

Effects of Barite Mining on Water Quality in Azara-Awe Local Government Area of Nasarawa State, Nigeria

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Abstract

This study seeks to ascertain the extent of barite mining pollution on water quality in Azara-Awe Local Government Area of Nasarawa state of Nigeria. To achieve this goal, two surface water and fourteen underground water samples were obtained in the study area. Nitric acid (0.2%) was added to water samples to preserve them for laboratory tests. The analysis was carried out at the Analytical Laboratory of the National Metallurgical Development Agency, Jos Nigeria. The parameters analyzed includes; Temperature, pH, Conductivity, Salinity, Total Dissolved Solid, Nitrate, Sulphate, Iron, Tin, Zinc, Copper, Cyanide, Cadmium, Chromium, Total Hardness, Calcium, Magnesium, Manganese and Nickel. The analyzed results were compared to the permissible limits as prescribed by the Federal Ministry of Environment of Nigeria. Results reveal that all parameters of the analyzed surface water fell within the permissible limits. Findings from the fourteen underground water samples analyzed indicate that most of the parameters are within the permissible limits, except sample one whose copper content 0.137mg/l is above the permissible limit of 0.1mg/l. Of the Samples, samples 10 and 11 fell within the permissible limit of total hardness, while samples 4 and 12 were above the permissible limit of 50mg/l of Magnesium content. It is pertinent to introduce sustainable measures in the process of barite mining to reduce its impacts on underground water quality. There is need for an advocacy campaign to enlighten artisanal barite miners on the direct link between their operations and environmental degradation.

Keywords: *barite, Mining, water quality, heavy metals, Azara-Awe LGA.*

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Introduction

Barite mining plays a significant role in income generation, employment among artisan miners in Nasarawa State of Nigeria (Oelofse *et. al.*, 2008). Barite is the chief constituent of lithopone paint. It is extensively used as an inert volume and weight filler in drilling mud, rubber, glass, paper. It is also widely used in several chemical industries (Abubakar *et. al.*, 2015). Veins of barite up to 1.8m wide and more than a kilometer long are associated with lead zinc lodes in many parts of Nasarawa State (Fig. 1). The principal known occurrences are at Azara, Alosi, Akiri, Wuse and Keana. Reserves of about 100,000 tons of good-quality barite have been proved more recently in the Azara area by the Nigerian Mining Corporation. Indeed, at the time of writing this article, about 18 veins measuring about 2m x 1000m were being mined under the supervision of the Nigerian Mining Corporation (Oelofse *et al.*, 2008).

Barite was first detected in Azara in the early 1960s (Courtesy of the Geological Survey of Nigeria, 1965). The Nigeria Barite Mining and Processing Company (NBMPC) Ltd., incorporated in 1988 was charged with the exploration and exploitation of barite in Azara and in any other part of Nigeria where this mineral was found. The NBMPC Ltd is wholly owned by the Nigeria Mining Corporation with its Headquarters in Jos. Initial reconnaissance revealed eighteen (18) veins at areas like Azara, Alosi, Akiri, Wuse and Keana in Awe Local Government Area. Of these eighteen (18) veins, detailed exploration works were carried out in five (5), and these revealed a total reserve of seven hundred and thirty thousand (730,000) metric tons of barite (Oelofse, *et. al.*, 2008). The mining of barite at Azara, provides a good source of income to the inhabitants, supplementing their income from farming. What is more, almost 80% of the total national supply of barite comes from Azara (Obaje, *et. al.*, 2006).

Yet barite mining poses threats and hazards that can jeopardize the environment by disrupting the ecological balance, water quality, wildlife, natural landscapes, agricultural lands, vegetation and economic trees (Aigbedion and Iyayi, 2007; Adegboye, 2012). Contaminants and toxic compounds from barite mining activities jeopardize the quality of surface and underground water, making it unsafe for drinking and industrial usage and disturbing the hydrology of the area where barite mining takes place (Roy *et. al.*, 2003). In Africa (Nigeria inclusive), poverty coupled with poor policy frameworks to address mining activities is a major threat to environmental sustainability (Oelofse, and Turton, 2008). With the increasing number of artisan miners in Africa, water quality has been polluted due to contamination (Oelofse and Turton, 2008). The contamination by barite mining can result in profound irreversible destruction of the environment. In many cases the polluted sites may never be fully restored, because pollution is so persistent that there is no available remedy (EEB, 2000).

