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# Assessment of Heavy-Metal Occurrence in Underground Irrigation Water and *Amaranthus Retroflexus* Vegetable in Jimeta, Yola Northeastern Nigeria.

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**Abstract**

Due to their persistence and non-biodegradability, toxic heavy metals (THM) like lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), and iron (Fe) contaminate agricultural soils and crops like garden vegetables, grains, and fruits. Therefore, this research aims to assess the concentrations of the heavy metals in underground water and determine the extent to which they constitute a threat to the cultivated *Amaranthus Retroflexus*. Seasonal data on water and vegetables were collected from the study area in November 2019 to March 2020 and November 2020 to March 2021 at the irrigated farm site, in Jimeta, Yola Northeastern, Nigeria. The water samples were collected from boreholes in the study area fifteen (15) water samples were taken for analysis. The laboratory test revealed that heavy metals (AS, AL, B, Cd and Zn), recorded in the underground water had an average below detection thresholds. However, Cr and Fe records show an average above detection threshold level of 7.3mg/l and 9.0mg/l respectively. These high figures were associated with the location of an e-waste dump site, which is close to the water sources. The metal transfer factor (TF) was highest in Fe, followed by Mn > Cr. Heavy metal concentrations in Amaranthus Retroflexus, recorded across seasons were within allowable maximum ranges sets by FAO and WHO, and as such are safe for human consumption. The study concluded by recommending the need for further studies on the impact of e-waste site location on the heavy metal content of the surrounding soil.

**Keywords:** Non-biodegradability, concentrations, e-waste, vegetables, toxic

## 1.0 Introduction

In the light of the increasing concern for environmental contamination and its impact on human health, the assessment of heavy metal presence in underground water and Amaranthus retroflexus vegetable in Jimeta, Yola Northeastern, Nigeria has become increasingly relevant. The presence of heavy metals such as lead, cadmium, nickel, zinc, and arsenic in water and food sources can lead to serious health problems, including neurological damage, developmental problems, and reproductive issues.

The presence of heavy metals in groundwater has been the focus of various studies in recent years, especially in Nigeria. For instance, Li *et al*, 2016, conducted a study that found high levels of lead, cadmium, and nickel in groundwater samples from different locations in Nigeria. Similarly, Jahanshahi, R., & Zare, M, 2015. found elevated levels of lead, cadmium, and zinc in some water sources in Lagos, Nigeria. These findings suggest that there is a need for further investigation of the presence of heavy metals in groundwater in Nigeria, particularly in the Yola, Northeastern region.

In addition to groundwater, the presence of heavy metals in food sources has also been a focus of research in recent years. For example, Rezaei, A., Hassani, H., & Jabbari, N. 2019, found elevated levels of lead, cadmium, and zinc in some vegetable crops in Iraq, Mthembu *et al*., 2020 investigated the presence of heavy metals in edible wild plants collected from contaminated sites in China and found elevated levels of lead, cadmium, and arsenic in some species. These studies highlight the importance of assessing the presence of heavy metals in food sources and the potential health risks associated with consuming these sources.

*Amaranthus retroflexus*, also known as redroot pigweed, is a widely distributed weed that is used as a vegetable in many regions of the world, including Nigeria. The plant has been shown to be a bio-accumulator of heavy metals, meaning it can absorb and store heavy metals from contaminated soil (Mohammed, S. A., & Folorunsho, J. O. 2015). This raises concerns about the potential health risks associated with consuming *A. retroflexus* grown in contaminated soils. Therefore, it is essential to assess the presence of heavy metals in *A. retroflexus* grown in Jimeta, Yola State, Nigeria.

The aim of this study is to assess the presence of heavy metals in underground water and *Amaranthus retroflexus* vegetable in Jimeta, Yola State, Nigeria. The results of this study will provide valuable information on the levels of heavy metals in these sources and help to determine the potential health risks associated with consuming these sources in this region. The findings of this study will also contribute to the growing body of literature on the presence of heavy metals in water and food sources and help to inform the development of effective strategies to mitigate the potential health risks associated with heavy metal contamination.

