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MINERAL SEPARATION AND HEAVY METALS STATUS IN DRINKING WATER AROUND ACTIVE MINING ENVIRONMENT.

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Abstract

Metallic ore minerals and water samples were collected for studies. The metallic ore minerals were collected from active mining areas from Maru and Anka in Zamfara States while water samples were collected 100 meters away from mining site but within the mining communities. The XRF results of the concentrated samples shows high concentration of elemental minerals such as Fe (85%), Si (59%), As (0.15%), Ag (0.025%) and Ga (0.04%). The results for pH in all the analyzed water samples ranges from (7.8-8.43), all the samples analyzed were within WHO(2008) SON(2015) limits pH range of 6.5 -8.5, all the water samples analyzed had the conductivity values ranges from (92.1-596.1 μS/cm) which are within the WHO(2008) and SON(2015) limits of 1000μS/cm, Hardness results for water samples ranges from (26.94 – 363.6mg/L), sample AWW-2 had hardness value above 150mg/l WHO(2008) and SON(2015) limit while other samples were within the limit. The results for metal concentrations shows that all the samples analyzed had their values above WHO (2008) and SON (2015) limit of 0.01mg/l for Pb, sample ASW had value above WHO limit of 0.003mg/l for Cd, the results for Fe, Zn and Cu were within WHO/SON limits for all the analyzed samples respectively.

Keywords: Atomic Absorption Spectrometer, Metallic ore Mineral, World Health Organization, X-ray Flouresence Spectroscopy (XRF), Zamfara State.

Introduction

Nigeria is blessed with abundant mineral resources and human resources capable of tapping these resources for industrial growth, however, but what is experienced today is that most of the mineral development, especially the exploitation is done by informal and in most cases illegal miners using very crude techniques with no consideration for the environment or human health. (Gyang and Ashano, 2010). The processes of Nigeria's mineral development greatly affect the environment largely due to the fact that most of the mining activities are carried out by artisanal and small-scale miners who lack appropriate technology and sufficient funds, and are reluctant to imbibe best practices in their operations (Malomo, 2007). Mining and milling of metal ores coupled with industrial activities have left a legacy of wide distribution of metal contaminants in soil. During mining, tailings (heavier and larger particles settled at the bottom of the flotation cell during mining) are directly discharged into natural depressions, including onsite wetlands resulting in elevated concentrations (DeVolder *et al.*, 2003). Soil heavy metal environmental risk to humans is related to bioavailability and assimilation pathways which include the ingestion of plant material grown in (food chain), or the direct ingestion (oral bioavailability) of, contaminated soil (Basta and Gradwohl, 1998). Monitoring the contamination of soil using heavy metals as indicator is of great concern due to their influence on ground water, surface water and also on plants, animals and humans (Sadhana, 2014). In the present study separation of metallic ore minerals was carried out using X-ray fluorescence spectroscopy, to ascertain the potential minerals in the studied communities as well as assessment of heavy metal status of water samples within mining communities in Anka and Maru, Zamfara State using Atomic Absorption Spectroscopy.

Materials and Method

Reagents and Glassware

All the equipment and glass wear used were thoroughly washed with detergent and rinsed several times with distilled water and oven dried before used. The reagents used were analytical grade reagents.

Sampling and Sample Collection

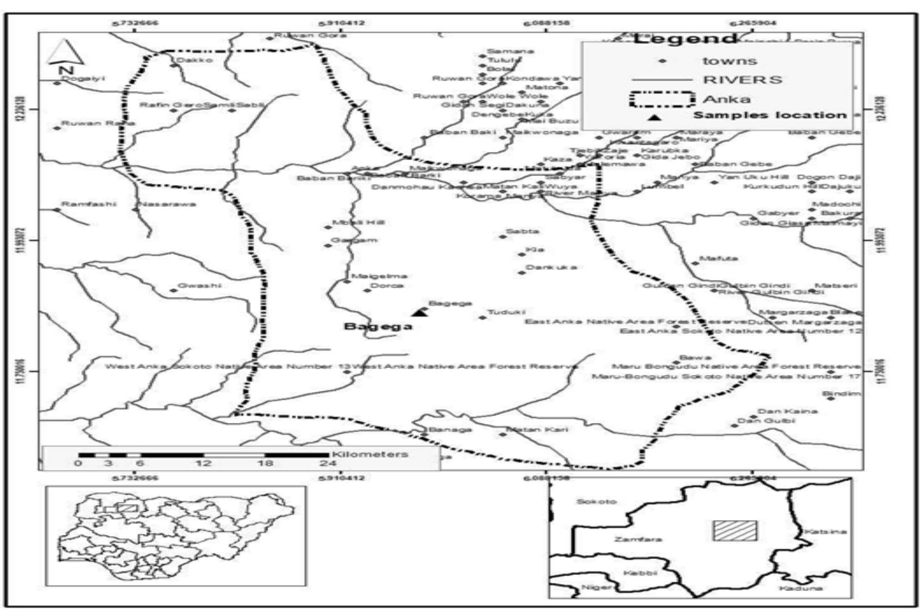
Metallic ores minerals samples were collected from Gold mining sites of Jabaka and Bagege areas in Maru and Anka Local governments. Water samples were collected within the two communities, all in Zamfara State, Nigeria. The samples were collected in a Polythene container and transferred to the laboratory for further treatment.

Collection of Water Samples

Water samples were collected into a clean ten litres container at interval of 2hrs thrice daily for each sampling point so as to obtain representative samples. A five liters clean sample container was filled from it. This was repeated for all the sampling point. 1cm^3 of Conc. HNO_3 was added to the samples for metal analysis and refrigerated. (Sholadoye and Nwoye,2016).

