

World News of Natural Sciences

An International Scientific Journal

WNOFNS 63(2) (2025) 410-430

EISSN 2543-5426

Evaluation of metallic element translocation in some plants grown on abandoned waste dump sites around Owerri, Imo State, Nigeria

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ABSTRACT

The study evaluated metallic element translocation in some plants grown on abandoned waste dump sites around Owerri, Imo State, Nigeria. Metallic element (Cr, Fe and Pb) level in soil and different parts of *Carica papaya* (CP), *Vernonia amygdalina* (VA), and *Musa acuminata* (MA) grown within the study sites were determined. Bio-concentration factor (B_{CF}) and ratio of translocation (T_F) of Cr, Fe, and Pb were evaluated. Fe level was the highest in soil ($284.67 \pm 0.51 \text{ mg/kg}$) followed by Pb ($51.04 \pm 0.83 \text{ mg/kg}$), also in plant parts Fe showed $30.77 \pm 0.40 \text{ mg/kg}$ while Cr has $9.06 \pm 0.20 \text{ mg/kg}$. Metallic element levels in the abandoned waste dump sites were greater than values obtained from the control. Single metal pollution index (P_i) suggested that metallic contaminant levels in the area has reached warning limit. Ecological risk analysis revealed low values. The results indicate that monomial ecological danger or risk (E_i) and potential ecological risk index (R_i) posed by the metallic elements have little or no consequence. B_{CF} value for Cr, Fe and Pb well less than one (< 1) in all the plants. T_F analysis indicated that 59.26 % of the metallic elements have their T_F less than (< 1), while 40.74% were slightly above one (> 1). Results of the study imply that the analyzed samples posed low risk. However, the study recommends discontinuation of cultivation of edible crops in the area. This is due to the tendency of metallic elements to bio-concentrate and bio-accumulate in living organisms after a long period.

Keywords: Ratio of translocation, bio-concentration factor, abandoned waste dump sites, metallic element, Owerri

1. INTRODUCTION

Most developing nations, like Nigeria, face the inevitable challenge of inadequate waste management and disposal systems as a result of growing populations, fast urbanization, industrialization, and loose environmental regulations (Okere *et al.*, 2018). In the majority of Nigeria's urban and rural areas, solid waste management is a significant environmental issue (Adefemi *et al.*, 2012). These wastes, which mostly consist of paper, food scraps, glassware, metal scraps, ceramics, and ashes, are indiscriminately disposed of and burnt in open fields or farmlands. Although farmers can use these wastes as fertilizer when they are properly composited and processed, it is concerning that they are frequently used in some Nigerian rural and urban areas to grow a variety of edible vegetables and plant-based foods without the wastes being properly sorted and processed (Obasi *et al.*, 2017).

The study area's waste management procedures are merely centered on collecting and disposing of rubbish in the open and excavated landfills (Arukwe *et al.*, 2012). Resulting from the lack of proper waste management, major waste dumpsites are then created in numerous sections of the city due to the irregular waste disposal that follows. This therefore puts the health of the local population at danger since the trash dumpsites serve as important breeding grounds for microorganisms and other disease-carrying mammals like rats (Adewuyi & Opasina, 2010). A worrisome scenario that is observable in most cities in Nigeria especially in Owerri is that majority of these dumpsites in most part of the city are usually abandoned when the waste dumpsite becomes uncontrollable. These abandoned waste dumpsites after a while are considered fertile ground for cultivation of vegetables and other crops.

Because of the many components of municipal garbage, the dumpsites may contain metallic elements and other contaminants that may translocate to the plants grown on the abandoned waste dumpsite (Wang & Hu, 2023).

Contamination of the ecosystem by metallic elements is among the universal environmental concern; this arises from the fact that some of these metallic elements are very hazardous to flora and fauna (Rahman *et al.*, 2024). Metallic elements especially the heavy metals that are present in soil have the tendency of contaminating plants grown on it (Kumar *et al.*, 2022). Though, the levels of these elements were initially low in soil. However, due to anthropogenic influence such as dumping of refuse and natural processes such as weathering, the concentrations of these metals have significantly increased leading to increased toxicity of these elements in the environment (Akoto *et al.*, 2018; Parvin *et al.*, 2019, Yang *et al.*, 2021; Wu *et al.*, 2021).

In the soil ecosystem, heavy metals have the ability to move and accumulate. Plants may absorb metal contaminants from the soil through their vascular system and roots. Metal buildup in soil could endanger humans, plants, and animals as well as compromise the safety of the ecosystem (Sulaiman & Hamzah, 2018). Even at low quantities, heavy metals can cause serious health problems when they build up in living things' tissues and organs because the body lacks an effective way to remove them.

Excessive metal concentrations in the plant may reduce stomata resistance, increase oxidative stress, and prevent the plant from chlorophyll production (Ashraf *et al.*, 2011). Metallic elements like cadmium and chromium can inhibit plant growth (Street, 2012). Metallic elements may enter human bodies through the food chain, damaging the central nervous system, especially in children (Zhao & Duo, 2015), and contributing to the progressive development of chronic disorders like cancer.

Soils in municipal garbage dumps are usually rich in organic matter after decomposition because of the deposition of various kinds of waste materials (Orimisan *et al.*, 2024). Because dumpsite soils are so fertile, many of them are being used to grow edible vegetables and other food crops (Fig. 1a), without first subjecting the soil to a thorough evaluation for possible ecological and health issues. Crops planted near landfills or waste dumpsites have the tendency of bioaccumulation of metals in their plant tissues as a result of plants absorbing metals from soils contaminated by leachates or with higher metal ion content.



Fig. 1(a-c). (a) abandoned waste dumpsite used for vegetable cultivation at Naze. (b) abandoned waste dump site undergoing reclamation at Nze, (c) abandoned waste dumpsite converted to residential/commercial layout along Akachi road in Owerri

Numerous studies have been conducted to study metal translocation and migration ability of heavy metals in soil-plant medium (Ukpong *et al.*, 2013; Olayiwola *et al.*, 2017; Nyiramigisha *et al.*, 2021; Wang and Hu, 2023; Orimisan *et al.*, 2024; Olowoyo *et al.*, 2012). However, none of these studies were conducted on abandoned or reclaimed waste dumpsite.

The major concern of this study is that almost all the abandoned waste dumpsites around and within Owerri has been reclaimed (Fig. 1b), some converted to either farmland (Fig. 1a) or residential/commercial layout (Fig. 1c).

The unfortunate thing about these developments is that Government Agencies do not carry out environmental impact assessment on some of these areas before authorizing its use either for crop cultivation, vegetable farming, and building of residential or commercial houses. Therefore, there is need to monitor the level of metallic elements in soils and plants grown within and around abandoned and reclaimed waste dump sites in Owerri, Imo State, Nigeria. This study is important especially as humans cannot do without food and people who are engaged in vegetable and crop farming on these abandoned waste dump sites are in a serious commercial venture to support their families.

