# Accumulation of heavy metals by gamba grass (Andropogon gayanus) due to artisanal gold mining in Zamfara State, Nigeria.

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## Abstract

Gamba grass (*Andropogon gayanus*) is among the most abundant and widely used pasture for grazing animals in the northern part of Nigeria. The present study was carried out to assess heavy metals (Lead, Cadmium, Chromium, and Zinc), in Gamba grass around mining, processing, and villages of Anka Local Government artisanal gold mining is taking place. Five (5) villages (Bagega, Dareta, Sunke, Tunga, and Abare) where mining activities are taking place were involved in the study, and Anka town with no record of mining activities served as control. In each of the five (5) villages, samples were taken from mining sites, processing sites, and the villages, together with the control making a total of sixteen (16) samples. Samples collected were analyzed for lead (Pb), cadmium (Cd), chromium (Cr), and zinc (Zn) using flame atomic absorption spectrophotometry. The concentration of Pb, Cd, Cr and Zn ranges from $0 – 60.20$ mg/kg, $1.50 – 3.60$ mg/kg, $0 – 25.30$ mg/kg and $0.50 – 37.80$ mg/kg respectively. The average concentration of the heavy metals varied significantly ($p < 0.001$) between the sites and locations and decreased in the order Pb > Zn > Cr > Cd. Results highlights that animals are feeding on gamba grass around all the villages ingest a significant amount of theses metals because the concentration of the metals in gamba grass exceeded the maximum permissible contents of 2 mg/kg Pb, 0.02 mg/kg Cd, 1.30 mg/kg Cr and 0.06 mg/kg Zn in plants as set by WHO, 1996. This quantitative evidence demonstrates the critical need to place mining regulations to protect the environment and animals. It is also essential to prevent excessive build-up of these metals in the food chain.

## 1.0 Introduction

Accumulation, toxicity, and persistence of heavy metals accumulated in our environment due to natural and anthropogenic activities, present a severe environmental problem in our world today. The illegal mining and intense mineral exploration in mining areas have resulted in the production of a large amount of waste material, leading to the release of toxic elements into the environment (Nuhu et al., 2014) particularly heavy metals (Abdu & Yusuf, 2013). These illegal and intense mineral exploration produces many waste material accumulating on the heaps or tailings (Ma et al., 2015). Without proper management, the minerals on the heaps and tailing serve as the source of heavy metals, which are often washed out by precipitation or carried by wind and eventually pollute the environment (Li et al., 2014; Liakopoulos et al., 2010).

Soils are a rich ecosystem, composed of both living and non-living matter, with many interactions between them. It is also a critical component because it can accumulate pollutants produced by natural and anthropogenic activities such as mining, industry, agriculture, vehicular movement, etc. Different processes interact together to aid the transport of heavy metals in soil, including physical, chemical, and biological processes (Violante et al., 2008). These polluted soils become the source of contamination of the environment and invariably, the food chain (Gholizadeh et al., 2015). The heavy metals are non-degradable and persistent, their presence in soil is stable, and long-term (Lizárraga-Mendiola et al., 2009), and these pose risks to the environment public health (Zhu et al., 2019).

Incidence of heavy metals contamination in Zamfara State Nigeria, in 2010 (Jurgen et al., 2010) captured much attention, and many kinds of research have been carried out to

assess the levels of the heavy metals in the affected areas (Abdu & Yusuf, 2013; Mohammed & Abdu, 2014; Nuhu et al., 2014; Oladipo et al., 2014; Orisakwe et al., 2017). However, to the best of our knowledge, little or no study has been carried out or reported on the accumulation of heavy metals on the popular Gamba grass in the study areas. This grass is among the dominant animal feed in the areas. Long-term, low-level exposure to everyday pollutants like heavy metals is detrimental to health (Arora et al., 2017). Therefore there is the need to assess this pollutant's levels to provide information on the level of risks for proper management. Therefore, this research was designed to determine the level of heavy metals on gamba grass in the selected villages of Zamfara State, Nigeria, and compare the standards of maximum permissible limits on plants for proper management.

