

Environmental Impacts of Rock Quarrying at the Afikpo Quarry Sites, Ebonyi State, Southeastern Nigeria

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Abstract - The importance of the quarrying industry to livelihood and development cannot be overemphasized. However, its activities result in significant damage to the immediate environment. This study investigates the environmental effects of quarrying activities in Afikpo, focusing on environmental degradation, health, and socio-economic implications for local communities. Field surveys, environmental assessments, and interviews with local residents and quarry operators were conducted to gather data on the extent of environmental degradation and its effects on the surrounding ecosystem. A total of 100 copies of a questionnaire were administered in the study area. Findings indicate that quarrying activities have led to substantial deforestation, soil erosion, and disruption of local hydrology, which in turn affects agricultural productivity and water availability for local populations. Additionally, the dust and noise generated by blasting and heavy machinery, as well as water quality degradation resulting from quarrying activities, pose health risks, including the possible impact of water quality degradation on the emergence and spread of antibiotic-resistant genes among nearby residents. The study also highlights the socio-economic trade-offs faced by communities, where the immediate economic benefits from quarrying often overshadow the long-term environmental costs. The results of this investigation underscore the urgent need for sustainable quarrying practices and effective regulatory frameworks to mitigate environmental impacts while considering the socio-economic realities of local communities. Recommendations include the implementation of rehabilitation plans for degraded sites, community engagement in decision-making processes, and the promotion of alternative livelihoods to reduce dependency on quarrying activities.

Keywords: Quarrying Activities, Environmental Degradation, Socio-Economic Impacts, Afikpo, Sustainable Practices

I. INTRODUCTION

Rock quarrying is a major economic activity in many developing countries, including Nigeria. It involves the extraction of minerals and rock fragments from the earth for commercial purposes. The environmental effects of rock quarrying have been a major concern for many years, especially in Afikpo, Ebonyi State, Nigeria [15]. This review aims to provide a detailed empirical and literature review of the environmental effects of rock quarrying in the study area, including the impact on the surrounding environment and the health of local communities.

Afikpo, Ebonyi State, is a small town located in the southeastern part of Nigeria. It is known for its rich cultural heritage, agriculture, and natural resources. However, in recent years, the town has faced various challenges due to the establishment of rock quarries in the area.

A rock quarry is a place where large blocks of rocks extracted from the ground are processed into various sizes and shapes for building and construction purposes [9]. The increasing demand for building materials in Nigeria, due to rapid population growth, has led to a persistent rise in the number of rock quarry sites in many parts of the country, including Afikpo, Ebonyi State [6].

The establishment of rock quarries in the study area has had both positive and negative effects on the town and its residents. On one hand, quarrying has provided job opportunities for the local people, with many of them employed as laborers and rock cutters. This has helped to reduce unemployment and poverty in the area, particularly among the youth [2,13].

However, on the other hand, the negative effects of rock quarrying in Afikpo, Ebonyi State, cannot be overlooked. The most visible and immediate effect is the destruction of the natural landscape and environment. The process of quarrying involves blasting and drilling of the rocks, which causes noise and air pollution. The land is also left with large, open pits and mounds of excavated waste materials, which can be hazardous and unsightly [30].

The environmental impact of rock quarrying in Afikpo, Ebonyi State, goes beyond just the physical destruction of the land. It also affects the quality of air and water in the area. The dust and debris from the quarrying process can contaminate the air and water, making them unsuitable for human consumption. This can lead to health problems for the residents, especially those living close to the quarry sites [6,10]. Moreover, these rock quarries also pose negative effects on agriculture through the reduction of land available for farming activities, leading to a decrease in agricultural productivity. This has not only affected the food security of the town but also the livelihoods of the farmers [5].

In addition to the environmental and agricultural impacts, the increased influx of people to Afikpo, Ebonyi State, in search of work in the quarries has also put pressure on the town's resources and infrastructure [8]. The town's road network, which was originally designed for light traffic, is now overburdened with heavy-duty trucks used to transport rock fragments from the quarry sites. This has led to the deterioration of roads and increased traffic congestion.

Furthermore, the rock quarry business in the study area has been marred by issues of land ownership and conflicts between the quarry operators and the host communities. In some cases, the quarry operators have encroached on the lands belonging to the local people, leading to tension and even violent clashes [8,12].

In conclusion, the establishment of rock quarries in Afikpo, Ebonyi State, has shown both positive and negative effects on the town and its residents. While it has provided job opportunities and contributed to the local economy, it has also caused significant environmental and social problems. It is essential for the government and stakeholders to address these issues and find a balance between the economic benefits and the negative impacts of rock quarrying. Proper regulation and enforcement of environmental laws and responsible mining practices can help mitigate the adverse effects of stone quarrying in Afikpo, Ebonyi State [8].

