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HEAVY METAL ACCUMULATION IN MAIZE (*Zea mays L.*) GRAIN GROWN ON DIFFERENT DUMPSITE SOILS

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ABSTRACT

This study was carried out at the Botanical Garden of the Department of Plant Science and Biotechnology, in Rivers State University (RSU), Port Harcourt, Nigeria with the aim of investigating heavy metal accumulation in maize grain grown on different dumpsite soils. Soils used were collected from three different locations with the control; Njemanze Dumpsite, Mile One Flyover Dumpsite and Chinda by Iwofe Dumpsite and analyzed for the presence of the following heavy metals; Cadmium (Cd), Chromium (Cr), Silver (Ag), Lead (Pb) and Mercury (Hg). Soil from Rivers State University Botanical Garden was used as control soil. The soils were analysed using the American Public Health Association (APHA 3111C) method to determine the heavy metal concentration level. The seeds of maize were sown into polybags containing the different soils and the maize plants were allowed to grow to maturity. The result showed the presence of heavy metals in all soil samples with Mile One Flyover Dumpsite having the highest concentrations (Cd; 46.771, Cr; 61.885, Ag 18.629, Pb; 354.386, Hg; 170.474) and RSU (Control soil) had the least concentrations (Cd; <0.001, Cr; 12.295, Ag; <0.001, Pb; <0.001, Hg; <0.0005) of the metals. The heavy metals in the maize grains of the matured maize plants were analysed. The result showed the maize grains of the plants in the soil from Mile One Flyover Dumpsite had high concentrations while the control soil from Rivers State University had low concentrations except Cr that was slightly high when compared to WHO standard.

KEYWORDS:

Heavy metals, Maize, Dumpsite soil, Concentrations.

1. Introduction

Metals with relatively high density are referred to as heavy metals (Yadav *et al*., 2019). Heavy metals contaminate soil used for agricultural processes, these contamination arises at all stages from industrial activities, mining of metallic ores, release of animal waste and fertilizers and indiscriminate disposal of domestic waste (Iderian, 2010; Verla *et al.*, 2017; Armienta *et al.*, 2020; Abdelgawad *et al.*, 2020).

The practice of open dumping of waste in Nigeria is on the increase as most cities, Port Harcourt inclusive are known to be covered with domestic waste and cabbages on major streets and drainages (Ideriah, 2010). The release of materials contaminated with heavy metals into the soil can contaminate the soil and with the rains, the metals seep into the soil and are later transferred into plants and into man when these plants are consumed (CoŞKun *et al*., 2006). There is also the belief that heavy metals are sometimes hazardous to human health and the health risk relating to heavy metals impacting on humans has been reported widely (Claire *et al*., 1991; Baker *et al*., 2000; Duruibe *et al*., 2007).

Some heavy metals are essential, while some are non-essential (Theron *et al*., 2012; Akanchise *et al.*, 2020). The heavy metals, cadmium, chromium, silver, lead and mercury investigated in this study are part of the list of non essential ones that are toxic, indicating that these metals are present in high concentrations (Goyer, 2004). These heavy metals spread evenly, are biologically toxic, and stay long in the soil environment (CoŞKun *et al*., 2006; Zhao *et al*., 2022). Since these heavy metals are present in the soil in concentrations higher than normal, plants, animals, micro organisms and humans are at risk of accumulation through food chain (Gonzalez Henao and Ghneim-Herrera, 2021), this in turn affects the use of land for agricultural production, food quality, food safety and security (Wuana and Okieimen, 2011).

Edible crops such as maize, millet, rice (Chaney *et al*., 2005) grown on contaminated soils have greater ability to accumulate heavy metals than those crops grown on soils that are free of toxic metals (Eriyamremu *et al*., 2005). Although plants under normal circumstances do not readily absorb large amount of heavy metals, the amount of heavy metals absorbed by plants is dependent on the heavy metal concentration, the variety of plant species, soil chemical components and soil pH (Lu *et al.*, 2015).

This paper seeks to ascertain heavy metal accumulation in maize grain grown on different dumpsite soils.