Due to improper planning and negligence of barite mining regulations, an appreciable amount of environmental degradation and ecological damage to water occurs in almost every barite site in Azara-Awe. The key questions are whether surface and groundwater supplies will remain fit for human consumption, and whether the quality of water in barite mining sites will remain adequate to support humans and wildlife (Anirudha, 2005). Barite can dissolve in water, and when it does, it can cause environmental and health hazards (Nirmal, *et. al.*, 2011). Generally, mining of solid minerals has been identified as a major source of heavy metals in the environment because such minerals generally contain both heavy and essential metals. In most developing countries like Nigeria, underground and river water has remained a major source of

water to the teeming population of the rural areas. Barite mining affects the quality of water resources, both surface and groundwater, at various stages of the life cycle of the mine and even after its closure (Younger *et. al.*, 2002).

Estimation of quality of water is extremely important for proper assessment of the associated hazards. These issues must be addressed within the context of the environmental requirements in place in the jurisdiction within which the mining occurs (Siegel, 2002; Nordstrom, 2008; Oden, 2012).

Study Area

The study area is situated at Nasarawa State. The state is within the Middle Benue Trough of Nigeria which lies between latitude 7° 45' and 9° 25' N of the equator and between longitude 7° and 9° 37' E of the Greenwich Meridian (Bimbol and Marcus, 2005). Azara mining site is located in Awe Local Government Area of Nasarawa State. The geographical coordinates 8° 22' North, 9° 15' East and has an altitude of 181.5m above sea level (Obaje, *et. al.*, 2006) (See Fig. 1).