II. STATEMENT OF THE PROBLEM

The extraction of rock fragments through quarrying has become a significant economic activity in Afikpo, Ebonyi State, Nigeria. However, the environmental consequences of this practice are increasingly coming under scrutiny. The process of quarrying often leads to land degradation, deforestation, loss of biodiversity, soil erosion, and water pollution. Local communities are likely to experience disruptions in their livelihoods, health issues, and alterations in the natural landscape [7]. Despite the economic benefits associated with quarrying, the environmental implications raise serious concerns that warrant thorough investigation [2]. This study seeks to identify and analyze the specific environmental effects of rock quarrying in Afikpo, aiming to provide a comprehensive understanding of both the negative impacts on the ecosystem and the socio-economic consequences for local residents.

III. AIM OF THE STUDY

The primary aim of this study is to evaluate the environmental effects of rock quarrying in Afikpo, Ebonyi State, and to provide recommendations for sustainable practices that can mitigate these impacts while supporting local economic development.

A. Objectives

To achieve this aim, the following objectives have been outlined.

1. To assess the extent of land degradation caused by quarrying activities in the Afikpo region.
2. To evaluate the impact of quarrying on local biodiversity, including flora and fauna, and surrounding ecosystems.
3. To analyze the effects of quarrying on soil quality and erosion patterns in the area.
4. To investigate water quality changes in nearby water bodies as a result of quarrying activities, including potential contamination.
5. To examine the socio-economic effects of quarrying on local communities, including health implications and changes in livelihood.
6. To recommend sustainable quarrying practices that can minimize environmental degradation while supporting economic growth.

B. Scope of the Work

This study will focus on selected quarry sites in Afikpo, Ebonyi State, Nigeria. The scope will include:

C. Geographical Scope

The research will be confined to specific quarry sites within Afikpo, examining both active and abandoned quarries.

D. Environmental Scope

The study will evaluate various environmental factors such as land-use changes, biodiversity loss, soil and water quality, and the ecological balance in the region.

E. Temporal Scope

Data will be collected over a period of six months to ensure a comprehensive understanding of seasonal variations in environmental impacts.

F. Socio-Economic Scope

The research will include surveys and interviews with local residents, quarry workers, and stakeholders to assess the socio-economic implications of quarrying.

G. Health/Economic Scope

This will be ascertained using surveys and interviews with local residents and quarry workers to understand the prevalent infections and the level of antibiotic stewardship among residents around the quarry sites.

H. Jurisdiction of the Study

The jurisdiction of this study is primarily set within the boundaries of Afikpo, Ebonyi State, Nigeria. The study will adhere to local regulations and guidelines concerning environmental research and community engagement. Ethical considerations will be paramount, ensuring informed consent from participants and respect for local customs and

traditions. The findings will be particularly relevant to policymakers, environmental agencies, local government, and community leaders in Ebonyi State as they navigate the balance between economic development and environmental sustainability in the context of stone quarrying.

IV. RESEARCH QUESTIONS

Some research questions focus on the environmental effects of rock quarrying in Afikpo, Ebonyi State:

1. What are the primary environmental impacts of rock quarrying in Afikpo, Ebonyi State?
2. How does rock quarrying affect local biodiversity and wildlife habitats in the Afikpo region?
3. What is the impact of rock dust generated from quarrying on air quality in surrounding communities?
4. How do quarrying operations contribute to soil erosion and land degradation in Afikpo?
5. What are the effects of water runoff from quarry sites on local water bodies and aquatic ecosystems?
6. How does noise pollution from quarrying activities affect the health and well-being of nearby residents?
7. To what extent does rock quarrying contribute to the loss of agricultural land in Afikpo?
8. What measures are currently in place to mitigate the environmental impacts of rock quarrying in the area?
9. How do quarrying operations affect the local climate and microclimate conditions in Afikpo?
10. What are the socio-economic impacts of rock quarrying on local communities in terms of employment and livelihoods?
11. How do quarrying practices impact the health of workers and nearby residents?
12. What role do local governance and policies play in regulating the environmental effects of quarrying in Afikpo?
13. How does the reclamation of abandoned quarry sites affect the local ecosystem?
14. What community awareness and perceptions exist regarding the environmental impacts of rock quarrying in Afikpo?
15. How do the environmental effects of rock quarrying in Afikpo compare to those in other regions with similar activities?
16. What are the long-term environmental consequences of quarrying on land use patterns in Afikpo?
17. How effective are current environmental assessments and monitoring practices for quarry sites in Ebonyi State?
18. What alternative sustainable practices can be implemented to minimize the environmental impact of rock quarrying?
19. How does the quarrying industry contribute to or mitigate climate change effects in Afikpo?
20. What are the potential rehabilitation strategies for degraded landscapes resulting from rock quarrying in the Afikpo region?

