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ENVIRONMENTAL IMPACT OF AIR POLLUTION FROM QUARRY ACTIVITIES ON AGRICULTURE AND BIODIVERSITY OF PLANT

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ABSTRACT

Nigeria has around 400 quarries and 2000 stone-cutting enterprises, with an annual output of 200 million metric tonnes of unprocessed stone and 30 million square metres of excellent stone. Regrettably, this industry is often linked with air pollution. In this study, two methods were employed to evaluate the impact of such acts on agricultural and plant biodiversity: particulate matter (PM) measurement and a social survey. Significantly high levels of particulate matter, dust, and total suspended solids (TSP) were found in the three sites studied in Ebonyi State, Nigeria. This suggests that there is a lot of dust and air pollution in the locations under study, much more than what is permissible by international guidelines. Additionally, it is shown that quarrying has a significant detrimental effect on plant survival, habitat degradation, and biodiversity. According to the results of the questionnaire, many different plants were impacted or even went extinct as a result of the stone-cutting and quarrying businesses. The most affected plant was the olive, which had an average response rate of 33%. According to the findings, it is strongly suggested to create a green belt around the quarrying area using pollutant-tolerant trees (often with broad leaves) to limit the spread of quarrying dust by intercepting, filtering, and absorbing pollutants.

KEYWORDS Agriculture, Air Pollution, Biodiversity, Plant, Quarries

1. Introduction

Quarrying is the process of removing nonmetallic rocks and aggregates from land as a kind of land use and a component of the local history [1]. The end products of this enterprise are crushed stones and dimensions, which are utilised in various aspects of daily living [2]. The stone and marble industries, known as "white-gold" in the local dialect, are regarded as prosperous ventures in Nigeria. In addition, this industry is being developed, expanded, and given priority by both the public and private sectors. Nigeria currently has 2000 companies, workshops, and more than 400 quarries, producing over 200 million tonnes of raw stone and 30 million square metres of good stone annually. About 4.5% and 5.5% of the gross national product (GNP) and gross domestic product (GDP) respectively are contributed by this industry. The industry has received an estimated 600 million US dollars in investment overall [3]. Nigeria accounts for 5% of the global production of marble and stone. Regrettably, these actions have a negative influence on the environment [4]. The extraction method actually relies heavily on large machinery and explosives, both of which are typically linked to soil and water contamination, air and noise pollution, habitat destruction, and harm to biodiversity [5–7]. From an agricultural perspective, discharged dust falls not only on land, vegetation, and trees, but also on surface waterways [6], having a variety of detrimental effects on the ecosystem as

a whole. Fertile soil is also disturbed and interrupted, and following excavation, holes are either abandoned or left empty, creating a large, chasm-like landscape. This is dangerous for people, animals, and cattle in addition to being ugly [8]. Damage to biodiversity [9], where plants (vegetation cover) constitute the primary element of the ecosystem and are crucial in preserving the equilibrium of carbon dioxide and oxygen in the atmosphere through photosynthetic activity [6], is another noteworthy adverse effect of quarrying on the environment. Environmental botanists and ecologists have recently expressed concern about these changes in plants and have recommended a cautious and cautious approach to activities that promote such changes [10]. The primary objective of this research was to evaluate the effects of the stone-cutting and quarrying sectors on the ecosystem in Abakaliki, Ebonyi State, Nigeria, in general, and plant biodiversity in particular.

2. Materials and Methods

2.1. The Study Area

The study was conducted in Nigeria's Ebonyi state capital, Abakaliki (Fig. **1**). It is situated at latitude 6' 19^{o} N and longitude 8° 6' E in southeast Nigeria's Savannah region. It has a total area of 5,670 square kilometres and 141,438 inhabitants. Typically, the setting is on a hilly plateau. Its temperature, which ranges from 270 to 310 degrees Celsius, is comparatively high. The study area experiences two distinct rainfall patterns in August, both of which are brief (April to July and September to November). The soil of the study area is ultisol.