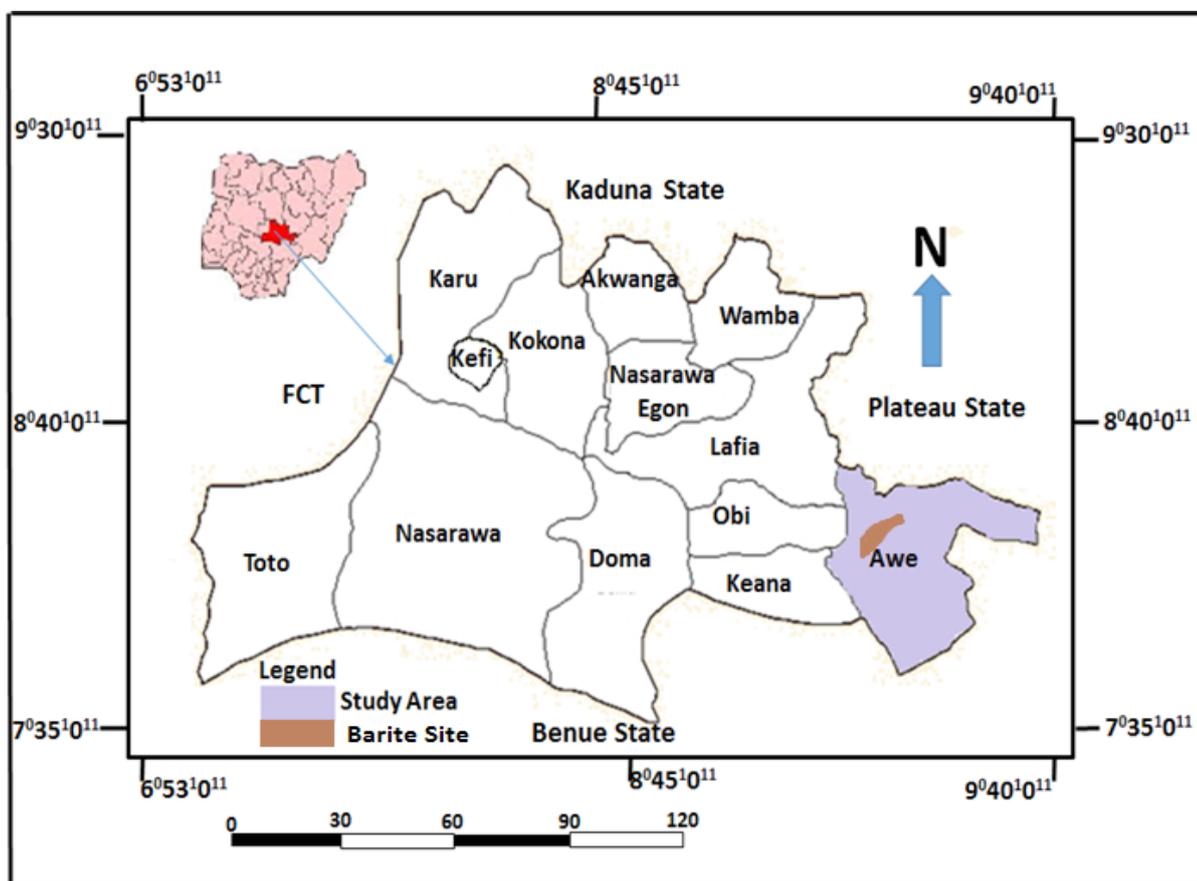


Figure 1: Map of the Study Area

Source: Department of Geography and Environmental Management GIS LAB, University of Abuja, Nigeria (2016).

The study area is geomorphologically within the upward Awe formation which consists of transitional sandstone, shale, siltstone and limestone and the fluvatile sandstone of the Keana Formation. The Azara area forms part of the north-eastern limb of the Keana anticlinorium. The major baryte mineralization is associated with the mineralized hydrothermal vein that is a consequence of the tectonic rifting that led to the emplacement of the Benue Trough which was in part controlled by trans-current fault activity (Benkhelil,

2000). The barite deposit in Azara occurs as hydrothermal veins within the cretaceous Keana sandstone of the middle Benue Trough. The defunct Nigerian Mining Corporation identified eighteen hydrothermal veins (Obaje, *et. al.*, 2005).

Due to the location of the study area in the tropical sub-humid climatic belt, the mean annual temperature is high. The highest temperature is recorded from January to March. A single maximum temperature is achieved in the month of March when maximum temperatures can reach 39°C. Minimum temperature on the other hand can drop to as low as 17°C in December and January. The onset of rain begins in the month of April which bring about a noticeable decline in temperature in the study area. This is made possible by the blanket effect of cloud cover over the area. Rainfall ceases by the end of October when a further decline in temperature in the area is made possible in November/December by the coming of the harmattan winds. The relative humidity in the study area rises from February to a maximum of about 88% in July. Steady rains commence in April, when the relative humidity will be at about 75%. During this period, the southern part of the state comes under the influence of the humid maritime air mass.

The predominant soil parent materials in the area are derived from cretaceous sandstones, siltstone, shale, limestone and ironstone of undifferentiated basement complex. These rocks are frequently overlain by gravely lateritic iron pans probably formed in the late tertiary era which are associated with concretion gravels and accumulation of alluvial deposits in “rivers flood plains”. The climatic phenomena and rock grade have yielded different soil types (Chaanda *et al.*, 2010). In the study area, the vegetation type is dominantly characterized with southern guinea savanna and some elements of northern guinea savanna with interspersions of grassland, tree savanna, fringing woodland or gallery forest along the valleys (Chaanda *et. al.*, 2010).

The people in the study area are mainly farmers. The major crops they produce include yam, cassava, melon, guinea corn, and other grains in large quantities for both consumption and trade. Substantial numbers of nomads reside in the area and are the main suppliers of milk, eggs, butter, hides and skin. The indigenous people are mainly farmers and the Hausas are petty traders. The Ibo and Yoruba are mainly traders in utensils, automobiles and building materials particularly in the local government headquarters and villages.

Methodology

In carrying out this study, a reconnaissance survey was undertaken to sample appropriate sites for the study. Information collected during this survey include the various barite deposit sites, mining sites, mining ponds generated as a result of barite mining activities. The physio-chemical parameters of the water samples analyzed are temperature, pH, conductivity, salinity, total dissolved solid, nitrate, sulphate, phosphate, iron, copper, total hardness, calcium, magnesium, manganese, nickel, cyanide, tin, zinc, chromium and cadmium.

