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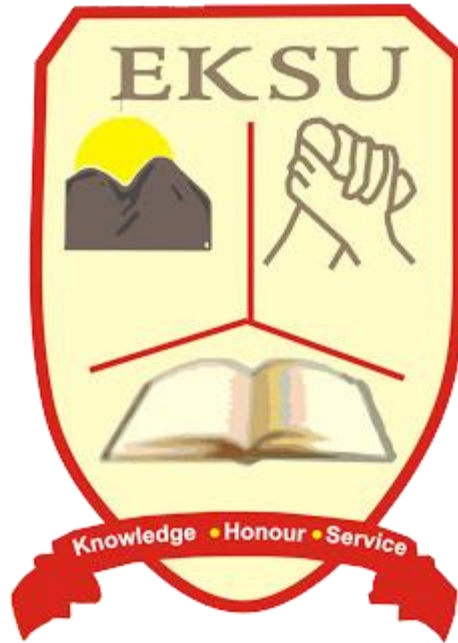
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CONTENTS

MARCH

1. Bitumen Seepage: Impact and Interaction on Heavy Metal Concentrations in Surface Water – Ogunmusa and Adeleke
2. Performance Evaluation of African Catfish (*Clarias gariepinus*) Fingerlings Fed African Locust Bean (*Parkia biglobosa*) Meal Diets – Obe et al
3. Supplemental values of Poultry litter, *Leucaena leucocephala* and Groundnut haulms on growth, nutrient digestibility, and economy of Yankasa rams' fattening
4. Comparative Evaluation of Bird Species Diversity in Different Ecosystems of Akure Forest Reserve, Ondo State – Ogunyemi
5. Boldness-aggression Syndromes in the zebrafish and the guppies – Oriyomo et al
6. Genetic Variability of some Tilapia Species from three different Reservoirs in Southwestern Nigeria - Onyeabor and Bello-Olusoji
7. Germination and Seedling Growth of African Star Apple (*Chrysophyllum albidum* G. Don Syn. *Gambeya albida*) in Soils of Ekiti State – Olayode
8. Comparative Assessment of the Avifauna Species Composition of the Beach Environment in Badagry-West Local Government, Lagos State. – Kolawole
9. Heavy Metals Concentration in African Mud Catfish (*Clarias gariepinus*) and Obscure Snakehead (*Parachanna obscura*) from River Ogbese, Ondo State, Nigeria – Abidemi-Iromini

SEPTEMBER

1. Water Physico-Chemical Parameters Inter-Relationship and Heterotrophic Fungal Count of Ureje Dam in Ekiti State, Nigeria – Akin-Obasola et al
2. Nutritional and Anti-nutritional Composition of *Parkia biglobosa* and *Adansonia digitata* in Guinea Savanna region, Taraba state, Nigeria – Sobola O.O
3. Effects of Quarry Activities on Physical and Chemical Properties of Soils in Ondo State, Nigeria – Olusola et al
4. Climate Change Impacts on Ecosystem Services and Livelihoods of Fringe Forest Communities in Ondo State, Nigeria. – Oyerinde and Adedoyin
5. Heavy Metal contents of Cocoa (*Theobroma cacao* L.) Beans and Plantation Soils in Ondo State, Nigeria - Fayinmiinu et al
6. Gender Role in Decision-making among Maize Farmers in Isaga-Orile Community of Ogun State, Nigeria – Fakoya et al.
7. Evaluation of the Nutritional Qualities of Edible Portions of Two Commercially Important Prawns in Southwest Nigeria - Oghini O
8. Poaching and its impact on Wildlife Population in Ise Forest Reserve, Ekiti State. – Orimaye et al.



Effects of Quarry Activities on Physical and Chemical Properties of Soils in Ondo State, Nigeria

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Abstract

Quarrying activities to obtain boulders, chips and stone dust for construction works, hard flooring and decorative polished slabs involve cutting or blasting rocks with explosives, crushing and haulage from the pit mines. The quarry is open to the air with the impacts of noise and vibrations and pollution from fumes, gases and dust particles which settle or are precipitated by rainfall on the adjoining area to alter the soil properties. This study was carried out to assess the effects of quarrying activities on the physical and chemical properties of soil samples collected at 0, 500 and 1000 m in cardinal directions around the quarry compared to samples from Aponmu Forest Reserve as the control. The soil samples were collected at 0-10, 10-20 and 20-30 cm depth for analysis using standard laboratory methods. The result shows significant differences in the properties of soil samples around the quarry from the soils in the natural forest. The clay content was not significantly different in all the directions, distances and depths. The silt was higher in the South direction at 0 m, 10-20 and 20-30 cm depths and the least value was recorded in the North direction at 1000 m and 0-10 cm depth. The sand portion was more abundant at the directions, distances and soil depths than the natural forest. Available macronutrients were higher at the sites than in the natural forest.

Keywords: Quarry, soil texture, available phosphorus, total nitrogen, exchangeable potassium,

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Introduction

The abundant mineral resources in Nigeria, on account of the solid geology, have attracted the establishment of petrochemical industries, iron and steel industries, science equipment centres and quarry industries (Adejuyigbe, 1995). The portion underlain by Pre-Cambrian Basement Complex igneous and metamorphic rocks consist of minerals which include granites, amphibolite, migmatite-gneisses, pegmatites, schists, granite-gneiss, quartzite etc (Oyinloye, 2011). The exploitation of these minerals necessitated opening up quarries to mine the materials needed in the construction

industry and traditional hard flooring such as granite, marble and clay.

