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Research paper

Heavy Metals Accumulation in Maize (Zeamys) Farland in FCT Abuja

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Heavy metal pollution in terrestrial ecosystem is of concern for a number of reasons. Pollutants in the soil may be absorbed through the roots together with soil water in which they are dissolved and may either cause injury to the plants or pass through the food chain when the plants are consumed. This study evaluated the level of accumulation of these heavy metals in maize farmland in Abuja. Five heavy metals (Zn, Cu, Fe, Pb and Cd) were assessed in maize grains and soil with respect to location and seasonal variation. The result showed that both the soil and maize planted in FCT are not contaminated with heavy metals. However, soil samples had higher heavy metals concentration compare to the maize grains. It was therefore concluded that heavy metals concentration was less than 1 mg/kg, in both the dry and raining season. The dry season samples have higher heavy metals concentration in both the soil and maize samples.

Keywords: Heavy metals, maize

INTRODUCTION

Heavy metals constitute subset of elements that exhibit metallic properties. They are metals and metalloids that are associated with contamination and potential toxicity (Dikinya, 2012). Some heavy metals are pollutants with harmful influences on the natural ecosystem and human health while others are essential elements or micronutrients (Fe,Zn,Cu) and they become harmful if present in excessive amounts, hence these micronutrients have a range of intake over which their supply is adequate to the body (Hassan *et al.,* 2011). Heavy metal pollution in terrestrial ecosystem is of concern for a number of reasons. Pollutants in the soil may be absorbed through the roots together with soil water in which they are dissolved and may either cause injury to the plants or pass through the food chain when the plants are consumed. Metals are natural components of the earth crust they can neither be degraded nor destroyed and will remain in the soil permanently until they are leached out, long term exposure and extensive use of agricultural land with frequent application of pesticides could result in heavy metals such as copper, nickel, zinc and cadmium accumulating in the top soil (Nicholas and Rashed, 2003). Contamination of soil by heavy metals is one of the most serious environmental problems that are implicated in human health process (Okoye and Okwute, 2014).

Maize is known as one of the main food sources for human being since ancient times. It is a domesticated plant and has many beneficial uses for human and animal. Pedro and Tracy, (1995) reported that maize has been one of the most intensively cultivated cereals worldwide, and it is known to be the main energy source in human food. In Nigeria, the most important cereals are sorghum, millet, rice, maize and wheat (Raluca and Simona, 2006). Of all these cereals, maize remains the most popularly grown and consumed in all-ecological zones of the country (Bernadeth, 2014). All living things are directly and indirectly dependent on soil for day to day needs and 95 % of the human food is derived from the earth. Soil has complex function which is beneficial to human and other living organism (Awokunmi *et al*., 2015). Soil is a mixture of minerals, organic matter gases, liquids and myriad of micro and macro organisms that can support plant life. Soil as a general term usually denotes the unconsolidated thin, variable layer of mineral and organic materials usually biologically active that covers rest of the earth land surface (Azubuike *et al.,* 2012).

Soil acts like a reservoir that holds water and nutrients plants need to grow. Some soils are large reservoirs with more holding capacity that release water and nutrients easily to plants, while other soils have limited reservoirs, all pore spaces in the soil are filled with water. Knowledge about available soil water and soil texture can influence the decision-making process, such as determining what crops to plant and when to irrigate. Plants take up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environments as well as from contaminated soils.The study aim to evaluate the level of accumulation of heavy metals in soil and maize plant in FCT and to compare the seasonal variation in heavy metal accumulation in maize and soil.

MATERIALS AND METHODS

Samples collection

A total of 36 sampling stations from both rain fed and irrigated farms were selected across the six area council in the FCT. Eighteen station ns from the rain fed farms and eighteen from the irrigated farms. The area council are Gwagwalada, Kuje, Bwari, Kwali, Abaji and Municipal Area Council.

Soil and maize samples were randomly collected from the sampling stations of each area council in the FCT monthly for the period of 6 month from the rain fed farms and other samples were also collected from three different sampling stations of each of the area council monthly for the period of 6 months from the irrigated farms. A total of 432 soil samples were collected for the study. One hundred and fourteen (108) soil samples and (108) maize samples were collected from the rain feed farms and another one hundred and fourteen (108) soil samples and (108) maize samples from the irrigated farms including the control.

The rain fed samples were collected in the month of July to December 2016 while irrigated samples were collected in the month of January to June 2017. This method is in line with the method described by Wagboe and Hymore, (2001). One kilogram of soil sample from 5 different points from each sampling station were randomly collected in the depth of 0-15.cm from the surface of the soil using metal cylinder borer and a simple centimetre ruler. Five (5) ears of maize samples were collected at the same point where the soil samples were collected.