Method of Water Sample Collection and Analysis

The basic materials and equipment used in carrying out this study were: one liter of plastic container, masking tape, marker, still camera, writing pad, GPS 60cx and cooling box. Two surface water and fourteen underground water samples were collected in July 2016 in nitric acid washed-plastic bottles. All the sampling bottles were washed with sample water before sampling to reduce contamination. After the collection, nitric acid (0.2%) was added as a preservative. The samples were marked and labeled with the source of water,

sampling location and date of water sample collection. The collected samples were preserved in an ice-block containing plastic cooling box and transported to the laboratory for analysis. Quality assurance and control of data were performed according to the specified method (Ishaya *et. al.*, 2013). The pH of the water samples was determined in-situ during sample collection using an Orion Star A221 pH portable meter (star A2210 series).

Table 1: Points of water samples collection

S/N	Item	Time	Easting	Northing
1	Well Water	3:45pm	9.310454	8.357977
2	Well Water	3:52pm	9.309869	8.358377
3	Well Water	3:06pm	9.309459	8.358572
4	Well Water	3:47pm	9.309069	8.358747
5	Well Water	3:49pm	9.306758	8.359664
6	Well Water	3:59pm	9.308699	8.358855
7	Well Water	4:14pm	9.307977	8.360863
8	Well Water	4:17pm	9.307470	8.360941
9	Well Water	4:28pm	9.306833	8.361444
10	Well Water	4:37pm	9.306167	8.359806
11	Well Water	4:54pm	9.305833	8.359611
12	Well Water	6:07pm	9.307139	8.359389
13	Well Water	6:18pm	9.307806	8.359167
14	Well Water	6:30pm	9.307917	8.359056
15	Down-stream water	7:15pm	9.306972	8.365389
16	Up-stream water	7:26pm	9.305556	8.368389