Sample Pretreatment for Rock Bearing Ores

The samples were air dried under laboratory conditions for a week, ground with mortar and pestle, then sieved with 2mm mesh sieve and stored in a clean and labeled container.



Source: Dept. of Geog. BUK (2019)

Figure 1: Bagega Sampling Site in Anka

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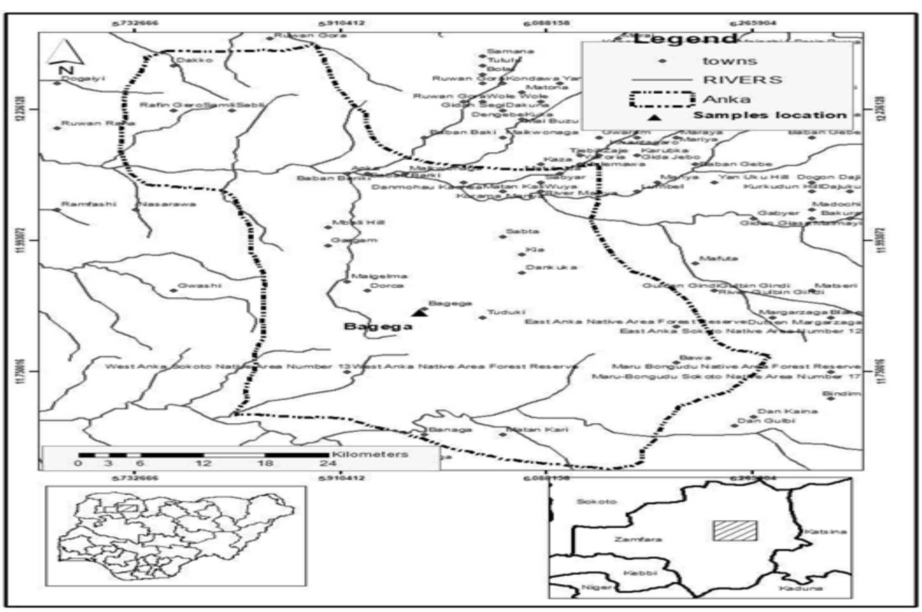

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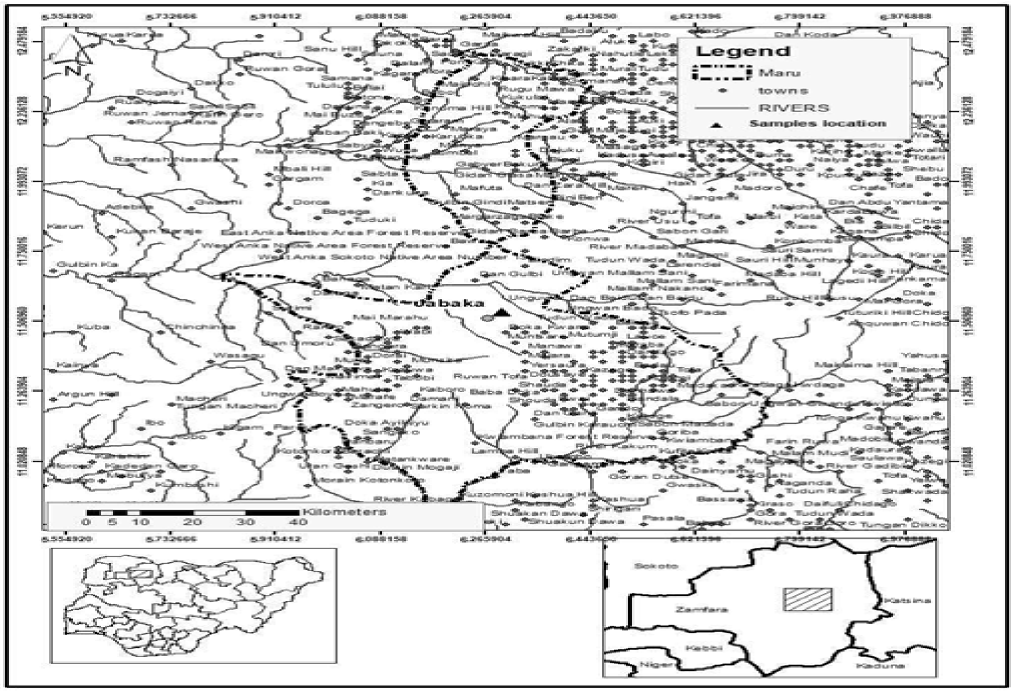

Source: Dept. of Geog. BUK (2019)

Figure 2: Sampling Site Jabaka in Maru

Table 1: Samples Identification and Coding for rock bearing mineral ores

S/N	Samples	Code
1.	Maru Gold mining site Zamfara	MGZ
2.	Anka Gold Mining site Zamfara	AGZ

Table 2: Sample Identification and Coding for Water Samples

1.	Anka Stream Water	ASW
2.	Anka Well Water 1	AWW1
3.	Anka Well Water 2	AWW2
4.	Maru Well Water 1	MWW1
5.	Maru Stream water	MSW
6.	Maru Well Water 2	MWW2

Concentration of Minerals Ores Samples

30g of the powdered sample was accurately weighed into 100ml container.50ml of bromoform was added to it and centrifuged at 4000 rpm for 10minutes. Then, removed and partially freezed the heavy minerals at the bottom part with liquid nitrogen while the light mineral was decanted. The sample was then warm to unfreeze the frozen bromoform and decanted, finally washed with 10ml acetone. The washed sample was accurately transferred into crucible for oven drying for about 12hrs at 56°C. This procedure was repeated for all the samples were subjected to XRF for elemental analysis (Jimoh, 2012).

