CONTAMINATION FACTOR OF HEAVY METALS DUE TO MINING ACTIVITIES IN PLATEAU STATE, NIGERIA.

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ABSTRACT
The work evaluates the contamination factor of water, soil and plant in some parts of Plateau State, Nigeria using XRF method from 12 sample each of soil, water and edible plants. The results showed that, CF of soil in different Local Government has values in trend with Mangu (5.3) > Barkin Ladi (5.2) > Jos East (4.7) >Jos South (4.4) > Bassa (4.3). Water has its trend as Barkin Ladi (4.5) > Jos South (4.2) > Mangu (4.1) > Bassa (2.9) > Jos East (2.7). Edible Plants has trend with Jos South (3.8) > Barkin Ladi (3.7) > Mangu and Jos East (3.5) > Bassa (3.4). 100 % of these values are higher than the world recommended limit of unity. It can be concluded that the soil, water and plants in the area are moderately contaminated and required regulatory control. Hence this research can be used as a reference data for the regulatory bodies like NNRA and the rest.

Keywords: Heavy Metals; Soil; Plant; Water; Contamination Factor.

INTRODUCTION

Plants received heavy metals from soils through ionic exchange, redox reactions, precipitation-dissolution, and so on. Which implies that the solubility of trace elements based on factors like minerals in the soil, soil organic matter, soil pH, redox potential, content, nutrient balance, other trace elements concentration in soil, physical and mechanical characteristics of soil, soil temperature and humidity, and so on (Jolly *et al.*, 2013). Metals distribution in plants is very heterogeneous and is governed by genetic, environmental and toxic factors. The variation of heavy metals in plant-soil association is based mainly on the levels of soil contamination and plant species (Ibrahim *et al.*, 2014). Plants traps heavy metals from the soil through the root and from the atmosphere through over ground vegetative organs (Jolly *et al.*, 2013). Some plants species have lower tolerance to toxic metals absorption in polluted mine soil as they accumulate high concentrations of Ni, Cr, As, Cd, and Pb (Naser *et al.*, 2011). More so, different plant species grown in the same soil may have different concentration of the same element (Jolly *et al.*, 2013). The same heavy metals can contaminate water through erosion. Transmission of metals from soil to plant tissues and from soil to water is studied in this work using an index called Contamination Factor (CF) (Usman *et al.*, 2020; Rilwan *et al.*, 2020).

MATERIALS AND METHOD

Materials

The materials that were used in carrying out this research are;

i. Hand trowel
ii. Plastic containers
iii. Hand gloves
iv. polyethylene sampling bottles
v. Geo-positioning System meter (GPS meter)
vi. Masking tape
vii. Permanent marker and Jotter
viii. X-Ray Fluorescence Spectrometry System (XRF)

STUDY AREA

Plateau is the twelfth-largest state in Nigeria. Approximately in the centre of the country, it is geographically unique in Nigeria due to its boundaries of elevated hills surrounding the Jos Plateau which is

its capital, and the entire plateau itself (Waida *et al.*, 2022).

Map of mining Local Government showing the sample points is presented in Figure 1.

