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SEASONAL VARIATION OF SOME POTENTIALLY TOXIC ELEMENTS UPTAKE OF MAIZE CROP GROWN ON WASTE DUMP-SITE SOIL OF W*AKALIGA*, KAMPALA, UGANDA.

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ABSTRACT

The aim of this study was to identify some selected Potentially Toxic Elements (PTE) in soils and maize crops grown on Wakaliga dumpsite and compare them with the standard set limits by national and international agencies such as the World Health Organization and (WHO). Samples were collected for two seasons, the dry (DS) season, May-July 2021, and the wet season (WS), September-November 2021. Samples collected were digested using HCL HNO_3 and hydrogen peroxide, then analyzed using Atomic Absorption Spectrophotometer. Results of the analysis of the soil and crop samples indicated that some of the investigated elements were found in concentration levels within the permissible limits while others were above the permissible set limits. The findings indicated the presence of potentially toxic elements; Zinc had a

Introduction:

Human activities such as industrial production, mining, agriculture and transportation, release high amounts of toxic metals into surface and ground water, soils, and ultimately to the biosphere. Accumulation of toxic elements in crop plants is of great concern due to the probability of food contamination through the soil-root interface. Though heavy metals like Cd, Pb and Ni are not essential for plant growth, they are readily taken up and accumulated by plants in potentially toxic forms. Ingestion of vegetables irrigated with waste water and grown in maximum level of 3.127±0.021 mg/kg and 1.060±0.036 mg/kg dry weight in dry-season and wet-seasons picked maize soils respectively, while the lowest concentrations of copper 0.0617±0.0021 to 0.074 mg/kg dry weight were found in wet-season picked maize-crop. Copper was found to exist below the permissible limits for all the picked soils as well as maize crops. Concentration of lead in maize was found to be within the permissible limit of 2.0 mg/kg dry weight while in other maize crops lead concentration was found to be below the permissible limits. Negligible amounts of cadmium were found in all the samples collected. Toxic elements in the soil samples were found to be below the permissible levels in arable soils as indicated by the WHO (1993). Besides, zinc concentrations were found to be higher in both crop and soil samples of the dry seasons followed by lead, copper and cadmium in this sequences Zn>Pb>Cu>Cd. This could be attributed to the availability of many discarded martials containing these elements in the environment as well as atmospheric deposit in case of lead exhausted by the moving vehicles within the city.

KEYWARDS: Dumpsite, W.H.O Toxic Elements, *Wakaliga,* Hydrogen Peroxide.

Soils contaminated with toxic metals possesses a possible risk to human health and wildlife. Heavy metal concentration in the soil solution plays an important role in controlling metal bioavailability to plants. Most of the studies show that the use of waste water contaminated with heavy metals for irrigation over long period of time increases the heavy metal contents of soils above the permissible limit. Ultimately, increasing the heavy metal content in soil also increases the uptake of heavy metals by plants depending upon the soil type, plant growth stages and plant species [12].

In Uganda, it is a usual practice to find vendors, hawkers and some women in markets selling food and vegetable crops like beans, sugarcane, bananas, spinach and soon in order to raise income to sustain their families. These crops are usually grown in villages in specified gardens free from waste contamination while others are picked from waste dump sites located in wet lands in towns and city centers. [13].There is no clear distinction between the crops picked from such wet lands and those from gardens located far away from the pollution of the cities and towns. So they end up mixing and selling

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them to different people around towns including unmindful passer-by city and town dwellers who have no clear knowledge about their source of origin and composition. Studies have shown that heavy metals from these wastes can accumulate in the soils at toxic levels hence the risk of crops grown in these areas getting contaminated with heavy metals and consequently endangering human health [13]. Severe effects of heavy metals include reduced growth and development, cancer, organ damage, nervous system damage and in extreme cases death. Exposure to some metals, such as mercury and lead, may also cause development of autoimmunity in which a person's immune system attacks its own cells. This can lead to joint diseases such as rheumatoid arthritis, diseases of the kidney as well as circulatory and nervous system [6].

MATERIAL AND METHOD

The study was conducted at *Wakaliga* an area within Rubaga Division, also called Lubaga Division. It is one of the divisions that make up the city of Kampala, Uganda. The division takes its name from Rubaga where the division headquarters are located. Rubaga Division lies in the western part of the city, bordering Wakiso District to the west and south of the division. The eastern boundary of the division is Kampala Central Division. Kawempe Division lies to the north of Rubaga Division. The coordinates of the division are 00 18N, 32 33E (Latitude: 0.3029; Longitude:32.5529) average rainfall for this period lies between 108.4-mm (4.27inches) to 148.7mm (5.85 inches) (WOM).

Figure 1: Map of Wakaliga (Source: Googlemaps.com)

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Soil sampling and chemical analysis

Soil samples were collected in triplicate between the months May-July 2021 and September - October 2017 at *Wakaliga* farms using hand auger and stainless steel hand shovel at the depth of 0-25cm to get full presentation of each sample point. As maize crops have shallow roots, however, to allow for leaching it was found reasonable to extent the soil collection to a depth exceeding 10cm. The soil samples were picked from the exact point where every maize plant were uprooted. All samples were packed in plastic bags and transported to laboratory for analysis.

