Evaluating the Comparative Variabilities of Metallic Concentrations in Fanalou and Freedom Surface Mines, Ikpeshi, Edo State, Nigeria

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ABSTRACT

This study identified and compared the concentration of selected heavy metallic ions on two surface mines, as found in the collected water and soil/sand samples at various drainage pits of the mine fields, by applying the method of Atomic Adsorption Spectrophotometry (AAS) principle. The results showed that the average concentration in the sampled water in Fanalou/Freedom are: Mg^{2+} ($\pm$ 32.10 / $\pm$ 46.70 mg/L), SO_4^{2-} ($\pm$ 1280.00 / $\pm$ 1642.67 mg/L), and Cl^- ($\pm$ 29.27 / $\pm$ 35.36 mg/L); and in the sampled soil/sand Fanalou/Freedom are Mg^{2+} ($\pm$ 250.500 / $\pm$ 152.200 ppm), Mn^{2+} ($\pm$ 4.120 / $\pm$ 1.940 ppm), Pb^{2+} ($\pm$ 1.062 / $\pm$ 1.233 ppm), Fe^{3+} ($\pm$ 2.510 / $\pm$ 2.036 ppm), Ni^{2+} ($\pm$ 1.5732 / $\pm$ 1.573 ppm), and SO_4^{2-} ($\pm$ 224.00 / $\pm$ 352.00 ppm). The variation for mean ionic composition from both fields have SO_4^{2-} to be the highest, followed by Mg^{2+} and Fe^{2+} to be the lowest, and followed by Ni^{2+} in the soil/sand samples; also, SO_4^{2-} was the highest, followed by Mg^{2+}, and Ni^{2+} to be the lowest, followed by Pb^{2+} in the water samples. This correlation of the amount of ionic concentration confirms a potential threat spreading around the axis of the Ikpeshi region.

Keywords: Surface Mines, Fanalou, Freedom, Ikpeshi, Metallic Concentration, Drainage Pits, Samples

1. INTRODUCTION

Metallic concentration is the level where metallic elements having significantly high magnitude is considered poisonous and toxic, though at concentrations of low amounts (Lenntech, 2004). Naturally, heavy metals are present as the composition of the crust of the earth possessing continuous environmental pollutants, since they are not biodegradable

(Lenntech, 2004) and (UNEP/GPA, 2014). Their availability in small quantities in nature may not however be hazardous to the environment (Stihi et al., 2011), but are contaminating and hazardous at larger amounts, especially when close to industrial events (Voica et al., 2012) and categorized as anthropogenic origin (Idri, 2008 and Ayni et al., 2011).

They are mostly attached to inactive chemical substances, though their concentrations multiply severally due to anthropogenic events (Mason, 2012). Many of the chemical bodies are naturally occurring, even though it is on the increase due to the out-play of anthropogeny on land (Huang et al., 2014) or in the marine environment (Macklin et al., 2006; Demirak et al., 2006; Li et al., 2008; Li et al., 2010; Bidai et al., 2016). The contamination of metallic concentrations in the water-base habitat fromed due to naturally occurring processes and happening because of the erosion of parent rocks. Chemical weathering of minerals, depositional events of the atmosphere and volcanism (Khan et al., 2012 and Adiana et al., 2011).

The exposure of humans to these hazardous heavy metals happens in various ways such as ingestion/interface of/ with polluted food and water, and subjection to air-laden particles (Lenntech, 2004 and UNEP/GPA, 2014). Metallic concentration with high amount of organic and inorganic pollutants can cause diseases related to water.

1. 1. Metallic Concentration of Mine Water and Soil

1. 1. 1. Soil

For ages, the soil was perceived as a store-house for pollutants considering the process of adsorption which coagulates organic and inorganic compounds unto contaminants (Nortjé and Laker, 2021; Popoola et al, 2012). The level of concentration of contaminants in the soil relies on climatic situations (Qiao et al., 2011) anthropogenic events Horváth et al., 2021; Koprivica et al., 2018), and atmospheric conditions (Duong and Lee, 2011), which includes speed and the direction of wind, rainfall, landscape (Khan et al., 2011) and plant vegetation (Kluge and Wassolek, 2012).

Considering anthropogenic interference, the capability of the structure of the soil layer to regain potentials is very low compared to the naturally undeterred soils. A constituent weathering decreases the potentials of the soil to fixate metals which are bound in the soil sediments that are of finer textures. Hence, these metals mobilize without stress into the atmosphere and underground water (Anna et al., 2010). These metals which are poisonous and contaminating tend to require unique treatment, since their separation from the parent sites is difficult (Singh and Goyal, 2019).

1. 1. 2. Water

The size of metals found in aquatic environment is of low concentrations. The main issue working up the natural environment has been how to stir up public interest, nowadays (Obasi et al., 2015). In surface waters, metallic concentrations are influenced by the elements of nature and anthropogenic actions, which has transcended into a world-wide issue because of its contaminating complexities which defy solutions and causing accumulated pollution (György et al., 2019).

These metallic-ions invasion intrudes the sea by ways of localized river encroachment, and present in the aquatic enclosures. Hence, the necessity to continuously observe the ecosystem in order to ascertain the level and degree of contaminants stay below permitted limits, otherwise, sanctions can be meted out to erring bodies (Śliwińska, 2019), weathering,

and also through anthropogenic events (De Mora et al., 2004; Hosseini and sajjadi, 2008) of which effects is adverse (Krupadm et al., 2006), especially since fine-texture sediments are readily present in the aquatic enclosures.