2. Materials And Methods

Soil Collection and Analysis

The soils used for the study were collected randomly from each of the three different dumpsites as well as the control in Port Harcourt Rivers State Nigeria using a soil auger.

Control: Rivers State University (RSU) Botanical Garden (Control soil),

Location 1: Njemanze dumpsite (Comprising of domestic waste),

Location 2: Mile-One Fly over Dumpsite (Mainly tyre waste),

Location 3: Chinda Dumpsite (Majorly plastic waste).

The soil samples were analyzed for 5 heavy metals (Cd, Cr, Ag, Pb, Hg).

Seed source

The test crop (hybrid maize – Oba Super 13) was sourced from Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

Experimental site

The experiment was carried out in the Department of Plant Science and Biotechnology, Botanical Garden, Rivers State University, Port Harcourt, Nigeria.

Heavy Metal Analysis

The method of American Public Health Association (APHA 3111C) was adopted for the analysis of the selected heavy metals (Cd, Cr, Ag, Pb, Hg). The acid digestion technique was used for the sample digestion while the atomic absorption spectrophotometer was used to assess the digested samples for the selected heavy metals (APHA, 2017).

3. RESULTS

Soil Analysis for Heavy Metals

The heavy metals (Cd, Cr, Ag, Pb, Hg) present in soil samples from three different dumpsites as well as the control are shown in Table. 4.1. The heavy metals (Cd, Cr, Ag, Pb, Hg) were present in the different soil samples with Mile One Flyover Dumpsite having high concentrations than the other locations. Pb and Hg were highest (Cd; 46.771, Cr; 61.885, Ag 18.629, Pb; 354.386, Hg; 170.474), in Chinda by Iwofe Dumpsite. Pb had the highest concentration (Cd; 1.710, Cr; 20.492, Ag; 14.307, Pb; 50.439, Hg; 36.270), Pb was also high for Njemanze Dumpsite but Ag and Hg were low (Cd; 0.456, Cr; 18.852, Ag; <0.001, Pb; 20.514, Hg; <0.0005). Rivers State University (Control) had low concentrations except Cr that was slightly high (Cd; <0.001, Cr; 12.295, Ag; <0.001, Pb; <0.001, Hg; <0.0005).

Analysis of Heavy Metals Present in Soil Samples Collected from Three Different Dumpsites in Port Harcourt (mg/kg)

S/N	Parameter	RSU (Control)	Njemanze Dumpsite	Mile One Flyover Tyre Dumpsite	Chinda by Iwofe Dumpsite	FMEnv Limits	WHO/FAO Limits
1	Cd	<0.001	0.456 ± 0.05^{a}	46.771 ± 5.43^{b}	1.710 ± 0.05^{c}	<1	3
2	Cr	12.295 ± 1.74^{a}	18.852 ± 3.89^{a}	61.885 ± 12.56^{b}	20.492 ± 1.23^{c}	10-200	50
3	Ag	<0.001	<0.001	18.629 ± 2.34^{a}	14.307 ± 2.25^{a}	0.1	1
4	Pb	<0.001	20.514 ± 1.78^{a}	354.386 ± 23.56^{b}	50.439 ± 3.41^{c}	2-200	100
5	Hg	<0.0005	<0.0005	170.474 ± 8.77^{a}	36.270 ± 8.33^{b}	0.05	0.05

Values are Expressed as Mean S.E.M (n=5). Means with Different Superscripts (a-c) are Significantly Different (Tukey, HSD, $p<0.05$)

The heavy metals (Cd, Cr, Ag, Pb, Hg) analyzed in maize grains of the maize plants established in soils collected from three different dumpsites as well as the control are shown in Table 4.2. The heavy metals (Cd, Cr, Ag, Pb, Hg) present in the maize grains of the plants in the soil from Mile One Flyover Dumpsite had high concentration except Ag (Cd; 8.085, Cr; 2.361, Ag<0.001, Pb; 15.947, Hg; 6.300). In Chinda by Iwofe Dumpsite, Cd and Ag were low (Cd; <0.001, Cr; 0.172, Ag; <0.001, Pb; 2.219, Hg; 3.933). In Njemanze Dumpsite, Cd, Ag and Hg were low (Cd; <0.001, Cr; 0.082, Ag; <0.001, Pb; 10.439, Hg; <0.0005) and Rivers State University (Control) had low concentrations except Cr that was slightly high (Cd; <0.001, Cr; 0.527, Ag; <0.001, Pb; <0.001, Hg; <0.0005).

