Water Quality as Affected by Quarry Activities in Ebonyi State, Nigeria

Odera Chukwumaijem Okafor

Ebonyi State University

Chima Njoku (✉ chimarco2001@yahoo.com)

Ebonyi State University <https://orcid.org/0000-0002-6261-7212>

Research Article

Keywords: Concentration, dissolved, pollution, quarry, solids

Posted Date: December 29th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1183204/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

The study was done in 2018, 2019 and 2020, during which quarry activities effects was determined on water qualities in Ebonyi State, Southeastern Nigeria. The following locations were selected: 0 – 50 m from quarry locations at Ishiagu, Umuoghara and Ngbo were selected with Non quarry location situated 3 km away from each location as control. Collected water samples were analysed for selected physical properties, chemical properties and heavy metal concentrations. The experimental design was carried out in a Completely Randomized Design (CRD) with F-LSD at ($p < 0.05$). The results obtained were compared with the established standards. Physical parameters studied in the sites within 0 – 50 m from quarry sites were higher than that of control and are within the recommended standards. Similarly, chemical parameters were higher the sites within 0 – 50 m from quarry sites than that of control and are within the standard, except pH in 2018 at Ishiagu and Umuoghara and pH of control in the three years of studied. Lead, cadmium and iron recorded values in sites within 0 – 50 m which were higher than that of control and the recommended standards whereas zinc observed in Ishiagu in 2018, 2019, 2019 were above standard and control. Zinc observed in Umuoghara and Ngbo were within standard but some values are either higher or lower than control. Based on the results water bodies in quarry sites should be subjected to treatment processes before domestic use to avoid ailments associated with water polluted with quarry activities.

1. Introduction

Quarrying is the process of extracting quarry materials, mainly rocks, from the ground surface or below (Banez *et al.*, 2010). Quarrying recovers non-metallic rocks and aggregates, whereas mining excavates the site for metallic mineral resources (Saha, 2011).

In developing countries like Nigeria, mineral resources exploitation is now essential commodities greatly sort for. A country like Nigeria is made up of essential resources (mineral) which have added greatly to the growth of the country's benefits, socio-economically. (Adekoya, 2003). Released dust falls not only on land, plants, and trees, but also on surface waters (Osha, 2006), generating a variety of harmful effects on the ecosystem as a whole. Water resources are also under severe strain in developing countries as a result of fast population increase and industrialization. Urbanization, industrialisation, deforestation, mining, agriculture, and energy consumption and abuse, particularly the exploitation of water bodies as sinks, all contribute to water quality degradation. Industrial and mining pollutants are dumped into bodies of water with little or no concern for the bodies' ability to absorb them. It is a common misconception that these bodies of water can be used as an endless dumping ground for rubbish. Natural purification of polluted streams takes time, and extremely polluted water might travel great distances in days before reaching a substantial level of purification (Henry and Heinke, 2005). Water pollution is a global problem that transcends national and international boundaries. Physically, physiologically, and chemically, the degrees of pollution and natural purification can be measured. The protection of aquatic life in any prospective receiving water body necessitates regular evaluations of the hydraulic and water quality characteristics of receiving water bodies (Longe and Omole, 2008). According to (Gunn and Hobbs, 2009) ground water can be affected through the passage of tiny dusty particles which can permeate through tiny holes and into the aquifer. During storm eventuality, there is tendency of debris of fine products of the marble cut affecting the ground water regime

(Drysdale *et al.*, 2001). Ground water quality can be affected by blasting of rocks which has been ascertained as the one major problem Spigner (2008).

According to the study carried out by Moore and Hughes (2009), they discovered no correlation between water quality and rock blasting in well water. If the flow of the groundwater is changed, there is tendency of polluting the groundwater systems, there is however, tendency of introduction of new area of recharge sources which may lead to water contamination. Due to pumping of groundwater, a situation may arise (Adamczyk *et al.*, 2008). Aquatic communities can be affected through release of quarry effluents, silts and other poisonous substances into the water bodies like, stream, river, pond etc (Vermeulen and Whitten, 2009). Ekmekçi (2003) in his noted that quarrying in conjunction with rock blasting can close the flow of ground water in the karst area, or lead in the change of flow rate of ground water direction and new route openings.

Environmental monitoring agencies are more effective in modern countries, and environmental rules are effectively enforced. Environmental quality monitoring is required in general, and water resource quality is monitored on a regular basis (Neal and Robson, 2000). As a result, any anomalous changes in the environment or water quality can be noticed quickly, and appropriate sanction can be taken before outbreaks spread. Many developing countries, on the other hand, have few or no environmental regulation, and those that do exist are rarely followed (Fakayode, 2005). According to Omosanya and Ajibade (2010), they noted that water bodies and aquatic environments are affected by the degrees of high particulate matters. The activities of quarrying in Ebonyi State, Southeastern Nigeria have impacted greatly on water bodies, the explosives used during rock blasting for material extraction and processing leads to release of particulate matters which causes water pollution (Guach, 2001).

Water table reduction increases the solidification of the zone, making it unsaturated, which has the tendency of altering the water PH in the unsaturated area; reverse of the biotic systems inhabiting in the rock voids; killing of the inhabitant species (Vermeulen and Whitten, 2009). Therefore, this study aimed at determining the water qualities of ponds within 0 – 50 m from quarry sites as affected by quarry activities.

