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Assessment of the Impact of Solid Wastes on Agricultural Soils and Plants: A Case Study of Kazaure, Jigawa State Nigeria

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Abstract: *Increased population growth coupled with heightened industrial processes and improved lifestyles have led to more generation of solid waste which end up in indiscriminate and unregulated dumpsites. These slid wastes are well repositories for heavy metals which can impact negatively on the ecosystem causing severe ecological damage affecting biota. In this study, soils and Chromolaena odorata collected from ten dumpsites in Kazaure town were assayed for their heavy metal content using Flame Atomic Absorption Spectrophotometer. Physicochemical parameters of the soil were also examined using standard analytical procedures. The results revealed varying concentration of the metals in the soil and plant sample. The mean concentrations (mg/kg) of the heavy metals in the soil were: 43.0±9.3>24.4±8.4>14.0±9.0>1.3±0.7, respectively while for Chromolaena odorata the mean metal concentrations (mg/kg) reveal: 36.20 ± 7.70, 21.10 ± 5.30, 11.20 ± 3.00 and 1.5 ± 0.8 for Zn, Cu, Pb and Cd, respectively. The general trend in the metal abundance in both the soil and Chromolaena odorata is: Zn>Cu>Pb>Cd. The metal level of metals in both the soil and plant is higher than the control sites and generally exceeded the WHO maximum permissible limits. The metal transfer factors were greater than unity in several sampling locations which suggest that the plant has high potential to translocate and bio accumulate the metal in its tissues. This implies higher risk concerns about the use of soils of dumpsites as manures to grow crops for consumption. Therefore regular monitoring and decontamination of the soils from the dumpsite needs to be done before using it for agricultural activities. Moreso, it is imperative that stringent waste management policies be put in place to mitigate contamination risks, and ensure resilient and secure food system*

Keywords: Dumpsites, physicochemical parameters, heavy metals, transfer factors Chromolaena odorata

I. INTRODUCTION

Geometric growth in population, heightened industrial processes coupled with demand for essentials lead to daily waste generation which end up in dumpsites and impact negatively on soils and surface environment (Mekonnen et al. 2020). Researchers establish that discharge of huge volumes of domestic, municipal and industrial solid wastes lead to serious ecological pollution that have the potentials of affecting biota. Improper waste management such as open dumping and incineration of solid wastes especially in developing and underdeveloped communities is turning out to be a global issue of immediate concern (Mekonnen et al. 2020). In many developing countries, huge wastes are generated and disposed indiscriminately without commensurate capacity for waste management resulting in severe heavy metal contamination which eventually leads to a risk to the aquatic and terrestrial ecosystems. Heavy metals can bioaccumulate in organisms over time and transfer through food chain to humans. Likewise, improperly disposed solid wastes generate toxic leachates (Vaccari, Vinti and Tudor, 2018; Daniel et al., 2021), especially from dumpsites which often percolates into surface water bodies or trickle through underground water, soils and other biophysical components of the environment resulting in adverse effect on humans, aquatic organisms, plants and animals (Agbeshie et al., 2020). In many communities, solid wastes at dumpsites are incinerated in preparation to sift and collect the decayed and accumulated rich organic soils for fertilization of crops on farms (Cortez and Ching, 2014). This practice results in emissions of fugitive and noxious fumes containing toxic metals (Sullivan and Woods, 2000). In some instances, abandoned dumpsites are converted into farmlands for cultivation of vegetables, crops and other edible or medicinal plants (Cortez and Ching, 2014). Unfortunately, most of the farmers use such soils ignorantly without the knowledge of the risk of the potentially toxic heavy metal uptake by the plants and subsequent transfer via food chain to humans (Ali and Khan 2018). Abdallah et al., (2011), Ukpong et al., (2013) and Ediene and Umoetok (2017), have reported that soils at dumpsites contain varying concentrations of heavy metals which could be absorbed by plants and subsequently transferred through food chain to humans and animals. Heavy metals such as lead (Pb), zinc (Zn), cadmium (Cd) and copper (Cu) which have specific gravity more than 5 gcm^{-1} (Cortez and Zing, 2014), are particularly established to present potential risk at concentrations in exceedance of the stipulated WHO and FAO limit. These metals tend to bioaccumulate, hence, increase in their toxic levels when ingested by living organisms (Musa and Ikhajiagbe,2019).