In an effort to increase awareness on the health concerns connected with inappropriate and indiscriminate waste disposal and their subsequent consequences on the ecosystem. This research endeavours to analyze the heavy metal loading of various plants grown on some abandoned dumpsites as well as the soil on which these plants are grown in Owerri, Imo State, Nigeria. Therefore, there is need to establish the migration and level of metallic element in the soils-crops medium in the study area. Hence, the study is aimed at evaluation of the metallic element translocation in some plants grown in abandoned waste dump sites around Owerri, Imo State, Nigeria. The objective of the study includes determining the level of metallic elements in soil and plant in order to establish the bioaccumulation and the extent of contamination.

2. MATERIALS AND METHOD

2. 1. Study area

The study was conducted within some abandoned waste dump sites situated in Owerri, the capital city of Imo State, Nigeria. The city is made up of three local government areas including, Owerri Municipal, Owerri west, and Owerri North local government areas (Fig. 2). The geographical coordinates of Owerri Capital Territory are 5.5096N and 7.0391E. Owerri is the biggest and fast developing city compared with other cities in the state like Orlu and Okigwe. As of 2016, its estimated population stood at 1,401,873 (NBS, 2011), this projected population must have significantly increased after almost a decade.

The total area that makes up the three local government areas is about 551.00 square kilometers (212.743 square miles). The city is drained by two major rivers, Nworie River in the south, and Otamiri River in the east. Because of its vibrant nightlife and abundance of hotels, casinos, and recreational parks, the city is considered a tourist destination. The abandoned waste dump sites are located in Irete,

Nekede, Avuvu and Naze. Majority of these abandoned waste dump sites have been converted to residential and commercial layouts. In most of these areas where waste dump sites were recovered people dwelling in the areas grow crops as well as vegetables to support their families.

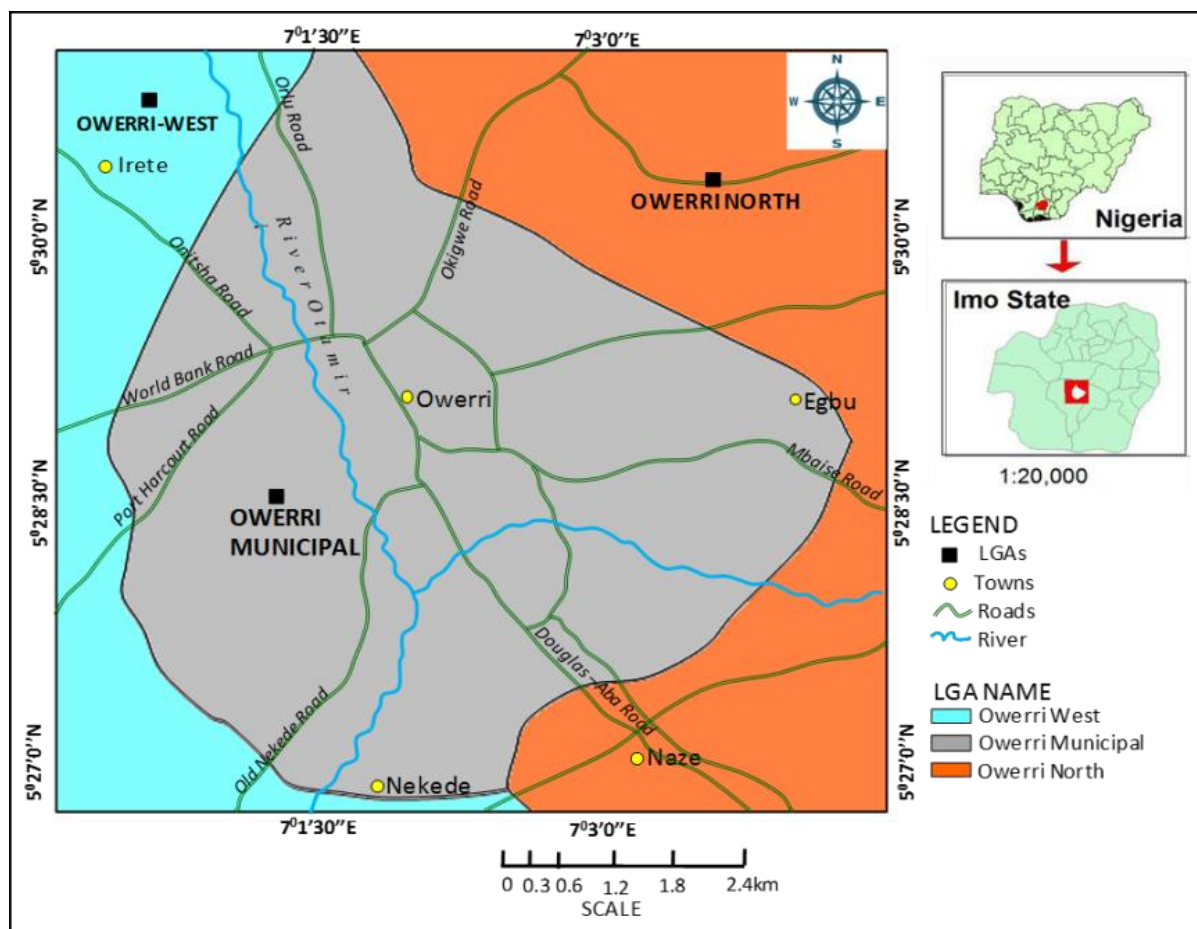


Fig. 2. Map of study area showing the three Local Government Areas that make up Owerri Capital Territory.

The area is part of the tropical rainforest zone, with two distinct seasons: the wet season and the dry season. In contrast, the dry season occurs in November and lasts until the end of March each year, while the wet season begins in April and lasts until October, peaking between June and September. The months of January through February are the warmest months of the dry season, with daytime temperature as high as around 30 °C.

July and August are associated with periods of intense precipitation, with the lowest recorded ambient temperatures being 20 °C or below. Evapotranspiration is thought to occur at a rate of 1450–1460 mm/year. The driest months in the region, November through December and January through March, also have low relative humidity (Iwuchukwu *et al.*, 2018). Rainfall continues to be an important aspect that has a big impact on environmental studies. The region receives between 2500 and 4000 mm of rain on average each year, with more than 89% of the total falling between May and September.

The frequent occurrence of rainfall events causes a lot of surface runoff due to the undulating nature of the catchment region, which causes issues with floods in the area. Events involving rainfall, in most cases occur as strong, furious showers which are accompanied by massive flooding.