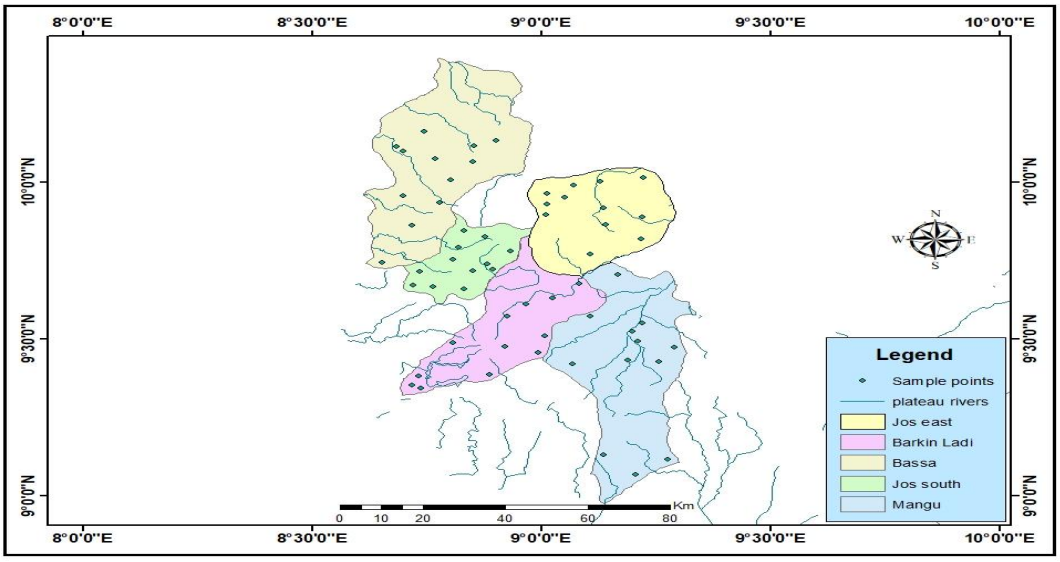

Figure. 1: Map of Mining Local Government Areas Showing Sample Points

Method

Sample Collection

Soil, water and vegetable samples were pair collected. A simple systematic random sampling technique was used to select twelve (12) soil sample, twelve (12) edible plant sample, and twelve (12) water samples from the Mining local government of Plateau State. Thirty-Sixty (36) samples in all were analyzed in this study. Vegetables' rooted soil samples were taken at 0-20 cm depth.

Soil Sample Collection

Twenty sample of soil from the Mining local government of Plateau State was collected. The sample was collected by coring tool to a depth of 5 cm or to the depth of the plough line. The collected samples each of approximately 4 kg in wet weight was immediately transferred into a high-density polyethylene zip lock plastic bag to prevent cross contamination. Each sample was marked with a unique identification number (sample ID) for traceability and its position coordinates were recorded for reference purposes using GPS meter.

Edible Plant Sample Collection

Twenty edible plant samples were collected from the Mining local government of Plateau State. The collected samples were immediately transferred into a high-density polyethylene zip lock plastic bag to prevent cross contamination. Each sample was marked with a unique identification number (sample ID) for traceability.

Water Sample Collection

Twenty water samples were collected from streams from the Mining local government of Plateau State. The collected samples were immediately transferred into plastic containers and was well covered to avoid cross contamination. Each sample was marked with a unique identification number (sample ID) for traceability.

Edible Plant Sample Preparation

Only the edible part of each plant sample was used for analysis. The plant samples were washed with ultrapure water three times. After the water had evaporated, the

plant samples were weighed, oven-dried at 65 °C for 48 h, weighed again and then crushed into powder. The heavy metal concentrations in edible portions of plant was determined on a wet weight basis. The edible plant sample was taken for XRF analysis.

Soil Sample Preparation

All soil samples were naturally air-dried until constant weight is reached. The dried soil samples were homogenized with pestle in a mortar, and then passed through standard sieves 0.9 mm, 0.3 mm, and 0.15 mm for analysis of pH, organic matter (OM) and heavy metal contents, respectively. Soil pH were measured using a pH electrode and the ratio of solid: water was 1:2.5. OM contents of soil samples were determined using the loss on ignition method. The soil sample was taken for XRF analysis.

Water Sample Preparation

Water samples for heavy metals determination was acidified with two (2) drops of concentrated HNO_3; Samples for Dissolved oxygen determination was fixed with 2 ml each of Manganese (II) sulphate solution (winkler A) and Alkali-iodide Azide reagent (Winkler B) per sample. These operations were carried out on the field. All samples were then placed in an ice-chest and taken to the laboratory on the same day. The digested water sample was taken XRF analysis.

Method of Data Analysis

Concentrations of elements was analyzed by the X-Ray Florescence Spectrometric Analysis available at Centre for Dryland Agriculture Bayero University, Kano. The results obtained was used to evaluate the contamination factor.

Contamination factor (CF)

The level of contamination by metals is expressed in terms of a contamination factor (CF) according to WHO (2015) as:

$$CF = \frac{C_m\,\text{Sample}}{C_m\,\text{Background}} \quad (1)$$

where C_m is the Concentration of sample from the flooded farm and C_m Background the Concentration of sample from the control area. If CF < 1: indicates low contamination. 1 < CF < 3: indicates moderate contamination. 3 < CF < 6: indicates considerable contamination. CF > 6: indicates very high contamination.

RESULTS AND DISCUSSION

Results

The results for the concentration levels of five heavy metals (Ni, Cr, As, Cd and Pb) was determined using XRF Cu-Zn method. The results for the concentration of heavy metals in water, soil and edible plants are further used to calculate the contamination factors as presented in Table 1, Table 2 and Table 3 for easy interpretation.

Table 1: Contamination Factor of Heavy Metals in Soil Samples.