Sources of heavy metals

Heavy metals are found in the environment both through natural/geogenic/lithogenic and anthropogenic sources. The natural or geological sources of the metals in the environment include weathering of metal-bearing rocks and volcanic eruptions. On the other hand, the global trends of industrialization and urbanization on earth have led to an increase in the anthropogenic sources of the metals (Nagajyoti, Lee and Sreekanth, 2010). The anthropogenic sources of heavy metals in the environment include smelting, mining and industrial, pharmaceuticals, agricultural activities and also discharge of wastewaters such as industrial effluents and domestic sewage which contribute heavy metals to the environment (Ali, Khan, and Ilahi 2019; Tchounwou et al., 2012). The persistence and non-biodegradability of heavy metals in the environment continue to constitute a serious health risk especially to animals and humans (Edo et al., 2024).

The Research Area

Due to rapid growth and development, Kazaure town hosts several small scale industries such as tie and dye, textiles, meat processing, welding, blacksmithing, mechanic workshops, food processing industries among others which generate large amounts of wastes on daily basis. These wastes are either deposited openly in abandoned buildings, on roadsides, in gutters or on the streets (**Figure 1a**), and on occasions clogging drains, creating feeding ground for pests that spread disease and creating a myriad of related health and infrastructural problems. Inefficient management methods of these solid wastes vitiates the aesthetic value of the environment, and incidentally pilot the contamination of soils, surface water **(Figure1b)**.

Figure 1: (a) Refuse dumpsites on the street and (b) Solid waste washed by rain runoffs on voyage to surface water body.

Most of the toxic metals arising from the generated wastes are washed away by runoffs into streams, rivers or open water repository **(Figure 1b)** hence contaminating the aquatic environment. Similarly, incineration of the wastes in dumpsites gets rid of the organic components while releasing toxic emissions, metal oxides and ashes at the sites which also have negative consequences (Kumari et al., 2019). Assessing the heavy metal concentration in the soils and plants, is a critical and important component of waste management and risk assessment at waste dumpsites. This study undertakes to determine the extent of heavy metal contamination of soils in 12 waste dumpsites and the influence of the solid waste on soil physicochemical properties. The study will focus on investigating the concentrations and evaluating the risk of four heavy metals pollution including Zn, Cu, Pband Cd. It is anticipated that, data obtained from the study will be used by environmental regulators, residents and farmers to broaden their knowledge on the risk accompanying waste dumpsites.

II. MATERIALS AND METHODS

Description of Sampling Area

Twele dumpsites were selectedas the sampling areas comprising Katoge (KTG), Psychiatric Hospital Kazaure (PHK), Shagari Lokon Rijiya (SLR), Shagari Gidan Ruwa (SGR), Local Government Quarters (LGQ), Lokon Shagon Mustapha (LSM). Others include Opposite Chiroman Ruga(OCR) along Daura highway, Kazaure Main Abattoir (KMA), Kanti Gabas behind Church (KGC), Kanti 'Yan Kifi (YKF), Poly Students' Hostel (PSH) and Poly Staff Quarters(PSQ) in 'Yan Makada. The sampling sites are indicated in the table below with the various geographical co-ordinates. The control site was an uncontaminated site in Hussaini Adamu Federal Polytechnic, Kazaure

Table 1. Sampling sites, their codes and geographical co-ordinates

Sampling Locations	Code	Geographical Co-ordinates
Katoge	KTG	12.00, 12.04
Psychiatric Hospital Kazaure	PHK	12.90, 12.00
Shagari Lokon Rijiya	SLR	12.21, 12.23
Shagari Gidan Ruwa	SGR	12.10, 12.20
Local Government Quarters	LGQ	12.09, 12.11
Lokon Shagon Mustapha	LSM	12.02, 12.09
Opposite Chiroman Ruga	OCR	12.31, 11.00
Kazaure Main Abattoir	KMA	12.00, 11.01
Kanti H/Gabas Church	KGC	12.01, 09.80
Kanti Yan Kifi	KYK	12.31, 10.11
Poly Students' Hostel	PSH	12.33, 12.05
Poly Staff Quarters	PSQ	12.11, 12.00
Hafed Poly	Ctrl	12.10,08.11

Sample Preparation:

Soil collection and preparation

Soil samples were collected at the dept of 0 – 30 cm using soil auger. The samples were conveyed in sterile polythene bags to the laboratory where it was air-dried and pulverized with a sterilized porcelain mortar and pestle. To obtain a composite representative sample, the samples were homogenized by coning and quartering as established in related literature (Sagagi et al., 2022). The sampled soils were then stored in air-tight polyethene bags and labelled accordingly before being subjected to different analytical techniques as described by Nwakife et al., (2022).

