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Assessment of Soil Quality Characteristics and Pollution Status of Farm Lands within Ugwuele Quarry Site, Uturu Abia State Nigeria

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Abstract— Assessment of physicochemical characteristics, soil enzymes and heavy metal concentrations of soil samples from farm lands within Ugwuele quarry site was carried out in both wet and dry seasons using standard analytical procedures. Soil samples were collected from different cardinal points of 200m and 400m from the centre, at depths of 0-30cm and 31-60cm. The result from this study shows that the soil temperature of the quarry site was higher in the dry season compared to wet season and decreased with increase in soil depth. Soil pH of the quarry soils was low and therefore acidic and ranged from 3.86±0.06 to 4.64±0.03. The result also shows that soil organic matter decreased from 31.10±0.85 to 1.34±0.01%. The soil enzymes; urease, alkaline phosphatase (ALP), acid phosphatase, hydrogen peroxidase and dehydrogenase decreased significantly ($p<0.05$) compared to control. Urease varied from 11.76±0.14 to 2.90±0.01, ALP 5.66±0.10 to 1.00±0.01mg/h, acid phosphatase 9.70±0.12 to 1.28±0.05mg/g/h, Hydrogen peroxidase 1.02±0.10 to 0.03±0.01m10.0$ML^{-1}KMnO_4g^{-1}$, dehydrogenase 5.44±0.16 to 1.01±0.02$mgTPFg^{-1}drysoil6h^{-1}(x10^{-5})$.The heavy metals (Co, Zn, Cr, Cd, As and Pb) were all present in the quarry soil and were significantly higher compared ($p<0.05$) to the control. It is therefore evident that quarry activities at Ugwuele decreased the fertility and suitability of the soil for growing crops.

Keywords— Quarry, heavy metals, soil enzymes, wet season, dry season

I. INTRODUCTION

Currently, the world is facing serious environmental problems which involve depletion of ozone layer, climate change, global warming, destruction of rainforest, soil and water pollution, and population growth. Industrial activities are on the top of the list of sources of this environmental pollution in developing countries [1] [2].
Despite the economic importance of mining industry, it is a source of soil and air pollutants in the environment thereby endangering plants and animals. Quarrying involves the extraction of rock, sand, gravel or other minerals from the ground in other to use them to produce materials for construction or other uses [3]. Quarrying leads to excavation of top soil necessary for agricultural activities causing a depletion of macronutrients and increases the concentration of heavy metals [4]. Excessive amount of heavy metals affects soil biological properties and may change its basic physicochemical properties.
In many developing countries like Nigeria local inhabitants cultivate some vegetables and other crop plants in the vicinity of quarry sites due to scarcity of land for agricultural purposes and/or lack of proper education. Soils of farm lands within the vicinity of quarry sites are likely to be polluted thereby reducing fertility and suitability of the soil to grow crops. If polluted soil is used to grow crops, the soil will in turn produce lower yields which are often contaminated [5]. This work is therefore aimed at evaluating the fertility potentials and pollution status of the soil from farms within Ugwuele quarry site .
Section 1 of this article contains introduction of the work, section 2 contains related work on quarry, its benefits and negative impacts. Section 3 contains the experimental procedure which includes the area of study, sampling methods and methods of analyses. Section 4 presents the results of the study and discuses the major findings. Section 5 concludes the research work with future directions.

II. RELATED WORK

Various researchers have tried to assess the effects of quarry activities. Lameed and Ayodele [13] observed that quarry activities caused the decrease in flora and fauna species within the ecosystem of a quarry site. Igbinovia *et al.* [14] found that long term exposure to dust and polluted air from quarry increased susceptibility to respiratory problems. The study carried out by Peter *et al.* [15] shows that stone quarrying has negative impacts on the air quality. Ogbonna *et al.*[3] observed that quarry activities at Ugwuele Uturu may have negatively affected the nutritional value of some plants growing within the quarry site. However, these studies did not show any detailed effect of quarry on the soil. There is therefore the need to

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assess the impact of stone quarrying at Ugwuele on the soil samples from farm lands within its vicinity; this necessitated this study.

III. EXPERIMENTAL PROCEDURE

3.1 Area of Study

Ugwuele quarry site in Uturu, Isuikwuato Local Government Area, Abia State Nigeria is the area of the present study. The quarry site which is operated by SETRACO company, lies within latitude 05^{O}50' 18" N of the equator and longitude 07^{O}25' 17" E of the Greenwich Meridian (Fig.1). The area is low lying with good road network.

Wet and dry seasons are the major climatic conditions in the area. The dry season starts in November and ends in March with low humidity and absence of clouds. The harmattan also occurs during this season. The wet season starts in April and ends in October [16]. The area lies within the tropical rainforest belt of Nigeria with an annual rainfall between 1500mm and 2000 with a mean temperature of 27^{O}C and relative humidity of over 70% [3]. The quarry situates around farm lands. The coastal plain sand (Oligocene Benin formation) is characteristic of the study area. The thickness of the sands and sandstones ranges from 2.0m – 2200.0m [17].