## 2. Materials and Methods

### 2.1 Study Station

The study was conducted in Jimeta-Yola, Northeastern Nigeria. The map of the sampling locations appears in Figure 1 whose locations were determined using geographic positioning system (GPS).

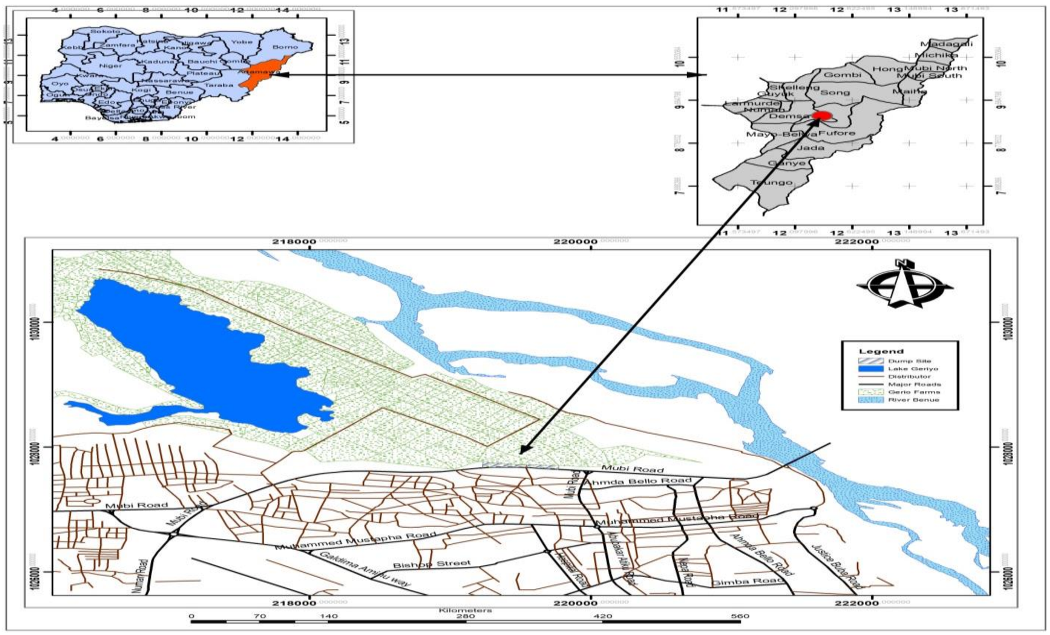


**Figure i.** Map of the study locations

### 2.2 Water and vegetable samples

A seasonal data on vegetable were collected from the study area in November 2019 to March 2020 and November 2020 to March 2021 at the irrigated farm site, in Jimata, Yola North, Nigeria. The water samples were collected from boreholes in the study area, fifteen (15) water samples were taken for analysis, five (5) from the upper part of the irrigation site, near the dumping site, followed by five (5) from the middle and the lower part respectively. Vegetable samples were also collected from the cropping sites adjacent to the boreholes.

Fifteen vegetable samples of *amaranthus retroflexus* were from collected random locations on the cropping site. After collecting the vegetables, they were put in clean polythene bags and labeled, while water samples were put in glass bottles which were rinsed thoroughly. Thereafter, all samples were taken to the laboratory for preparation and analysis.

2.3 Laboratory Analysis

In situ measures such as pH, EC of the water samples were determined on the spot using pH meter and conductivity meter respectively. The Laboratory analysis was carried out at the Adamawa State University Soil Science and Chemistry Lab. The following parameters were analyzed; TDS, TH, $Cl^-$, $CO_3^-$, $HCO_3$, (titration method) Kalagbor, I. A., Dighi, N. K., & James, R. (2015). Ca, Mg, K, Na and heavy metals (As, Al, B, Cd, Cu, Cr, Fe, Mn, Zn,). Calcium and magnesium were measured by EDTA titrimetric method. Chloride by standard AgNO3 titration and bicarbonate by titration with HCl. Sodium, potassium by flame photometer. Analyses for As, Al, B, Cd, Cu, Cr, Fe, Mn, Pb, Zn in water and vegetable samples were carried out using Atomic Absorption Spectrophotometer (AAS) Kempton *et al*., 1982, Ayers, R. S 1977. The laboratory results were computed and organized using simple descriptive statistics.