V. GEOLOGY AND HYDROGEOLOGY OF THE STUDIED AREA

A. Geology of Afikpo

The geology of Afikpo is characterized by a complex mix of sedimentary and igneous rocks, which have been shaped by millions of years of geological processes [1]. The oldest rocks in Afikpo are the Precambrian basement rocks, which are estimated to be over 1.5 billion years old. These rocks are mainly composed of gneisses, schists, granite, and migmatites. They were formed through intense heat and pressure that caused the metamorphism of older sedimentary and igneous rocks [1,6].

The most prominent feature of the geology of Afikpo is the Cross River and Enugu Escarpment, which runs through the town from northeast to southwest. This escarpment is made up of steep cliffs and plateaus, formed by the erosion of the softer sedimentary rocks, leaving behind the harder basement rocks [6].

The sedimentary rocks in Afikpo are mainly from the Cretaceous period, around 66 to 145 million years ago. These rocks are primarily sandstones, shales, and lime stones, which were deposited in shallow marine environments [1]. The presence of marine fossils, such as ammonites and bivalves, in these rocks indicates that the area was once covered by a sea.

The Imo River, which runs through Afikpo, has also played a significant role in shaping the geology of the area. It has eroded and carved out deep valleys, creating a diverse landscape of hills and gorges. The river has also deposited alluvial sediments along its banks, which are used for agriculture by the local community [15].

The town of Afikpo also sits on the Benue Trough, a rift system that extends from Cameroon to northern Nigeria. This rift is believed to have formed during the separation of the African and South American continents, and it is characterized by thick layers of sedimentary rocks. The rich oil and gas reserves in this region are evidence of the presence of these sedimentary rocks [6,9]. In addition to these geological formations, Afikpo is also known for its mineral deposits, including coal, limestone, and lead. However, these resources have not been extensively exploited due to the lack of proper mining infrastructure in the town.

The geology of Afikpo has played a significant role in shaping the landscape, economy, and culture of the town. The rugged terrain and rich mineral resources have made it a suitable location for agriculture and small-scale mining activities [1]. The presence of the Imo River and fertile soils has also made it a key agricultural hub in the region. Understanding the geology of Afikpo is important not only for its economic significance but also for its cultural and historical value.

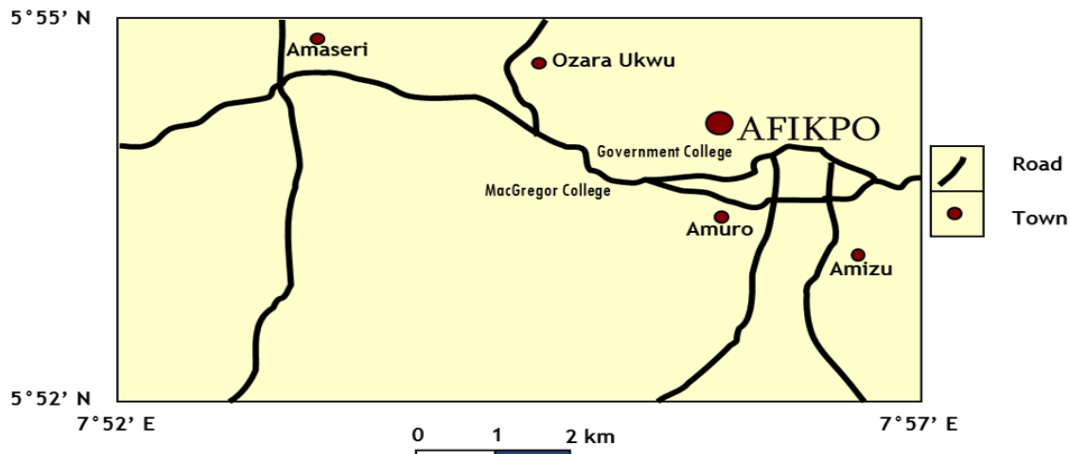


Fig. 1 Location and accessibility map of the study area

B. Accessibility

Afikpo town is easily accessible due to the good road network in the area. The road leading to Amasiri is tarred, and at the Amasiri/Afikpo Junction, there is a trunk link to Abakaliki. The area is also accessible via river.