Digestion of Water Samples

5.0 liters of each water samples was evaporated to dryness using Pyrex beaker and hot plate. The residues were digested with $50cm^3$ of $0.25moldm^{-1}$ HNO_3 and transferred into $120cm^3$ plastic container for Atomic Absorption Spectrophotometer analysis. Metals Concentrations were extrapolated from standard calibration curve (Jimoh and Sholadoye, 2011).

pH Measurement

The pH of the samples were determined with a pH meter model 3510 Jenway after calibrated with a standard buffer Solution of pH 4 and 9.2. The procedure was repeated for all the samples and for water samples (Ademoroti, 1996).

Conductivity Measurement

The conductivity of the samples was measured with a model 4010 Jenway after calibrated with 0.01KCl solution. The procedure was repeated for all the soil samples as well as water samples (Ademoroti, 1996).

Turbidity Measurement

The turbidity of the water samples was measured with a colorimeter model DR/890 after calibrated with 0.01KCl solution. The procedure was repeated for the remaining water sample (Ademoroti, 1996).

Total Hardness Determination

$100cm^3$ of water sample was pipetted into a $250cm^3$ conical flask. $2cm^3$ of ammonium buffer solution (pH 10) and 3 drops of Erichrome blackT indicator were added to it. The mixture was then titrated with 0.01M disodium EDTA(disodium ethylene diamminetetral acetic acid) until the colour changed from wine red to blue. The procedure was repeated twice to obtain the average titre value(Ademoroti,1996).Blank titration was carried out using $100cm^3$ of deionized water subjected to the same treatment as samples. The total hardness concentration was calculated thus

$$\text{Hardness } CaCo_3(mg/l) = \frac{A - B \times M \times 1000}{\text{Sample Volume}}$$

Results and Discussion

Elemental Analysis of Ore Samples:

Gold Minerals Sample Jabaka.

The elemental compositions of untreated and treated gold ore samples were shown in Figure 3. The results revealed high concentration and predominant of Fe, Si and Al in both untreated and treated samples than gold been mined in the mining area. The associated minerals in the ore samples were Ag, Zn, Cu and Ga which were minor in the ore matrix. The analysis also provides baseline information on anthropological impact on the environmental pollution of the environment.

Gold minerals Sample Bagega.

The elemental compositions of Bagega gold ore samples were shown in Figure 4. The results show that Fe, Si and Al were predominant elements in the ore samples. The concentrations of the elements in the untreated sample were Fe (23.70%), Si (67.00%) and Al (9.05%) while the concentrations in the treated sample were Fe (35.15%), Si (59.00%) and Al (4.01%). The results also show other associated mineral elements such as Ag, Au, Pb, Zn, S, Cu, Ga and As.