**2.4 Risk Assessment Models**

1. Transfer Factor (TF)

The results for soil and the *amarantus retroflexus* were employed to determine the transfer factor. (TF) as given in the following equation (Adesodun *et al*., 2010)

$$TF = \frac{[Heavy\ metals]vegetables\ \mathrm{mg/kg}}{[Heavy\ metals]\times underground\ water\ mg/l} \quad (1)$$

Where $[Heavy\ metals]vegetables\frac{\mathrm{mg}}{\mathrm{kg}}$ = Concentration of heavy metal in A. retroflexus leaf

$[Heavy\ metals] \times underground\ water\,\frac{mg}{l}$ = Concentration of heavy metal in underground water.

2. Contamination Factor (CF):

The Contamination Factor (CF) is calculated using Equation (2) and shows site specific contamination of toxic substances (Adesodun *et al*., 2010)

$$CF = \frac{Cm(sample)}{Cm(background)} \quad (2)$$

where Cm(sample) = metal concentration at a contaminated site; Cm(background) = concentration of a given element in background sample. The CF is based on 4 categories of contamination: Low (CF < 1), moderate (1 < CF < 3), considerable (3 > CF < 6), and very high (CF > 6).

## 3.0 Results and Discussions

### 3.1 Heavy metals in the irrigation water in the study area

The findings of borehole testing done on irrigation water in the study region in November 2019 (table 1) and March 2020 (table 2) show that the amounts of heavy metals As, Al, B, Cd, and Zn in the water are below the detection threshold. In November, Cr did not surpass the suggested maximum values as indicated by Doneen, L. D. 1975 of 0.01 mg/l with a peak value of 0.05 and a lowest value of 0.00 mg/l, while in March 2020, the greatest value of 0.03 and the lowest value of 0.00 mg/l went below the required maximum levels. The month of November in 2019 has the highest readings at 7.3 mg/l and the lowest values at 4.1 mg/l, with the mean values being 5.9 mg/l. This figure is higher than the maximum concentration of iron (Fe) in irrigation water that is recommended, which is 5.0 mg/l. The highest value recorded in March 2020 was 7.6 mg/l, while the lowest value recorded was 3.0 mg/l, with mean values of 4.7 mg/l. It was found that boreholes 1, 2, 3, 4, and 7 have concentrations that are higher than the maximum allowed, whereas boreholes 6, 8, 9, 10, 11, 12, 13, 14, and 15 have concentrations that are lower than the maximum allowed for irrigation water. Those with high values could have been negatively affected by the dumpsite that was located near the farming region. The mean value for manganese in the month of November 2019 is 0.385 mg/l, with the greatest value being 0.64 and the lowest value being 0.150 mg/l. Boreholes 1 through 12 have values that are higher than the acceptable values, whereas boreholes 13 through 15 have values that are lower than the maximum recommended value of 5.0 mg/l. The mean value for the month of March 2020 was 4.203 mg/l, with the greatest value being 0.459 mg/l and the lowest value being 0.140 mg/l. According to Doneen, L. D. 1975, the maximum recommended concentration in irrigation water is 0.2 mg/l, although the water in the area has a concentration that is higher than that. The results show fluctuations in November and March that could be due to the impact of seasonal variation, which could have affected the November results due to flooding and saturation of the water levels. The fluctuations could also be because seasonal variation could have been caused by natural occurrences.