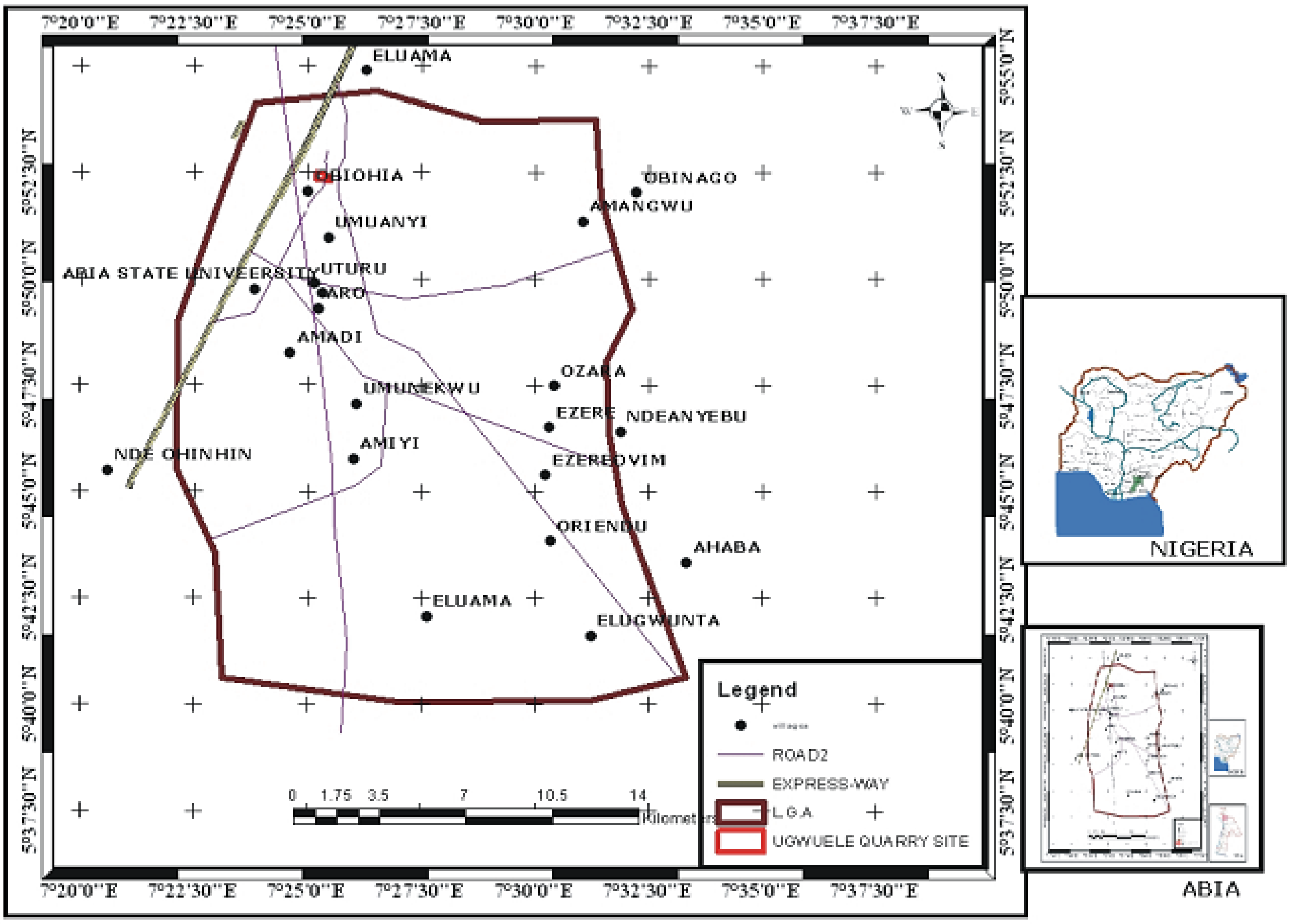

Fig. 1: MAP OF ISUIKWUATO SHOWING UGWUELE QUARRY SITE

3.2 Soil Sampling

Soil samples (0-30 and 31-60cm depth) were collected from a point very close to the epicenter of the quarry and referred to as the center. Four (4) other samples were collected from different cardinal points of 200m and 400m from the center using a plastic auger. At each point, depths of 0-30cm and 31-60cm were considered separately. Control samples were collected at a distance of 6.8km from the quarry site. Auger and polythene bags were washed with water and dried before the samples were collected. The samples were collected in two seasons – wet and dry seasons (in August and February, 2019). The collected soil samples were stored in sealed polythene bags and transported to the laboratory for pre-treatment and analysis.

3.3 Extraction of the Soil Samples

The soil samples were air-dried, mechanically ground using a stainless steel roller, mortar and pestle. The ground soil was sieved to obtain <2mm fraction. The soil samples were then digested in a mixture of concentrated trioxonitrate (V) acid (NHO_3) concentrated hydrochloric acid (HCl) and 27.5% hydrogen peroxide (H_2O_2) as described by USEPA for the analysis of heavy metals [18].

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The digest was filtered (using Whatman filter paper No. 42) into 50ml standard flask and made to the mark with de-ionized water.

3.4 Methods of Analysis

The cation exchange capacity of the soil sample was determined by ammonium saturation method described by APHA [19]. The soil organic carbon was determined using the method as described by Whitney [20]. The method as described by Olorunfemi *et al*. [21] was used for the determination of soil pH. Soil temperature and moisture content were determined using the method described by Ezirim and Chikezie [22]. The electrical conductivity of the soil samples was determined using a digital electrical conductivity meter as described by Alef and Nanniperi [23]. The atomic absorption spectrophotometer (AAS) determination of heavy metals was carried out as described by James [24]. The method described by Onwuka [25] was used in the determination of soil dehydrogenase. Soil hydrogen peroxidase was also determined by the method described by Osuocha *et al*. [26]. The determination of soil urease, alkaline phosphatase and acid phosphatase were done using the methods described by Ubeda et al.[27]

3.5 Statistical Analysis

Statistical analyses were carried out with the use of Analysis of Variance (ANOVA) and standard T-distribution test using statistical package for social sciences (SPSS), version 20 and group means were compared for significance at $p<0.05$.