## 2.0 Materials and Methods

### 2.1 Study area, plant samples collection and preparation

The plant samples for the study were collected from six

(6) locations, i.e. Abare, Sunke, Tungar Kudaku (Tunga), Bagega, Dareta, and Anka town (Figure 1) from Anka Local Government of Zamfara State, Nigeria. According to Jurgen et al. (2010), Abare and Sunke are confirmed heavy metals contaminated area, Bagega is suspected, and Dareta is a remediated area. Anka, with no record of heavy metals contamination, served as our control.

The plant samples were sampled from six (6) different villages/locations. In each of the locations, apart from Anka town (i.e. control site), sampling was done from the processing site, mining site, and the villages, while only one sample was collected from Anka. At each sampling site, five subsamples were randomly collected. Samples were taken from the whole above-ground portion of Gamba grass (*Andropogon gayanus*) (i.e. the most populous grass in all the study areas). All the samples were collected in three replicates. The plant samples were oven-dried at 65°C to constant weight, ground, and sieved through 0.5 mm mesh and kept in a polythene bag before analysis.

### 2.2 Determination of total heavy metals concentration in
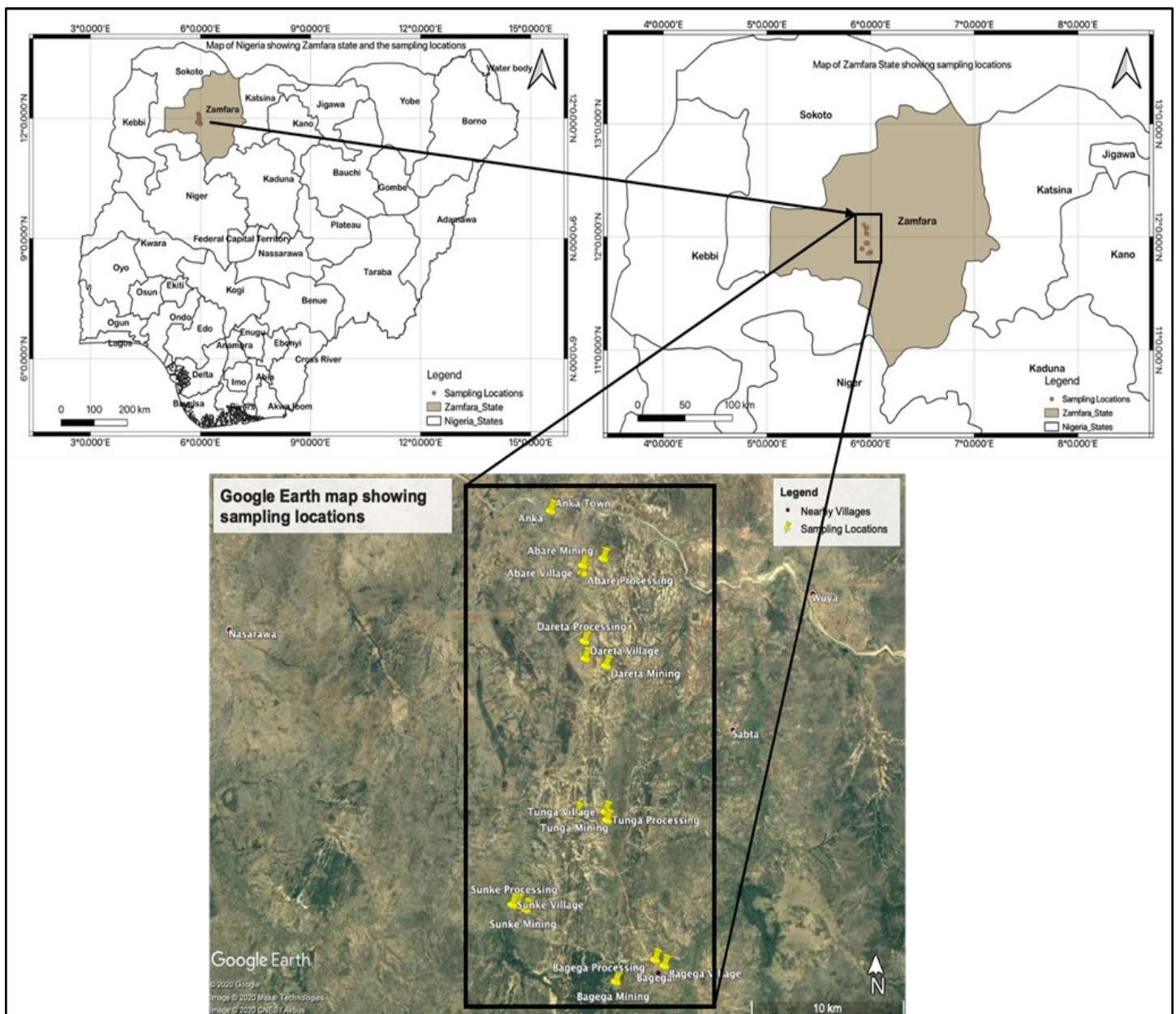


Figure 1: Maps showing Nigeria, Zamfara State, and the sampling locations

*plant samples*

From the plant samples, 1g of each sample was placed in a conical flask, and a mixture of concentrated $HNO_3$: $HClO_4$: HF in the ratio 3:1:3 was added (Nwajei & Gagophien, 2000). The mixtures were then heated to $80^0C$ for 3 hrs. The digests were filtered into a 100 ml standard plastic bottle and made to 100 ml with deionized water.