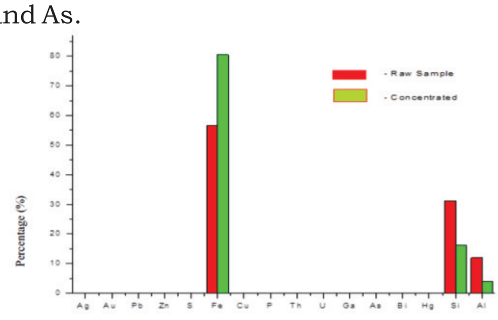

Figure 3: Minerals Analyzed from Jabaka Gold Mining Site, Zamfara State

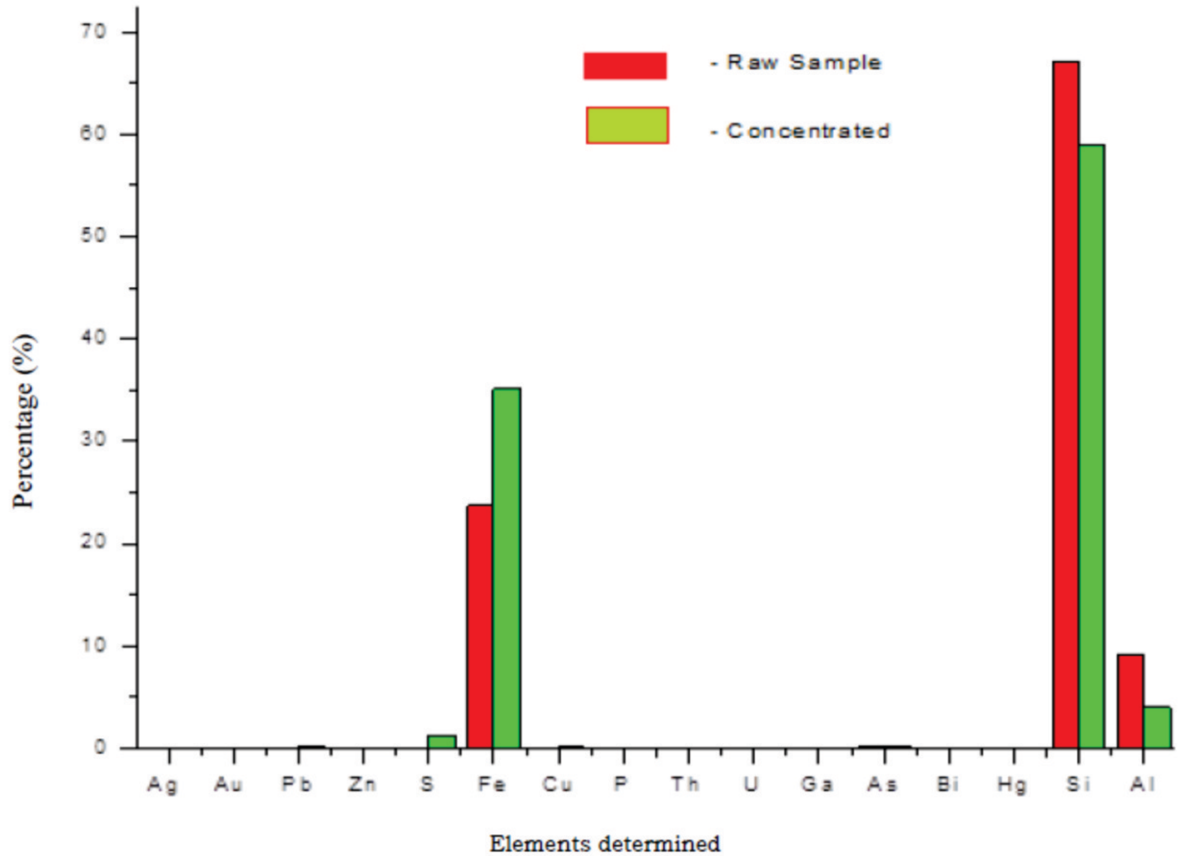

Figure 4: Minerals Analyzed from Bagega Gold Mining Site, Zamfara State

Water Analysis

pH results for water Samples

The pH results for the water samples analysed were presented in the Figure 5. The results range from 7.8-8.43. Sample AWW1 had the least value of 7.8±0.03 and Sample ASW had the highest value of 8.43±0.06. All the samples analysed were within the WHO (2008) and SON (2015) limit of 6.5-8.5.

Conductivity of the Water Samples

The conductivity values for the analysed water samples were presented in Figure 6. The values ranges from 54.2-341.3μS/cm. Sample ASW had the least value of 54.2±1.34 while sample AWW-1 had the highest value of 341.3±2.0μS/cm. All the samples analysed were within the WHO (2008) and SON (2015) limits of 1000 μS/cm.

Hardness for the Water Samples

The levels of hardness in the analysed samples were presented in Figure 7. The results range from 26.94-363.63mg/L. Sample ASW had the least value of 26.94±0.014mg/L and Sample AWW-2 had the highest value of 363.63±0.014mg/L. All the samples analysed were within WHO (2008) and SON(2015) limits of 150mg/L except Sample AWW-2, a well water sample. The principal ions causing hardness in natural water are calcium and magnesium. Small quantities of Iron (II), manganese (II) and Aluminium may also contribute to the water hardness (Ademoroti, 1996).