The major routes in the area are as follows:

1. Enugu-Okigwe Expressway
2. Okigwe-Abakaliki Expressway
3. Abakaliki-Afikpo Expressway
4. Cross River-Uwana-Afikpo Expressway

There are also several footpaths leading to various farms, river sections, and streams where outcrops are encountered. Outcrops are also located along road cuts.

V. RELIEF AND DRAINAGE

Afikpo and its environs are characterized by an undulating relief. This relief is due to the alternation of sandstone and shale, as well as differential weathering and erosion, which give rise to the undulating landform [3]. The sandstone constitutes the ridges due to its high resistance to weathering and erosion, while the lowland constitutes the shale due to its lower resistance to weathering and erosion. The contact between the sandstone and shale is located at

the base of the hill [3]. The shale plains are dissected by several small streams, some of which are seasonal, originating from nearby sandstone ridges, which are generally bare and support vegetation as well as the percolation of swampy rain through the sandstone ridges to form streams [8]. Consequently, the sandstones are aquifer-forming.

Amasiri sandstone is faulted, with a stream flowing in the fault zone, implying that mechanical and chemical weathering are very active in the area, causing a rough surface on the sandstone outcrop.

Afikpo's drainage system is primarily by the Cross River and its tributaries: Iywka River in the north, and Ubei and Tiara Rivers in the south. Their numerous tributaries traverse the area in a general east-west direction. The ridges, however, have good drainage systems, which become poorer as the area descends towards the lowlands. Dendritic drainage is highly common, as well as radial drainage in hilly areas. These tributaries empty into the Cross River, which in turn empties into the South Atlantic Ocean. The major drainage pattern in the area is a trellis drainage pattern, resulting from the alternation of sandstone and shale.

