

Comparative Study of Selected Soil Samples From Industrial Areas of Kogi State

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ARTICLE INFO

Received Date: 02/05/2025

Accepted Date: 10/08/2025

Publication Date: 30/08/2025

Page Number: 75- 80

Available at: www.ijbrs.com

ABSTRACT

The work reports the concentration of heavy metals and physiochemical parameters in some selected soil samples from industrial areas in Kogi State, Nigeria. The concentration of heavy metals that was worked upon on each of the samples were gotten using Atomic Absorption Spectrophotometer (AAS). The final concentration of Zinc (Zn) in Ajaokuta (Ajaokuta) sample was 53.44 mg/kg while that of Obajana (Obj) was 166.68 mg/kg. The concentration of Chromium (Cr) in Ajaokuta (Ajaokuta) sample was 113.92 mg/kg while that of Obajana (Obj) was 31.04 mg/kg. The concentration of Nickel (Ni) in Ajaokuta (Ajaokuta) sample was 5.42 mg/kg while that of Obajana (Obj) was 69.50 mg/kg. The concentration of Cadmium (Cd) in Ajaokuta (Ajaokuta) sample was -3.14 mg/kg while that of Obajana (Obj) was -0.62 mg/kg. The concentration of Copper (Cu) in Ajaokuta (Ajaokuta) sample was 59.88 mg/kg while that of Obajana (Obj) was 104.98 mg/kg. The concentration of lead (Pb) in Ajaokuta (Ajaokuta) sample was 197.28 mg/kg while that of Obajana (Obj) was 98.64 mg/kg. The concentration of mercury (Hg) in Ajaokuta (Ajaokuta) sample was -5.60 mg/kg while that of Obajana (Obj) was -5.40 mg/kg. The physicochemical results include; soil organic matter (%) for Ajaokuta (Ajaokuta) which was 1.85 while for Obajana (Obj) was 1.47; pH for Ajaokuta (Ajaokuta) was 2.670 while for Obajana (Obj) was 6.096; and Conductivity ($\mu\text{S}/\text{cm}$) for Ajaokuta (Ajaokuta) was 184.5 while for Obajana (Obj) was 320.4. Comparing the concentration of each of the heavy metals with WHO (World Health Organization) and USEPA (United State Environmental Protection Agency), Zinc, Chromium, Copper and Lead were found to be above the permissible limit in sample Ajaokuta (Ajaokuta) while Nickel, Cadmium and Mercury were below the permissible limit. In sample Obajana (Obj); Zinc, Nickel, Copper and Lead were found to be above the permissible limit, while Chromium, Cadmium, and Mercury were below the permissible limit set by WHO (World Health Organization) and USEPA (United State Environmental Protection Agency). The ranking of the occurrence of the metals from the least to greatest in sample Ajaokuta (Ajaokuta) are $\text{Hg} > \text{Cd} > \text{Ni} > \text{Zn} > \text{Cu} > \text{Cr} > \text{Pb}$ indicating that the concentration of lead in the location was high. The ranking of the occurrence of the metals from the least to the greatest in sample Obajana (Obj) is $\text{Hg} > \text{Cd} > \text{Cr} > \text{Ni} > \text{Pb} > \text{Cu} > \text{Zn}$ indicating that the concentration of Zinc was high in the sample location. The two soil samples have Organic Matter value to be within the range of a typical agricultural soil, it is then good for agricultural activities, the pH indicates that the soil samples from the location was acidic and the electrical conductivity shows the amount of salts in the soil.

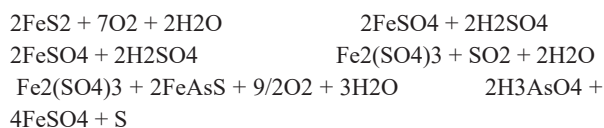
KEY WORDS: Soil, Heavy Metals, Ph, Organic Matter, Electrical Conductivity.

INTRODUCTION

Heavy metals are naturally present in the soil, geologic and anthropogenic activities have increased the concentration of these elements to the amounts that are harmful to both plants and animals. Some of these activities includes burning of fossil fuels, use of pesticides and fertilizers in agriculture, mining and smelting of metals, production of batteries and other products in industries, sewage sludge, and municipal waste disposal, therefore, beside the natural activities, almost all human activities also have potential contribution to produce heavy metals as side effects (20). Heavy metals have been defined by several researchers. The term heavy metal is a collective term that applies to group of metals and metalloids, with atomicity of density greater than 4g/cm³ or 5 times or more great than water (19).

The aim of this work is to evaluate the high level of heavy metals in the industrial areas of Kogi State as to ensure that the safety of the land is minimized of potential hazards. While the objectives are; to determine heavy metals contamination on soil samples in industrial areas. Determine the physicochemical analysis on the soil samples. Also compare the level of heavy metals on two different soil samples with the permissible limit by World Health Organization (WHO), United State Environmental Protection Agency (USEPA).