2. 2. Sample collection and preparation

Soil and plant samples were obtained from abandoned waste dumpsites located in Irete (IE), Nekede (NK), Avuvu (AV), and Naze (NZ) in the month of June, 2025. In an attempt to disperse the sampling point impartially, soil samples were gathered using a basic random sampling approach. A soil auger was used to collect homogenized soil samples from five sub-samples arranged in a "W" shape from the topsoil at 0-15 cm in the different sample locations and place them in black plastic bags and labelled appropriately. A total of 12 soil samples (three from each site) and two samples for control were also collected for the study from areas where there is no previous or present anthropogenic influence. After the samples were knotted, they were taken to the lab for examination. Samples of soil were allowed to air dry in the laboratory, and undesired elements such as plant materials, broken bottles, nylon, and others unwanted materials were eliminated. A 2 mm work strainer was used to sieve the soils after being crushed, which were then stored for further study.

Also, the root and leave of some edible plant species (*Carica papaya* (CP), *Vernonia amygdalina* (VA) and *Musa acuminata* (MA)) selected for the study was gathered from the abandoned waste dumpsites. The choice of these plant species is based on the fact that they are edible with medicinal properties and source of food. These selected plant species were also collected from areas with no known anthropogenic activities to serve as control for the plant. The collected plant samples were tied with tape and labeled before being placed in dark polyethene bags. The plants parts were transported to the laboratory, separated into root, leaves, and washed in distill water to get rid of dust and dirt particles and dried in an oven at 60 °C with DHG – 9023A. To indicate the same sample location, soil and plant samples were labeled accordingly. Every approach used for the collection and analysis of samples closely followed standard procedure (Onyechere *et al.*, 2022).

2. 3. Sample analysis

The samples were subjected to digestion in order to determine the level of metallic elements in the soil and plant parts. 3g of each sample was combined with 20mL of 4 M solution of nitric acid (HNO₃) and heated in a fume cupboard for a period of 4hrs at 90 °C. On completion of digestion the cooled solutions were filtered through a filter paper into 25 mL standard flask and deionized water was used to fill up the flask to mark. The proper standard solutions were prepared and Agilent 240FS Fast Sequential Flame atomic absorption spectrophotometer was used to measure the amounts of metallic elements (Cd, Fe and Pb) in the digest (Onyenechere *et al.*, 2022). Both soil and plant samples underwent the same processes in the determination.

2. 4. Quality control

Throughout the analysis, established procedures were followed to ensure accuracy and precision of the results and to maintain quality control in the analytical methods used. Standard procedures with laboratory quality assurance were carefully followed, samples were tested in triplicate, and results were derived as mean values to assure the quality of analytical data. Finlab Chemical Labs, Nigeria Ltd. provided the analysis with reagents of high analytical standard. All of the glassware and containers used for sample collection and analysis were cleaned using deionized water and detergents. The glassware was then oven-dried using DHG 9023A (B. Brans Scientific and Instrument Company, England) after being further soaked overnight in a

10% HNO₃ in 1% HCl solution. High purity double-distilled deionized water for sample analysis was provided by Eco-Still Mark, BSIC/ECO-4 (Bhanu Scientific Instruments Company, India). For metallic content analysis, the Agilent 240FS fast sequential flame absorption spectrophotometer having a sensitivity of more than 0.9Abs and a precision of roughly < 0.5% RSD. For elements found in soil and water, the instrument's detection limit is 0.0001 ppm; for elements that form hydrides, the value is lower at ppb levels.

2. 5. Data Analysis

The metallic element was evaluated firstly based on their effect when accumulated in plants using translocation and bio-concentration factors. Secondly, the potential ecological risk of the metals was evaluated to establish the level of metallic element pollution of the abandoned waste dump site.

2. 5. 1. Ratio of translocation (T_F) and bio-concentration factor (B_{CF})

The ratio of translocation (T_F) and bio-concentration factor (B_{CF}) were calculated for the plants' ability to absorb metallic elements. The bio-concentration factor (B_{CF}) was determined as indicated in Eq. (1). B_{CF} value less than 1.00 means that the plant has the ability to absorb metallic substances, but cannot accumulate it. However a B_{CF} value greater than 1.00 may indicate the possibility of metal accumulation in the plant.

$$B_{CF} = \frac{C_p}{C_s} \quad (1)$$

The level of metallic element in plant is represented by C_p , while that in the soil is C_s as shown in Eq. (1).

Translocation of metallic element in the sampled plants was estimated according to Eq. (2) as shown below.

$$T_F = \frac{C_L}{C_R} \quad (2)$$

where: T_F is the ratio of translocation or capacity of the plant to translocate metallic element, C_L and C_R are respectively the metal concentration in plant leaves and roots.

2. 5. 2. Ecological risk index

The potential risk posed by the metals to the environmental was determined to establish the level of pollution of the abandoned waste dump site according to the metal toxicity as well as the environmental response. The possible ecological risk (R_i) due to the analyzed metallic element was evaluated using Eq. (3), (4) and (5) as shown below:

$$P_i = \frac{C_S}{C_R} \quad (3)$$

$$E_t = TR_i \times P_i \quad (4)$$

$$R_i = \sum E_t \quad (5)$$

where C_s represents the metal concentration in the samples, C_R represents the metal reference value, and P_i represents the single metal pollution index. The Department of Petroleum Resources' target value, DPR (mg/kg) was used as the reference concentrations in the analysis, where $Cr = 100$, $Fe = 38000$, and $Pb = 85$ (DPR, 2002). E_t is the monomial possible ecological risk factor of the metal, while TR_i stands for the toxic response factor of the metal with values in the order, $Fe = 1 < Cr = 2 < Pb = 5$. R_i is the possible ecological hazard brought on by the total contamination. The potential ecological damage presented by the metals under investigation were categorized as $E_t < 40$ represents little risk, $40 - 79$ shows moderate risk, $80 - 159$ suggests considerable risk, $160 - 319$ indicates high risk, while $E_t > 320$ indicates extremely high risk. In the same way, $R_i < 150$ denotes low risk, $150 - 299$ is an indication of moderate risk, $300 - 599$ stands for considerable risk, while $R_i > 600$ is an indication of extreme high risk (Onyechere *et al.*, 2022).

3. RESULT AND DISCUSSION

The result of sample analysis is presented in Table 1 for the level of Cr, Fe, and Pb in CP, VA, MA, and soil from study site. Concentration of Cr, Fe and Pb in roots and leaves of CP, VA and MA recorded were varied. However, the roots had a little elevated levels of the metallic elements compared to the leaves. Metallic concentrations are often higher in roots than in leaves and other parts of plants (Zhao and Duo, 2015).