IV. RESULTS AND DISCUSSION

Soil temperature is the measure of the internal heat energy content of the soil. The temperature of the soil plays a role in plant growth, the timing of budburst or leaf fall, the rate of decomposition of organic wastes and other chemical, biological and physical processes taking place in the soil [28]. The results from this study show that the soil temperature of the quarry site was significantly higher ($p<0.05$) in the dry season than in the wet season. This is likely to be caused by difference in weather; considering the fact that the main source of soil temperature is the solar radiation which is intense in the dry season. Osuocha *et.al*.[29] reported similar result. The results from the present study also show that the soil temperature of the quarry site decreased significantly ($p<0.05$) with increase in soil depth. This may be mainly because soil is an insulator of heat flowing between the atmosphere and the solid earth. Hence, the higher the soil depth, the greater the soil mass; this results to greater heat insulation and therefore lower temperature. Again, in all the seasons, the soil temperature of the quarry site was significantly higher ($p<0.05$) compared to the control. This could be because of lower organic matter recorded in the quarry site. Decrease in organic matter leads to high soil temperature [28] [30].

Soil pH measures soil acidity or alkalinity. It is an excellent indicator of a soil's suitability for plant growth. The results from the present study show that the pH of the quarry soils was low and therefore acidic. This agrees with [31] that reported low pH in a quarry soil. This low pH in the present study area may be because of oxidative weathering of some minerals in the rocks. It has been reported that oxidation of pyrite in the mine spoil causes acidic conditions to form in soils near the mine spoils [32] [33]. The results from this study also show that the pH was significantly higher ($p<0.05$) in the wet season than in the dry season. This is mainly because of the dilution by the rain, of the soil acidity during the wet season. The results also show that the pH of the quarry soil increased significantly ($p<0.05$) with increase in soil depth. This may also be because the soil moisture of the quarry increased with soil depth and therefore more dilution of acidity occurs as we go down the soil. It can also be seen from the results that the pH value increased, distance away from the quarry centre. This could also be because there were lesser quarry spoils some distance away from the centre which leads to lesser oxidation and hence increased pH value.

Soil electrical conductivity is the current carrying capacity of the soil. It gives a clear idea of the soluble salts present in the soil. The results from this study show that the quarry soils have more electrical conductivity when compared to the control soil sample. These high values could be because of the leached spent explosive materials which accumulated on the soil surface. The increased level of heavy metals determined in the present study area may have contributed to the high E.C. [31] [29]. The results from the present study also reveal that electrical conductivity was significantly higher ($p<0.05$) in the dry season than in the wet season, higher in the top-soil than in the sub-soil and higher in the centre than distance away. This trend could be attributed to the fact that the factors (such as heavy metals) that contributed to the increased E.C are higher in the dry season, at the top-soil and at the centre.

Soil organic matter is the part of the soil that comprises plant or animal tissue in different stages of decomposition. It promotes soil fertility in diverse ways such as increasing soil's cation exchange capacity and enhancing soil microbial biodiversity and activity [34]. Results from the present study reveal that organic matter content of the quarry soil was significantly lower ($p<0.05$) compared to the control. This difference could be because of lesser plant cover and higher soil temperature observed in the quarry. High temperature leads to decrease in soil organic matter [35]. The results of the present study also show the presence of higher organic matter in the lower soil (31 - 60cm depth) than in the upper soil (0 – 30cm depth). This could be attributed to high accumulation of organic matter which is often favoured at the lower soil which is cooler and wetter [35]. It could also be because of the aforementioned reasons, that the soil organic matter was lower at the centre of the quarry than some distance from it, as seen from the results.

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Table1: Physicochemical Characteristics of Soil Samples in Ugwuele Quarry Site Uturu (Wet Season)

