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PHYSICOCHEMICAL CHARACTERISTICS OF THE SOIL AROUND THE QUARRY SITES IN OGUN STATE, NIGERIA

Hassan, I. A.
Department of Biological Science, Lagos State University of Science and Technology, Ikorodu, Lagos State, Nigeria.
Author's E-mail: hassan.ia@lasustech.edu.ng

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ABSTRACT

Quarrying of rock for construction purposes is a significant industry in Nigeria thus enhancing the economy. This study aimed at assessing the physicochemical parameters of the soil around the quarry sites across selected Local Government Areas in Ogun State. Geographic Information System approach was used to map the various quarry locations in Ogun State, from which eight sites were selected namely Isara, Idode, Iwaye, Ogbere, Ilagbe, Adelokun, Baaki Ake and Igodo. A total of 48 soil samples (topsoil and subsoil) were collected for cation exchange capacity (CEC), electrical conductivity (EC) and Particle size distribution using standard procedures. Sampling was done in dry and wet seasons. Data were subjected to descriptive and inferential statistics using SAS package (9.4 version). However Variable Quality Control Package was used to determine the Control Limit for the soil parameters. Sixty quarries were identified. The electrical conductivity of 505.1±0.6 µS/cm of the topsoil at Igodo in the wet season was above the Upper control limit (UCL) of 501.6 µS/cm. The CEC of topsoil and subsoil in all locations (dry and wet seasons) were lower than the control, with the exception of Isara and Baaki Ake in subsoil (wet season). The sand sizes and percentage weights of sizes (topsoil) of Idode and Adelakun were higher than the control (75 – 150 µm with 74.0%) in dry season; while in wet season, Adelokun (180 µm and 62.4%) was higher than the control (75 – 150 µm and 15.1%). In the subsoil during dry season Idode and Baaki Ake were higher than the control (75 – 150 µm and 71.5%); while during wet season Baaki Ake and Adelokun were higher than the control (75 – 150 µm and 19.4%). In conclusion, quarries had polluted the surrounding soils with sandy particle, EC and reduce CEC values.

Keywords: physicochemical, characteristics, soil, quarries

INTRODUCTION

Open mines that produce minerals are typically referred to as open pit mines. Quarrying is a form of surface mining used when the rock is close to the surface of the land. The way that quarrying is done depends on the rock, the miners are digging out of the ground and what the rock will be used for after it's mined (Banez *et al.,* 2010).

Furthermore, active and abandoned quarries have been a source of negative environmental effects which have led to erosion, formation of sinkholes, and contamination of soil and also the loss of biodiversity. All these problems arise from contamination of the chemicals locked up in mineral exploring and released during mining (Oyinloye and Ajayi, 2015; Julie *et al.*, 2018).

Rock and rock mineral exploitation activities are sources of change in the physical and chemical composition of the soils. According to Ayodele *et al.* (2014), the soils of Ikole-Ekiti around quarry were slightly acid loamy sands to sands in the topsoil and sandy loam to sands in the subsoil, organic matter was 0.71 – 2.93% and 0.55 – 1.76% in the topsoil and subsoil respectively; however, Cationic exchange capacity (CEC) was 4.95 – 9.12 and 4.64 – 9.47 cmol.kg^{-1} for the 0 – 15 cm and 15 – 30 cm layers of soil, respectively. The soil properties are formed from the parent materials derived from basement complex rocks, especially in soil reaction, coarse-textured surface layer (loamy sand to sand with mean 8.9% clay) overlying fine-textured subsoil (sandy loam to sand with mean 12.2 % clay) and decreasing organic matter with soil depth (Ayodele *et al.,* 2014). Soil pH ranged from 6.65 to 8.23, sand from 55.8 to 75.0%, silt from 16.6 to 34.6%, clay from 8.43 to 13.6%, and organic matter from 0.97 to 4.84%, respectively (Etim and Adie, 2012). The result of properties of topsoil samples within the vicinity of a major quarry in Nigeria had pH that ranged from 6.65 to 8.23 for topsoil samples within a spherical span of 500 m away from the blasting and crushing area (Etim and Adie, 2012). The average pH of background soil was 6.87 ± 0.35, while that of the quarried limestone was 8.74 ± 0.52. pH decreased with increase in distance from the blasting and crushing area. A sharp decrease in pH occurred in topsoil samples; 200 m far away from the exploration arena and comparable with the background pH (Etim and Adie, 2012). The organic matter content of topsoil samples in the study carried out by Etim and Adie, (2012) ranged from 0.97 to 4.84% comparable with average of 3.31 ± 1.73% for background soil. The particle size analysis for all topsoil samples studied by Wenzel (2005) was in the order: 55.8 to 75.0% > 16.6 to 34.6% > 8.43 to 13.6% for sand, silt, and clay, respectively.

Again, like many other man-made activities, quarrying involves the production of significant amounts of waste. Some types of quarries do not produce large amounts of permanent waste, such as soil and gravel quarries, whereas others will produce significant amounts of waste material such as clay and silt (Wang, 2007). Soil pollution from quarrying activities reduce soil moisture and soil organic contents (Zwolak *et al.*, 2019). Nitrogen and ammonia in soils are produced by the action of microorganisms on the soil organic matter. Soils close to quarries may contain significant amount of contaminant like dusts and chemicals that can inhibit microbial activities thereby reducing the available nitrogen content of soils (Olatunde *et al.*, 2021).

With increasing number of quarries in Ogun State, there are many public complaint about activities of quarries. Be that as it may, the perceived environmental pollution arising from quarry activities cannot be ascertained unless an impact analysis is carried out (Hassan, 2022). Hence, this study; physicochemical characteristics of the soil around the quarry sites in Ogun State, Nigeria.

MATERIALS AND METHODS

3.1 Study Area

Ogun State lies between latitude 7.9031 - 6.3142°N and longitude 2.7073 - 4.5750°E. Its geographical location makes it easily accessible to Lagos, the commercial capital of Nigeria, industrial hub to main seaport. Ogun State covers a geographical area of 16,980.55 square kilometres with a population of about 3,751,140 (NPC, 2006).The state is within the Rain forest zone of Nigeria and enjoys a tropical climate with distinct wet and dry seasons. Wet season in Ogun State lasts between seven and eight months; (April to October) and the dry season running through November to February (Hassan, 2022).

Sampling Techniques

Purposive sampling method was used to select eight (8) quarry locations in the study area. Sampling was carried out in eight (8) selected locations due to their closeness (500 – 1000 m) to the quarry sites in all six local government areas and still in operation. Two (2) locations were selected from each of Odeda and Obafemi/Owode Local Government Areas due to presence of higher number of quarry sites in them. One location was sampled from each of the remaining four (4) Local Government Areas. Sample locations in each Local Government Area with their respectively coordinates 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	3.4230	7.138
Remo North	Isara	CCECC	3.534	7.155
Odeda L.G	Igodo	F.W.S.AN.H.Concept 2	3.492	6.931
Odeda L.G	Ilagbe	DLK	3.553	6.931
Obafemi/Owode	Baaki Ake	Blaco	3.625	7.119
Obafemi/Owode	Adelokun	Zanex	4.070	6.965

Longtitude (Long), Latitude (Lat)
Source: Field survey, (2016)

Sample Collection

The soil samples were collected with soil auger at various depth of the soil of Topsoil (0 – 15 cm) and Subsoil (15 – 30 cm); at three different spots from each location and bulked so as to take sample to be analysed and this was repeated thrice on different areas of the same location. Three soil samples each were collected from Topsoil and subsoil in each location; making a total of 6 samples per location and 48 in all 8 sampled locations. The soil samples were collected twice; between November 2015 and July 2016, covering both dry and wet seasons. The following physical and chemical parameters were determined: pH, Total organic carbon content (TOC),Cation exchange capacity(CEC), Electrical conductivity (EC), Temperature, Nitrate, Particle size distribution (% sand, % clay, % silt). The means and standard deviation of each three samples per location (physico-chemical) were calculated

Laboratory Soil Analysis

Grain size/particle size distribution was carried out using Bouycous hydrometer method as described by Chopra and Kanwar (2011).

Cationic exchange capacity; the soil sample was percolated with sodium acetate, the excess salt in them was removed and the absorbed sodium exchanged by percolation with ammonium acetate (NH_4OAc).

pH meter (Jenway pH model 3150) was used to measure pH . The calibration was carried out by the measurement of the buffer solutions of 4.0, 6.8 and 9.22. A 20 g of soil sample (topsoil and subsoil) and 20 mL of distilled water were added together to make slurry. The rinsed electrode was dipped into deionised water and the electrode was later dipped into the slurry sample to determine the pH. The slurry was allowed to stand for 30 minutes with intermittent stirring. The coarse particles were allowed to settle after the last stirring before the pH reading was taken.

The temperature of the sample was determined using mercury in glass thermometer.

Temperature reading was taken from the soil in situ during the production hours. It was measured by dipping the thermometer into the depth of 0 – 15 cm and 15 – 30 cm of the soil from the surface.

Electrical conductivity was determined using the method described by Reeuwijk (2002). Percentage Total organic carbon in the treated soil samples was determined by oxidation with potassium dichromate and titration with ferrous sulphate reagent (FAO, 2019).

Nitrate content was determined by modifying Kjeldahl method as described by (He *et al.*, 1990).

