# IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 6 ISSUE : 7 Print / Issue Publication Date: 25-Feb-2022

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2021.v06i07.002

Indexed In

Google Scholar · Open Access · doi · Crossref

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*International Journal of Engineering Applied Sciences and Technology, 2021*
**Vol. 6, Issue 7, ISSN No. 2455-2143, Pages 6-9**
Published Online November 2021 in IJEAST (http://www.ijeast.com)

# GEOCHEMICAL ASSESSMENT OF SOIL USED FOR FARMING FROM AN ABANDONED MINING SITE IN JOS-SOUTH L.G.A., USING ATOMIC ABSORPTION SPECTROSCOPY (AAS) TECHNIQUES

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**ABSTRACT - This study was undertaken to assay the geochemical assessment of soil used for farming from an abandoned mining site in Jos-South L.G.A., using Atomic Absorption Spectroscopy (AAS) techniques, Plateau state, Nigeria. A modified sequential extraction procedure of Tessier *et. al*., (17) was used in separating the total metal concentrations into four operationally defined fractions (exchangeable and carbonate, Fe and Mn oxides, organic matter, and residual fractions).Where it was discovered that the bulk of metals were partitioned to the residual fraction (Zn- 138.85ppm, Pb-55.59ppm and Cd-2.5ppm) which implies that the soils of the farmland are not polluted by any of the metals studied. Pollution indices also as compared with Banat *et. al*., (3) standards, indicated minimal contamination of the soils matrix with Cd, which had enrichment factor value of 15.4 and I-geo factor of 4. The bulk partitioning of the metals onto the residual fraction indicates a lithogenic origin of the heavy metals, i.e. the heavy metals were directly inherited from the parent material, and also a low risk of contaminant transfer under normal cultural practices. However, It is recommended that soil sample collections should be done in such a way that mobility index can be calculated, because it is a more reliable indicator which considers the weakly adsorbed fractions alone, after a sequential extraction has been done.**

**Key words:** *Atomic Absorption Spectrometer (AAS), Soil, Ex-Mining Area.*

## I. INTRODUCTION

Tin mining industry which is also the largest producer of columbite in Jos plateau state started in 1902 (1). The mining of tin has been largely responsible for profound changes in the landscape and in the social economic structure of study area (1). Limited arable land is experienced in Jos plateau area, according to (14) this is due to the high rate of surface mining. (15), revealed that mined soils are poorer in agricultural value compared to adjoining natural land. Crops grown on such mined land are of low agricultural value, quick maturing and low-nutrient demanding, such as acha, dauro, maize, millet and Irish potato. (4) revealed that the indiscriminate mining on the Jos plateau, led to many parts of the area being exposed to erosion and reduces the available arable land for crop production. The volume of mineral tripped off during mining reduces the nutrient present in the soil (1). Jos South local government area is an extensively mined area, which was dominated by use of heavy earth – moving equipment and draglines. As a result, the zone is characterized by deep excavations and dumping of high overburden, mine ponds, mine tailings and slurry wash deposits (13, 12). According to (8), the major problem of the area still remains the devastated and de-vegetated land and mine spoils; depriving the inhabitants of fertile farmland. The deep mining which is an excavation of underlying sand has created mining pits, man-made lakes, pools and ponds which have great effect on both the people and agricultural practices. Mining ponds have always been death traps for people and animals (6).

Heavy metal contamination is one of the serious environmental problems limiting plant productivity and threatening human health (10). Inputs of heavy metals to agricultural soils can occur from a variety of sources. These include the application of bio-solids, fertilizers, livestock manure, agrochemicals, and irrigation water and from atmospheric deposition. Some of the concerns about accumulation of heavy metals in agricultural soils stem from their possible negative impacts on soil fertility and in some case their potential to accumulate in the human chain (8,11). Among the substances that contribute anthropogenically to pollution of the biosphere, trace elements are the most toxic. Lead, Zinc and Cadmium are toxic metals of increasing environmental concern as they enter the food chain in significant amounts (10).

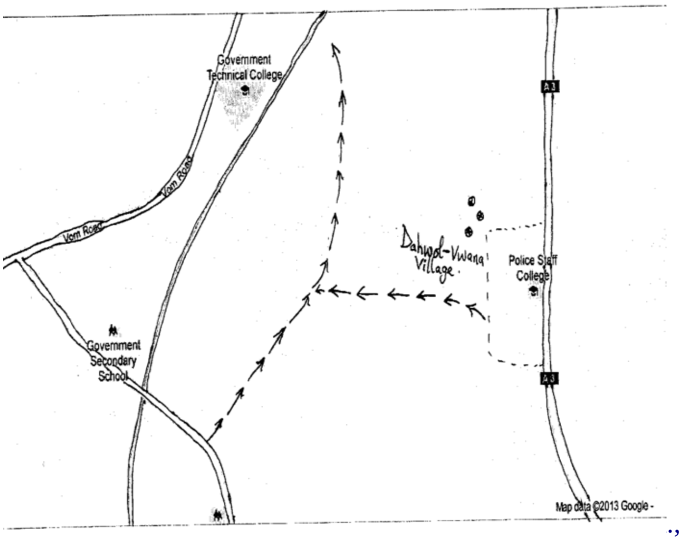
Currently, majority of the soil dug from the mining holes in Dahwol-vwana village, Jos-South L.G.A. have been scattered on their farmlands. There is therefore the need for studies to establish the level of these metals in the soil on these farms. The aim of this study is to assess the geochemical species of soil used for farming from an abandoned mining site in Jos-South L.G.A, using AAS techniques and to analyze through the following objectives: -