The samples' heavy metals concentrations were measured using flame atomic absorption spectrophotometry (Varian model-AA240FS) in the Ahmadu Bello University Multi-User Laboratory. The heavy metals determined include; cadmium (Cd), lead (Pb), chromium (Cr), and zinc (Zn).

2.3 Statistical analyses

Data collected was analyzed using SAS 9.0 (SAS, 2002), where there are significant differences, the Duncan Multiple Range Technique (DMRT) tests were used to separate the means.

2.4 Quality assurance and control

Quality assurance and quality control were essential to ensure the reliability of measurements. In this study, all experimental reagents used were of analytical grade. Distilled water was used throughout the experimental procedure. Each plant samples were analyzed in triplicate, and one standard sample was analyzed after every three experimental samples to ensure the accuracy of the results. Field blank and experimental blank samples were also analyzed to ensure the accuracy of data obtained

## 3.0 Results and Discussion

The concentrations of heavy metals in plant (*Andropogon gayanus*) samples from all the study locations and sites varied significantly ($p < 0.01$). The concentration of Pb, Cd, Cr, and Zn ranges from $0 - 60.20$ mg/kg, $1.50 - 3.60$ mg/kg, $0 - 25.30$ mg/kg and $0.50 - 37.80$ mg/kg respectively. The average concentration of the heavy metals decreased in the order Pb > Zn > Cr > Cd.

