Image 2020

Seed collection

To get an effective output, the research require seeds free from holes, insect infections and other factors that may affect early germination. Therefore, the best recognized shops in Katsina state were contacted for the purchase and supply.

Methods

A compete randomized design was adopted for this research. The experiment was set up in the garden of Umaru Musa Yar'adua University, Katsina using spinach (*Amarantus hybridus L.*) and cabbage (*Brassica oleracea L.*). Then, 50kg of sand was collected from each of the three study sites along River Ginzo. The collected soil samples were measured as 2.5kg each and placed in a clay pot that has a depth of 25cm and a diameter of 36mm. Each treatment was replicated nine (9) times from each different types of soil collected. Five (5) seeds each of spinach and cabbage were planted at about 0.5cm depth and watered once daily with the polluted water collected from the study area for a period of six (6) months. Analysis of heavy metals and mineral elements in samples was carried out using Atomic Absorption Spectrophotometer. Results were analysed using Microsoft excel sheet and presented in bar charts.

RESULT AND DISCUSSION

Heavy Metals in Cabbage

Heavy metals concentration in leaves of cabbage showed concentrations of Cadmium in samples Kofar Marusa and

Kofar Durbi and Kofar Sauri as 0.40±0.01ppm, 0.39±0.01ppm and 0.19±0.01ppm respectively as shown in figure 2. Also, values of Cadmium in the sample was discovered to be the second most concentrated element in leaves of cabbage. This differ with the findings of Anthony *et al.* (2007) who reported Cadmium as the fifth concentrated element among the toxic metals analysed in leaves of cabbage.

The concentration of Chromium in leaves of cabbage showed similar levels in samples Kofar Marusa and Kofar Durbi as 1.00±0.01ppm and 1.00±0.02ppm respectively. This reflects the highest chromium as indicated in figure 3. This finding differ with the result of Ndibukke (2018) where chromium was found to be the third concentrated toxic heavy metal analysed in leaves of cabbage.

Similar to the concentration of Cr in leaves of cabbage, both Kofar Marusa and Kofar Durbi samples have the same mean values of Pb 0.17±0.01ppm. However, mean values of Pb in leaves of cabbage indicated that it is the third most concentrated heavy metals in leaves of cabbage.

Zinc element showed varying concentrations among the three sampling points with overall least values in the kofar marus and kofar durbi 0.13±0.01ppm and 0.14±0.01ppm while Kofar Sauri sample have the highest 0.22±0.02ppm mean value of Zn as shown in figure 5. which is a reflection of the lowest concentration of Zinc in the water and this differ with the report of Anthony *et al.*, (2007), which reported Zinc have the highest mean concentration among the elements analysed in leaves of cabbage.

Generally, all mean values of Zn in the treatment groups were within the permissible limits and higher than the mean values the control groups.

Roots of cabbage for the three sampling points showed that concentration of Cd ranged from 0.22±0.01ppm at Kofar Durbi to 0.39±0.01ppm at Kofar Sauri. The analysis further revealed that Cr has the highest mean value among all elements analysed in the root of cabbage in samples of Kofar Marusa 0.62±0.02ppm while Pb was found to have the lowest mean concentration among all elements analysed with a value of 0.13±0.12ppm in sample of Kofar Durbi which is differ with the finding of Boamponsem *et al.* (2012) where pb was found to be the highest concentrated element and Cd the lowest in roots of cabbage. The concentration of Zn in the sample wassame in samples as in the Kofar Durbi and Kofar Sauri with mean values of 0.22±0.21ppm.

Laboratory analysis of heavy metals in the head of cabbage revealed that metal concentrations were within the WHO/FAO (2007) permissible limit with the exception of Cd as shown in figure 2. The highest concentrated element in the head of cabbage was found to be Cr with a value of 0.63±0.01ppmwhile Pb (0.13±0.12ppm) is the least concentrated toxic heavy metals in all samples obtained from Kofar Durbi. The finding is similar to that of Christopher *et al.* (2014) on heavy metal contamination of cabbage sections from different farms in Ghana which stated that the inner whiter section of cabbage is safer for human consumption.

