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Physicochemical Profile of Water Bodies Around the Quarry Sites in Ogun State, Nigeria

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Abstract
Quarrying of rock for construction purposes is a significant industry in Nigeria thus enhancing the development of economy activities. This study examined the physicochemical characteristics of water bodies around the quarry sites in Ogun State. Geographic Information System approach was used to map the various quarry locations in Ogun State, of which eight sites were selected namely Isara, Idode, Iwaye, Ogbere, Ilagbe, Adelokun, Baaki Ake and Igodo. A total of 48 samples from surface and ground water were collected and analysed from the eight selected locations for electrical conductivity, dissolved Oxygen, pH using standard procedures. Sampling was done in dry and wet seasons between November 2016 and July 2017. Data were subjected to descriptive and inferential statistics using SAS package (9.4 version). Sixty quarries were identified in the selected locations. The pH values of surface water (dry season) in all locations were within the WHO standard (6.5-8.5), with the exception of Adelokun (6.20±3.00) and Baaki Ake (6.40±1.97). All values of the pH of the surface water (wet season) fell within the WHO limit with the exception of Iwaye (6.30±2.00). The values of Dissolved Oxygen in surface water (wet season) and ground water (both seasons) across locations were higher than the WHO limit (2.0 mg/L). However, the water bodies in surrounding localities of quarries increased with pH and Dissolved Oxygen.

Keywords: Physicochemical, Profile, Water, Quarry, Pollution

INTRODUCTION

Quarries can cause significant impact to the environment. However, with the right planning and management, many of the negative effects can be minimised or controlled and in many cases, there is great opportunity to protect and enhance the environment, via the translocation of existing habitats or the creation of new ones. Therefore, achieving an equilibrium between natural ecosystems, project planning, formulation and implementation is needed. Such extraction of raw materials from their natural habitats by mining, drilling, harvesting and those that relate to large scale water resources development projects, construction, agriculture, energy, industry and development projects, considerably affect the natural environment (Fedra *et al.*, 2005).

The high concentrations of heavy metals in stream water within quarrying environment in area could be attributed to the tailing waste generated from mining activities, industrial and

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geological weathering of the rocks (Ekpo *et al.,* 2013). According to Darwish (2008); Khaled (2005) heavy metals enter the aquatic environment through geological weathering and human activities. The removal of top soil and surface rock strata can increase the accessibility of groundwater to contamination and may affect the quality of water recharging of an aquifer, and excavation below the water table may lead to de-watering of adjacent watercourses and surface water. Nigeria being a developing country almost 90 % of her water need come from Surface water, which is used for different purpose like; drinking and cooking etc. The quantity, physical and chemical quality of surface and ground waters is affected by quarrying activities (Ekpo *et al.,* 2013). This indicates that the environment may be polluted as a result of quarry activities and geological weathering of rocks by natural processes (Ekpo *et al.,* 2013). Ekpo *et al.,* 2013 reported that the concentration of heavy metals in bottom sediment were significantly higher than those recorded in water samples around the quarry site and geological weathering of rocks at the bottom substratum. This is because sediments act as reservoir for all contaminants and organic matter descending from the quarry site and ecosystem (Ekpo *et al.,* 2013). Heavy metals contamination of the environment from different mine operations including active and abandoned quarries was reported in the past by various authors such as Zuhairi *et al.* (2009). Quarries operations pollution of surrounding water bodies is of a major concern. For instance quarry dust can change the chemistry of water resources by dissolving therein (Enger and Smith, 2002). Quarry sand dust blown by wind can also settle in the surrounding water bodies and cause pollution. Sayara (2016) asserted that the improper management of the quarry wastes is the main reason for the increase of the total suspended solids (TSS) levels in Hebron groundwater in Palestine. Furthermore, the operations of quarry disrupt the existing movement of surface water and groundwater; they interrupt natural water recharge and can lead to reduced quantity and quality of drinking water for residents and wildlife near or downstream from a quarry site (El-Nashar, 2009). Urich, (2002) also affirmed that operations of quarries affect groundwater quality. Water quality do change because of the karst characteristics of hard limestone and infiltrated into soil around the operation (Nasserdine *et al.,* 2009; Abu Khalaf, 2010; Ojekunle *et al.,*2015). The industry, unfortunately discharge dust that settles not only on land, plants and trees, but also on surface waters used for drinking and other domestic chores by the community (Oyinloye and Ajayi, 2015; Osha, 2006). There were no work that had really addressed the physicochemical profile of the water bodies around quarry site, as it has been done extensively on the heavy metals. However, with these foregoings; the study of physicochemical profile of water bodies around the quarry sites in Ogun State, Nigeria was prompted.

MATERIALS AND METHODS

Study Area

The geographical location of Ogun State lies between latitude 7.9031 - 6.3142 ° N and longitude 2.7073 - 4.5750 ° E and very close to Lagos state, the economic capital of Nigeria, that surrounded with Atlantic Ocean. Ogun State has landmass of 16,980.55 square kilometres with a population of about 3,751,140 (NPC, 2006). The state is situated in the Rain forest zone of Nigeria and has a climatic weather of wet and dry seasons that falls between April to October and November to February respectively (www.ogun state.gov.ng).

This granite deposits are widely distributed in Ogun State. Quarrying started since the ancient time in Nigeria but never grow to this extent until British colonial administration was established in Nigeria. Quarrying of granite for construction is gaining ground and widespread as small scale industry in Nigeria; because it is less capital intensive compared to mineral extraction. Figure 1 shows the locations of quarry sites in the Local Government Areas of Ogun state.

