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Evaluating the Environmental and Agricultural Impacts of Cement Industry Emissions on Communities Surrounding BUA Cement Factory, Sokoto State, Nigeria

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ABSTRACT

Cement production and limestone quarrying generate dust and gaseous emissions that can affect the environment, agriculture, and the wellbeing of nearby communities. This study evaluated the environmental and agricultural impacts of industrial emissions on communities around the BUA Cement factory on the Kalambaina Formation in Wamakko Local Government Area, Sokoto State, Nigeria. A mixed-methods design was used. Perception data were collected with a five-point Likert-scale instrument. Qualitative data came from key informant interviews with community leaders, farmers' representatives, BUA environmental officers, quarry personnel, and environmental agency officials. Descriptive statistics, NVivo thematic analysis, and Spearman's rank-order correlation were used for analysis. Respondents agreed that emissions and associated mining activities had affected their environment (grand mean = 4.03, against a criterion mean of 3.00). Dust deposition, reduced air quality, noise, soil degradation, and effects on crops and water resources were all reported. Interviews showed that dust is felt almost daily and is worst in the dry season, with reports of coughing, sneezing, and eye irritation. Concerns about water quality and the handling of complaints also emerged. Perceived environmental effects were strongly and significantly related to proximity to the facility ($r_s = -0.859$, $p = 0.001$). The study recommends regular independent air, water, and soil monitoring, dust-control measures, and stronger community engagement and complaint mechanisms.

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INTRODUCTION

Mineral resources constitute an important component of the natural resource base of many developing countries, providing essential raw materials for industrial production, infrastructure development, employment generation and economic growth. Minerals such as limestone, granite, iron ore, clay and other industrial minerals are widely exploited to support construction, manufacturing and other economic activities. In Nigeria, mineral exploitation has increasingly become an important economic activity because of the country's abundant geological resources and the need to diversify the economy beyond petroleum. However, the exploitation of mineral resources is frequently associated with environmental challenges, particularly where extraction activities are not adequately regulated or accompanied by effective environmental management practices (Obaje, 2009).

The Kalambaina Formation is particularly significant to the industrial development of Sokoto State because of the limestone resources exploited by BUA Cement Company. The company's Sokoto cement operations are located within Wamakko Local Government Area, approximately 12 kilometres

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west of Sokoto metropolis. Limestone extraction takes place within designated quarry areas around the industrial facility. The company's quarrying and cement production activities are therefore important components of the local industrial economy, while simultaneously raising environmental and social management concerns for neighbouring communities (African Development Bank, 2022).

Another major environmental concern associated with cement production and limestone exploitation is industrial emission. Cement manufacturing involves several processes that generate atmospheric pollutants, including particulate matter, nitrogen oxides, sulphur dioxide and carbon dioxide. Dust can originate from quarrying, crushing, grinding, material handling, clinker production, storage and transportation. These emissions may affect ambient air quality and contribute to the deposition of dust on vegetation, residential buildings, farmland and water sources. The African Development Bank (2022) environmental assessment identifies quarrying, material transportation, crushing, grinding and cement handling as important sources of dust and atmospheric emissions at the BUA Sokoto facility.

The environmental implications of industrial emissions are particularly important for communities located close to cement production facilities. Continuous exposure to suspended dust and other atmospheric pollutants may create environmental discomfort, reduce visibility, affect vegetation and increase concerns about respiratory health. Dust deposition on agricultural crops may also affect plant surfaces and interfere with normal agricultural activities. However, the actual magnitude of pollution and its effects should be established through environmental monitoring rather than relying entirely on residents' opinions.
One of the major problems concerns industrial emissions generated by quarrying and cement manufacturing activities, dust and particulate matter originating from excavation, crushing, material transportation and cement production may affect the environmental quality of neighbouring settlements. Although industrial emissions are recognized as an important environmental concern in cement-producing areas, there is a need to examine how these emissions are experienced by surrounding communities and whether effective measures are available to control their environmental effects.