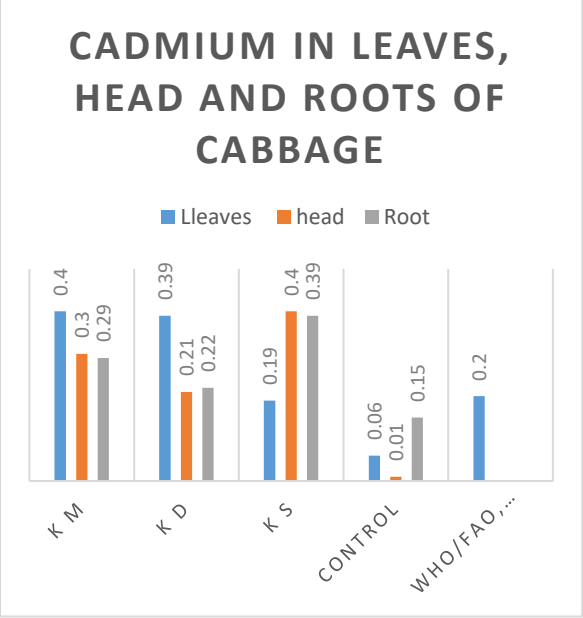

Figure 2: levels of Cadmium in leaves, head and roots of cabbage

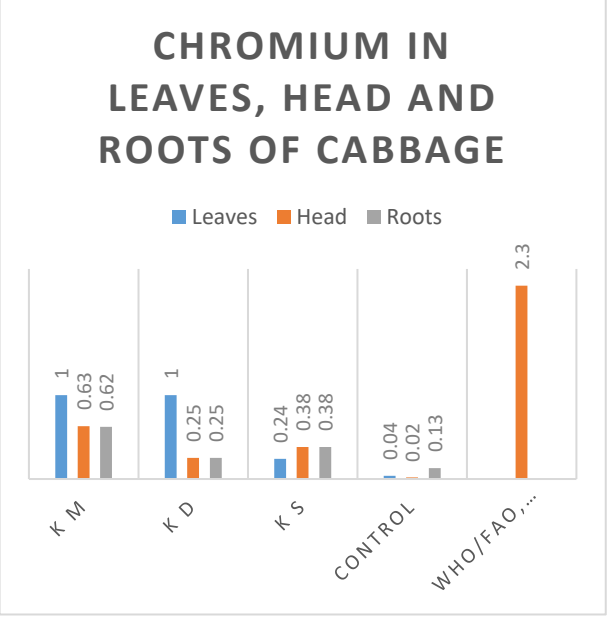

Figure 3: levels Chromium in leaves, head and roots of cabbage

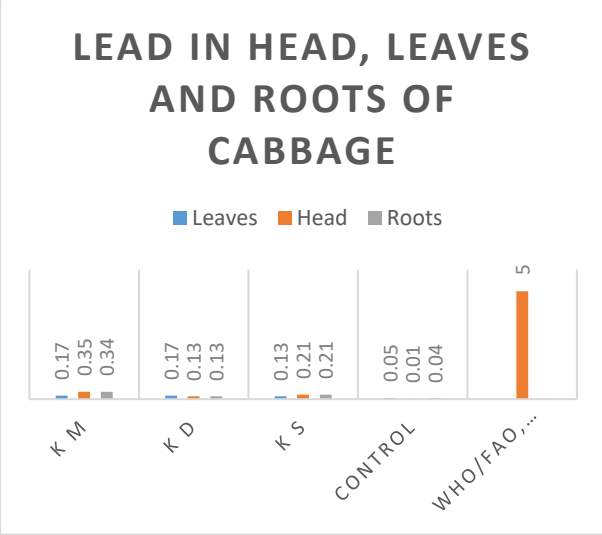

Figure 4: Lead in leaves, head and roots of cabbage

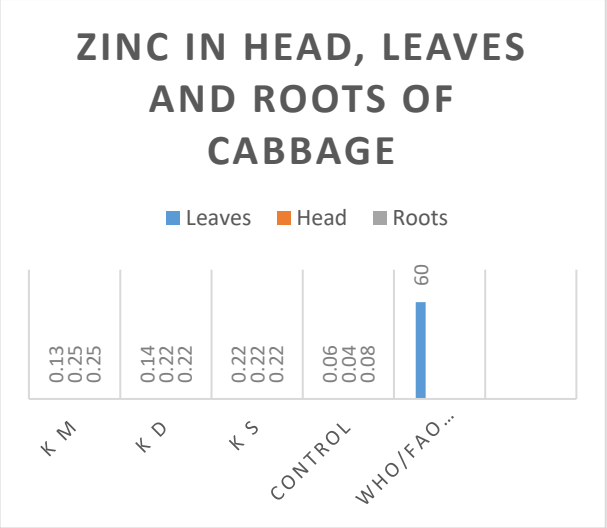

Figure 5: Zinc in leaves, head and roots of cabbage

Heavy Metals in Spinach

Leaves of Spinach

Figure 6 shows the levels of heavy metals in leaves, stems and roots of spinach. The result further showed that concentration of Cd in spinach leaves of all the treatment groups are greater than the WHO/FAO (2007) permissible limit of 0.20ppm for cadmium in green leafy vegetables. This finding is similar with the findings of Safana *et al*., (2018).

Mean concentration values of Pb in spinach leaves sample were found to be within the 5.00ppm permissible limit standard of WHO/FAO (2007) as indicated in figure 6. The concentration of Pb (0.65±0.01ppm) was found to be highest in leave samples of Kofar Durbi. The result of this finding is similar to of Jitendre *et al.* (2017)

Concentrations of Zn in samples analysed for heavy metals are within the 60.00ppm WHO/FAO (2007) permissible limit in green leafy vegetables. Moreover, concentrations of all treatments groups were found to be higher than that of the control 0.06±0.00ppm as presented in figure 9. Generally, higher concentrations of heavy metals (Cd, Cr and Pb) in leaves samples of spinach is linked with high absorption rate of heavy metals by spinach due to its large surface area. Also, this finding with the result of Abdul Latif *et al.* (2018).