Table 1.0 Heavy metals in borehole water samples mg/l in November 2019

| | As | Al | B | Cd | Cr | Fe | Mn | Zn | Pb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BDL | BDL | BDL | BDL | 0.05 | 7.3 | 0.645 | BDL | BDL |
| 2 | BDL | BDL | BDL | BDL | 0.02 | 7.0 | 0.495 | BDL | BDL |
| 3 | BDL | BDL | BDL | BDL | 0.02 | 6.5 | 0.465 | BDL | BDL |
| 4 | BDL | BDL | BDL | BDL | 0.01 | 7.1 | 0.280 | BDL | BDL |
| 5 | BDL | BDL | BDL | BDL | 0.01 | 6.8 | 0.480 | BDL | BDL |
| 6 | BDL | BDL | BDL | BDL | 0.01 | 6.3 | 0.565 | BDL | BDL |
| 7 | BDL | BDL | BDL | BDL | 0.02 | 6.1 | 0.325 | BDL | BDL |
| 8 | BDL | BDL | BDL | BDL | 0.01 | 5.7 | 0.622 | BDL | BDL |
| 9 | BDL | BDL | BDL | BDL | 0.01 | 5.9 | 0.440 | BDL | BDL |
| 10 | BDL | BDL | BDL | BDL | 0.01 | 5.7 | 0.330 | BDL | BDL |
| 11 | BDL | BDL | BDL | BDL | 0.01 | 5.5 | 0.223 | BDL | BDL |
| 12 | BDL | BDL | BDL | BDL | 0.00 | 5.3 | 0.180 | BDL | BDL |
| 13 | BDL | BDL | BDL | BDL | 0.00 | 4.6 | 0.150 | BDL | BDL |
| 14 | BDL | BDL | BDL | BDL | 0.00 | 4.2 | 0.320 | BDL | BDL |
| 15 | BDL | BDL | BDL | BDL | 0.00 | 4.1 | 0.250 | BDL | BDL |
| Mean | | | | | 0.01 | 5.87 | 0.385 | 0.00 | 0.00 |
| SD | | | | | 0.01 | 1.01 | 0.153 | 0.00 | 0.00 |

SD=Standard Deviation. BDL= Below Detection Level

Table 2.0 Heavy metals in borehole water samples mg/l in March 2020

| | As | Al | B | Cd | Cr | Fe | Mn | Zn | Pb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BDL | BDL | BDL | BDL | 0.03 | 7.6 | 0.459 | BDL | BDL |
| 2 | BDL | BDL | BDL | BDL | 0.01 | 6.0 | 0.431 | BDL | BDL |
| 3 | BDL | BDL | BDL | BDL | 0.01 | 6.5 | 0.367 | BDL | BDL |
| 4 | BDL | BDL | BDL | BDL | 0.00 | 5.7 | 0.302 | BDL | BDL |
| 5 | BDL | BDL | BDL | BDL | 0.01 | 6.0 | 0.344 | BDL | BDL |
| 6 | BDL | BDL | BDL | BDL | 0.01 | 4.9 | 0.312 | BDL | BDL |
| 7 | BDL | BDL | BDL | BDL | 0.01 | 6.0 | 0.332 | BDL | BDL |
| 8 | BDL | BDL | BDL | BDL | 0.01 | 3.6 | 0.314 | BDL | BDL |
| 9 | BDL | BDL | BDL | BDL | 0.00 | 3.0 | 0.298 | BDL | BDL |
| 10 | BDL | BDL | BDL | BDL | 0.00 | 3.4 | 0.221 | BDL | BDL |
| 11 | BDL | BDL | BDL | BDL | 0.00 | 4.8 | 0.199 | BDL | BDL |
| 12 | BDL | BDL | BDL | BDL | 0.00 | 3.0 | 0.176 | BDL | BDL |
| 13 | BDL | BDL | BDL | BDL | 0.00 | 3.5 | 0.154 | BDL | BDL |
| 14 | BDL | BDL | BDL | BDL | 0.00 | 3.8 | 0.154 | BDL | BDL |
| 15 | BDL | BDL | BDL | BDL | 0.00 | 3.0 | 0.140 | BDL | BDL |
| Mean | | | | | 0.01 | 4.72 | 0.28 | | |
| SD | | | | | 0.01 | 1.50 | 0.10 | | |