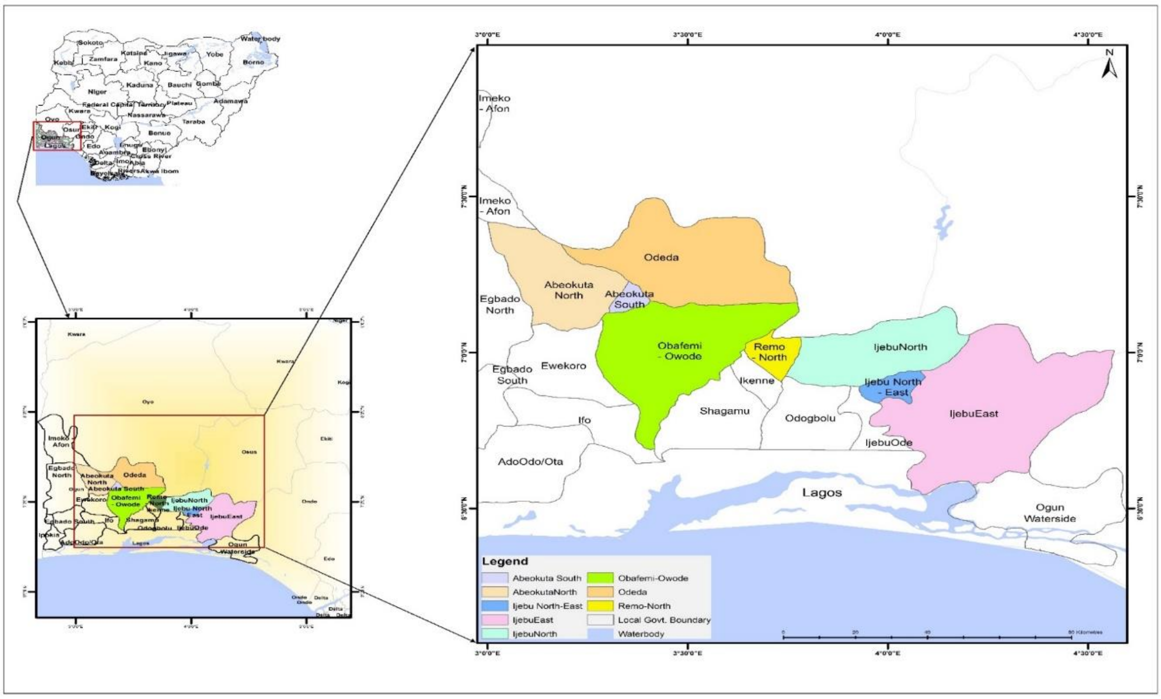

Figure 1: Map of quarry sites Local Government Areas in Ogun State.

Sample Collection

Inventory of quarry sites

All quarry sites in Ogun State were identified and their coordinates were taken using Geographical Positioning System (GPS) between November, 2015 and July, 2017. Categorisation of the various quarries identified were carried out, using the following criteria; sizes and status.

The sizes were based

- on their landmass in square kilometre (km^2); any quarry less than 2 km^2 were classified as small; while those above 2 km^2 were classified as big quarry
- Number of crushers: quarry with less than two was classified as small; while the quarry with more than two was classified as big.
- Tonnes of granite produced per week; quarry that produces less than 500,000 tonnes was classified as small and above the 500,000 tonnes of granite as big.

The status was based on existence (production of granite) of the quarries at as when the survey was carried out. Thus classified as; active, inactive or closed down. However, a locational map of all quarries was produced (Figure 2).

Sampling Techniques

Purposive sampling method was used to select eight (8) quarry locations in the study area and due to their closeness (500 – 1000 m) to the quarry sites in all six local government areas sampled. Two (2) locations were selected from the Odeda and Obafemi/Owode Local Government Areas (LGA) because of the presence of higher number of quarry sites in the two Local Government Areas. However, one location was sampled each from the remaining four Local Government Areas. Sample locations in each Local Government Area are presented in Table 1.

Table 1: Selected quarry sites in Ogun State

Local government area	Locality or village	Industry	Long(E)°	Lat(N)°
Ijebu East	Ogbere	Julius Berger	3.557	6.889
Ijebu North East	Iwaye	Paras	3.631	7.175
Ijebu North	Idode	CCECC	3.423	7.138
Remo North	Isara	CCECC	3.534	7.155
Odeda	Igodo	F.W.S.AN.H.Concept 2	3.492	6.931
Odeda	Ilagbe	DLK	3.553	6.931
Obafemi/Owode	Baaki ake	Blaco	3.625	7.119
Obafemi/Owode	Adelokun	Zanex	4.070	6.965

Longitude (Long), Latitude (Lat)
Source: field survey 2017

Collection of water samples

Samples were collected from both surface and ground water (hand dug well); three from each sampling location (quarry sites) in November, 2016 and July, 2017. The water samples were collected twice; covering both dry and wet seasons. Subsequently, analysed for pH, electrical conductivity, total suspended solid, total dissolved solid, temperature, dissolved oxygen and chloride.

Water analysis

The physico-chemical parameters were analysed using American Public Health Association (APHA, 2008) analytical methods

Data analysis

Data were analysed using descriptive (mean, standard deviation,) and inferential analysis (T-test) to compare and show variations among the parameter concentrations in the study areas and compare the results with World Health Organization standard (2017).

RESULTS AND DISCUSSION

Table 2: Categorisation of Quarry

S/N.	Quarry Name	Long(E)°	Lat(N)°	Quarry Location	LGA	Funtionality	Size
1.	A.G.I Ltd	3.25727	7.10122	Igbo Ora road	Odeda	Active	Small
2.	ABL Granite Comp Ltd	3.26660	7.14436	Boruboru	Obafemi Owode	Active	Big
3.	Akile Resources Ltd	3.64091	7.12627	Aberu- agba	Obafemi Owode	Closed down	Small
4.	Blaco Nigeria Ltd	3.62519	7.11907	Baaki ake	Obafemi Owode	Active	Big