Quarry operations involve the removal of vegetation, alteration of slopes and creation of mine pits for excavation which affect the landscape and destroy wildlife natural habitats. The processes of rock cutting and blasting with powerful explosives for processing and sizing into boulders (large chunks of stones), slabs, slates, chips and stone dust produce local environmental impacts which include noise and vibration and the air pollution associated with the fumes, gases and dust particles released into the

atmosphere. These dust particles are numerous and varied due to the different sources of broadcast (Laj and Sellegri, 2003). Two types of particles are to be distinguished: the primary particles that are cleared directly in the atmosphere from the rock mining processes and dust raised from dry soil by haulage vehicles and the secondary particles formed in the atmosphere following chemical transformations. The deposition is complex and controlled by atmospheric stability, the surface roughness and diameter of the particles (Hosker and Lindberg, 1982). The atmospheric deposition of particulate matter will eventually occur usually after a supporting wind current or precipitation from rainfall causing the settlement of the particles on the surrounding land. Quarry dusts (predominantly particulates) vary in size and contain oxides of Ca, K, Si and Na which can enter into the soil as dry, humid or occults deposits to undermine its physical and chemical properties (Okafor, 2006). Since quarrying activities have the potential to cause significant impact on the environment (Okafor, 2006), the development of quarrying industries should be monitored and the negative externalities and environmental impacts

assessed to avoid wrong attitude to industrial growth and maximize the benefits in the provision of natural resources for the development of socio-economic infrastructure (roads, buildings etc), creation of employment and source of revenue and foreign exchange (Hilson, 2002).

Akure North Local Government Area (LGA) is one of the eighteen (18) LGAs in Ondo State, Nigeria. It is characterized by undulating topography of mainly nearly level to gently undulating ancient plains with scattered hills, steep-sided rock outcrops and dome-shaped inselbergs as shaped by on the underlying Pre-Cambrian Basement Complex rocks (Facts and Figures about Ondo State" (2010). The rocks are sources of the raw materials that stimulated the location of many rock quarrying and crushing industries in the LGA. This study was carried out to assess the impact of rock quarrying activities at Stoneworks Industries Limited, Akure in Ondo State, Nigeria on the physical and chemical properties of soils in the adjoining land compared to the soils in Aponmu Forest Reserve far-removed from the operations area.

Materials and Methods

Study area

The study was carried out at Stoneworks Industries Limited, Akure along the Akure-Owo expressway within Akure North Local Government Area, of Ondo State. It is tucked within fairly massive porphyritic granite rock outcrops, as part of the underlying Pre-Cambrian Basement Complex rocks of Southwestern Nigeria, on latitude N 07° 16.5229' and longitude E 05° 14.2754' and the elevation is on 396 m above the sea level. The lithology is coarse porphyritic biotite-hornblende-granite as found in the massive outcrops of granitic rocks (Okoronkwo *et al*., 2006) on all sides of the site. The study area is a built-up environment with several churches, market, schools, and commercial and residential buildings. The soils samples studied were collected at 0-10, 10-20 and 20-30 cm depth within the vicinity of the quarry and at Aponmu Forest Reserve which served

as the control. The reserves is about at about 20 km south of Akure on Latitude 7° 18'N and Longitude 5° 02'E. The samples were obtained at 0, 500 and 1000 m sequentially away from the quarry industry using the bulk sampling method at each sampling point. Triplicate samples were taken at each collection points. The sampling points were far enough from the expressway to avoid contamination that can occur through localized pollution from road traffic. The samples were bulked for each point, air-dried, sieved (< 2 mm) and stored for laboratory analysis.

The soils were analyzed for particle size distribution, pH, organic carbon, total N, exchangeable cations and available P using standard laboratory procedures (Udo *et al.*, 2010). The figures were subjected to Analysis of variance and test of significance were carried out.

