

Effects of Baryte 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 baryte 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 it for laboratory test. The analysis was carried out at 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, depicts that all the parameters are within the permissible limits, except sample one of which the copper content 0.137mg/l is above the permissible limit of 0.1mg/l. Sample 10 and 11 out of the 14 samples fell within the permissible limit of the total hardness, while sample 4 and 12 out of the 14 samples are above the permissible limit of 50mg/l of Magnesium content. It pertinent to introduce sustainable measure in the process of baryte mining activity to reduce its impacts on underground water quality. There is need for advocacy campaign to enlighten artisanal baryte miners on the direct link between their operations and environmental degradation.

Keywords: Baryte, Mining, Water Quality, Heavy Metals.

INTRODUCTION

Globally, the mining sector plays significant role on income generation, employment, economic growth and development (Jerome, 2003; Oelofse *et al.*, 2008). Mining, however, poses major threats and hazards that can jeopardize ecosystems of nations. Mining operations completely alter ecosystems by disrupting the ecological balance, water resource quality, wildlife's, natural landscapes, agricultural lands, vegetation as well as economic tree crops(Ojo and Adeyemi 2003; Aigbedion and Iyayi 2007; Adegboye, 2012).

The magnitude and significance of impact on environment due to mining varies from mineral to mineral and also on the potential of the surrounding environment to absorb the negative effects of mining, geographical disposition of mineral deposits and size and method of mining A major environmental problem relating to mining in many parts of the developing world is uncontrolled discharge of contaminated

water (or decant) from abandoned mines operations (Ranjna *et al.*, 2013).

Baryte is the chief constituent of lithopone paint and it is also extensively used as an inert volume and weight filler in drilling mud, rubber, glass, paper and highly used in several chemical industries. Veins of barites up to 1.8m wide and more than a kilometer long are associated with lead zinc lodes in many parts of Nasarawa State. The principal known occurrences are at Azara, Alosi, Akiri, Wuse and Keana. Reserves of about 100,000 tons of good-quality barites have been proved more recently in the Azara area by the Nigerian Mining Corporation in this area, and 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).

Baryte was first detected in Azara in the early 1960s (Courtesy of Geological Survey of Nigeria, 1965). The Nigeria Baryte Mining and Processing Company (NBMPC) Ltd., incorporated

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in 1988 was charged with the exploration and exploitation of baryte in Azara and any part of Nigeria where baryte 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. Out of these eighteen (18) veins, detail 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 baryte (Oelofse *et al.*, 2008). The mining of baryte at Azara, apart from farming provides good source of income to the inhabitants of Azara communities and almost 80% of the total national demand of baryte comes from Azara (Obaje *et al.*, 2006).

Contaminants and toxic compounds from mining activities jeopardizes quality of surface and underground water by making it unsafe for drinking and industrial usage, disturbing the hydrology of the area (Roy *et al.*, 2003). In Africa (Nigeria inclusive), poverty coupled with poor policy frameworks to address mining activities and the mining industry is a major threat to environmental sustainability (Oelofse, and Turton, 2008). With the increasing number of artisan's miners in Africa, water quality have been polluted due to contamination (Oelofse and Turton, 2008). The release to the environment of mining waste can result in profound irreversible destruction of ecosystem. In many cases the polluted sites may never be fully restored, for pollution is so persistent that there is no available remedy (EEB, 2000).

Due to improper planning and negligence on mining regulations, an appreciable amount of environmental degradation and ecological damage to water occurs in almost every mining site in Nigeria. The key questions are whether

surface and groundwater supplies will remain fit for human consumption, and whether the quality of water in mining sites will remain adequate to support human and wildlife (Anirudha, 2005). Baryte can dissolve in water and, when dissolved, can cause an environmental and health hazard (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 as component. In most developing countries like Nigeria, underground and river water has remained a major source of water to the teaming population of the people in the rural areas. Baryte mining affects quality of water resources, both surface and groundwater, at various stages of the life cycle of the mine and even after its closure of the mine (Younger *et al.*, 2002; Ifatimehin, Kolawale, and Ishaya, 2008).