5.	Blue Bridge Mineral	3.53384	7.13519	Okudu (Ago-iwoye)	Ijebu North	Active	Big
6.	C.C.E.C.C.Nig. Ltd	3.42959	7.15479	Isara-Remo	Remo North	Active	Big
7.	C.C.E.C.C.Nig. Ltd	3.46266	7.13813	Idode (Ago-iwoye)	Ijebu North	Active	Big
8.	C.N.C	3.56635	7.09551	Itesi,Orile Ilugun	Odeda	Active	Small
9.	C.S.A	3.68757	7.08926	Omo Ologede	Odeda	Active	Small
10.	Capital	3.60643	7.06390	Olodo	Odeda	Active	Big
11.	Casagrande Nig. Ltd	3.65545	7.06813	Ayoyo	Odeda	Closed down	Big
12.	Caxtban Nigeria Ltd	3.70954	7.13996	Erunwon-Odamo	Obafemi Owode	Closed down	Big
13.	Chesy fen ltd	3.63348	7.08926	Ijako Oya	Obafemi Owode	Active	Big
14.	China Harbour Engineering company (Nig.) Ltd	3.42051	7.09855	Agbede,Ogbere	Ijebu East	Closed down	Big
15.	Crown	3.60474	6.98108	Eye	Odeda	Active	Small
16.	Crushed dragon 1	3.52868	7.02841	Ogbere	Ijebu East	Inactive	Small
17.	Crushed dragon 2	3.57896	7.34257	Ago Iwoye	Ijebu North	Active	Big
18.	D.L.K	3.55319	6.93122	Ilagbe	Odeda	Active	Small
19.	Desroto Trust &Investment Company Ltd	3.50164	6.96840	Idi-Osan	Odeda	Inactive	Small
20.	Enptech Nigeria Ltd	3.40867	6.74614	Omosanya	Odeda	Inactive	Small
21.	F.W.S.A.N.H.Concept	3.44079	6.79938	Ilawo	Odeda	Closed down	Big
22.	F.W.S.A.N.H.Concept2	3.49150	6.88896	Jagun (Igodo)	Odeda	Active	Big
23.	Fam Construction Ltd	3.57178	7.02418	Banja	Odeda	Closed down	Small
24.	Glo World	3.45516	7.04447	Mile 12	Obafemi Owode	Inactive	Big
25.	Green Palm	3.65567	7.35346	Igbo Ora	Odeda	Active	Small
26.	Higher Ground Quarries Ltd	3.29881	7.29124	Solomo	Obafemi Owode	Active	Big
27.	H.H.L Nigeria Ltd	3.32020	7.30289	Apesin Eruwon	Obafemi Owode	Active	Big
28.	Lab Integrated Services Ltd	3.65703	7.38982	Ijeun	Obafemi Owode	Active	Big
29.	Jia Bio 1	3.62714	7.32455	Ijeun	Obafemi Owode	Active	Big
30.	Jia Bio 2	3.64127	7.26068	Obele	Odeda	Close down	Small
31.	Julius Berger Nig.	3.55681	7.31186	Oko -Eko, Ogbere	Ijebu East	Active	Big
32.	Julius Berger Nig.	3.52498	7.25491	Ago Iwoye	Ijebu North	Active	Big
33.	Kepxing	3.59896	7.39148	Ilawo Kaho Onigbogbo	Odeda	Active	Small
34.	Krisjam Investment	3.72299	7.23508	Sokan	Odeda	Active	Small
35.	Milatex Geneworks	3.56876	7.24661	Tigbori, Ogbere	Ijebu East	Closed down	Small
36.	Mofals Constructions	3.67299	7.28722	Ipara-Oke (Ijebu ode)	Ijebu north east	Inactive	Small

37.	More & S.A More Ltd	3.69753	7.17460	Idi-Osan	Obafemi Owode	Inactive	Small
38.	Multiverse Resource2	3.53181	7.16744	Alagutan	Obafemi Owode	Active	Big
39.	Multiverse Resources1	3.52667	7.22667	Oloparun	Obafemi Owode	Closed down	Big
40.	New Technics Construction co. Ltd	3.76039	7.17890	Ayoyo	Odeda	Inactive	Small
41.	Navy	3.49285	7.24768	Adigbe-abeokuta	Abeokuta South	Closed down	Small
42.	Obasanjo Holdings	3.51211	7.35397	Odeda	Odeda	Inactive	Big
43.	Prestige Chen Jun Quarry Ltd	3.59885	7.29588	Idi-Osan	Obafemi Owode	Active	Small
44.	P.W Nigeria Ltd	3.42617	7.41843	Foke	Obafemi Owode	New	Big
45.	Paras Crushing Company Limited	3.63068	7.17492	Iwaye	Ijebu North east	Active	Small
46.	Ratcom Nig. Ltd. 1	3.95329	6.96707	Ago Iwoye	Ijebu North	Close down	Small
47.	Ratcom Nig. Ltd. 2	3.95806	6.74107	Oko -Eko, Ogbere	Ijebu East	Active	Big
48.	S.J.A WestAfrica Ltd	3.99467	6.75539	Efon	Odeda	Active	Big
49.	Strong Tower Infastructure & Development Nig. Ltd	3.24839	7.02042	Layanran	Obafemi Owode	Active	Big
50.	Sandcrete Engineering Nig. Ltd	3.73153	7.00816	Degbe	Obafemi Owode	Inactive	Small
51.	Sanju Sanny Nig Ltd	4.12709	6.77149	Iyanju	Odeda	Inactive	Small
52.	Saunders	4.15701	6.76269	Oke-Ata	Abeokuta North	Closed down	Small
53.	Shepherd's Value Pack Company Limited	4.16964	6.79054	Arege	Odeda	Closed down	Small
54.	Svegao Nig. Ltd	3.59689	7.38752	Sosun	Odeda	Active	Small
55.	Unicontinental International Eng. Company Ltd	4.14335	6.79352	Ogbe	Obafemi Owode	Active	Big
56.	Veritas	4.11795	6.79749	Omo Ologede	Obafemi Owode	Active	Big
57.	Western Quarry Ltd	4.15174	6.81605	Kenta Logemo	Odeda	Active	Big
58.	Zanex International Ltd	4.07007	6.96505	Adelokun	Obafemi Owode	Active	Big
59.	Zhong Tai	3.46262	7.13813	Ago Iwoye	Ijebu North	Active	Big
60.	Zouchling Chang	3.32516	7.12927	Abaru	Obafemi Owode	Active	Big