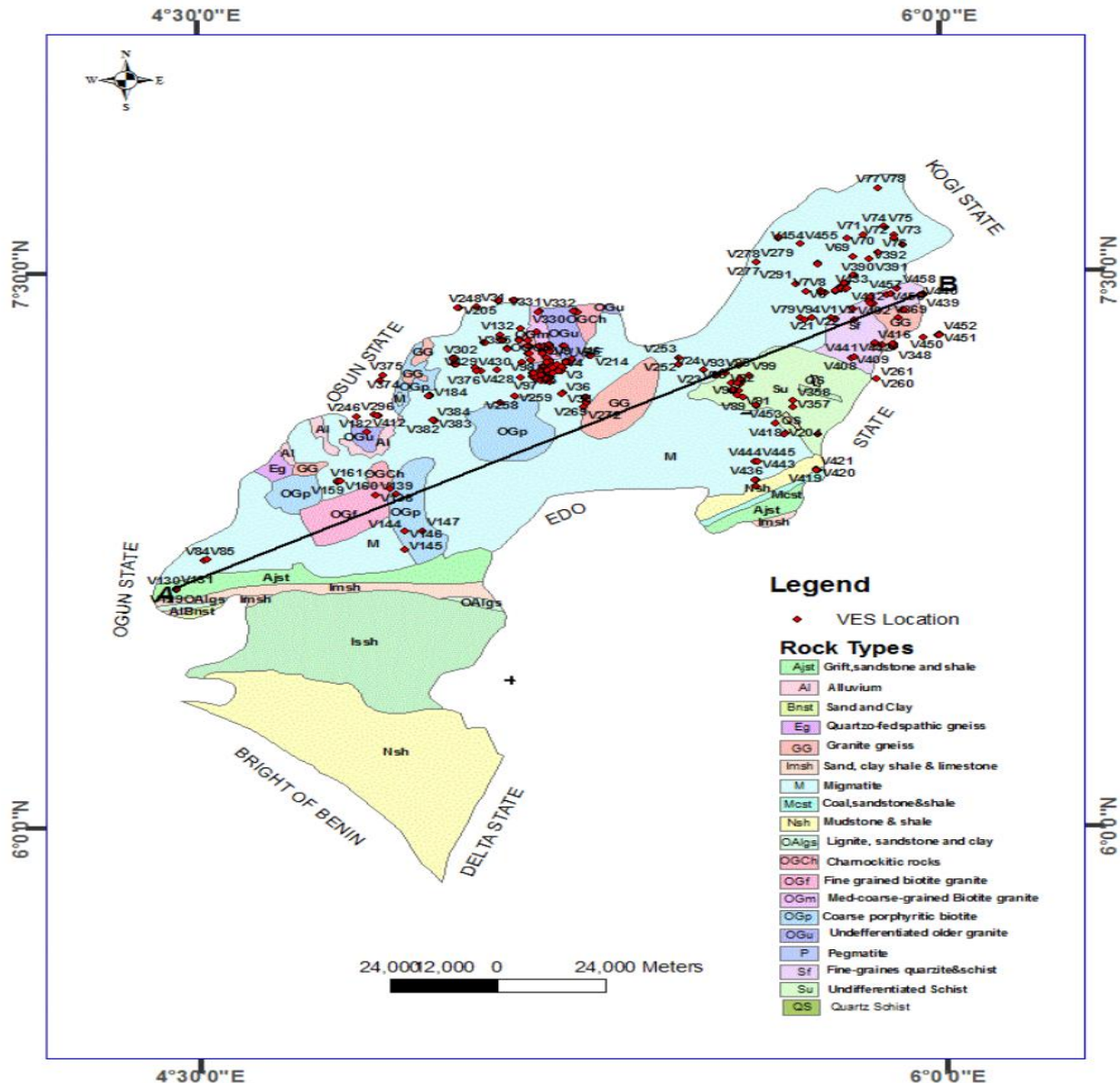


Fig. 1: Geological map of Ondo State (Adapted from NGSA, 2006)

Source: Mogaji, *et al.*, 2011

Data Analysis

Data obtained were analyzed using descriptive statistics that include the use of means and standard deviation. Also, one-way analysis of variance (ANOVA) was employed to test for the presence of significant difference. Where significant differences occurred, means separation was carried out with Duncan Multiple Range Test (DMRT).

Results and Discussion

The result in Table 1 shows that the farther the distance the higher the abundance of sand. The

abundance of sand at 500 m and 1000 m is higher than that of the natural forest. The highest abundance of sand was 75.40 ± 5.00 at 1000 m North, while the lowest abundance of sand is 68.40 ± 2.00 in all directions at 0 m. The highest abundance of silt was 9.00 ± 1.73 at 0 m in the South, East and West directions, while the lowest abundance was 2.00 ± 1.00 at 1000 m northward. It's also shows that the lowest abundance of clay was 22.60 ± 2.65 and this was the same in all directions and distances, except at 0 m north which had the highest abundance of 23.10 ± 3.54 respectively. The

abundance of sand at all directions and distances was slightly lower than that of the natural forest. Table 1 below shows the result of organic carbon and it was recorded that the highest abundance of organic carbon was 1.91 ± 0.16 at 1000 m east, while the lowest abundance of 0.10 ± 0.02 was recorded at 0 m north. It also shows that the abundance was generally low at 0m compared to 500 m and 1000 m respectively. Abundance of organic matter was higher 3.22 ± 2.51 at 500 m west, while the lowest abundance was 0.35 ± 0.01 at 0 m north. It also shows that the abundance was high at 500m compared to 0 m and 1000 m respectively. From the table nitrogen was higher in all directions and distances (ranging from 0.24 ± 0.10 to 0.63 ± 0.05) than the abundance at the natural forest which is 0.17 ± 0.00 . It also shows that the abundance was high at 500m compared to 0 m and 1000 m. Phosphorus was higher in all directions and distances (ranging from 3.11 ± 0.02 to 12.61 ± 0.02) than the abundance at the natural forest which was 2.88 ± 0.02 . It also shows that the abundance of $5.37 \pm 0.03/0.02$ at 0m was same in all directions. Potassium was higher in all directions and distances (ranging from 0.09 ± 0.02 to 0.20 ± 0.02) than the abundance at the natural forest which was 0.07 ± 0.00 . At 0 m West and 500 m south, the abundance was same at 0.16 ± 0.02 .

Table 2 below shows that the farther the distance of the quarry, the higher the abundance of sand. The highest abundance of sand was 75.40 ± 0.00 at 1000 m north and 75.40 ± 2.65 at 1000 m west, while the lowest abundance was 66.40 ± 2.00 in all directions at 0 m. for silt the farther the distance, the lower the abundance of silt. The highest abundance of silt was 12.00 ± 1.00 in all directions at 0 m, while

the lowest abundance was 2.00 ± 1.00 at 1000 m north and 2.00 ± 0.00 at 1000 m west. The highest abundance of clay was 22.60 same in all directions and distances with little differences in standard error, except at 1000 m north which had the lowest abundance of 22.00 ± 2.00 . It also shows that the highest abundance of organic carbon was 1.70 ± 0.07 at 1000 m East, which was higher than the abundance at the natural forest, while the lowest abundance was 0.16 ± 1.12 at 0 m South. It also shows that the abundance was high at 500m compared to 0 m and 1000 m. The highest abundance of organic matter was 3.13 ± 0.01 at 1000 m east, which was higher than the abundance of 2.78 ± 0.01 at the natural forest, while the lowest abundance was 0.38 ± 0.11 at 0 m south. It also shows that the abundance was high at 500m compared to 0 m and 1000 m. Nitrogen was higher in all directions and distances (ranging from 0.31 ± 0.03 to 0.60 ± 0.01) than the abundance at the natural forest which was 0.19 ± 0.02 , except at 1000 m West, where the abundance of nitrogen was 0.19 ± 0.05 . At 500 m north and west the abundance was same at 0.34 ± 0.12 . Phosphorus was higher in all directions and distances (ranging from 3.50 ± 0.02 to 7.39 ± 0.02) than the abundance at the natural forest which was 3.44 ± 0.02 . It also shows that the abundance of 5.13 ± 0.02 at 0m was same in all directions. Potassium was higher in all directions and distances (ranging from 0.11 ± 0.02 to 0.18 ± 0.02) than the abundance at the natural forest which was 0.09 ± 0.02 , except at 1000 m North, where the abundance of potassium was same as that of the natural forest.