2. Materials And Methods

3.1 The location of the study

The research was conducted in the 3 Senatorial Zones of Ebonyi State which consists of Ishiagu (Ebonyi South), Umuoghara (Ebonyi Central) and Ngbo (Ebonyi North) of Ebonyi State, Southeastern Nigeria. The study areas are located between latitude $05^{\circ} 03^1$ and $05^{\circ} 30^1$ N with longitude $07^{\circ} 0^1$ and $07^{\circ} 15^1$ E, latitude $05^{\circ} 51^1$ and $05^{\circ} 59^1$ N with longitude $07^{\circ} 24^1$ and $07^{\circ} 40^1$ E, latitude $05^{\circ} 52^1$ and $05^{\circ} 60^1$ N with $07^{\circ} 30^1$ and $07^{\circ} 37^1$ E. The Northern, Southern, Eastern and Western gates (Benue, Abia, Cross River and Enugu State) are the borders of Ebonyi State, with a total mass of land, 1,533 kilometres square (Egboka and Okpoko, 1984). Two primary trade winds influence climatic conditions: the warm moist southwest trade winds during the rainy season (April – October) and the dry and dusty harmathan (November – March). Dry and dusty air characterizes the dry seasons, resulting in a high evapotranspiration rate and reduced water levels. Heavy floods, soil leaching, groundwater penetration, and percolation are all hallmarks of the rainy

season. The temperature averages of the study locations were in increase with 27.1 °C, 35 °C and 31 °C for Ishiagu, Umuoghara and Ngbo, and the highest mean daily temperature of 31 °C for the year, respectively. They have bimodal rainfall patterns (April - July) and (September - November), with a brief dry spell in August known as August break. The average annual rainfall in the location is between 1250 and 2000 mm. The mean annual rainfall of the areas ranges from 1250 – 2000 mm. The wet months of Ebonyi State have a relative humidity of 90%, whereas the dry months (November to March) have a relative humidity of 60–70%. (Egboka and Okpoko, 1984).

However, trees in the study areas are of hard and soft wood which has been cut down for city beautification and improvement like road construction, buildings and mining activities with other commercial and tertiary impacts on the vegetation (Egboka and Okpoko, 1984). Therefore, the vegetation of the study locations are derived savannah as stated by Njoku and Mbah (2012).

The study locations demography was estimated to be 80,300, 13,286 and 9,570 for Ishiagu, Umuoghara and Ngbo, respectively, according to the 2006 census figure (National Population Census, 2006). However, 2021 projection were estimated to be 160,600, 26,321 and 18,690 for Ishiagu, Umuoghara and Ngbo, respectively with annual growth rate of 2.85%. Consequently, farming is the core activities of the Ishiagu, Umuoghara and Ngbo people. The few social amenities in the areas are manned by non-native and others, mostly women, work in the salt industry. Males are into production of large quantities of yam, cassava and rice respectively. Though all these men and women take part in all these occupations which is their major occupation; since no day passes without their going to farm.

Due to the establishment of tertiary institutions like Federal College of Agriculture, College of Health Technology and Seminary schools, Ishiagu, Umuoghara and Ngbo are now one of the commercial hubs in the state. These have created activities such as banking, petty trading, quarrying etc in those locations.

The location have become a rapidly growing areas with percentage of migrant settlers like (Hausa, Yoruba) etc and also infiltration of students in the localities. The major water bodies in the study sites are the Ikwo stream, Udaokpuru-Achi stream and Okpuru-Ngba Stream. The area belongs to derived savannah agro-ecology zone of Nigeria and comprised mostly mixture of eastern prototypes vegetation comprising of semi-savannah grassland with forests and swamps as reviewed by Njoku *et al.* (2015).

2.2 Site selection, Experimental design and Sampling

The study area was preliminary surveyed and the locations selected were showed under.

Ishiagu = 0 - 50 m away from Ishiagu quarry site

Umuoghara = 0 - 50 m away from Umuoghara quarry site

Ngbo = 0 - 50 m away from Ngbo quarry site

Control = above 3 km away from each quarry sites.

Three (3) replicates of each sample were done in each site with Completely Randomized Design (CRD) used as experimental design. However, materials used for sampling are labelled sterilized plastic cans with lids, masking tape and permanent marker. Three replicate of water samples were collected in a pond at 0 - 50 m away from Ishiagu quarry site, 0 - 50 m away from Umuoghara quarry site, 0 - 50 m away from Ngbo quarry site and above 3 km from each quarry locations and used as control. Water samples were collected using 50 cl bottles. The bottles were rinsed thoroughly with water; masked with tape, labelled and subjected for laboratory examination for physical selected water properties, chemical properties and heavy metals concentrations determination.

2.3 Analysis of Laboratory

2.3.1 Physical Parameters Determination

Physical parameters determined were as follows:

Colour

The percentage transmittance of light was used to ascertain the colour transmittance of each sample. However, photo-electronic colorimeter with model AE – 11M was an instrument used in the determination of colour transmittance (Hossain *et al.*, 2001).