Estimation of the 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 in Nasarawa State. The state is within the Middle Benue Trough of Nigeria and lies between latitude $7^{\circ} 45'$ and $9^{\circ} 25'$ N of the equator and between longitude 7° and $9^{\circ} 37'$ E of the Greenwich meridian (Obaje, 2006). Azara mining site is located in Awe Local Government Area of Nasarawa State and has geographical coordinates $8^{\circ} 22'$ North, $9^{\circ} 15'$ East and has an altitude of 181.5m Above Sea Level (Obaje, 2006).

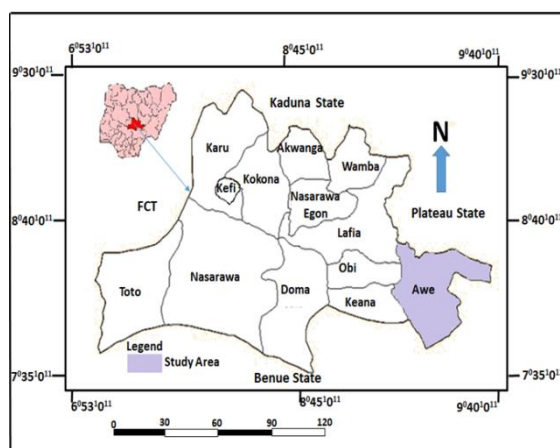


Figure 1. Map of the Study Area

The study area is geomorphologically within the upward Awe formation which consists of transitional sandstone, shale, siltstone and limestone and the fluvial 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 baryte 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.*, 2008).

Temperature in the study area is generally high partly because of its location in the tropical sub-humid climatic belt. 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 brings about a noticeable decline in temperature in the study area. This is made possible by the blanket effect of cloud cover over the area. The cessation periods of rainfall is by October ending 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%. At this period, the southern part of the state is coming under the influence of the humid maritime air mass. By August when the Inter Tropical Discontinuity (ITD) is at its tropical maritime wind (MI).

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 associated to 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 for 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 Hausa are petty traders. The Ibo and Yoruba are mainly traders in utensils, automobiles and building materials particularly in the local government headquarter and villages.

METHODOLOGY

This study centres around the assumptions that the mining of Baryte at Azara-Awe of Nasarawa State has no effects or pollution on water quality and there is no significant implication(s) of baryte mining on water quality. A reconnaissance survey was carried out to select the appropriate sites of the study. Information collected during this survey includes the various baryte deposit sites, mining sites, ponds generated as a result of the mining activities.

Method of Water Sample Collection and Analysis

The basic materials and equipment's 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 to reduce contamination. After collection, nitric acid (0.2%) was added as a preservative. The samples were marked and labeled after the source of water, sampling location and date of water sample collection. The collected samples were preserved in 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). pH of the water samples was determined in-situ during samples collections.

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Table1. 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