MATERIAL AND METHODS

Given the multifaceted nature of industrial pollution and its socio-environmental consequences, the study employed a mixed-methods research approach. This approach integrates quantitative and qualitative techniques to allow for a more holistic understanding of the problem under investigation. While quantitative methods facilitated the measurement of trends and patterns, qualitative methods provided deeper insights into community experiences, perceptions, and adaptive responses.

The population of the study consists of residents of selected communities located around the BUA Cement mining and industrial operations at the Kalambaina Formation site. The target population includes household heads, farmers, livestock owners, traders, industrial workers and other adult residents who have relevant experience or knowledge of the environmental conditions of the study area. The population also include selected institutional stakeholders, particularly officials of BUA Cement Company, environmental regulatory personnel, community leaders and representatives of relevant government institutions.

A structured KII interview was administered to selecting respondents in the surrounding communities as mentioned earlier. It examined the environmental effects of industrial emissions. It contains questions relating to dust deposition, perceived air-quality changes, environmental discomfort, effects on vegetation, agricultural activities and the condition of residential surroundings. A five-point Likert scale was used for selected perception-based questions, with response categories ranging from strongly agree to strongly disagree. The responses were analyzed using descriptive and comparative statistical techniques using thematic analysis of the interview responses, and research hypothesis test. Questionnaire responses relating

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to dust deposition, perceived air-quality changes and environmental effects was summarized

REVIEW OF RELATED LITERATURE

In Nigeria, industrial emissions remain a major environmental concern, particularly in urban and peri urban areas where industries are located close to residential settlements. Weak environmental monitoring, poor waste management practices. Inadequate community awareness have exacerbated the vulnerability of local populations. Communities in proximity to industrial facilities often experience increased exposure to harmful pollutants, resulting in long-term socio-economic and environmental consequences.

Industrial emissions represent a major source of environmental deterioration across the world. In the pursuit of economic expansion and industrial development, activities such as manufacturing, power generation, mining, and waste management discharge significant amounts of pollutants into the environment. These emissions consist of greenhouse gases like carbon dioxide and methane, particulate matter, sulphur dioxide, nitrogen oxides, heavy metals, and liquid industrial wastes (Plate.1.). The United Nations Environment Programme reports that industrial operations contribute substantially to global air and water pollution. Thereby driving climate change, ecosystem decline, and heightened disaster risks (UNEP, 2019).



Plate1. Gases from industrial emission in the BUA industry

At the global level, industrial emissions are associated with climate instability, increasing global temperatures, acid precipitation, biodiversity loss. The degradation of air and water resources. Communities situated near industrial areas, both in developed and developing nations, are often exposed to greater environmental hazards. In many developing countries, inadequate environmental regulations. Weak enforcement mechanisms intensify the adverse effects of industrial pollution, increasing exposure to health hazards and threatening local livelihoods (World Bank, 2020). As a result, industrial emissions are increasingly viewed as slow-developing hazards that weaken sustainable development and community resilience.

Effects of Industrial Emissions on the Environment

Industrial emissions represent one of the most significant contributors to global environmental degradation, exerting widespread impacts across multiple ecological media. These emissions, which include gaseous pollutants, particulate matter, liquid effluents, and hazardous wastes, disrupt the balance of natural systems by contaminating air, soil, and water resources. While the literature on industrial pollution is extensive, there is a notable bias toward examining air pollution, often at the expense of integrated analyses that consider soil and water interactions. This imbalance limits holistic understanding of how emissions simultaneously affect interconnected ecosystems.

Air pollution has received the greatest scholarly attention, with studies documenting its role in climate change, acid rain, and declining air quality. Pollutants such as carbon dioxide, sulphur dioxide, and nitrogen oxides contribute to global warming, respiratory illnesses, and ecosystem stress. However, soil and water pollution, though equally critical, are less frequently analyzed in synergy with atmospheric impacts. Industrial effluents discharged into rivers and lakes degrade aquatic habitats, reduce biodiversity, and contaminate drinking water supplies. Similarly, deposition of heavy metals and chemical residues into soils diminishes fertility, alters microbial

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activity, and compromises agricultural productivity.