The Soil samples were dried in an oven at 40^{o}c for 24 hours and sieved using a 2 mm nylon sieve. The finely ground 1.25g of each sample was digested with nitric acid and hydrochloric acid (HCl / HNO_3 3:1) in a 50ml Pyrex Conical flask on electric plate at medium heat. The digest was heated to near dryness and then cooled. Afterwards, 5.0ml of nitric acid was added, followed by 4.0 ml of hydrogen peroxide and heated again to near dryness for complete digestion. The flask walls were washed with 10ml of de-ionized water and 25ml of hydrochloric acid was added, mixed and heated again. The resulting supernatant was allowed to cool then transferred into a 250 ml standard flask and made up to the mark with deionised water. Heavy metals like copper, zinc, cadmium and lead were analyzed by direct aspiration into Perkin Elmer Model 2380, Atomic Absorption Spectrophotometer [9].

Plant sampling and chemical Analysis

maize crops were all randomly collected from *Wakaliga* farms in the Kampala suburb using a stainless steel knife and scissors.The leaves were washed with distilled water to remove soil dirt packed in polyethylene bags and transported to the laboratory within 6 - 12hours at 4^{o}c.

Maize(Zea mays)

A 10 g sample of grounded grain is weighed in a 250-mL beaker and 40 mL of conc HNO_3 was added, covered with a watch glass and let to stand at room temperature for 2 hr. The beaker was then placed on a hot plate to heat slowly for 35 mins after which the mixture was heated again at 70 °C for 3 hr. After cooling, the solution 2 mL of 70% $HClO_4$ was added and heated until a clear solution was obtained. When the digestion process was completed, $HClO_4$ was removed by evaporation. The residue was then treated with 5 mL of conc HCl. An equal volume of distilled water was added with subsequent evaporation to dryness. Finally 1.0 mL of conc Hydrochloric acid was also added and the mixture warmed briefly after which 15 mL water was then added and heating continued for 15 min. The solution was then transferred into a 25-mL volumetric flask, and made up to volume with distilled water [4].

RESULTS AND DISCUSSION

Table 1.1: Descriptive Analysis of Dry Season (DSS) Results for Soil and Plant samples

Source	Metal	Median	Mean	Std. Dev	Variance	Range	Sum	SEM
Maize soils	Zinc	3.120	3.127	0.021	0.000	0.040	9.380	0.012
	Copper	0.790	0.787	0.015	0.000	0.030	2.360	0.009
	Lead	0.950	0.940	0.036	0.001	0.070	2.820	0.021
	Cadmium	0.116	0.116	0.002	0.000	0.004	0.348	0.001
Maize crop	Zinc	2.050	2.360	0.563	0.317	0.990	7.080	0.325
	Cupper	0.078	0.074	0.008	0.000	0.014	0.222	0.005
	Lead	0.710	0.717	0.031	0.001	0.060	2.150	0.018
	Cadmium	0.005	0.005	0.002	0.000	0.003	0.014	0.001

Table 1.2: Descriptive Analysis of Wet Season Results For Soil And Plant Samples

Source	Element	Median	Mean	Std. Dev	Variance	Range	Sum	SEM
Maize soil	Zinc	1.070	1.060	0.036	0.001	0.070	3.180	0.021
	Cupper	0.420	0.420	0.020	0.000	0.040	1.260	0.012
	Lead	1.066	1.066	0.002	0.000	0.003	3.199	0.001
	Cadmium	0.015	0.016	0.002	0.000	0.003	0.048	0.001
Maize crop	Zinc	1.050	1.047	0.045	0.002	0.090	3.140	0.026
	Cupper	0.610	0.617	0.021	0.000	0.040	1.850	0.012
	Lead	0.029	0.028	0.003	0.000	0.005	0.084	0.002
	Cadmium	0.004	0.004	0.002	0.000	0.004	0.012	0.001