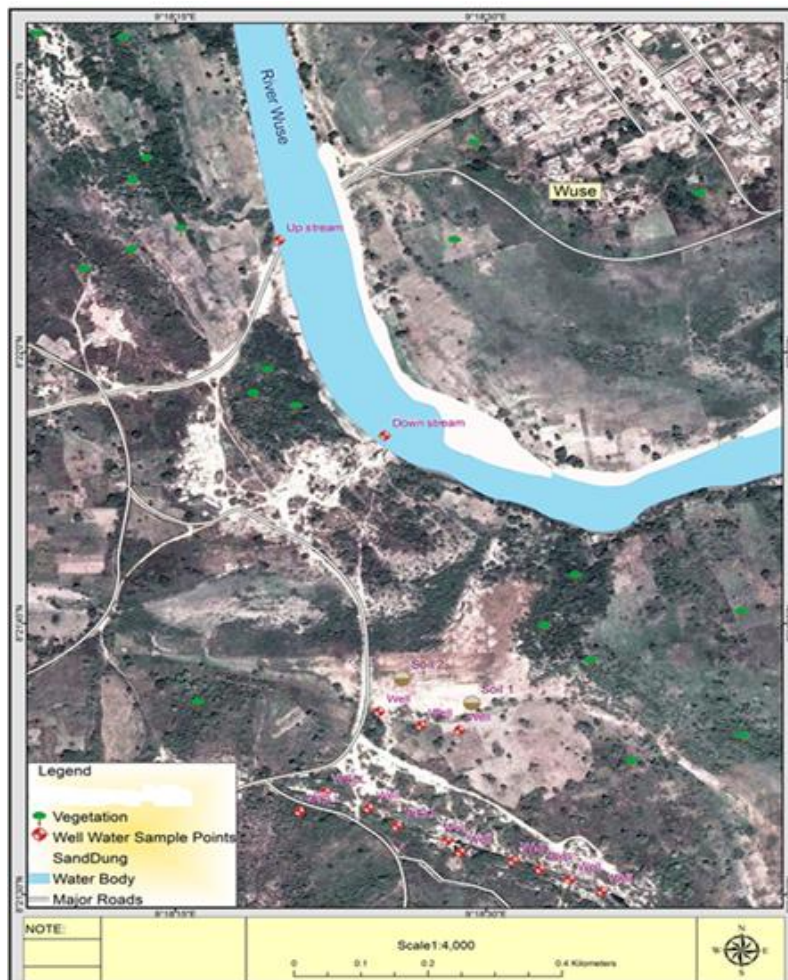


Figure2. Map of study area depicting water sampling points

Water Samples' Analyses

Apart from the pH measurement that was done in-situ, all other analysis were done using Aanalyst100 (Perkin-Elmer) spectrophotometer located at the Analytical Laboratory of the

National Metallurgical Development Agency, Jos Nigeria. Each of the collected samples were 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 are not contaminate, all the glassware and plastic containers used for the analyses were treated with nitric acid and rinsed with distilled water. Quality assurance and control was performed according to the specified method of Soylak *et. al.*, 2002a). Determinations of Chemical Oxygen Demand (COD), sulfate, carbonates, silicates and heavy metals were done according to standard analytical methods described by APHA (2005).

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.

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 Aanalyst100 (Perkin-Elmer) spectrophotometer. The machine was equipped with an HGA-800 furnace and an AS-72 autosampler. All lamps used were hollow cathode multi-element lamps, except for As, Cd and Pb.

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 Cland SiO_2 (Akan *et. al.*, 2009) and spectro photolorimetry for NH_4^+ (Sharma, 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 sulfate anions was based on standard methods (APHA-AWWA-WEF, 2005). To do that, thirty drops of NaOH (1:1 mvm)

were added to 50 ml of sample. The solution was shaken for 2 min in order to precipitate Mg (OH). 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 let aside for 1 min 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.

RESULTS

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, cynide, tin, zinc, chromium, cadmium.

Result of Physical/Chemical parameters of Surface Water

Findings in this study reveals that surface water samples both up-stream and down-stream from the river are within the permissible limit as prescribe FME of Nigeria. Prior to the findings, it is clear that the river water from the locality is not contaminated as a result of baryte mining (See table 4.2). This may likely be due to the distance of the mining sites from the available river.

Results of Physical/Chemical parameters of Underground Water

Findings from the fourteen underground water samples collected in this study area depicts 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 one fell within the permissible limit. The permissible limit as prescribe by FME as 0.1mg/l while the result of sample one is 0.137mg/l. Copper is an essential element for living organisms, including humans, and-in small amounts-necessary in our diet 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 it. However, children under one year old that have not yet developed this mechanism, as a result, 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 and should also exercise particular care

in limiting exposure to copper. Childhood Cirrhosis associated with excessive copper concentrations (Nirmal *et. al.*, 2011; Ishaya *et. al.*, 2016). The copper content of most of the underground water does not exceed prescribe requirements, although concentrations can be higher in well water and in hard water where mining activities takes place.