Conductivity

The SANXIN SX723 meter was used in the determination of each sample conductivity. The probe was dipped into each sample in a beaker, stirred and allowed to settle and the result digitally read and recorded (Hossain *et al.*, 2001).

Total Solids (TS)

This was determined by taking 50 ml of each sample in a cleaned, dried and weighed beaker (W_1) and allowed to evaporate to dryness at 100 – 105 °C. Then, cooling the beaker and drying in desiccators to get (W_2) (Bhagure 2010).

Calculation was done as follows:

$$\text{Total Solids (TS) mg l}^{-1} = w_2 - w_1 \times 1000$$

Sample (ml)

w_1, w_2 will be in milligram (mg).

Total Dissolved Solids (TDS)

The sample was mixed and filtered. Then 100 ml⁻¹ of the filtrate was weighed into evaporating plate. They were dried for 1 hour at room temperature in a desiccator. Then, after the samples have been dried, the process continued till the final mass of the samples was ascertained (Hossain *et al.*, 2001).

Total Suspended Solids (TSS): The TS and TDS below was used in the determination of total suspended solids:-

That is Total Solids subtracting Total Dissolved Solids to give you Total Suspended Solids.

2.3.2 Determination of chemical parameters

Chemical parameters were determined as follows:

pH

The pH meter was used to ascertain water pH. The electrode of pH meter was rinsed thoroughly with distilled water before immersion into the samples.

After calibrating the meter with the buffers, the electrode(s) and glassware were rinsed with distilled water. A carefully measured 100 ml⁻¹ of samples was placed in a 150 ml⁻¹ beaker. All samples were made to come to room temperature in the tightly capped bottle before analysis (Jung, 2001). It took up to 3 minutes for the reading to become stable. When it was stable, the pH was recorded to the nearest 0.01 pH unit.

Nitrate

The turbid metric method was used in the determination of Nitrate (NO₃⁻). It is also used for samples which organic content are low and high because of dissolved organic matter interferences Stavrianou (2007).

Chloride

The argentometric titrimetric method was used to determine chloride. It was measured using a comparator disc and a colour filter that was acceptable for the situation. To neutralize the amount of carbonate and bicarbonate and provide 1 ml in excess, 25 ml⁻¹ of water sample was transferred to a 150 ml⁻¹ conical flask and added 0.01N H₂SO₄ with methyl orange. It was also tinted dark yellow with 5-6 drops of potassium chromate indicator. With constant stirring, the contents were titrated against a 0.02N AgNO₃ solution until the first brick red hue appeared. The normalcy of AgNO₃ was established by comparing it to a NaCl solution (Jung, 2001)

Calcium

Titration with an estimation approach was used to determine calcium content. The water sample was filtered to remove any suspended matter. It was done to prevent the flame photometer's capillary tuning from being clogged (Jung, 2001).

Magnesium

Magnesium and Potassium were determined by the complexometric titration method using EDTA salt and Eriochrome black T as an indicator. In a 100 ml⁻¹ conical flask, a 10 ml⁻¹ water sample was obtained and diluted with about 25 ml⁻¹ distilled water. Before doing a batch of measurements, 5 ml⁻¹ of 10% NaOH

solution was added to elevate the pH of the sample, and 20 ml⁻¹ of 0.01 calcium chloride was titrated with 0.01N of EDTA to evaluate the EDTA concentration (Jung, 2001).

2.3.3 Determination of heavy metals (lead, cadmium iron and zinc)

The samples (Pb, Cd, Fe and Zn) were digested first, by measuring 50 ml⁻¹ of sample that is acid-preserved into a beaker. Then adding 5 ml⁻¹ concentrated HNO₃ (Nitric Acid) and a few boiling clips. The mixture is heated slowly in a hot plate to about 20 ml⁻¹. Then heating continued with addition of concentrated HNO₃ continuously until a light coloured clear solution is obtained. This is an indicator of completeness of digestion. The instrument used was Flame Atomic Absorption Spectrophotometer, model 10 VGP and Buck Scientific (American Public Health Association, 1998).

2.4 Statistical and Data analysis

All data was statistically evaluated using analysis of variance and Fishers Least Significance Difference (F-LSD) at a probability threshold of 5% in a Completely Randomized Design (CRD) as reported by Obi (2002) and reviewed by Njoku et al (2021). However, all water values were compared to World Health Organisation (WHO) standards (World Health Organization, 2017).

3. Results

3.1 Water physical properties as affected by quarry activities

In the three (3) years of the study, Table 4 indicates the effects of quarry activities on selected physical parameters of the water. The values of colour transitivity, conductivity, total solids, total dissolved solids, and total suspended solids differed significantly ($p < 0.05$) between the four locations tested. Table 4 shows that in 2018, control had a lower colour transitivity value of 0.01 than Ishiagu, Umuoghara, and Ngbo by 600, 1000, and 700%, respectively. Colour transitivity increased in the order of Control < Ngbo < Umuoghara < Ishiagu in 2019, but dropped in the sequence Ishiagu > Umuoghara > Ngbo > Control in 2020.