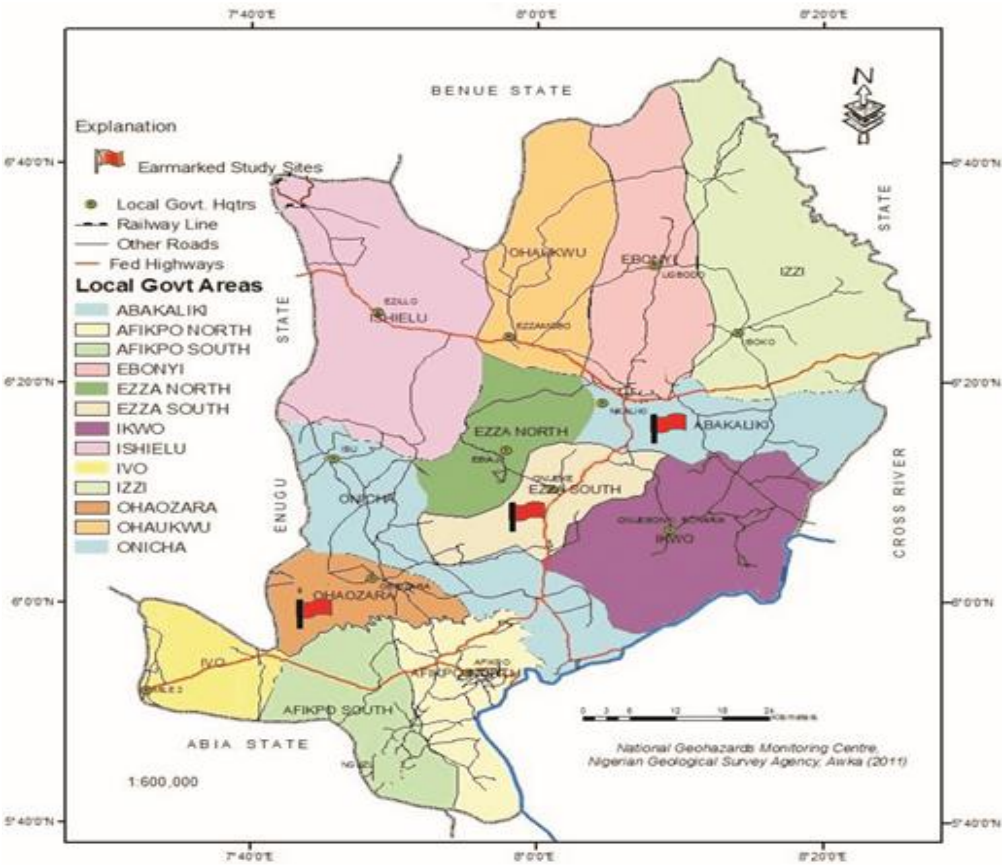

Fig 1. A map of Ebonyi State showing the study site

2.2. Data Collection

The effects of the stone-cutting and quarry industries on the agriculture and biodiversity of plants in Abakaliki, Ebonyi State, were evaluated using two primary techniques. First, particulate matter (PM) was measured using a laser-operated portable computer (OPC; Aerocet 531, MetOne, USA) equipped with five channels (PM_1, $PM_{2.5}$, PM_7, PM_{10}, and TSP). This instrument is automatic and can estimate PM in the following ranges: PM ≤ 0.5 and PM ≤ 10 in count mode, and 1, 2. 5, 7, and 10 µm in aerodynamic diameters in mass mode. At three distinct locations, four measurements were carried out at a ground distance of 400 to 600 metres from the operation areas. Every location had its equipment positioned 1.5 metres above the floor, and each location saw an hour of sampling time. The second approach was created specifically for this purpose and was based on a social survey (structured questionnaire and interview).

2.3. Data Analysis

Chi-square tests for significantly different data ($p < 0.05$) were used in the Statistical Package for Social Sciences (IBM, SPSS, version 15) to analyse the data.

3. Results and Discussion

Anthropogenic activities such as stone-cutting businesses and quarries have caused significant harm to plant survival and biodiversity in recent decades. In light of this, quarrying has a well-documented negative impact on the environment [9], as it produces significant amounts of air pollution that negatively impact plants, or vegetation cover, which is the primary component of the ecosystem and plays a key role in maintaining the equilibrium between the amount of oxygen and carbon dioxide through photosynthetic activities [6]. Table 1 illustrates the elevated levels of particulate matter/dust (PM) and total suspended solids (TSP) observed in the three locations under study. This suggests that there is a lot of dust and air pollution in the locations under study, much more than what is allowed by international guidelines. For instance, total suspended solids (TSP) have WHO requirements of 60 µg/m^3, however in the three locations under investigation, TSP showed highly significant levels of 0.4188 (mg/m^3), 1.5359 (mg/m^3), and 1.4204 (mg/m^3) in comparison to the standards. Furthermore, locations 3 (1.4204 mg/m^3) and 2 (1.5359 mg/m^3) showed highly significant values in relation to the first location. In contrast to the first location, where grasses and shrubs predominate, the obtained significances in locations 2 and 3 may be attributed to the intensive different types of trees that impose vegetation cover, blocking and suspending existing particulate matter and dust (fewer barriers). In addition, these two areas run parallel to the typical wind direction, which is from the northwest and carries dust and particulate matter from the industries in the direction of the fruit trees. The other four employed channels (PM_1, $PM_{2.5}$, PM_7, and PM_{10}) all showed a similar pattern in particulate matter/dust (PM), with high amounts of PM found in the three studied locations (Table 1). When compared to other measured PM, it is evident that PM_{10} has the largest concentrations. This could be explained by the fact that small PM are typically driven to higher altitudes by wind and then deposited by various sink processes.