Source: Researcher Fieldwork, 2016

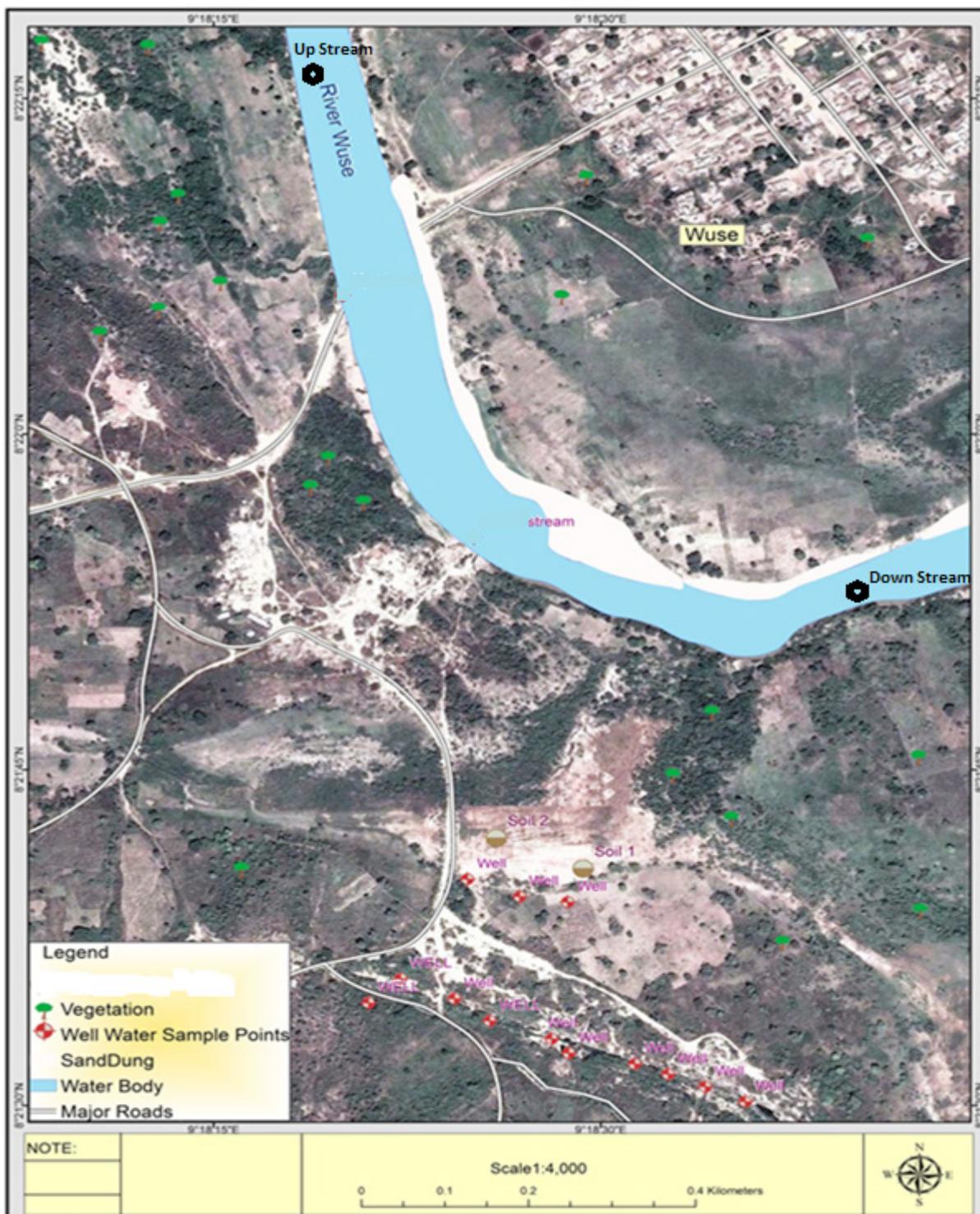


Figure 2: Map of study area depicting water sampling points

Source: Adapted from Google Earth (2016)

Water Samples' Analyses

Apart from the pH measurement that was done in-situ, all other analyses were done using an Analyst100 (Perkin-Elmer) spectrophotometer located at the Analytical Laboratory of the National Metallurgical Development Agency, Jos, Nigeria.

Each of the collected samples was filtered using membrane papers to remove all solids. The pH of the filtrate was then set to 2 ± 0.2 with 1M nitric acid and stored at 4°C until time of analysis. In making sure

that the water samples were not contaminated, all the glassware and plastic containers used for the analysis were treated with nitric acid and rinsed with distilled water. Quality assurance and control was performed according to the specified method developed by Soylak *et. al.*, 2000). Determinations of Chemical Oxygen Demand (COD), sulfate, carbonates, silicates and heavy metals were done according to standard analytical methods described by APHA (2005).

***i* pH Measurement**

The pH measurements were carried out at 25.8°C using an E603 Metrohm pH-meter equipped with a glass electrode. The pH-meter was calibrated against Crison buffer standard solutions.

***ii* Heavy Metals**

Heavy metals' analyses were carried out using atomic absorption spectroscopy (AAS) with electrothermic atomization in graphite furnace for the determination of the total content of Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd and Pb. The instrument used was an Aanalyst100 (Perkin-Elmer) spectrophotometer. The machine was equipped with an HGA-800 furnace and an AS-72 autosampler. Lamps used were hollow cathode multi-element lamps, except for As, Cd and Pb.

***iii* Other Chemical Parameters**

To measure COD, the samples were oxidized using $K_2Cr_2O_7$ at 150°C for two hours. After reaching the required room temperature, the samples were analysed at 420nm using a spectrophotometer HACH DR2000. Ion Chromatography was used to test for Cl and SiO_2 (Akan *et. al.*, 2009) and spectrophotocolorimetry for NH_4^+ (Sharma *et. al.*, 2003).

Concentrations of total nitrogen and total phosphorous were measured by digestion and filtration methods respectively, through membrane filter papers. The digestion was made with potassium peroxosulfate. After the digestion and filtration through a < 0.45- μ m membrane filter, the totals were determined by continuous flow analyzer as suggested by WHO (2003). Ammoniacal-N determination was performed by the phenate method described by Sharma (2003).

The analysis of sulphate anions was based on standard methods (APHA-AWWA-WEF, 2005). Thirty drops of NaOH (1:1 mvm) were added to 50 ml of the sample. The solution was shaken for 2 minutes in order to precipitate MgOH. Hydroxy-2 naphthol blue was added under stirring until a pink-violet color was obtained. The suspension was rapidly titrated by adding EDTA (0.0100 M) to the end point, characterized by a sky-blue colour. The suspension was set aside for 1 minute in order to check the stability of the colour.

The result obtained of the surface water and underground water samples were compared with the Federal Ministry of Environment water quality suitability standard for domestic use to ascertain implication of the findings.