Water conductivity recorded lower value of 0.04 μScm^{-1} in control in 2018. The conductivity observed in control was ascertained to be lower than Ishiagu, Umuoghara and Ngbo by 250, 150 and 175%, respectively. The increase order in conductivity in 2019 was ascertained to be Control < Ngbo < Umuoghara < Ishiagu, whereas the decrease order in conductivity in 2020 was Ishiagu > Umuoghara > Ngbo > Control. Total solid of control was 35.05 mg l⁻¹ lower, whereas the range of 92.50 – 119.90 mg l⁻¹ was recorded in total solids of quarry locations in 2018. There is a record of lowest value of 35.80 mg l⁻¹ of total solids in control in 2019. Control total solids was observed to be lower than Ishiagu, Umuoghara and Ngbo by 390, 353 and 460%, respectively. Total solids recorded lower value of 35.87 mg l⁻¹ in control in 2020, while that of quarry locations ranged between 131.01 – 169.00 mg l⁻¹. The lowest total dissolved solids recorded in control was 32.50 mg l⁻¹, while the range between 50.00 - 56.60 mg l⁻¹ was recorded in total dissolved solids of quarry locations in 2018. In 2019, Control < Ngbo < Umuoghara < Ishiagu was the order of increase of total

dissolved solids, whereas Ishiagu > Umuoghara > Ngbo > Control was the order of decrease of total dissolved solids in 2020. Total suspended solids had lower value of 28.45 mg l⁻¹ in control, while that of quarry locations ranged between 37.75 – 91.25 mg l⁻¹ in 2018. In 2019, the order of increase in total suspended solids was Control < Ngbo < Umuoghara < Ishiagu, whereas the order of decrease in total suspended solids decreased in 2020 was Ishiagu > Umuoghara > Ngbo > Control.

3.2 Water chemical properties as affected by quarry activities

Table 2 shows the effects of quarry activities on water pH, nitrate, chloride, calcium, magnesium, and sodium. The figures for 2018, 2019 and 2020 were likewise significantly different ($p < 0.05$) in the table. In 2018, it was discovered that the pH value of control was 287, 46 and 57% lower than that of Ishiagu, Umuoghara and Ngbo, respectively. In 2019, pH fell in the order Ishiagu > Umuoghara > Ngbo > Control, but pH rose in the order of Control < Ngbo < Umuoghara < Ishiagu in 2020. Nitrate was measured at 0.67 mg l⁻¹ in the control group in 2018. This observed nitrate in control was lower than that of Ishiagu, Umuoghara and Ngbo by 3, 25 and 6%, respectively. In 2019, the lowest nitrate level was 0.68 mg l⁻¹ in control, whereas, nitrate levels in quarry locations varied from 0.73 to 0.85 mg l⁻¹. In 2020, the lowest nitrate level was 0.80 mg l⁻¹ in control, whereas, nitrate levels in quarry locations ranged from 0.81 to 0.90 mg l⁻¹. In 2018, the chloride concentration of water in the control was 5.30 mg l⁻¹, which was 55, 62, and 17% lower than that of Ishiagu, Umuoghara, and Ngbo, respectively. In 2019, the lowest concentration of chloride in the control was 5.70 mg l⁻¹, while quarry concentrations ranged from 16.00 - 37.43 mg l⁻¹. At 2020, the control had the lowest chloride level of 5.78 mg l⁻¹, whereas, chloride levels in quarry areas ranged from 16.10 - 37.68 mg l⁻¹.

In 2018, the calcium content of water in control was 9.19 mg l⁻¹, which was lower than that of Ishiagu, Umuoghara, and Ngbo by 10, 58, and 16%, respectively. Calcium values declined in 2019 in the order of Ishiagu > Umuoghara > Ngbo > Control; whereas calcium values climbed in 2020 in the order of Control < Ngbo < Umuoghara < Ishiagu. Magnesium levels in the control were 49, 70, and 50% lower in 2018 than in Ishiagu, Umuoghara, and Ngbo, respectively. In 2019, the lowest magnesium level was 10.05 mg l⁻¹ in control, whereas magnesium levels in quarry locations ranged from 14.64 to 24.46 mg l⁻¹. Control had the lowest magnesium level of 10.55 mg l⁻¹ in 2020. The magnesium level in the control group was lower than in Ishiagu, Umuoghara and Ngbo. In 2018, sodium levels in the control were 441, 374, and 174% lower than in Ishiagu, Umuoghara, and Ngbo, respectively. In 2019, sodium levels grew in the following order of Control, Ngbo, Umuoghara, and Ishiagu, but sodium levels fell in the following order of Ishiagu > Umuoghara > Ngbo > Control in 2020.