SD=Standard Deviation. BDL= Below Detection Level

In the study region, the results show that the levels of As, Al, B, Cd, and Zn, as well as Pb, were below the detection threshold in November 2020 (Table 3.0) and March 2021 (Table 4.0). The data for November 2020 show the greatest value of 0.08 mg/l and the lowest value of 0.03 mg/l, with mean values of 0.05 mg/l. The results for March 2021 show the highest value of 0.01 mg/l and the lowest value of 0.00 mg/l. The findings indicate that they are lower than the maximum values that are suggested.

In table 3.0 for the month of November 2020, the values for Fe range from a high of 9.0 mg/l to a low of 6.0 mg/l, with a value of 5.6 mg/l serving as the mean. The Fe readings are higher than the maximum concentrations that are recommended to be in irrigation water. Table 4.0 shows that the findings for the month of March 2021 ranged from a high of 5.6 mg/l to a low of 1.8 mg/l, with a mean value of 5.3 mg/l for the whole month. In Table 3.0 for the month of November 2020, the value of Mn ranges from its greatest point of 0.667 mg/l to its lowest point of 0.32 mg/l, with a mean value of 7.648 mg/l. According to the findings of Doneen, L. D 1975 the maximum concentration that should be allowed in irrigation water is 0.2 mg/l. According to the findings, it is at a higher level than is indicated. Table 4.0 data show that the month of March 2021 had mean values of 5.15 mg/l, with the greatest value being 0.521 mg/l and the lowest value being 0.200 mg/l. According to the findings, the recommended values were surpassed in the area.

Table 3.0 Heavy metals in borehole water samples mg/l in November 2020

| | As | Al | B | Cd | Cr | Fe | Mn | Zn | Pb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BDL | BDL | BDL | BDL | 0.08 | 9.0 | 0.667 | BDL | BDL |
| 2 | BDL | BDL | BDL | BDL | 0.05 | 9.0 | 0.550 | BDL | BDL |
| 3 | BDL | BDL | BDL | BDL | 0.05 | 8.0 | 0.463 | BDL | BDL |
| 4 | BDL | BDL | BDL | BDL | 0.07 | 8.0 | 0.378 | BDL | BDL |
| 5 | BDL | BDL | BDL | BDL | 0.05 | 7.9 | 0.596 | BDL | BDL |
| 6 | BDL | BDL | BDL | BDL | 0.04 | 8.0 | 0.587 | BDL | BDL |
| 7 | BDL | BDL | BDL | BDL | 0.05 | 7.5 | 0.800 | BDL | BDL |
| 8 | BDL | BDL | BDL | BDL | 0.04 | 7.0 | 0.830 | BDL | BDL |
| 9 | BDL | BDL | BDL | BDL | 0.04 | 7.0 | 0.541 | BDL | BDL |
| 10 | BDL | BDL | BDL | BDL | 0.06 | 7.0 | 0.496 | BDL | BDL |
| 11 | BDL | BDL | BDL | BDL | 0.04 | 7.4 | 0.410 | BDL | BDL |
| 12 | BDL | BDL | BDL | BDL | 0.03 | 7.0 | 0.360 | BDL | BDL |
| 13 | BDL | BDL | BDL | BDL | 0.04 | 7.0 | 0.300 | BDL | BDL |
| 14 | BDL | BDL | BDL | BDL | 0.04 | 6.0 | 0.350 | BDL | BDL |
| 15 | BDL | BDL | BDL | BDL | 0.03 | 6.0 | 0.320 | BDL | BDL |
| Mean | | | | | 0.05 | 7.5 | 0.510 | | |
| SD | | | | | 0.01 | 0.89 | 0.165 | | |