Translocation of metallic element is inhibited by roots, which also shield other plant components from metal pollution (Liu *et al.*, 2009). Table 1 revealed higher concentration of Fe in all the sampled plants compared to other analyzed metallic elements, with elevated levels in the roots than leaves.

This result is not unexpected, especially as Fe is need by plant for growth and physiological development (Olowoyo *et al.*, 2012). The range of Fe concentration is $2.57 \pm 0.20 - 30.77 \pm 0.40$ mg/kg in root, $2.65 \pm 0.20 - 18.37 \pm 0.20$ mg/kg in leaves, and $99.10 \pm 0.60 - 284.67 \pm 0.51$ in soil.

Table 1. Concentration of metallic elements in *Carica papaya* (CP), *Vernonia amygdalina* (VA) and *Musa acuminata* (MA).

Site	ME	PP	CP (mg/kg)	VA (mg/kg)	MA (mg/kg)	Soil (mg/kg)	DPR value (mg/kg)
IE	Cr	Leaves	8.23±0.17	7.50±0.20	9.60±0.20	36.67±0.60	100.00
		Root	10.15±0.28	10.10±0.36	8.47±0.30		
	Fe	Leaves	18.13±0.45	14.57±0.32	17.37±0.20	230.27±0.70	38,000.00
		Root	20.37±1.07	25.50±0.30	30.77±0.40		
	Pb	Leaves	6.65±0.49	7.47±0.25	5.58±0.14	51.04±0.83	85.000
		Root	7.53±0.31	6.63±0.21	7.54±0.30		

NK	Cr	Leaves	4.57±0.50	2.53±0.25	5.50±0.40	28.50±0.40	
		Root	3.58±0.21	4.58±0.24	3.71±0.10		
	Fe	Leaves	15.27±0.45	17.34±0.25	14.53±0.30	216.20±5.03	
		Root	15.24±0.61	16.38±0.16	12.70±0.20		
	Pb	Leaves	3.78±0.40	1.83±0.08	2.76±0.10	47.73±0.40	
		Root	3.27±0.40	1.40±0.10	3.52±0.07		
AV	Cr	Leaves	1.58±0.19	1.43±0.06	2.67±0.20	26.23±0.64	
		Root	1.53±0.08	1.66±0.07	2.47±0.14		
	Fe	Leaves	7.16±0.55	8.54±0.14	12.57±0.20	192.80±0.72	
		Root	6.73±0.40	7.74±0.21	13.63±0.20		
	Pb	Leaves	2.03±0.31	3.57±0.14	2.60±0.10	45.57±0.41	
		Root	1.79±0.08	2.49±0.12	2.23±0.06		
NZ	Cr	Leaves	1.75±0.10	1.50±0.10	1.77±0.10	21.20±0.60	
		Root	1.46±0.05	1.30±0.10	2.33±0.30		
	Fe	Leaves	10.43±0.40	8.63±0.15	11.57±0.30	284.67±0.51	
		Root	8.49±0.27	6.70±0.20	13.21±0.10		
	Pb	Leaves	2.92±0.49	2.60±0.10	2.82±0.70	39.20±0.10	
		Root	2.65±0.20	3.55±0.13	1.84±0.10		
Cnt 1	Cr	Leaves	0.76±0.09	1.38±0.20	0.70±0.10	7.55±0.32	
		Root	0.72±0.04	0.93±0.10	0.83±0.10		
	Fe	Leaves	3.69±0.16	2.65±0.20	3.57±0.20	99.10±0.60	
		Root	2.57±0.20	2.39±0.10	4.37±0.30		
	Pb	Leaves	0.30±0.05	0.16±0.01	0.72±0.10	8.50±0.90	
		Root	0.39±0.03	0.13±0.01	0.80±0.10		
Cnt 2	Cr	Leaves	0.72±0.04	0.85±0.03	0.71±0.10	6.69±0.50	
		Root	0.63±0.05	0.72±0.04	0.60±0.04		
	Fe	Leaves	5.54±0.26	7.61±0.40	6.50±0.20	108.67±0.50	

	Root	4.85±0.34	8.50±0.30	7.43±0.40		
Pb	Leaves	0.44±0.09	0.42±0.04	0.58±0.10	5.63±0.30	
	Root	0.48±0.07	0.45±0.03	0.59±0.10		

Note: ME - metallic elements, PP - plant parts, Cnt - control

Also, increased levels of Fe were found in the leaves of CP, VA and MA at site NK as well as site NZ. This could be due to the fact that Fe plays a crucial role in a photosynthetic process that takes place in the chloroplast. Since chloroplasts are located in the leaf's green portion, Fe will primarily build up there. The high value of Fe suggests that the leaves are engaged in metabolic processes. Every step required for photosynthesis, including transpiration and solar absorption, will raise the amount of Fe in the leaves (Sulaiman and Hamzah, 2018). The observed high concentration of Fe in both plant and soil samples are associated with high abundance of Fe in the crust.

However, lower levels of Fe were recorded in control samples compared to samples from the abandoned waste dumpsites. This is an indication that the abandoned dump sites contributed to elevated values Fe observed in the study.

The levels of Cr are in the range of 0.70 ± 0.10 – 9.60 ± 0.20 mg/kg in leaves, 0.60 ± 0.04 – 10.15 ± 0.28 mg/kg in roots, and 6.69 ± 0.30 – 36.67 ± 0.60 mg/kg in soil. The highest Cr level in plant parts was found in roots followed by leaves. In the soil samples, highest value was recorded at site IE while lowest value was observed at Cnt 2. In the Plants, CP and VA showed elevated Cr values compared to MA. This could be attributed to materials that contain Cr that may have been deposited in the waste dump site before they were abandoned.

Variable levels of Cr were reported in harvested medicinal plants from Ogbomoso, in Western part of Nigeria (Ajasa *et al.*, 2004).

Pb values as shown in Table 1 ranged from 0.16 ± 0.01 – 7.47 ± 0.25 mg/kg in leaves, 0.13 ± 0.01 – 7.54 ± 0.30 mg/kg in roots, and 5.63 ± 0.30 – 51.04 ± 0.83 mg/kg in soils. Lower values of metallic element concentrations were recorded in leaves compared to roots, with VA showing higher values. Also root of MA showed increased value of Pb than root of other sampled plants. Though, elevated levels of Pb were recorded in the study, however, these values are far lower than the background level according to DPR Environmental guidelines and standards for the petroleum industry in Nigeria (2002). The increased Pb level is associated with longer soil retention period of Pb which can exist in the soil for many years and it has tendency to accumulate in plants (Rahman *et al.*, 2024).