3.3 Selected water heavy metal contents as affected by quarry activities

Table 3 shows the effects of quarry activities on water levels of lead, cadmium, iron, and zinc. In 2018, 2019 and 2020, the values of lead, cadmium, iron, and zinc in the different places tested differed significantly ($p < 0.05$). In 2018, the effects of quarry activities on lead were 267, 337, and 538% in control with 0.063 mg l⁻¹ compared to Ishiagu, Umuoghara, and Ngbo, respectively. Lead levels fell in 2019 in the order Ishiagu > Umuoghara > Ngbo > Control, then rose in 2020 in the order Control Ngbo Umuoghara Ishiagu. In 2018,

cadmium in control was lower in control than Ishiagu, Umuoghara and Ngbo cadmium by 863, 130 and 115%, respectively. However, 0.065 mg l⁻¹ of cadmium was recorded in control in 2018, while cadmium in quarry locations ranged between 0.593 – 0.863 mg l⁻¹. In 2020, control was lowest with 0.080 mg l⁻¹ of cadmium, whereas cadmium in quarry locations ranged between 0.610 – 0.876 mg l⁻¹. Iron in 2018 had lower value of 0.048 mg l⁻¹ in control than Ishiagu, Umuoghara and Ngbo iron by 154, 982 and 144% in 2018, respectively. Lowest iron of 0.051 mg l⁻¹ was recorded in control; while the range of 4.800 – 7.500 mg l⁻¹ iron was recorded in the location of quarry in 2019. In 2020, control was lowest with 0.062 mg l⁻¹ of iron, whereas the range of iron in quarry locations was 4.950 – 8.000 mg l⁻¹. In 2018, the increase of zinc was in the conformity Control < Ngbo < Umuoghara < Ishiagu. The sequence of Ishiagu > Umuoghara > Ngbo > Control was the decrease in zinc in 2019, whereas 0.030 mg l⁻¹ was the lowest zinc value recorded in 2020 and 0.120 – 3.030 mg l⁻¹ was the range of zinc value in the location of quarry.

Table 1: Effect of quarry activities on colour, conductivity, total solids, total dissolved solids and total suspended solids of water

Location			Colour			Conductivity			Total Solids		
Total Dissolve Solids			Total Suspended Solids								
(mg l ⁻¹)			(% transmittance)			(µScm ⁻¹)			(mg l ⁻¹)		
2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Ishiagu											
56.60	88.10	90.00	0.07	0.11	0.16	0.14	0.31	0.36	119.90	143.00	144.00
				91.75	95.90	95.00					
Umuoghara											
55.00	66.00	70.01	0.11	0.14	0.18	0.10	0.17	0.20	92.50	130.07	131.01
				57.20	61.00	61.06					
Ngbo											
50.00	63.00	66.05	0.08	0.10	0.14	0.11	0.11	0.18	111.40	168.50	169.00
				37.25	43.00	44.33					
Control											
32.50	44.00	46.01	0.01	0.03	0.05	0.04	0.04	0.07	35.05	35.80	35.87
				28.45	28.00	28.70					
F-LSD (p < 0.05)											
4.59	5.71	8.11	0.01	0.03	0.02	0.02	0.03	0.04	8.90	15.78	15.94
				15.75	0.95	8.98					
WHO											
			50			500			500		
	500				150						

Note: Ishiagu = 0 - 50 m away from Ishiagu quarry site; Umuoghara = 0 - 50 m away from Umuoghara quarry site; Ngbo = 0 - 50 m away from Ngbo quarry site; Control = above 3 km away from each quarry sites and WHO = World Health Organization

Table 2: Effect of quarry Activities on pH, nitrate, chloride, calcium, sodium and magnesium of water

Location	pH	Nitrate	Chloride
Calcium	Magnesium	Sodium	

(mg l ⁻¹)			(mg l ⁻¹)			(mg l ⁻¹)			(mg l ⁻¹)			
2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	
Ishiagu			6.01	8.23	8.40	0.69	0.75	0.84	36.01	37.43	37.68	23
23.46	23.60		14.60	14.73	15.43	40.10	41.05	42.13				
Umuoghara			6.28	7.81	7.90	0.84	0.85	0.90	29.27	30.01	32.00	15.
15.30	15.50		24.31	24.46	24.80	35.10	36.01	37.04				
Ngbo			6.73	7.33	7.40	0.71	0.73	0.81	15.50	16.00	16.10	
11.10	11.22	11.61		14.59	14.64	15.34	20.30	20.44	21.31			
Control			4.28	5.29	5.31	0.67	0.68	0.80	5.30	5.70	5.78	
9.19	9.23	9.40		9.76	10.05	10.55	7.40	7.48	7.66			
F-LSD (p < 0.05)			3.56	5.44	5.57	0.12	0.19	0.25	5.06	5.43	5.73	
2.32	2.44	2.70		5.82	8.10	3.87	7.25	7.55	8.02			
WHO			6.5 - 8.5				10			250		
200			250				500					

Note: Ishiagu = 0 - 50 m away from Ishiagu quarry site; Umuoghara = 0 - 50 m away from Umuoghara quarry site; Ngbo = 0 - 50 m away from Ngbo quarry site; Control = above 3 km away from each quarry sites and WHO = World Health Organization

Table 3: Effect of quarry activities on lead, cadmium, iron and zinc of water

Location	Iron			Lead			Zinc			Cadmium		
	(mg l ⁻¹)			(mg l ⁻¹)			(mg l ⁻¹)			(mg l ⁻¹)		
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
Ishiagu				1.746	1.753	1.770				0.588	0.593	
0.610		7.460	7.500	7.660		3.015	3.019		3.030			
Umuoghara				2.185	2.189	2.210				0.855	0.863	0.876
4.760	4.800	4.950		0.195	0.196	0.220						
Ngbo				3.450	3.470	3.540				0.766	0.769	0.790
6.960	6.980	8.000		0.098	0.100	0.120						
Control				0.063	0.066	0.080				0.061	0.065	
0.080	0.048	0.051	0.062		0.010	0.014		0.030				
F-LSD (p < 0.05)				0.31	0.32	0.33				0.01	0.01	0.04
2.39	2.41	2.77		0.04	0.05	0.05						
WHO				0.01							0.003	
			2.0						3.0			