Nitrogen as ammonia content was determined by direct nesslerisation method using the following reagents and steps; 1 mL of zinc sulphate solution (10% w/v) was added to 1 g of the sample. Then mixed thoroughly with glass stirring rod, then 0.4 to 0.5 mL of 6.25M NaOH was added to obtain a pH of 10.5. It was clarified by centrifuging or filtering through a filter paper and the first 25 mL of the filtrate was discarded. A 5.0 mL of the filtrate was measured into a 25 mL measuring cylinder. One to two drops of EDTA was added, to prevent cloudy tubes. Nesslerised by adding 1 mL of nessler reagent, then diluted to the mark with distilled H_2O. The blank solution was also subjected to the same treatment as the sample. A working standard solution was prepared from the Stock solution and treat as above. After 10 minutes the absorbance for both the samples, blank and standard on an Ultra Violet (UV) -Visible Spectrophotometer (Jenway 7300 model) at a wavelength of 430 nm was read.

Calculation:

M = (Standard Absorbance – Blank Absorbance)/Standard Concentration

NH_4^+ - N (mg/l) = (Sample Absorbance – Blank Absorbance)/M

NH_4^+ (mg/l) = (mg/l NH_4^+ -N) * 1.216 (1)

Data analysis

Soil was analysed using descriptive (mean, standard deviation, percentage) and inferential analysis (ANOVA, T-test Duncan Multiple Range Test) to compare and show variations among the parameter concentrations in the study areas. However, Variable Quality Control Package was also used to determine the control limit for the soil parameters: Upper Control Limit (UCL) and Lower Control Limit (LCL).

RESULT

Table 2: Physico-chemical Parameters of Top Soil (0 –15 cm) in Dry Season (N=3).

Parameters	Ogbere	Iwaye	Idode	Isara	Ilagbe	Adelokun	Baaki Ake	Igodo	Control	Out of Control Limit
pH	6.6±0.9	6.8±2.1	6.7±1.2	7.1±2.1	6.8±0.2	6.4±3.2	6.2±3.1	5.9±2.9	6.8±0.0	No
Temperature (°C)	31.1±2.4	30.9±1.0	31.0±3.0	30.9±0.1	26.9±0.2	27.5±0.3	26.5±0.1	26.6±0.1	30.8±0.0	No
Electrical Conductivity (µS/cm)	236.2±1.1	303.1±1.3	397.5±2.9	489.4±1.2	245.5±0.0	225.3±0.2	195.6±1.1	235.8±1.3	264.5±0.0	No
Total organic carbon content, (%)	0.3±2.2	2.6±0.1	4.0±0.2	1.20±1.0	1.9±0.1	2.5±0.3	2.7±0.1	2.90±0.2	3.9±0.0	No
Nitrate Nitrogen (mg/kg)	2.5±0.1	19.5±0.9	24.5±1.3	14.9±2.1	38.3±1.1	61.7±0.3	68.9±1.0	58.4±0.9	26.7±0.0	No
Ammonium Nitrogen (mg/kg)	4.4±2.0	61.5±0.9	66.4±0.3	40.4±1.4	116.2±2.9	158.5±0.2	173.7±2.0	136.6±1.2	66.6±0.0	No

Table 3: Physico-chemical Parameters of Top Soil (0 – 15 cm) in Wet Season (N=3).

Parameters	Ogbere	Iwaye	Idode	Isara	Ilagbe	Adelokun	Baaki Ake	Igodo	Control	Out of Control Limit
pH	6.5±0.1	7.1±0.8	6.6±0.1	7.0±1.2	7.0±0.9	7.2±0.3	7.3±1.3	7.4±2.0	6.2±0.0	No
Temperature (°C)	26.1±0.9	26.5±1.0	26.3±0.1	27.0±0.2	30.7±1.0	30.5±0.79	30.6±1.1	30.4±1.3	26.6±0.0	No
Electrical conductivity (µS/cm)	241.5±0.1	262.2±0.3	205.2±1.1	234.6±0.8	252.6±0.9	320.3±0.7	314.2±1.0	505.1±0.5	250.2±0.0	Yes
Total organic carbon content (%)	3.0±0.9	2.1±0.9	2.9±0.5	2.7±0.9	0.3±1.8	2.7±0.9	4.2±0.9	1.9±0.9	3.2±0.0	No
Nitrate- nitrogen (mg/kg)	62.3±11.2	45.2±2.9	73. 1±2.1	66.4±2.0	9.4±0.8	25.2±1.0	31.5±1.8	21.6±0.3	88.9±0.0	No
Ammonium- nitrogen (mg/kg)	148.8±2.1	125.5±3.0	184.4±2.8	167.5±1.0	15.9±2.8	70.6±2.1	74.0±2.1	50.7±2.9	162.3±0.0	No

Table 4: Physico-chemical Parameters of Sub Soil (15 – 30cm) in Dry Season (N = 3).

Parameters	Ogbere	Iwaye	Idode	Isara	Ilagbe	Adelokun	Baaki Ake	Igodo	Control	Out of Control Limit
pH	6.6±0.2	6.8±0.9	6.7±0.1	7.1±1.0	6.7±0.9	7.2±0.4	6.6±0.2	6.8±1.0	6.6±0.0	No
Temperature (°C)	30.9±±0.8	31±0.7	30.8±0.8	30.9±1.0	30.8±0.7	30.9±0.7	30.9±0.2	31±1.2	30.9±0.1	No
Electrical conductivity (µS/cm)	255.4±3.0	217.4±2.1	487.4±3.0	471.3±2.1	487.4±2.8	471.3±2.1	255.4±1.0	217.4±2.4	255.4±0.2	No
Total organic carbon content, (%)	0.2±0.3	1.9±0.9	3.2±0.2	1.1±0.8	3.2±0.3	1.1±0.2	0.2±0.3	1.9±0.2	0.2±0.0	No
Nitrate Nitrogen (mg/kg)	2.2±0.5	17.3±0.2	22.7±1.0	12.2±0.7	22.7±0.4	12.2±0.2	2.2±1.0	17.3±0.1	2.2±0.0	No
Ammonium Nitrogen (mg/kg)	3.7±0.7	53.0±1.0	60.6±0.3	39.4±0.8	98.6±0.2	147.2±0.3	162.70±0.5	128.8±0.3	64.3±0.1	No

Table 5: Physico-chemical Parameters of Sub Soil (15 – 30 cm) in Wet Season (N = 3).

Parameters	Ogbere	Iwaye	Idode	Isara	Ilagbe	Adelokun	Baaki Ake	Igodo	Control	Out of Control limit
pH	6.9±1.0	6.8±0.2	7.1±0.2	7.1±0.9	7.3±0.4	7.1±0.3	7.0±0.4	7.4±1.0	6.4±0.0	No
Temperature (°C)	26.4±0.1	26.8±0.8	26.3±0.3	27.1±0.4	30.5±0.2	29.5±0.3	30.4±0.1	30.5±0.3	27.0±0.1	No
Electrical conductivity (µS/cm)	235.6±3.0	244.5±3.0	197.8±3.0	226.4±3.2	360.3±3.0	224.7±2.7	496.1±1.8	479.5±3.7	248. 4±0.2	No
Total organic carbon content (%)	2.9±0.1	2.3±0.2	2.6±0.7	2.6±0.7	0.4±0.3	2.0±0.2	3.4±0.5	1.3±0.9	3.1±0.0	No
Nitrate- nitrogen (mg/kg)	55.6± 0.3	44.9±0.9	66.0±0.5	64.0±0.3	10.3±0.2	24.9±0.8	29.9±0.3	20.5±0.1	76.5±0.1	No
Ammonium-nitrogen(mg/kg)	136.0±0.7	110.4±0.4	171.5±0.3	155.7±0.3	14.5±0.4	60.1±0.3	69.2±0.7	48.0±0.9	155.5±0.2	No

Table 6: T-test for for Physico-chemical Contents in Top Soil Sample Sample Dry and Wet Season (N = 3).

Location	Dry	Wet	T - test	P - value
Ogbere	46.8±1.0	52.7±0.2	3.0	0.1
Iwaye	70.8±0.7	76.1±0.1	2.5	0.2
Idode	88.4±0.3	76.1±0.8	1.3	0.7
Isara	97.3±0.7	102.8±0.3	4.1	0.2
Ilagbe	80.3±0.8	78.1±0.9	2.1	0.1
Adelokun	72.6±0.9	84.2±0.3	7.2	0.1
Baaki Ake	78.9±0.2	83.1±0.2	1.2	0.1
Igodo	77.7±0.2	81.4±0.3	2.3	0.3
Control	66.6±0.2	89.6±0.2	2.2	0.3

Table 7: T-Test for Physico-chemical Contents in Sub Soil Sample Sample between Dry and Wet Season (N = 3).

Location	Dry	Wet	T - test	P - value
Ogbere	49.8±0.4	70.6±0.7	7.0	0.0
Iwaye	54.6±0.5	58.0±0.6	3.4	0.3
Idode	101.9±2.0	106.0±0.1	9.1	0.1
Isara	93.7±1.0	89.9±0.9	3.2	0.4
Ilagbe	111.6±1.2	72.6±0.8	3.2	0.0
Adelokun	108.3±0.1	80.5±0.8	9.1	0.0
Baaki Ake	76.3±0.8	78.5±0.8	8.1	0.0
Igodo	67.2±0.7	77.2±0.7	12.1	0.4
Control	59.9±0.5	44.7±0.4	13.1	0.3

Table 8: Cationic Exchange Capacity of Topsoil and Subsoil (N = 3).

