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REVIEW

Impact of Past Mining Activities on Water Resources Around Active and Abandoned Mines and Quarries in Ebonyi State, South-Eastern Nigeria - A Mini Review

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ABSTRACT

This paper presents a review on previous activities of mining on water resources around active and abandoned mines/quarries across Ebonyi State, South-Eastern, Nigeria. As high demand for water increases due to population growth and rapid development across the state, it is of upmost importance to periodically review water quality and also monitor water resources. However, less information is available on evaluation of impact on mining activities on water resources. For the purpose of this research, related articles were downloaded from Google, published article on effect of mining on water resources was download and thoroughly studied to evaluate effect of mining on water resources of the study area. Findings revealed that past mining activities has lead to chains of complex chemical reactions that has altered the quality of water resources.

1. Introduction

The southern portion of Benue Trough is richly blessed with various mineral deposits. These mineral deposits cuts across each zone of the study area ranges from: (1) lead-zinc at Abakaliki, Ameka, Amorie, Mkpuma Akpatakpa, Amanchara and Alibaruhu and Enyigba in the form of their ores of sphalerite and galena respectively often associated with barytes mineralization of the southern Benue Trough sediments that it is primarily made up of four lodes namely; Ishiagu, Ameri and Ameki Enyigba (Figure 1a) (2). the abandoned limestone quarry at Nkalagu area that occur within the Turonian age of the Eze-Aku Formation (Figure 1b) (3) Salt/Brine that occur within Cretaceous rocks at Uburu, Okposi and Abakaliki (4) limestone quarry that occur at Umuoghara and others. The open cast and underground mining is used in mining of the above listed minerals, the presence of these mineral has attracted attention of both local and international investors. Mining of these minerals date back to 1925 [1], for example, lead-zinc mineral was exploited by a German mining company before the Nigerian civil war. The company employed open cast mining and the galena and sphalerite were beneficiated at the site by differential floatation using xanthate collector [2]. Mining within the study area occur in large and small scale, these activities has left most mining areas with abandoned mines pits, whose ephemeral runoffs are captured by short-lived streams that flows into the river and infiltrate into aqui-

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fer system. In the same vein, it has also caused series of ecohydrological and environmental problems, which have drawn attention from the public, the government and academia [3]. Previous scholar were of the view that mining activities within the study area has altered the quality of water resources and that of soil [4-10]. The effect of mining activities on water resources arise at different phase of the mining cycle, the mining processes, the mineral processing and operational stage. Globally, mining activities is one of the major activities that cause decline in water quality and most of the mining areas are faced with seious problems related to potable water both in terms of quantity and quality [11]. Generally, in the course of mining operation, huge quantities of water are generated and discharged into natural drainages without any beneficial use, leaving these areas as water deficit. In most cases, the discharged mine water were considered unsuitable for drinking purpose with presence of heavy metals that are in high concentrations, these mine water is referred to Acid Mine Drainage (AMD). [12] describe AMD as a chemical process developed due to oxidation of sulfide minerals under humid conditions, though it involves range of complex chemical reactions, geochemical, biochemical and physiochemical processes determined by local geology and geomorphology features. These processes often lead to acid mine generation alongside with several preventive and enhancing factors. [12] further pointed out that AMD is accepted as the principle water contaminant facing the mining industry. It is like a household name associated with different kind of mines. AMD can easier travel long distances causing a range of e ects that may persist for decades [8]. AMD in abandoned and active mine are influenced by several factors such as the hydrology, hydrogeology, mineralogy, geology, climate conditions and topography. It is related to the geographical conditions within the mine and is site specific. Research carried out within the area suggested that mining activities has greatly affected water quality within the mine and quarries areas [13-17], for more on this see Table 1. Although different scholar have carried out research around active and abandoned mines in Ebonyi, to best of our knowledge larger percentage of their research were geared towards assessment of effect of mining activity on soil and heavy metals released from mining activities with emphasis on its absorption/intake in human and its effect on human. The aim of this paper is to discuss a synoptic overview of effect of past mining activities on water resources of study area.