Table 1: Mean Summary for Soil properties at 0 – 10 cm Soil Depth

	Direction	Sand (%)	Silt (%)	Clay (%)	Organic Carbon (%)	Organic Matter (%)	Nitrogen (%)	Phosphorus	Potassium
0m	North	68.40 ± 2.00 ^a	8.50 ± 2.12 ^a	23.10 ± 3.54 ^b	0.10 ± 0.02 ^c	0.35 ± 0.01 ^c	0.55 ± 0.01 ^a	5.37 ± 0.03 ^a	0.17 ± 0.01 ^a
	South	68.40 ± 2.00 ^a	9.00 ± 1.73 ^a	22.60 ± 2.65 ^b	0.20 ± 0.18 ^c	0.44 ± 0.16 ^c	0.54 ± 0.01 ^a	5.37 ± 0.02 ^a	0.16 ± 0.01 ^a
	East	68.40 ± 2.00 ^a	9.00 ± 1.73 ^a	22.60 ± 2.65 ^b	0.61 ± 0.89 ^b	1.18 ± 1.43 ^b	0.57 ± 0.05 ^a	5.37 ± 0.02 ^a	0.19 ± 0.04 ^a
	West	68.40 ± 2.00 ^a	9.00 ± 1.73 ^a	22.60 ± 2.65 ^b	0.67 ± 1.00 ^b	1.20 ± 1.47 ^b	0.46 ± 0.14 ^a	5.37 ± 0.02 ^a	0.16 ± 0.02 ^a
	Natural Forest (Control)	68.40 ± 3.00 ^a	6.00 ± 2.00 ^a	25.60 ± 2.00 ^a	2.25 ± 0.05 ^a	3.61 ± 0.01 ^a	0.17 ± 0.01 ^b	2.88 ± 0.02 ^b	0.07 ± 0.00 ^b
500m	North	74.40 ± 3.46 ^a	3.00 ± 1.00 ^a	22.60 ± 2.65 ^b	1.42 ± 1.14 ^b	2.51 ± 1.89 ^b	0.57 ± 0.04 ^a	6.53 ± 0.01 ^a	0.18 ± 0.01 ^a
	South	73.40 ± 3.00 ^a	4.00 ± 0.00 ^a	22.60 ± 2.65 ^b	1.24 ± 0.98 ^b	2.18 ± 1.61 ^b	0.58 ± 0.05 ^a	6.61 ± 0.01 ^a	0.16 ± 0.02 ^a
	East	73.40 ± 1.00 ^a	4.00 ± 1.00 ^a	22.60 ± 2.65 ^b	1.41 ± 1.13 ^b	2.50 ± 1.89 ^b	0.60 ± 0.06 ^a	6.14 ± 0.02 ^a	0.19 ± 0.02 ^a
	West	73.40 ± 2.65 ^a	4.00 ± 2.00 ^a	22.60 ± 2.65 ^b	1.84 ± 1.50 ^b	3.22 ± 2.51 ^a	0.43 ± 0.09 ^a	5.37 ± 0.01 ^a	0.13 ± 0.05 ^a
	Natural Forest (Control)	68.40 ± 3.00 ^b	6.00 ± 2.00 ^b	25.60 ± 2.00 ^a	2.25 ± 0.05 ^a	3.61 ± 0.01 ^a	0.17 ± 0.00 ^b	2.88 ± 0.02 ^b	0.07 ± 0.00 ^b
1000m	North	75.40 ± 5.00 ^a	2.00 ± 1.00 ^b	22.00 ± 2.00 ^b	0.95 ± 1.01 ^c	1.65 ± 1.71 ^b	0.53 ± 0.03 ^a	5.21 ± 0.02 ^b	0.14 ± 0.02 ^a
	South	73.40 ± 3.00 ^a	4.00 ± 1.00 ^a	22.60 ± 0.00 ^b	1.71 ± 0.07 ^b	2.93 ± 0.13 ^b	0.63 ± 0.05 ^a	12.61 ± 0.02 ^a	0.20 ± 0.02 ^a
	East	73.40 ± 3.00 ^a	4.00 ± 1.00 ^a	22.60 ± 2.00 ^b	1.91 ± 0.16 ^b	3.11 ± 0.39 ^a	0.42 ± 0.16 ^a	3.97 ± 0.02 ^b	0.13 ± 0.04 ^a
	West	74.40 ± 3.46 ^a	3.00 ± 1.00 ^a	22.60 ± 2.00 ^b	0.99 ± 1.51 ^c	1.70 ± 2.60 ^b	0.24 ± 0.10 ^b	3.11 ± 0.02 ^b	0.09 ± 0.02 ^a
	Natural Forest (Control)	68.40 ± 3.00 ^a	6.00 ± 2.00 ^a	25.60 ± 2.00 ^a	2.25 ± 0.05 ^a	3.61 ± 0.01 ^a	0.17 ± 0.00 ^b	2.88 ± 0.02 ^b	0.07 ± 0.00 ^a

Note: *Note: Mean with the same letters in the same column is not significantly different*