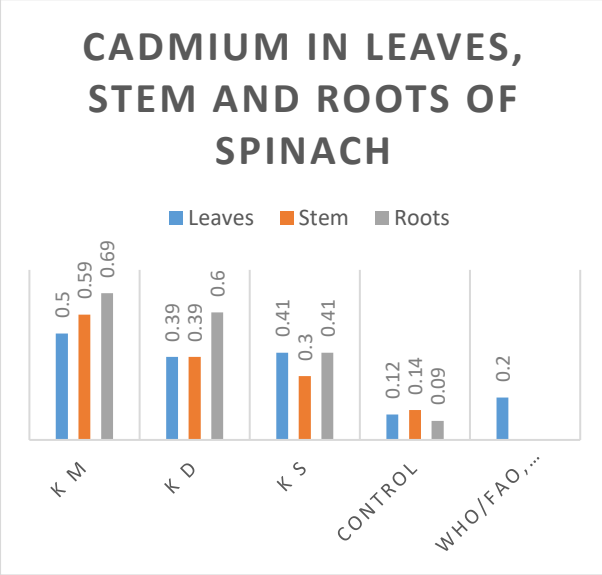

Figure 6: Cadmium in leaves, head and roots of spinach

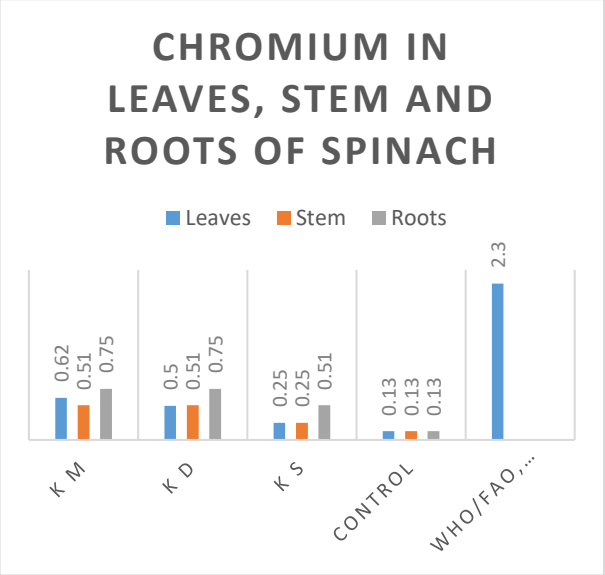

Figure 7: Chromium in leaves, head and roots of spinach

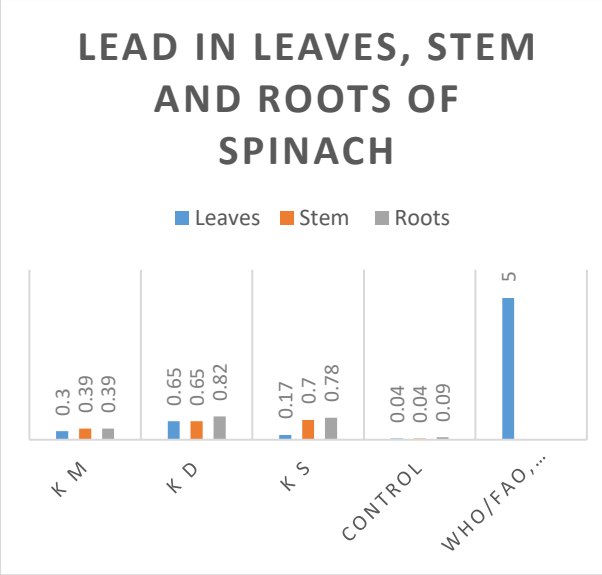

Figure 8: Lead in leaves, head and roots of Spinach

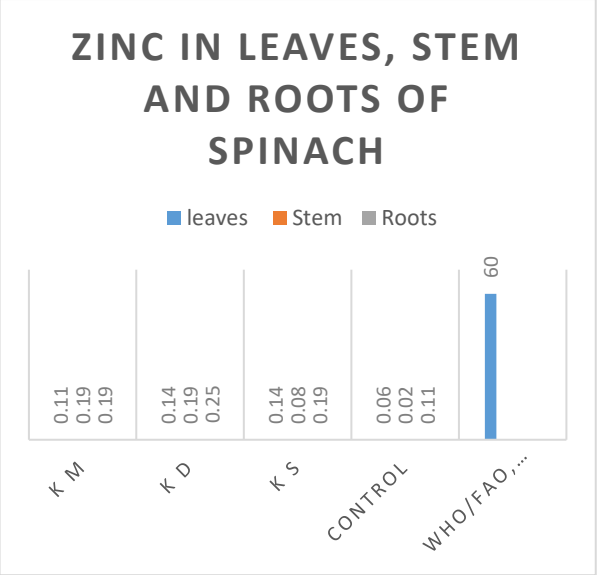

Figure 9: Zinc in leaves, head and roots of Spinach

Concentration of Mineral Elements in Cabbage

Figure 10 presents the levels of mineral elements in cabbage leaves where values of Ca in samples of Kofar Marusa and Kofar Durbi as 1.33±0.01ppm and 1.33±0.06ppm respectively. Lowest mean concentrations in the leave samples are 0.03±0.01ppm and 0.05±0.01ppm in samples of Kofar Sauri and that of Kofar Durbi respectively. All mineral elements in samples of the study areas have shown to have more concentration in samples of Kofar Marusa as shown in figure 10, 11, 12 and 13 with least concentrations in samples of Kofar Durbi and general distribution patterns as Ca>Mg>K>Na. The distribution pattern revealed that Ca has the highest concentration while Na has the least levels in all samples of the study areas analysed. Moreover, all elements in the head of cabbage share a common distribution pattern as Mg>Ca>K>Na.