1. 2. The location and Geology of The Study Area (Ikpeshi)

The areas of study are Fanalou Nigeria Company Limited and Freedom Nigeria Company limited, both located in Ikpeshi. The Fanalou Surface Mines lie between longitudes 6°10'00"E and 6°15'00"E, and latitudes 7°08'00"N and 7°10'00"N of Ikpeshi; while the Freedom Surface Mines lie between longitudes 6°15'00"E and 6°08'30"E, and latitudes 7°11'00"N and 7°06'00"N of Igarra.

These two quarries are situated in Igarra town which has the coverage area of approximately 3000 Km^2. The climatic temperature range of this region is from 23 °C to 28 °C (Eludoyin et al., 2014), while the cumulative rainfall ranges between 1270 mm – 1790 mm (NMA, 2020). Igarra has a depressing topography and high steep/gentle lying contour; majorly rocks, i.e. denatured meta-sedimentary schists sliced by plutons of igneous structures (Agumuo and Egesi, 2016) that possesses complex basement and revealed valleys, and pronounce ridges caused by forces of tectonism alongside weathering which has impacted the soil of the region (Odeyemi, 1976).

Figure 1. Author at the location of the surface mine in Fanalou Mines, Ikpeshi – Edo State

Figure 2. Author at the location of the surface mine in Freedom Mines, Ikpeshi – Edo State

2. MATERIALS AND METHODOLOGY

In this study, three mine pit production sites each were selected from Fanalou and Freedom Surface Mines, Ikpeshi. The concentrations of heavy metals were determined in the soil, and water collected. The mean value was calculated and recorded (Table 1)

2. 1. Methodology

The metallic and non-metallic concentration challenges on Fanalou and Freedom Surface Mines have been monitored by the analysis of ions in its soils and water; from different surface mine locations in the study areas, using Atomic Absorption Spectrophotometry (AAS) analysis and Turbidity Tests. These were carried out in the laboratory.

2. 3. Collection of Water Samples/Laboratory Tests

The collection of soil and water sample were conducted at the field of Fanalou Nigeria Company Limited and Freedom Nigeria Company limited; but the test analysis for other parameters such as the ph, total dissolved solids and conductivities were conducted in the laboratory of Yaba College of Technology, Chemical Engineering Department, Nigeria; while the Atomic Absorption Spectrophotometry (AAS) analysis and Turbidity Tests were carried out in the laboratory of the Federal University of Technology, Akure, Chemistry Department, Nigeria.

Water samples were obtained randomly inside the mines of the two study areas. Soil samples were also cautiously collected and packed in bottles and polythene containers for easy identification. These samples were mobilized to the laboratory for analysis/testing, to determine the ionic amounts and values for conductivities, turbidity, ph, temperatures, and total dissolved solids and oxygen.
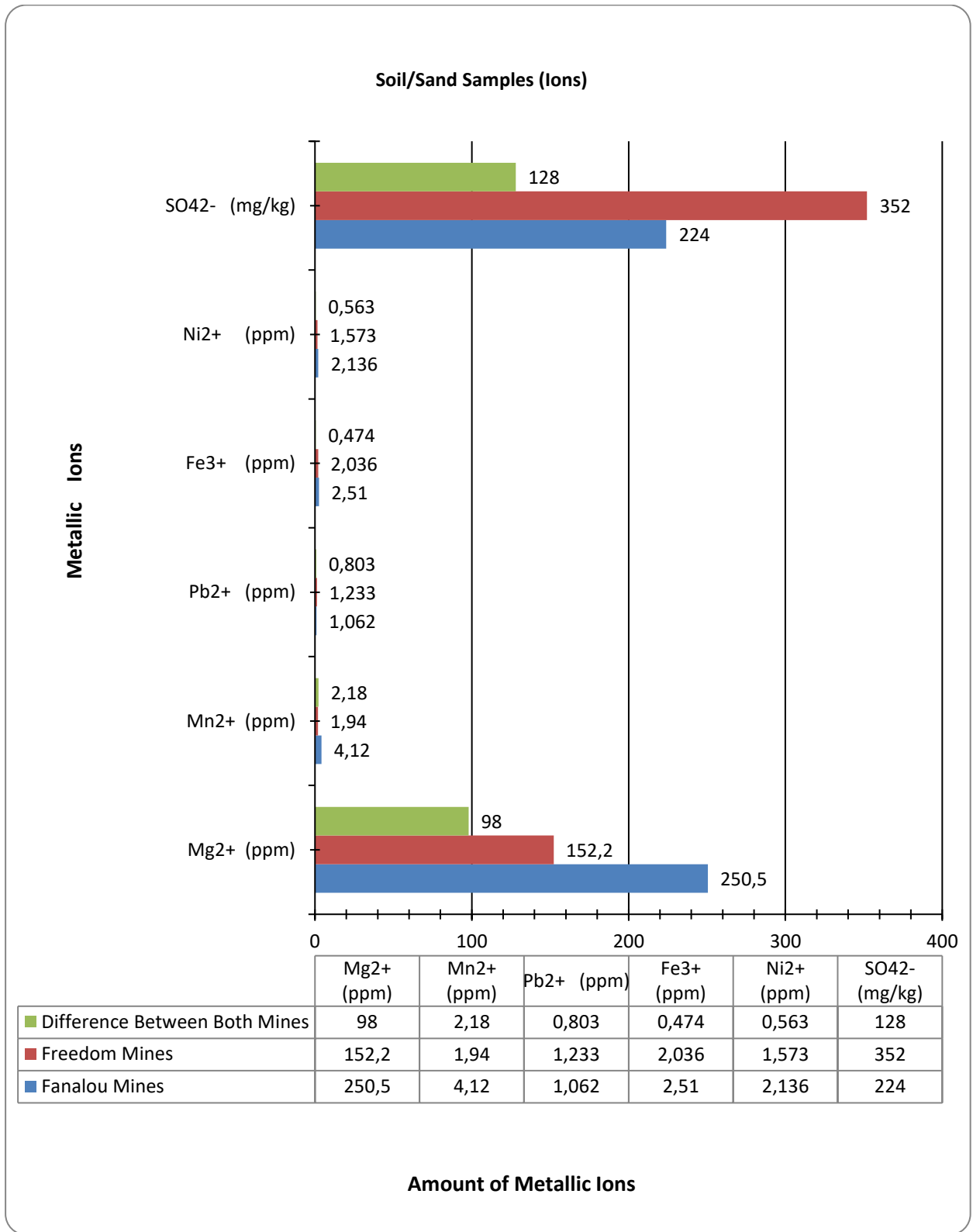