3. 1. Index of pollution

Extent of pollution of the sampled sites by metallic element was determined using single metal pollution index (P_i) with Eq. 3. Single metal pollution which is also referred to as over-limit relationship of metallic pollutants was above 0.1. Over-limit relationship value greater than 0.1 indicates warning limit (Zhaoyong *et al.*, 2015). The result of single metal index of pollution presented in Table 2 indicates that Cr and Pb have values of P_i greater than 0.1 except the control samples. This is result suggested that the abandoned dump sites are contaminated, though the areas have been reclaimed. This is evident in the level of metallic element found in the plants grown on the abandoned dump sites.

Table 2. Result of single metal index of pollution and Ecological risk.

Site	P_i		
	Cr	Fe	Pb
IE	0.367	6.060e-3	0.600
NK	0.285	5.589e-3	0.562
AV	0.262	5.074e-3	0.536
NZ	0.212	7.491e-3	0.461
Cnt 1	0.076	2.608e-3	0.100
Cnt 2	0.067	2.830e-3	0.066
E_t			
IE	0.734	6.060e ⁻³	3.000
NK	0.570	5.589e ⁻³	2.810
AV	0.524	5.074e ⁻³	2.680
NZ	0.424	7.491e ⁻³	2.305
Cnt 1	0.152	2.608e ⁻³	0.500
Cnt 2	0.134	2.830e ⁻³	0.330
R_i	2.538	0.030	11.625

3. 2. Ecological risk and toxicity analysis

The results of ecological risk analysis of the analyzed elements are shown in Table 2. The results indicate that monomial ecological danger or risk (E_t) and potential ecological risk index (R_i) posed by the metallic element have little or no consequence. E_t ranged from 2.608e⁻³ - 3.000, with all the values less than 40 (< 40) suggesting that the metallic elements pose only little risk. Similarly, R_i ranged from 0.030 – 11.625 with Pb showing the highest R_i value which was less than 150 (<150), indicating that the metal posed low risk. However, there is need for caution in the use of the study area for cultivation of edible crops. The metallic elements Cr and Pb are known for their toxicity at low levels.

Chromium is one of the most abundant elements in the crust (Mohanty and Kumar, 2013). Found in many states of oxidation (Rodriguez *et al.*, 2007), and is believed that Cr in Cr³⁺ and Cr⁶⁺ forms have greater toxicity on living organisms (Mohanty and Kumar 2013). International Agency for the Research on Cancer noted that Cr is a group one carcinogenic material to human as a result of its elevated toxicity (Jaishankar *et al.*, 2014).

Critical toxicity of Cr results in the commencement of diffuse hyperplasia of the smaller intestine, which is the greatest maximum limit and sign of cancer in mammals (Health Canada, 2015). Also, documented report revealed that prolonged exposure to Cr decreases fertility of male animals (Hong *et al.*, 2001). This suggests that intake of Cr contaminated plant may affect the health of human being and put him at risk of infertility and illness linked to cancer.

Fe is a vital component that is required for the growth and survival of living things; it is also important for their metabolism (Valko *et al.*, 2005). The element is abundant naturally because of Fe-containing soils like laterites but the concentration could be increased due to anthropogenic influence. Little infants are exposed to foods with high concentrations of Fe, which makes them extremely vulnerable to toxicity of Fe (Albretsen, 2006). Consuming too much Fe- containing material can cause fatalities, gastrointestinal issues, and an elevated cancer risk (Sane *et al.*, 2018). Consuming too much Fe can harm the liver as well as other important organs and cells in the body (Asare-Donkor *et al.*, 2016).

Pb as a heavy metallic element is one of the major environmental pollutants due to its extensive use, high toxicity, persistence, and accumulation in soil and water environments (Rahman *et al.*, 2024). Pb acid batteries that are not disposed of appropriately may cause elevated Pb levels in the environment. The careless disposal of products that contain Pb including metal pipes, paints, and lead batteries may contribute to elevated Pb concentrations in the ecosystem (Boateng *et al.*, 2019). Unborn offspring and toddlers may experience neurological issues if they consume plant materials or food with high Pb level.

Pb in consumables like drinking water has been connected to brain damage and neurological conditions (Bulut and Baysal, 2006, Adindu *et al.*, 2024).

3. 3. Bio-concentration factor (BCF) of the metallic elements

The result of BCF analysis is presented in Fig. 3a - f for Cr, Fe and Pb in the sampled plants. The results indicate that BCF value for Cr, Fe and Pb were less than one in all the sites. Though elevated concentration of Fe was reported in the study as revealed in Table 1, but low BCF value for Fe was recorded. This could be attributed to plant's daily demand of Fe for growth as it is important for photosynthesis.

This is an indication that the studied plant parts, roots and leaves can absorb but cannot accumulate any of the metallic elements. BCF result of this study suggested that bioavailability of Pb was low. However, BCF values for Pb were lower at IE and NK compared to AV, NZ, Cnt1 and Cnt 2.

It is worthy of note that in addition to abandoned waste, the sites with increased BCF values may have received traffic induced Pb through atmospheric deposition. The result of this study is in agreement with finding of a related work on *Oryza sativa* (Juen *et al.*, 2014), but differ from earlier report on *Chromolaena odorata* (Tanhan *et al.*, 2007).

BCF values of Cr in all plants parts sampled were all lower than one (<1) as indicated in Fig. 3a - f. This is an indication that the plant parts can absorb Cr but not accumulation. The roots were observed to absorb more Cr than leaves, but in some cases like in CP more Cr was absorbed in the leaves than in roots in some sites. Increased absorption of Cr on plant leaves may be due to various factors such as soil composition, deposition of atmospheric metallic elements, absorption capacity. This could be affected by meteorological parameters as well as nature of the plant (Olowoyo *et al.*, 2012).

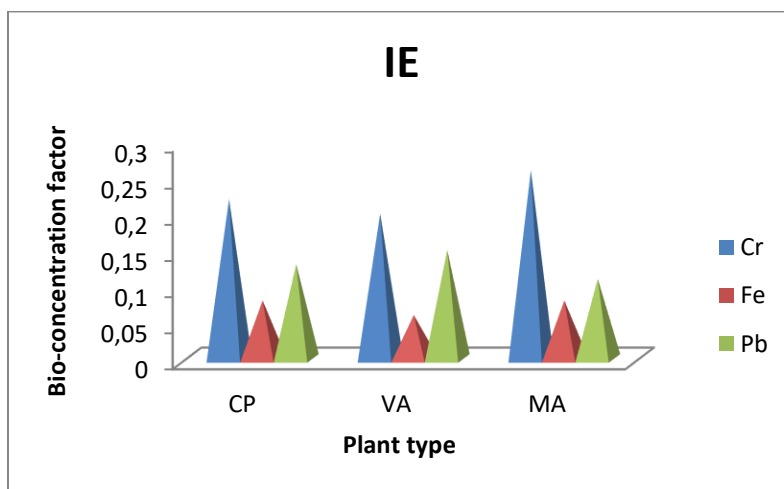


Fig. 3a. B_{CF} of the analyzed metallic elements in CP, VA and MA at site IE.