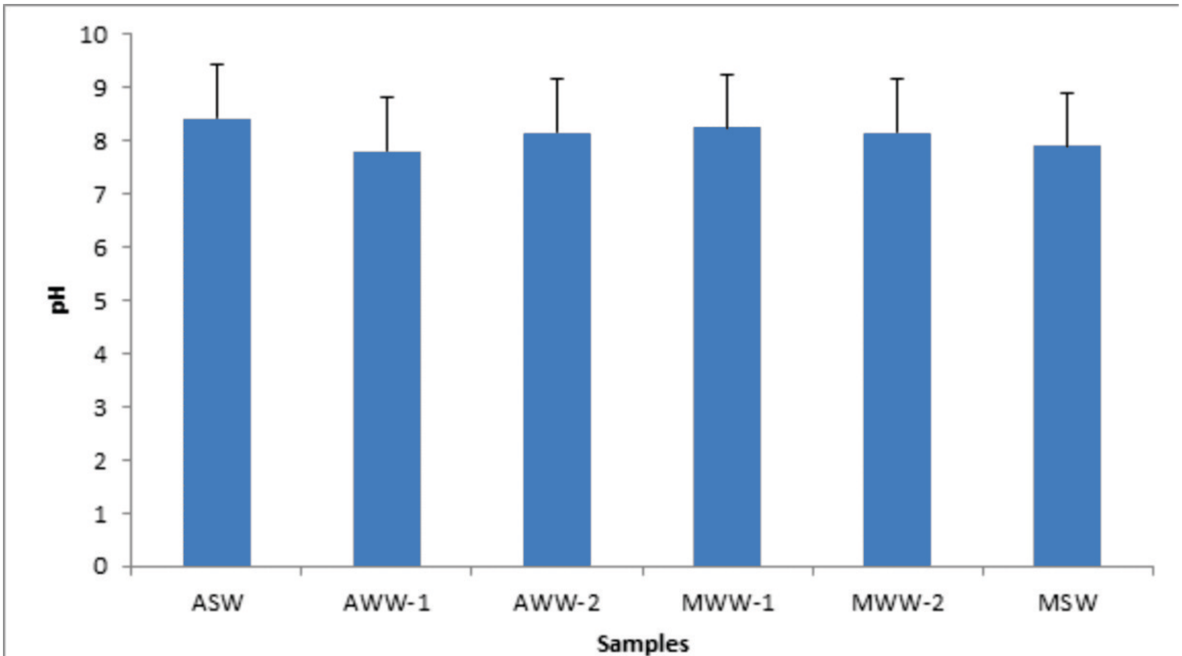

Figure 5: pH results of Water Samples

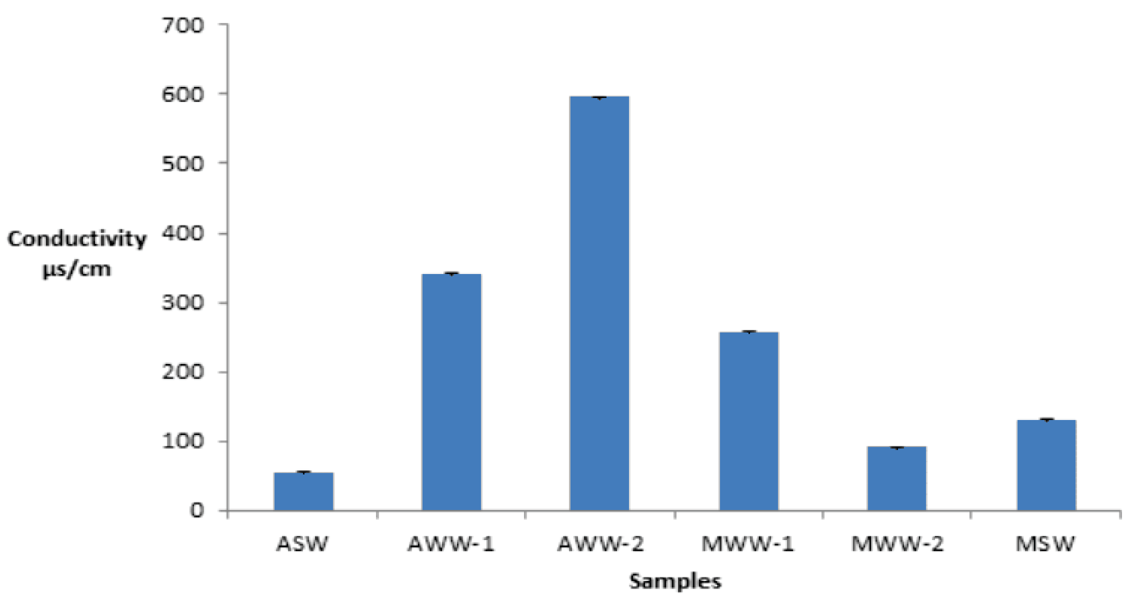

Figure 6: Conductivity results of the Samples

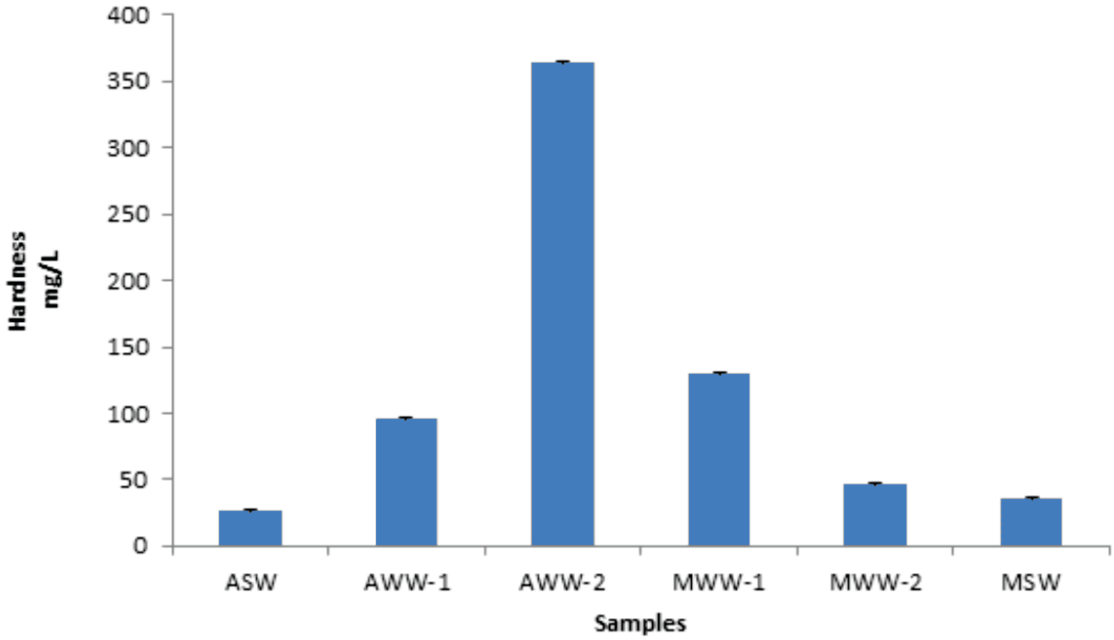

Figure 7: Hardness results in the Samples

Metal Concentration in Water Samples.

Lead

Lead concentration in the samples analysed were presented in Figure 8. The concentrations range from 0.18-0.33mg/L. Sample MWW-2 had the least value of 0.18±0.012mg/L and Sample had the highest value of 0.33±0.05mg/L. All the samples analysed were above WHO (2008) and SON (2015) limits of 0.01mg/L. The high concentration of lead in the analysed samples actually reflect the impact of illegal mining activies in the environment where illegaly mined minerals are been taken to all part of the community including water sources for processing. Mark *et al.,* (2014) also reported high level of lead concentration in mining environment in their studies. The concentration of lead in the present studies also agreed with (0.031- 0.25) mg/L reported by Samuel *et al.,* (2015).

Iron

The concentrations of iron in the analysed samples were presented in Figure 9. The values ranges from not detected to 0.24 mg/L. Sample AWW-1 had the highest concentration of 0.24±0.02 mg/L while least concentration of 0.08 mg/L was observed in sample ASW. All the samples analysed were within WHO (2008) and SON (2015) limits of 0.30 mg/L.