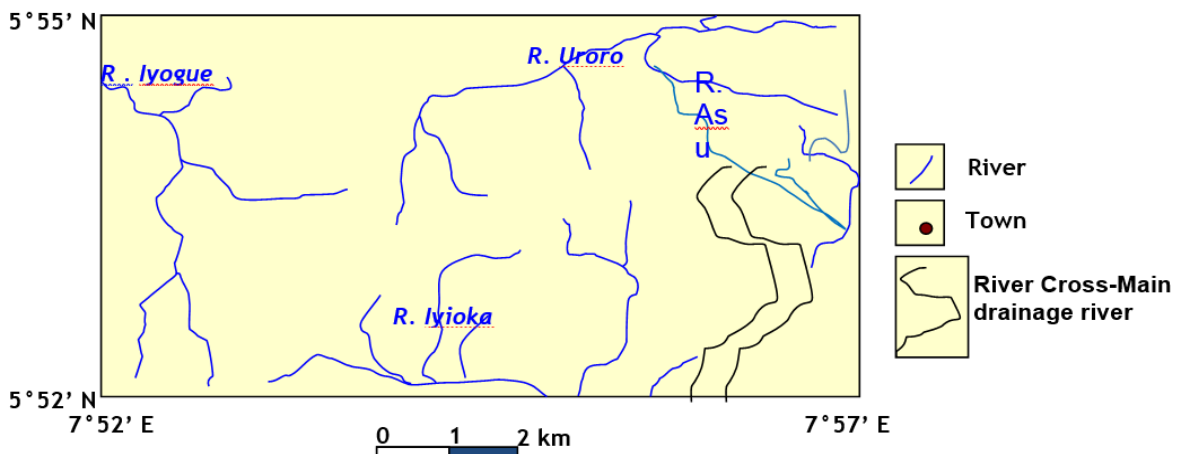


Fig. 2 Drainage map of the study area

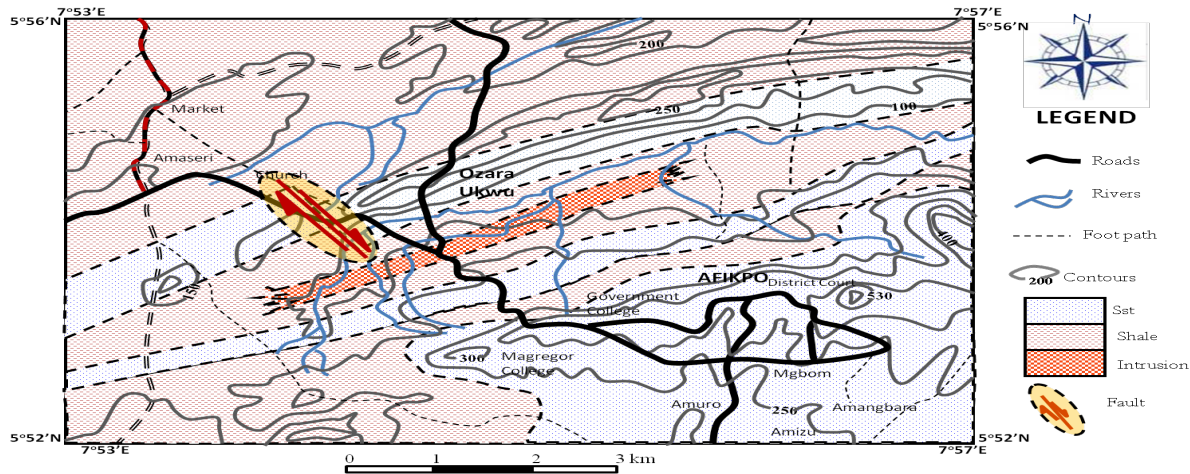


Fig. 3 Geologic map of study area



Fig. 4 Samples of rocks for quarry and mining sites in the studied areas

A. Geological Formation and Depositional History

1. Hydrology of the Studied Area

a. Surface Water: The springs and river channels are the major surface water sources in the study area (Afikpo). Springs occur when water flows from rock to the land surface naturally, discharging where the water table intersects the land surface. Water can also flow through fractured rock in the study area [11].

b. Subsurface/Groundwater: Due to the alternation of sandstone and shale beds, the study area is a very good aquifer for the storage of water for commercial and economic use, further enhanced by the presence of a fault system that juxtaposes the sandstone bed with the shale beds, entrapping the accumulated groundwater. Sandstone normally has a maximum porosity of 30%, with about half of this value being common [11].

VI. PETROLOGY / GEOCHEMISTRY

The geochemical studies of the quarried rocks, primarily consolidated sandstone (Amasiri and Akpoha sandstones)

and dolerites within the Afikpo area, show that the sandstone facies are preferentially enriched with silica. The major oxide composition of Amasiri Sandstone indicates that SiO₂ ranges from 55.56% to 71.78%, TiO₂ ranges from 0.05% to 0.25%, Al₂O₃ ranges from 13.83% to 25.22%, Fe₂O₃ ranges from 0.42% to 1.88%, K₂O ranges from 4.66% to 6.14%, Na₂O ranges from 0.17% to 4.3%, MgO ranges from 0.07% to 0.81%, CaO ranges from 0.22% to 0.64%, and MnO ranges from 0.01% to 0.02% [16]. The major element composition of Akpoha Sandstone reveals that SiO₂ ranges from 64.78% to 68.63%, TiO₂ ranges from 0.12% to 2.20%, Al₂O₃ ranges from 14.07% to 16.01%, Fe₂O₃ ranges from 3.40% to 9.36%, K₂O ranges from 0.22% to 1.99%, Na₂O ranges from 3.25% to 4.93%, MgO ranges from 0.10% to 1.73%, and MnO ranges from 0.01% to 0.05% [17]. The major element geochemistry of the pyroclastics within Akpoha suggests the following ranges: SiO₂ from 65.44% to 65.58%, TiO₂ from 0.457% to 1.212%, Al₂O₃ from 13.33% to 13.4%, Fe₂O₃ from 1.78% to 5.83%, K₂O from 0.06% to 0.32%, Na₂O from 4.60% to 4.39%, MgO from 0.52% to 3.02%, and MnO from 0.028% to 0.047%. The petrographic investigation reveals that the pyroclastics are leucocratic and contain some volcanic bombs [18]. The mineral composition is quartz (20%),

pyroxene (25%), plagioclase (30%), K-spar (20%), and biotite (4%). The mineralogical study shows that the dolerites are composed of plagioclase (45%), olivine (20%), pyroxene (15%), iron oxide (5%), biotite (10%), and quartz (3%) [18].

The trace elements in the crystalline rocks within the Southern Benue Trough are nearly forty-five in number and categorized into four groups: the high-field strength elements (HFSE, Be, U, Hf, Sn, Mo, Nb, Ta, and Zr), the large-ion lithophile elements (LILE, Cs, Rb, Pb, Ba, Sr, HREE, and Eu), the rare earth elements (REE, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu), and the transition elements (Ni, Cr) [19]. There are also some areas in the study region that recorded the presence of halite, which can be used in the manufacturing of salt for domestic and industrial use.

VII. METHODOLOGY

1. Site Selection: The first step in studying the environmental effects of a rock quarry was to select suitable quarry sites in Afikpo, Ebonyi State. These sites were representative of the different types of rock

quarries in the area and had recorded a history of quarrying activities.