SD=Standard Deviation. BDL= Below Detection Level

Table 4.0 Heavy metals in borehole water samples mg/l in March 2021

| | As | Al | B | Cd | Cr | Fe | Mn | Zn | Pb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BDL | BDL | BDL | BDL | 0.01 | 5.2 | 0.521 | BDL | BDL |
| 2 | BDL | BDL | BDL | BDL | 0.00 | 5.6 | 0.489 | BDL | BDL |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | BDL | BDL | BDL | BDL | 0.00 | 5.3 | 0.432 | BDL | BDL |
| 4 | BDL | BDL | BDL | BDL | 0.00 | 3.9 | 0.358 | BDL | BDL |
| 5 | BDL | BDL | BDL | BDL | 0.01 | 3.4 | 0.435 | BDL | BDL |
| 6 | BDL | BDL | BDL | BDL | 0.00 | 2.7 | 0.312 | BDL | BDL |
| 7 | BDL | BDL | BDL | BDL | 0.00 | 4.0 | 0.397 | BDL | BDL |
| 8 | BDL | BDL | BDL | BDL | 0.00 | 2.6 | 0.400 | BDL | BDL |
| 9 | BDL | BDL | BDL | BDL | 0.00 | 3.0 | 0.312 | BDL | BDL |
| 10 | BDL | BDL | BDL | BDL | 0.00 | 3.4 | 0.299 | BDL | BDL |
| 11 | BDL | BDL | BDL | BDL | 0.00 | 2.8 | 0.300 | BDL | BDL |
| 12 | BDL | BDL | BDL | BDL | 0.00 | 3.0 | 0.221 | BDL | BDL |
| 13 | BDL | BDL | BDL | BDL | 0.00 | 2.5 | 0.243 | BDL | BDL |
| 14 | BDL | BDL | BDL | BDL | 0.00 | 1.8 | 0.200 | BDL | BDL |
| 15 | BDL | BDL | BDL | BDL | 0.00 | 2.0 | 0.234 | BDL | BDL |
| Mean | | | | | 0.001 | 3.41 | 0.343 | | |
| SD | | | | | 0.003 | 1.18 | 0.100 | | |

SD=Standard Deviation. BDL= Below Detection Level

### 3.2 Quality of vegetables in the study area

According to the findings for the month of March 2020 (Table 5) and March 2021 (Table 6), the levels of Al, As, Cr, Mn, and Pb in the area for amaranthus retroflexus are all below the threshold for detection. Zn indicates a range of values in March 2020, with the greatest being 0.389 mg/kg, the lowest being 0.234 mg/kg, and the average being 0.276 mg/kg. Zn readings in vegetables all fell below the FAO/WHO maximum allowed limits of 99.40 mg/kg in both March 2020 and March 2021. These limits are set for vegetables. The mean value for Zn in March 2021 was 0.311 mg/kg, and the highest value was 0.401 mg/kg, while the lowest value was 0.277 mg/kg. All of these values were lower than the maximum allowable levels. In March of 2020, the value of Fe ranged from a high of 0.179 mg/kg to a low of 0.150 mg/kg, with a value of 0.355 mg/kg serving as the average. Fe had a mean value of 0.324 mg/kg in both March 2020 and March 2021, with a top value of 0.201 mg/kg and a lowest value of 0.170 mg/kg. In March 2021, the highest value of Fe was 0.201 mg/kg. The boundaries of Fe are not set in stone.

For the month of March 2020, the Cu values range from a high of 0.476 mg/kg to a low of 0.367 mg/kg, with a value of 0.036 mg/kg serving as the average. The Cu value for the month of March 2021 showed a range from its maximum of 0.497 mg/kg to its lowest of 0.411 mg/kg, with a value of 0.465 mg/kg serving as the mean. Both in March 2020 and March 2021, the levels of copper were lower than the maximum allowable limit set by the FAO and WHO, which is 4.0 mg/kg. In contrast to the findings of Sulaiman, B. A., Sulaiman *et al*., 2021, Yaradua *et al*., 2017, this region demonstrates that green vegetables grown from *Amaranthus retroflexus* are suitable for human consumption.