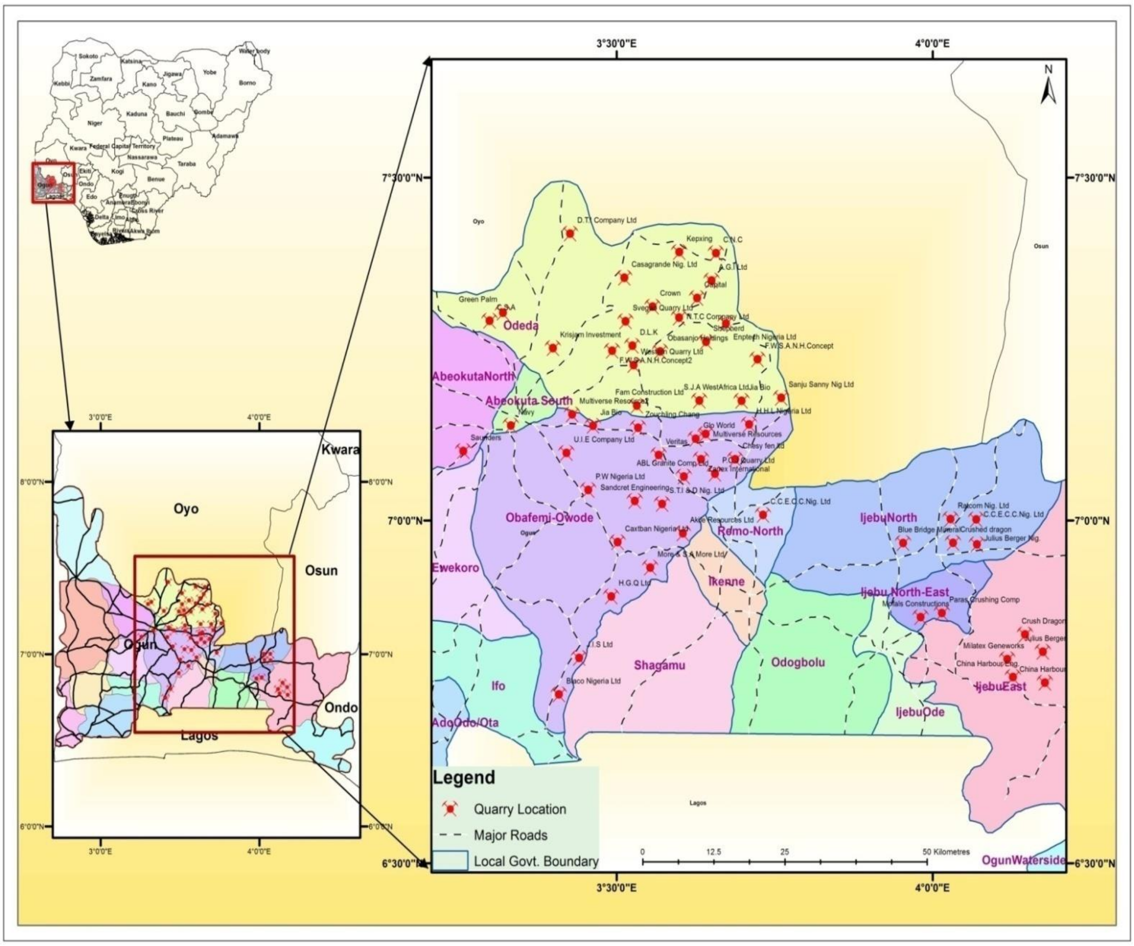

Figure 2: Distribution of Quarrying Sites in Local Government Areas
Source: field survey (2017)

Table 3: Physico-chemical Contents of Surface Water in Dry Season (N = 3)

Parameters	Ogbere	Iwaye	Idode	Isara	Adelokun	Ilagbe	Baaki Ake	Igodo	Control	WHO (2017)	T-test value	p-value
pH	6.72±2.10	7.08±2.90	7.10±3.00	7.06±2.20	6.20±3.00	6.60±1.45	6.40±1.97	6.50±2.40	7.02±3.00	6.5-8.5	-2.29	.051
T °C	28.2±1.00	37.9±2.22	28.0±2.12	27.8±1.69	28.6±2.00	28.2±3.00	27.7±0.67	28.9±2.78	28.3±3.00	35-40	-7.58	.000
EC (µS/cm)	128.30±2.1	50.70±1.00	176.1±1.00	286.4±2.22	124.8±2.10	143.5±1.45	128.4±0.36	134.2±1.4	72.9±2.40	1000	-38.68	.000
TDS (mg/L)	61.2±3.20	25.2±0.89	83.0±2.22	135.4±2.1	62.6±3.00	69.5±2.40	61.5±1.00	57.6±2.1	36.4±2.1	1200	-109.08	.000
TSS (mg/L)	5.68±2.18	13.09±2.8	14.68±2.1	8.59±2.22	14.97±2.10	12.45±2.18	14.18±1.45	11.35±0.7	13.53±1.80	30	-17.41	.000
CL (mg/L)	5.44±0.05	0.58±2.1	8.34±2.8	6.70±1.45	3.99±2.00	4.08±2.40	4.12±2.1	4.92±2.10	0.48±3.00	250	-333.05	.000
DO (mg/L)	4.38±2.40	5.85±2.2	3.81±2.22	2.76±1.3	5.91±2.1	7.28±2.10	5.35±2.00	6.34±2.9	4.17±1.45	2.0	10.35	.000

T = Temperature, EC = Electrical conductivity, TDS = Total dissolved solid, TSS = Total suspended solid, CL = chloride, DO = Dissolved solid.