2. Field Survey: A field survey was conducted to gather information on the current state and condition of the selected quarry sites. This involved on-site observations, measurements, and data collection on environmental and geological parameters. A total of 100 questionnaires were administered to nearby residents, including workers.

3. Socio-Economic Survey: A socio-economic survey was conducted to assess the current and potential impacts of the rock quarry on the surrounding community. This included an assessment of the social and economic benefits and costs associated with the quarry.

4. Data Analysis: The data were analyzed using Microsoft Excel.

VIII. RESULTS AND DISCUSSION

One hundred (100) respondents, comprising 53 males and 47 females, aged 30 to 55 years, residing within the studied area, were selected for the study using a structured questionnaire. The results of the analysis are stated below.

TABLE I SUMMARIZED RESULT

Sl. No.	Items	Yes(%)	No(%)
1	Are there primary environmental impacts of rock quarrying in Afikpo, Ebonyi State?	94	06
2	Does rock quarrying affect local biodiversity and wildlife habitats in the Afikpo region?	87	13
3	Are there impacts of rock dust generated from quarrying on air quality in surrounding communities?	85	15
4	Do quarrying operations contribute to soil erosion and land degradation in Afikpo?	97	03
5	Are there effects of water runoff from quarry sites on local water bodies and aquatic ecosystems?	86	14
6	Does noise pollution from quarrying activities affect the health and well-being of nearby residents?	91	09
7	Does rock quarrying contribute to the loss of agricultural land in Afikpo?	67	23
8	Are there measures currently in place to mitigate the environmental impacts of rock quarrying in the area?	32	68
9	Do quarrying operations affect the local climate and microclimate conditions in Afikpo?	56	44
10	Are there socio-economic impacts of rock quarrying on local communities in terms of employment and livelihoods?	69	31
11	Do quarrying practices impact the health of workers and nearby residents?	71	29
12	What role do local governance and policies play in regulating the environmental effects of quarrying in Afikpo?	21	79
13	Does the reclamation of abandoned quarry sites affect the local ecosystem?	54	46
14	Is there community awareness and perception regarding the environmental impacts of rock quarrying in Afikpo?	38	62
15	Do the environmental effects of rock quarrying in Afikpo compare to other regions with similar activities?	67	23
16	Are there long-term environmental consequences of quarrying on land use patterns in Afikpo?	88	12
17	Are there current environmental assessments and monitoring practices for quarry sites in Ebonyi State?	37	63
18	Are there alternative sustainable practices that can be implemented to minimize the environmental impact of rock quarrying?	40	60
19	Does the quarrying industry contribute to or mitigate climate change effects in Afikpo?	72	22
20	Are there potential rehabilitation strategies for degraded landscapes resulting from rock quarrying in the Afikpo region?	26	76

Source: Field report (2023)

IX. COMPONENTS' POTENTIAL RISK ASSESSMENT

Considering the results of the analysis of respondents' feedback, the three components of the environment - air, land, and water - are affected to varying degrees. Their potential risk levels were computed based on the percentage of respondents who confirmed their occurrence, the interactions between the components, and the nature of the contaminants.

- A = Air pollution = 85(response 3 of Table I)
- B = Land degradation = 97 (response 4 of Table I)
- C = Water quality degradation = 86 (response 5 of Table I)

Air pollution within the studied area is caused by the introduction of rock dust into the air during quarrying activities (A1). Since the chemistry of the quarried rocks has not indicated the presence of volatile compounds, land and water quality degradation have little to no impact on air quality within this area. Therefore, the potential value of A (A potential) may be given as:

$$A_{\text{potential}} = A^1$$

Assuming that $A^1 = 85$

$$A_{\text{potential}} = 85$$

Land degradation (B) can occur as a result of combined inputs from air pollution (A), water quality degradation (C), and the direct introduction of contaminants onto land (B1). Particulate matter introduced into the air during quarrying of rocks dissolves in precipitation and is deposited on land. The degree of contribution of water quality degradation to land degradation is lesser compared to the effect of land degradation on water quality. This is due to the flow of water (from high gradient to low gradient) and the rate of dissolution of these contaminants in water (a universal solvent). Therefore, the potential value of B is (B potential) may be given as:

$$B_{\text{potential}} = A + B^1 + C \text{ (to a lesser degree)}$$

Assuming that $B^1 = 97$

$C = 40$ (fraction of initial C)

$$B = 85 + 97 + 40 = 222$$

Water quality degradation (C) is an outcome of combined inputs from air pollution (A), land degradation (B), and the direct introduction of contaminants into the surrounding water bodies (C1). This is explained by the fact that particulate matter in the air dissolves in precipitation and is deposited directly into surface water or percolates through the soil profile into groundwater. The land may be degraded by pollutants, which are often leached into the water. Therefore, the potential value of C is (C potential) may be given as:

$$C_{\text{potential}} = A+B+C^1$$

Assuming that $C^1 = 86$

$$C = 85 + 97 + 86 = 268$$

This suggests that, ignoring the effect of natural attenuation (which depends on several factors), the water resources

around Afikpo quarry sites are at a higher risk of potential pollution compared to other aspects of the environment (Table II).