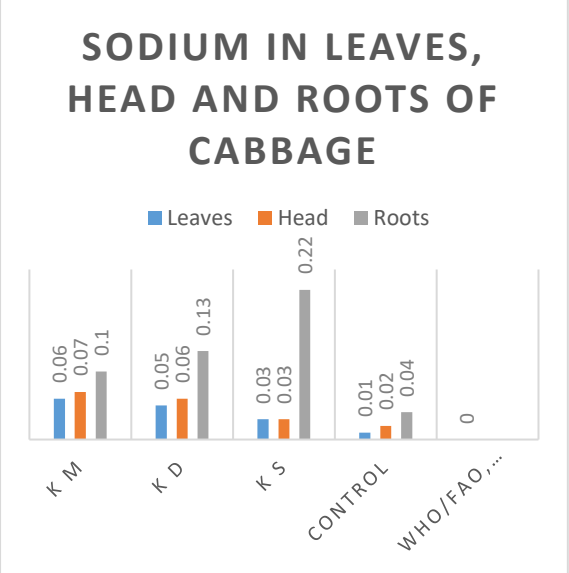

Figure 10: Sodium in leaves, head and roots of Cabbage

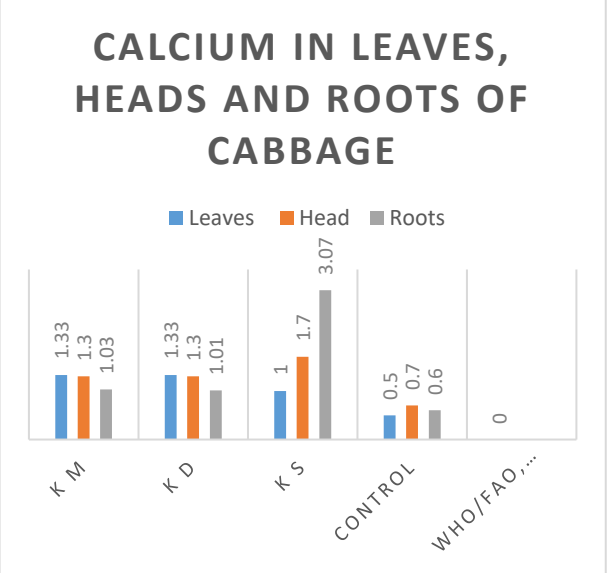

Figure 11: Calcium in leaves, head and roots of Cabbage

Mineral Elements In Spinach

The mean values of K, Mg, and Na in Kofar Sauri samples have lowest concentrations of 0.11±0.01p0pm, 0.81±0.01ppm and 0.16±0.01ppm respectively as presented in figures 12, 13 and 14. Moreover, levels of these elements have the distribution pattern of Kofar Marusa>Kofar Durbi> Kofar Sauri which means that mean levels of K, Mg and Na are highest in Kofar Marusa and lowest in Kofar Sauri. The report of the present research on lowest level of K in spinach leaves indicated that the level is lower than the mean concentration of 5,458mg/100g reported by Kabiru *et al.* (2007) and Muhammad *et al* (2014) where value of K in leaves of spinach to be 18.41mg/kg on the study of the Effects of Three Drying Techniques on Mineral Composition of Some Leafy Garden Vegetables. For mean level of Ca element in the spinach leaves, the pattern of distribution is Kofar Marusa>Kofar Sauri>Kofar Durbi, contrary to the distribution pattern of K, Mg and Na as stated above.