Table 5: Heavy metals in *amaranthus retroflexus* mg/kg in March 2020

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| | Al | As | Cr | Cd | Zn | Fe | Cu | Mn | Pb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BDL | BDL | BDL | BDL | 0.365 | 0.175 | 0.445 | BDL | BDL |
| 2 | BDL | BDL | BDL | BDL | 0.389 | 0.150 | 0.466 | BDL | BDL |
| 3 | BDL | BDL | BDL | BDL | 0.324 | 0.150 | 0.454 | 1.80 | BDL |
| 4 | BDL | BDL | BDL | BDL | 0.289 | 0.159 | 0.450 | BDL | BDL |
| 5 | BDL | BDL | BDL | BDL | 0.257 | 0.175 | 0.476 | BDL | BDL |
| 6 | BDL | BDL | BDL | BDL | 0.249 | 0.179 | 0.475 | BDL | BDL |
| 7 | BDL | BDL | BDL | BDL | 0.263 | 0.175 | 0.458 | BDL | BDL |
| 8 | BDL | BDL | BDL | BDL | 0.255 | 0.168 | 0.433 | BDL | BDL |
| 9 | BDL | BDL | BDL | BDL | 0.248 | 0.177 | 0.474 | BLD | BDL |
| 10 | BDL | BDL | BDL | BDL | 0.257 | 0.152 | 0.459 | BLD | BDL |
| 11 | BDL | BDL | BDL | BDL | 0.234 | 0.170 | 0.381 | BDL | BDL |
| 12 | BDL | BDL | BDL | BDL | 0.245 | 0.175 | 0.421 | BDL | BDL |
| 13 | BDL | BDL | BDL | BDL | 0.253 | 1.179 | 0.406 | BDL | BDL |
| 14 | BDL | BDL | BDL | BDL | 0.257 | 1.175 | 0.367 | BDL | BDL |
| 15 | BDL | BDL | BDL | BDL | 0.255 | 0.177 | 0.392 | BDL | BDL |
| Mean | | | | | 0.276 | 0.302 | 0.437 | 0.120 | |
| SD | | | | | 0.046 | 0.355 | 0.036 | 0.465 | |

SD=Standard Deviation. BDL= Below Detection Level

Table 6: Heavy metals in *amaranthus retroflexus* mg/kg in March 2021

| | Al | As | Cr | Cd | Zn | Fe | Cu | Mn | Pb |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BDL | BDL | BDL | BDL | 0.397 | 0.189 | 0.487 | BDL | BDL |
| 2 | BDL | BDL | BDL | BDL | 0.401 | 0.200 | 0.490 | BDL | BDL |
| 3 | BDL | BDL | BDL | BDL | 0.362 | 0.170 | 0.470 | 1.80 | BDL |
| 4 | BDL | BDL | BDL | BDL | 0.321 | 0.170 | 0.470 | BDL | BDL |
| 5 | BDL | BDL | BDL | BDL | 0.300 | 0.188 | 0.488 | BDL | BDL |
| 6 | BDL | BDL | BDL | BDL | 0.277 | 0.197 | 0.497 | BDL | BDL |
| 7 | BDL | BDL | BDL | BDL | 0.283 | 0.199 | 0.470 | BDL | BDL |
| 8 | BDL | BDL | BDL | BDL | 0.294 | 0.186 | 0.469 | BDL | BDL |
| 9 | BDL | BDL | BDL | BDL | 0.288 | 0.190 | 0.489 | BLD | BDL |
| 10 | BDL | BDL | BDL | BDL | 0.304 | 0.188 | 0.470 | BLD | BDL |
| 11 | BDL | BDL | BDL | BDL | 0.281 | 0.190 | 0.411 | BDL | BDL |
| 12 | BDL | BDL | BDL | BDL | 0.286 | 0.201 | 0.443 | BDL | BDL |
| 13 | BDL | BDL | BDL | BDL | 0.294 | 1.200 | 0.447 | BDL | BDL |
| 14 | BDL | BDL | BDL | BDL | 0.287 | 1.199 | 0.447 | BDL | BDL |
| 15 | BDL | BDL | BDL | BDL | 0.296 | 0.190 | 0.423 | BDL | BDL |
| Mean | | | | | 0.311 | 0.324 | 0.465 | 0.120 | |
| SD | | | | | 0.041 | 0.356 | 0.026 | 0.465 | |