The Pb concentrations in the plants of all the study sites (Figure 2) except Anka town (not detected) exceeded the maximum permissible contents of 2 mg/kg as set by World Health Organization (WHO, 1996). Sunke mining, Sunke village, and Tunga village have values within the normal ranges of $5 - 10$ mg/kg (Kabata-Pendias, 2001) while the majority exceeded these ranges. All the processing sites have values above the normal ranges. This signifies that the metal ores processing has a significant contribution to the accumulation of Pb on the plant samples, as Blanco et al. (2017) observed that Pb was mostly accumulated above the normal permissible limit close to the Pb emission sources. Rotkittikhun et al. (2006) discovered that plants could accumulate more than 1000 mg/kg Pb in their shoots, and Pb was found to be more accumulating on the fleshy leaves (Azariz et al., 2020). This confirmed our results that if proper management is not taking, the plants in the processing areas can accumulate more Pb thousand times the maximum permissible limits, and the shoots and leaves that animals feed on, accumulating the highest Pb.
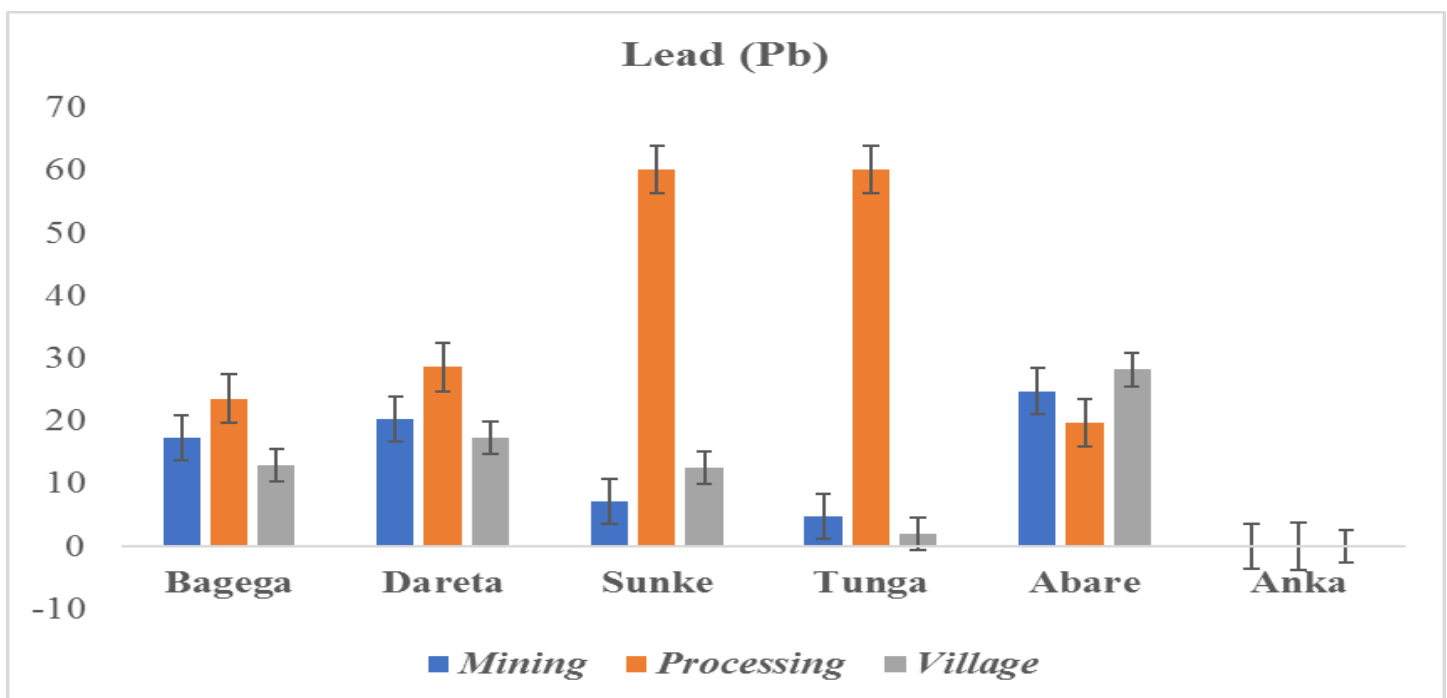


Figure 2: Lead (Pb) contents in the plant (Andropogon gayanus) from the study locations of Anka Local Government, Zamfara State (mg/kg)

The Cd concentrations in plants from all the study sites (Figure 3) including Anka town (control site) exceeded the maximum permissible limit of 0.02 mg/kg as set by World Health Organization (WHO, 1996) and 0.10 mg/kg as set by Macnicol and Beckett (Farid et al., 2015). There is no significant difference in Cd concentrations between the sites and the locations ($p > 0.05$). The result revealed that all the study sites, including the control site, have Cd concentration above the permissible limits. This indicates that

Cd accumulation is not only attributed to mining activities alone, but atmospheric deposition and sewage sludge also added Cd to the topsoil and plants (Bigalke et al., 2017). This calls for remediation and further studies on Cd in our environment, as Cd contamination in agricultural soils poses a severe problem for crop quality and human health (Khan et al., 2019). Zhang et al. (2016) suggested that the application of $1.5 - 3.0$ t/ha biochar can reduce Cd content in soil and ultimately its accumulation in plants.