Note: Ishiagu = 0 - 50 m away from Ishiagu quarry site; Umuoghara = 0 - 50 m away from Umuoghara quarry site; Ngbo = 0 - 50 m away from Ngbo quarry site; Control = above 3 km away from each quarry sites and WHO = World Health Organization

4. Discussions

Effect of quarry activities on water properties

The values of colour transitivity, conductivity, total solids, total dissolved solids, and total suspended solids differed significantly ($p < 0.05$) between the different locations tested. Colour transitivity was lower in the control than in the three locations tested. This could be due to the dissolution effect of waste water created in the quarry, as well as an increase in water volume due to rainfall. The values were not higher than the recommended standard.

In comparison to the control, water conductivity showed greater levels in all three locations studied. Higher conductivity readings could be caused by evaporation, which causes organic matter to concentrate and mineralize, or by evaporation, which causes nutrients to concentrate. They were not higher than the recommended standards. Total solids were higher in the locations studied, compared to control. The high total solid levels, on the other hand, were caused by quarry effluents seeping into the research sites' water bodies. Total solids measurement can be useful as an indicator of the effects of run-off from building, agricultural practices, and other sources, according to the American Public Health Association (1998). Total dissolved solids in water were higher in both locations studied, relative to control. This can have an impact on the water body's refractive capability and light dispersion pattern. They were not high when compared to the recommended limit of 500 mg l^{-1} (World Health Organisation, 2017). Total suspended solids in control was not higher than total suspended solids in Ishiagu, Umuoghara and Ngbo, but were not higher than the recommended standards. Total suspended solids, on the other hand, are filterable particles in water that can be organic (algae, zooplankton, and bacteria) or inorganic (silt, clay, calcium, magnesium, sodium, chloride, and so on), and when present in excess, can impair light absorption. Quarry activities have an impact on water.

The pH readings of the various places investigated were found to be higher than the control pH and to be within the World Health Organization's (WHO) maximum acceptable limit of 6.5-8.5. The pH of the water varied from slightly acidic to slightly alkaline, ranging from 4.28 to 8.40. Because pH is influenced by dissolved minerals and effects the oxidation, solubility, and toxicity of metals at low values, it could be linked to decreasing water levels generating larger concentrations of base cations (Woldeab *et al.*, 2018). Metals have a high solubility at low pH (Adimalla, 2019). The conversion of non-toxic ammonium to the hazardous form of unionized ammonia is aided by a pH over 8.5 (Salari *et al.*, 2018). The biological elements of water are also determined by pH. The impacts of quarry activities on nitrate were both lower in the control compared to the research areas, however they were both under the maximum allowable limit, as shown in Table 2. However, high nitrate occurrence can be attributed to the natural process of organic mineralization and washed into the water bodies by surface run-off (Adimalla, 2019). Chloride content of water was lower in control when compared to Ishiagu, Umuoghara and Ngbo quarry locations. This could be owing to the lack of quarry activity in the vicinity of the control. When compared to the three different locations studied, the calcium concentration of water was lower in the control. This could be owing to the lack of quarry activity in the vicinity of the control. They did not exceed the World Health Organization's (WHO) maximum acceptable limit of 200 mg l^{-1} , with the exception of Ishiagu, who exceeded the maximum permissible limit for both

years of the trial. In 2018, 2019, and 2020, the effects of quarry activities on magnesium were both higher in Ishiagu, Umuoghara, and Ngbo compared to control, however none were higher than the prescribed standard. This could be due to the weathering and leaching of magnesium metals into water bodies through runoff. Sodium were both higher in the three different studied locations when compared to control in both years and were within the maximum permissible limit of 500 mg l^{-1} . This may be due to the resultant effect of leaching of sodium chemical constituents present in mined material through runoff processes into the water bodies. Sodium is necessary for good health, however exceeding the maximum allowed amount of 500 mg l^{-1} can lead to health problems like hypertension and vomiting (World Health Organization, 2017). Chloride, calcium, and magnesium are also important elements for all creatures, and they are found in the shells of many aquatic invertebrates as well as vertebrates' bones. Calcium and magnesium are also crucial nutrients for plants and animals to achieve optimal growth and productivity. When these elements are present in excess in water bodies, however, they tend to contribute to water hardness (Norton *et al.*, 2002).

The effects of quarry operations on lead were 70, 87, and 96% lower in control compared to Ishiagu, Umuoghara, and Ngbo, respectively. They were all above the maximum permissible limit of 0.01 mg l^{-1} .