Group	Temperature (°C)	pH	E.C. (µs/cm)	Organic Matter (%)	Moisture (%)	C.E.C. (cmol/kg)
ControlA	26.00±0.08^{a}	7.55±0.01^{a}	52.10±0.63^{a}	78.86±0.41^{a}	19.90±0.01^{a}	40.24±0.02^{a}
ControlB	25.40±0.10^{a}	7.98±0.03^{a}	50.71±0.78^{a}	80.15±0.83^{a}	21.50±0.09^{a}	48.19±0.01^{a}
North A	27.00±0.46^{b}	5.02±0.33^{b}	87.68±0.08^{b}	13.37±18.83^{b}	45.88±0.02^{b}	18.13±0.01^{b}
North B	26.00±0.15^{c}	5.12±0.07^{b}	73.13±0.03^{c}	19.93±17.19^{c}	49.65±0.04^{c}	24.29±0.03^{c}
North C	26.90±0.09^{d}	5.04±0.05^{c}	66.80±0.01^{d}	18.33±12.42^{d}	39.78±0.02^{d}	15.38±0.02^{d}
North D	26.60±0.10^{e}	5.09±0.35^{d}	47.41±0.02^{e}	21.94±19.43^{e}	55.54±0.02^{e}	31.23±0.14^{e}
South A	27.50±0.05^{f}	5.14±0.04^{b}	58.82±0.02^{f}	28.89±4.64^{f}	20.88±0.02^{f}	23.43±0.05^{f}
South B	26.30±0.02^{g}	5.19±0.01^{e}	47.41±0.08^{g}	31.55±0.05^{g}	31.58±0.01^{g}	27.32±0.10^{g}
South C	27.00±0.10^{h}	5.12±0.02^{b}	43.25±0.05^{h}	37.83±6.04^{h}	27.32±0.00^{h}	37.83±0.15^{h}
South D	26.10±0.05^{i}	5.93±0.04^{f}	16.75±0.01^{i}	50.75±9.42^{i}	34.35±0.01^{i}	46.65±0.07^{i}
East A	27.20±0.02^{j}	4.50±0.02^{g}	146.70±57.73^{j}	1.34±o.01^{k}	41.20±0.04^{j}	20.75±0.05^{j}
East B	26.80±0.05^{k}	5.10±0.00^{b}	82.27±0.02^{k}	19.21±1.06^{k}	45.31±0.02^{k}	22.82±0.12^{k}
East C	26.50±0.00^{l}	6.30±0.10^{h}	88.21±0.02^{l}	61.13±0.70^{l}	40.81±0.01^{l}	19.52±0.01^{l}
East D	26.30±0.04^{m}	6.11±0.02^{i}	80.75±0.05^{m}	66.55±0.09^{m}	47.78±0.07^{m}	23.40±0.01^{m}
West A	27.50±0.05^{n}	4.70±0.02^{j}	141.02±57.75^{n}	15.58±0.35^{n}	45.60±0.20^{n}	38.19±0.02^{n}
West B	27.00±1.11^{b}	4.60±0.01^{j}	141.72±57.70^{n}	15.78±0.4^{o}	49.45±0.05^{o}	39.68±0.05^{o}
West C	27.10±0.05^{b}	6.10±0.00^{k}	121.86±57.78^{o}	46.00±0.19^{p}	31.80±0.08^{p}	40.60±0.01^{p}
West D	26.00±0.10^{o}	6.90±0.02^{l}	100.26±57.78^{p}	66.08±0.38^{q}	33.33±0.01^{q}	45.32±0.01^{q}
Centre A	27.60±0.10^{f}	4.40±0.17^{g}	155.42±0.10^{q}	5.26±0.45^{r}	20.44±0.08^{r}	14.41±0.02^{r}
Centre B	27.10±0.09^{q}	4.60±0.03^{j}	151.90±0.08^{r}	7.15±0.89^{s}	24.20±4.62^{s}	17.80±0.0^{s}

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same column having different letters of alphabet are statistically different (p<0.05) using Least Significant Difference (LSD). **Legend:** A = 200m distance, 0-30cm depth; B= 200m distance, 31-60cm depth; C= 400m distance, 0-30cm depth; D = 400m distance, 31-60cm depth.

Table 2: Physicochemical Characteristics Of Soil Samples in Ugwuele Quarry Siteuturu (Dry Season)

Group	Temperatue(°c)	pH	E.C. (µs/cm)	Organic matter (%)	Moisture (%)	C.E.C.(cmol/kg)
ControlA	28.20±0.45^{a}	6.52±0.01^{a}	61.41±0.09^{a}	41.02±88.84^{a}	8.98±0.03^{a}	36.70±0.03^{a}
ControlB	28.00±0.09^{a}	6.60±0.02^{a}	57.30±0.13^{a}	46.23±0.18^{a}	10.44±0.08^{a}	36.90±0.02^{a}
North A	29.20±0.01^{b}	3.86±0.06^{b}	100.70±0.10^{b}	8.46±53.18^{b}	21.70±0.11^{b}	10.24±0.12^{b}
North B	28.90±0.10^{c}	3.91±0.01^{b}	91.08±0.08^{c}	11.49±45.92^{c}	23.12±0.03^{c}	11.44±0.03^{c}
sNorth C	31.00±0.00^{d}	4.01±0.01^{c}	94.22±0.11^{d}	10.25±48.40^{d}	19.34±0.01^{d}	10.12±0.01^{d}
North D	28.50±0.17^{e}	4.08±0.03^{d}	81.77±0.14^{e}	13.90±39.15^{e}	20.01±0.11^{e}	11.32±0.09^{e}
South A	30.39±0.16^{f}	4.28±0.08^{e}	79.62±0.01^{f}	15.16±37.21^{f}	12.62±0.02^{f}	18.88±0.01^{f}
South B	29.99±0.02^{g}	4.31±0.01^{f}	78.48±0.09^{g}	20.00±33.81^{g}	14.72±0.08^{g}	21.64±0.04^{g}
South C	30.01±0.08^{h}	4.56±0.05^{g}	60.40±0.10^{h}	17.64±24.57^{h}	10.22±0.08^{h}	20.63±0.10^{h}
South D	29.65±0.13^{i}	4.64±0.03^{h}	40.66±0.08^{i}	17.82±13.16^{i}	12.33±0.10^{i}	21.90±0.10^{i}
East A	31.24±0.12^{j}	4.10±0.01^{i}	152.11±0.06^{j}	5.10±84.88^{j}	21.85±0.07^{b}	10.35±0.05^{j}
East B	30.72±0.07^{k}	4.12±0.02^{i}	96.20±0.10^{k}	10.81±49.36^{k}	23.04±0.02^{j}	11.42±0.11^{c}
East C	30.44±0.12^{l}	4.33±0.02^{j}	107.50±0.10^{l}	25.80±47.05^{l}	20.15±0.01^{k}	15.91±0.10^{k}
East D	29.28±0.09^{m}	4.45±0.62^{k}	93.00±0.10^{m}	28.18±37.36^{m}	21.19±0.02^{l}	16.74±0.02^{l}
West A	30.60±0.10^{n}	3.91±0.01^{l}	157.24±0.12^{n}	8.63±85.73^{n}	26.92±0.02^{m}	30.38±0.04^{m}
West B	30.00±0.00^{o}	3.98±0.04^{l}	151.81±0.09^{o}	9.60±82.30^{o}	27.22±0.09^{n}	31.62±0.02^{n}
West C	29.89±0.09^{p}	4.00±0.01^{c}	144.01±0.10^{p}	30.72±65.51^{p}	10.41±0.08^{o}	32.71±0.02^{o}
West D	28.40±0.17^{q}	4.09±0.04^{m}	120.92±0.09^{q}	31.10±0.85^{q}	11.37±0.08^{p}	33.64±0.13^{p}
Centre A	31.90±0.10^{r}	4.00±0.02^{c}	159.15±0.10^{r}	5.15±0.69^{r}	17.66±0.08^{q}	9.74±0.01^{q}
Centre B	31.70±0.00^{s}	4.00±0.01^{c}	154.65±0.10^{s}	7.00±6.32^{s}	23.10±1.06^{c}	10.84±0.12^{r}