Analysis of Heavy Metals Present in Maize Grains Harvested from Three Different Dumpsites in Port Harcourt (mg/kg)

S/N	Parameter	RSU (Control)	Njemanze Dumpsite	Mile One Flyover Dumpsite	Chinda by Iwofe Dumpsite	WHO /FAO Limits
1	Cd	<0.001	<0.001	8.085 ± 1.65^{a}	<0.001	0.05
2	Cr	0.527 ± 0.03^{a}	0.082 ± 0.002^{b}	2.361 ± 0.11^{c}	0.172 ± 0.03^{a}	0.05
3	Ag	<0.001	<0.001	<0.001	<0.001	0.1
4	Pb	<0.001	10.439 ± 1.11^{a}	15.947 ± 2.34^{c}	2.219 ± 0.24^{b}	0.1
5	Hg	<0.0005	<0.0005	6.300 ± 1.05^{d}	3.933 ± 0.33^{c}	0.001

Values are Expressed as Mean S.E.M (n=5). Means with Different Superscripts (a-d) are Significantly Different (Tukey, HSD, $p<0.05$)

4. DISCUSSION

This study has shown that soils collected from Mile One Flyover Dumpsite, Chinda by Iwofe Dumpsite, Njemanze Dumpsite, and Rivers State University (Control soil) contain heavy metals; Cadmium, Chromium, Silver, Lead, Mercury.

The heavy metals were present in all four soil samples with varying concentrations. The variation in the heavy metal concentrations showed Mile One Flyover Dumpsite had high concentrations of cadmium, chromium, and lead, this could be attributed to the tyre waste contained in the soil. Chinda by Iwofe Dumpsite had high concentration of chromium, lead and mercury, the Njemanze Dumpsite had high concentration of chromium and lead and Rivers State University (Control) with low concentration of the metals except chromium that was present, Ag was low in all soil samples This agrees with the findings of Awokunmi, *et al*. (2010) and Uba *et al*. (2008) that the amount of toxic heavy metals contained in soil collected from different dumpsites were found to be significant. This study is also is in line with the statement of Riz wan et al., (2017) that maize can possibly transfer metals to their aerial parts due to accumulation of the metals from contaminated soil in the maize plant (Rizwan *et al*., 2017).

This study has also shown that the maize grains contain the analysed heavy metals (Cd, Cr, Ag, Pb, Hg) as represented in Table. 2. While this present study investigated the effect of heavy metal contaminated soil on the growth and yield of maize, Clemens (2002) investigated the effect that heavy metal has on maize grown on crude oil contaminated soil. Both studies are similar as their results showed that the accumulation of heavy metals by plants and its availability in the food we eat is determined by the micronutrient and toxic metal content of the soil used for propagation.

This present study also agrees with Agbogidi *et al*. (2007) who analyzed the heavy metal (Fe, Zn, Cr, Mn) content of harvested maize grains in contaminated soil and observed that the content of heavy metal in maize grains harvested from the crude oil contaminated soils were significantly different ($p \leq 0.05$) when compared with the grains harvested from the uncontaminated soils. This demonstrates that when soils are contaminated with heavy metals, there is gradual building up of the metals contained in the soil during growth and developmental stages, making the leaves and grains potentially toxic, which, if consumed as food has the potential to cause harm to livestock and man.

5. CONCLUSION

This study has shown that soils collected from dumpsite contain heavy metals. The heavy metal contained soils when used to grow maize can accumulate in the harvested maize grains. The presence of the heavy metals in the maize grains poses a concern as to whether these metals will be accumulated in the human body when consumed. The result of this study therefore suggests that soils used for plant growth should be free from heavy metal contamination.

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