Plant sample collection and preparation

The plant selected for the heavy metal study was *Chromolaenaodorata (L.)* also known as Siam weed. It is a typical weedy herb native of tropical Africa, commonly found in the dumpsites. The plant leaf is rich in phytochemicals making it very crucial in traditional medicine serving as anti-bacterial, anticancer, anticonvulsant, antidiabetic, anti-diarrheal, anti-fungal, anti-inflammatory, antioxidant, and antiparasitic(Sirinthipaporn and Jiraungkoorskul, 2017). The fresh plantsamples were obtained from all the refuse dumpsites. The samples in their prime conditions were properly wrapped in paper and tagged before being conveyed to the Hussaini Adamu Federal Polytechnic herbarium where it was identified by a certified Botanist Mustapha Saidu Abdullahi in the Department of Science Laboratory Technology (SLT), School of Science and Technology Kazaure. The plant samples were thoroughly washed with distilled water and allowed to drain at room temperature. The samples were thereafter dried in a hot air oven at 40 °C for 48 h and subsequently pulverized into powder using pestle and mortar according to established protocol described by Sagagi et al. (2022) and were stored in polythene bags for further analysis.

Digestion of samples for AAS analysis

Digestion of soil sample and metal analysis:

The pulverized soil samples from each of the sampling sites were passed through a 2 mm sieve. The fine earth fractions were retained for analysis. 5 g of the soil samples was each placed in 100 ml beaker and 3 ml of 30% hydrogen peroxide was added following the procedure described by Shriadah (1999). This was left to stand for 60 min until the vigorous reaction ceased. Then 75 ml of 0.5 M HCl solution was added and the content heated gently at low heat on hot plate for about 2 h. The digest was then filtered into 50 ml standard flask and made up to the mark. The metal contents (Zn, Cu, Pb, Cd) were investigated in the digested aliquots by Agilent Technologist 200 series Flame Atomic Absorption spectrophotometer (FAAS).

Digestion of plants sample and metal analysis:

The digestion of the plant sample was conducted according to the procedure described by Awofolu (2005). 0.5 g of the sieved plant sample was accurately weighed into 100 ml beaker. A mixture of 5 ml concentrated trioxonitrate (V) acid and 2 ml perchloric acid was added and this was digested on low heat using hot plate until the content reduced to about 2 ml. The digest was allowed to cool and filteredinto a 50ml standard flask using Whatman Filter Paper No. 42.The beaker was rinsed with small portions of double distilled water and filtered into the flask and made up to mark with deionized water. The metals (Pb, Zn, Cd, and Cu) in the digested aliquots of the samples were analyzed by Agilent Technologist 200 series Flame Atomic Absorption spectrophotometer.

Determination of Physicochemical Parameters

Some selected physicochemical screenings were conducted on the soil samples from the 12 dumpsites using standard procedure as described by Rahul, (2015) and Elbehiry et al., (2020). Soil pH was determined in a ratio 1: 2.5 (soil/water) suspension by a pH-meter meter previously calibrated using pH4, pH7 and pH10. Soil salinity was measured as electrical conductivity (EC) in a ratio 1:5 (soil/water) solution with an EC-meter. Soluble (Cl^-) anions were measured volumetrically according to method of Black (1965). Soil organic carbon (OC) was determined by the method of Walkey and Black (1934). The soil texture was determined using the hydrometric, et al., 2017method (Obianefo).

Transfer factor (TF)

The transfer factors (TF), also referred to as accumulation factor, uptake factor or concentration factor (Emurotu and Onianwa, 2017) of heavy metals from soils to plants were calculated based on the formula reported by Cui et al. (2005):

$$TF = \frac{metal\ concentration\ in\ plant\ tissue\ from\ the\ site}{metal\ concentration\ in\ soil\ from\ the\ site}$$

III. RESULTS AND DISCUSSION

Characterization of refuse dumpsites wastes

The results of characterization of the refuse dumpsite wastes is depicted in **Table 2.0.**Ten types of solid wastes were identified and the most abundant were textile materials constituting between 0.00 to 47.60%. High textile waste could be attributed to the numerous tailoring business outlets in many parts of the town. Textile waste may take a long time to decompose in landfills, contributing to environmental pollution and greenhouse gas emissions. Moreover, the chemicals used in textile production can contaminate water bodies. Plastic waste trailed in percent abundance in all the sampling sites from each zone. The ubiquitous nature of plastic waste can be attributed to the wide application of plastic materials in packaging, domestic utensils and other automobile parts. Plastic materials are now replacing the use of metallic utensils in most households (Pilapitiya and Ratnayake, 2024). The percent plastic wastes in the dumpsites found was between 14.80 -44.80%. Plastics particles may enter our bodies through food, water, and air, potentially causing respiratory and digestive issues. Moreover, plastics release harmful chemicals like BPA and phthalates, which can disrupt hormones and lead to developmental problems. The may also harbor bacteria and viruses, increasing the risk of infections. Glass waste were also found in abundance in the sampling sites which can be traced to numerous construction exercises witnessed in the town. Recently, Kazaure town is witnessing rapid expansion and growth due to urbanization resulting in the erection of so many residential, institutional and commercial buildings to accommodate the increasing population and commercial activities. Glass waste component of the waste consists of between 2.40 to 24.80%. Improperly disposed glass waste can litter landscapes and harm wildlife and it can break down into tiny particles that can be ingested or inhaled, potentially causing respiratory or digestive issues.The general trend in abundance of the solid wastes is in the order: Plastics>Textiles>Others>Glass>Plants>Stones>Bones>Tiles>Papers.