Table 2: Mean Summary for Soil Properties at 10.1 – 20.00 cm Soil Depth

	Direction	Sand	Silt	Clay	Organic Carbon	Organic Matter	Nitrogen	Phosphorus	Potassium
0m	North	66.40 ± 2.00 ^a	12.00 ± 1.00 ^a	22.60 ± 1.00 ^a	0.83 ± 1.27 ^b	1.42 ± 1.91 ^b	0.39 ± 0.19 ^a	5.13±0.02 ^a	0.12 ± 0.04 ^a
	South	66.40 ± 2.00 ^a	12.00 ± 1.00 ^a	22.60 ± 1.00 ^a	0.16 ± 1.12 ^b	0.38 ± 0.11 ^c	0.50 ± 0.01 ^a	5.13±0.02 ^a	0.13 ± 0.03 ^a
	East	66.40 ± 2.00 ^a	12.00 ± 1.00 ^a	22.60 ± 1.00 ^a	0.20 ± 0.19 ^c	0.48 ± 0.27 ^c	0.52 ± 0.04 ^a	5.13±0.02 ^a	0.16 ± 0.04 ^a
	West	66.40 ± 2.00 ^a	12.00 ± 1.00 ^a	22.60 ± 1.00 ^a	0.62 ± 0.90 ^b	1.25 ± 1.62 ^b	0.43 ± 0.12 ^a	5.13±0.02 ^a	0.13 ± 0.03 ^a
	Natural Forest (Control)	66.40 ± 2.00 ^a	9.00 ± 1.73 ^b	24.60 ± 0.00 ^b	1.62 ± 0.02 ^a	2.78 ± 0.01 ^a	0.19 ± 0.02 ^b	3.44±0.02 ^b	0.09 ± 0.02 ^b
500m	North	73.40 ± 3.00 ^a	4.00 ± 2.00 ^b	22.60 ± 3.00 ^a	1.34 ± 1.06 ^a	2.36 ± 1.71 ^a	0.34 ± 0.12 ^a	3.84 ± 0.02 ^b	0.12 ± 0.04 ^b
	South	72.40 ± 3.46 ^a	5.00 ± 2.00 ^b	22.60 ± 0.00 ^a	1.26 ± 1.00 ^a	1.07 ± 0.60 ^b	0.58 ± 0.09 ^a	7.23 ± 0.03 ^a	0.18 ± 0.02 ^a
	East	73.40 ± 0.00 ^a	4.00 ± 0.00 ^b	22.60 ± 0.00 ^a	1.24 ± 0.98 ^a	2.19 ± 1.56 ^a	0.40 ± 0.06 ^a	3.50 ± 0.02 ^b	0.12 ± 0.04 ^b
	West	71.40 ± 3.00 ^a	6.00 ± 2.00 ^b	22.60 ± 3.00 ^a	1.61 ± 1.30 ^a	2.85 ± 2.14 ^a	0.34 ± 0.12 ^a	3.97 ± 0.03 ^b	0.11 ± 0.05 ^b
	Natural Forest (Control)	66.40 ± 2.00 ^b	9.00 ± 1.73 ^a	24.60 ± 0.00 ^a	1.62 ± 0.02 ^a	2.78 ± 0.01 ^a	0.19 ± 0.02 ^a	3.44 ± 0.02 ^b	0.09 ± 0.02 ^b
1000m	North	75.40 ± 0.00 ^a	2.00 ± 1.00 ^b	22.00 ± 2.00 ^a	0.84 ± 0.94 ^b	1.46 ± 1.61 ^b	0.41 ± 0.14 ^a	4.87 ± 0.00 ^b	0.09±0.02 ^b
	South	72.40 ± 2.00 ^a	5.00 ± 0.00 ^b	22.60 ± 2.00 ^a	0.87 ± 0.84 ^b	1.02 ± 0.40 ^b	0.60 ± 0.01 ^a	7.39 ± 0.02 ^a	0.17±0.02 ^a
	East	73.40 ± 3.00 ^a	4.00 ± 0.00 ^b	22.60 ± 3.46 ^a	1.70 ± 0.07 ^a	3.13 ± 0.01 ^a	0.31 ± 0.03 ^b	3.58 ± 0.00 ^b	0.11±0.02 ^b
	West	75.40 ± 2.65 ^a	2.00 ± 0.00 ^b	22.60 ± 2.65 ^a	0.92 ± 1.27 ^b	1.61 ± 2.17 ^b	0.19 ± 0.05 ^b	5.06 ± 0.02 ^b	0.13±0.02 ^b
	Natural Forest (Control)	66.40 ± 2.00 ^b	9.00 ± 1.73 ^a	24.60 ± 0.00 ^a	1.62 ± 0.02 ^a	2.78 ± 0.01 ^a	0.19 ± 0.02 ^b	3.44 ± 0.02 ^b	0.09±0.02 ^b

Note: Mean with the same letters in the same column is not significantly different

The result on table 3 also shows the result of the soil parameters of both physical and chemical properties of soil as affected by the distance of the quarry and the result shows the soil depth at 20.1-30 cm respectively. The results revealed that the farther the distance of the quarry, the higher the abundance of sand (Table 3) below. The abundance of sand at 500 m and 1000 m was higher than that of the natural forest. The highest abundance of sand was 75.40 ± 1.73 at 1000 m west, while the lowest abundance of sand was 67.40 ± 0.00 in all directions at 0 m. silt was abundant 10.00 ± 1.73 at 0 m in all directions, which was higher than the abundance of silt at the natural forest. The lowest abundance was 2.00 ± 1.00 at 1000 m west. The highest abundance of clay was 22.60 same in all directions and distances with little differences in standard error, except at 1000 m East and 500 m south which had the lowest abundance of $21.60 \pm 2.00/3.00$.