Figure 1a. Lead-zinc mine at Enyigba mining site

Figure 1b. Limestone quarry site at Nkalagu

Table 1. Previous research on mining activities and its effect on water resources around mines across the study area

Author(s)	Location	Geology	Field of study	Geochemical Characterization/Water type
[17]	Nkalagu	Asu River Group (ARG) / Eze Aku Formation (EAF)	Groundwater Analysis	(Cl^{-}-SO_4^{2-}) is the dominant facies
[8]	Ebonyi state	ARG/EAF	Groundwater Analysis	Ca^{2+} +Mg^{2+} + Cl^{-} (Water type)

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[18]	Umuoghara	ARG	Groundwater Analysis	$Ca^{2+}+Mg^{2+}+Cl^{-}$ (Water type)
[19]	Ameka	ARG/EAF	Groundwater and surface water analysis	Not specified
[13]	Mkpuma Ekwaoku	ARG	Groundwater and surface water analysis	Not specified
[15]	Mkpuma Ekwaoku	ARG	Groundwater Analysis	TH classification (Soft and hard water type)
[20]	(1)Akpala, Ohinya Ezza and Eziekwu river (2)Groundwater sample was collected at Ebia, Ogboji and Akaeze areas	ARG/EAF	Groundwater and surface water analysis	Not specified
[21]	(1)Okposi (2) Uburu	ARG/EAF	Groundwater and surface water analysis	Water resources were classified into three group: (1)Calcium bicarbonate (2) Sodium chloride and (iiii)Sodium/potassium bicarbonate
[23]	Amachara	ARG	Groundwater and surface water analysis	Rock water interaction (mineral dissolution)
[17]	Umuoghara	ARG	Groundwater	(1)Rock water intraction (2)$Ca^{2+}>Mg^{2+}>-Cl->SO_4^{2-}>Na^{+}+K+>HCO_3^{-}$ water trend (3)$Na^{+}-SO_4^{2-}$ **water type**
[10]	Enyigba, Mkpuma Akpatakpa, Ameka, Amorie, Amanchara and Alibaruhu.	ARG/EAF	Groundwater and surface water analysis	
[23]	Enyigba	ARG		Not specified

2. Location and Physiography

The study area is accessible through various networks of roads see Figure 2. The two major seasons that exist in the study area is the wet and dry seasons. The wet season spans from March to ending of October, while the dry season spans from October to ending of February, with temperature range of 25 and 29°C between the dry season and 16° and 28°C during the rainy season. While the average monthly rainfall ranges from 3.1 mm in January and 270 mm in July [8].The annual rainfall of the study area ranges from 1750 to 2250 mm. [8] was of the view that the climate of the area tends to support pollution from the mining and quarry activities. It was observed that surface runoff that transport the pollution and also assist infiltration of water is caused by high amount of rainfall. The study area lies within the rainforest region of southeastern Nigeria, with evergreen vegetation and humid climate. The area comprises of vegetation with underground creepers and thick trees in most rural areas [8]. Most of the trees are tall in some locations, with buttress roots around river bodies, while the vegetation is influenced by various factors these include; geology, drainage, rainfall and topography. [24], further pointed out that the study area lies within the low land rainforest region. The drainage system of the study area is dendritic, the major river that drain the study area is the Ebonyi River with other tributaries such as the Iyiodu and Ngada rivers control the drainage with the underlying lithology [8,16].