Figure 3. Collecting samples on Surface Mines

3. RESULTS AND DISCUSSION

3. 1. Results

Field results were compiled from the tests and analysis of the parameters of dissolved soil/sand, and of in-situ mine water, using Atomic Absorption Spectrophotometry (AAS). The result is seen in Figure 1 and 2.

Figure 4. Mean Composition on Fanalou and Freedom Surface Mines
Using Soil/Sand Samples

Table 1. Mean Ionic Composition on Fanalou and Freedom Surface Mines Using Soil/Sand Samples

	Soil/Sand Samples (Ions)					
Field	Mg^{2+} (ppm)	Mn^{2+} (ppm)	Pb^{2+} (ppm)	Fe^{3+} (ppm)	Ni^{2+} (ppm)	SO_4^{2-} (mg/kg)
Fanalou	250.5	4.12	1.062	2.51	2.136	224
Freedom	152.2	1.94	1.233	2.036	1.573	352
Difference	98	2.18	0.803	0.474	0.563	128
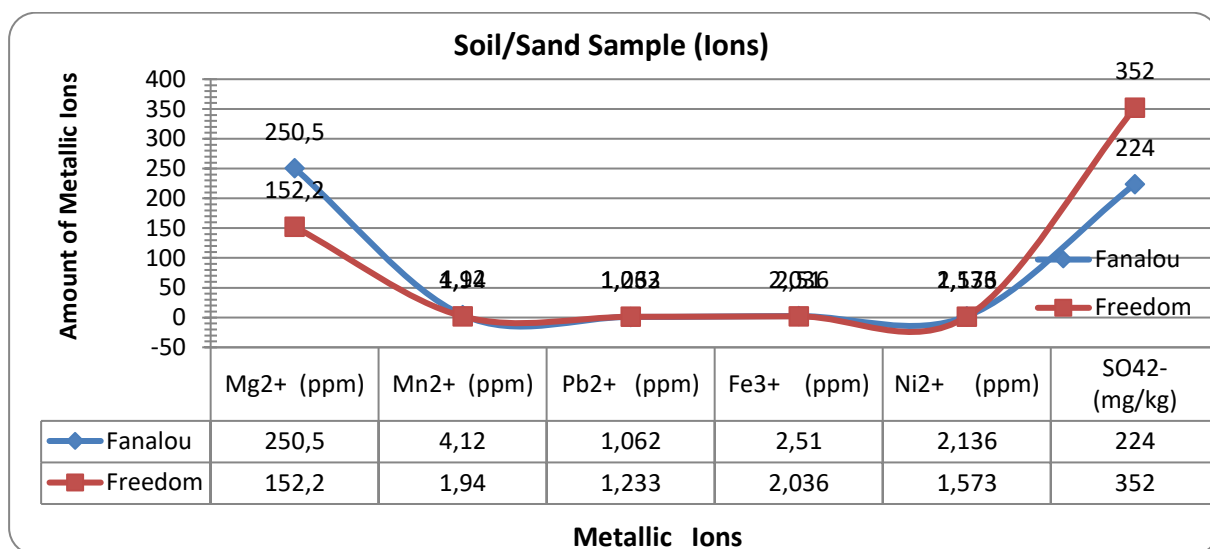
Figure 5. Comparison of Soil/sand samples between Fanalou and freedom Fields

Table 2. Mean Ionic Composition on Fanalou and Freedom Surface Mines Using Water Samples