Table 4: Physico-chemical Contents of Surface Water in Wet Season (N=3)

Parameters	Ogbere	Iwaye	Idode	Isara	Adelokun	Ilagbe	Baaki Ake	Igodo	Control	WHO (2017)	F-test value	p-value
pH	6.70±1.00	6.30±2.00	7.30±2.23	7.00±2.4	7.10±1.11	6.90±1.98	7.10±1.98	6.80±2.90	6.70±2.4	6.5-8.5	-6.33	.000
T °C	28.0±1.09	37.4±2.90	28.4±2.23	27.9±1.09	27.6±2.23	27.4±2.4	26.8±2.00	27.2±1.00	26.8±2.90	35-40	-7.99	.000
EC (µS/cm)	248.2±2.4	349.9±1.09	299.8±2.00	428.2±1.11	112.8±2.90	138.5±1.98	119.7±1.00	128.6±2.90	104.2±1.09	1000	19.84	.000
T DS (mg/L)	115.9±2.00	167.9±2.00	136.4±2.90	202.9±2.90	47.2±1.11	66.4±2.4	60.4±2.23	59.2±1.09	53.5±2.00	1200	-4.96	.001
TSS (mg/L)	12.13±3.1	15.5±1.00	10.16±2.3	13.13±2.9	16.44±0.1	16.33±2.90	18.26±0.2	14.34±0.3	7.52±0.3	30	15.14	.000
CL (mg/L)	9.54±0.2	12.23±2.90	4.11±0.9	7.88±2.8	5.13±1.00	5.69±3.1	5.35±0.2	5.11±3.0	1.22±2.5	250	227.23	.000
DO (mg/L)	5.20±0.9	6.33±0.2	5.05±0.9	4.35±3.1	4.22±2.9	7.61±0.8	6.41±2.5	6.81±2.90	8.45±1.6	2.0	12.05	.0000

T = Temperature, EC = Electrical conductivity, TDS = Total dissolved solid, TSS = Total suspended solid, CL = chloride, DO = Dissolved solid.

Table 5: Physico-chemical Contents of Ground Water in Dry Season (N=3)

Parameters	Ogbere	Iwaye	Idode	Isara	Adelokun	Ilagbe	Baaki Ake	Igodo	Control	WHO (2017)	T-test value	p-value
pH	7.04±2.4	7.12±1.7	7.06±2.23	7.07±1.7	6.50±2.8	6.90±0.9	6.80±2.9	6.70±3.0	7.10±2.8	6.5-8.5	-1.10	.302
T °C	28.1±0.5	27.7±2.5	27.9±2.4	28.0±2.90	27.5±2.8	27.8±1.6	26.9±1.9	27.4±1.25	28.2±2.4	35–40	-72.34	.000
EC (µS/cm)	139.3±0.5	189.2±2.23	59.6±3.00	252.2±2.91	66.2±3.0	72.4±1.7	61.2±2.8	68.8±2.9	86.3±2.0	1000	-38.79	.000
TDS (mg/L)	67.0±3.0	89.4±2.90	28.0±2.4	119.5±1.98	34.8±0.5	38.4±0.2	27.6±3.00	26.2±2.90	42.5±1.25	1,200	105.08	.000
TSS (mg/L)	6.29±2.8	10.74±3.00	4.97±3.0	7.86±2.23	12.46±0.2	9.68±1.7	13.41±1.6	10.78±3.00	8.64±2.0	30	22.26	.000
CL (mg/L)	6.57±2.8	7.89±0.2	0.71±1.6	5.42±0.5	3.11±2.0	2.86±1.7	3.44±3.0	3.86±3.0	0.36±1.98	250	295.86	.000
DO (mg/L)	3.94±3.0	3.30±1.98	5.35±2.0	3.39±0.11	5.32±2.4	6.11±2.23	4.94±0.2	5.47±3.0	3.83±1.6	2.0	12.97	.000

T = Temperature, EC = Electrical conductivity, TDS = Total dissolved solid, TSS = Total suspended solid, CL = chloride, DO = Dissolved solid.

Table 6: Physico-chemical Contents of Ground Water in Wet Season (N=3)

Parameters	Ogbere	Iwaye	Idode	Isara	Adelokun	Ilagbe	Baaki Ake	Igodo	Control	WHO (2017)	T-test value	p-value
pH	6.90±2.23	6.50±1.24	6.90±2.0	6.60±2.23	6.80±1.7	7.20±2.7	7.30±0.5	6.90±1.7	6.95±0.23	6.5 - 8.5	-7.18	0.000
T °C	27.8±0.2	36.5±1.7	27.6±2.0	27.0±2.4	26.7±1.23	26.9±1.98	25.9±2.23	26.8±0.17	26.2±0.2	35 – 40	-8.78	0.000
EC (µS/cm)	137.8±2.23	188.7±2.4	166.8±0.23	250.4±1.89	65.6±2.23	70.7±2.7	59.7±2.0	72.9±1.7	64.5±0.5	1000	-38.04	0.000
TDS (mg/L)	60.1±2.8	95.8±1.7	77.9±1.98	111.8±2.4	28.9±1.98	31.7±1.7	26.9±1.24	33.8±2.23	28.4±1.23	1,200	4.43	0.002
TSS (mg/L)	7.62±2.8	11.65±2.4	6.45±2.23	8.55±2.7	12.83±2.4	12.25±2.8	16.35±1.7	11.42±1.24	5.80±2.8	30	-17.9	0.000
CL (mg/L)	7.63±2.23	9.68±2.8	0.98±2.7	4.24±2.23	2.01±2.8	3.88±0.5	4.33±1.23	4.68±1.24	0.84±0.23	250	251.79	0.000
DO (mg/L)	4.614±1.24	3.934±1.98	4.465±2.8	3.744±2.23	3.67±1.9	6.326±0.5	5.147±2.0	6.026±3.00	7.244±0.5	2.0	11.43	0.000

T = Temperature, EC = Electrical conductivity, TDS = Total dissolved solid, TSS = Total suspended solid, CL = chloride, DO = Dissolved solid.