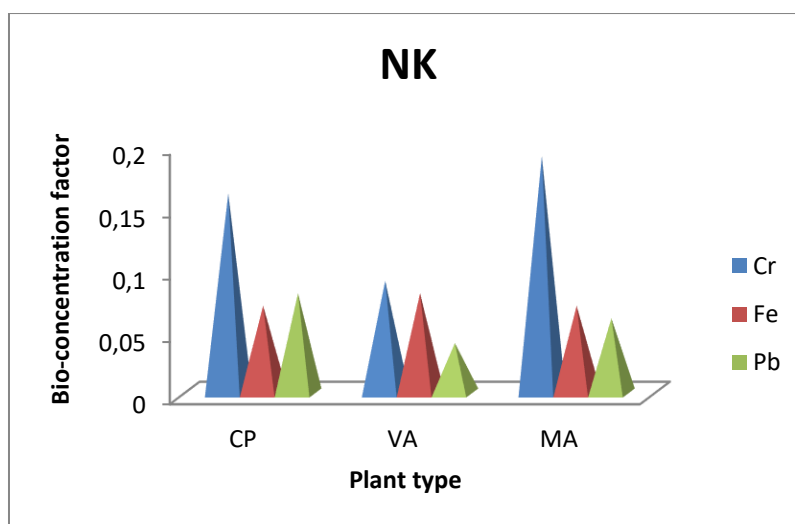


Fig. 3b. B_{CF} of the analyzed metallic elements in CP, VA and MA at site NK.

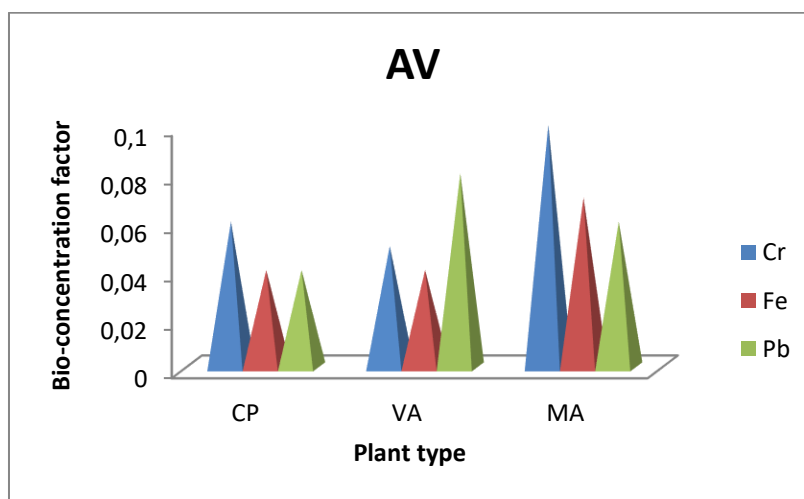


Fig. 3c. B_{CF} of the analyzed metallic elements in CP, VA and MA at site AV.

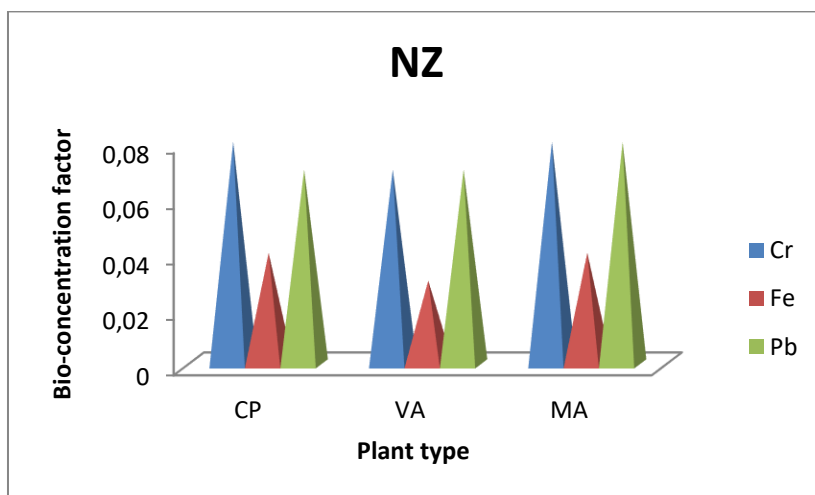


Fig. 3d. B_{CF} of the analyzed metallic elements in CP, VA and MA at site NZ.

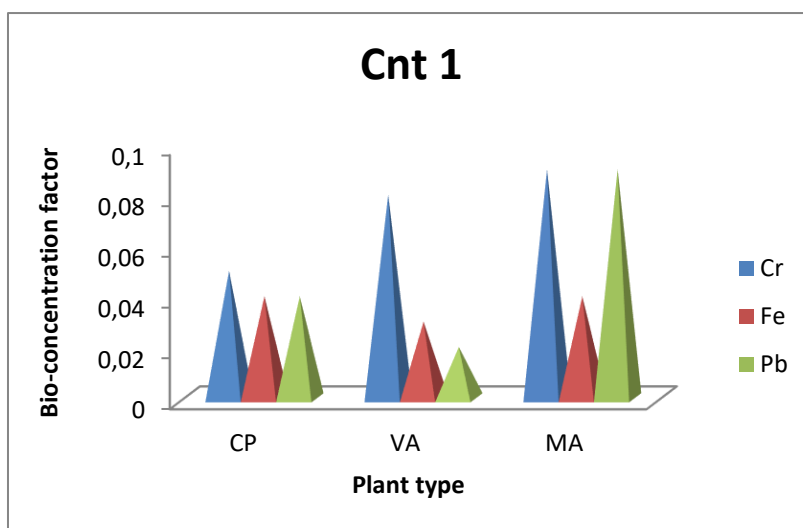


Fig. 3e. B_{CF} of the analyzed metallic elements in CP, VA and MA at the site Cnt 1.