The samples collected were kept in an appropriately labelled polythene bag and taken to the laboratory for analysis. Samples collected were analysed for the presence and quantity of Cadmium (Cd), Iron (Fe), Copper (Cu), Zinc (Zn) and Lead (Pb) as randomly selected from the list of the top ten heavy metals that are classified by WHO (2015) cited in Benadesh (2014).

Determination of heavy metals in the samples

Sample preparation

The method described by Wagboe and Hymore, (2001) and that of Mathew *et al.* (2012) was adapted for sample preparation. This method involve placing the soil samples collected on a paper for air drying on bench after fresh plants, stones and animal debris have removed. The samples were left on bench for 3-4 days to air dry at room temperature. The dried soil samples were pounded in a mortar into a fine powder and passed through a 2 mm nylon sieve and store in small labelled plastic container. About 1.0 g of the ground samples of both the maize and soil was homogenized and digested with 20 mls of 1:1(v/v) concentrated HNO_3 and HCl acids (Analar grade) in 100 ml beaker. The flask was swirled gently and heated in an electro thermal heater until evolution of white fumes marking the end of the digestion process. The digest then cooled and filtered through whatman No 1 filter paper into 50 ml volumetric flask and diluted to 50 ml mark with distilled water.

Preparation of standard solutions

Standard solutions of the five metals was prepared by dissolving (1.60g) Lead nitrate $Pb(NO_3)_2$, (4.39g), Zinc sulphate $ZnSO_4$, (3.148 g), Copper sulphate $CuSO_4$, (4.84g), Iron sulphate $FeSO_4$ and Cadmium sulphate $CdSO_4$ (3.148 g) analytical reagent grade in one litre of deionised water to get standard solution of 1000 m/l.

Metals determination in the samples

The Five heavy metals (Zinc, Copper, Iron, Lead and Cadmium) was determined by running the prepared samples through atomic absorption spectrophotometer machine and the absorbance of each sample was taken in line with method described by (Wagboe and Hymore, 2001).

Calibration curve

The calibration curve for the five heavy metals was plotted with 0.5 ppm,1 ppm, 1.5 ppm ,2 ppm , 2.5 ppm, 3 ppm and 3.5 ppm for copper, Lead and Cadmium. 5 ppm, 10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm was plotted for Iron and Zinc. The concentration of the metals in ppm analysed in the sample was obtained by reference to the standard curves.

RESULTS AND DISCUSSION

From the results obtained during the raining season, the

concentrations of Zinc (Zn) were higher in the soils compare with their concentrations in the maize grains from all the sampling station except in Kubwa station where Zn has higher concentration in the maize sample (3.00 mg/kg/) compare to soil (1.5). However, higher Zn concentration was observed in soil from Garki (3.5), and Kwali station (3.00) compare to other sampling stations in FCT Abuja (Table 1). Copper concentration (Cu) was higher in the soils samples compare with their concentrations in the maize grains. Higher concentration of copper was observed in Gwarinpa compare to other stations in FCT. Higher concentration was recorded in maize (2.00) compare to soil (0.5) in Bwari station**.** Lead concentration during the raining season was observed to be higher in soil when compared with maize from all the location except in Kwali, Gwagwalada, Kubwa and Bwari where it was observed that Pb concentration was higher in maize than in soil. It was also observed that iron concentration was higher in soil compare to maize from all the sampling stations in FCT Abuja. However, higher concentration of Fe was observed in Garki location compared to other locations. The concentration of Cd was higher in maize compare to their concentrations in soils from all the sampling stations. Higher concentration of cadmium was observed in Abaji compare to other sampling stations Iron concentration was found to be higher in all the sampling stations in soil and maize compare to the concentration of Zn, Pb, Cd and Cu.

The result for dry season also showed similar pattern. It showed that Zn concentration was higher in soil compare to maize in all the locations. Higher concentration of Zn was observed in Zuba and Gaupe. Copper concentrations was observed to be higher in soil compare to maize in Gwarinpa, Bwari, Zuba,Tunganmaje, and Gaupe. A very low concentration of Cu however was observed in all other locations in FCT Abuja. Lead concentrations was very low in all the locations in both the soil and maize in FCT however higher soil lead concentrations was observed in Zuba and Gaupe Iron concentration was observed to be higher in soil compare to maize in all the locations in FCT. Higher soil iron concentration was observed in Lugbe compare to other locations Low cadmium concentration was generally observed from all the locations. Where available they are more concentrated in soil compare to maize. Cd concentration ranges from 1 mg /kg to 2.3 mg/ kg (Table 1).