Table 2 shows the number of quarry sites and their locations. This shows that the locations were relatively close, since they were all located in Ogun State, Nigeria. The data on Table 2 showed that 38.3 % of the quarry sites were located in Odeda Local Government Area (LGA), 35.0 % were located in Obafemi Owode LGA, 10.0 % were located in Ijebu North LGA, 8.3 % were located in Ijebu East LGA, while 1.7 % each were located in Abeokuta North LGA, Remo North LGA and Abeokuta South LGA. This shows that Odeda LGA has the highest number of quarry sites among the LGAs sampled in Ogun State, Nigeria.

Figure 2 indicates that most quarry sites were clustered in Odeda and Obafemi-Owode LGAs of Ogun state. This implies that the presence of geological material (granite) of commercial quantity and quality are found or present in these two LGAs. In terms of impact (either positive or negative), the two LGAs will benefit or suffer more than others in Ogun state. The geographical spread of quarry sites in the Local Government Areas is also represented in Figure 2.

Table 2 presents the functionality of quarry sites; about 61.6 % of the quarry sites in Ogun state were active, 21.7 % were closed while 16.7 % were inactive. However, the closed sites are the quarry sites that are no longer operational, because the granite there had been exhausted. Inactive sites simply mean that they were temporarily non-operational for one reason or the other; among these were government policy; management crises; economic situation of the country; such as fuel scarcity and lack of patronage. In case of government policy, Ogun state government was demanding royalty in 2014 from the quarry operators. The backlash of this move was a protest that led to the stoppage of operations in some quarry sites until the matter was resolved.

The active quarry sites has the highest percentage, this means that most of the quarry sites among the sampled ones are active and this will positively impact the result of the physico-chemical analysis of the water in the dry and wet seasons. The status and size of quarry sites (Table 2) shows that 55.0 % of the quarry sites studied were big, while 45.0 % are small. This means that most of the quarry sites among the sampled ones were big. The activities of the big quarry sites on the locations where they were sited will most likely have impact on the overall result.

Table 3 shows the physico-chemical contents of surface water (SW) in dry season analysed. The pH values range between 6.20±3.00 and 7.10±3.00; with only three locations e.g. Iwaye, Idode and Isara; 7.08±2.90, 7.10±3.00 and 7.06±2.20 respectively were higher than the control (7.02±3.00). Whereas, the other five locations were lower. This implies that quarrying affects the pH values of the surrounding surface water in dry season by lowering their pH (Sayara, 2016; Darwish, 2008). When compared these values with the WHO standard (6.5-8.5); only two locations namely Adelokun (6.20±3.00) and Baaki Ake (6.40±1.97) were not within the WHO standard, because they were acidic; which is not good for consumption. However, there were no significant difference among the values of pH across the locations

With the exception of four locations namely Ogbere (28.2±1.00 ^{o}C), Idode (28.0±2.12 ^{o}C), Isara (27.8±1.69 ^{o}C) and Baaki Ake (27.7±0.67 ^{o}C) that were lower than the control (28.3±3.00 ^{o}C). Other four locations were higher; with the highest temperature found in Iwaye (37.9±2.22 ^{o}C). This implies that quarrying increases the temperature of the surface water in dry season; because there is possibility that those locations with lower values than the control value can rise up to surpass the control, as time goes on (Ekpo *et al.*, 2013). All the temperature values across locations fell within the WHO standard (35-40 ^{o} C) and there were significant differences among the temperature values across the locations.

Only Iwaye (50.70±1.00 μS/cm) was lower than the control (72.9±2.40 μS/cm). Other locations were higher and ranged between the 124.8±2.10 μS/cm (Adelokun) and 176.1±1.00 μS/cm (Idode). This implies that quarry activities increased the Electrical Conductivity of the surface water during dry season (Ekpo *et al.*, 2013). All the values of electrical conductivity across locations were within the WHO limit (1000 μS/cm) and there were significant differences among the values in all locations.

All the Total dissolved Solid values across the locations were higher than the control (36.4±2.1 mg/L); except Iwaye (25.2±0.89 mg/L). This indicates that quarry activities had increased the total dissolved solid of the surface water in the dry season (Sayara, 2016). When these values compared with WHO limit (1,200 mg/L), they were far from the limit. There were significant differences among the values across the locations.

Among the Total Suspended Solid values across the locations, only three locations were distinctly greater than the control (13.53±1.8 mg/L); namely Idode (14.68±2.1 mg/L), Adelokun (14.97±2.10 mg/L) and Baaki Ake (14.18±1.45 mg/L). The others were lower; hence, it can be concluded that quarrying does not affect the Total Suspended Solid in surface water during dry season (Sayara, 2016). All values across the locations were lower than the WHO limit of 30 mg/L. However, there were significant differences among the values across the locations.

Chloride values range between (Iwaye) 0.58±2.1 - 8.34±2.8 mg/L (Idode) and none was lower than the control (0.48±3.00 mg/L). This means that quarrying increases the chloride of the surface water in dry season. It is advantageous for the waterbody as the chloride will kill any germ present therein (Oyinloye and Ajayi, 2015). The WHO limit of 250 mg/L were far above all the values of the chloride across locations and there were significant differences among the chloride values across locations.

Among all locations, Dissolved Oxygen values; only Idode (3.81±2.22 mg/L) and Isara (2.76±1.3 mg/L) were lower than the control (4.17±1.45 mg/L). This means that the remaining six locations were higher. This also means that dissolved oxygen in surface water around quarries were increased by quarry activities. The WHO limit of 2.0 mg/L was far less than the values of dissolved oxygen in all locations. This bodes well for the water, and is a clear indication that Biological Oxygen Demand (BOD) of the water is very low. Hence, the water is less polluted with organic waste that can attract pathogenic organisms and there were significant differences among the values in all locations (Ekpo *et al.*, 2013).