Table 2: Characterization of refuse dumpsites wastes (%)

Solid Wastes	Sampling Locations											
	KTG	**PHK**	**SLR**	**SGR**	**LGQ**	**LSM**	**OCR**	**KMA**	**KGC**	**YKF**	**PSH**	**PSQ**
Textiles	14.00	9.20	47.60	12.80	4.80	14.80	16.80	33.20	22.40	9.20	0.00	37.60
Plastics	14.40	37.60	23.60	33.60	42.80	36.40	25.20	20.00	28.00	14.80	44.80	16.00
Glass	11.60	4.40	2.40	16.00	8.80	15.20	24.80	17.20	9.20	16.00	14.80	22.00
Plants	7.60	27.60	9.20	10.80	2.00	16.80	10.00	20.00	12.80	20.00	14.80	10.40
Stones	8.40	3.20	4.40	0.00	8.00	0.00	13.20	0.00	18.80	15.20	0.00	0.00
Bones	0.00	0.00	0.00	2.80	0.00	6.00	0.00	6.80	0.00	3.60	0.00	4.00
Tile	0.00	0.00	0.00	4.00	13.20	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Papers	0.00	0.00	0.00	2.80	0.00	0.00	0.00	2.80	2.00	3.20	4.40	0.00
Others	44.00	18.00	12.80	17.20	20.40	10.80	10.00	0.00	6.80	18.00	21.20	4.40

Physicochemical properties

The result of the physicochemical characteristics of the soilsampleis shown in Table 3.0.As observed, soil pH is seen to be weakly acidic with values ranging between 5.90 ± 0.14 - 6.95 ± 0.07 except for SGR and LSM where the soils were observed to be neutral. Soil pH plays an important role in metal bioavailability, toxicity and leaching capability to the surrounding areas especially in summer time (Abdallah et al., 2012). Heavy metals are mostly more soluble and leach out in acid pH (Alloway, 1995). Generally, low pH values may be associated with dumpsites that receive low rainfall percolation where leaching tends to be very intense and the base forming cations are left to dominate the exchange complex in place of Al^{3+} and H^{+} (Okunola *et al*, 2007). The pH of soil affects all soil properties i.e chemical, physical and biological

The level of total organic carbon (TOC) in the soil was in the range of 1.16 ± 0.59%, to 6.38±2.86 and the corresponding TOM varied in the range of 2.00 - 11.00±2.00%. Researchers have indicated that some metal fractions can be occluded to the soil organic content thereby making it imperative to determine the organic carbon in soil samples (Balpande, 2021). Soil organic matter can also influence the uptake of heavy metals by plants. In agricultural soils, higher organic matter could be attributed to over-fertilization especially with organic fertilizers (Song et al. 2016). Research has also revealed that apart from other factors such as presence of dolomite and phosphates, organic matter in soils also reduces the concentration of metals by precipitation, adsorption and complexation (Abdallah et al., 2012) making them unavailable to the plants.

The result of the soil textural quality revealed that the soils from the dumpsites contained the three different soil components which is in the sequence Sand>Silt>Clay. KTG recorded the lowest value (%), 1.90% while YKF recorded the highest value of clay, (7.10%). The silt content of the soil in the studyarea was in the range of 2.40 - 31.10 recorded for LGQ and PSQ, respectively. The range of the sand content recorded ranged between 64.5 - 94.40 % suggesting that the soil was generally classified as coarse textured soils (loamy sand).