Result of physical/chemical parameters of surface water

Findings in this study reveal that surface water samples both up-stream and down-stream from the river are within the permissible limit as prescribed by FME of Nigeria. Prior to the findings, it was made clear that the river water from the locality is not contaminated as a result of barite mining (see Table 4.2). This may

be due to the distance of the mining sites from the available river.

The FME limit of temperature is 40°C which is higher than the sampled water temperature value of 28.4°C upstream and 28.3°C of the downstream water temperature. The pH levels of 6.8 for both upstream and downstream fell within the permissible limits of 6-9. The conductivity level of the sample upstream is 81.1 µS/cm and that of the downstream is 83.8 µS/cm. These values are far below the permissible limit of 1000 as prescribed by FME. The salinity permissible limit is 0.1mg/l, depicting suitability, as the downstream and upstream surface water quality were at 0.04mg/l respectively. The total dissolved solid upstream and downstream were 58.9mg/l and 60.4mg/l which are far below the permissible limits of 1000mg/l making the water upstream and downstream suitable with reference to total dissolved solid. Nitrate, sulphate, phosphate, iron, tin, zinc, copper, cyanide, cadmium, chromium, total hardness, calcium, magnesium, manganese and nickel also fell within the permissible limits of FEM declaring the water suitable for consumption.

Table 2: Physical/Chemical parameters of Surface Water

S/N	PARAMETERS (units in mg/l)	UPSTREAM		DOWNSTREAM		FME LIMIT
		Results	Remark	Results	Remark	Standard Limit
1	TEMPERATURE (°C)	28.4	Permissible	28.3	Permissible	<40
2	pH	6.8	Permissible	6.8	Permissible	6-9
3	CONDUCTIVITY (µS/cm)	81.1	Permissible	83.8	Permissible	1000
4	SALINITY (%)	0.04	Permissible	0.04	Permissible	0.1
5	TOTAL DISSOLVED SOLID	58.9	Permissible	60.4	Permissible	1000
6	NITRATE (NO ₃)	0.054	Permissible	0.055	Permissible	20
7	SULPHATE	8.7	Permissible	9.2	Permissible	500
8	PHOSPHATE	0.055	Permissible	0.059	Permissible	5
9	IRON	0.158	Permissible	0.16	Permissible	1.5
10	TIN	0.026	Permissible	0.03	Permissible	<1
11	ZINC	0.004	Permissible	0.004	Permissible	<1
12	COPPER	0.142	Permissible	0.142	Permissible	<1
13	CYANIDE	0.022	Permissible	0.023	Permissible	<1
14	CADMIUM	0.035	Permissible	0.037	Permissible	<1
15	CHROMIUM	0.028	Permissible	0.028	Permissible	<1
16	TOTAL HARDNESS	17.12	Permissible	24.24	Permissible	200
17	CALCIUM	17.12	Permissible	17.12	Permissible	150
18	MAGNESIUM	ND	Permissible	17.12	Permissible	50
19	MANGANESE	0.015	Permissible	0.015	Permissible	0.2
20	NICKEL	0.038	Permissible	0.039	Permissible	<1

Source: Researcher Analyzed Water Samples 2016

Results of physical/chemical parameters of underground water

Findings from the fourteen underground water samples collected in this study area indicate that the concentration of temperature, pH, conductivity, total dissolved solid, nitrate, sulphate, phosphate, iron, manganese, nickel, cyanide, tin, zinc, chromium and cadmium are all within the permissible limit as prescribe by the Federal Ministry of Water Resources.

The copper content of all the samples except Sample 1 fell within the permissible limit which is 0.1mg/l; the result of sample one is 0.137mg/l (see Table 2). Copper is an essential element for living organisms, including humans, and small amounts of it in our diet are necessary to ensure good health. However, too much copper as observed in sample one can cause adverse health effects such as vomiting, diarrhea, stomach cramps, and nausea. It has also been associated with liver damage and kidney disease. Though, the human body has a natural mechanism for maintaining the proper level of copper in the body. However, children under one year old who have not yet developed this mechanism, are more vulnerable to the toxic effects of copper. People with Wilson's disease also have a problem with maintaining the proper balance of copper in the body and also exercise care in limiting their exposure to copper. Childhood Cirrhosis is associated with excessive copper concentrations which can get into children through contaminated water (Nirmal *et. al.*, 2011; Ishaya *et. al.*, 2016). The copper content of most of the underground water does not exceed prescribed requirements, although concentrations can be higher in well water and in hard water where mining activities takes place.