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same column, having different letters of alphabet are statistically different (p<0.05) using Least Significant Difference (LSD). **Legend:** A =200m distance, 0-30cm depth; B = 200mdistance, 31-60cmdepth; C = 400m distance, 0-30cm depth; D = 400m distance, 31-60cm depth.

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Table3: Concentration (Mg/Kg) of Heavy Metals in Soil Samples in Ugwuele Quarry Site (WS)

Group	Cobalt (Co)	Zinc (Zn)	Chromium (Cr)	Cadmium (Cd)	Arsenic (As)	Lead (Pb)
Control A	0.99±0.03^{a}	2.43±0.11^{a}	10.62±0.62^{a}	0.49±0.21^{a}	1.96±0.01^{a}	2.01±0.01^{a}
Control B	0.97±0.11^{a}	2.38±0.14^{a}	10.61±0.44^{a}	0.45±0.01^{a}	1.96±0.06^{a}	2.00±0.01^{a}
North A	3.84±0.34^{b}	6.93±0.03^{b}	46.04±0.08^{b}	0.91±1.26^{b}	5.86±0.08^{b}	7.11±0.01^{b}
North B	3.81±0.55^{b}	6.91±0.17^{b}	45.01±0.12^{c}	0.92±0.94^{b}	5.21±0.05^{b}	7.02±0.03^{c}
North C	3.77±0.01^{c}	6.88±0.18^{c}	46.01±0.09^{d}	0.85±0.08^{c}	6.00±0.01^{c}	7.18±0.02^{d}
North D	3.78±0.10^{c}	6.85±0.18^{d}	45.28±0.05^{e}	0.81±19.01^{c}	5.08±0.02^{d}	7.12±0.03^{e}
South A	2.42±0.04^{d}	6.66±0.04^{e}	47.25±0.02^{f}	1.36±0.13^{d}	5.07±0.02^{d}	6.91±0.01^{f}
South B	2.41±0.03^{d}	7.62±0.20^{f}	47.00±0.14^{g}	1.30±0.53^{e}	4.62±0.01^{e}	6.25±0.01^{g}
South C	2.40±0.20^{e}	6.44±0.02^{g}	46.79±0.16^{h}	1.35±0.04^{f}	5.05±0.00^{f}	6.88±0.01^{h}
South D	2.25±0.06^{f}	6.31±0.05^{h}	45.68±0.11^{i}	1.28±0.10^{g}	5.05±0.09^{f}	6.80±0.01^{i}
East A	4.03±0.12^{g}	5.08±0.03^{i}	50.03±0.33^{j}	1.57±0.01^{h}	4.71±0.05^{g}	7.82±0.03^{j}
East B	4.00±0.02^{h}	4.96±0.02^{j}	49.89±0.52^{k}	1.53±0.00^{i}	4.72±0.11^{g}	7.28±0.10^{k}
East C	3.98±0.25^{i}	4.90±0.19^{k}	50.00±0.12^{l}	1.33±0.20^{j}	4.63±0.19^{h}	7.71±0.12^{l}
East D	3.86±0.02^{j}	4.83±0.03^{l}	49.60±0.15^{m}	1.30±0.31^{k}	4.19±0.10^{i}	7.70±0.05^{l}
West A	3.57±0.05^{k}	6.01±0.11^{m}	31.21±1.20^{n}	0.62±0.05^{l}	3.19±0.12^{j}	7.94±0.02^{m}
West B	3.49±1.12^{l}	5.97±0.25^{n}	30.42±0.50^{o}	0.60±0.12^{m}	3.09±0.03^{k}	7.91±0.00^{m}
West C	3.01±0.01^{m}	5.87±0.02^{o}	31.15±0.31^{p}	1.79±0.11^{n}	3.08±0.09^{l}	7.20±0.11^{n}
West D	2.97±0.11^{n}	5.81±0.01^{p}	31.13±1.02^{p}	1.74±0.16^{o}	3.02±0.30^{m}	7.14±0.02^{o}
Centre A	2.50±0.00^{o}	7.62±0.10^{q}	51.15±0.18^{q}	1.04±0.15^{p}	6.60±0.05^{n}	8.26±0.04^{p}
Centre B	2.38±0.07^{p}	7.42±0.13^{r}	50.10±0.07^{l}	1.02±0.33^{p}	6.55±0.54^{o}	8.07±0.01^{q}

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same column, having different letters of alphabet are statistically different ($p<0.05$) using Least Significant Difference (LSD). **Legend:** A =200m distance, 0-30cm depth; B = 200mdistance, 31-60cmdepth; C = 400m distance, 0-30cm depth; D = 400m distance, 31-60cm depth; WS= Wet Season.