Soil Parameters	KTG	PHK	SLR	SGR	LGQ	LSM	OCR	KMA	KGC	YKF	PSH	PSQ
pH	7.85 ± 0.21	6.95 ± 0.07	8.35 ± 0.07	7.15 ± 0.07	5.90 ± 0.14	7.00 ± 0.14	6.05 ± 0.07	6.1 ± 50.07	6.75 ± 0.07	6.35 ± 0.07	6.90 ± 0.12	6.80 ± 0.28
TOM	7.00 ± 1.41	3.00 ± 1.41	9.00 ± 1.41	3.00 ± 1.41	2.00 ± 0.00	7.00 ± 1.41	4.00 ± 0.0	6.00 ± 0.00	10.00 ± 0.00	3.00 ± 1.41	11.00 ± 1.41	7.00 ± 1.41
TOC	4.06 ± 1.67	1.74 ± 0.48	5.22 ± 3.08	1.74 ± 0.48	1.16 ± 0.59	4.06 ± 1.67	2.32 ± 1.19	3.48 ± 1.78	5.8 ± 2.97	1.74 ± 0.48	6.38 ± 2.86	4.06 ± 1.67
Cl^-	14.96 ± 0.57	24.66 ± 0.57	32.94 ± 0.29	13.95 ± 0.86	5.86 ± 0.86	5.86 ± 0.29	6.47 ± 0.57	5.46 ± 0.86	25.26 ± 0.29	9.50 ± 0.86	14.75 ± 0.29	9.10 ± 0.29
Electrical Cond.	699± 1.41	901.50± 2.12	343.00± 2.83	804.00± 1.41	803.00± 1.41	166.50± 3.54	128.50± 2.12	141.00± 1.41	279.50± 0.71	399.00± 1.41	887.50± 2.12	301.00± 1.41
% Clay	1.90	2.00	5.80	4.40	2.40	2.10	2.20	4.50	3.80	7.10	5.00	4.20
% Silt	3.70	12.00	7.70	15.60	2.40	4.30	8.90	14.20	11.30	17.90	20.00	31.30
% Sand	;94.40	86.00	86.50	80.00	95.20	93.60	88.90	81.30	84.90	75.00	75.00	64.50
Soil Texture	Sand	Loamy Sand	Loamy Sand	Loamy Sand	Sand	Sand	Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand

Table 3. Soil Physicochemical Parameters

The Table reveal variations in the soil chloride content. The highest Cl^-concentration 32.94 ± 0.29 was recorded at SLR, and the lowest recorded Cl^- was 5.46 ± 0.86 at KMA. Several studies have revealed that Cl^- in soil, interact with heavy metal ions such as Cd^{2+}, Pb^{2+}, and Zn^{2+} to form soluble metal-Cl complexes with chloride, thereby increasing the dissolution of heavy metals into the soil solution. enhancing their mobility (Fan et al 2024). The result of the electrical conductivity (EC) (µS/cm) range from 128.50±2.12 to 901.50±2.12 highlighting the soil salinity. The highest EC is at PHK while the lowest is at OCR. EC measures the soil's total soluble ion content, including heavy metal ions. Higher EC often correlates with elevated heavy metal concentrations, as both contribute to soil salinity (Gomaa et al., 2020).

Heavy metal Contents

Heavy metals in Soil

Figure 2. shows the results of the heavy metal analysis. The data shows that lead (Pb) concentration ranged between 4.50 mg/kg recorded at SGR to 36.0 mg/kg observed at KMA. LSM and PSH recorded 20 mg/kg, respectively. The mean value for Pb in the study area is 14.04 ±8.96 mg/kg. The highest concentration of Pb at KMA suggests higher anthropogenic activities in the area. Pb is a component of leaded fuel that acts as an anti-knocking agent. It is also believed to emanate from lead-bearing wastes including battery production paints and electronic materials along with food packaging material, PVC materials and insecticides (Agbeshi et al., 2020). The concentration of Pb in the various soil samples were however, lower than the maximum tolerable levels proposed for agricultural soil (90–400 mg/kg) set by WHO (WHO 1996). In comparison, the results from this study aligns with the findings of Umoh and Etim (Umoh and Etim, 2013) for soils reported from dumpsites within Ikot Ekpene in Akwa-Ibom State Nigeria. Long term exposure to Pb is risky, since bioaccumulation and bio-magnification can take place.

Zinc was observed to have the highest concentrations among the toxic metals under study. PHK had the highest recorded concentration (63.50 mg/kg) followed by LSM (50.0 mg/kg) and KMA (49.50 mg/kg). The mean concentration of Zn in the study was 43.04±9.27 mg/kg. The presence of Zn observed in the study is ascribed to use of the metal as components of vehicle lubricating oils. Other anthropogenic sources of Zn may include wastes from non-ferric metal industry, construction industries and agro-practice (Kalagbor et al., 2014). Zinc is also used in the manufacture of some components of vehicle engines (Borahet al., 2020). Eludoyin and Afolabi (2021) similarly reported a range of Zn concentration between 3.0377 to 4.7902 mg/kg with an average value of 4.0140 mg/kg. Zn is known to be a highly mobile element whose toxicity results in carcinogenic, neurologic and hematological complications. It is also reported to causehypertension, organs function disorders in animals (Kalagbor et al., 2014). The level of zinc in this study is however, within the permissible limit of 300– 400 mg/kg as recommended by WHO in agricultural soil. Typically, zinc can act as a micronutrient but at higher concentration, it becomes phytotoxic to plants (Alloway, 1995).