To determine and evaluate the geochemical species (fractions) of Pb, Cd, and Zn in some farmlands in an ex-mining area in dahwol-vwana village, Jos-south L.G.A Plateau state, Nigeria.

Total enrichment factor and geo-index analyzed to assess the level of contamination.

## II. METHOD

### STUDY AREA




The AAS experiments, they shall be performed with analytical guide chemicals (17).

Some Needed Materials for AAS Analysis

- Weighing balance
- Volumetric flask (100ml)
- Micro Kjeldahl digestion apparatus

### SAMPLE COLLECTIONS

The soil samples collections were done in farms that surrounded three abandon mining holes in Dahwol-Vwana village, in Kuru district, Jos-south L.G.A., Plateau state. These were done after the ridges formed on the farms closer to the ex-mining holes.

Furthermore, horizontal spacing range of distances were covered and measured, even as the soil were collected as shown below;

Table 1: Sample of the First Ex-Mining Hole Area ($N09^0 44.662' E008^0 50.590'$)

| Northward | Distance covered | East ward | Distance covered | West-ward | Distance covered | Southward | Distance covered |
|---|---|---|---|---|---|---|---|
| $A_1$ | 2.3m | $A_3$ | 8.1m | $A_4$ | 3.4m | $A_6$ | 5.8m |
| $A_2$ | 12.0 m | HIP OF SAND | | $A_5$ | 10.0m | $A_7$ | 14.2m |

Where sample A is the soil sample.

Table 2: Sample of the Second Ex-Mining Hole Area ($N09^0 44.656' E008^0 50.591'$)

| Northward | Distance covered | East ward | Distance covered | West-ward | Distance covered | South ward | Distance covered |
|---|---|---|---|---|---|---|---|
| $A_8$ | 1.8m | NO FARM | | $A_{10}$ | 3.1m | $A_{12}$ | 9.2m |
| $A_9$ | 8.5m | | | $A_{11}$ | 11.2m | $A_{13}$ | 15.1m |

Where sample A is the soil sample

Table 3: Sample of the Third Ex-Mining Hole Area($N09^0 44.638' E008^0 50.577'$)

| Northward | Distance covered | Eastward | Distance covered | West-ward | Distance covered | Southward | Distance covered |
|---|---|---|---|---|---|---|---|
| HIP OF SAND | | STAGNATE WATER | | NO FARM | | $A_{14}$ | 19.4m |
| | | | | | | $A_{15}$ | 28.5m |

Where sample A is the soil sample

These samples were obtained, then carefully separated each in polythene bags to avoid mixing and further labeled with cellulose tape to avoid mistaken identity.

**Sample Collection at Control Area**

The samples collections (the control) was done in a virgin area ($N009^0 41.062'$ $E008^0 45.003'$) in Trade-Centre village, along Vom road, in Kuru district, Jos-south L.G.A., Plateau state.

### DATA ANALYSIS

Analysis of variance (ANOVA) was used to determine significant differences for zinc and in total extractable metal concentrations; the relationships among the various metal fractions and soil properties were determined using correlation analysis, and the sample means were compared using Fisher's Least Significant Difference (LSD0.05). All statistical data analyses were performed using SAS V 9.0 (SAS, 2002).

Metal enrichment factor (EF) for Pb, Cd and Zn was calculated based on the following relation, as proposed by (16):

*International Journal of Engineering Applied Sciences and Technology, 2021*
**Vol. 6, Issue 7, ISSN No. 2455-2143, Pages 6-9**
Published Online November 2021 in IJEAST (http://www.ijeast.com)

EF=(Msoil)/(Mearthcrust) (1)

Where Msoil is the metal concentration in the soil and Mearthcrust is the average metal concentration in the earth crust, which is approximately 14.0, 0.2 and 75.0ppm for Pb, Cd and Zn respectively. The geo-accumulation index (I-geo), as proposed by Muller (1969), was calculated by computing the base 2 logarithm of the measured total concentration of the metal over its background concentration using the following mathematical relation (Muller 1969;Ntekim et al. 1993):

$$I\text{-}geo=\log_2(C_n/1.5B_n) \quad (2)$$

Where Cn is the concentration of metal n in the soil, Bn is the soil background concentration of heavy metal n and 1.5 is a factor compensating the background data (correction factor) due to lithogenic effects.