Location	Cationic Exchange Capacity (CEC) (Cmol/kg)				
	Dry Season		Wet Season		
	0 – 15 cm	15 – 30 cm	0 – 15 cm	15 – 30 cm	Mean±SD
Ogbere	6.1±0.2	6.0±0.2	6.2±0.2	6.7±0.2	6.3±0.3^{d}
Iwaye	6.9±0.2	6.4±0.2	7.0±0.2	7.4±0.2	6.9±0.4^{b}
Idode	6.4±0.2	6.4±0.2	6.5±0.2	6.8±0.2	6.5±0.2^{c}
Isara	7.1±0.2	7.1±0.2	7.2±0.2	7.8±0.3	7.3±0.3^{a}
Ilagbe	5.6±0.2	5.7±0.2	5.8±0.2	5.9±0.2	5.7±0.1^{e}
Adelokun	6.6±0.2	6.6±0.2	6.6±0.3	7.0±0.2	6.7±0.2^{b,c}
Baaki Ake	7.1±0.2	7.3±0.2	7.2±0.3	7.7±0.3	7.3±0.3^{a}
Igodo	5.8±0.2	5.9±0.2	5.8±0.2	6.2±0.2	5.9±0.2^{e}
Control	7.3±0.0	7.2±0.0	7.2±0.0	7.4±0.0	7.3±0.1^{a}
Mean±SD	6.5±0.6^{b}	6.5±0.6^{b}	6.6±0.6^{b}	7.0±0.7^{a}	

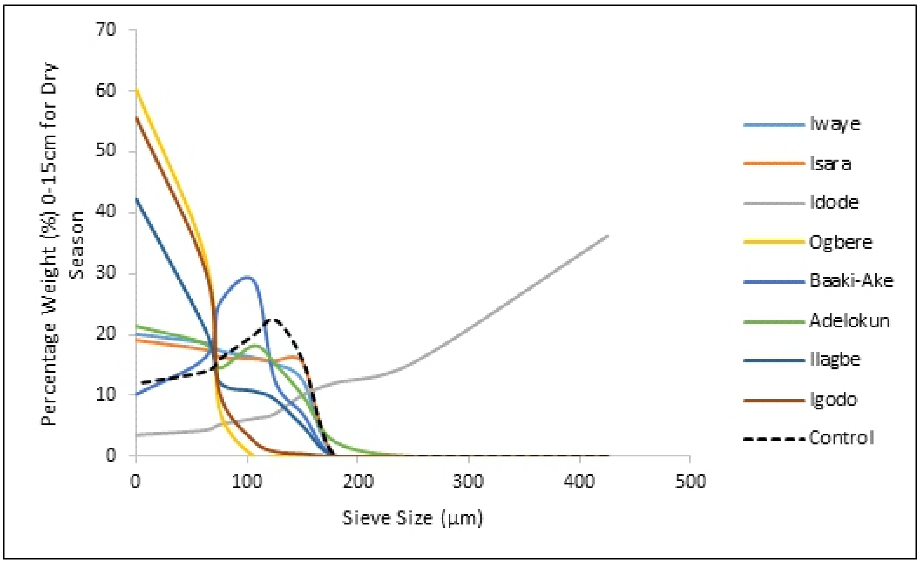

Figure 1: Particle Size Distribution of Top Soil in Dry Season.

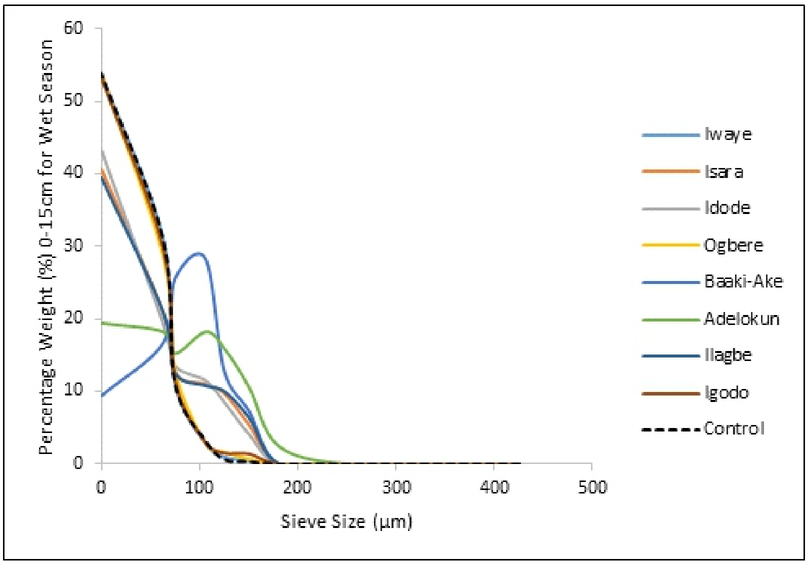

Figure 2: Particle Size Distribution of Top Soil in Wet Season.

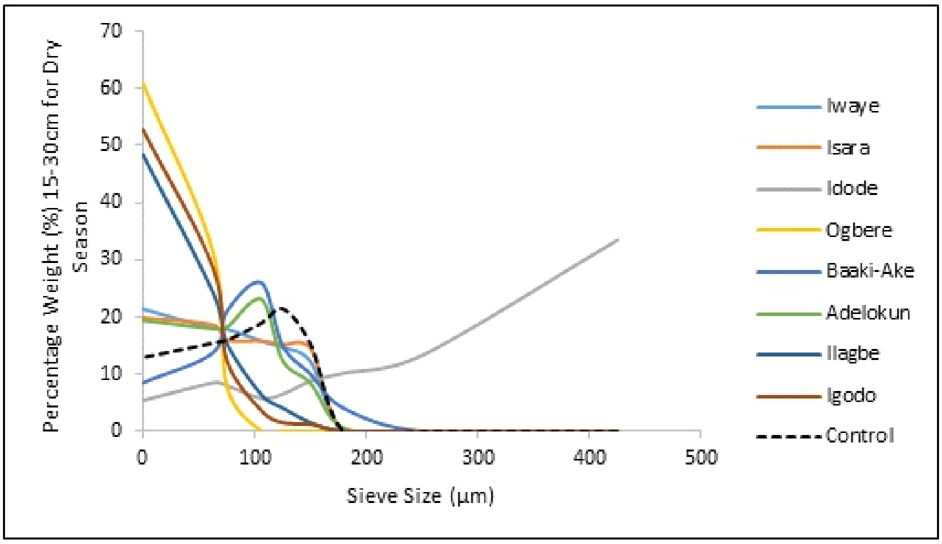

Figure 3: Particle Size Distribution of Sub soil in Dry Season.

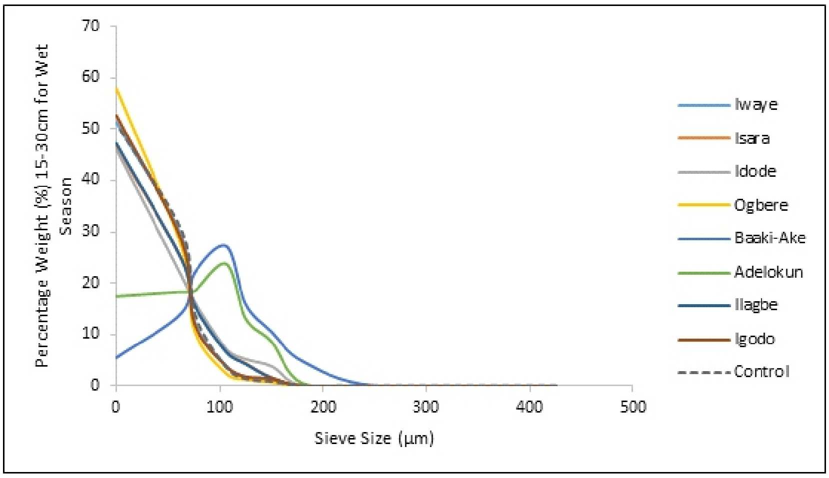

Figure 4: Particle Size Distribution of Subsoil in Wet Season.

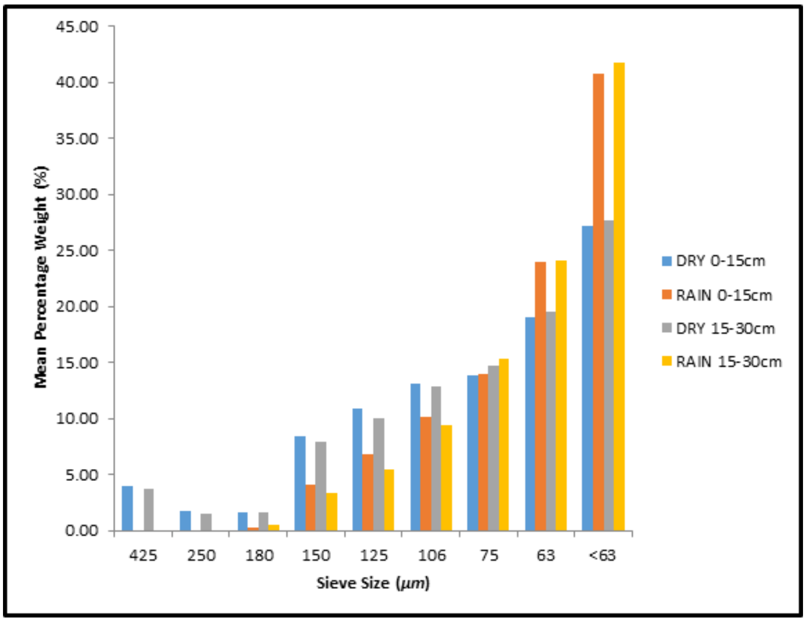

Figure 5: Analysis of clay size distribution by season.