The study was conducted to identify and compare the levels of Potentially

Toxic Elements (PTEs) in maize grown on dumpsites soils from *Wakaliga,* Kampala. Two seasons were used for sampling, wet season (WS) and dry season (DS). After all the samples were digested and analyzed, the results obtained showed that PTEs were bit higher in maize picked in dry season (DS) than those picked in wet season(WS), as shown in table 1.1 above. This could be as a result of many factors including changes in pH, Temperature as well as dilution and diffusion [11]. For instance, decrease in the pH of soil solutions accelerates absorption of anion while its increase favors the absorption of cation. By implication, during wet seasons(WS) pH is usually low resulting in increase in the absorption of anion while during dry seasons(DS), pH levels of soils is usually high leading to increase in the absorption of cations such as Zn, Cu, Pb and Cd. With respect to temperature, absorption of mineral salts is affected by increase in temperature to a certain level which by implication means that during dry seasons (DS) when temperatures are high, absorption of mineral salts such as Zn, Cu, Pb and Cd which are to be considered toxic when found in high concentrations also increases. Results obtained(Table 1.1) showed significant increase in the uptake of Zinc by the maize crop examined during the dry season (2.360 ± 0.563). Zinc is an essential trace element, necessary for plant, animals and microorganisms [10][2], Zinc Serves as structural ions in transcription factors and is stored and transferred in metallothioneins. It is "typically the second most abundant transition metal in organisms" after iron and it is the only metal which appears in all enzyme classes [2]. In proteins, Zn ions are often coordinated to the amino acid side chains of aspartic acid, glutamic acid, cysteine and histidine. However, despite its numerous benefits, Zinc in high concentration can be so lethal. The relative high level of Zn in, may be attributed to the availability of Zinc containing wastes from agricultural and animal wastes manure and sludge, corroded galvanized roofing sheets, old water pipes, cosmetics and pharmaceuticals all found discarded in most urban dumpsites. Lead was also found to be the second most absorbed metal after zinc. However, unlike Zinc which was found to be in high concentration during dry season (DS) only, Lead was found to be in high concentration during both seasons in all the maize crops examined (Table 1.1and 1.2).as this study could be due to the fact that lead containing substances were found

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everywhere in the environment emanating from vehicle exhausts, water pipes, paints, building materials, glass batteries etc. Apart from absorbing metals from the ground through the roots by translocation, plants may also possibly absorb metals such as lead in gaseous form directly through the leaves from the atmospheric lead deposition released by moving vehicles. Similarly, copper was also found in small quantities in all the crops examined (Table 1.1) as well as in soil samples collected (table 1.2) . These results testify that, Cu concentrations discovered by this study in all the crops examined as well as soil samples collected for both seasons were far below the standard set limits of 36 mg/kg in soil and 10 mg/kg in Crops Table 1.3 [8].this study revealed that, Cu concentration in dry season (DS) maize was 0.074 ± 0.008mg/kg. Lower concentrations of Cu in crops as obtained during wet season by this study may be as a result of the fact that Cu and pb are largely absorbed from top soil particles reducing their availability to plants. It is worth noting that; copper is one of the transition elements needed by both plants and animals and for human health. For instance, a human adult requires a daily intake of 3-5mg of Cu and contain around 100mg of it, mostly attached to protein; an amount exceeded only by iron and zinc. Copper deficiency results in anemia while congenital inability to excrete copper results in its accumulation leading to an ill health condition known as Wilson's disease [5]. The highest copper wa 0.005 in dry season while lowest was 0.004 ± 0.002 were obtained in wet seasons.

Cd was found in very negligible quantities in all maize crops and their soil samples examined from both seasons and collected from *wakaliga* dumpsite. results obtained which showed that the concentrations obtained were far below the standard set limits of 0.8mg/kg in soil and 0.02mg/kg in crops [8].

Cation Exchange Capacity is apparently reduced by factors such as human induced developmental projects such as constructions and other socio-economic activities which drastically reduce the sizes of dumpsites where these crops are grown subsequently leading to reduction in the amount of metal uptake by the plants. Besides, heavy rainfall also contributes to leaching of the available metals from top soils by making them far from the reach of plant roots. The ability of plants to accumulate essential metals enables them to acquire other non-essential metals.[3]. Generally, metal

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uptake is increased in plants that are grown in areas with increased soil contamination. Among the metals analyzed, Cd and Zn are fairly mobile and are readily absorbed by plants [7]. This also may contribute to the higher presence of Zn metal found in *wakaliga* dumpsite.

TABLE 1.3: world health organization (who) standard for metals

SEASONS	METALS	UNIT	WHO
Wet Seasons	**Zn**	Mg/kg	50
	Cu	Mg/kg	36
	Pb	Mg/kg	85
	Cd	Mg/kg	0.8
Dry Seasons	**Zn**	Mg/kg	50
	Cu	Mg/kg	36
	Pb	Mg/kg	85
		Mg/kg	0.8

CONCLUSIONS

Although concentrations of all the analysed elements in the soil samples collected were found to be below the permissible set limit by the WHO/FAO for soils used for agricultural activities, but for plants there were variations in metal concentrations between the two seasons. In most dry seasons samples collected (crops) there was a significant increase in the metal concentrations when compared to those from wet season. But may not rule out that with time this metals uptake by the plant may be increased due to many environmental factors especially increased in the level of deposit of toxic containing waste on the dumpsite, indiscriminate disposal surface runoff and pH which may subsequently lead to bioaccumulation and end up causing serious health hazard to the consumers of these food crops. Lower concentrations of the metals obtained in this study may also be attributed to the fact that being a dumpsite for sometimes, *Wakaliga* dumpsite is now mostly being overtaken for developmental projects such as constructions which in turn reduce the abundance of these toxic metals for plant uptake. Besides, high rainfall being experienced in the area also contributed to lessening the abundance of the metals through leaching.

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