The abundance of sand at all directions and distances was slightly lower than that of the natural forest. Organic carbon has the highest at 1.63 ± 1.06 at 500 m west, while the lowest abundance was 0.27 ± 0.17 at 0 m south. It also shows that the abundance was low at 0m compared to 500 m and 1000 m. The highest abundance of organic matter was 2.81 ± 1.87 at 500 m west, while the lowest abundance was 0.64 ± 0.02 at 500 m south. It also shows that the abundance was low at 0m compared to 500 m and 1000 m. Abundance of nitrogen was higher in all directions and distances (ranging from 0.31 ± 0.08 to 0.54 ± 0.15) than the abundance at the natural forest which was 0.25 ± 0.02 , except at 1000 m West, where the abundance of nitrogen was 0.20 ± 0.08 . Phosphorus was higher than that of the natural forest (4.82 ± 0.02) in only three (3) locations, which were 6.84 ± 0.00 at 500 m north, 5.44 ± 0.02 at 500 m South and 14.58 ± 0.02 at 1000 m South. It also shows that the abundance of 3.73 ± 0.02 at 0m was same in all directions. potassium was higher than that of the natural forest (0.13 ± 0.02) in only four (4) locations, which were 0.17 ± 0.06 at 0 m East, 0.16 ± 0.05 at 500 m North, 0.20 ± 0.03 at 1000 m South and 0.16 ± 0.02 at 1000 m West. It also shows that the abundance of $0.13 \pm 0.03/0.02$ has more frequency at all the locations.

Table 4 shows the soil properties as affected by directions from the rock quarry. There was no significance difference in the sand and clay contents across the directions but the natural forest reserve contained the least amount of sand. The highest sand recorded at northern direction (720.7 g kg^{-1}) did not differ from the least obtained in the southern direction (707.3 g kg^{-1}). The clay and silt contents were highest in soils from the natural forest and significantly different from all the directions of the quarry site. Thus, the soils were sandy clay loams at the quarry site and natural forest. The quarry site contained significantly higher available P than the forest and differed across the directions with the highest value in the southern direction (7.57 mg kg^{-1}) and least in the east (4.38 mg kg^{-1}). The N content was highest in the southern direction (5.3 g kg^{-1}) which significantly differed from the other directions and the natural forest with the least value (2.0 g kg^{-1}). The exchangeable K in the southern direction was significantly higher than the other directions while the natural forest gave the least value ($0.10 \text{ cmol kg}^{-1}$). The organic matter content was higher in the natural forest than all the other directions which gave similar values.

Table 5 shows the effects of sampling distance from the quarry on soil properties. The sand content was highest at 1000 m and did not differ from the value at 500 m while the natural forest had the least value. The silt was highest at 0 m in the quarry site and followed by the natural forest but least at 1000 m away from quarry site. The natural forest contained higher clay than the quarry site which had similar values at all the sampling distances. The available P was most abundant at 1000 m and differed significantly from other sampling distances while the natural forest contained the least amount. Total N and exchangeable K were significantly higher at all distances away from the quarry site than the natural forest but showed slight decrease with distance. The organic matter was highest at natural forest and differed significantly from all the distances but 0 m contained the least amount.

Table 3: Mean Summary for Soil Properties at 20.1 – 30 cm Soil Depth

0m	Direction	Sand	Silt	Clay	Organic Carbon	Organic Matter	Nitrogen	Phosphorus	Potassium
	North	67.40 ± 0.00 ^a	10.00±1.73 ^a	22.60 ± 0.00 ^a	0.79 ± 0.73 ^b	1.36 ± 1.24 ^a	0.33 ± 0.14 ^a	3.73±0.02 ^a	0.11 ± 0.04 ^b
	South	67.40 ± 0.00 ^a	10.00±1.73 ^a	22.60 ± 0.00 ^a	0.27 ± 0.17 ^c	1.06 ± 0.72 ^a	0.45 ± 0.06 ^a	3.73±0.02 ^a	0.12 ± 0.02 ^b
	East	67.40 ± 0.00 ^a	10.00±1.73 ^a	22.60 ± 0.00 ^a	0.46 ± 0.16 ^b	0.80 ± 0.26 ^a	0.50 ± 0.15 ^a	3.73±0.02 ^a	0.17 ± 0.06 ^a
	West	67.40 ± 0.00 ^a	10.00±1.73 ^a	22.60 ± 0.00 ^a	0.61 ± 0.42 ^b	1.05 ± 0.69 ^b	0.37 ± 0.07 ^a	3.73±0.02 ^a	0.13 ± 0.01 ^b
	Natural Forest (Control)	66.40 ± 1.00 ^a	9.00±1.73 ^a	24.50 ± 2.00 ^a	2.22 ± 0.02 ^a	3.53 ± 0.01 ^a	0.25 ± 0.02 ^a	4.82±0.02 ^a	0.13 ± 0.02 ^b
500 m	North	73.40 ± 0.00 ^a	4.00 ± 2.00 ^b	22.60 ± 3.00 ^a	1.59 ± 1.03 ^b	2.74 ± 1.81 ^a	0.54 ± 0.12 ^a	6.84 ± 0.00 ^a	0.16 ± 0.05 ^a
	South	71.40 ± 2.00 ^a	7.00 ± 1.00 ^b	21.60 ± 3.00 ^a	0.37 ± 0.03 ^c	0.64 ± 0.02 ^a	0.36 ± 0.04 ^a	5.44 ± 0.02 ^a	0.13 ± 0.03 ^b
	East	72.40 ± 3.00 ^a	5.00 ± 0.00 ^b	22.60 ± 2.00 ^a	1.13 ± 0.63 ^b	1.93 ± 1.11 ^a	0.38 ± 0.02 ^a	4.59 ± 0.00 ^a	0.13 ± 0.03 ^b
	West	71.40 ± 2.65 ^a	6.00 ± 0.00 ^b	22.60 ± 1.00 ^a	1.63 ± 1.06 ^b	2.81 ± 1.87 ^a	0.31 ± 0.08 ^a	4.12 ± 0.02 ^a	0.13 ± 0.03 ^b
	Natural Forest (Control)	66.40 ± 1.00 ^b	9.00 ± 1.73 ^a	24.50 ± 2.00 ^a	2.22 ± 0.02 ^a	3.53 ± 0.01 ^a	0.25 ± 0.02 ^a	4.82 ± 0.02 ^a	0.13 ± 0.02 ^b
1000 m	North	74.40 ± 4.00 ^a	3.00 ± 1.00 ^c	22.60 ± 3.46 ^a	1.14 ± 1.05 ^b	2.51 ± 1.08 ^a	0.52 ± 0.08 ^a	4.20±0.02 ^b	0.11 ± 0.05 ^b
	South	71.40 ± 2.65 ^a	6.00 ± 1.73 ^b	22.60 ± 1.00 ^a	0.55 ± 0.15 ^c	0.93 ± 0.29 ^b	0.54 ± 0.15 ^a	14.58±0.02 ^a	0.20 ± 0.03 ^b
	East	71.40 ± 1.73 ^a	7.00 ± 1.00 ^b	21.60 ± 2.00 ^a	1.22 ± 0.26 ^b	2.11 ± 0.42 ^a	0.31 ± 0.08 ^a	3.42±0.02 ^b	0.10 ± 0.02 ^b
	West	75.40 ± 1.73 ^a	2.00 ± 1.00 ^c	22.60 ± 0.00 ^a	1.04 ± 1.06 ^b	1.78 ± 1.82 ^a	0.20 ± 0.08 ^a	3.73±0.02 ^b	0.16 ± 0.02 ^a
	Natural Forest (Control)	66.40 ± 1.00 ^b	9.00 ± 1.73 ^a	24.50 ± 2.00 ^a	2.22 ± 0.02 ^a	3.53 ± 0.01 ^a	0.25 ± 0.02 ^a	4.82±0.02 ^b	0.13 ± 0.02 ^b