DISCUSSION

Table 2 presents the physico-chemical parameters of the topsoil samples during dry season. The pH ranged from (Igodo) 5.9±2.9 – 7.1±2.1 (Isara). Except at Igodo, the pH of the soil sample indicates an acidic medium. This portends ecological risk on metal availability. Etim and Adie (2012) reported in their study that the pH of topsoil samples within the vicinity of a major quarry in Nigeria ranged from 6.65 to 8.23 at the spherical span of 500 m away from the blasting and crushing area. Moreso, none of the value of the pH was out of the control limit; that is, upper control limit (UCL) and lower control limit (LCL) 7.6 and 5.7, respectively.

The temperature varies between 26.5±0.1 - 31.1±2.4 °C with Baaki Ake had the lowest and Ogbere had the highest. However, some locations Ogbere, Iwaye, Idode and Isara were higher than the control (30.8±0.0 °C); while some others: Ilagbe, Adelokun, Baaki Ake and Igodo were lower (Zwolak *et al.*, 2019). However, these locations were among the quarry sites that protested the royalty that the Ogun state government initiated. The government policy resulted in the stoppage of production for sometimes until the matter was resolved and the production activities resumed. Hence could affect the amount of heat generated by the affected quarries. For this reason quarries increase the temperature of the topsoil around them. The temperature values were within the Control Limit: 32.6 °C (UCL) and 25.7 °C (LCL). Ogbere should be on watch list as the trend there was alarming regarding the temperature (31.1 °C) very close to 32.6 °C (UCL).

The electrical conductivity (EC) of Ilagbe (303.1±1.3 µS/cm), Adelokun (489.4±1.2 µS/cm) and Baaki Ake (397.5±2.9 µS/cm) were higher than the control site (264.5±0.0 µS/cm); whereas the other five locations were lower. This is in agreement with what Olatunde *et al.* (2021) reported; that EC values in the quarry sites studied ranged between 34 - 267 µS/cm. This means that electrical conductivity is not affected by the quarry activities but all the values were within the Control Limit (UCL) 492.8 - (LCL) 83.4 µS/cm.

Total organic carbon in all locations were lower than the control site (3.9±0.0 %) except Idode (4.0±0.2 %). This implies that quarrying reduces total organic carbon content of the topsoil in the dry season. This is comparable to the work of Etim and Adie (2012), in which they reported that the organic matter content of topsoil samples within the vicinity of a limestone quarry in Southwestern Nigeria ranged from 1.0 to 4.8%. Moreover, all the values across locations were within the Control Limit (CL): 5.5 - (-0.6)%.

The nitrate values among the locations ranged between 68.9±1.0 and 2.5±0.1 mg/kg; Baaki Ake had the highest and Ogbere had the lowest. Some locations like Ilagbe, Adelokun, Baaki Ake and Igodo were higher than the control site (26.7±0.0 mg/kg) while some locations such as, Ogbere, Iwaye, Idode and Isara were lower (Olatunde *et al.*, 2021). However, those locations where nitrate values were lower than the control were as a result of intensive subsistence farming going on there by locals (villagers) and not because of the ongoing quarry activities. Hence, quarrying does not affect the nitrate of the top soil during dry season. All the nitrate values were within the 77.5 mg/kg (UCL) and -7.5 mg/kg (LCL).

Ammonium of the top soil during the dry season had it that; four locations like Ilagbe (116.2±2.9 mg/kg) Adelokun (158.5±0.2 mg/kg) Baaki Ake (173.7±2.0 mg/kg) Igodo (136.6±1.2 mg/kg) were higher than the control site (66.6±0.0 mg/kg); whereas other locations like; Ogbere, Idode, Iwaye and Isara were lesser than the control site (Olatunde *et al.*, 2021); mainly because of the vigorous subsistence farming ongoing in these locations; hence, the nutrient erosion (ammonium) at the top soil in the location experiences. However, all the values were within the Control Limit of 200.7 mg/kg (UCL) and -17.5 mg/kg (LCL).

Table 3 presents the analysis of the physico chemical content of the topsoil in the wet season; with the pH values (6.5±0.1 – 7.4±2.0) in all locations higher than the control site (6.2±0.0); with this, pH tends to be neutral during wet season in all locations; which implies that quarry activities do not increase the acidity nor the alkalinity of the top soil in wet season. Moreso, all the values fell within the control limit of 8.0 (UCL) and 5.9 (LCL).

The values of temperature in all locations were higher-than-the control (26.6 °C), with the exception of three locations namely, Ogbere (26.1±0.9 °C), Iwaye (26.5±1.0 °C) and Idode (26.3±0.1 °C) that were lower than the control (Zwolak *et al.*, 2019). The values of these three locations were in very close range with control; which means that with time, they would meet and surpass the control value with an increase in quarrying activities; which implies that quarrying affects the temperature of the topsoil during wet season. All values of temperature across locations were within the 31.4 °C (UCL) and 25.2 °C (LCL).

The electrical conductivity values ranges between 205.2±1.1 (Idode) and 505.1±0.5 µS/cm (Igodo). Only three locations namely, Ogbere (241.5±0.1 µS/cm), Idode (205.2±1.1 µS/cm) and Isara (234.6±0.8 µS/cm) were lower than the control (250.2±0.01 µS/cm) (Olatunde *et al.* 2021). Hence, it can be averred that quarry activities affect the top soil in wet season. However, all values were within 501.6 µS/cm (UCL) and 73.1 µS/cm (LCL) of the Control Limit with the exception of Igodo (505.1±0.5 µS/cm) that higher than the UCL (501.6 µS/cm).

Total organic carbon values across the locations; (Ilagbe) 0.3±1.8- 4.2±0.9 % (Baaki Ake) were lower than the control (3.2±0.0 %) with the exception of Baaki Ake (4.2±0.9 %). This shows that quarrying depreciates the total organic carbon of the topsoil during wet season. The result obtained in this study conformed with the work of Ayodele *et al.* (2014) on the soils of Ikole-Ekiti where quarry located, were organic matter was 0.7-2.9 % in the topsoil. Moreover, all the values were within the Control Limit of 6.5 % (UCL) and -1.3 % (LCL).

The nitrate values ranged between 9.4±0.8 and 73. 1±2.1 mg/kg and none of these values in all locations higher than the control (88.9±0.0 mg/kg) (Olatunde *et al.*, 2021). Though quarry activities were lesser during this period and in addition peoples living around these quarries that were not originally farmers, took the advantage of the downpour and started farming. Hence depreciates the nitrate of the topsoil in the wet season. However, none of the values fell below the Control Limit; the 133.6 mg/kg (UCL) and -55.8 mg/kg (LCL).

Lastly, all ammonium values in all locations were lesser than the control site (162.3±0.0 mg/kg), with the exception of the Idode (184.4±2.8 mg/kg) and Isara (167.5±1.0 mg/kg) (Olatunde *et al.*, 2021). Therefore, quarrying does not affect the ammonium content of the top soil in wet season but affected by farming. However, all the values across locations were within the 258.5 mg/kg (UCL) and -36.3 mg/kg (LCL).

The Table 4 shows the analysis of the physico chemical contents of the subsoil in the dry season. The pH values (6.6±0.2 – 7.2±0.4) across the locations show that no locations was lesser in value or extremely higher than the control (6.6±0.0); (that is, all locations tend to be neutral; and are not affected by quarrying). This result was vindicated by the study of Etim and Adie (2012) that reported the soil pH of the study area (quarry) in Western south of Nigeria ranged from 6.7 to 8.2. However, all the pH values fell within Control Limit of 7.7 (UCL) and 5.9 (LCL).

No location except Ilagbe (30.8±0.7 °C) was lesser than the control (30.9±0.1 °C) in term of the temperature of the subsoil in the dry season (Zwolak *et al.*, 2019). This means that the temperature of the subsoil were affected by quarry activities. Also, all values of the temperature fell within the UCL (31.2°C) and LCL (30.6 °C)

Iwaye (217.4±2.1 μS/cm) and Igodo (217.4±2.4) were only locations that were lower than the control (255.4±0.2 μS/cm) regarding the electrical conductivity of the subsoil in dry season (Olatunde *et al.* (2021). This implies that quarrying affects the electrical conductivity of the subsoil in dry season. All the values of electrical conductivity were within 561.9 μS/cm (UCL) and 131.1 μS/cm (LCL).

In term of total organic carbon, none of the location was lower than the control (0.2±0.0 %) namely Ogbere (0.2±0.3 %), Iwaye (1.9±0.9 %), Idode (3.2±0.2 %), Isara (1.1±0.8 %), Ilagbe (3.2±0.3 %), Adelokun (1.1±0.2 %), Baaki Ake (0.2±0.3 %) and Igodo (1.9±0.2 %). This implies that quarrying affects the total organic carbon in subsoil during the dry season. The subsoils of Ikole-Ekiti where quarry located had organic matter ranged from 0.6-1.8 % (Ayodele *et al.,* 2014). However, none of the locations has violated the Control Limit; 5.9 % (UCL) and -3.0 % (LCL).