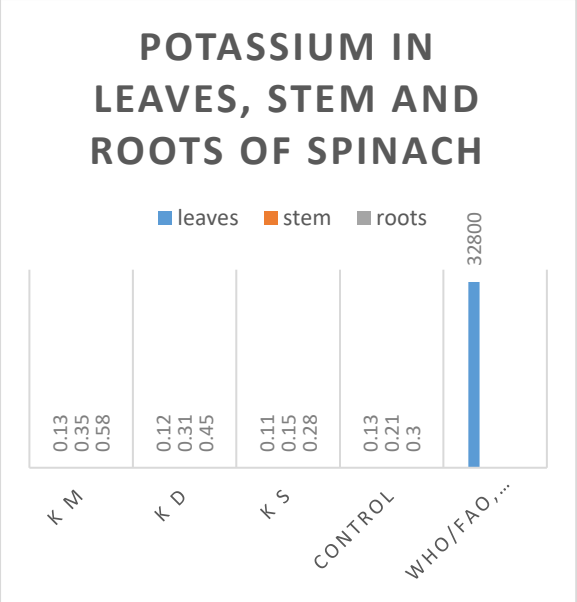

Figure 12: Potassium in Leaves, stem and roots of Spinach

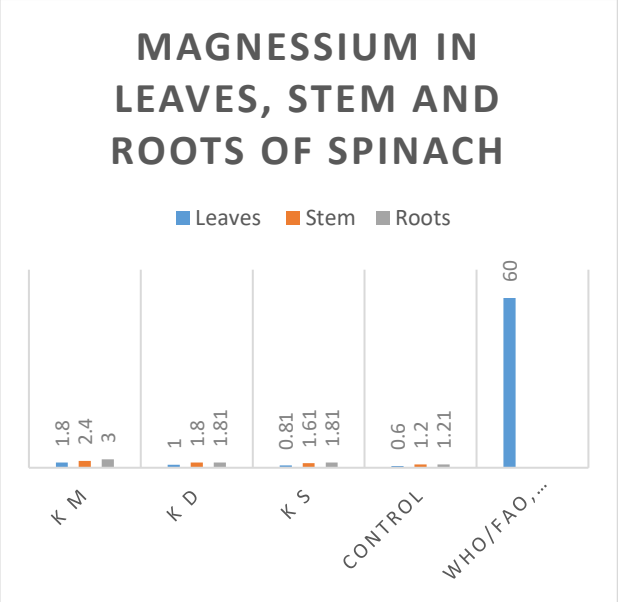

Figure 13: Magnessium in Leaves, stem and roots of Spinach

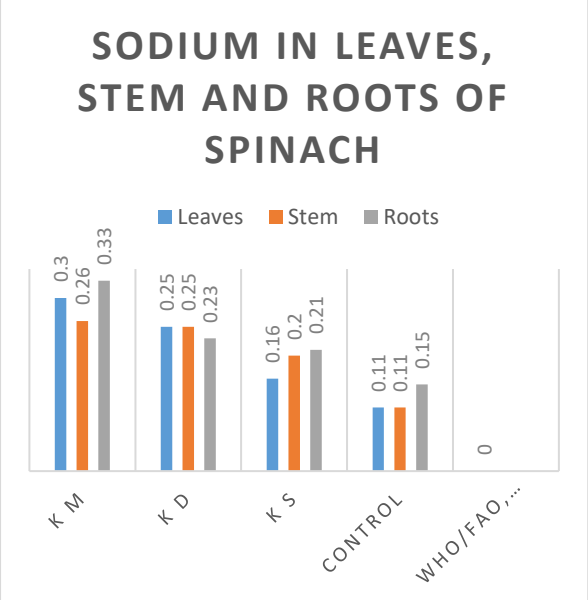

Figure 14: Sodium in Leaves, stem and roots of Spinach

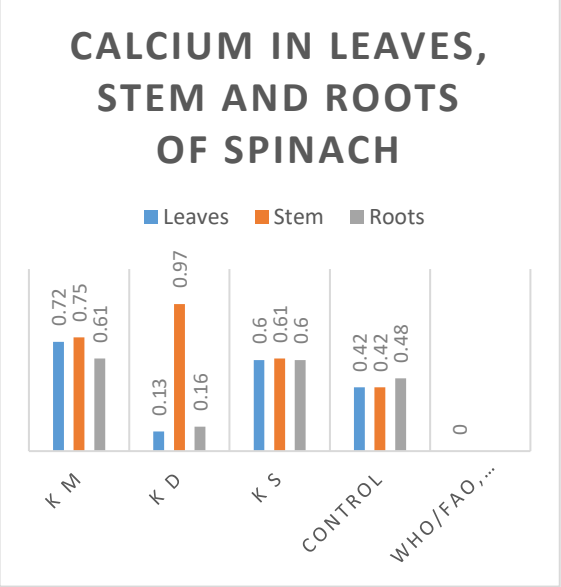

Figure 15: Calcium in Leaves, stem and roots of Spinach

CONCLUSION

The findings of the present research showed that leaves, stems and roots samples of Cabbage and spinach contaminated with Cd, Cr, Pb and Zn, with values of cadmium above permissible limit in samples. This can pose a health risk hazard to the residents of the study area. Also, the analysis showed that mineral elements (K, Na, Mg and Ca) in parts of the vegetables analysed are within the set standards for green leafy vegetables.

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