The concentration of Cd ranged between 0.5 mg/kg to 2.50 mg/kg. The mean Cd level recorded being 1.33 ±0.6 mg/kg. Although this metal revealed the lowest concentration among the toxicmetals under study, it is however, one of the most toxic metals reported by many researchers (Abdallah, Uzairu and Okunola, 2015). The level of Cd in the dumpsite soil samples were higher than the natural limits of 0.01– 0.8mg/kg in agricultural soil, as recommended by WHO (1996). Cadmium presence in agricultural soils and crops poses great concerns due to its eco-toxic nature. (Eludoyin and Afolabi (2021). It can easily be taken up and readily accumulated by most plants and subsequently get to levels that can constitute adverse effect to the plants themselves, consequently posing a significant threat to animals and humans that consume the plants.

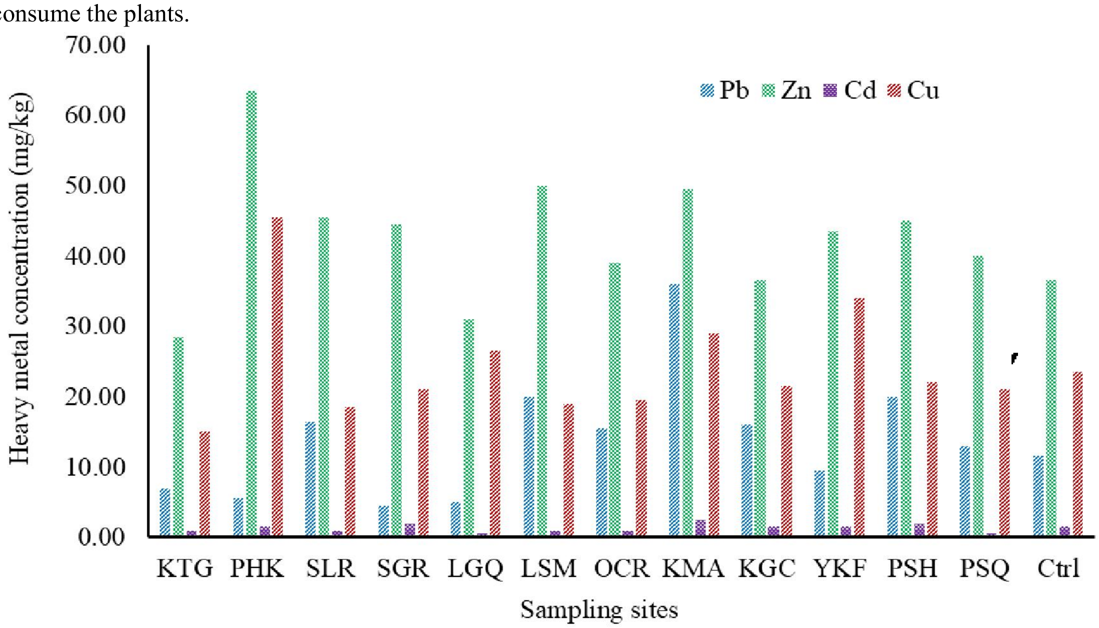

Figure 2. Heavy metal concentration (mg/L) in soil

Copper (Cu) had concentration in the range of 15.0 mg/kg to 45.50 mg/kg. The highest Cu concentration being 45.5 mg/kg was recorded at PHK followed by 34.0 mg/kg and 29.0 mg/kg recorded at YKF and KMA, respectively. The mean concentration of Cu in the study is 24.38±8.40 mg/kg which is below the permissible limit. On comparative, the control revealed lower concentration level compared to the dumpsites. In a related study, Eludoyin and Afolabi (2021), reported the contamination of Cu at abandoned dumpsites in the range of 0.982 to 1.901 mg/kg, with an average value of 1.391 mg/kg. They also reported a range from 3.007 to 3.471 mg/kg, with an average value of 3.262 mg/kg in active site of the studied dumpsites in Obio/Akpor Local Government Area of Rivers State. In the present study, the reported values of Cu in all the study areas have not exceeded the WHO stipulated allowable limit which is 36.0 mg/kg Osmani,

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Bani& Hoxha, (2015).In general, the concentration of all the heavy metals in the soil samples from the dumpsites were higher in values in comparison with the uncontaminated control site. The general sequence in metal abundance in the study area as observed in the analysis (Zn) >24.4±8.4 mg/kg (Cu) >14.0±9.0 mg/kg (Pb) >1.3±0.7 mg/kg (Cd).