Table4: Concentrations (Mg/Kg) of Heavy Metals in Soil Samples in Ugwuele Quarry Site Uturu (DS)

Group	Cobalt (Co)	Zinc (Zn)	Chromium (Cr)	Cadmium (Cd)	Arsenic (As)	Lead (Pb)
Control A	1.07±0.25^{a}	2.50±0.04^{a}	10.71±0.13^{a}	0.55±0.11^{a}	2.00±0.15^{a}	2.71±0.02^{a}
Control B	1.02±0.01^{a}	2.46±0.03^{a}	10.65±0.18^{a}	0.50±0.12^{a}	1.99±0.00^{a}	1.62±0.04^{a}
North A	5.21±0.01^{b}	8.10±0.24^{b}	48.02±0.20^{b}	1.68±0.16^{b}	5.91±0.13^{b}	9.12±0.02^{b}
North B	5.06±0.14^{c}	7.96±0.11^{c}	48.00±0.19^{b}	1.65±0..26^{b}	5.91±0.12^{b}	9.09±0.01^{c}
North C	4.26±0.00^{d}	7.20±0.21^{d}	48.00±0.11^{b}	1.99±0.19^{c}	5.68±0.01^{c}	9.01±0.02^{d}
North D	4.21±0.25^{e}	6.82±0.11^{e}	47.79±0.15^{c}	1.96±30.33^{c}	5.66±0.17^{c}	9.00±0.01^{d}
South A	3.14±0.33^{f}	7.81±0.00^{f}	49.61±0.09^{d}	3.82±0.12^{d}	4.81±0.03^{d}	8.51±0.19^{e}
South B	3.10±0.05^{g}	7.78±0.04^{g}	49.41±0.00^{e}	3.78±0.06^{e}	4.77±0.06^{e}	8.47±0.11^{f}
South C	3.09±0.10^{g}	7.64±0.06^{h}	48.80±0.23^{f}	2.49±0.01^{f}	4.62±0.00^{f}	8.00±0.01^{g}
South D	3.02±0.08^{h}	7.59±0.02^{i}	48.62±0.14^{g}	2.40±0.02^{g}	4.60±0.15^{f}	7.97±0.03^{h}
East A	6.12±0.12^{i}	5.71±0.09^{j}	53.34±0.07^{h}	2.66±0.05^{h}	5.99±0.04^{g}	9.99±0.15^{i}
East B	6.10±0.09^{i}	5.67±0.01^{k}	53.30±0.07^{i}	2.64±0.20^{h}	5.98±0.01^{g}	9.98±0.01^{i}
East C	5.89±0.31^{j}	5.00±0.21^{l}	51.11±0.18^{j}	2.00±0.22^{i}	5.12±0.08^{h}	8.68±0.01^{k}
East D	5.89±0.09^{j}	4.82±0.09^{m}	51.03±0.11^{j}	2.00±0.15^{i}	5.22±0.18^{i}	8.65±0.11^{l}
West A	4.39±0.22^{k}	6.91±0.20^{n}	31.48±0.11^{k}	1.03±0.02^{j}	3.71±0.04^{j}	10.01±0.0^{m}
West B	4.41±0.00^{k}	6.88±0.09^{o}	31.48±0.16^{k}	1.00±0.30^{j}	3.66±0.09^{k}	9.98±0.02^{n}
West C	4.35±0.24^{l}	5.25±0.04^{p}	32.12±0.07^{l}	0.98±0.04^{k}	3.51±0.08^{l}	9.510.13^{o}
West D	4.33±0.26^{m}	5.24±0.07^{p}	32.09±0.02^{m}	0.96±0.15^{k}	3.50±0.22^{l}	9.42±0.14^{p}
Centre A	3.54±0.19^{n}	9.56±0.08^{q}	55.51±0.10^{n}	3.97±0.17^{l}	7.18±0.06^{m}	11.19±0.1^{q}
Centre B	3.51±0.01^{n}	9.46±0.03^{r}	55.40±0.11^{o}	3.97±0.00^{l}	7.14±1.03^{n}	11.14±0.0^{r}

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same column, having different letters of alphabet are statistically different ($p\leq 0.05$) using Least Significant Difference (LSD). **Legend:** A =200m distance, 0-30cm depth; B = 200mdistance, 31-60cmdepth; C = 400m distance, 0-30cm depth; D = 400m distance, 31-60cm depth; DS = Dry Season.

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Table 5: Concentrations of Soil Enzymes in Ugwuele Quarry Site, Uturu (Wet Season)