## Cadmium (Cd)
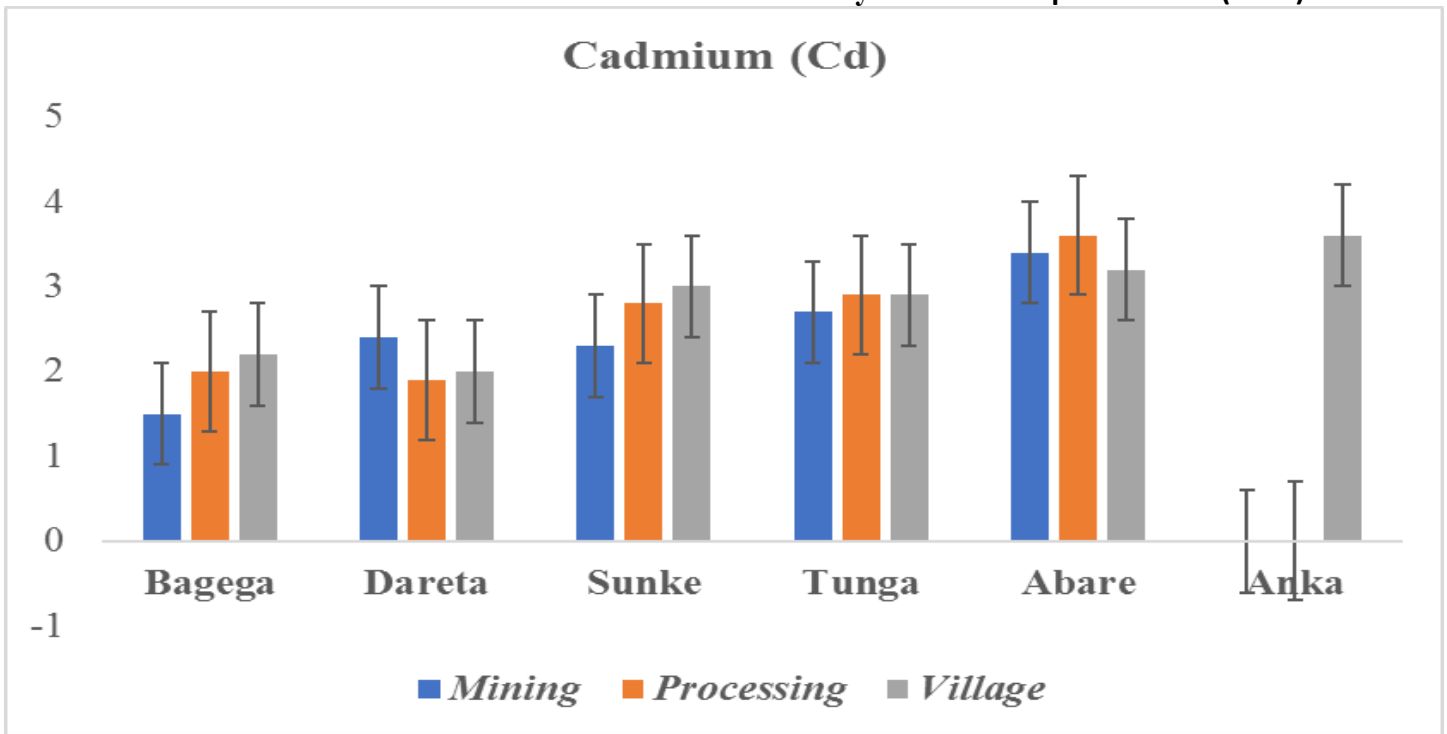


Figure 3: Cadmium (Cd) contents in the plant (Andropogon gayanus) from the study locations of Anka Local Government, Zamfara State (mg/kg)