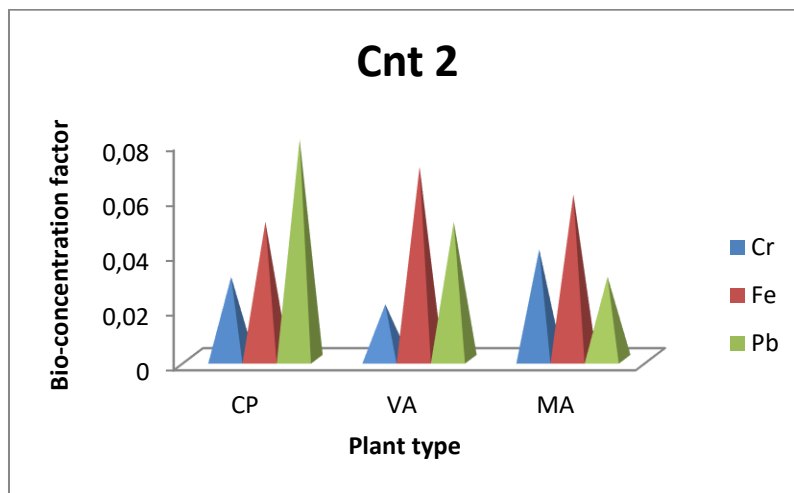


Fig. 3f. B_{CF} of the analyzed metallic elements in CP, VA and MA at site Cnt 2.

3. 4. Translocation factor (T_F)

The ratio of translocation of metallic element from root to leaves was computed for Cr, Fe, and Pb according to Eq. 2. The ratio of translocation of Cr, Fe, and Pb in CP, VA, and MA at IE, NK, AV, NZ, Cnt 1, and Cnt 2 are displayed in Fig. 4a - f. It was observed that samples from abandoned waste dumpsites and control samples show related trend in their ratio of translocation. 59.26 % of the metallic elements have their ratio of translocation lower than one (< 1), while 40.74% were slightly above one (> 1). This result of (59.26 %) transfer ratio being < 1 indicates that majority of the accumulated metal ions in the root were not easily mobilized to the plant leaves.

However, only 40.74% of the accumulated ions in the roots were mobilized to the leave part of plant. This suggests that the metallic elements were poorly transported to the leaves, which is not unexpected as the root functions as a barrier that hinders easy access of the contaminants to the leaves (Sulaiman and Hamzah, 2018). This work agrees with similar report on metal translocation and uptake (Olowoyo *et al.*, 2012; Juen *et al.*, 2014).

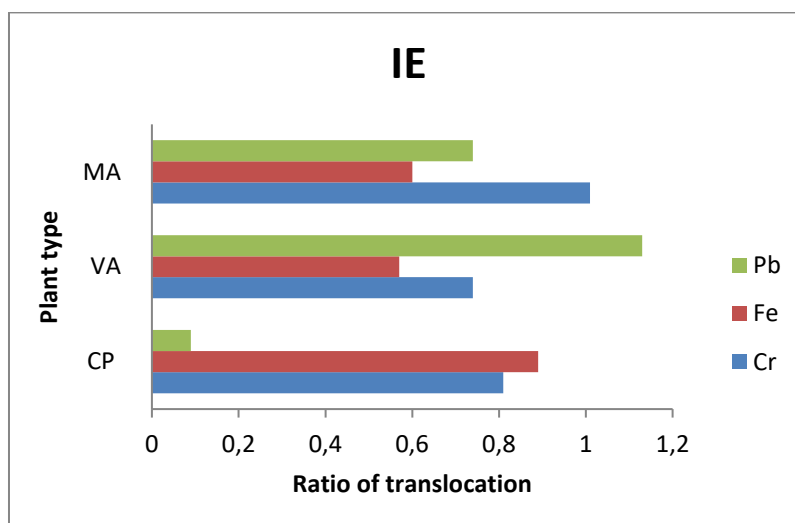


Fig. 4a. T_F of Cr, Fe and Pb from roots to leaves of CP, VA and MA at IE.

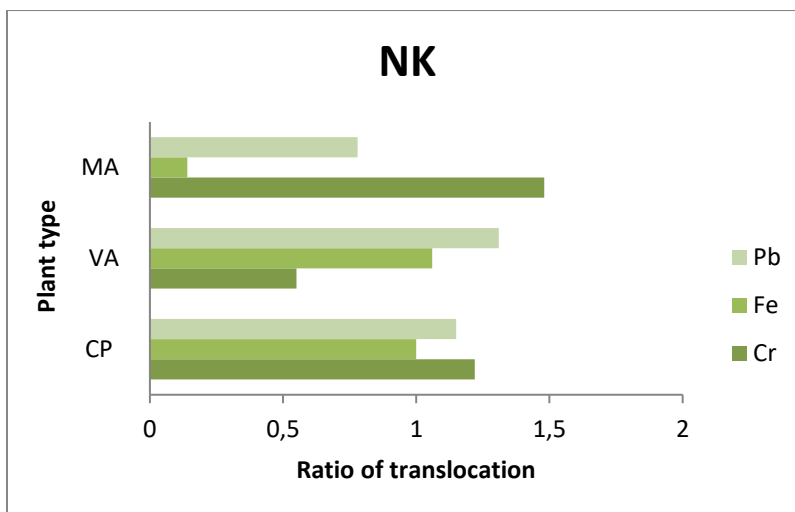


Fig. 4b. T_F of Cr, Fe and Pb from roots to leaves of CP, VA and MA at NK.

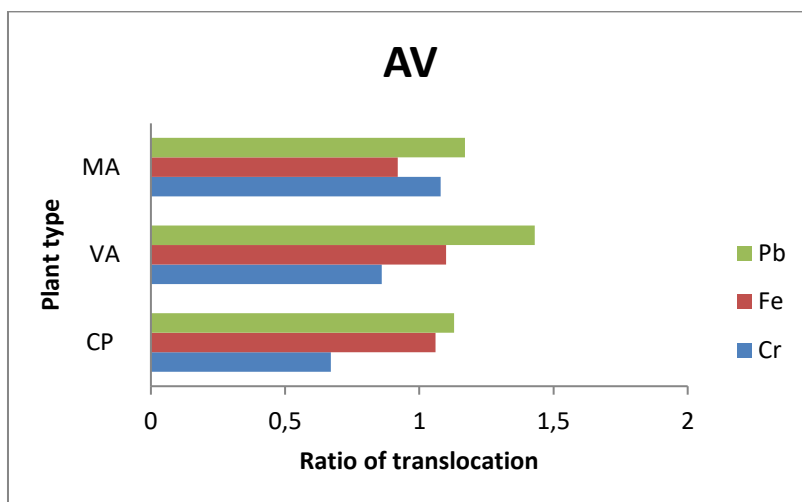


Fig. 4c. T_F of Cr, Fe and Pb from roots to leaves of CP, VA and MA at AV.