Note: Mean with the same letters in the same column is not significantly different

Table 4: Soil physical and chemical properties at different cardinal directions of the quarry site

Direction	Sand (g kg ⁻¹)	Silt (g kg ⁻¹)	Clay (g kg ⁻¹)	Textural Class	Available P (mg kg ⁻¹)	Total N (g kg ⁻¹)	Exchangeable K (cmol kg ⁻¹)	Organic matter (g kg ⁻¹)
North	720.7a	53.9 ^d	225.2 ^b	SCL	5.08 ^b	4.6 ^b	0.13 ^b	18.2 ^b
South	707.3a	68.9 ^b	224.9 ^b	SCL	7.57 ^a	5.3 ^a	0.16 ^a	11.8 ^b
East	710.7a	65.6 ^{bc}	224.9 ^b	SCL	4.38 ^c	4.5 ^b	0.15 ^d	19.4 ^b
West	715.1a	60.0 ^{cd}	226.0 ^b	SCL	4.40 ^{bc}	3.3 ^c	0.13 ^c	19.4 ^b
Natural Forest	670.7b	80.0 ^a	248.9 ^a	SCL	3.71 ^d	2.0 ^d	0.10 ^e	29.8 ^a
SE±	4.6	2.8	4.0		0.00	0.2	0.01	2.6

Mean values with the same letters are not significantly different (P<0.05)

SCL= Sandy clay loam

Table 5: Soil physical and chemical properties at various distances from the quarry site

Distance	Sand (g kg ⁻¹)	Silt (g kg ⁻¹)	Clay (g kg ⁻¹)	Textural Class	Available P (mg kg ⁻¹)	Total N (g kg ⁻¹)	Exchangeable K (cmol kg ⁻¹)	Organic matter (g kg ⁻¹)
0 m	673.3 ^b	98.3 ^a	230.9 ^b	SCL	4.54 ^c	4.1 ^a	0.14 ^a	12.0 ^c
500 m	716.7 ^a	53.3 ^c	229.9 ^b	SCL	5.02 ^b	4.0 ^a	0.14 ^a	24.6 ^b
1000 m	724.5 ^a	45.3 ^d	229.1 ^b	SCL	5.52 ^a	3.7 ^b	0.13 ^a	22.6 ^b
Natural Forest	670.7 ^b	80.0 ^b	248.9 ^a	SCL	3.71 ^d	2.0 ^c	0.10 ^b	29.8 ^a
SE±	3.6	2.2	3.0		0	0.1	0.00	2.0

Means with the same letters are not significantly different (P<0.05) SCL= Sandy clay loam

Table 6 shows the effect of quarrying activities of the properties of soils at various depths. The contents of the particle sizes differed significantly with sand highest at 0-10 cm depth which 10-20 and 20-30 cm contained the highest silt while clay did not differ with depth in the quarry site. The natural forest contained the least amount of sand but highest silt and clay but the values show that the quarry site and forest had sandy clay loams. The available P, total N and exchangeable K were more abundant at 0-10 cm soil depth and somewhat decreased with depth in the quarry site. The natural forest contained the least available P, total N and exchangeable K but had the highest amount of organic matter which did not differ significantly with soil depth in the quarry site.

Table 6: Soil properties at different depths in the quarry site and natural forest

Soil depth (cm)	Sand (g kg ⁻¹)	Silt (g kg ⁻¹)	Clay (g kg ⁻¹)	Textural Class	Available P (mg kg ⁻¹)	Total N (g kg ⁻¹)	Exchangeable K (cmol kg ⁻¹)	Organic matter (g kg ⁻¹)
0-10	713.3 ^a	54.3 ^c	231.9 ^b	SCL	5.31 ^a	4.4 ^a	0.14 ^a	21.8 ^b
10-20	701.3 ^b	71.3 ^b	229.6 ^b	SCL	4.69 ^c	3.7 ^b	0.13 ^b	17.8 ^b
20-30	700.0 ^b	71.3 ^b	228.4 ^b	SCL	5.09 ^b	3.7 ^b	0.14 ^{ab}	19.6 ^b
Natural Forest	670.7 ^c	80.0 ^a	248.9 ^a	SCL	3.71 ^d	2.0 ^c	0.10 ^c	29.8 ^a
SE±	3.6	2.1	3.0		0	0.1	0.00	10.2

Means with the same letters are not significantly different (P<0.05) SCL= Sandy clay loam)

