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# Post remediation assessment of trace Elements level in soils and plants of Dareta gold mining area, Zamfara State, Nigeria

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## Abstract

This study investigated the Concentrations of the toxic metals Pb, As, Cr, Zn, Fe, and Cu in soils and plants in Dareta gold mining village, Zamfara State, Nigeria Samples were collected and analysed following standard Laboratory methods. The values obtained were compared with nearby unpolluted area as control. All the soils indicated contamination with the toxic metals Pb, As, Cr, Zn and Cu, above the maximum allowed limits. With the exception of Cd and Ni which were not detected. Cr has the highest Concentration in both Samples indicative of possible mineral deposit in the area. Proper mining regulations and monitoring could help control further contamination.

**Keywords:** Remediation; Concentration; Plant; Soil; Dareta; Gold; Mining

## Introduction

People of the world have long been conscious of the importance of minerals to sustenance of life and solution of problems. In his quest to satisfy his needs and aspirations for better living conditions through resource exploitation, man has created an increasing number of environmental problems. He exploit nature, and in so doing upset the natural equilibrium which in turn have been proved to be harmful to man himself. Following each use of water and the exploitation of land and water resources, various forms of pollution contributes to the degradation of the environmental quality [1]. Metals are natural components of the earth crust. They cannot be degraded or destroyed. Increase in agricultural, mining and industrial processes have resulted in an increase concentration of metals in air, water and soil. These metals taken in by plants and animals subsequently find their way into the food chain and enter the human body through ingestion. Inhalation and absorption through the skin are other means through which they gain access into the human body [2]. Ground water may be contaminated with metals from waste water discharges or by direct contact with metals-contaminated soils, sludge's, mining wastes, and debris. Metal-bearing solids at contaminated sites can originate from a wide variety of sources in the form of airborne emissions and process solid wastes [1].

## Plant Samples Collection

Three different plant varieties were selected for this study, as follows: Plant (A) adensonia Digitata called Baobab known as kuka in Hausa, plant (B) senna occidentalis called coffee senna known as tafasa in Hausa and amaranthus spinosus called thorny pig weed known as Rukubu in Hausa [3,4].

The choice of these plants is primarily due to the fact that, they are widely distributed around compounds and as weeds in cultivated and uncultivated lands. It is common practice of the people in the area, including these plants in their meal preparations. Baobab which is called kuka in Hausa is used in the preparation of soup for meal called tuwo. senna occidentalis - tafasa is also used in the preparation of stew for meal; it is consumed when cooked with ground nut cake amaranthus spinosus is used in the preparation of soup and eaten when cooked. Both of these are essential nutritional additives to the body system. Accumulation of the contaminated plants in the human and animal system could pose health risks.

## Plant Sample Treatment and Analysis

Plant samples were oven dried at 105°C until a constant dried weight was obtained. The dried samples were milled using laboratory pestle and mortar milled to powder and sieved using standard 0.149 mm No. 100 mesh and appropriately labeled as described [5]. The samples were digested using Nitric Acid-Perchloric Acid ($HNO_3$-$HClO_4$), 2:1 ratio and allowed to stand overnight as described by Faithfull [6]. The digested samples were analyzed for Pb, Cu, Zn, Cd, As, Ni, Cr Mn, and Fe, Concentrations of the metals in solution was determined by atomic absorption spectrophotometer [7,8].

## Soil sample Collection and Treatment

Three different locations were chosen for soil sampling, namely; Soil A, Compound – east of the mosque, Soil B, Communal centre – old grinding site and soil C, processing area. Soil samples were collected from three different locations in the selected areas of Dareta village. Top soil was randomly collected at a depth 0 – 15 cm at each sample plot within a distance of about 1m × 1m in each of the location as adapted by [4].

Exactly 1 Kg of the soil samples were obtained by cone and quartering method from each of the locations, the sample was homogenized and oven dried at 105°C until a constant dry weight was obtained. Exactly 1g of the homogenized oven dried soil was subjected to wet-acid digestion method, Di-acid mixture analytically graded $HNO_3$-$HClO_4$ was used as described by Faithful, [8-11]. To each of 1 g of the homogenized oven dried soil sample in a clean 100 cm³ beaker 5 cm³ of distilled water was added to wet the soil and 3 cm³ of Concentrated $HNO_3$ was added and digested on electrically heated block under fume hood for 1 hr at 145°C further digestion of the sample was carried out by adding 4 cm³ of $HClO_4$ and heated to

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240°C for further one hour. The mixture was then cooled and filtered through whatman No. 42 filter paper and make up to 50 cm³ with distilled water [8].

## Analyses of Samples using Atomic Absorption Spectroscopy (AAS)

The standard stock solutions (1000 ppm) of Fe, Zn, Cu, Mn, Pb, Cr, Ni, and Cd supplied by the manufacturer of the spectrophotometer were used to prepare working standard solutions by appropriate dilutions. Spectrophotometer (Alpha 4 Model) was set up in accordance with the manufacturers' instructions for each element to be analysed. These include fuel (acetylene) and oxidant (oxygen gas) selection, burner type, an optimum wavelength and slit-with settings. A calibration curve was used to determine the unknown concentration of an element in a solution. The instrument was calibrated using several solutions of known concentrations. The absorbance of each known solution was measured and then a calibration curve against absorbance was plotted. The sample solution was fed into the instrument the absorbance of the element in this solution was measured. The unknown concentration of the element was then calculated from the calibration curve.