Table 4 presents the physico-chemical parameters of surface water (SW) in wet season across locations; with pH having values range between (Iwaye) 6.30±2.00 and 7.30±2.23 (Idode) across locations and all above control (6.70±2.4), with the exception of Iwaye (6.30±2.00) that was lower and acidic. This connotes that quarrying does not affect the pH values of surface water in the wet season. However, all other values of the pH with the exception of Iwaye fell within the WHO limit (6.5-8.5) (Sayara, 2016; Darwish, 2008) and they were neutral. However there were significant differences among the values across locations.

The temperature ranges as follow 26.8±2.00 - 37.4±2.90 ° C across locations; with Baaki Ake and Iwaye as their respective locations and were higher than the control (26.8±2.90 ° C); which connotes that temperatures of the surface water were increased by the quarry activities during the wet season (Ekpo *et al.*, 2013). Interestingly, and these values fell within the WHO limit of 35-40 ° C and there were significant differences among the values in all locations.

All the Electrical Conductivity values (112.8±2.90 - 349.9±1.09 µS/cm) in all locations were higher than the control (104.2±1.09 µS/cm); which implies that quarrying increases electrical conductivity of the surface water in the wet season. However, none of these values of electrical conductivity in all locations were higher than the WHO limit (1000 µS/cm) and there were significant differences among these values in all locations (Ekpo *et al.*, 2013).

Total Dissolved Solid (47.2±1.11 - 167.9±2.00 mg/L) across locations were higher than the control (53.5±2.00 mg/L); except Adelokun (47.2±1.11 mg/L); which connotes that quarrying increases the total dissolved solid of the surface water in wet season and all values were less than the WHO limit of 1,200 mg/L. However, there were significant differences among all the values in all locations (Oyinloye and Ajayi, 2015).

Total Suspended Solid values of all sampled locations (10.16±2.3 – 18.26±0.2 mg/L) were higher than the control (7.52±0.3 mg/L). This simply means that quarry activities increase the total suspended solid of surface water during wet season (Sayara, 2016). Among the values of Total Suspended Solid; none was higher than the WHO limit (30 mg/L) and there were significant differences in all values across locations.

The values of chloride in all locations (4.11±0.9 – 12.23±2.90 mg/L) were higher than the control site (1.22±2.5 mg/L); which implies that quarrying increases the chloride of the surface water during wet season. It is good for the water as the chloride will disinfect any germ presents in the water body. However, none of these values of the chloride were higher than the WHO limit (250 mg/L) (Oyinloye and Ajayi, 2015). There were significant differences among the values across locations.

Dissolved Oxygen values range between 4.22±2.9 and 7.61±0.8 mg/L and none was higher than the control (8.45±1.6 mg/L). Hence, quarrying depreciates Dissolved Oxygen of the surface water during wet season. Moreover, those values of dissolved oxygen were far higher than the WHO limit (2.0 mg/L) (Ekpo *et al.*, 2013) and there were significant differences among the values across locations.

Table 5 shows the physico-chemical parameters of ground water (GW) across locations in the dry season. However, with exception of Iwaye (7.12±1.7), the pH of GW in dry season in all locations (6.50±2.8 – 7.12±1.7) were lower in value than the control (7.10±2.8) and this shows that quarrying affects the pH of GW in dry season. When comparing this values with WHO limit of 6.5-8.5, this is apparent that all the values were within the limit and neutral (Sayara, 2016). There were no significant differences in the values across the locations.

None of the temperature values across locations (26.9±1.9 – 28.1±0.5 ^{o}C) were up to the control (28.2±2.4 ^{o} C). This means that quarrying does not affect the temperature of GW in dry season. All the temperature values fall within the WHO limit (35-40 ^{o}C)
(Ekpo *et al.*, 2013; Enger and Smith, 2002) and there were significant differences among the values across locations.

Electrical Conductivity (EC) of Ogbere (139.3±0.5 µS/cm), Iwaye (189.2±2.23 µS/cm) and Isara (252.2±2.91 µS/cm) were higher than the control (86.3±2.0 µS/cm). The other five locations were lower; thereby indicating that quarry activities does not affect the surrounding GW in the dry season. Moreover, all EC values across the locations (59.6±3.00 – 189.2±2.23 µS/cm) were lower than the WHO limit (1000 µS/cm) (Ekpo *et al.*, 2013) and there were significant differences among the values across the locations.

Except Total Dissolved Solid (TDS) of Ogbere (67.0±3.0 %) Iwaye (89.4±2.90 %) and Isara (119.5±1.98 %) that exceeded the control value of 42.5±1.25 %; other five locations were not up to the control; which implies that quarrying does not affect the TDS of GW in dry season and the values in all locations were lower than the WHO limit (1,200 %). However, there were significant differences among the values in all locations (Oyinloye and Ajayi, 2015).

Among the Total Suspended Solid (TSS) values; only Ogbere (6.29±2.8 mg/L), Idode (4.97±3.0 mg/L) and Isara (7.86±2.23 mg/L) were lower than the control (8.64±2.0 mg/L). Whereas other five locations were higher; which means quarry activities affect the TSS of the GW in the dry season. However, none of the values in all locations close to the WHO limit of 30 mg/L and there were significant differences among the values in all locations.

The chloride values range between 0.71±1.6 and 7.89±0.2 mg/L; and among these values none was lower than the control (0.36±1.98 mg/L). This shows that quarrying adds to the chloride of the GW in dry season. Hence, it is good for the water as the chloride would disinfect any germ inside the GW. Thereby making it free from water borne diseases. However, the chloride in all locations had never exceeded the permissible limit of WHO (250 mg/L) and there were significant differences among the values in all locations (Sayara, 2016; El-Nashar, 2009).