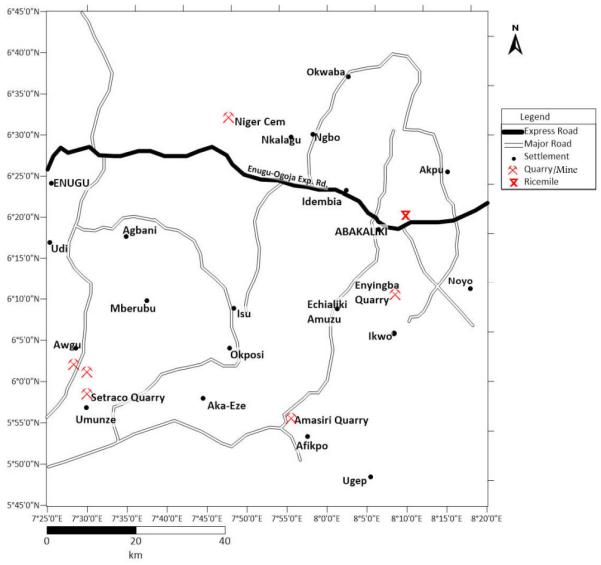

Figure 2. Location Map of Showing active and abandoned mine in the study area

3. Geology of the Study Area

The study area is lies within the southern Benue Trough with a sedimentary succession of pre-Santonian periods that span from Albian and Turonian age see Figure 3 and Table 1. The Asu River Group of the Albian age is represented by [25] with two formations Abakaliki and Ebonyi Formations that underlie it [26]. [26] stated that the lithofacies of Asu River Group consists of alternating shales and siltstones with presences of fine grained micaceous and feldspathic sandstones, mudstones, and limestones. [28]

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were of the view that there have been reports of intrusions of magmatic rocks ranging from basic/intermediate igneous rock within the Ishiagu area. [29,30] also reported pyroclastic intrusions within the Abakaliki area. The Eze Aku Group is Turonian in age, according to [31] it unconformably overlies the Asu River Group in the study area. It includes all the lithostratigraphic units deposited in the late Cenomanian to Turonian age of the southern Benue Trough [31] which includes the the Nkalagu limestone, Eze-Aku shales and Amasiri sandstone. [32,33] were of the view that integration of magmatism, tectonism and diagenesis trigged major alteration of chemical constituents of rocks within the area, thereby baking them and leading to their common use as construction materials [34-36]. [37,38] stated that lead-zinc minerals occur in veins as open space-fillers within en echelon, tensional, and steeply dipping fracture systems and that in the dark-gray to black shales of the Asu River Group also encouraged their rampant excavation.

Table 1. Stratigraphic table of the study area (Modified after, [39])

Period	Age	Group	Formation	Member
Cretaceous	Tournian	Eze-Aku	Nkalagu Eze Aku shales	
	Albian	Asu River	Abakaliki Volacnics	Pycroclastics Dolerites/doiorities
			Asu River shales	Shales and sandstones
Precambrian Basement Complex				

4. Method of Investigation

Articles published within the last 4-10 years were reviewed to assess the effect of past mining activities around active and abandoned mines on water resources of the study area, and also to reduce water resource pollution. [40,41] methods was adopted for this study. Article related to this study were searched by google search engines, open access journal sites (SCOPUS, Pub-Med, Taylor Francis, Elsevier and Springer etc.). These relevant articles and papers were studied in full and information gotten was stored in the database with details of publication particulars, study location, period, approach, methodology for assessing past impact of mining activities as shown in Table 1. The results of impact past mining activities on water resources was captured, and conclusion drawn out. And further, to interpret the status and quality of research carried out within the study area, [40] method was employed for this study with some modifications to suit the aim and objectives of this paper. The steps that were adopted to evaluate the effect of mining and quarrying on water resource quality included the following;

(1) Evaluation of AMD/hydrogeochemical processes that influence water resource

(2) The type of water facies that exist within the study area.

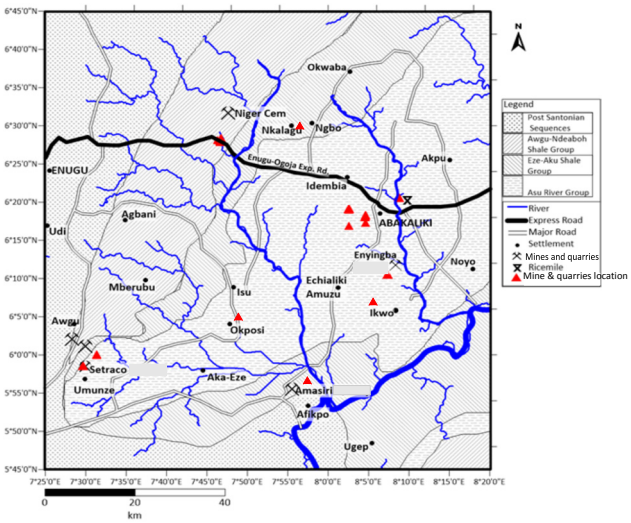

Figure 3. Geology Map of the Study Area

Source: [8]

5. Result and Discussion

The impact of past mining activities was evaluated by reviewing previous published literature within the area, with emphasis on hydrochemical processes and water quality.