The Chemistry involves in heavy metal pollution of water, soil and air includes; mining activities and other geochemical processes often result in the generation of Acid Mine Drainage (AMD), a phenomenon that is commonly associated with mining activities. It is generated when pyrite (FeS₂) and other sulphide minerals in the aquifer and present and former mining sites are exposed to air and water in the presence of oxidizing bacteria, such as Thiobacillus ferrooxidans, and oxidized to produce metal ions, sulphate and acidity(18).



METHODOLOGY

Sample Collection: A selected soil samples were collected from two different industrial areas within Kogi State taking note of the distance not far from the industries and the temperatures were taken at sample collection site. Each of the samples was properly labeled and transported in polythene bags to the laboratory where the soil samples were prepared for analyses.

List of Equipment Used: pH-meter, Conical flasks, 100ml Volumetric flasks, Beakers, measuring cylinder, Wash bottles,

Hot plate, Spatula, glass stirring rod, Pipettes, Kjeldahl Digestion tube, Weighing-balance, Sieving pan, Test tubes, Oven, Water bath, Filter papers, digestion tubes, digestion tube rack, syringe, Google glass, Plastic funnels, Fume cupboard, Flame Atomic Absorption Spectrophotometer, manufactured by Thermo-Scientific Spectrometer model ICE-3000 AA02134104 v1.30.

Reagents: 0.01M CaCl₂, pH 4.00 and pH 7.00 buffer solution, deionized water, concentrated hydrochloric acid, Nitric acid and the soil samples.

Procedure:

Determination of Soil pH

1. 10g of soil samples was put into each 50ml beakers. It was weighed to the nearest 1g only.
2. To the soil in one beaker was added 20ml of distilled water. This gives a soil: solution ratio of 1:2.
3. To the soil in second beaker was added 20ml of CaCl₂. The use of this salt solution will demonstrate the effect of a neutral salt on the pH of the soil solution.

It was allowed to stand for 30mins, stirring occasionally with a glass stirring rod. This allowed time for aggregates to break down so that the solution equilibrates with all of the soil and for the sample to equilibrate with atmosphere CO₂. The pH of the soil in each beaker was determined with the pH meter.

Digestion of the Soil Samples

1. The digestion tubes were sterilized by washing with soap rinsed with tap water, then distilled water, soaked in acid rinse and finally rinsed in distilled water
2. Put in an oven to dry at 60oc for some minutes.
3. A 5g of each sample was weighed using weighing balance and poured into a conical flask.
4. A 25ml of Aqua regia (a mixture of Hydrochloric acid (HCl) and Nitric acid (HNO₃) in the ratio 3:1) was measured and poured into the flask containing the sample and was placed on a digester.
5. The digester was turned on at a temperature starting from 60oc to 180oc for one and a half hours.
6. Constant checking at 10 minutes interval in order to prevent it from drying until a clear solution was observed.
7. Then the mixture was cooled.
8. It was then filtered into a 100ml volumetric flask using filter paper and made up to mark with distilled water.
9. Elemental analysis was carried out using the Flame Atomic Absorption Spectrometer (F-AAS) manufactured by Thermo-Scientific Spectrometer model ICE-3000 AA02134104 v1.30, situated in Sheda Science and Technology Complex, Abuja and also in Albert Einstein Bioscience Centre National Cereals Research institute Badeggi, Niger State to determine heavy metals present with the aid of the standards.

Final concentrations of the metals in the soil samples were calculated using the following formula (Wodaje Addis and Alemayehu Abebaw, 2017):

$$\text{Concentration} \left(\frac{\text{mg}}{\text{kg}} \right) = \frac{\text{Conc. of sample} - \text{conc. of blank} \times \text{volume}}{\text{Weight of sample}}$$

where V = Final volume (100 mL) of solution, and M = Initial weight (5 g) of sample measured.

Determination of Organic Matter: To determine soil organic matter (SOM), Loss on Ignition (LOI) method was used by the loss of weight of the soil sample heated at a high temperature. Temperature of Loss on Ignition (LOI) method is enough to burn organic matter of soil but should not decompose carbonates present in the soil (11). First soil samples were placed in oven at 105oC for 24hr, and then the samples were placed in muffle furnace (of Nycraft Company) for 2hr at 360oC. Percentage Organic Matter (%OM) was calculated by comparing the weight of a sample before and after the soil has been ignited (17):