The data generated from the rain fed samples was analyzed with Pearson correlation and linear regression using SPSS version 21 to compare the level of accumulation of heavy metals in soil and maize during the raining season .The result from Pearson correlation indicated that a strong positive relationship exist between the concentrations of heavy metals in soil and maize (r=0.894,P >0.05).The P-value which indicated that there was a statistically significant difference and Pearson value indicated a very strong relation. The result from linear regression shows R^2 0.799, indicated that soil heavy metals concentration contribute 79.9% of variability of heavy metals concentrations in maize. The coefficient table indicated that as the heavy metals concentration in soil increase so also that of the maize. It could also be predicted that increase in the concentration of any of the heavy metals in soil e.g Zinc by 0.1 g, there is the tendency of the increase in the concentration of metals in maize by 0.21 g therefore if the concentration of heavy metals in soil continues to increase under the same condition, there is the tendency of the maize heavy metals to increase by 6.89 g in 30 years (Table 2).

The data from the irrigated farms were also further subjected to Pearson correlation statistical analysis .The result showed that there was a strong positive relationship between the heavy metals concentration in soil and that in maize.(r =0.893, P>0,05). The P-value indicated that there was no statistically significant difference. Regression analysis showed that $R^{2=}$ 0.797) which means soil heavy metals contribute 79.7% of the variation of heavy metals in maize .The coefficient table indicated that increase in soil heavy metals will result to increase in maize metals. The tables also predicted that increase in any of the soil heavy metals concentration by 0.1 g there is tendency of increase in the metals concentration of maize metals by 0.70 g (Table 2).

From Pearson correlation table there is a strong positive relationship between the heavy metal in soil and maize. The p value is 0.89, indicated that there is a statically significant difference. The result from regression R^2 value is 0.797 translated into percentages is 79.7% which indicated that soil heavy metals contribute 79.7% of heavy metals in maize. The coefficient table indicated that increase in soil heavy metals results to increase in maize heavy metals .This table also predicted that increase in any of the soil heavy metals concentration by 0.1g there will be an increase in the concentration of maize heavy metals by 0.70g The result from one way sample t test showed that there was a statistical significant difference between the soil heavy metals from the rain fed farms and irrigated farms having a slightly higher concentration than the rain fed farms. This means that soil heavy metals are more concentrated in irrigated farms compare to rain fed farms.

The high concentration of heavy metals from the irrigated farms may be as a result of high temperature as metals are activated basically during high temperature Wagboe and Hymore, (2001) reported that absorption and accumulation of heavy metals in plant tissue depend upon many factors include season which include temperature, moisture, organic matter, pH and nutrient availability. In Beta vulgaris higher concentrations of heavy metals were recorded during the summer season, compare winter season.

To compare the level of heavy metals concentrations between rain fed farms and the irrigated farms in maize, data were subjected to one way analysis of variance

Table 1. Mean rain fed heavy metal concentration in soil and maize with respect to location.

Location	Zn		Cu		Pb		Fe		Cd	
	Soil	Maize	Soil	Maize	Soil	maize	soil	Maize	soil	Maize
Nyanya /Rido	2.5	2.08	2.26	0.39	0.12	ND	41.67	10	ND	ND
Gwarinpa Kampam 4	2	2.5	0.16	0.15	0.08	0.1	40	12.5	ND	ND
Garki/Kampam 4	3.63	2	0.13	0.22	0.16	ND	45.83	9.17	ND	ND
Kubwa Kampam 4	1.78	2.05	0.63	0.01	ND	ND	45.83	10	ND	ND
Bwari Rido	1.58	3	0.37	002	ND	ND	44.17	5.88	ND	0.6
Mpape Kampam 4	1.92	2.42	0.22	0.02	ND	0.23	35.28	10	ND	0.3
Zuba/ Kampam 4	2.37	1.97	0.12	0.5	ND	0.1	38.33	5.83	ND	ND
Tunganmaje/Rido	2.2	2.1	0.45	0.2	0.06	ND	37.8	6.67	ND	ND
Gwagwalada Kampam 4	2.13	1.58	0.13	0.51	0.02	0.1	44.17	5.83	ND	ND
Gaupe/Rido	2.4	2	1.25	0.18	0.06	0.01	40	16.33	0.3	ND
Kuje Kampam 4	2.42	2.25	0.4	0.17	0.05	0.01	38.33	5.83	0.3	0.3
Robochi/ Kmpam 4	3	2.82	0.35	0.95	0.03	0.01	28.83	5.83	ND	0.6
Sheda/Rido	1.67	2.1	0.01	0.23	0.12	0.03	27.5	6.67	0.6	ND
Yangojekampam 4	2	1.97	0.01	0.25	ND	0.1	28.33	15	ND	0.6
Kwali/kampam 4	1.41	1.13	0.01	0.1	0.01	0.02	42.50	10	ND	ND
Yaba/Kampam 4	3.17	2.5	0.1	0.2	ND	0.05	40	9.67	ND	1.5
Paikonbas/Rido	2.33	2.17	0.08	0.18	0.1	0.05	40.83	7.5	ND	1.21
Abaji/Kampam 4	1.75	2.53	0.53	0.1	ND	0.01	44.17	6.83	ND	1.51