All the study sites' Cr concentrations in the plant (Figure 4) except Abare village (not detected) exceeded the maximum permissible limit of 1.30 mg/kg as set by WHO (1996). The trends in Cr accumulation is similar to that of Cd. This is in agreement with the findings of Nuhu et al. (2014). Hence, we cannot conclude that Cr accumulation is caused by mining alone, but other sources of Cr contamination should be explored.
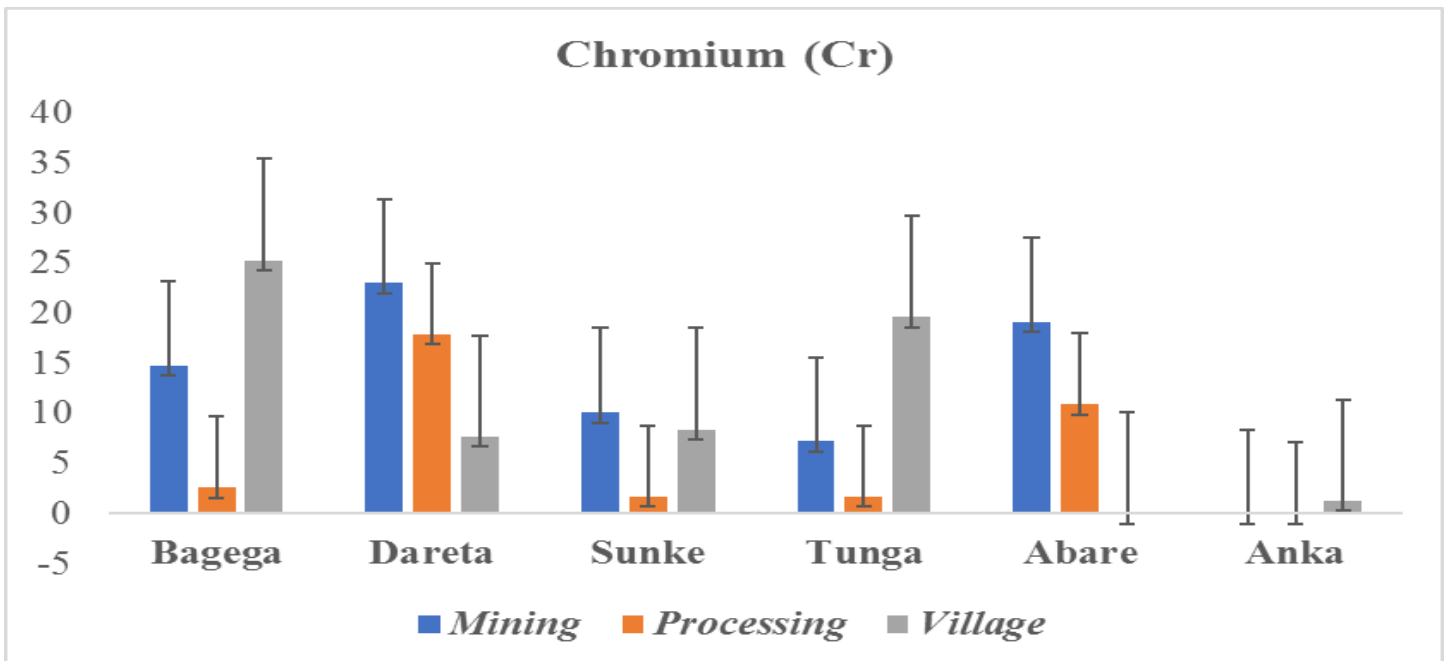
## Chromium (Cr)



Figure 4: Chromium (Cr) contents in the plant (Andropogon gayanus) from the study locations of Anka Local Government, Zamfara State (mg/kg)