TABLE II COMPONENTS POTENTIAL RISK LEVELS

Component	Value	Percentage Risk
Air Pollution	85	15%
Land Degradation	222	39%
Water Quality Degradation	268	46%

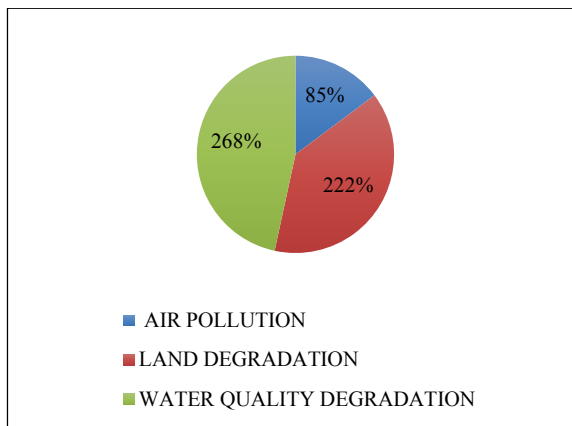


Fig. 1 Components potential risk values (in %)

The environmental effects of rock quarrying in Afikpo, Ebonyi State, quarry sites are a complex and multifaceted issue that has significant impacts on the natural environment, local communities, and the economy. This section will discuss the adverse effects of this activity in Afikpo, Ebonyi State quarry sites, as well as possible solutions to mitigate these impacts.

A. Destruction of Natural Habitats

One of the major environmental impacts of rock quarrying is the destruction of natural habitats through deforestation and habitat fragmentation [32]. Quarrying activities require the removal of topsoil and vegetation, which disrupts the ecosystem and destroys the habitat of various plant and animal species. In Afikpo, Ebonyi State, quarrying has resulted in the loss of biodiversity, as well as the displacement of native species. This is also affirmed by the results of the analysis of the respondents' feedback in responses 2 and 5 of the survey results (Table I).

B. Air Pollution

The process of crushing and blasting rocks in a quarry site releases dust and other particulate matter into the air. The burning of fossil fuels as a source of energy for operating the machines also introduces gases such as carbon monoxide (CO) and carbon dioxide (CO₂) into the atmosphere. These can have harmful effects on human health. The dust can cause respiratory problems such as asthma, bronchitis, and irritation of the eyes and throat [28]. The pollution from quarrying can also contribute to the

formation of acid rain, which can harm plants and aquatic life. The majority of the local residents within the quarry sites attested to the prevalence of dust-polluted air within the environment, especially during the dry season (Response 3 of Table I). The quarrying of crystalline rocks can redistribute radionuclides in rock dust, which have the capability of increasing the exposure levels and radiation dose rates of workers and nearby residents [26].

C. Noise Pollution

The operation of heavy machinery and blasting in quarry sites generates high levels of noise, which can be a nuisance to local communities [27]. Noise pollution from rock quarrying can also have negative impacts on wildlife, disrupting their behavior and communication. This has been confirmed as one of the challenges faced by nearby residents, especially those who farm close to the quarry sites (Response 6 of Table I).

D. Contamination of Water Sources

Quarrying activities employ explosives, fuel oil, and other chemicals used in both blasting and operating the machines. These can be washed by surface runoff into nearby rivers and streams [31, 33], while some of the pollutants can percolate through the soil to the groundwater. In some parts of the Southern Benue Trough (Afikpo, Ameta, Mgbom, Ozara, Ishiagu, Lokpaukwu, Uturu), most of the crystalline rocks are being quarried with mechanized instruments and are also quarried by local miners.

The quarrying of these rocks releases some of the rock particulates into the environment. When elemental constituents of these particulates come into contact with water vapor, they dissolve and percolate into both soil and groundwater [19]. Quarrying activity breaks down the rocks into fragments, increasing the surface area available for weathering. The weathering of rocks also releases their elemental constituents into the environment. These affect the quality and availability of drinking water for nearby communities (Responses 3 and 5 of Table I).