Nitrate values (2.2±0.5 – 22.7±1.0 mg/kg) across locations were not lesser than the control (2.2±0.0 mg/kg) (Olatunde *et al.*, 2021); which implies that quarry activities affect the nitrate of the subsoil in dry season positively. However, intensive farming among locals always reduces the nitrate content of the soil; judging from the closeness of the values of the nitrate in the locations to the control. None of the locations had exceeded the control limit of 43.0 mg/kg (UCL) and -18.3 mg/kg (LCL).

Four out of eight locations were lower in content of ammonium than the control (64.3±0.1 mg/kg); namely; Ogbere (3.7±0.7 mg/kg), Iwaye (53.0±1.0 mg/kg), Idode (60.6±0.3 mg/kg) and Isara (39.4±0.8 mg/kg). The remaining four locations were Ilagbe (98.6±0.2 mg/kg), Adelokun (147.2±0.3 mg/kg), Baaki Ake (162.7±0.5 mg/kg) and Igodo (128.8±0.3 mg/kg) were higher than the control (Olatunde *et al.*, 2021); probably because the other four locations were coming up. However, judging from the fact thus, the values of these four locations were very close to the control. Moreover, extensive farming among the villagers around these four quarries also reduced the ammonium content of the soil. With this, it can be concluded that quarrying increases the ammonium of the subsoil in dry season. None of the ammonium values across locations exceeded the Control Limit of 183.9 mg/kg (UCL) and -15.4 mg/kg (LCL).

Table 5 reveals the analysis of the physico chemical content of the subsoil in the wet season; with pH values ranging between 6.8±0.2 and 7.4±1.0; in Iwaye and Igodo respectively. However, none of these values were lower than the control (6.4±0.0); which means that quarrying does not affect the pH values of subsoil in wet season. This is also because the values tend to be neutral than acidic or alkaline (Etim and Adie 2012) and all the values fell within the control limit (7.8 – 6.3).

The values of the temperature fell within the 26.3±0.3 - 30.5±0.3 °C; with Idode had lowest value and Igodo had highest value; with only Ogbere, Iwaye and Idode had values lower than the control (27.0±0.11 °C) (Zwolak *et al.*, 2019). It can be deduced that quarrying affects the temperature values in subsoil during wet season. Generally speaking, quarry activities are always low during wet season as the end user of the quarry products were on break during wet season; hence low patronage (quarry activities) responsible for lower temperature values in many locations compared with the dry season. All values in all locations fell within the control limit (31.8 – 24.8 °C).

Electrical conductivity of five locations namely Ogbere, Iwaye, Idode, Isara and Adelokun; were having these values; 235.6±3.0, 244.5±3.0, 197.8±3.0, 226.4±3.2 and 224.7±2.7 μS/cm respectively and were lower than the control (248. 4±0.2 μS/cm) Olatunde *et al.*, (2021). However, it can be said that electrical conductivity of the subsoil were not affected by quarry activities. Moreover, all the values across the locations were within the control limit (646.5 and - 98.7 μS/cm).

The total organic carbon values of the subsoil in wet season ranges between 0.4±0.3 and 3.4±0.5 % and all were lower than the control (3.10±0.0 %) with the exception of Baaki Ake (3.40±0.5 %) that was higher. As such, one can categorically conclude that quarry activities depreciate the total organic carbon content of the subsoil in wet season. Ayodele *et al.* (2014) asserted that, organic matter showed poor correlations with all the heavy metals determined. All the values were within the control limit (5.6 and -1.0%).

None of the values of nitrate (10.3±0.2 – 66.0±0.5 mg/kg) in all locations higher than the control (76.5±0.1 mg/kg) (Olatunde *et al.*, 2021). This implies that quarry activities depreciate the nitrate of the subsoil in wet season, couple with farming activities around some of the quarries. The values in all locations fell within the Control Limit (106.1 and -31.2 mg/kg).

With the exception of Idode (171.5±0.3 mg/kg) and Isara (155.7±0.3) that had value higher than the control (155.5±0.2 mg/kg); other six locations were lower than the control (Olatunde *et al.*, 2021). Hence, it can be said that quarrying did not increase the ammonium; rather depreciate the ammonium of the subsoil in wet season coupled with the farming activities going on around some of the quarries. The values across the locations were within the Control Limit (270.8 and -76.9 mg/kg).

Table 6 presents the T - test data samples analysis of physico-chemical of the topsoil between dry and wet season. In the dry season; the mean values of physico-chemical of the topsoil at Ogbere (46.8±1.0); while the wet season was 52.7±0.2. Hence, there is no significant difference in the value of the physico-chemical parameters of top soil at Ogbere between the two seasons. Iwaye (70.8±0.7 and 76.1±0.1); Idode (88.4±0.3 and 76.1±0.8); Isara (97.3±0.7 and 102.8±0.3); Ilagbe (80.3±0.8 and 78.1±0.9), Adelokun (72.6±0.9 and 84.2±0.3); Baaki Ake (78.9±0.2 and 83.1±0.2) and Igodo (77.7±0.2 and 81.4±0.3) were not significantly different from one another in the various locations in dry and wet season.

Table 7 shows T-test for Physico-chemical contents in subsoil sample between dry and wet season. In all locations, there were no significant differences between the dry and wet season values; with the exception of the following locations, Ogbere, Ilagbe, Adelokun and Baaki Ake.

Table 8 illustrates Cationic Exchange Capacity (CEC) in the soil. It shows that in dry season at depth of 0 – 15 cm; CEC values range 5.6±0.2 to 7.1±0.2 cmol/kg with Ilagbe (lowest) and Isara (highest) respectively. The values of CEC across locations were lower than the control site (7.3±0.0 cmol/kg). This implies that quarry activities reduce the CEC of the topsoil in dry season. Cationic Exchange Capacity was 5.0 - 9.1 cmol/kg for the 0 – 15 cm layers of soil in Ikole – Ekiti (Ayodele *et al.,* 2014). At 15 – 30 cm, CEC values range (5.7±0.2 – 7.1±0.2 cmol/kg) with Ilagbe (lowest) and Isara (highest) respectively and none was higher than the control (7.2±0.0.03 cmol/kg). The implication is that quarrying reduces the CEC of the surrounding soil at 15 – 30 cm depth; hence, the ability of the soil to hold positively charged ions, influencing soil structure stability, nutrient availability, soil pH and the soil reaction to fertilisers and other ameliorants will be decreased in both topsoil and subsoil. Ayodele *et al.* (2014) also reported that CEC was 4.6 - 9.5 cmol/kg for the subsoil in Ikole – Ekiti. This means that the low CEC in the soil will affect soil qualities listed above as regard CEC.

In the wet season at depth of 0 – 15 cm, CEC values range from 5.8±0.2 (Ilagbe) – 7.2±0.2 cmol/kg (Isara) and all were lower than the control (7.2±0.0 cmol/kg). Hence, quarry activities reduce the CEC of the surrounding soil at depth 0 - 15 cm (Ayodele *et al.,* 2014). For depth 15 – 30 cm, the CEC were 5.9±0.2 cmol/kg (lowest) and 7.8±0.3 cmol/kg (highest) in Ilagbe and Isara respectively and all CEC values in all locations were lower than the control (7.4±0.0) except Isara (7.8±0.3 cmol/kg) and Baaki Ake (7.7±0.3 cmol/kg). Hence, it can be deduced that quarrying reduces the CEC of the soil at 15 – 30 cm depth (Ayodele *et al.,* 2014). The quarry sites soil might not be good for agriculture as the soil nutrient might be poor and the pH might be acidic as result of low CEC values. However, there were significant difference in the CEC values across locations and season as presented in Table 8.

The post hoc test that was conducted using Duncan Comparison test was also presented in the Table 8. From the result of the test, the locations: Ogbere, Iwaye, Idode, Isara, Ilagbe, Adelokun, Baaki Ake , Igodo and control had 6.1±0.2, 6.9±0.2, 6.4±0.2, 7.1±0.2, 5.6±0.2, 6.6±0.2, 7.1±0.2, 5.8±0.2 and 7.3±0.0 cmol/kg (CEC) respectively in 0-15 cm (topsoil). Also, the following values were recorded; 6.0±0.2, 6.4±0.2, 6.4±0.2, 7.1±0.2, 5.7±0.2, 6.6±0.2, 7.3±0.2, 5.9±0.2 and 7.2±0.0 cmol/kg for 15-30cm (subsoil) respectively; all in the dry season. However, the mean and standard deviations (Mean±SD) of CEC of topsoil and subsoil for all locations in dry season were $6.5±0.6^b$ and $6.5±0.6^b$ respectively. According to Ayodele *et al.* (2014); they reported that the only significant correlations were between CEC and Zn (r=0.56 p>0.01) in the soil in Ikole-Ekiti.