However, the presence of lead in all of the sampling locations showed that the water had been contaminated by an anthropogenic source (Norton *et al.*, 2002). It is revealed that in both the 2018 and 2019 study years, all cadmium readings in Ishiagu, Umuoghara, and Ngbo were greater than cadmium in the control, and were more than the recommended standard. However, the high levels of cadmium in the water could be due to surrounding farmland nitro-phosphate fertilizers (Norton *et al.*, 2002). Iron levels in control were lower in both years when compared to Ishiagu, Umuoghara, and Ngbo. Except for the control, which had 0.048, 0.051, and 0.062 mg l^{-1} , they were all above the World Health Organization's maximum allowed limit of 2.0 mg l^{-1} . Also, as compared to the control, the elevated quantity of iron could be attributable to soil particles containing iron deposition in the water during rainy surface runoff. Zinc had lower value in control compared to values recorded in Ishiagu, Umuoghara and Ngbo. They were within the recommended standard. Zinc is a non-toxic metal that does not bioaccumulate in living organisms. Heavy metals found in natural water bodies are even necessity for life (Mustapha, 2016).

However, According to Agyarko *et al.* (2010), heavy metals in water cause severe vomiting, diarrhoea, bloody urine, liver, kidney failure, anaemia, inhibition of haemoglobin synthesis, cardiovascular system. It also causes death in aquatic life and disturbance in variety of crop production.

5. Conclusion

The observed parameters studied were significantly higher in water within 0 – 50 than the control in all the sites studied in the three years of study. Physical and chemical parameters studied were within the recommended standards of 6.5 – 8.5 in all the sites in the three years of study with exception of pH in control which recorded values lower than the standard. The concentration of lead, cadmium and iron were higher in sites within 0 – 50 m from quarry than control and were also above standard whereas the concentration of zinc were higher in sites within 0 – 50 m from quarry than control and were within the standard with the exception of zinc concentration at Ishiagu which are above the standard for the three years

of the study. According to the obtained results, quarry activities have harmful effect to water and aquatic organisms residing in the water in the areas.

Therefore, there is need to treat the water before subjecting it to domestic uses.

Declarations

Funding

There is no fund, grant, or other support received during the preparation of this manuscript.

Competing Interests

We have no relevant financial or non-financial interests to disclose.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Professor Chima Njoku and DrOdera Chukwumaijem

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

ACKNOWLEDGEMENTS

Our profound appreciation goes to God Almighty for His protection, goodness and mercy throughout the period of this study.

We also, express our gratitude to the staff of Department of Soil Science and Environmental Management, Ebonyi State University, who made their laboratory facilities available for the analysis of this research. Top on the list are the laboratory technologists, Mrs P.N. Ngene and Mr. Ajana J. Anayao.

References

1. Adamczyk, A.F., Motyka, J, Wilk, Z, and Witczak, S. (2008). Mine drainage of a karstic aquifer and the related protection problems – Olkusz Mining District, Poland: Proceedings if the IAH 21st Congress,Guilin, China, Geologic Publishing House, Bejing, China, Pp. 1097-1104.
2. Adekoya, J.A. (2003). Environmental effects of solid minerals mining. *Journal of Physical Science* 8: 625 - 640.
3. Adimalla, N.; Qian, H. (2019). Groundwater quality evaluation using waterquality index (WQI) for drinking purposes and human health risk (HHR)assessment in an agricultural region of Nanganur, south India. *Journal of Eco-toxicology*. 176: 153–161.

4. Agyarko, V.X., Osita, R.I., and Chukwu, A.A. (2010). Effect of an Abattoir wastes on soil and water physico-chemical properties of an Abattoir site in a typical palendult of Midwestern Nigeria. *Environ Monit Assessment*. 45: 209 - 221.
5. American Public Health Association. (1998). Standard Methods for the Examination of Water and Wastewater. American Public Health Association, American Water Works and Water Pollution Control Federation 20th Edition. Washington DC, USA.
6. Banez, J., Mae Ajaon, J. R., Bilolo, A.A and Dailyn, J.M. (2010). Quarrying and Its Environmental Effects. *Journal of Environmental Geology*. 8:1 – 2.
7. Bhagure, G. R. and Mirgane, S. R. (2010). Heavy Metals Contaminations in groundwater and soils of Thane Region of Maharashtra, India, *Environ Monit Assess* 4: 1 - 10.
8. Drysdale, R., Pierotti, L., and Baldacci, F. (2001). Suspended sediments inkarst spring waters near Massa (Tuscany), Italy: *Environmental Geology*. 40: 1037 - 1050.
9. Egboka, B.C.E., and Okpoko, E.I. (1984). Gully Erosion in the Agulu- Nanka Region of Anambra State, Nigeria". *Journal of Challenges in African Hydrology and Water Resources*. 7: 330 – 340.
10. Ekmekçi, M. (2003). Impact of quarries on karst groundwater systems, in Günay, G., Johnson, A.I., and Back, W., eds, *Hydrogeological processes in karst terranes: Proceedings of the Antalya Symposium and Field Seminar, October (2000)*, IAHS Publication no. 207: 3 - 6.
11. Fakayode, S.O. (2005). Impact assessment of industrial effluent on water quality of the receiving Alaro River in Ibadan, Nigeria. *Ajeam- Ragee*.10:1 - 13.
12. Federal Department of Agriculture and Land Resources (1987) Reconnaissance Soil Survey of Anambra StateNigeria; Soil Report FDALR, Kaduna.
13. Gauch, H.G. (2001). *Multivariate Analysis in Community Ecology* Cambridge University Press. Pp. 85.
14. Gunn, J, and Hobbs, S.L. (2009). Limestone quarrying: hydrogeological impacts, consequences, implications: in Drew, David, and Hötzl, Heinz, eds.: *Karst hydrology and human activities – Impacts, consequences and implications*, A.A. Balkema. 11: 192 - 201.
15. Henry, J.G. and Heinke, G.W. (2005). *Environmental Science and Engineering*. Prentice Hall. New Delhi. 2: 421 - 491.
16. Hossain, A, Rabbi, M.F, Abih, A.R and Sadek, S. (2001). Heavy metal problems in Soil and Water, a Growing threat for Public Health in Bangladesh: An Overall Perspective and Management Modelling Approach. Sata, K. and Iwasa, Y (Edition).*Proceedings of the Internal Symposium on Soil and Water Pollution 7 – 10 May, (2001); Saitand Japan."*
17. Jung, M. C. (2001). Heavy Metal Contamination of Soils and Waters in and around the Imecheon Au-Ag mine, Korea. *Applied Geochemistry*. 16: 136 - 137.
18. Longe, E.O. and Omole, D.O. (2008). Analysis of Pollution Status of River Illo, Ota, Nigeria. *The Environmentalist*. 28:4 - 12.
19. Moore, J.D and Hughes, T.H. (2009). Effect of quarry blasting on ground water quality in a limestone terrain in Calhoun County, Alabama: *Water Resources Research Institute Bulletin* 38, Auburn University, 21: 72.