Table4.1 Physical/Chemical parameters of Surface Water

S/N	Parameters (units in mg/l)	Up-Stream		Down-Stream		Fme Limit Standard Limit
		Results	Remark	Results	Remark	
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

The total hardness of the fourteen underground water sample reveals that only two samples (samples 10 and 11) fell within the permissible limit of the Federal Ministry of Environment. The remaining twelve water samples content total hardness of the underground water depicts unacceptability for consumption. Exposure to hard water has been suggested to be a risk factor that could exacerbate eczema on human. High level of total hard water increases soap usage or increases soap salt residues on the skin or on clothes that are not easily rinsed off and that lead to contact irritation (Thomas and Sach, 2000; Langan, 2009; Abaje, *et. al.*, 2009). In agreeing with the findings of this study, water supplies from groundwater around solid minerals mining often encounter significant levels of hardness (Langan, 2009, Ishaya and Abaje, 2009).

The Calcium content of all the fourteen water samples are above the permissible (150mg/l)

limit of the Federal Ministry of Environment. To a great extent, individuals are protected from excess intakes of calcium by a tightly regulated intestinal absorption and elimination mechanism through the action of 1,25 dihydroxyvitamin D, the hormonally active form of vitamin D. When calcium is absorbed in excess of need, the 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).

Magnesium content of two underground water samples (samples 4 and 12) are above the permissible limit of 50 mg/l. Sample four has magnesium content of 51.4 mg/l while sample 12 has magnesium content of 51.4mg/l. Excess magnesium causes hypermagnesaemia associated with a significantly decreased ability to excrete magnesium. Increased intake of magnesium in water may cause a temporal 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 suggest that consumers adapt to these levels as exposures continue. Laxative effects have also been associated with

excess intake of magnesium in water (Langan, 2009, Ishaya and Abaje; 2009).

There was significant similarities between total hardness and calcium glaringly exceeded the permissible limits as prescribe by FME. The source of the calcium and total hardness are undoubtedly the baryte mining within the drainage basin. The high amount of calcium in the form of carbonate usually result to the hardness of the water from the mining ponds. Temporally the hardness of the water is removed by boiling the water. This will impact economically on the 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).

Table4.2. 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	22.6	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

CONCLUSION

The study aimed at ascertaining the extent of baryte mining pollution on water quality in Azara-Awe Local Government Area of Nasarawa State of Nigeria. This study has examined the impact of artisanal mining of baryte water quality. The study conclude that surface water samples both up-stream and down-stream from the river are within the permissible limit as prescribe Federal Ministry of Environment of Nigeria. Temperature, pH, conductivity, total dissolved solid, nitrate, sulphate, phosphate, iron, manganese, nickel, cyanide, tin, zinc, chromium and cadmium concentration from the fourteen underground

water samples were all within the permissible limit as prescribe by the Federal Ministry of Environment of Nigeria..

The copper content of all the samples except sample one fell within the permissible limit. Too much copper as observed in sample one can cause adverse health effects, including vomiting, diarrhea, stomach cramps, and nausea. The total hardness of the fourteen underground water sample reveals that only two samples (samples 10 and 11) fell within the permissible limit of the Federal Ministry of Environment. Twelve of the underground water samples contain total hardness unacceptability for consumption and exposure to hard water exacerbate factor that

could lead to eczema on human. Calcium content of all the underground water samples are above the permissible (150mg/l) limit of the Federal Ministry of Environment. Excess consumption of calcium affects kidney excretion. Magnesium content of two of the underground water samples (samples 4 and 12) are above the permissible limit of 50mg/l. Excess magnesium causes hypermagnesaemia associated with a significantly decreased ability to excrete magnesium.

RECOMMENDATIONS

The following recommendations were made based on the findings of this study;

- It is pertinent to introduce sustainable measure in the process of baryte mining activity to reduce its impacts on underground water quality.
- There is need for advocacy campaign to enlighten artisanal baryte miners on the direct link between their operations and environmental degradation.
- In addition, regulatory government agencies should provide extension services such as training on mining and environmental/safety issues.

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