During wet season, the topsoil in locations such as Ogbere, Iwaye, Idode, Isara, Ilagbe, Adelokun, Baaki Ake, Igodo and the control site had the following values of CEC, 6.2±0.2, 7.0±0.2, 6.5±0.2, 7.2±0.2, 5.8±0.2, 6.6±0.3, 7.2±0.3, 5.8±0.2 and 7.2±0.0 cmol/kg respectively. Whereas the following values of CEC were obtained from the subsoil of the same locations during the wet season: 6.7±0.2, 7.4±0.2, 6.8±0.2, 7.8±0.3, 5.9±0.2, 7.0±0.2, 7.7±0.3, 6.2±0.2, 7.4±0.0 cmol/kg respectively. Moreover, the CEC (Mean±SD) of topsoil and subsoil with their corresponding groups were $6.6±0.6^b$ and $7.0±0.7^a$ respectively. In addition, 0 – 15, 15 – 30 cm (dry season) and 0 – 15 cm (wet season) were similar in their CEC values; hence 0 – 15, 15 – 30 cm (all in dry season) carried subscript *b* and different from 15 – 30 cm (wet season) with superscript *a* as shown in Table 8.

Ogbere had CEC of 0-15cm and 15-30cm has 6.1±0.2 and 6.0±0.2 cmol/kg respectively in dry season. Also, the values of the CEC for corresponding depths in wet season were 6.2±0.2 and 6.7±0.2 cmol/kg respectively and their mean value with standard deviation (Mean±SD) was 6.3±0.3 and was grouped under superscript *d* (Ayodele *et al.,* 2014).

Iwaye had 6.9±0.2 and 6.4±0.2 cmol/kg for top soil and subsoil respectively in dry season. For wet season, CEC values for top soil and subsoil were 7.0±0.2 and 7.4±0.2 cmol/kg respectively; with Mean±SD values for both dry and wet season being 6.9±0.4. They also belong to the group *b* (Ayodele *et al.,* 2014).

Idode with 6.4±0.2 and 6.4±0.2 cmol/kg at top soil and subsoil during dry season respectively, also for wet season the values were 6.5±0.2 and 6.8±0.2 cmol/kg in the top soil and subsoil respectively; with their Mean±SD for both dry and wet season (6.51±0.2). They are grouped into *c* (Ayodele *et al.,* 2014).

Isara recorded 7.1±0.2 and 7.1±0.2 cmol/kg for top soil and subsoil respectively during dry season, and 7.2±0.2 and 7.8±0.3 cmol/kg for top soil and subsoil respectively during wet season. They had Mean±SD (7.3±0.4) and grouped under *a* (Ayodele *et al.,* 2014).

Furthermore; Ilagbe with 5.6±0.2 and 5.7±0.2 cmol/kg in top soil and subsoil respectively during the dry season. Also, Ilagbe had 5.8±0.2 and 5.9±0.2 cmol/kg in top soil and subsoil respectively during wet season and their Mean±SD was 5.7±0.1 and grouped as *e* (Ayodele *et al.,* 2014).

However; top soil and subsoil of Adelokun had 6.6±0.2 and 6.6±0.2 cmol/kg in dry season respectively. Whereas, the top soil and subsoil in wet season had 6.6±0.3 and 7.0±0.2 cmol/kg respectively and was group into *b* and *c* with Mean±SD of 6.7±0.2 (Ayodele *et al.,* 2014).

During the dry season, Baaki Ake with 7.1±0.2 and 7.3±0.2 cmol/kg in top soil and subsoil respectively. It also had 7.2±0.3 and 7.7±0.3 cmol/kg in topsoil and subsoil respectively during wet season, with Mean±SD of 7.3±0.3 and classified into group *a* (Ayodele *et al.,* 2014).

During dry season the topsoil and subsoil in Igodo had 5.8±0.2 and 5.9±0.2 cmol/kg respectively; with mean values of 5.8±0.2 and 6.2±0.2 cmol/kg in topsoil and subsoil respectively during wet season and Mean±SD value of 5.9±0.2. It was also classified under *e* (Ayodele *et al.,* 2014).
Finally, the control site had 7.3±0.0 and 7.2±0.0.0 cmol/kg for 0 – 15 and 15 – 30 cm respectively during dry season and contained 7.2±0.0 and 7.4±0.0 cmol/kg in top soil and subsoil respectively during wet season and grouped under *a* with Mean±SD of 7.3±0.1.

In addition, the mean difference in locations and season or depth were significantly different. Isara, Baaki Ake and the control (in group *a*) had the highest mean cationic exchange capacity (CEC). This implies that group *a* would be better off in term of the soil structure stability, nutrient availability, soil pH and soil reaction to fertilisers; followed by Iwaye and Adelokun (in group b), then Idode (in group *c*) and Adelokun (in group b, *c*) and Ogbere (in group *d*), while the least is Ilagbe and Igodo (in group e). Adelokun was classified into group *b* and *c*. However, locations in the same group were not significantly different in their means but rather significantly different from the locations in other groups as illustrated in Table 8.

The percentage weights of particle sizes of the topsoil (0 – 15 cm) during dry season were presented in Figure 2. In lieu of this, the three particles that make up the soil with their corresponding sizes in µm are presented as follows; sand varies from > 63 to 425 µm, silt varies from 20 to 63 µm and clay varies from < 20 µm to < 63; on which Figures 2, 3, 4 and 5 are discussed. The control site gave the sand sizes range as 75 – 150 µm with their corresponding percentage of 16 – 15.6% and totaled to 74.0%; silt at sieve size of 63 µm had 14% and the clay with the sieve size of < 63 had 12%.

At Iwaye, the topsoil had the percentage of the particle sizes vary as follow; the sand size was 61.3%, provided that sand sizes vary as sieve size of 75 – 150 µm. Hence, the summation of 17.4, 16.2, 15.2 and 12.5% of all the percentages within the range; give total percentage of 61.3 %; silt particle size at 63 µm only, hence it was 18.6 % and clay size was put at < 63 µm and was 20.1%. Comparing sand size of Iwaye (75 – 150 µm) 61.3% to that of control site (75 – 150 µm) 74.0% (Etim and Adie, 2012). This implies that the quarrying had not yet contaminate the soil at Iwaye as sand sizes of the same range of 75 – 150 µm were lower than the control site.

The percentages of the particle sizes in Isara as follows, sand sizes with their corresponding percentages vary from 75 – 150 µm and 16.3 – 15.4 % respectively and it was 63. 4 %; silt size at 63 µm was 17.5% and clay size at < 63 µm was 19.1%. Likewise Isara had the same range of sand sizes (75 – 150 µm) of 63. 4 % with the control site but different percentage of 74.0% (which was higher than the Isara) (Ayodele *et al.,* 2014). This implies that quarry activities is yet to contaminate the surrounding topsoil in Isara.

For Idode, the percentage of the sand size was 92.2% as it varies from sieve size of 75 – 425 µm with their corresponding percentages of 5.2 – 36.2% respectively. Hence, the summation gives the total (92.2%) of sand size. The silt size at 63 µm was 4.3 %; while that of the clay size at < 63 µm was 3.5 %. From the foregoings, it is evident that quarry activities had serious effect on the surrounding soil; as the sand sizes range 75 – 425 µm and of 92.2% were higher than that of the control site (75 – 150 µm) with 74.0% (Ayodele *et al.,* 2014).

Furthermore, at Ogbere, the sand size was put at 75 µm and the percentage was 7.8%. The sieve size at 63 µm (silt) had percentage of 32.1%; while the sieve size at < 63 µm (clay) was 60.2%. Quarrying does not have effect on the surrounding soil because having sand sizes of 75 µm with the 7.8% compared this with the control sand sizes (75 – 150 µm) of 74.0% (Etim and Adie, 2012).

Baaki Ake had the sand particle sizes vary from 75 – 150 µm with their corresponding percentages of 25.1 – 7%. It puts total percentage of the sand particle size at 73.4%; the silt particle size at 63 µm was 16.4% and that of the clay size at <63 was 10.2%. With these quarry activities has not yet contaminate the surrounding topsoil as control site (75 – 150 µm) had 74.0% (Etim and Adie, 2012).

The sand sieve size at Adelokun vary from 75 – 180 µm with their corresponding percentages of 14.5 – 2.3% which give a total of 60.2%. The silt sieve size at 63 µm gives 18.4%; while the clay size at < 63 gives 21.4%. The above results show that the surrounding topsoil had been affected by the bigger size of the sandy particles as it varies from 75 – 180 µm but with lesser percentage of 60.2 %, when compared to the control of (75 – 150 µm) at 74.0% (Ayodele *et al.,* 2014).

Ilagbe with sieve size from 75 – 150 µm and their corresponding percentages from 12.2 – 5% give the total sand size of 37.3%. The sieve size of 63 µm connotes silt was 20.5% of the topsoil. Meanwhile, sieve size of < 63 (clay) with the corresponding percentage of 42.2%. Quarry activities has not affected the surrounding soil as the sandy particle sizes range from 75 – 150 µm with lesser percentage of 37.3% when compared to the control site (75 – 150 µm) of 74.0% (Ayodele *et al.,* 2014).

Finally, Igodo showed that sand particle sizes range from 75 – 150 µm and their corresponding percentages range from 10.5 – 0.4% thereby giving a total of 14.2%. More so, the silt at the sieve size of 63 µm was 30.2% while clay at < 63 µm was 55.6%. The foregoings confirm that the surrounding topsoil in the Igodo has not yet been disturbed by the quarry activities. This is because the sand particle sizes were of the same range but of lesser percentage at 14.2% when compared with the control site 74.0%. The particle size analysis for all topsoil samples studied by Wenzel (2005) was in the order: 55.8 to 75.0% > 16.6 to 34.6% > 8.43 to 13.6% for sand, silt, and clay, respectively.