Group	Urease ($mgNH_3Ng^{-1}drysoil2h^{-1}$)	ALP (mg/h)	Acid Phospatase (mg/g/h)	Hydrogen Peroxidase ($m10.0mlKMnO_4g^{-1}$)	Dehydrogenase ($mgTpFg^{-1}drysoil6h^{-1}(x10^{-5})$)
Control A	31.20 ± 0.08^{a}	7.81 ± 0.01^{a}	$9.23\pm0.97a$	2.17 ± 0.05^{a}	11.62 ± 0.09^{a}
Control B	30.92 ± 0.02^{a}	7.10 ± 0.01^{a}	9.80 ± 0.01^{a}	2.09 ± 0.01^{a}	11.58 ± 0.09^{a}
North A	9.30 ± 0.20^{b}	4.15 ± 0.10^{b}	6.10 ± 0.10^{b}	0.46 ± 0.13^{b}	3.13 ± 0.06^{b}
North B	9.47 ± 0.11^{c}	4.88 ± 0.08^{c}	6.76 ± 0.10^{c}	0.59 ± 0.09^{c}	3.21 ± 0.11^{c}
North C	11.76 ± 0.14^{d}	5.47 ± 0.12^{d}	4.93 ± 0.11^{d}	0.32 ± 0.08^{d}	4.75 ± 0.10^{d}
North D	11.17 ± 0.11^{e}	5.66 ± 0.10^{e}	4.99 ± 0.16^{e}	0.41 ± 0.08^{e}	4.92 ± 0.07^{e}
South A	8.83 ± 0.08^{f}	1.98 ± 0.18^{f}	7.01 ± 0.10^{f}	0.44 ± 0.08^{f}	5.29 ± 0.16^{f}
South B	8.95 ± 0.05^{g}	2.00 ± 0.10^{g}	7.11 ± 0.09^{g}	0.50 ± 0.10^{g}	5.01 ± 0.00^{g}
South C	6.87 ± 0.08^{h}	4.00 ± 0.26^{h}	5.09 ± 0.01^{h}	0.83 ± 0.08^{h}	5.34 ± 0.12^{h}
South D	7.00 ± 0.10^{i}	4.23 ± 0.09^{i}	5.97 ± 0.09^{i}	0.87 ± 0.08^{i}	5.44 ± 0.16^{i}
East A	6.99 ± 0.06^{j}	4.01 ± 0.09^{j}	9.15 ± 0.09^{k}	0.56 ± 0.14^{j}	3.90 ± 0.55^{j}
East B	6.15 ± 0.08^{k}	4.56 ± 0.00^{k}	9.70 ± 0.12^{l}	1.02 ± 0.10^{k}	3.76 ± 0.14^{k}
East C	7.33 ± 0.11^{l}	3.29 ± 0.15^{l}	6.55 ± 0.13^{m}	0.31 ± 0.09^{l}	3.99 ± 0.10^{l}
East D	7.84 ± 0.11^{m}	3.51 ± 0.10^{m}	7.60 ± 0.10^{n}	0.67 ± 0.10^{m}	4.00 ± 0.00^{l}
West A	4.13 ± 0.11^{n}	5.03 ± 0.10^{n}	4.79 ± 0.00^{o}	0.77 ± 0.14^{n}	5.10 ± 0.17^{m}
West B	4.79 ± 0.09^{o}	5.14 ± 0.08^{o}	5.12 ± 0.09^{p}	0.48 ± 0.02^{b}	5.23 ± 0.05^{n}
West C	7.65 ± 0.10^{p}	2.09 ± 0.10^{p}	3.49 ± 0.16^{q}	0.91 ± 0.10^{o}	5.07 ± 0.10^{o}
West D	7.98 ± 0.08^{q}	2.17 ± 0.09^{q}	3.53 ± 0.08^{r}	1.00 ± 0.00^{p}	5.17 ± 0.08^{p}
Centre A	6.07 ± 0.11^{r}	1.11 ± 0.09^{r}	2.51 ± 0.09^{s}	0.11 ± 0.09^{q}	2.03 ± 0.11^{q}
Centre B	6.00 ± 0.10^{r}	1.88 ± 0.00^{s}	2.76 ± 0.08^{t}	0.23 ± 0.08^{r}	2.41 ± 0.08^{r}

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same column, having different letters of alphabet are statistically different ($p<0.05$) using Least Significant Difference (LSD). **Legend:** A =200m distance, 0-30cm depth; B = 200mdistance, 31-60cmdepth; C = 400m distance, 0-30cm depth; D = 400m distance, 31-60cm depth.

Table 6: Concentrations of Soil Enzymes in Ugwuele Quarry Site, Uturu (Dry Season)

GROUP	Urease ($mgNH_3Ng^{-1}drysoil2h^{-1}$)	ALP (mg/h)	Acid Phospatase (mg/g/h)	Hydrogen Peroxidase ($m10.0mlKMnO_4g^{-1}$)	Dehydrogenase ($mgTpFg^{-1}drysoil6h^{-1}(x10^{-5})$)
Control A	18.41 ± 0.09^{a}	4.40 ± 0.02^{a}	5.31 ± 0.01^{a}	$1.14\pm0.02a$	6.91 ± 0.02^{a}
Control B	18.20 ± 0.07^{a}	4.17 ± 0.04^{a}	5.32 ± 0.01^{a}	$1.11\pm0.01a$	8.20 ± 0.08^{a}
North A	4.18 ± 0.15^{b}	2.62 ± 0.02^{b}	3.20 ± 0.09^{b}	0.08 ± 0.01^{b}	1.66 ± 0.06^{b}
North B	4.80 ± 0.09^{c}	2.98 ± 0.03^{c}	3.52 ± 0.02^{c}	0.10 ± 0.02^{c}	1.83 ± 0.04^{c}
North C	5.01 ± 0.10^{d}	3.02 ± 0.01^{d}	2.15 ± 0.05^{d}	0.05 ± 0.02^{d}	1.78 ± 0.03^{d}
North D	5.20 ± 0.12^{e}	3.41 ± 0.01^{e}	2.40 ± 0.05^{e}	0.05 ± 0.00^{d}	1.94 ± 0.03^{e}
South A	3.47 ± 0.06^{f}	2.00 ± 0.01^{f}	3.82 ± 0.02^{f}	0.03 ± 0.01^{e}	2.33 ± 0.03^{f}
South B	3.60 ± 0.09^{g}	1.44 ± 0.04^{g}	3.93 ± 0.04^{g}	0.03 ± 0.01^{e}	2.31 ± 0.02^{f}
South C	3.64 ± 0.01^{h}	1.25 ± 0.05^{h}	4.01 ± 0.01^{h}	0.05 ± 0.02^{d}	2.45 ± 0.05^{g}
South D	3.70 ± 0.09^{i}	1.69 ± 0.08^{i}	2.22 ± 0.02^{i}	0.07 ± 0.00^{f}	2.67 ± 0.03^{h}
East A	6.86 ± 1.74^{j}	2.16 ± 0.05^{j}	3.74 ± 0.05^{j}	0.11 ± 0.02^{c}	1.11 ± 0.01^{i}
East B	5.93 ± 0.02^{k}	2.50 ± 0.09^{k}	3.96 ± 0.07^{k}	0.15 ± 0.02^{g}	0.76 ± 0.06^{j}
East C	6.21 ± 0.01^{l}	2.99 ± 0.02^{l}	2.79 ± 0.05^{l}	0.12 ± 0.01^{h}	2.00 ± 0.01^{k}
East D	6.45 ± 0.08^{m}	3.00 ± 0.03^{d}	3.02 ± 0.03^{m}	0.18 ± 0.03^{i}	2.20 ± 0.17^{l}
West A	2.90 ± 0.01^{n}	3.51 ± 0.04^{m}	2.30 ± 0.01^{n}	0.24 ± 0.01^{j}	2.77 ± 0.08^{m}
West B	2.94 ± 0.03^{o}	3.66 ± 0.05^{n}	2.90 ± 0.00^{o}	0.12 ± 0.02^{h}	2.89 ± 0.02^{n}
West C	3.50 ± 0.01^{p}	1.92 ± 0.02^{o}	1.55 ± 0.05^{p}	0.19 ± 0.02^{i}	3.01 ± 0.02^{o}
West D	3.52 ± 0.02^{p}	2.11 ± 0.01^{p}	2.09 ± 0.09^{q}	0.20 ± 0.01^{k}	3.26 ± 0.02^{p}
Centre A	4.77 ± 0.07^{q}	1.00 ± 0.01^{q}	1.28 ± 0.05^{r}	0.04 ± 0.02^{l}	1.01 ± 0.02^{q}
Centre B	4.84 ± 0.08^{r}	1.21 ± 0.01^{r}	0.80 ± 0.01^{s}	0.16 ± 0.02^{g}	1.56 ± 0.03^{r}