20. Mustapha, M.K.; Wulum, J.C. (2016). Seasonal assessment, treatment and removal of heavy metal concentrations in a tropical drinking water reservoir. *Ekol. Bratislava*. 35, 103 – 113.
21. Neal, C., and Robson, A.J. (2000). A Summary of River Water Quality Data collected within the Land-Ocean Interaction Study: Core Data for Eastern UK Rivers Draining to the North Sea. *Sci. Total Environ*. 252: 585 - 665.
22. Njoku, C., Uguru, B.N., and Mbah, C.N. (2015). Effect of Rice Husk Dust on Selected Soil Chemical Properties and Maize Grain Yield in Abakaliki, South Eastern Nigeria; *Applied Science Reports* 12 (3): 143 – 149.
23. Njoku, C., Mbah C.N., Elom O and Agwu J.O. (2021). Effect of Mechanic village activities on selected soil properties in Abakaliki Southeastern Nigeria. *Journal of Agriculture and Ecology Research International*. 22 (1): 10 – 16.
24. Norton, R.H., Jude, L.O., Kate, W.B. (2002). Enrichment and characterization of a microbial community from tannery effluent for degradation of pentachlorophenol. *World Journal of Microbial Biotechnology*; 18: 693 - 698.
25. Obi, I.U. (2002). Statistical methods of detecting difference between treatment means and research methodology issues in laboratory and field experiments. 2nd Edition; Ap Express publishers limited Nsukka, Nigeria.
26. Omosanya K.O. and Ajibade O.M. (2010). Environmental Impact of Quarrying on Otere Village, Odede, South Western Nigeria". *Ozean; Journal of Applied Sciences*. 6: 75 - 82.
27. Osha, O.L. (2006). Information Booklet on Industrial Hygiene. Revised Edition. U.S. Department of Labour OSHA/OICA Publications, Occupational Safety and Health Administration, Washington, USA. 17: 23 - 35.
28. Saha, D.C and Padhy, P.K. (2011). Effects of Stone Crushing Industry on Shorearobusta and Madhucaindica Foliage in Lalpahari Forest" *Atmospheric Pollution Research*, 2: 463 - 476.
29. Salari, M.; Salami, E.; Afzali, S.H.; Ehteshami, M.; Conti, G.O.; Derakhshan, Z.; Sheibani, S.N. (2018). Qualityassessment and artificial neural networks modeling for characterization of chemical and physical parameters of potable water. *Food Chem. Toxicol*. 118: 212–219.
30. Spigner, B.C. (2008). Land surface collapse and ground-water problems in the Jamestown area, Berkley County, South Carolina: South Carolina Water Resources Commission Open-File Report: Pp.78-1.
31. Stavrianou, W. (2007). The Western Australian Contaminated Sites Act. The Applicability of Risk Assessment as a basis for the Assessment and Management of Site Contamination, 4: 1 - 92.
32. Vermeulen, J, and Whitten, T. (2009). Biodiversity and cultural property in the management of limestone resources: World Bank, Washington, D.C., Pp.120.
33. Woldeab, B.; Beyene, A.; Ambelu, A.; Buam, I.; Mereta, S.T. (2018). Seasonal and spatial variation of reservoir water quality in the southwest of Ethiopia. *Environ. Monit. Assess. J*. 20: 190 - 163.
34. World Health Organization, (2017). Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum; World Health Organization: Geneva, Switzerland. ISBN 9241546964.

Figures

Figure 1

A Nigerian Map depicting Ebonyi State.