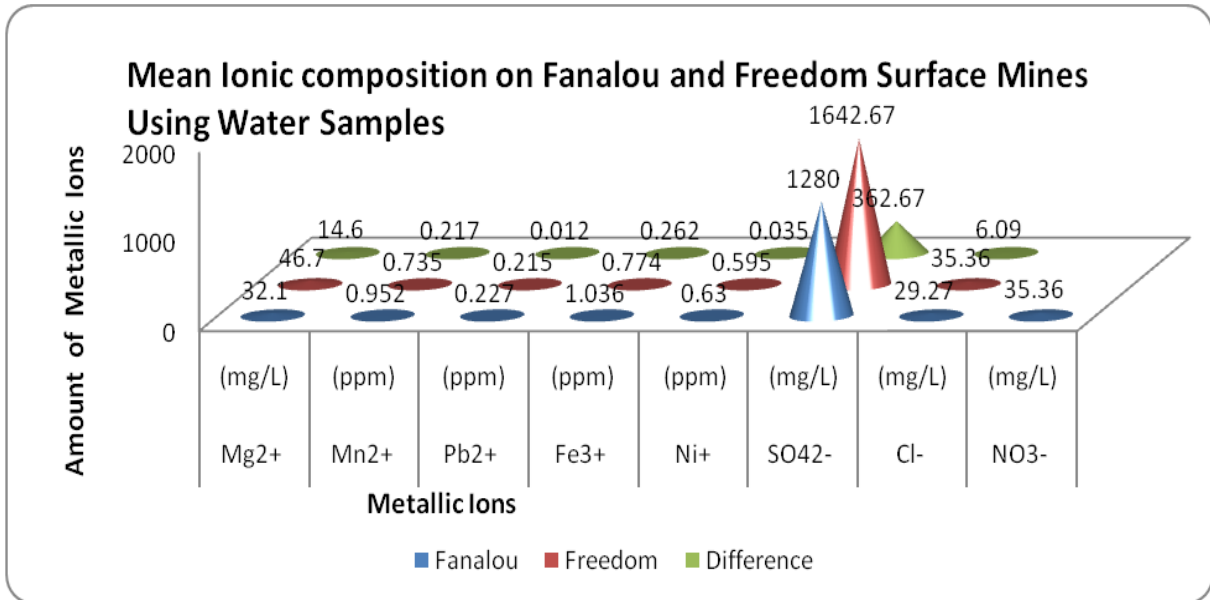|	Water Samples (Ions)							
Field	Mg^{2+} (mg/L)	Mn^{2+} (ppm)	Pb^{2+} (ppm)	Fe^{3+} (ppm)	Ni^{+} (ppm)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	NO_3^{-} (mg/L)
Fanalou	32.1	0.952	0.227	1.036	0.63	1280	29.27	35.36
Freedom	46.7	0.735	0.215	0.774	0.595	1642.67	35.36	
Difference	14.6	0.217	0.012	0.262	0.035	362.67	6.09	