## Calculation of Result

The concentration of each element (C), in the samples was calculated using equation:

$C = (a-b) \times V/m$ [4]

Where

C= concentration of the element in the test sample (μg/g);

a = concentration in the test solutions (μg/cm³);

b = mean concentration in the blank solutions (mg/L);

V = volume of the test solution (cm³);

m = weight of the test portion (g)

## Dilution factor (DF)

Dilution factor is defined as: total volume of solution per aliquot volume.

DF= volume of sample after dilution/volume before dilution.

## Data analyses

The data obtained from the analyses were reported as mean ± standard deviation of triplicate analyses computed using Microsoft excel 2007 version shown in Table 1.

## Result and Discussion

Plants are very effective exposure route in metals toxicity and have been used by many scientists in determining the concentrations of metals and possible toxicity factors [12,13]. The concentrations of metals in plants samples were presented in (Table 1), six metals (Pb, As, Cr, Zn, Cu and Fe) were detected in the plants samples. The trends in the concentrations of metals in the plants samples is in the following order Fe>>Zn>>Cr>Cu>Pb>>As. Cadmium, Nickel and Manganese were not detected in the plants samples.

The concentrations of metals in plants samples in (Tables 1 and 2) showed the concentrations of metals in the plants samples, were higher in (PC) for Fe and Zn followed by plant B (PB) for Fe. Lead concentration was higher in (PB) (3.16 ± 1.01 mg/l), this can be compared with the findings of [12] studied the effect of gold mining on vegetation and soil in south western Nigeria. Generally lead concentrations in all the plants samples is above the critical value for lead in vegetables 0.3 mg/l.

When observed the metals concentrations in the plants exceed allowable limit, plant C, hyperaccumulator of iron and zinc, while plant B is hyperaccumulator of Pb, while plants A is a hyperaccumulator of Cr. Generally metals were not detected in the control samples except for Cr. Metals concentrations, was observed to be high in all the plants samples. Therefore consuming such plants could pose serious health risk.

| Critical Value* | PLANT (C) | PLANT (B) | PLANT (A) | ELEMENT |
|---|---|---|---|---|
| 5.0 | 2.53 ± 0.21[a] | 3.16 ± 1.01[a] | *2.53 ± 1.10[a] | Pb |
| NA | 1.33 ± 0.15 | 1.16 ± 0.81 | 0.83 ± 0.21 | As |
| NA | 78.84 ± 0.62[a] 9.78 ± 0.11[b] | 52.46 ± 1.49[a] 8.51 ± 0.02[b] | 96.3 ± 0.22[a] 7.31 ± 0.23[b] | Cr |
| 60 | 189.73 ± 5.68 [a] | 177.70 ± 11.25 [a] | 113.67 ± 7.05 [a] | Zn |
| 40 | 43.13 ± 1.33 [a] | 40.86 ± 1.89 [a] | 52.73 ± 1.47 [a] | Cu |
| NA | 7076.67 ± 355.57 [a] | 836.33 ± 79.97 | 1593.30 ± 70.23 | Fe |

*Arithmetic Mean ± Standard Deviation of three replicate determinations
[a] polluted sample [b] control sample [ab] both polluted and control samples
Cd, Ni and Mn, not detected, NA not available ND[b] not detected in control Pb, As, Zn and Cu Plant (A) adensonia digitata (B) Senna occidentalis (C) amaranthus spinosus

**Table 1:** Metal Concentrations (μg/g) In the Plant Samples.

| CC | SAMPLE (C) | SAMPLE (B) | SAMPLE (A) | METAL |
|---|---|---|---|---|
| 3.56 ± 0.08 | 269.29 ± 15.15 | 246.40 ± 7.11 | 305.30 ± 66.75 | Pb |
| ND | 0.50 ± 0.10 | 1.43 ± 0.31 | 0.50 ± 0.25 | As |
| 7.93 ± 0.35 | 364.00 ± 24.60 | 328.40 ± 26.57 | 428.80 ± 1.06 | Cr |
| ND | 160.60 ± 6.43 | 123.90 ± 17.80 | 202.80 ± 5.63 | Cu |
| NS | 32033.00 ± 808.20 | 2440.00 ± 589.60 | 25900.00 ± 2605.00 | Fe |
| ND | 160.60 ± 6.43 | 191.31 ± 4.51 | 686.60 ± 36.74 | Zn |

Values are Arithmetic Mean ± Standard Deviation of three replicate determinations
ND not detected, NS, not sampled.
Sample (A) Compound, Sample (B) Communal Centre, Sample(C), Processing area
CC: Control

**Table 2:** Concentrations (μgg⁻¹) of Pb, As, Cd, Cr, Ni, Cu, Fe, Mn and Zn in the Soils samples.

Soil is considered by most researchers as the final sinks for metals in the environment and since they are not degradable they remain persistent until remediation is carried out. The concentrations of metals were generally high in the soils samples than the water and plant samples. In general the trend in the concentration of metals in the soil samples is Fe>>>>Zn>Cr>Pb>Cu>>>As. The result can be compared with that reported by [12]. However, the metal concentrations in the control sample were very low, an indication of high contamination of the soil in the study area. Heavy metal pollution of soil enhances plant uptake causing accumulation in plant tissues and eventual phytotoxicity effects and can change plant communities [6,13] lead having the highest concentration in both samples. Lead was indicated as one of the potential toxic metals that posed detrimental health effect [14]. High lead content in the soils exposes greater number of the inhabitants to lead contamination via inhalation, ingestion and dermal contact [15].

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