ND=Not detected

Table 2. Mean irrigated heavy metals concentration in soil and maize with respect to location.

Stations	Zn		Cu		Pb		Fe		Cd	
	soil	Maize	Soil	Maize	Soil	maize	soil	Maize	soil	maize
Lugbe /kampam 4	1.5	ND	2.5	ND	ND	ND	50	12	ND	ND
Gwarinpa/kampam 4	1.8	ND	ND	ND	ND	ND	50	22	ND	ND
Lugbe/Rido	ND	ND	ND	ND	ND	ND	45	40	ND	ND
Kubwa/kampam 4	ND	1.8	ND	ND	ND	ND	45	50	ND	ND
Usmandam1/kampam 4	1.5	ND	ND	ND	0.1	ND	50	45	ND	ND
Usman dam 2 Rdo	ND	ND	2	ND	ND	ND	50	30	ND	ND
Zuba/kampam 4	ND	ND	ND	ND	ND	ND	45	40	ND	ND
Tungan maje/kampam 4	2.5	ND	2.5	ND	0.4	ND	50	10	ND	ND
Giri/Rido	3.5	ND	2.5	ND	0.5	ND	50	10	ND	ND
Sauka/kampam 4	ND	ND	ND	ND	ND	ND	45	40	ND	ND
Kuje/kampam 4	ND	ND	ND	ND	ND	ND	40	35	ND	ND
Kuje/Rido	ND	ND	ND	ND	ND	ND	40	40	ND	ND
Yangoje kampam 4	ND	ND	ND	ND	ND	ND	35	44.17	ND	ND
Yangoje/kampam 4	ND	ND	ND	ND	ND	ND	40	40	ND	ND
Kwali/Rido	ND	ND	ND	ND	ND	ND	49.16	15	ND	ND
Gadabiyu/kampam 4	ND	ND	ND	ND	ND	ND	50	34.2	ND	ND
Gadabiyu/kampam 4	ND	ND	ND	ND	ND	ND	50	50	ND	ND
Abaji/Rido	1	1	ND	ND	ND	ND	50	48.3	ND	ND
Control kampam 4	ND	ND	ND	ND	ND	ND	45	35	ND	ND
Control Rido	ND	ND	ND	ND	ND	ND	40	30	ND	ND

(ANOVA) at 95% level of significance. The result showed that heavy metals have higher concentration in irrigated farms maize sample compared to the rain fed farms. High concentration of heavy metals in maize could be ascribed to high concentration of heavy metals in soil during the irrigation season. Studies on the soil of Vasai Creek, Maharashtra, revealed higher concentration of heavy metals during the dry season than raining season (Rajesh *and* Raju, 2013).

Higher concentrations of heavy metals during the dry season are as a result of high temperature during the dry season. The melting point of most of these metals is high for instance cadmium melting point is 320.9°C, and boiling point 765°C. Zinc is brittle and crystalline at ordinary temperature it becomes ductile and malleable when heated between 110°C and 150°C. Studies on heavy metal concentrations in plants grown in waste water-irrigated soils were found to be significantly higher

during the dry compare to raining season (Khillare *et al*., 2004).

Conclusion

The level of accumulation of heavy metals (Zn, Cu, Fe, Pb and Cd) on soil and maize grains in FCT was found to be less than one (< 1.0mg/kg).The concentration of heavy metals in soil and maize grains in FCT were not statistically significant but however, the mean concentration in soil was higher than the concentration in maize grains. It can also be concluded that the heavy metals has higher concentrations from the irrigated samples compared to rain fed samples in both the maize and soil samples Base on the findings of this study it can be concluded that the soil of maize farmland in FCT is not contaminated with heavy metals.

Recommendations

(i) Farmers that are engage in dry season farming should be enlighten on the dangers of using contaminated water for irrigation farming to avoid fast accumulation of heavy metals in soil and crops.
(ii) There should be the need for awareness campaign by Non-Governmental Organisation (NGOs),Government agencies, learned persson on the harmful effect of farming on farmland that are contaminated with heavy metals.

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