Cadmium

Cadmium concentrations in analysed samples were illustrated in Figure 10. Cadmium were only detected in two samples (ASW and AWW-1). Sample ASW (0.007±0.00mg/L) had cadmium concentration above WHO(2008) and SON(2015) limit of 0.003mg/L and sample AWW-1(0.001±0.001mg/L) was within WHO/SON limits. The high concentration of cadmium in the sample ASW may be due to processing of mined minerals in nearby water bodies. Asamoah, 2009 also reported concentration of cadmium in drinking water in artisanal gold mining communities within the Kibi traditional area, Ghana, with mean values of cadmium in river water at Apapam, Bunso, Kibi-Deaf, and Obronikrom as 0.006, 0.008, 0.008, and 0.010 mg/L, respectively which above WHO limits of 0.003 mg/L. Cadmium causes adverse health effects such as kidney damage, bronchitis, and osteomalacia (soft bones) at very low exposure levels (Young, 2005).

Zinc

Zinc concentrations in all the samples analysed were presented in Figure 11. The concentration ranges from 0.003 mg/L - 0.11 mg/L.The concentration of zinc in all the samples analysed were within the WHO (2008) and SON (2015) limits of 3.0 mg/L. Asamoah,2009 reported zinc concentration that ranged from 0 to 0.190 mg/L from surface water in Newmont Ghana gold mining concession areas which also within WHO limits. Zinc plays an essential role in human metabolism. It is vital for the proper functioning of more than 300 enzymes, for the stabilization of DNA, gene expression and transfer of nervous signal (Stefana *et.al,* 2006). However high concentration of zinc can be toxic to organism.

Copper

Copper concentrations in the analysed samples were shown in Figure 12. The concentrations ranges from not detected to 0.015 mg/L. The concentrations of copper in the present studies were within WHO (2008) and SON (2015) limits of 1.0 mg/L. Casimir *et al.,* 2015 also reported copper concentrations in the range of (0.03 -0.06) mg/L in drinking water in Kaltungo area of Gombe State, Nigeria.Copper is an essential nutrients but at high concentration it caused stomach and instestinal distress, liver,kidney damage and anemia (WHO,2004).