The 2022 BUA Sokoto Environmental and Social Impact Assessment prepared by SRK Consulting provides important operational evidence concerning the potential sources of atmospheric pollution at the Kalambaina facility. The assessment identified quarrying, limestone transportation, crushing, grinding, clinker production, material storage, cement bagging and transportation as activities capable of generating particulate emissions. It also considered gaseous emissions, including carbon monoxide, carbon dioxide, nitrogen oxides and sulphur dioxide. The report is particularly relevant because it identifies the principal operational sources of emissions that should be considered during environmental monitoring. However, an environmental assessment of predicted or potential impacts does not automatically establish the actual concentration of pollutants experienced by neighbouring communities. This creates an opportunity for the present research to examine community experiences and, where possible, undertake independent environmental measurements.



Plate 2. Effects of industrial emission on Agricultural lands in Gantsare community

Mitigation Strategies against Risks Associated with Industrial Emissions

Industrial emissions remain one of the most pressing environmental challenges of the modern era, contributing to climate change, air pollution, and widespread ecological degradation. These emissions also pose significant risks to public health and economic stability, particularly in regions where communities depend heavily on natural resources for survival. Effective mitigation therefore requires a comprehensive and multifaceted approach that combines technological innovation, regulatory enforcement, sustainable industrial practices, and nature-based solutions.

One of the most effective ways to reduce industrial emissions is through a transition to cleaner energy sources. Historically, industries have relied heavily on coal and heavy fuel oil, both of which are carbon-intensive and produce significant amounts of particulate matter and sulfur dioxide. Fuel switching to natural gas or biomass offers a relatively quick reduction in emissions since these fuels emit fewer pollutants per unit of energy produced (Munsif et al., 2021). Electrification of industrial processes is another critical pathway. By shifting from fossil fuel-based systems to electricity, industries can leverage decarbonized grids to achieve substantial emission reductions. For example, electrified heating systems in manufacturing can replace coal-fired boilers, thereby cutting emissions significantly when powered by renewable electricity (WHO, 2021).

RESULT AND DISCUSSION

Table 1: Effects of industrial emissions on the environmental conditions and surrounding communities.

S/N	Statements	SA	A	U	D	SD	Mean	Remarks
1.	Dust from mining and cement production activities is noticeable in my community.	5	3	1	1	0	4.20	Accepted
2.	Dust settles on roofs, windows, household items and other surfaces.	4	4	1	1	0	4.10	Accepted
3.	Industrial emissions have reduced air quality in the surrounding communities.	3	5	1	1	0	4.00	Accepted

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S/N	Statements	SA	A	U	D	SD	Mean	Remarks
4.	Smoke or visible emissions from industrial operations are occasionally observed in the area.	3	4	2	1	0	3.90	Accepted
5.	Noise from mining, blasting and industrial machinery disturbs residents.	5	3	1	1	0	4.20	Accepted
6.	Mining and industrial activities have affected the quality or availability of local water resources.	2	5	2	1	0	3.80	Accepted
7.	Dust deposition has affected agricultural activities and the growth of crops.	3	4	2	1	0	3.90	Accepted
8.	Mining activities have contributed to soil degradation in the surrounding environment.	4	3	2	1	0	4.00	Accepted
9.	Industrial activities have affected the general environmental quality of my community.	5	3	1	1	0	4.20	Accepted
10.							4.03	Accepted

Source: Field survey, 2026

Table 1 show industrial emissions have negatively affected environmental conditions and surrounding communities. Specifically, Item 1 revealed that dust from mining and cement production activities was noticeable in the community (Mean = 4.20); Item 2 revealed that dust settled on roofs, windows, household items and other surfaces (Mean = 4.10); Item 3 revealed that industrial emissions reduced air quality in surrounding communities (Mean = 4.00); Item 4 revealed that smoke or visible emissions from industrial operations were occasionally observed in the area (Mean = 3.90); Item 5 revealed that noise from mining, blasting and industrial machinery disturbed residents (Mean = 4.20).