Heavy metal content in *Chromoleana odorata* (L)

The concentration of heavy metals in the studied plant *Chromolaenaodorata (L.)* also known as Siam **weed**is illustrated in **Figure 3**. The data reveal concentrations of metals in the dumpsites were higher than that of the control which aligns with reports from other researchers (Akinola, 2019). Pb concentration was in the range of 6.50 mg/kg to 16.00 mg/kg. The mean concentration being 11.17±3.04 mg/kg. The high level of Pb observed in sample obtained from PHK maybe related to high anthropogenic activities recorded in the area particularly due to vehicular density. Lead contaminations may also occur in plants growing on contaminated soils, through air deposition or through sewage sludge/waste water (Oluwole et al., 2013). In the present study, the concentrations of Pb are quite generally higher than the permissible levels by (WHO, 2009) in vegetables of 2.0 mg/kg. Zinc (Zn) depicted the highest concentration in the plant sample, recordinghighest concentration level (51.00 mg/kg) in samples harvested at KTG. The range in the metal concentration was between 23.50 to 51.00 mg/kg. Zn is an essential element in human diet and it is required to maintain the functioning of the immune system. It is also a natural constituent of soils in terrestrial ecosystem and it is taken up actively by roots (Adesuyi et al., 2015). However, higher concentration beyond the permissible limit can result in ecological and health risk. The range of Cd concentration was between 0.50 recorded in plant sample harvested from SLR, LGQ and YKF, respectively, to 3.00 mg/kg recorded in plants sample collected from OCR. The mean value recorded in the studied plant is 1.46±0.81 mg/kg. Cadmium is known for its high toxicity and it is a non-essential element in foods and natural waters and it accumulates principally in the kidneys and liver (Aderinola et al., 2016). The FAO/WHO (2001), safe limit for Cd consumption in vegetables is 0.02 mg/kg. The findings in this study suggests that the concentration of Cdwas in exceedance of the permissible limit set by FAO/WHO in vegetable.

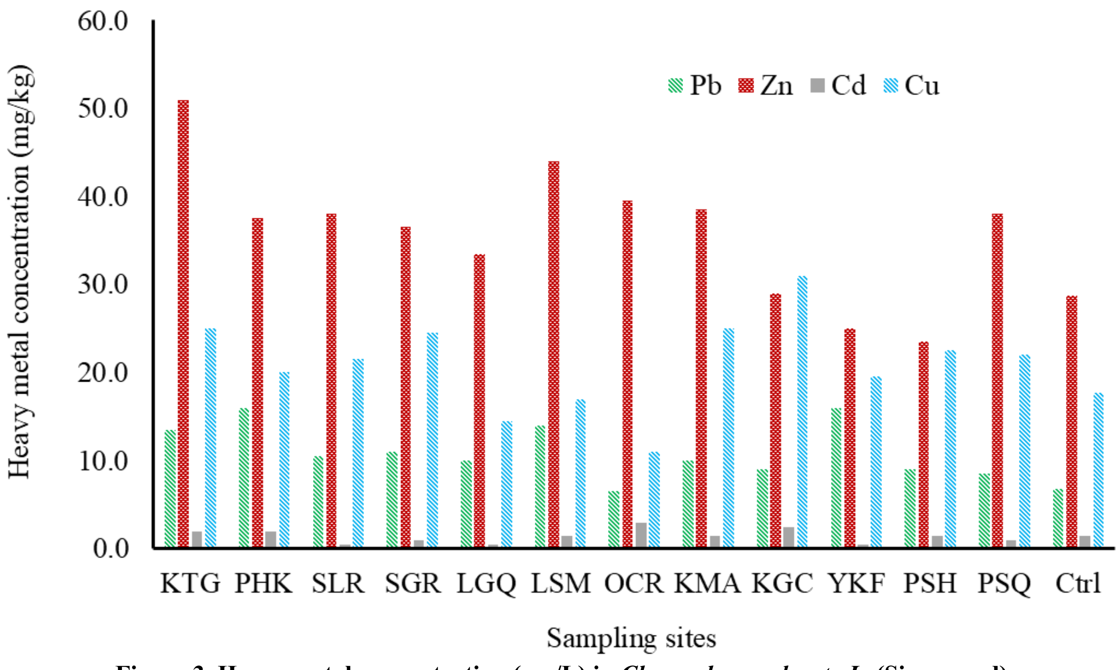

Figure 3. Heavy metal concentration (mg/L) in *Chromolaenaodorata L.* (Siam weed)

Copper level in the plant sample ranged between 11.00 mg/kg to 31.00 mg/kg. Cu is considered as an essential element to human and plant life as metalloproteins and function as enzymes especially when present in lesser amount, but in excessive amounts, it exerts detrimental effects (Kumar et al., 2021) such as anemia, diabetes, inflammation, kidney and liver dysfunction and vitamin C deficiency (Aderinola et al., 2016). Even though Cu toxicity is rare, its metabolism is enhanced by molybdenum and zinc constituents in the body (Oladele and Fadare, 2015). The general trend in the mean toxic metal concentration in the plant samples follows the pattern: Zn (36.20 ± 7.70 mg/kg) >Cu (21.10 ± 5.30 mg/kg)>Pb (11.20 ± 3.00 mg/kg)> Cd (1.5 ± 0.8 mg/kg).