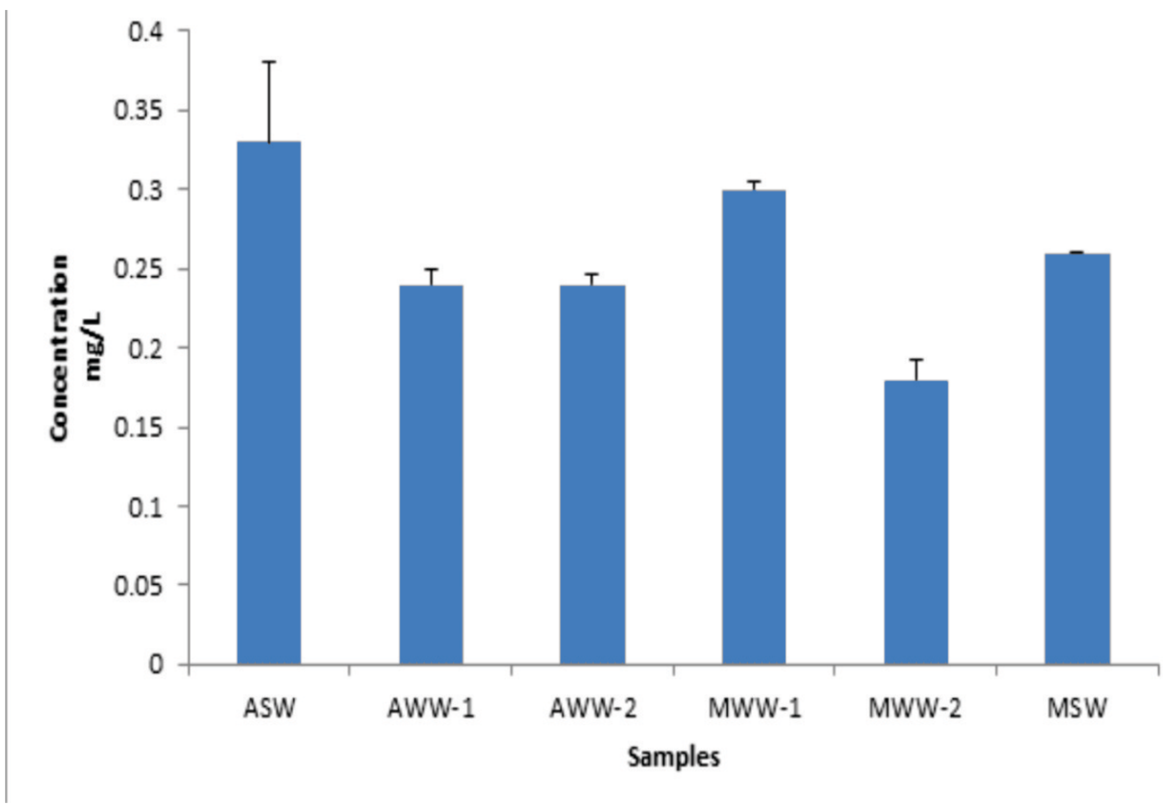

Figure 8: Lead concentrations in the Samples

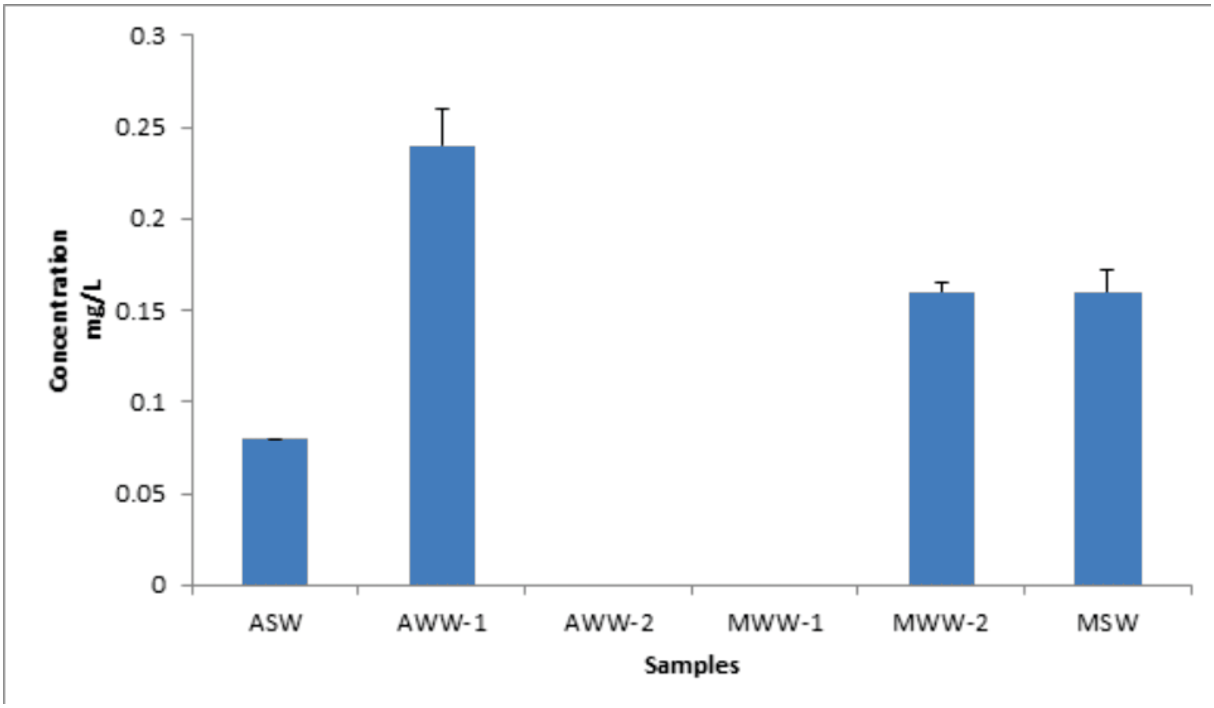

Figure 9: Iron Concentration in the Samples

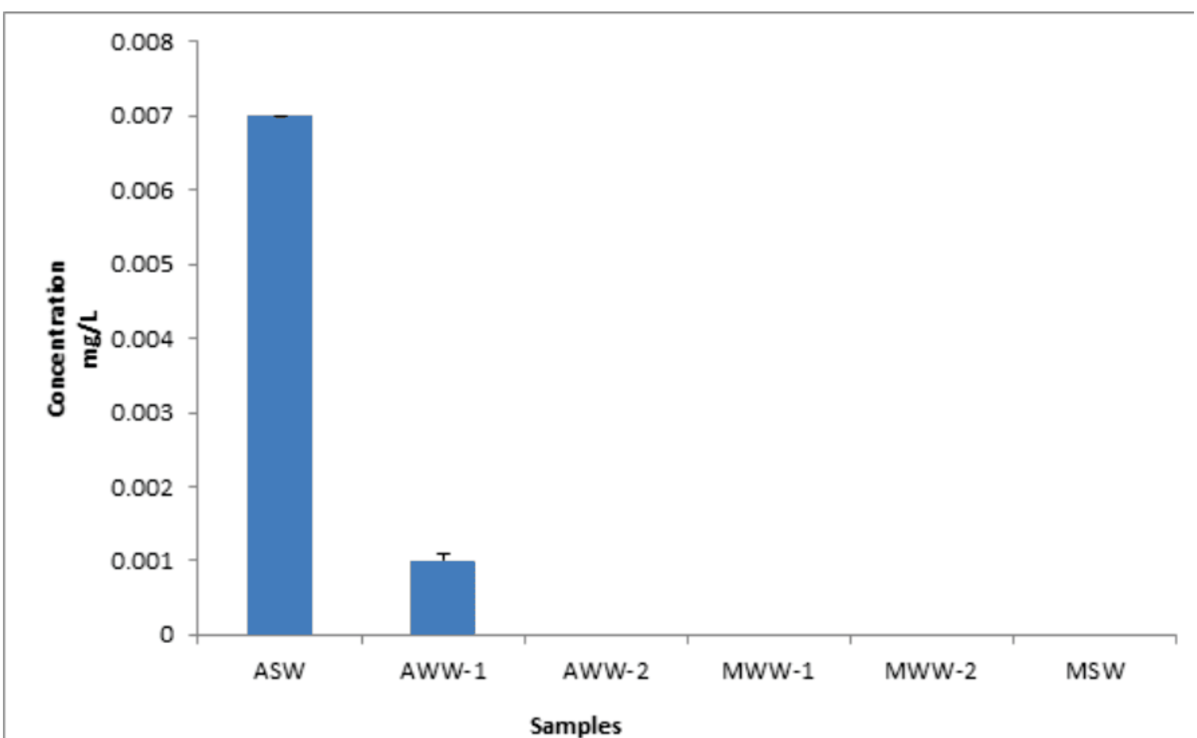

Figure 10: Cadmium Concentration in the Samples

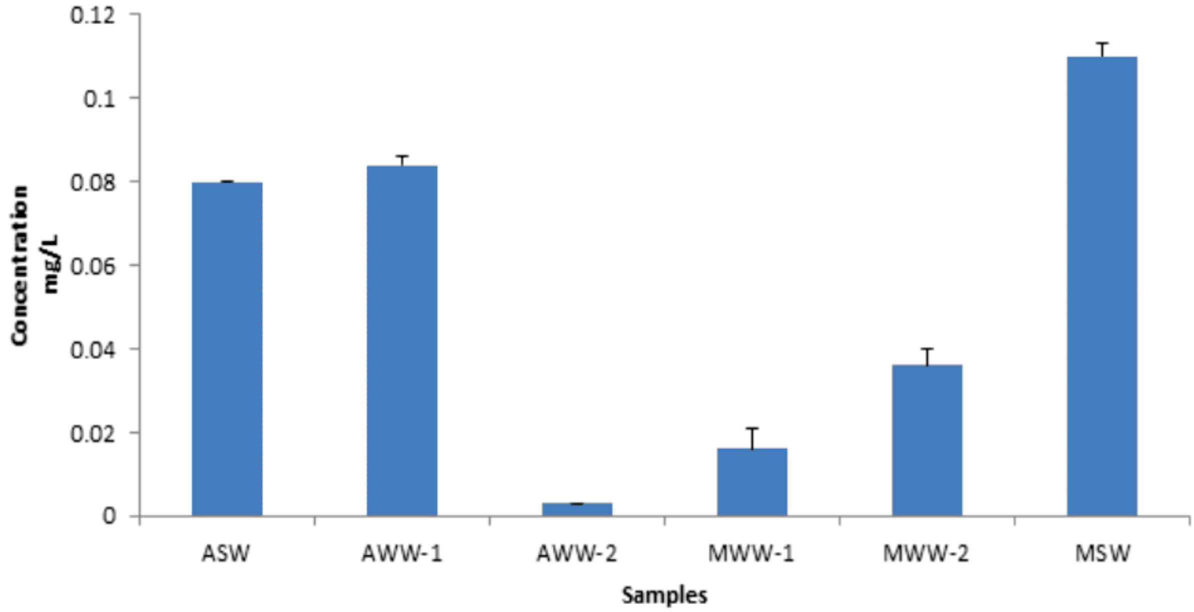

Figure 11: Zinc Concentration in the Samples

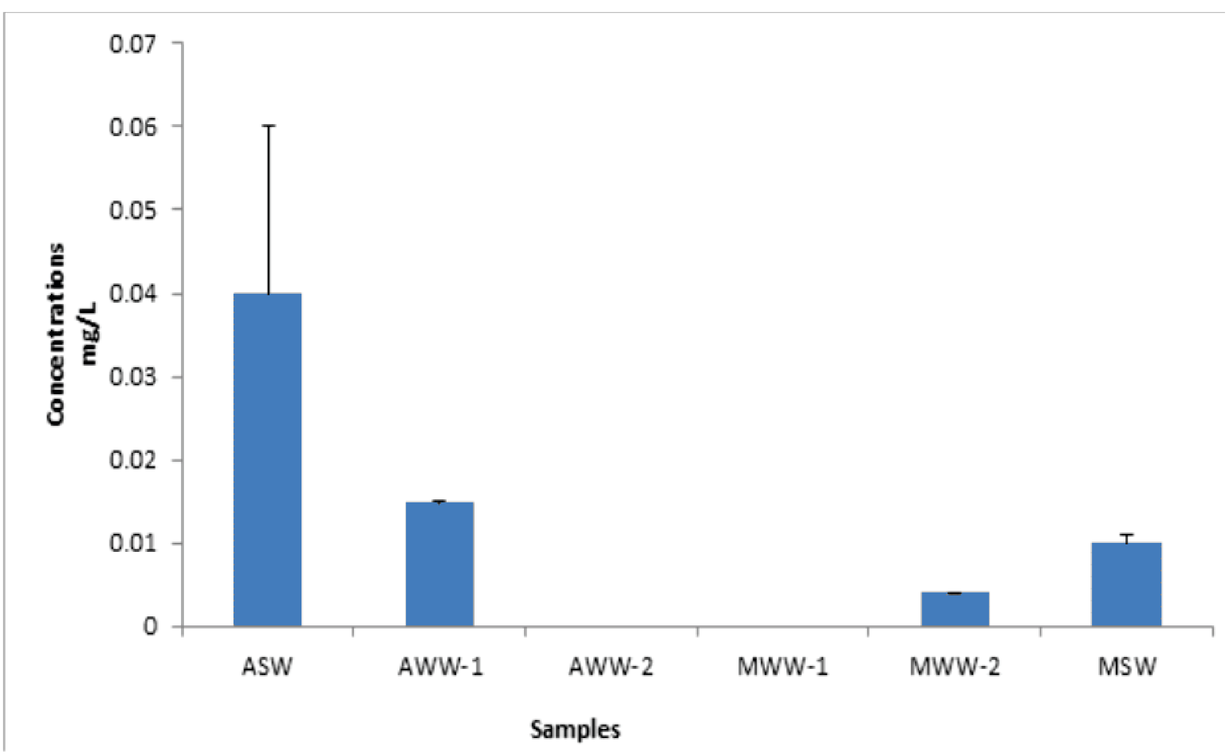

Figure 12: Copper Concentration in the Samples

Conclusion

The result of XRF mineral analysis revealed much information about potential minerals as well as toxic metals present in the study areas, about 84.10% Fe and 13.10% Si were found in a gold mining area whereas the percentage of gold was 1%. The result shows that there are other minerals which are present in large concentration than mineral of interest and toxic metals such as Hg (0.06%) and As (0.095%) have been observed after XRF analysis of concentrated samples. The result of metal concentration in the water samples shows that the concentrations of Pb in all the samples analysed were above WHO limits, Cd had concentrations within the limits in few samples while Fe, Zn and Cu were within the WHO limits in all the analysed samples.

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