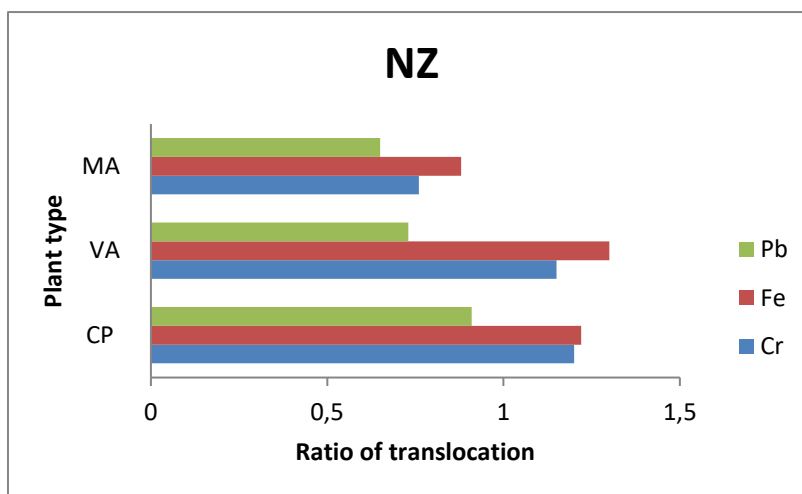


Fig. 4d. T_F of Cr, Fe and Pb from roots to leaves of CP, VA and MA at NZ.

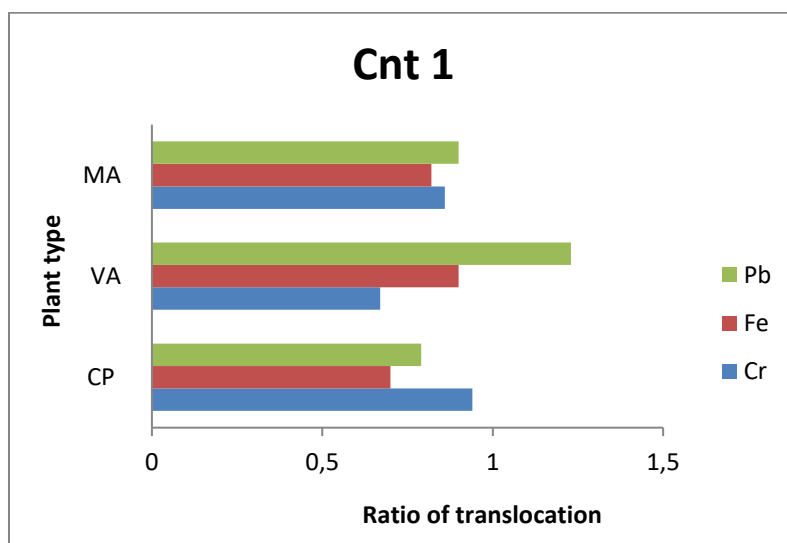


Fig. 4e. T_F of Cr, Fe and Pb from roots to leaves of CP, VA and MA at Cnt 1.

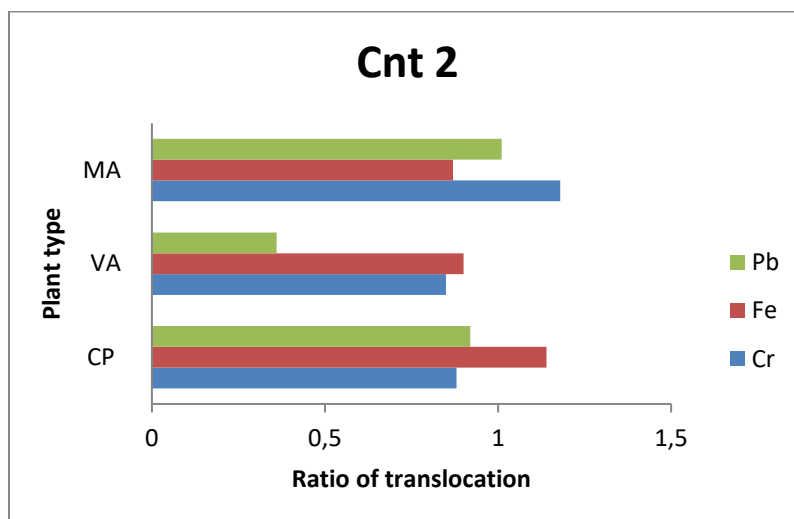


Fig. 4f. T_F of Cr, Fe and Pb from roots to leaves of CP, VA and MA at Cnt 2.

4. CONCLUSIONS

Slightly increased levels of Cr, Fe, and Pb were recorded in soil from IE, NK, AV, and NZ compared to Cnt 1 and Cnt 2. However, these values were below the DPR limit of the analyzed parameters. The plant samples from control sites (Cnt 1 and Cnt 2) showed lower concentration of Cr, Fe, and Pb compared to those from IE, NK, AV, and NZ. The values were not unexpected as the study area was an abandoned waste dump site. Hence, the metallic element level may have been influenced by the waste materials dumped in the area. Moreover, atmospheric influence and traffic related inputs most have contributed to the observed level of metallic elements recorded in both plant parts and soils.

Analysis of index of pollution using single metal pollution index (P_i) also referred to as over-limit relationship of metallic pollutants showed values above 0.1. This suggests that metallic contaminant levels in the area has reached warning limit. This calls for concern and need to discontinue cultivation of the area for edible plants.

Ecological risk analysis revealed low values. The results indicate that monomial ecological danger or risk (E_i) and potential ecological risk index (R_i) posed by the metallic elements have little or no consequence. The monomial and potential ecological risk of the analyzed metallic elements are of little or low risk. However, there should be caution before crops planted in the area are consumed especially when it involves plants with high metallic element accumulation capacity. This is because of toxicity concern when these elements contaminate plant grown in such areas. The health of consumers and occupants of the area could be at risk.

B_{CF} value for the metallic elements (Cr, Fe and Pb) was below one. Though elevated concentration of Fe was reported in the study as revealed in Table 1, but low B_{CF} value for Fe was recorded. This could be attributed to plant's daily demand of Fe for growth as it is important for photosynthesis. B_{CF} result of this study suggests that bioavailability of Pb was low with values for Pb lower at IE and NK compared to AV, NZ, Cnt 1, and Cnt 2.

The ratio of translocation showed similar trend in the study. 59.26 % of the metallic elements have their ratio of translocation lower than (< 1), while 40.74% were slightly above

one (> 1). This result (59.26 %) is suggestive that accumulated metal ions in the root were not easily mobilized to the plant leaves. The result of the study implies that the analyzed samples posed low risk, bio-concentration factor was less than one, and translocation of the metallic ion from root to leaves was poor. The use of the study sites for cultivation of edible crops should not be allowed further, as the observed low risk could change to high risk. This is due to the tendency of metallic elements to bio-concentrate and bio-accumulate in living organisms after a long period.

Funding

This research was supported by the Tertiary Education Trust Fund (TETFund) of the Federal Government of Nigeria with reference No. TETF/DR&D/CE/UNI/OWERRI/IBR/2025/VOL.1

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