%OM = weight at 105oC (g) – weight at 360oC (g) / weight at 360oC (g) × 100

RESULTS AND DISCUSSION

Results of the final concentration of Zinc (Zn) in Ajaokuta (Ajaokuta) sample were 53.44 mg/kg while that of Obajana (Obj) was 166.68 mg/kg. The concentration of Chromium (Cr) in Ajaokuta (Ajaokuta) sample was 113.92 mg/kg while that of Obajana (Obj) was 31.04 mg/kg. The concentration of Nickel (Ni) in Ajaokuta (Ajaokuta) sample was 5.42 mg/kg while that of Obajana (Obj) was 69.50 mg/kg. The concentration of Cadmium (Cd) in Ajaokuta (Ajaokuta) sample was -3.14 mg/kg while that of Obajana (Obj) was -0.62 mg/kg. The concentration of Copper (Cu) in Ajaokuta (Ajaokuta) sample was 59.88 mg/kg while that of Obajana (Obj) was 104.98 mg/kg. The concentration of lead (Pb) in Ajaokuta (Ajaokuta) sample was 197.28 mg/kg while that of Obajana (Obj) was 98.64 mg/kg. The concentration of mercury (Hg) in Ajaokuta (Ajaokuta) sample was -5.60 mg/kg while that of Obajana (Obj) was -5.40 mg/kg. The physicochemical results include; soil organic matter (%) for Ajaokuta (Ajaokuta) which was 1.85 while for Obajana (Obj) was 1.47; pH for Ajaokuta (Ajaokuta) was 2.670 while for Obajana (Obj) was 6.096; and Conductivity (μS/cm) for Ajaokuta (Ajaokuta) was 184.5 while for Obajana (Obj) was 320.4.

Heavy Metal Analyses: Comparing the concentration of each of the heavy metals with WHO (World Health Organization) and USEPA (United State Environmental Protection Agency), Zinc, Chromium, Copper and Lead were found to be above the permissible limit in sample Ajaokuta (Ajaokuta) while Nickel, Cadmium and Mercury were below the permissible limit. In sample Obajana (Obj); Zinc, Nickel, Copper and Lead were found to be above the permissible limit, while Chromium,

Cadmium, and Mercury were below the permissible limit set by WHO (World Health Organization) and USEPA (United State Environmental Protection Agency). That is, there is enrichment of the metals that were above the standards in the soil locations more than the others. The ranking of the occurrence of the metals from the least to greatest in sample Ajaokuta (Ajaokuta) are Hg>Cd>Ni>Zn>Cu>Cr>Pb indicating that the concentration of lead in the location was high. The ranking of the occurrence of the metals from the least to the greatest in sample Obajana (Obj) is Hg>Cd>Cr>Ni>Pb>Cu>Zn indicating that the concentration of Zinc was high in the sample location.

Table 1. Results of Heavy Metal Concentration in Ajaokuta (Ajaokuta) and Obajana (Obj)

Heavy Metals	Ajaokuta (Ajaokuta) (mg/kg)	Obajana (Obj) (mg/kg)
Zinc	53.44	166.68
Chromium	113.92	31.04
Nickel	5.42	69.50
Cadmium	-3.14	-0.62
Copper	59.88	104.98
Lead	197.28	98.64
Mercury	-5.60	-5.40

Figure 1: Concentration of heavy metals in Ajaokuta (Ajaokuta).

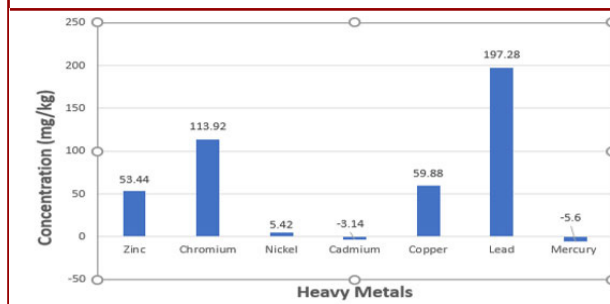
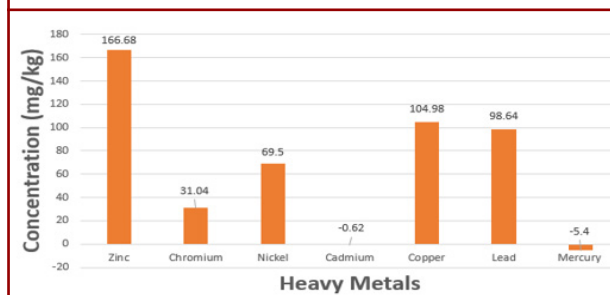


Figure 2: Concentration of heavy metals in Obajana (Obj)



Soil electrical conductivity is the amount of salts in soil (salinity of soil). It is an important indicator of soil health. The electrical

conductivity of the two samples, Ajaokuta (Ajao) and Obajana (Obj) are given in the table below;

Table 2. Results of Soil Organic Matter percentage of Samples Ajaokuta (Ajao) and Obajana (Obj)