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SD=Standard Deviation. BDL= Below Detection Level

### 3.3 Assessment of Transfer Factor (TF) for Heavy Metals in vegetables *amaranthus retroflexus*.

### 3.3.1 Transfer Factor (TF)

The Transfer factor (TF) for only Cr, Fe, and Mn were estimated, because the remaining heavy metal are measured below detection level. The transfer factors for *amaranthus retroflexus* were estimated for March 2020 and March 2021. As shown in table 7 *amaranthus retroflexus* recorded the highest value for Fe (15.62914) for March 2020, and Fe (10.52469) for March 2021. TF for Cr in *Amaranthus Retroflexus* (mg/kg) in March 2020 and 2021 recorded 0.0362319 and 0.0032154 respectively (see table 7 for details). According to Iyama,eet al., 2021, high values *TF* indicate low retention capacity. Similarly, *TF* above 1 indicates hyper-accumulation, especially in soils, according to Eze and Ekanem Lian *et al*., 2022, but values of 0.1 indicated that plant was excluding metals from its tissues, while the *TF* values of 0.2 indicated the probability of metal contamination by anthropogenic activities Adedokun *et al*., 2016. The *TF* values obtained from studied *amaranthus retroflexus* showed indications of poor accumulation of heavy metals (specifically Fe and Zn) in vegetable, suggesting affinity of metal to the soil colloids, hence preventing vegetable from entry into the metals Wang *et al*., 2012. The relatively low *TF* result obtained for vegetables in this study is consistent with earlier finding by Liphadzi *et al*, 2005, for most plants species. Similarly, Fe is plant essential elements, and most plants have the potential to keep them Jain *et al*., 2016. The occurrence of heavy metals in the ecosystem is catastrophic to plant and organisms, including humans, because of their bio-accumulating tendency and toxicity (Nduka, J. K. C., & Orisakwe, O. E, 2007).

Table 7: Transfer Factor for *Amaranthus Retroflexus* (mg/kg)

| Heavy Metals | Transfer Factor March. 2020 | March. 2021 |
|---|---|---|
| As | BDL | BDL |
| Al | BDL | BDL |
| B | BDL | BDL |
| Cd | BDL | BDL |
| Cr | 0.0362319 | 0.0032154 |
| Fe | 15.629139 | 10.524691 |
| Mn | 0.6407323 | 0.7376344 |
| Zn | BDL | BDL |
| Pb | BDL | BDL |

BDL= Below Detection Level

## 4. Conclusions

The study reveals that heavy metals (AS, AL, B, Cd and Zn), recorded in the underground water recorded an average of below detection thresholds. However, Cr and Fe records show an average above detection threshold level of 7.3mg/l and 9.0mg/l respectively. These high figures were associated with the location of an e-waste dump site which is close to the water sources. Moreover, the level of heavy metal concentrations in soils across the study area are widely reported to be within allowable range set by European Union (EU). Heavy metal concentration in the *Amaranthus Retroflexus* recorded across seasons were within allowable maximum ranges sets by FAO and WHO, and as such are safe for human consumption. The study concluded by recommending the need for further studies on the impact of e-waste site location on heavy metal content of the surrounding soil.

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