The Zn concentrations in plants from all the study sites (Figure 5) including Anka town (control site) exceeded the maximum permissible limit of 0.06 mg/kg as set by World Health Organization (WHO, 1996). There is a significant difference in Zn concentrations between the sites and the locations ($p < 0.05$). The result revealed that all the study sites including the control site have Zn concentrations above the permissible limits, with only the Dareta processing site have a value (0.50 mg/kg) less than the maximum permissible limit of 0.60 mg/kg of Zn in plants (WHO, 1996). This also agreed with Mohammed and Abdu (2014) findings in one of the study areas.
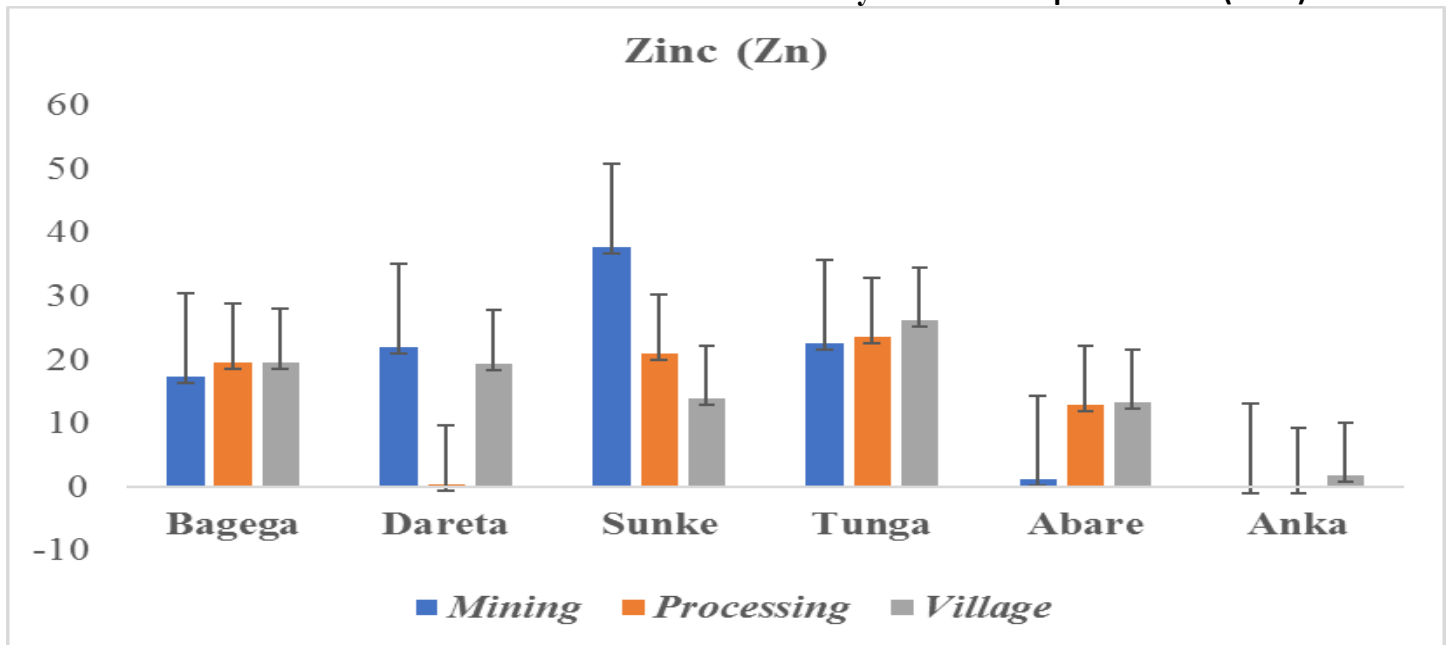
Figure 5: Zinc (Zn) contents in the plant (Andropogon gayanus) from the study locations of Anka Local Government, Zamfara State (mg/kg)

## 4.0. Conclusion and Recommendation

From the results above, it is evident that Gamba grasses (*Andropogon gayanus*) from all the study locations had concentrations of Pb, Cd, Cr, and Zn above the maximum permissible limit of the metals in plants except Anka town (control site) where Pb was not detected. For Cd, Cr, and Zn, even the control site recorded concentrations above the permissible limits. Therefore, the plants' high level of heavy metals would not be tied strictly to mining activities, but other heavy metal contamination sources should be considered. This quantitative evidence demonstrates the critical need to put in place mining regulations to protect the environment and residents, especially children, from Pb pollution in the area, and remediation of the contaminated areas is highly recommended.

## 5.0. Acknowledgement

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