Sample Town	Ni	Cr	As	Cd	Pb	Total
Bassa	0.9	0.8	0.9	0.9	0.8	4.3
Jos South	0.9	0.8	1.0	1.0	0.7	4.4
Barkin Ladi	0.9	0.7	1.5	1.4	0.7	5.2
Mangu	0.9	0.7	1.5	1.4	0.7	5.3
Jos East	0.8	0.7	1.2	1.2	0.7	4.7
Mean	0.9	0.7	1.2	1.2	0.7	4.8

Cr = Chromium; Cd = Cadmium; As = Arsenic; Pb = Lead; Ni = Nickel.

Table 2: Contamination Factor of Heavy Metals in Water Samples.

Sample Town	Ni	Cr	As	Cd	Pb	Total
Bassa	0.10	0.8	0.8	0.8	0.4	2.9
Jos South	0.11	0.7	1.7	1.1	0.6	4.2
Barkin Ladi	0.16	0.6	2.1	0.9	0.7	4.5

Mangu	0.14	1.0	1.3	0.7	0.9	4.1
Jos East	0.14	0.6	0.9	0.7	0.5	2.7
Mean	0.1	0.7	1.4	0.8	0.6	3.7

Cr = Chromium; Cd = Cadmium; As = Arsenic; Pb = Lead; Ni = Nickel.

Table 3: Contamination Factor of Heavy Metals in Edible Plants Samples.

Sample Town	Ni	Cr	As	Cd	Pb	Mean
Bassa	0.6	0.7	0.2	1.0	0.9	3.4
Jos South	0.5	0.6	0.3	1.5	0.9	3.8
Barkin Ladi	0.6	0.6	0.3	1.3	0.9	3.7
Mangu	0.5	0.5	0.3	1.4	0.8	3.5
Jos East	0.5	0.4	0.3	1.5	0.8	3.5
Mean	0.5	0.6	0.3	1.3	0.9	3.6

Cr = Chromium; Cd = Cadmium; As = Arsenic; Pb = Lead; Ni = Nickel.

Comparison of Results with World Health Organization (WHO)

The results presented on Table 1, Table 2 and Table 3 were used to plot charts in order to compare the results of the present study with World Health Organization (WHO) as seen in Figure 2, Figure 3 and Figure 4.

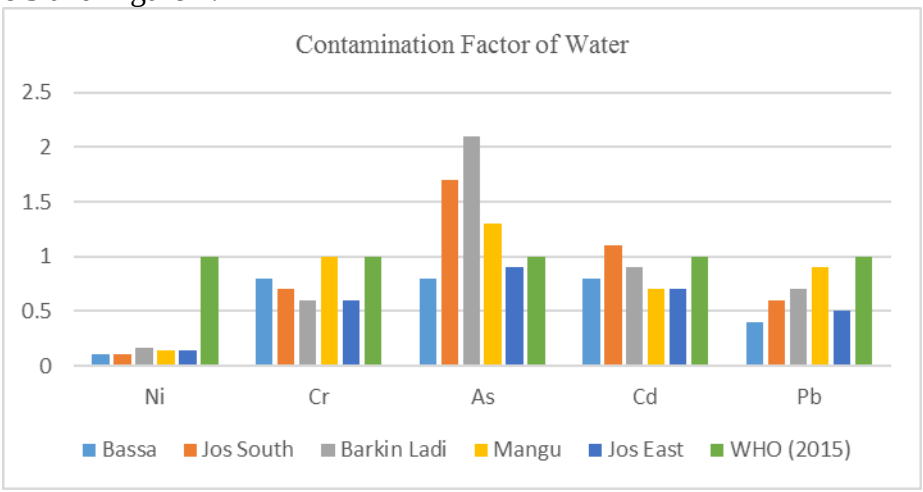

Figure 2: Comparison of Contamination Factor of Water with World Health Organization