Figure 6. Mean Composition on Fanalou and Freedom Surface Mines Using Water Samples
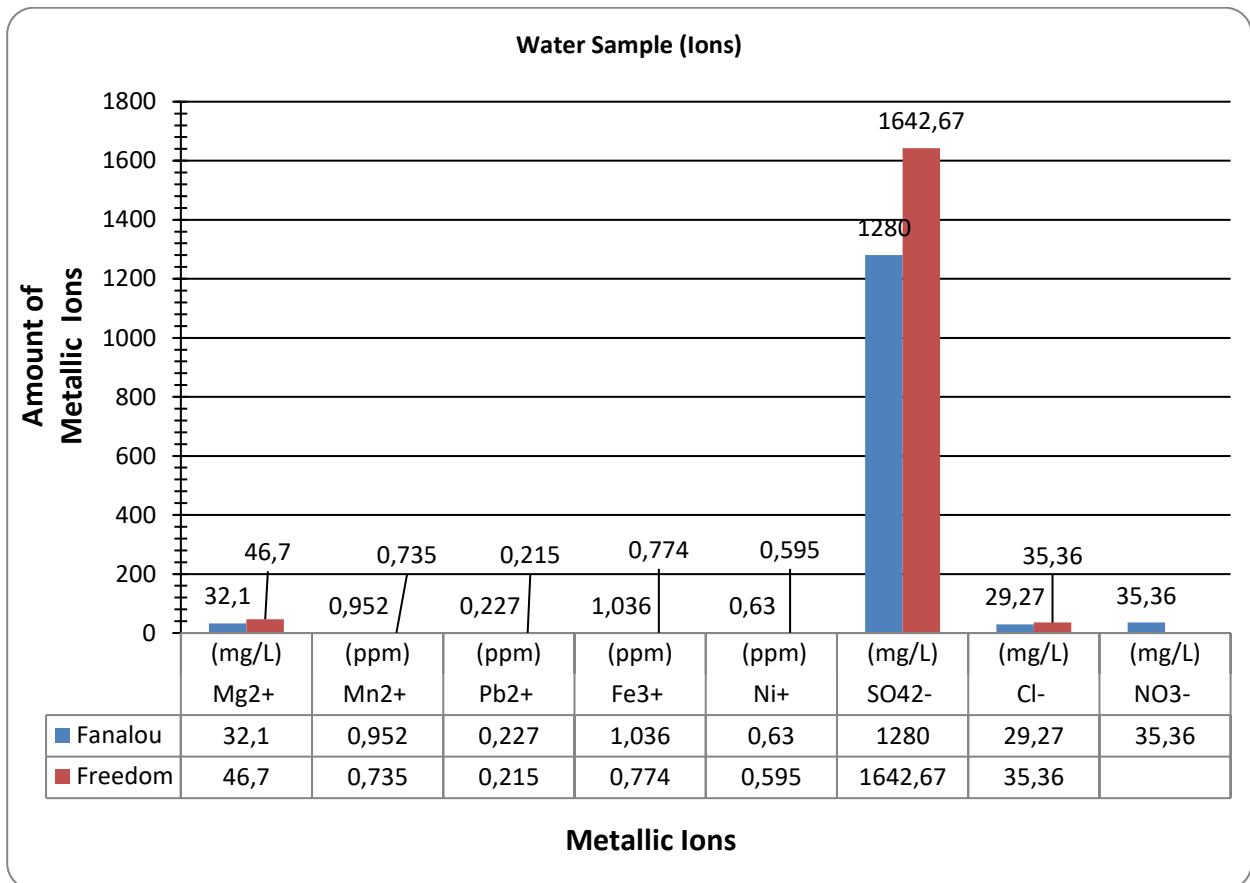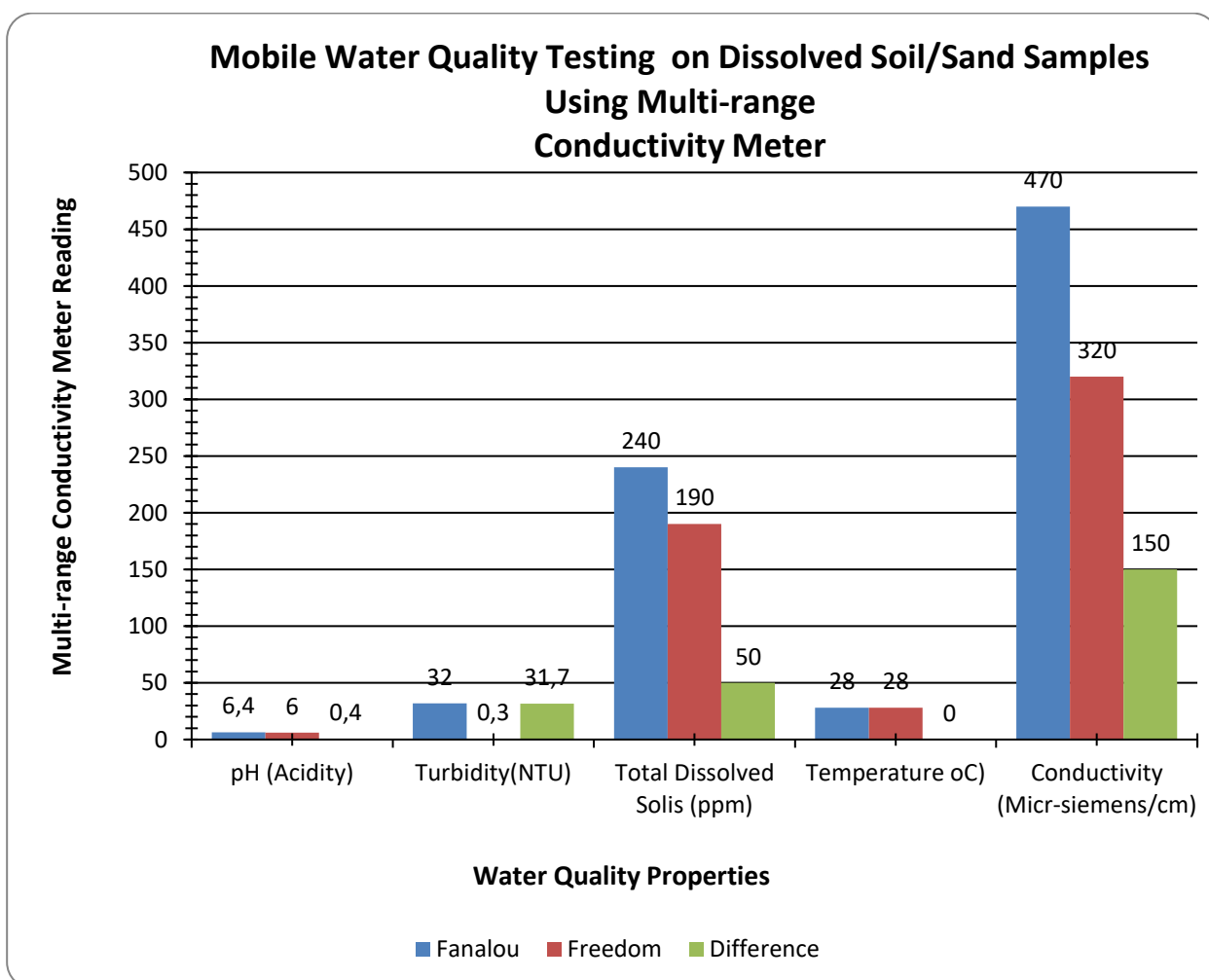

Figure 7. Comparison of Soil/sand samples between Fanalou and freedom Fields

Table 3. Analysis of Mine Water and Soil Parameters

Mobile Water Quality Testing on Dissolved Soil/Sand Samples Using Multi-range Conductivity Meter					
	ph (Acidity)	Turbidity (NTU)	Total Dissolved Solids (ppm)	Temperature (°C)	Conductivity (micro-Siemens/cm)
Fanalou	6.4	32	240	28	470
Freedom	6	0.30	190	28	320
Difference	0.4	31.7	50	0	150