However, the reason why most sampled locations were lower than the control in term of sand particle size deposit percentage was that the sandy particle needs wind to carry and deposit them in the nearby villages further from the quarries; which are not forthcoming as a result of present of thick forests around most quarries that act as a wind breaker.

The percentage of particle sizes of the topsoil (0 – 15 cm) during wet season were demonstrated in Figure 3. The control site had its sand sizes varying from 75 – 150 µm with their respective percentage of 11 – 0.3% and added together to give 15. 1%. The silt counterpart at 63 µm had 31 % and clay size at < 63 had 53.9% (Wenzel, 2005).

Iwaye showed that the sand particle sizes of topsoil range from 75 – 150 µm in the wet season with weight percentages range from 11.1 – 0.45% respectively; thereby total to 15.3%. More so the silt size at 63 µm was of 31% weight percentage and clay size at < 63 was 53.7%. However, while comparing this location with the control; the sand particle sizes of both were 75 – 150 µm with their total weight percentages in Iwaye (15.3%) and the control (15.1%) were almost same (Wenzel, 2005).

Hence, the quarrying has not increased the sandy particle deposit in this location in the wet season.

In Isara, the sand particle sizes vary from 75 – 150 μm with weight percentages vary from 12.5 – 5.4 respectively; thereby totaled to 38.6%. The silt size is put at 63 μm had percentage (20.8%) and the clay size is put at < 63 had 40.6%. While comparing this location with the control, the sand particle sizes 75 – 150 μm is the same with the control, but they differed in their total weight percentages; Isara (38.6%) and the control (15.1%) (Wenzel, 2005). Which means that quarry activities have increased the total weight percentage of the sandy particle in the top soil of the location during wet season.

Furthermore, the sand sizes vary from 75 – 150 μm in Idode with their respective percentages ranging from 13.5 – 4.1%. Put together as 37.6%. Silt at 63 μm with the percentage of 19.2% and clay at < 63 μm was 43.2 %. The quarry activities had increased this location topsoil by increasing the weight percentage of the sandy particle sizes (75 – 150 μm) to 37.6%, when compared with that of control (15.1%) (Wenzel, 2005).

The Ogbere had the sand sizes at 75 – 150 μm with their respective weight percentages (12.8 – 0.65) totaled as 17.9 %. However, silt at 63 μm had 28.5% as weight percentage and clay size at < 63 had 53.64%. The total weight percentage of sandy particles was 17.9% and was higher than the control (15.1 %) which possessed same sand particle sizes (75 – 150 μm) (Wenzel, 2005). Hence, the quarrying had affected the topsoil of this locality.

The weight percentage of the sand particle sizes (75 – 150 μm) of topsoil in Baaki Ake were as follows: 25.6, 28.2, 12.8 and 7.3% and however, can be added together to give 73. 8%, while that of silt size (63 μm) was 16.7% and clay size (< 63) was 9.4%. Moreover, sand particle sizes (75 – 150 μm) had the weight percentage 73. 8%, which was higher than the control (15.1%) (Etim and Adie, 2012). This shows that quarrying had increased the percentage of the sandy particles in the surrounding topsoil.

As regard Adelokun sand particle size, it varies from 75 – 180 μm; with weight percentages 15.2 – 2.5 respectively and total together as 62.4%; while silt at 63 μm was 18.2% and clay at < 63 μm was 19.4%. The sandy particle sizes of this location (75 – 180 μm) with their total weight percentage (62.4%) were higher than that of the control (75 – 150 μm) with total weight percentage of 15.1% (Etim and Adie, 2012). Hence, it is obvious that quarrying activities had increased the sandy particle size of topsoil around the quarry site to 180 μm and total weight percentage to 62.4%.

For Ilagbe; the sand particle sizes vary from 75 – 150 μm with their respective weight percentages of 12.5 – 6.4% and added together to give 39.7%; while the silt counterpart at 63 μm had the 20.8% and the clay size at < 63 μm had 39.5%. The weight percentage of the sandy particle size in this location is 39.7 % and higher than the control (15.1 %) at the same size range of 75 – 150 μm (Ayodele *et al.,* 2014). Hence, the soil around this quarry had been hiked with high percentage of sandy particle.

Meanwhile, the sand particle sizes of Igodo vary from 75 – 150 μm with their corresponding weight percentage of 11 – 1.4% and totaled together to give 17.2%. The silt at 63 μm had 29.6% and the clay size at < 63 μm had 53.2%. With increase in the weight percentage of this location (17.2) compared with the control (15.1%) at the same sand particle size range of 75 – 150 μm. It can be concluded that the topsoil around the quarry site had been hiked with higher percentage of the sandy particles at this range (75 – 150 μm), (Etim and Adie, 2012).

The reason why most sand particle sizes varied at 75 – 150 μm in most locations apart from Adelokun (75 – 180) in wet season was the fact that quarry activities were not pronounced during wet season because most of the end user of the quarry products were always on break. Hence much bigger sandy particles could not be added coupled with the fact that in the wet season, the rain runoff will always cause soil erosion. Hence most top layer of the soil which likely to be sandy will be eroded away.

The percentage weights of particles of sub soil (15 – 30 cm) during dry season are illustrated in Figure

4. Firstly, control site has its sand particle sizes at 75 – 150 µm with their respective percentage, 16 – 15.1%; totaled together as 71.5%; while silt size at 63 µm was 15.5% and clay at < 63 µm was 13%.

Iwaye sand sieve sizes range from 75 – 150 µm with corresponding percentage 17.9 – 12.2, total to 60.6%; the silt was 18% at sieve size of 63 µm and the clay at sieve sieze of < 63 was 21.4 %. This location was compared with the control site of sand particle size at 75 – 150 µm with 71.5% (Ayodele *et al.,* 2014). Hence, this implies that quarry activities had not increased the sandy particle of subsoil of this location.

Isara sand particle sizes range from 75 – 150 µm with the corresponding percentage of 16 – 14.5 %; total to 61.5%; silt at the 63 µm was 18.6%; while clay sieve size at < 63 µm was 19.9%. The control site had the same particle size range with this location but lesser percentage (61.5%) than that of control site (71.5%) which means quarrying had not yet increased the sandy particle sizes of this location (Ayodele *et al.,* 2014).

As for Idode, the sand particle sizes ranged from 75 – 425 µm with their percentage 8 – 33% respectively and totaled together to 86.1%; silt at 63 µm had 8.5%; while clay with particle sizes of < 63 had 5.4%. This location had increased in sand particle sizes ranged fom 75 – 425 µm and weight percentage of 86.1% compared with that of the control site of 75 – 150 µm and 71.5 % respectively (Ayodele *et al.,* 2014). This implies quarry activities had really touched this location. Hence, the surrounding subsoil had an increase in the sand particle sizes with their percentage.

Furthermore, Ogbere had sand particle size at only 75 µm with 7.9%; while silt at 63 µm was 31.3% and clay particle size at < 63 was 60.9%. Ogbere sand particles size was just at 75 µm with the percentage of 7.85%; which was far less than the control in term of particle sizes variation and percentage; saying that this location had not been affected by quarry activities with their sandy particles. Wang, (2007) reported that some quarries do not produce large amounts of permanent waste, such as soil and gravel quarries, but produced significant amounts of waste material such as clay and silt.

With Baaki Ake, the sand particle size ranges from 75 – 180 µm and had 21 – 4% respectively; total together to be 76%; while silt of 63 µm was 13.8% and clay of < 63 µm was 8.5%. This location had wider range of sandy particles and higher weight percentage (75 – 180 µm) of 76%; more than the control (75 – 150 µm) and 71.5% respectively (Ayodele *et al.,* 2014). This means that deposition of sandy particles from quarry activities had affected the subsoil composition of the locality in dry season.

Moreover, Adelokun sand particle sizes of the sub soil in dry season was at 75 – 180 µm with the 18.2 – 0.5% respectively and total together to be 62.6%; while silt at 63 µm had 18% and clay of the particle size of < 63 µm had 19.4%. This location contains larger sand particles (75 – 180 µm) than the control (75 – 150 µm) with lesser total weight percentage of 62.6%, when compared with the control (71.5%) (Ayodele *et al.,* 2014) It can be concluded that this location was yet to be fully affected.

For Ilagbe, the sand particle sizes were 75 - 150 µm with 15.4 – 1.5% respectively and totaled together to be 27.4%. Moreso, silt at 63 µm had 24.4 % and the clay size at < 63 was 48.4%. This location had the same range of sand particle sizes with the control (75 - 150 µm) but with lesser percentage (27.4 %); meaning that the location had not been affected by the sandy particles deposition from quarry (Wang, 2007).

In Igodo, the sand particle sizes at 75 – 150 µm with respective 12.4 – 1.2%; totaled together to give 18.7%. However, silt at 63 µm sieve size had 28.5% and clay at < 63 µm sieve size had 52.8% (Wang, 2007). This location had the same sand particle sizes which range from 75 – 150 µm with the control site but lesser total weight percentage of 18.7%; than the control (71.5 %). This implies that this location was far from being affected by the quarry activities (Ayodele *et al.,* 2014).