Item 6 revealed that mining and industrial activities affected the quality or availability of local water resources (Mean = 3.80); Item 7 revealed that dust deposition affected agricultural activities and crop growth (Mean = 3.90); Item 8 revealed that mining activities contributed to soil degradation in the surrounding environment (Mean = 4.00); and Item 9 revealed that industrial activities affected the general environmental quality of the community (Mean = 4.20). Overall, the findings revealed that industrial emissions and associated mining activities had substantially affected environmental conditions and the well-being of surrounding communities, as indicated by the grand mean of 4.03, which was above the criterion mean of 3.00. This implies that dust pollution, reduced air quality, noise disturbance, water-resource degradation, agricultural effects and soil deterioration were perceived as notable environmental challenges in the study area.

The thematic analysis of interview responses, conducted using NVivo, generated the theme of frequency of dust pollution and associated health implications in the surrounding communities. Responses from community leaders, farmers' representatives, BUA environmental officers, quarry personnel and environmental agency officials indicated that dust pollution was a recurring environmental concern, particularly during the dry season when reduced rainfall and increased wind movement encouraged the suspension and dispersal of dust from quarrying, mineral transportation and cement production activities. A community leader observed that "dust pollution is experienced almost every day, particularly during the dry season when quarrying and the movement of heavy-duty trucks generate considerable dust in the community."

Similarly, a farmers' representative stated that "dust settles on our roofs, household properties and farm crops, making it difficult for residents and farmers to avoid its effects." Regarding associated health problems, a community member explained that "people in the community frequently experience coughing, sneezing and eye irritation, especially when dust concentration increases." An environmental

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agency official further remarked that "prolonged exposure to airborne particulate matter from mining and industrial operations can constitute a serious environmental health concern for neighbouring communities." These responses suggest that dust pollution constitutes a major environmental challenge around the Kalambaina Formation, with potential implications for respiratory health, household sanitation and agricultural activities.

The second theme generated was changes in water quality, major environmental concerns and institutional responsiveness to complaints. Interview responses indicated concerns about possible changes in the condition of community water sources, including increased turbidity, changes in water colour, unusual taste and odour, and reduced water availability. A community leader observed that "some residents have expressed concerns about changes in the appearance and quality of water sources since the expansion of mining and industrial activities." Similarly, a farmers' representative explained that "the most serious environmental problems include dust pollution, declining soil quality and concerns about the availability of clean water for domestic and agricultural purposes."

On the reporting of environmental complaints, a community representative stated that "residents have raised concerns about dust and other environmental disturbances, but the level of feedback and attention received has not always been satisfactory." In contrast, a BUA environmental officer maintained that "the company recognises environmental complaints from host communities and engages relevant stakeholders to address issues relating to its operations." Overall, the responses suggest that dust pollution, potential water-quality deterioration and associated health concerns constitute significant environmental issues in the study area. They also highlight the importance of strengthening environmental complaint-reporting mechanisms, improving communication between BUA Cement and host communities, and ensuring regular monitoring of air and water quality.

Hypothesis Testing

Below hypothesis was tested in order to determine whether the observed effects between the variables are statistically significant or it has occurred by chance.

H_0: There is no statistically significant relationship between residents' proximity to the industrial facility and their perception of the environmental effects of industrial emissions.

Table 2: Spearman's Rank-Order Correlation Test

Variables	N	Spearman's rho (r_s)	Sig. (2-tailed)	Decision
Residents' proximity and perception of environmental effects	10	-0.859	0.001	Significant

Source: Field survey, 2026

Table 2 shows Spearman's Rank-Order Correlation Test. The findings revealed a strong negative and statistically significant relationship between residents' proximity to the industrial facility and their perception of the environmental effects of industrial emissions, as indicated by Spearman's rank-order correlation coefficient (r_s = -0.859) and a significance value of 0.001, which was less than the 0.05 level of significance. Consequently, the null hypothesis (H_{02}), which stated that there was no statistically significant relationship between residents' proximity to the industrial facility and their perception of the environmental effects of industrial emissions, was rejected.

This implies that residents' perceptions of environmental effects varied significantly with their distance from the industrial facility, with the negative correlation indicating that greater proximity (lower distance rank) was associated with stronger perceptions of environmental effects. The finding suggests that communities

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closer to the industrial facility may experience or perceive greater exposure to industrial emissions, highlighting the need for distance-sensitive environmental monitoring, pollution control and targeted mitigation measures.