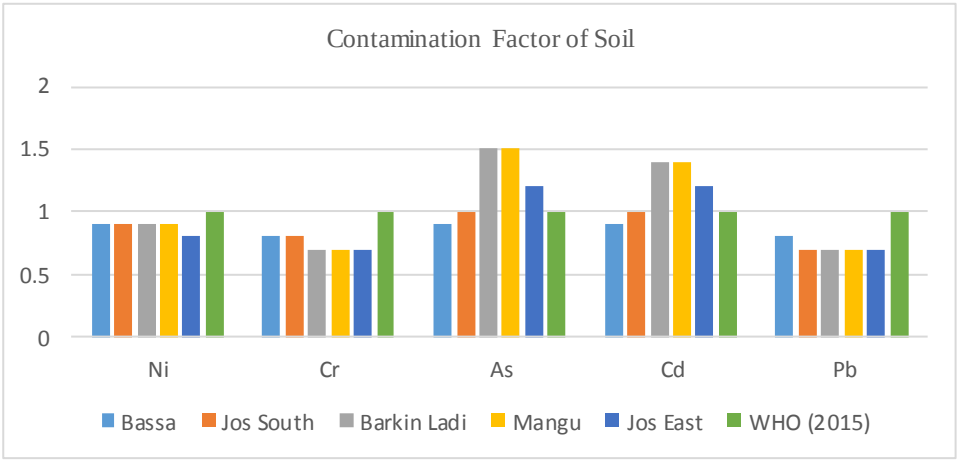

Figure 3: Comparison of Contamination Factor of Soil with World Health Organization

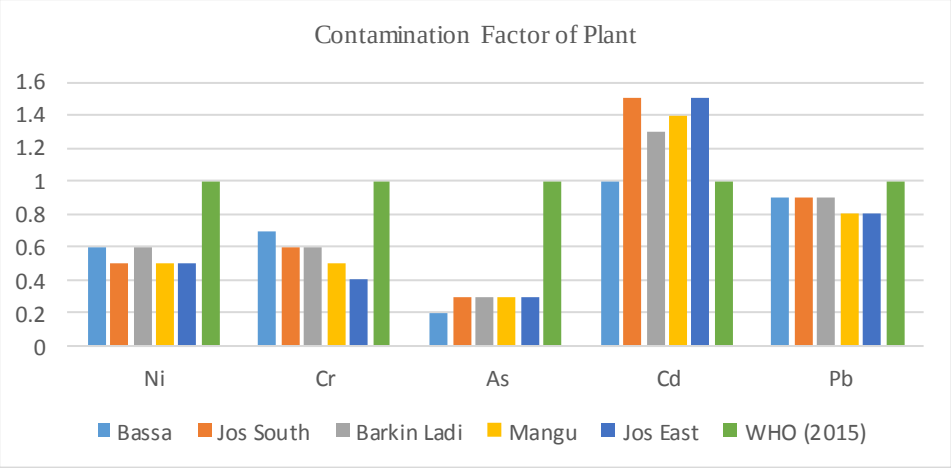

Figure 4: Comparison of Contamination Factor of Plant with World Health Organization

DISCUSSION

Concentration of different elements in plants depends on the relative level of exposure of plants to the contaminated soil as well as the deposition of toxic elements in the polluted air by sedimentation. In this study, the Contamination Factor (CF) for various metals showed that the CF values differed slightly between the locations.

The total contamination factor CF of soil in different Local Government has values in trend with Mangu (5.3) > Barkin Ladi (5.2) > Jos East (4.7) >Jos South (4.4) > Bassa (4.3). Water has its trend as Barkin Ladi (4.5) > Jos South (4.2) > Mangu (4.1) > Bassa (2.9) > Jos East (2.7). Edible Plants has trend with Jos South (3.8) > Barkin Ladi (3.7) > Mangu and Jos East (3.5) > Bassa (3.4). Based on the results presented, the water in Jos South is moderately contaminated with Arsenic (As) and Cadmium (Cd) while that of Barkin Ladi and Mangu are moderately contaminated with Arsenic (As) considering the World Health Organization recommended value of CF < 1 as low contamination, 1 < CF < 3 as moderate contamination, 3 < CF < 6 as considerable contamination and CF > 6 as very high contamination. The soil in Barkin Ladi, Mangu and Jos East is moderately contaminated with Arsenic (As) and Cadmium (Cd) considering the World Health Organization recommended value of CF < 1 as low contamination, 1 < CF < 3 as moderate contaminations, 3 < CF < 6 as considerable contamination and CF > 6 as very high contaminations. The plants in Jos South, Barkin Ladi, Mangu and Jos East is moderately contaminated with Cadmium (Cd) considering the World Health Organization recommended value of CF < 1 as low contamination, 1 < CF < 3 as moderate contaminations, 3 < CF < 6 as considerable contamination and CF > 6 as very high contaminations.

CONCLUSION

Based on the findings of this study, It can therefore be concluded that the soil, water and plants in the study area are moderately contaminated and call for serious concern and regulatory control. Hence this research can be used as a reference data for the regulatory bodies like NNRA and the rest.

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