Figure 5 presents the percentage weights of particles of sub soil (15–30 cm) during wet season. The control site has sand particle sizes varying from 75–150 µm with their respective weight percentages 13.9 – 0.8% and total to 19.4%; while the silt weight percentage at 63 µm was 29.8% and that of the clay at < 63 µm was 50.8% (Wenzel, 2005).

Iwaye had sand particle sizes range from 75 - 150 µm, with the weight percentages of 12.8 – 1.3%; total together to 19.68% and the silt at 63 µm had 29%; while clay size at < 63 µm had 51.3% (Wang, 2007). However, while comparing this location with the control site, sand particle sizes 75 – 150 µm and with weight percentages of 19.4%. Hence, this location subsoil had not been affected by quarry activities.

The sand particle sizes of Isara vary from 75 – 150 µm with corresponding weight percentages of 15.9 – 1.6% and added together to 28.7%. The particle size of the silt at 63 µm was 24.6%; while that of the clay at < 63 µm was 46.7 %. This location had the same sand sizes range (75 – 150 µm) with the control but differed in the weight percentages constitution; which was 28.7% for Isara and 19.4% for control site. Hence, the quarry had deposited more of weight percentage of the sandy particle in this range (Wang, 2007).
Idode sandy particles vary from 75 – 150 µm with their respective percentages 16.5 – 3.8% and added up to 32.7% and the silt at 63 µm had 21.3%; while clay size at < 63 had 46 % (Wang, 2007). Moreover, in Idode (21.3 %) the weight percentage differed from control (19.4 %) at the same sandy particle sizes range of 75 – 150 µm (Wenzel, 2005). However, this is saying that quarry responsible for the higher weight percentage with the same particle size range.

With Ogbere, the particle sizes of sand particles range from 75 – 150 µm and their corresponding percentages were 10.8 – 0.7% and total to 15.2%; the silt particle at 63 µm was 27 % and clay size at < 63 was 57.9% (Wang, 2007). Quarry activities had not yet impacted on the subsoil in wet season; simply because the weight percentage of Ogbere (15.15%) was lesser than control (19.4%) at the same sieve size range.

Furthermore, Baaki Ake sand sizes vary from 75 – 180 µm with their respective weight percentages 21.9 – 4.8% and totaled to, 80.3%; while the silt size at 63 µm was 14.2% and clay size at < 63 µm was 5.5%. The quarry had really impacted on the subsoil; simply because the sandy particle sizes of the soil around quarry were 75 – 180 µm with 80.3% weight percentage; which was higher than the control of 75 – 150 µm with 19.4% weight (Wenzel, 2005).

The particle sizes of the sand in Adelokun vary from 75 – 180 µm with weight percentages from 18.4 – 0.5% respectively and totaled to 64.3%; while the silt size at 63 µm was 18.3% and the clay size at < 63 µm was 17.4%. However, quarry at Adelokun village had increased the subsoil with the higher grain of sand particle of 75 – 180 µm with higher weight percentage of 64.30% compared to control subsoil at 75 – 150 µm with 19.4% (Wenzel, 2005).

Moreover, the sand sizes in Ilagbe vary from 75 – 150 µm and their weight percentages were 15.8 – 1.54% respectively and total together to 28. 10%; the silt at 63 µm was 24.6%; while clay size at < 63 µm was 47.2% (Wang, 2007). Though both subsoil around the quarry and the control were of the same grain size of 75 – 150 µm, the subsoil around quarry had higher weight percentage of 28.1% than the control.

Igodo sand particle sizes of subsoil in wet season vary from 75 – 150 µm with their weight percentages 12.2 – 1.4% respectively; total together as 19.2%. The silt at 63 µm was 28.2% while clay size at < 63 µm was 52.6% (Wang, 2007). The subsoil around quarry and the control had similar subsoil sandy particle sizes range (75 – 150 µm) and very close weight percentages; Igodo (19.2%) and control (19.4%). This implies that the Igodo subsoil sandy particles were yet to be increased.

Figure 5 shows that the percentage (%) of clay ranges between above 25 to above 40%; slit range from above 15% to less than 25% while sand ranges from above 0% to below 15% in both seasons. The clay and silt % in top or subsoil was higher in wet season than the dry season; while, it is reverse in the case of the sand; the % is higher at top and subsoil in the dry season than the wet season. However, the % of the clay and silt at 15 – 30 cm were higher than the 0 –15 cm in both seasons; whereas sand % is higher at 0 – 15 cm than 15 – 30 in both seasons (Wenzel, 2005).

CONCLUSION

The Gross Domestic Product (GDP) of the state is increased by the activities of the quarry but less attention were paid to the environmental implication of it. Though most of the sampled locations were higher in physicochemical parameters examined than the control site, but were still within Control Limit. Moreover, only electrical conductivity at Igodo in wet season (topsoil) was higher than the Upper Control Limit. CEC of topsoil and subsoil in all locations (dry and wet seasons) were lower than the control, with the exception of Isara and Baaki Ake in subsoil (wet season) which implied that the quarry had affected the surrounding soil negatively. The sand particle sizes and percentage weights of sizes (topsoil) of Idode and Adelakun were higher than the control in dry season; while in wet season, Adelokun was higher than the control. In the subsoil during dry season, Idode and Baaki Ake were higher than the control; while during wet season Baaki Ake and Adelokun were higher than the control. However, the parameters like pH, temperature, TOC, ammonia, and nitrate in both seasons were not affected; that is they were within the Control Limit. Hence, attention must be paid to the quarry activities by various stakeholders so as to prevent the other parameters not yet escalating to the alarming rate to do so and government should also re-assess the Environmental Impact Assessment (EIA) certificates of the operators so as to find reason and lasting solution to those parameters that out of the control; for the soil to be protected for sustainable use.

REFERENCES

Ayodele, O. J., Shittu, O. S. and Balogun, T. 2014. Heavy metal pollution assessment of granite quarrying operations at Ikole-Ekiti, Nigeria. *International Journal of Environmental Monitoring and Analytical.* 2(6): 333-339. doi: 10.11648/j.ijema.20140206.16. 26 - 35

Banez, J., Mae Ajaon, S., Bilolo, J. R. and Dailyn, J. M. 2010. Quarrying and Its environmental effects.p 225. http:www.scribd.com. (7 Jan. 2019)

Chopra, S.L., and Kanwar, J.S. 2011. Analytical agricultural chemistry, MacMillian Press, London. 331pp.

Etim, E. U. and Adie, G. U. 2012. Assessment of toxic heavy metal loading in topsoil samples within the vicinity of a limestone quarry in South Western Nigeria. *African Journal of Environmental Science and Technology*. 6(8): 322-330. doi: 10.5897/ajest12.041. ISSN 1996-0786

FAO. Food and Agricultural Organization. 2019. *Standard operationg procedure for soil organic matter: Titration and Colorimetric method.* Global Soil Laboratory Network.

Hassan, I. A. 2022. Metals Distribution in the Water Bodies around Quarry Sites in Ogun State, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 15(4) : 511-531. d oi :ejesm.org/doi/v15i4.9

He, X.T. Mulvaney, R.L. and Banwart, W.L. 1990. A rapid method for total nitrogen analysis using microwave digestion. S*oil Science Society of America Journal*, 54(6): 1625-1629. doi.org/10.2136/ sssaj1990.0361 5995005400060019x

Julie, C., Renaud, J., Elise, B., Fabrice, B. and Thierry, D. 2018. Impact of quarry exploitation and disuse on pedogenesis. *CATENA, Elsevier* 160 (160): 354-365.10.1016/j.catena.2017.09.012. hal-01790691.

National Population Comission (NPC). 2006. Federal Republic of Nigeria, Legal notice on publication of 2006 census final results. http//www.npc.ng.org. (6 Apr. 2021)

Ogun state fact sheet. https://www.ogun state gov.ng. (3 Feb. 2021)

Olatunde, K.A., Towolawi, T., Kolawole, I., Aiyelabola, N., Michael, O., Warrie, E.,

Oludiran, O. and Awomade, I. 2021. Soil Quality and Metal Distribution Around Stone Quarries Within Abeokuta, Southwest, Nigeria. *Ife Journal of Science,* 23(2), 53 – 61 dx.doi.org/10.4314/ijs.v23i2.6

Oyinloye, M. A., and Ajayi, E. A. 2015. Environmental impact assessment of quarry activities in Oba-Ile, Ondo state; Nigeria. *The Journal of MacroTrends in Energy and Sustainable.* 3 (1): 32 – 45.

Reeuwijk L. P. 2002. *Procedures for soil analysis. Sixth edition. Technical paper 9.*

Wang, A. 2007. Principle of environmental impact assessment best practice: "Environmental Protection China: The role of law". International Association for Impact Assessment. 120 – 128pp.

Wenzel, W. W. 2005. Environmental factors affecting metal mobility. Abstracts of Workshop themed: Metal fluxes and stresses in terrestrial ecosystems held from October 15th – 20th. (ed) Swiss Federal Institute for Forest, Snow and Landscape Resources, WSL, Birmensdorf), Switzerland. 108.

Zwolak, A., Sarzyńska, M., Szpyrka, E. and Stawarczyk, K. 2019. Sources of Soil Pollution by Heavy Metals and Their Accumulation in Vegetables: a Review. *Water, Air and Soil Pollution* 230, Article 164.
doi.org/10.1007/s11270 - 019-4221-y.