Table 1. Mean Concentration of Particulate Matter (Dust) at Three Sampling Locations

Parameters	Location I	Location II	Location III	STDEV
PM_1 (mg/m^3)	0.0036	0.0042	0.0069	0.0012
$PM_{2.5}$ (mg/m^3)	0.0344	0.0615	0.0792	0.0145
PM_7 (mg/m^3)	0.2367	0.6516	0.6264	0.1336
PM_{10} (mg/m^3)	0.3259	1.0797	0.9440	0.2471
TSP (mg/m^3)	0.4188	1.5359	1.4204	0.3621

Regrettably, this massive form of air pollution has a detrimental effect on the environment around it [4], particularly on plant biodiversity and habitat degradation [5], foliar injury [11], pollination and plant pest control [12], and crop yield loss [13]. In order to evaluate the influence of this type of pollution on plant biodiversity and agriculture, roughly 200 questionnaires were dispersed throughout the study location. The large diversity of extinct plants caused by the stone-cutting and quarrying industries was indicated by the collected results. In fact, 12.3% (citrus trees, wheat, wild flowers, vegetables, garden, wild lettuce, gundelia); 10.2% (wild plants); 10.2% (African star apple); 4.3% (thyme); 2.7% (pineapple); 1.1% (olive); and were susceptible to the extinction from the farmers point of view. African star apple was found to be the fruit tree most impacted by quarries and the stone-cutting industry, with an average response rate of 31%. Conversely, 8.6% of respondents claimed that all African star apple and pineapple species had gone extinct. Other respondents stated that quarrying was responsible for the disappearance of 6.4% of African star apple and pineapple. Only 2.7% of respondents said that these activities had caused the extinction of all fruit trees.

Concerning the impact on crop yields, a vast majority of the respondents (95%) stated that the crop yields decreased by at least 30% annually. Physiological mechanisms behind these causes could be attributed to one or combinations of the following factors: dusts might cover the leaves with white layer decreasing thereby the total chlorophyll cells exposed to light and thus reducing the total photosynthetic activity [14]; dusts also reduce plant growth (number of leaves, leaf surface and size) affecting therefore photosynthesis, respiration and transpiration [15]; some released toxic compounds (fluoride, Magnesium, Lead, Zinc, Copper, Beryllium, Sulphuric acid and Hydrochloric acid) are injurious to the vegetation [5]; leaf trichomes (hairs) are affected negatively by dust decreasing therefore the natural defence mechanisms of the plant against pests and diseases [6, 14, 15]. Apart from the previously mentioned adverse effects, quarrying and crushing also lead to soil erosion and water pollution (80% and 70% of the respondents, respectively). These two issues exacerbate the negative effects on agriculture, since the properties of the soil and water are impacted by the wet and dry deposition of particulate matter. This being said, and in accordance with [7], quarrying has caused changes in the properties of the soil, leading to the discovery that the soil in and surrounding the mining area (0–1 km) is alkaline (pH 11.2–11.7). This was explained by the high concentrations of hydroxyl, carbonate, and bicarbonate found in the minerals of the mined materials.

4. Conclusions and Recommendations

The study area's agriculture was adversely impacted by the high amounts of particulate matter (dust) produced by the quarrying and stone-cutting entities. Dust deposition decreased crop production and caused the extinction of several tree species and plant cover. In addition, by

affecting soil and water, two essential resources for agriculture, these actions exacerbated the issue. However, further research is needed to explore the impact of such enterprises on plant physiology and the physicochemical qualities of soil and water. According to the findings, it is strongly suggested to create a green belt around the quarrying area using pollutant-tolerant trees (often with broad leaves) to limit the spread of quarrying dust by intercepting, filtering, and absorbing pollutants.

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