Discussion

The physical properties of the soil at the quarry site of percentage sand, silt and clay that are present in the soil at the quarry site that were considered for this research, these parameters were measured and it was discovered that for percentage sand as reported in result of tables 4, 5 and 6 show that there is significant difference. The result shows that quarry activities affected the abundance of sand in the study area because sand was significantly lower than the natural forest when compared them in relation to their direction. Thus, it is therefore reported from the research that sand, silt and clay from the table 4, 5 and 6 above were significantly difference from the result of natural forest when compared. Bewekta and Stroosnijder (2003),

Martinez-Mena *et al.* (2008) showed the same results in their studies therefore the result of the two researchers agreed with the finding of this result. Also, the result of Kiakojouri and Taghavi, (2014) show a similar result with this research, in their own research, there is a shift from one agricultural system such as shifting cultivation, mixed farming to another in the level of the soil physical properties therefore, it can be justified that by decreasing the SOM and soil aggregate sustainability during the changes in the direction and distance to the soil surface, amount of erosion increases and consequently during the erosion clay and silt are separated and move to the downstream area (Celik, 2005;

Bewekta and Stroosnijder, 2003). Due to these reasons the physical properties in the west direction were completely higher than other direction this can be due to the movement of the erosion towards the west direction (Table 4) so that during the movement amount of clay at both of 0-10 cm and 10-20 cm as well as 20-30 cm depth have no significant difference but it increased with increase in depth in the quarry site (Kiakojouri and Taghavi Gorgi, 2014) Also, the result shows that quarry activities affected the abundance of clay and other physical properties as examined in this study. More so, this is similar to the result of (Paramesha *et al.*, 2006 and Babitha *et al.*, 2017) who reported that the substantial amount of coarse and fine sand is getting added into the soil by quarry activities this is due to the fact that during quarry, more particle were added when there is breaking of the rocks.

The result of phosphorus from this research is shown in tables 4, 5 and 6 above the results shows that there were significant differences in the abundance of

phosphorus at the direction, distance away from the quarry site as well as soil depth. The result of the phosphorus was higher at southern direction. Also, the abundance of phosphorus was more at all the directions, distances and soil depths than the natural forest. Phosphorus was more abundant at the South direction, 1000 m away from the quarry site and at 0-10 cm soil depth respectively. The lowest abundance was at east direction, 0 m which was on the quarry site and 10.1-20 cm soil depth. Phosphorus (P) is also a key nutrient for agricultural yields and is essential in assessments of how soil is healthy.

Along with nitrogen, P is the main nutrient that limits the agricultural yields, especially in highly weathered, oxidic soils, where the major part of the total soil P is fixed in clay minerals and oxides. The available P in the soil solution is present as orthophosphates, but the microbial P and organic-P are also stocks that can rapidly become available. Procedures for assessment of P availability have been well established (Pankhurst *et al.*, 2003; Zhang *et al.*, 2006a). Though the available P mean value of 6 mg kg⁻¹ was found in this research for surface soils though it is below the limitation as the value is below 15 mg kg⁻¹ as recorded by (Holland *et al.*, 1989) and higher than the result of (Ezenwa, *et al.*, (2014);

Unanaonwi and Amonum (2017) in their experiment. There is significant difference in the abundance of nitrogen. Also, the abundance was more at all the directions, distances and soil depths than the natural forest ecosystem. Nitrogen was more abundant at the South direction, 0 m which was on the quarry site and at 0-10 cm soil depth respectively. The lowest abundance was at West direction, 1000 m away from the quarry site and at the 10.1-20 cm and 20.1-30 cm soil depth respectively. Though, nitrogen (N) is the most required plant nutrient, which is found in several chemical forms in soil (Cantarella, 2007), resulting in a very dynamic behavior. Soil nitrogen has been assessed mainly as mineral N, especially nitrate, organic N or potentially mineralizable N, as stored in the soil organic matter. There is significant difference in the abundance of potassium. Also, the abundance was more at all the directions, distances and soil depths than the natural forest. It was observed that there was slight difference in the abundance of phosphorus at all the directions, distances and soil depths. Potassium was more abundant at the South direction, both 0 m which was

on the quarry site and 500 m having same values and at 0-10 cm and 20.1-30 cm soil depth having same values. The lowest abundance was at West direction, 1000 m away from the quarry site and 10.1-20 cm soil depth. It was observed that the abundance of Phosphorus, Nitrogen and Potassium were higher than that of the natural forest.

More so, it was shown on tables 4, 5 and 6 there is significant difference in the abundance of organic carbon compared to the natural forest. Arif *et al.*, (2013) reported that quarry activities resulted in to loss of organic carbon and other vital nutrient in the soil. Though, there is no significant difference in its abundance in the directions and soil depth. It was recorded that soil organic carbon is also a key attribute in assessing soil health, generally correlating positively with crop yield (Bennett *et al.*, 2010). With this record it was revealed that this quarry site will not support the growth of crops compared to the forest soil and if the plants or crops were planted they will experience a stunted growth. As shown on Tables 4, 5 and 6 there is significant difference in the abundance of organic matter compared to the natural forest, but there is no significant difference in its

abundance in the directions and soil depth, which further explains that the effect of the quarry activities on the percentage of organic carbon at the directions and soil depths was the same.

Conclusion

This study had revealed the impact of quarry activities on the physical and chemical properties of soil in the study site. Results from the study revealed the implication of the quarry activities based on the distance of the quarry as well as the depth of the soil on the impact of physical and chemical properties of the soil. The main impacts of the quarrying activities on the environment are the broadcasts of dusts and gases. These particles or dusts are very numerous and varied. Thus, quarry activities had significant effects on the on the soil properties of the study area. The top soil had more life form than the lower layers. The abundance of sand, phosphorus, nitrogen and potassium was higher at the quarry site than that of the natural forest. Quarry activities affect the abundance of organic carbon and organic matter.

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