Parameter	AJAO (%)	OBJ (%)
Organic Matter	1.85	1.47

Table 3. Results of Soil pH in Ajaokuta (Ajao) and Obajana (Obj) Samples

Parameter	Ajaokuta (Ajao)	Obajana (Obj)
pH	2.670	6.096

Figure 3: Soil pH of Ajaokuta (Ajao) and Obajana (Obj) respectively Soil Electrical Conductivity ($\mu\text{S}/\text{cm}$)

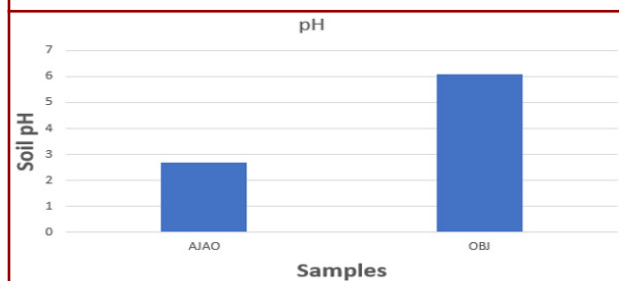


Table 4. Results of Soil Conductivity ($\mu\text{S}/\text{cm}$) for Ajaokuta (Ajao) and Obajana (Obj) Samples

Parameter	Ajaokuta (Ajao)	Obajana (Obj)
Conductivity ($\mu\text{S}/\text{cm}$)	184.5	320.4

Figure 4: Electrical conductivity in Ajaokuta (Ajao) and Obajana (Obj) respectively.

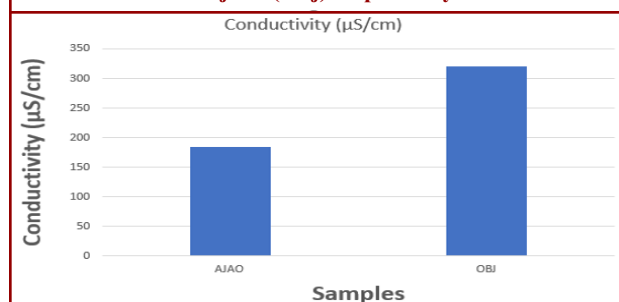
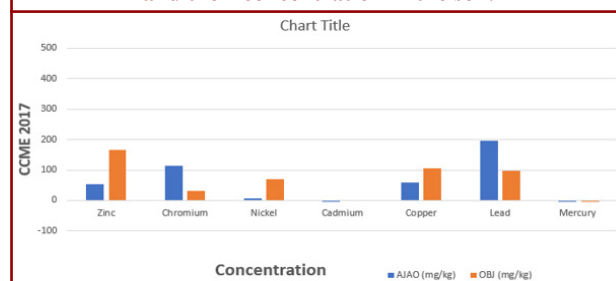


Table 5. Permissible Limits for Heavy Metals in Soil

Elements	WHO (1996) (mg/kg)	CCME (2007) (mg/kg)	USEPA (2002) (mg/kg)
Zn	50.00	500.00	1100.00
Cr	100.00	250.00	11.00
Ni	35.00	100.00	72.00
Cd	0.80	3.00	0.48
Cu	36.00	150.00	270.00
Pb	85.00	200.00	200.00
Hg	-	0.80	1.00

Figure 5: Permissible limits for the various heavy metals and their concentration in the soil.



CONCLUSION

Heavy metal contamination in soil is very dangerous to human health because of agricultural activities that will be carried out on the soil. The results above shows that there were presence of heavy metals in the soil locations and they were found in high concentration (such as, Zinc-53.44mg/kg, Chromium-113.92mg/kg, Copper-59.88mg/kg, Lead-197.28mg/kg in sample Ajaokuta (Ajao) and Zinc-166.68mg/kg, Nickel-69.5mg/kg, Copper-104.98mg/kg, Lead-98.64mg/kg in sample Obajana (Obj) except for Mercury and Cadmium therefore posing potential risk for inhabitants.

While the findings were geared towards providing baseline data on the current pollution states of the industrial areas, constant monitoring of the levels of contamination is deemed necessary, the industries in the areas should be cautioned and guarded against anthropogenic activities caused by industrial effluents, atmospheric deposition, erosion of geological matrix, domestic savage and mining wastes etc. would be suggested against soil contamination (18)

Recommendation

1. Considering the conclusion of this assessment, there is need for constant monitoring of heavy metal concentrations in the industrial areas of Ajaokuta (Ajao) and Obajana (Obj).
2. Concentrations of other heavy metals like Arsenic, Manganese, Aluminum, Cobalt, Tin and others should

be assayed.

3. The process of remediation could be carried out to get a healthy soil formation for every human activity.

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