Figure 8. Mobile Water Quality Testing on Dissolved Soil/Sand Samples using Multi-range Conductivity Meter
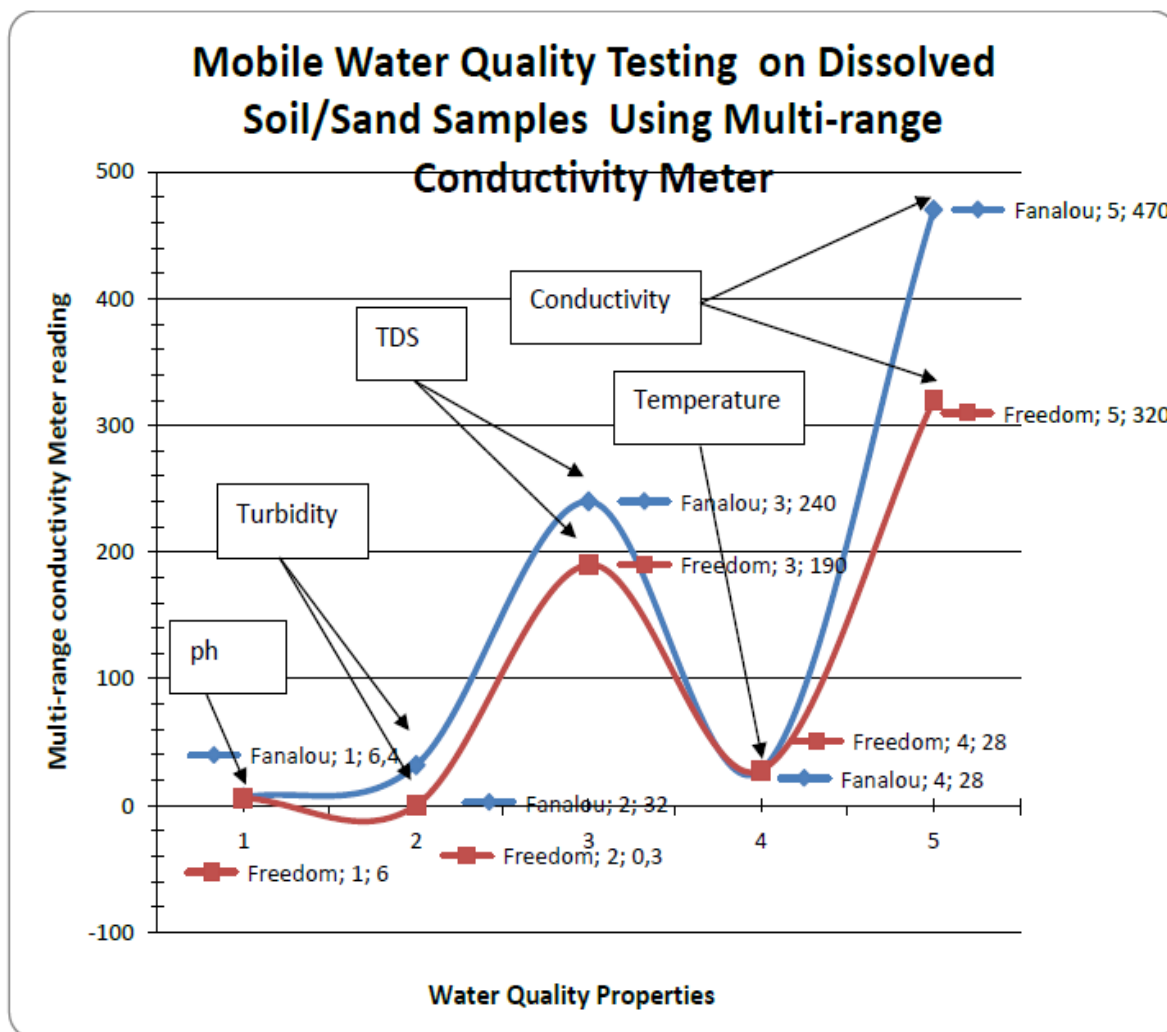
Figure 9. Comparison of Soil/sand samples between Fanalou and freedom Fields