5.1 Acid Mine Drainage and Hydrogeochemical Processes

For better understanding of impact of past mining activities/AMD on water resources within the study area, it is of upmost importance to first discuss briefly the geochemical processes that generate and neutralize acid drainage (summarized by [42], and references therein). [10] conducted a study on impact of lead-zinc mining on water resources of Enyigba, Mkpuma Akpatakpa, Ameka, Ameri, Amanchara and Alibaruhu. Water sample was collected within the area with the aim of evaluating its health risks on inhabitant of the area. Findings from their research revealed that lead concentration was high around active mines and they further attributed the high concentration of lead to mineralization process of lead. They also stated that pH fell within acidic to basic range, and that acidic water exist around the mine area and in turn contribute to AMD within the area. They were of the view that water resources of the area are considered unfit for domestic

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use. [8] investigated groundwater quality around active and abandoned mine across Ebonyi state, they stated that mining and quarrying activities generate AMD within active and abandon mines. Their findings pointed out that pH of groundwater within the area were considered more acidic than basic especially around mines, and that groundwater was of $Ca^{2+}+Mg^{2+}+Cl^{-}$ water type which means that groundwater is considered to be permanently hard. The permanent hardness of groundwater was attributed to high concentrations of Mg and Ca ions in groundwater. [8] further pointed out that values obtained from TDS showed that groundwater fell within fresh water category. [16] studied groundwater quality within abandoned Nkalagu limestone quarry, Ebonyi state Nigeria. A total of 13 groundwater sample was evaluated to carefully assess the influence of past mining activities on groundwater suitability for irrigation. From their findings, it was observed that 53.85% of groundwater samples were of (Cl^{-}-SO_4^{2-}) dominant, 15.38% were of (SO_4^{2-}- Cl^{-}-HCO_3^{-}) and (SO_4^{2-}-Cl^{-}) dominant, while 7.69% were of (Mg^{2+}-SO_4^{2-}-Cl^{-}-HCO_3^{-}) and (Cl^{-}-SO_4^{2-}-HCO_3^{-}) dominant type. Ionic contents revealed that Mg^{2+} dominant and SO_4^{2-}-Cl^{-} were the dominant ions in groundwater. [17] used geochemical and Source Rock Deduction (SRD) in evaluating and characterization of groundwater quality around Umuoghara limestone quarry, their findings revealed that groundwater were of $Ca^{2+}>Mg^{2+}>Cl^{-}>SO_4^{2-}>Na^{+}+K^{+}>HCO_3^{-}$ water trend. SRD showed that groundwater were of various origin, and Soltan classification revealed that groundwater were of Na^{+} - SO_4^{2-} water type.

5.2 Related Article on Water Type and Their Facies

The water resources of Ohaozara was studied by [21] their findings revealed that water facies evolution were of different types namely; calcium bicarbonate, sodium chloride and sodium/potassium bicarbonate facies that exist within the northern and southern parts respectively and that the geochemical facies of the area were linked to bedrocks. [21] were of the view that the origin of HCO_3^{-} facies were linked to carbonate rich sandstone, sandstone/siltstones that underlie the northern part of the area, while Nacl facies were linked to brine loaded bedrocks, weathered/fractured shale that lies within Okposi/Uburu area. They further stated that the dominant anions are HCO_3^{-} and Cl^{-} and dominant cation are Ca^{2+} and Na^{+}.

6. Conclusion

Mining activities around active and abandoned mines pose threat to the quality and quantity of water resources around the world. Findings from reviewed papers revealed that mining activities in the past has negatively influence water resources of the study area. It was also observed that most research carried out around the mines within Ebonyi State were based on assessment/studies of effect of mine on soil with emphasis on heavy metals. To the best of our knowledge, published research on impact of mining on water resource is limited. Emphasis is not placed on assessment of mining activities on water resources and also to determine the water facies/hydrogeochemical process around these mines sites across the study area. There is no proper water management plan around active and abandoned mine site across the Ebonyi state, Nigeria, water from these mines are often discharged without any treatment or beneficial use. However, if proper water management is adopted, the water generated during and after mining operations can be harnessed and used for domestic, industrial and irrigation purpose.

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