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same column, having different letters of alphabet are statistically different ($p<0.05$) using Least Significant Difference (LSD). **Legend :** A =200m distance, 0-30cm depth; B = 200mdistance, 31-60cmdepth; C = 400m distance, 0-30cm depth; D = 400m distance, 31-60cm depth

Soil moisture content is the water holding capacity of any given soil. It influences all biochemical transformation and microbial activities in the soil. Results from this study show that soil moisture of the quarry increased significantly with depth. Olorunfemi *et al.* [21] reported similar result. This may be due to reduced aggregation and pore space of the subsurface layers and increased bulk density down the soil layers. The results also reveal that the soil moisture of the present study area was significantly higher ($p<0.05$) during the wet season than in the dry season. This is likely to be mainly because of the higher amount of rainfall in the wet season.

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Cation exchange capacity is a measure of the quantity of cations that can be absorbed and held by a soil. Most plant nutrients are cations. Results obtained from this study show that C.E.C of the quarry soil was significantly lower ($p<0.05$) compared to the control. It also increased from the centre of the quarry to distance away. This could be because of high temperature and low pH recorded in the quarry which were also more in the centre than other points away from it. Onwuka [28] and Amos-Tautua *et.al*. [36] reported similar trend of results. The results of the present study also show that C.E.C. was significantly lower ($p<0.05$) in the dry season than in the wet season, and also increased with depth. The reason could be the same with the ones stated earlier.

Heavy metals are metallic chemical elements that have relatively high densities and are toxic or poisonous at low concentration. High levels of heavy metals in soil adversely affect the soil fertility in diverse ways such as reduction of soil microbial biomass level [8]. The results from the present study show that all the analyzed heavy metals were present in all the selected areas of the quarry. Wang *et. al*. [10] reported that rock quarry is a major source of heavy metals in soil. In all the areas and in the two seasons, chromium (Cr) recorded the highest concentration (55.51±0.10mg/kg). The high level of chromium may be attributed to the high level of chromite that occurs in rocks as reported by Megan et al. [34]. The results obtained in this study also show that the concentration of the analyzed heavy metals decreased with depth and distance. Ciazela and Siepak [38] reported similar results. The results from the present study also reveal that the levels of heavy metals in the soil samples of the quarry were significantly higher ($p<0.05$) during the dry season than in the wet season. This could be because of the higher level of pollutants and lower pH recorded during the dry season.

Soil enzymes play pivotal biochemical roles in the whole process of organic matter decomposition in the soil system. Their activities therefore enhance soil fertility. Results obtained from the present study area show that the activities of analyzed enzymes were significantly lower ($p<0.05$) compared to the control. This may be mainly because of lower organic matter and higher heavy metal content of the quarry soils. Qingshui *et.al*. [12] and Loeppmann *et.al.* [39] reported that heavy metal pollution and low organic matter content of a soil decrease its enzyme activity. The results from this study also reveal that enzyme activities were lowest at the centre and increased with distance and depth. The results also show that enzyme activities were significantly lower ($p<0.05$) in the dry season than in the wet season. All these should be due to the difference in the levels of organic matter and heavy metals of the area under study.

V. CONCLUSION AND FUTURE SCOPE

Quarry activities and processes at Ugwuele quarry site Uturu, had some negative impacts on the soil within the vicinity of the quarry. These negative impacts were higher in the dry season than in the wet season. The fertility and suitability for crop production of the soil within the quarry were significantly decreased by the quarry activities. We therefore recommend that farmers should be educated and encouraged not to cultivate in farms around quarry sites because these farms may be polluted by toxic heavy metals. Vegetables can accumulate toxic heavy metals from these polluted farms thereby posing health risk to anyone that consumes them. For future studies, vegetables from these farms should be evaluated to determine the concentration of toxic heavy metals in them.

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