The total hardness of the fourteen underground water samples reveals that only Sample 3 with a value of 171.2mg/l, Sample 10 with a value of 188.3mg/l and Sample 11 with value of 171.2mg/l fell below 200 the permissible limit of the Federal Ministry of Environment (see Table 2). The remaining eleven water samples containing total hardness of the underground water were revealed to be unwholesome for consumption, with values of 205.5mg/l for Sample 1; 222.6mg/l for Sample 2; 239.7mg/l for Sample 4; 222.6mg/l for Sample 5; 205.5mg/l for Sample 6; 222.6mg/l for Sample 7; 205.5mg/l for Sample 8; 239.7mg/l for Sample 9; 239.7mg/l for Sample 12; 222.6mg/l for Sample 13 and 205.5mg/l for Sample 14 (see Table 2). It has been suggested that exposure to hard water is a risk factor that could exacerbate eczema in human. High levels of total hard water increases soap usage and leaves on the skin or on clothes soap salt residues that are not easily rinsed off and that lead to contact irritation (Thomas and Sach, 2000; Langan, 2009; Abaje, *et. al.*, 2009). Consistent with the findings of this study, water supplies from groundwater around solid minerals mining often encounter significant levels of hardness (Langan, 2009).

The Calcium content of all the fourteen water samples is above the permissible (150mg/l) limit of the Federal Ministry of Environment, with values of 171.1 mg/l for Sample 1; 188.3mg/l for Sample 2, 154.1mg/l for Sample 3; 188.3mg/l for Sample 4 and 5; 171.2mg/l for Sample 6; 188.3mg/l for Sample 7 and 8; 205.6mg/l for Sample 9; 154.1mg/l for Sample 10; 154.1mg/l for Sample 11 and 188.3mg/l for Samples 12 and 13; with Sample 14 having a value of 171.2mg/l (see Table 2). To a great extent, individuals are protected from excess intake of calcium by a tightly regulated intestinal absorption and elimination mechanism through the action of 1,25 dihydroxy vitamin D, (the hormonally active form of vitamin D). When more calcium is absorbed than is needed, excess is excreted by the kidney in healthy people who do not have renal impairment. Concern for excess calcium intake is directed primarily to those who are prone to milk

alkali syndrome (the simultaneous presence of hypercalcaemia, metabolic alkalosis and renal insufficiency) and hypercalcaemia. Although calcium can interact with iron, zinc, magnesium and phosphorus within the intestine, thereby reducing the absorption of these minerals, available data do not suggest that these minerals are depleted when humans consume diets containing calcium above the recommended levels (Langan, 2009; Ishaya *et. al.*, 2014).

The magnesium content of two underground water samples (Samples 4 and 12) is above the permissible limit of 50mg/l. Sample 4 has a magnesium content of 51.4mg/l while Sample 12 has magnesium content of 51.4mg/l (see Table 2). Excess magnesium causes hypermagnesaemia, associated with a significantly decreased ability to excrete magnesium. Increased intake of magnesium in water may cause a temporary adaptable change in bowel habits (diarrhoea), but seldom causes hypermagnesaemia in persons with normal kidney function. Drinking water with high magnesium can have a laxative effect, although research suggests that consumers adapt to these levels as exposure continues. Laxative effects have also been associated with excess intake of magnesium in water (Langan, 2009, Ishaya and Abaje; 2009).

The laboratory results for total hardness and calcium content from underground water samples show some similarity with those for both total hardness and calcium glaringly exceeding the permissible limit prescribed by FME. The source of the calcium and total hardness is undoubtedly the barite mining within the drainage basin. The high amount of calcium in the form of carbonate usually results in the hardness of the water from the mining ponds. Temporarily the hardness of the water is removed by boiling. This has economic implications for users of the underground water for laundry purposes, as much money will be spent on soap and boiling to soften the water (Ndinwa and Ohwona, 2014).