Transfer factor (TF)

Figure 4.0 presents the results of the transfer factors (TF) of heavy metals from soils to plants calculated according to the formula reported by Cui et al. (2005). The results revealed that Pb TF values ranged between 0.28 to 2.91 with five dumpsites having TF values greater than unity. Zinc had TF values ranging from 0.52 to 1.79 while Cd showed the highest TF values of 3.00 recorded at OCR, 2.00 at KTG and PSQ. TF values of 1.67, 1.5, 1.33 and 1.0 were recorded at KGC, LSM, PHK, and LGQ, respectively. On the other hand,Cu recorded TF values in the order 1.67, 1.44, 1.17, 1.16, 1.05 and 1.02 at KTG, KGC, SGR, SLR, PSQ and PSH, respectively.

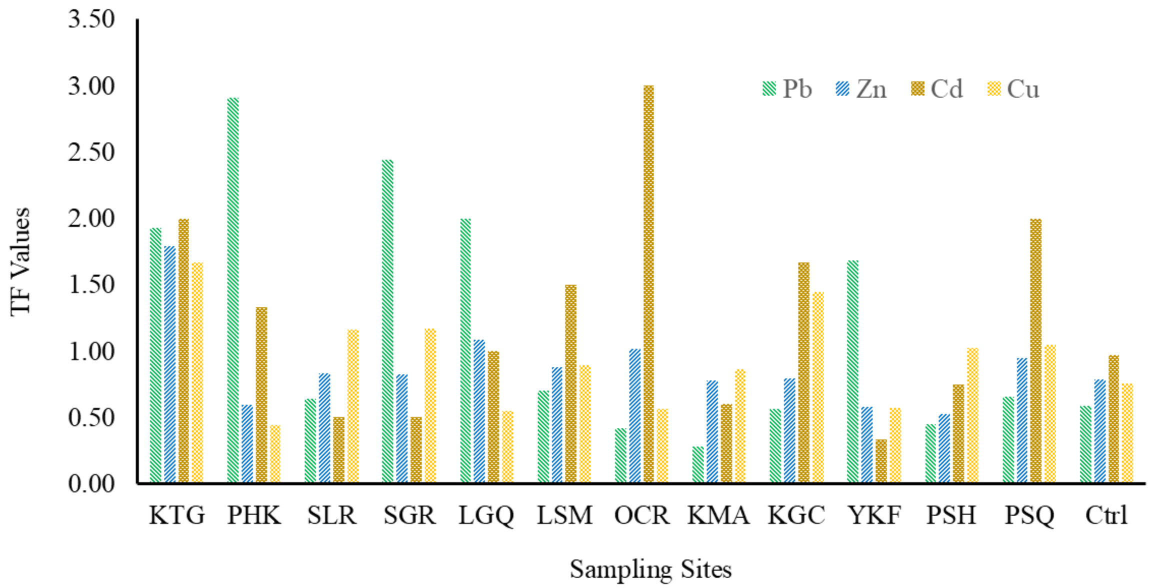

Figure 4. Soil heavy metal transfer factor (TF)

The TF is regarded as an index for evaluating the transfer potential of the metal from soil to plant (Abdallah et al., 2015). The TF values observed to be greater than unity in several of the sampling locations signifies the plant's potential to accumulate the heavy metal in those areas.It can also imply that *Chromolaena odorata* plants have the potential to uptake and subsequently translocate these heavy metals in their parts. The trend in TF values were in the order: Cd>Pb>Zn>Cu.

IV. CONCLUSION

This study has revealed that the soil and *Chromolaena odorata* collected from dumpsites in Kazaure town showed varying concentrations of Pb, Zn, d and Cu. The concentrations of metals in soil and plants from the dumpsites were higher than the control site. The trend in the metal abundance in both the soil and in *Chromolaena odorata* is: Zn>Cu>Pb>Cd. The transfer factors were generally observed to be greater than unity reflecting the plant's potential to translocate and bioaccumulate the metals in the tissues. The concentration of the metals in the dumpsites were in exceedance of the permissible limit of toxic metals in agricultural soils. This suggests that soils from dumpsites should be amended before applying them as manures to fertilize crops on farms in order to avoid health risk associated with heavy metal transfer through food chain.

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