Table 4. Mobile Water Quality Testing on Dissolved Water Samples Using ph Meter

Field	ph (Acidity)	Total Dissolved Solids (ppm)	Temperature (°C)	Conductivity (micro-Siemens/cm)
Fanalou	7.2	290	28	580
Freedom	6.5	280	28	560
Difference	0.7	10	0	20
Standardized De-ionized Water	7	250	28	510
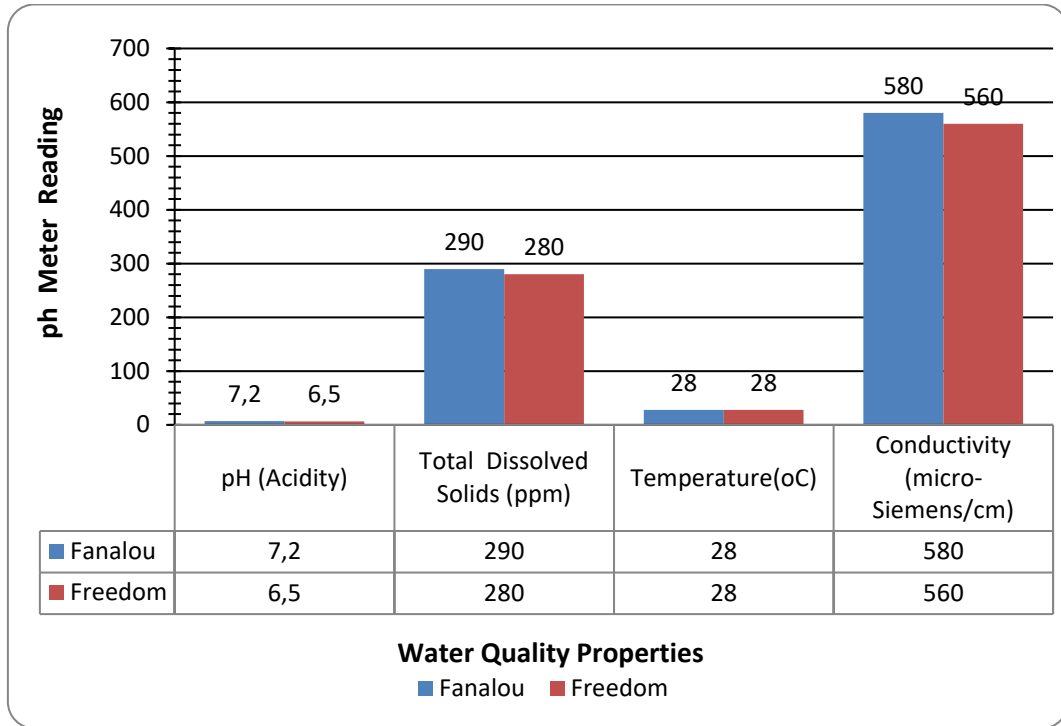
Figure 10. Mobile Water Quality Testing on Water Samples using ph Meter
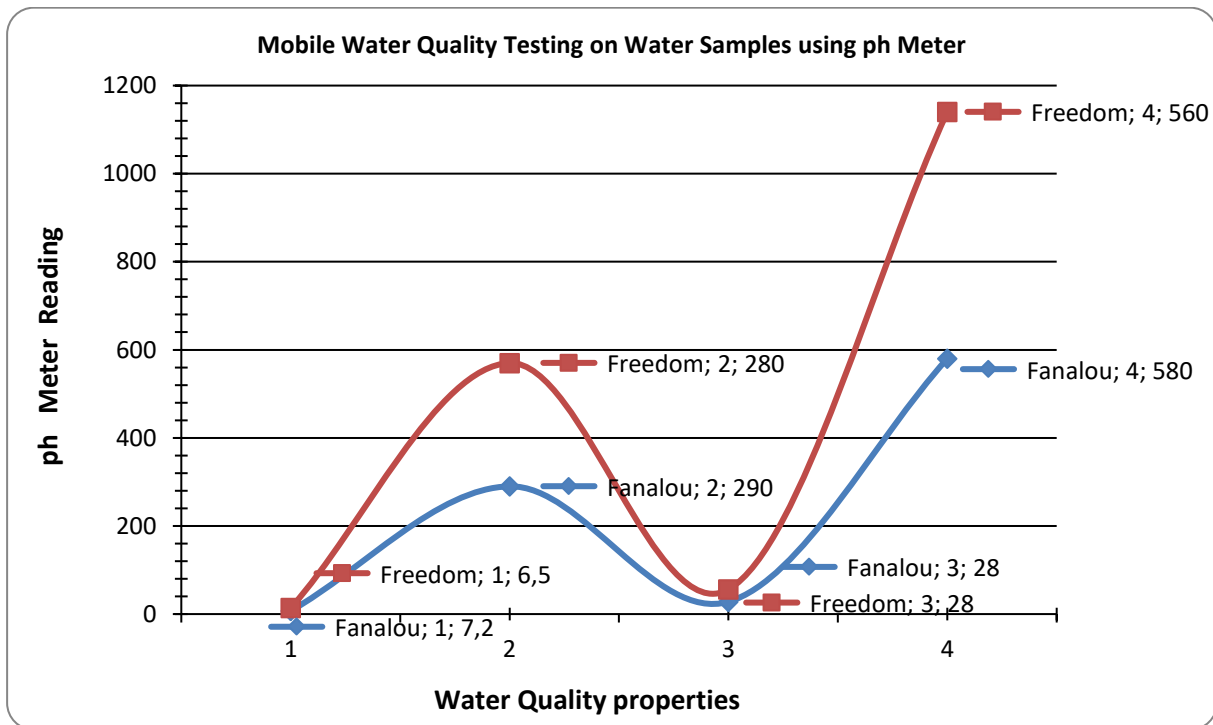
Figure 11. Comparison of Soil/sand samples between Fanalou and freedom Fields

3. 1. 1. Variation relationship testing for Both Fields

Table 5. Testing the relationship of the metallic concentration and other components between the two fields – making Fanalou field data as independent variables (i.e. y) and freedom data as dependent variables (i.e. x).

Type of Variation	
y α x y = kx k = y/x	y α 1/x y = k/x k = xy

Table 6. Variation relationship considering Table 5.

	Soil/Sand Samples (Ions)					
Field	Mg^{2+} (ppm)	Mn^{2+} (ppm)	Pb^{2+} (ppm)	Fe^{3+} (ppm)	Ni^{2+} (ppm)	SO_4^{2-} (mg/kg)
Fanalou (y)	250.5	4.12	1.062	2.51	2.136	224
Freedom (x)	152.2	1.94	1.233	2.036	1.573	352
Using direct variation; k = y/x	k = 1.645	k = 2.124	k = 0.861	k =1.233	k = 1.358	k = 0.636
Using indirect/inverse variation; k = x*y	k = 38126.1	k = 7.9928	k = 1.300	k = 5.110	k = 3.360	k = 78848

Table 7. Variation relationship considering Table 5.