Except Iwaye (3.30±1.98 mg/L) and Isara (3.40±0.11 mg/L); all other locations had Dissolved Oxygen (DO) values higher than the control (3.83±1.6 mg/L). This shows that quarry activities increased the DO of GW in dry season and all locations including the control site were higher than the WHO standard of 2.0 mg/L. This is good for the GW because the more dissolved oxygen a water body has, the better for it. Hence, it can be concluded that, it is free from dead organic matter, waste or chemical compound that is consuming DO. Furthermore, the more it is far from microorganisms causing water borne diseases, the better (Ekpo *et al.*, 2013; Khaled, 2005). Moreover, there were significant differences among the DO values across locations.

Table 6 shows the physico-chemical parameters of ground water (GW) across all the locations in wet season. The pH in all locations (6.50±1.24 – 7.30±0.5) were lower than the control (6.95±0.23), with the exception of Ilagbe (7.20±2.7) and Baaki Ake (7.30±0.5) that were higher. This means that quarrying affects the pH of GW in wet season by reducing its value. However, all the values of pH in all locations fell within the WHO permissible limit of 6.5 – 8.5; which means the GW in wet season is neither acid nor alkaline, but neutral. This is good for the GW and there were significant differences among the values across the locations (Sayara, 2016; Abu Khalaf, 2010).

All the location temperature values (25.9±2.23 – 36.5±1.7 ^{o}C) were higher than the control (26.2±0.2 ^{o}C) except Baaki Ake (25.9±2.23 ^{o}C) that was lesser. This implies that quarrying increased the temperature of GW in the wet season. Also, when compare the WHO range (35 – 40 ^{o}C) with all the temperature values across locations, they were all found to fall within the range. There were significant differences among the temperature values in all locations (Ekpo *et al.*, 2013; Nasserdine *et al.,* 2009).

Baaki Ake (59.7±2.0 µS/cm) had the lowest value of Electrical Conductivity (EC) among all other locations (65.6±2.23 to 250.4±1.89 µS/cm) and it was also found to be lower than the control (64.5±0.5 µS/cm). However, it can be concluded that quarry activities affect the EC of

GW positively in the wet season (Sayara, 2016). All the values of EC across locations were lower than WHO standard of 1000 µS/cm and there were significant differences among the EC values across locations.

The Total Dissolved Solid (TDS) values range between 26.9±1.24 – 111.8±2.4 mg/L and except Baaki Ake (26.9±1.24 mg/L), that was lower than the control (28.4±1.23 mg/L); Hence, it can be deduced that quarrying affects the TDS of GW positively in wet season and none of the TDS values exceeds the WHO limit (1200 mg/L) (Ekpo *et al.*, 2013). There were significant differences among the TDS values across locations.

None of the Total Suspended Solid (TSS) values (6.45±2.23 – 16.35±1.7 mg/L) in all locations were found to be lower than the control value (5.80±2.8 mg/L). Hence, it indicates that quarry activities increase the TSS of the GW in the wet season (Sayara, 2016; Enger and Smith, 2002). All the values across the locations were lower than the WHO Value of 30 mg/L and there were significant differences among the values of TSS across the locations.

The chloride ranges between 0.98±2.7 – 9.68±2.8 mg/L across locations and none was lower than the control (0.84±0.23 mg/L) which means that quarry activities increased the chloride content of the GW in the wet season. This is good for the GW, because chloride is a disinfecting agent. As such, there is less likehood that microorganism in the water body will survive. Moreover, all values were lower than the WHO limit of 250 mg/L (Sayara, 2016; Urich, 2002). However, there were significant differences among the values of the chloride in all locations.

None of the Dissolved Oxygen (DO) values (3.74±2.23 – 6.33±0.5 mg/L) across locations higher than the control (7.24±0.5 mg/L); which means quarry activities deplete the DO of the GW in the wet season. All the values across locations include control were higher than the WHO limit (2.0 mg/L) (Ekpo *et al.*, 2013; Zuhairi *et al*. 2009). There were significant differences among the values of DO across locations.

CONCLUSION

There is no gainsaying that heavy metal are locked up in the granite (stone) extracted from the quarry but what that has not been extensively investigated is the physico- chemical component; which this work is trying to address. However, all the pH values of the surrounding surface water in dry season were affected but within the WHO standard, with the exception of two locations (Adelokun and Baaki Ake). All Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Electrical Conductivity (EC), and chloride during dry season across the locations were lower than their corresponding WHO limits. The WHO limit was far less than the values of Dissolved Oxygen (DO) in all locations. In addition in wet season, all the values of the pH in surface water fell within the WHO limit with the exception of Iwaye. All temperature, EC, TDS, TSS, and chloride values fell within their corresponding WHO limits in all locations. The values of DO in all locations were higher than the WHO limit.

Furthermore, the pH of the ground water (GW) in the dry season were within the limit and neutral. All the temperature, EC, TDS, TSS, and chloride values fell within their corresponding WHO limits. The DO of GW in dry season in all locations including the control site were higher than the WHO standard. Moreover, the values of pH, temperature, EC, TDS, TSS, and chloride of ground water (wet season) in all locations fell within the WHO permissible limit. Finally, DO of the GW in the wet season across locations were higher than the WHO limit. However, the reason why most results in dry season were higher than wet season is not far–fetched. This is because construction and infrastructure sectors that are the major end users of the quarry products are always on break during wet season; hence low patronage of the quarry products and the quarry activities are lesser. Though not all the physico-chemical parameters analysed were above the WHO limit but the chances that they can aggravate to that level is present; in as much as the quarry activities continue in those areas. Hence, attention has to be drawn to the water bodies around the quarry as regard their physico-chemical characteristics; as most inhabitants of these areas are villagers and solely depend on these water bodies as their source of water for drinking, bathing cooking, laundry etc. However, so as to prevent any anomaly that can arise from the physico-chemical parameters with higher values than WHO permissible limit.

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