Table 3. Physical/Chemical Parameters of Underground Water (Borehole)

S/N	PARAMETERS (units in mg/l)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	FME LIMIT
1	TEMPERATURE (°C)	32.7	32.6	32.6	32.7	32.6	32.7	32.7	32.6	32.8	32.8	32.7	32.7	32.6	32.7	<40
2	pH	6.4	6.5	6.4	6.6	6.5	6.4	6.7	6.6	6.4	6.3	6.6	6.8	6.5	6.5	6.5-8.5
3	CONDUCTIVITY (µS/cm)	584	582	579	577	585	588	591	584	544	564	568	559	588	581	1000
4	SALINITY (%)	0.33	0.34	0.35	0.32	0.34	0.35	0.34	0.33	0.33	0.35	0.34	0.31	0.36	0.34	0
5	TOTAL DISSOLVED SOLID	457	463	395	455	468	511	503	467	484	489	454	520	411	488	1000
6	NITRATE	0.039	0.037	0.038	0.039	0.035	0.035	0.033	0.037	0.038	0.037	0.036	0.038	0.038	0.036	10
7	SULPHATE	7.7	10.6	8.7	7.6	7.5	8.9	9.2	9.1	8.8	8.6	8.5	7.9	8.1	7.8	500
8	PHOSPHATE	0.046	0.043	0.045	0.042	0.044	0.046	0.045	0.046	0.043	0.043	0.042	0.044	0.045	0.044	5
9	IRON	0.109	0.111	0.108	0.107	0.110	0.109	0.110	0.109	0.108	0.112	0.111	0.101	0.113	0.111	1.5
10	COPPER	0.137	0.021	0.021	0.021	0.019	0.021	0.021	0.022	0.021	0.021	0.021	0.021	0.021	0.02	0.1
11	TOTAL HARDNESS	205.5	222.6	171.2	239.7	222.6	205.5	222.6	205.5	239.7	188.3	171.2	239.7	222.6	205.5	200
12	CALCIUM	171.2	188.3	154.1	188.3	188.3	171.2	188.3	188.3	205.6	154.1	154.1	188.3	188.3	171.2	150
13	MAGNESIUM	34.24	34.24	17.1	51.4	34.3	34.3	34.4	17.2	34.3	34.3	17.1	51.4	34.3	34.3	50
14	MANGANESE	0.026	0.022	0.022	0.021	0.023	0.021	0.02	0.022	0.021	0.020	0.021	0.021	0.019	0.02	0.2
15	NICKEL	0.029	0.028	0.029	0.025	0.026	0.026	0.028	0.025	0.026	0.027	0.028	0.028	0.025	0.028	<1
16	CYANIDE	0.022	0.02	0.02	0.019	0.02	0.018	0.021	0.02	0.021	0.019	0.02	0.02	0.018	0.019	<1
17	TIN	0.025	0.019	0.016	0.021	0.021	0.02	0.019	0.01	0.014	0.012	0.011	0.011	0.016	0.022	<1
18	ZINC	0.001	0.031	0.019	0.018	0.027	0.022	0.023	0.024	0.023	0.023	0.034	0.023	0.024	0.017	<1
19	CHROMIUM	0.022	0.024	0.025	0.021	0.021	0.021	0.022	0.021	0.021	0.020	0.018	0.02	0.019	0.019	<1
20	CADMIUM	0.029	0.028	0.027	0.032	0.025	0.029	0.031	0.031	0.03	0.029	0.029	0.024	0.029	0.028	<1

Source: Researcher Analyzed Water Samples 2016

Conclusion and Recommendation

This study aimed at examining the impact of barite mining on surface and underground water quality in Azara-Awe Local Government Area, Nasarawa State of Nigeria. The study concludes that the mining of barite has not increased the concentration of heavy metals in the surface water both upstream and downstream of the mining sites as the values of heavy metals from the two sources are within the permissible limit prescribed by FME of Nigeria. The calcium content of all the underground water samples is above the permissible (150mg/l) limit prescribed by the FME. The total hardness of the fourteen underground water samples reveal that only three samples (Samples 3, 10 and 11) fell within the permissible limit of FME, while the magnesium content of two of the underground water samples (Samples 4 and 12) are above the permissible limit of 50mg/l prescribed by the FME of Nigeria. The study concludes that barite mining in Azara-Awe Local Government of Nasarawa State in Nigeria has not increased the concentration of heavy metals in surface and underground water.

This notwithstanding, there is still the need to monitor the situation year after year and encourage the conversion of abandoned mining ponds into fishing ponds. This has the capacity of diversifying the economic base of the miners and communities around the mining sites.

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