E. Land Degradation

Quarrying activities can cause land degradation by altering the soil pH and organic carbon content [29], reducing the productivity of the land for agriculture and other purposes. The removal of topsoil and vegetation can lead to erosion and leaching of nutrients, making the land less fertile and susceptible to landslides. The results of the analysis of feedback from the respondents show that quarrying activities in Afikpo have impacted both the availability and quality of agricultural lands within the area (Responses 4, 7, and 16 of Table I).

F. Health/Economic Implications

The introduction of different contaminants into both the air and surrounding water bodies around Afikpo quarry sites

may have resulted in the prevalence of common diseases such as stomach upset and respiratory infections, as complained by the respondents (Responses 3, 5, and 11 of Table I). The assumed difficult-to-treat nature of these common infections may be due to two reasons. The first reason may be due to the continuous intake of these contaminants through both air and drinking water [24].

Some contaminants, such as heavy metals (present in crystalline rocks in Afikpo) and organic pollutants, have the tendency to bio accumulate within the human system due to their persistent nature, thereby making the treatment of these common diseases difficult. The second reason may be due to the constant consumption of unprescribed antibiotics in a bid to treat these recurring common infections [25]. The abuse of antibiotics results in the development and spread of resistance within the pathogenic organisms in the human body (antimicrobial resistance), making further treatments ineffective and increasing the risk of disease spreading [20].

Antimicrobial resistance (AMR) is a significant global health challenge that occurs when microorganisms such as bacteria, viruses, and fungi develop the ability to resist the effect of antimicrobial agents (antibiotics, antifungals, or antivirals) designed to kill or inhibit them [21, 22]. This renders previously effective treatments ineffective. The prolonged consumption of common antibiotics and the need to take stronger antibiotics due to the ineffectiveness of the common ones leads to increased treatment costs, resulting in more expensive treatments and higher healthcare costs [23]. This may impact the finances of the local residents around the quarry sites.

X. RECOMMENDATIONS OF THE STUDY

To mitigate the adverse environmental impacts of rock quarrying in Afikpo, Ebonyi State, the following solutions can be adopted:

1. Proper Waste Management: Quarry operators should implement effective waste management systems to prevent pollution of air, water, and soil. This includes proper storage and disposal of hazardous materials and the use of green technology to reduce emissions.

2. Reclamation and Restoration of Quarry Sites: After quarrying activities are completed, the land should be restored and rehabilitated to its natural state. This can include planting vegetation, controlling erosion, and landscaping to minimize the visual impact of the quarry site.

3. Community Engagement and Awareness: Local communities should be actively engaged and informed about the potential impacts of quarrying activities. This can help in creating a sense of ownership and responsibility toward the environment and ensure sustainable quarrying practices.

4. *Adoption of Sustainable Quarrying Practices:* Quarry operators should adopt sustainable practices such as reducing the use of explosives, conserving water, and minimizing disturbances to the natural environment. This can help reduce the negative impacts of quarrying on the environment.

5. *Government Regulation and Enforcement:* The government should enforce strict regulations and policies on quarry operations to ensure environmental protection. This can include conducting regular environmental impact assessments and monitoring the compliance of quarry operators with environmental standards.

6. *Monitoring and Reporting Systems:* Ongoing monitoring systems should be established to track environmental impacts from quarry activities. Regular reporting can help address issues promptly and maintain transparency with stakeholders.

7. *Public Awareness Campaigns:* Educational campaigns should be conducted to raise awareness about the environmental impacts of quarrying. Informing the public about the importance of sustainable practices can foster community support for conservation efforts.

8. *Collaboration with NGOs and Environmental Organizations:* Partnerships with non-governmental organizations (NGOs) and environmental groups should be encouraged to leverage expertise and resources in managing the ecological impacts of quarrying. Collaborative initiatives can enhance conservation efforts and community engagement.

9. *Research and Development of New Antibiotics:* The government should invest in the development of new antibiotics to replace the ineffective ones. The use of antibiotics should be regulated and limited to cases where they are truly necessary. This will reduce the prevalence of antibiotic-resistant pathogens in both the human system and the environment.

XI. CONCLUSION

The environmental effects of stone quarrying in Afikpo, Ebonyi State, are significant and multifaceted, impacting biodiversity, water quality, and the well-being of local communities. However, by implementing the recommendations outlined above, stakeholders can work toward mitigating these adverse impacts. A combination of sustainable practices, community involvement, and stringent regulations will not only preserve the local environment but also ensure that the benefits of quarrying contribute positively to the region's health, economy, and social fabric. Ultimately, adopting a holistic approach to quarry management can lead to a balance between economic development and environmental stewardship, fostering a healthier ecosystem for future generations.

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