## III. RESULTS AND ANALYSIS

Table 4: Mean and standard deviation and range of extractable concentration of Pb, Cd, and Zn in an ex-mining site of Dahwol-vwana village, Jos-south, northern Nigeria.

| Heavy Metal | Sequential | | Extraction | |
|---|---|---|---|---|
| | Fraction 1:Exchangeable+ Carbonate bound | Fraction 2: Reducible | Fraction 3:Oxidizable | Fraction 4: Residual |
| Zn Mean, SD<br>Range | 5.92± 3.65b (3.95-7.30) | 5.42±2.62b (2.40-6.99) | 4.49± 0.99a (3.39-5.32) | 138.85±34.33a (116.93-178.41) |
| Pb Mean, SD<br>Range | 6.04± 3.73a (3.85-9.59) | 6.31 ± 4.56c (2.21-11.23) | 9.86 ± 6.97b (4.67-17.79) | 55.59 ± 6.78b (48.81-62.37) |
| Cd Mean, SD<br>Range | 0.23± 0.12c (0.09-0.44) | 0.20± 0.18b (0.09-0.44) | 0.13 ± 0.07c (0.09-0.20) | 2.51 ± 0.09a (2.40-2.56) |

Means followed by the same letters are not statistically different at 5% probability level

Metal enrichment

Table 5: Measurements of metal pollution in soils and sediments

| Index of geochemical accumulation | I-geo Class | Designation of soil quality |
|---|---|---|
| 5-10 | 6 | Extremely contaminated |
| 4-5 | 5 | Strongly/extremely contaminated |
| 3-4 | 4 | Strongly contaminated |
| 2-3 | 3 | Moderately contaminated |
| 1-2 | 2 | Uncontaminated/moderately contaminated |
| 0-1 | 1 | Contaminated |
| 0-0 | 0 | Uncontaminated |

Source: Banat *et.al*. (2005).

Table 6: Average and background concentration, enrichment factor, calculated I-geo index, and grade of pollution intensity of Pb, Cd and Zn in analyzed samples from Dahwol-vwana village, Jos-south.

| Heavy metal | Average value (ppm) | *Background Concentration (ppm) | EF | I-geo | I-geo grade | Pollution intensity |
|---|---|---|---|---|---|---|
| Pb | 77.8 | 14.0 | 5.6 | 1.9 | 2 | Moderately contaminated |
| Cd | 3.07 | 0.2 | 15.4 | 3.4 | 4 | Strongly contaminated |
| Zn | 154.7 | 75.0 | 2.1 | 0.5 | 1 | Contaminated |

Lindsay (1979)

## IV. DISCUSSIONS

**Fractionation of Pb, Cd, and Zn**

**Lead fractions**

Fractionation results partitioned the bulk of the total concentration of Pb to the residual fractions (table 4). The residual fraction represents metals associated with silicate clay minerals (Hlavay *et al* 2004). The relatively high percentage of the residual fractions in this soil indicates alithogenic origin of the metal contaminants (11). In Dahwol-vwana village, as high as 71.5% of the total Pb concentration were bound to the residual fractions. The exchangeable+carbonate fraction of the soil held the least percentage (7.8%) of the total Pb concentration recorded. The exchangeable +carbonate metal ions measure those trace metals that are released most readily into the environment; this fraction corresponds to the form of metals most available for plant uptake and could be released by merely changing the ionic strength of the soil medium (7).

The concentration of Pb fraction was held unto the OM fraction as 8.1 %. Organic matter has an affinity for heavy metals, forming stable complexes with them; especially the divalent ions, for which organic matter exhibits a high degree of selectivity compared to monovalent ions (7).

**Cadmium fractions**

The bulk of the total Cd was partitioned to the residual fraction (81.8% of the total Cd), followed by the exchangeable+carbonatefraction which held 7.5% of total Cd (table 4). The exchangeable+carbonate bound Cd was lower than that of Pb for the whole study area, however the oxide bound fraction was next to the residual. The percentage of Cd partitioned to the oxide fraction is 6.5 % for the study area.

**Zinc fractions**
Organically bound fraction of Zn accounted for 89.8% of total Zn (table 4). The strong ability of Zn to form complexes with OM reduces Znphyto toxicity in the environment (Kashem *et al*. 2007), thereby making the risk of pollution from Zn in this region minimal. The oxide fraction accounted for 2.9% of the total Zn concentration.

## V. CONCLUSION

Results of this research showed that the soils of the farmlands are not contaminated with Pb, Cd, and Zn. This implies that the soils of the farmlands are not polluted by any of the metals studied.
Therefore, there is a low risk of metal transfer from the soil to the growing crops.

**RECOMMENDATIONS**
It is recommended that soil sample collections should be done in such a way that mobility index can be calculated, because it is a more reliable indicator which considers the weakly adsorbed fractions alone, after a sequential extraction has been done.

In the case of further similar work, the heavy metal concentration of the plants (Irish potatoes) and their stems (i.e before transplanting) should be assessed.

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