	Water Samples (Ions)							
Field	Mg^{2+} (ppm)	Mn^{2+} (ppm)	Pb^{2+} (ppm)	Fe^{3+} (ppm)	Ni^{2+} (ppm)	SO_4^{2-} (mg/kg)	Cl^{-} (mg/L)	NO_3^{-} (mg/L)
Fanalou (y)	32.1	0.952	0.227	1.036	0.63	1280	29.27	35.36
Freedom (x)	46.7	0.735	0.215	0.774	0.595	1642.67	35.36	
Using direct variation k = y/x	k = 0.687	k = 1.295	k = 1.0561	k = 1.339	k = 1.358	k = 0.780	k = 0.828	
Using indirect / inverse variation k = x*y	k = 1499.7	k = 0.700	k = 0.049	k = 0.802	k = 0.375	k = 210261.6	k = 1034.99	

Table 8. Variation relationship considering Table 5:

Mobile Water Quality Testing on Dissolved Soil/Sand Samples Using Multi-range Conductivity Meter					
	ph (Acidity)	Turbidity (NTU)	Total Dissolved Solids (ppm)	Temperature (°C)	Conductivity (micro-Siemens/cm)
Field					
Fanalou (y)	6.4	32	240	28	470
Freedom (x)	6	0.3	190	28	320
Using direct variation; k = y/x	k = 1.067	k = 106.67	k = 1.263	k = 1.000	k = 1.469
Using indirect / inverse variation; k = x*y	k = 38.4	k = 61.44	k = 45600	k = 784	k = 150400

(A)

(B)

(C)

Figure 12(A-C). Mobile Water Quality Testing Using Hannah Instruments
(Multi-range Conductivity Meter – Code HI9033 and ph Meter – Code HI9812 – 5).

Table 9. Variation relationship considering Table 5.

Mobile Water Quality Testing on Dissolved Water Samples Using ph Meter				
Field	ph (Acidity)	Total Dissolved Solids (ppm)	Temperature (°C)	Conductivity (micro-Siemens/cm)
Fanalou (y)	7.2	290	28	580
Freedom (x)	6.5	280	28	560
Using direct variation; k = y/x	k = 1.108	k = 1.035	k = 1.000	k = 1.035
Using indirect/inverse variation; k = x*y	k = 46.8	k = 81200	k = 784	k = 324800

4. DISCUSSION

Comparing figure 4 and 5 with the World Health Organization (WHO) standards and the United State Environmental Protection Agency (USEPA). Nitrate in water is beyond the

USEPA limit (i.e. 4 – 9 mg/L), but less than WHO limit (i.e. 45 mg/L) on Fanalou Mines; Chloride, Sulphate in water are within the WHO limit (i.e. 11 – 42 mg/L and 400 mg/L) on both fields; Iron, Lead in water are within WHO limit (10 to 50 mg/L and 25 mg/L) for Fanalou Mines, but beyond limits in Freedom Mines; Nickel, Lead in the soil are within limits (i.e. 35 mg/kg and 85 mg/kg) of the WHO for both fields (Figure 1).

Table 6 and 9 has proved that the variation relationship between Fanalou and Freedom Mine Fields are directly proportional to each other in their metallic/ionic concentrations, and in other parameters. In Table 6 (i.e. soil/sand samples), the trend in both fields are having Mg^{2+} is 1.645 ppm, Mn^{2+} is 2.124 ppm, Pb^{2+} is 0.861 ppm, Fe^{3+} is 1.233 ppm, Ni^{2+} is 1.358 ppm, and SO_4^{2-} is 0.636 mg/kg.

In table 7 (i.e. water samples), the trend in both fields are having Mg^{2+} is 0.687 ppm, Mn^{2+} is 1.295 ppm, Pb^{2+} is 1.056ppm, Fe^{3+} is 1.339 ppm, Ni^{2+} is 1.059 ppm, and SO_4^{2-} is 0.780 mg/kg, and Cl^- is 0.828 mg/L.

In table 8 (i.e. mobile water quality testing on dissolved soil/sand samples using multi-range conductivity meter), the pattern is ph is 1.067 acidity, Turbidity is 106.67 NTU, Total Dissolved Solids is 1.263 ppm, 1.000 °C, and Conductivity is 1.469 micro-Siemens/cm.

In Table 9 (i.e. mobile water quality testing on dissolved water samples using ph meter), the pattern is ph is 1.108 acidity, Total Dissolved Solids is 1.035 ppm, 1.000 °C, and Conductivity is 1.035 micro-Siemens/cm.

These results of variance shows close values for both soil/sand and water samples, which indicates and verify that concentrations in both fields are from the same geological formation and region.

5. CONCLUSION AND RECOMMENDATION

This field research study is based on Fanalou and Freedom Nigeria Company Limited, which are surface mines in Ikpeshi, Nigeria. This project considers the variations that is composed in the ionic/concentrations of soil/sand and water from these two surface mines. Apart from the care to be observed about corrosion avoidance to mining facilities such as drilling, blasting, hauling/mucking, pumping and processing, the ionic sizes in the individual mines stands as an inherent threat to man and the adjoining environment. It is hence recommended that water be managed and well-handled by nullifying the ionic amounts to the barest minimum prior to been pumped into the water drainages that sucks away into the community (Amosu and Adeosun, 2021), and the right choice of accessories and facilities which has capacities to resist corrosion made (Amosu, 2021).

Nomenclature

Mg^{2+} = Magnesium ion
Mn^{2+} = Manganese ion
Pb^{2+} = Lead ion
Fe^{3+} = Iron ion
SO_4^{2-} = Sulphate ion
Cl^- = Chloride ion
NO_3^- = Nitrate ion

Ppm = parts per million

Mg/L = milligram per liter

Mg/kg = milligram per kilogram

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