Summary of The Study

The study began from the recognition that quarrying, crushing, grinding, clinker production, and transportation at the BUA Sokoto facility are established sources of particulate and gaseous emissions (African Development Bank, 2022; SRK Consulting, 2022). Because an impact assessment predicts potential effects without establishing what residents actually experience, the research examined how host communities around the Kalambaina Formation perceive these emissions and their consequences.

The perception survey showed that respondents accepted all nine statements on environmental effects, with item means ranging from 3.80 to 4.20 and a grand mean of 4.03, well above the criterion mean of 3.00. The strongest agreement was recorded for noticeable dust, noise disturbance, and general deterioration of environmental quality (Mean = 4.20 each). Respondents also agreed that dust settles on household surfaces (Mean = 4.10), that air quality has declined and soil has degraded (Mean = 4.00 each), that crop growth has been affected and visible emissions occur (Mean = 3.90 each), and that local water resources have been affected (Mean = 3.80).

The thematic analysis of interviews produced two themes. The first was the frequency of dust pollution and its associated health implications. Participants described dust as an almost daily experience, most intense in the dry season when reduced rainfall and stronger winds, together with quarrying and heavy-truck movement, increase dust suspension, and they reported coughing, sneezing, and eye irritation. The second theme concerned changes in water quality and institutional responsiveness to complaints. Participants reported changes in turbidity, colour, taste, odour, and availability of water, and community representatives stated that responses to their complaints were not always satisfactory, while the company's environmental officer maintained that complaints are recognised and addressed through stakeholder engagement. The hypothesis test rejected the null hypothesis of no relationship between proximity to the facility and perceived environmental effects. Spearman's rank-order correlation revealed a strong, negative, and statistically significant association (r_s = −0.859, p = 0.001), indicating that residents closer to the facility reported stronger environmental effects.

CONCLUSION

The findings demonstrate that residents of communities around the BUA Cement facility perceive industrial emissions and associated mining activities as a significant and recurring environmental burden. Dust pollution is the most prominent concern, and its effects extend to household sanitation, respiratory comfort, soil condition, and agricultural activity. The strong relationship between proximity and perceived effects suggests that exposure is uneven and likely concentrated in the settlements nearest to the plant and quarry.

The study further shows that the issue is not only environmental but also one of governance and communication, since community concerns about water quality and the responsiveness of the company and regulatory institutions remain unresolved. The results are, however, based on perception and interview evidence from a small sample, and they therefore indicate where the problem lies without quantifying actual pollutant concentrations. Independent instrumented monitoring is required to confirm the levels of exposure and to guide appropriate mitigation.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Independent environmental monitoring. Regulatory agencies, in collaboration with BUA Cement and a university partner, should conduct regular measurement of PM10 and PM2.5 and sampling of water and soil at sites located at varying

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distances from the facility, with intensified sampling during the dry season.

2. Dust control at source. BUA Cement should apply water suppression on haul roads and stockpiles, cover trucks transporting materials, and pave and maintain access roads, while enclosing or fitting filtration systems to crushing, grinding, and bagging points and reviewing blasting schedules.
3. Protection of farmland and water sources. Crop and soil assessments should be undertaken in affected farming communities such as Gantsare, with compensation provided where damage is documented, and community water sources should be tested, with safe alternative supplies provided where contamination is confirmed.
4. Health surveillance and awareness. Local health facilities should be supported to record and report respiratory and eye complaints, and communities nearest the facility should be prioritised for health outreach and awareness programmes.
5. Stronger grievance and communication mechanisms. A documented complaint channel with defined response timelines should be established, outcomes should be made public, and regular consultation meetings should be held between BUA Cement, regulators, and host communities.
6. Distance-sensitive mitigation. Buffer zones, tree belts, and windbreaks should be established, with targeted interventions directed first to the settlements closest to the facility.
7. Further research. Future studies should use larger samples, incorporate objective measurements of air, water, and soil quality, and examine the long-term agricultural and health effects of emissions more fully.

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