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Environmental Impact of Quarrying Activities on Air Quality and Noise Levels in Orogbangba Town of Kwara State.

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Abstract

The environmental impacts of quarrying activities on air quality and noise levels in Orogbangba Town, Kwara State, Nigeria, were evaluated, with a focus on the residential settlements of Passa, Ire Akari, and Alubarika. Data were systematically collected from 15 georeferenced sampling nodes within a 1.29 km radius of the Kaidi Quarry epicentre over ten weeks. Air quality parameters, including carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), were measured using calibrated ToxiRAE Pro sensors, while noise levels were assessed with ATP 901A dosimeters.

The findings indicate substantial degradation of the ambient environment. Carbon monoxide (CO) concentrations peaked at 22 ppm, surpassing World Health Organisation (WHO) safety thresholds by 120 per cent, while mean concentrations of nitrogen dioxide (NO_2) at 1.8 ppm and sulfur dioxide (SO_2) at 2.1 ppm consistently exceeded Federal Ministry of Environment (FMEnv) and WHO regulatory limits. Spatial Kriging interpolation mapping identified high-risk hotspots of gaseous emissions that corresponded directly with quarry operational hours. Additionally, noise levels reached up to 95 dBA at stations closest to the quarry, significantly exceeding the National Environmental Standards and Regulations Enforcement Agency (NESREA) daytime limit of 70 dBA. These results demonstrate that quarrying activities in Orogbangba produce acoustic toxicity and hazardous air pollution, presenting chronic respiratory and auditory health risks to residents. The study determines that existing mitigation strategies are insufficient and recommends the implementation of stricter buffer zones and continuous environmental auditing to protect public health in the affected communities.

Keywords: Quarrying Impacts, Air Quality, Noise Pollution, GIS Spatial Analysis, Environmental Compliance

Introduction

The accelerated pace of urbanisation and industrialisation, particularly in developing nations, has led to a surge in construction activity. The construction activities are essential for economic growth and infrastructure development. As Oyinloye and Ajayi (2014) stated, quarrying, a form of open-pit mining, is the primary means of extracting construction materials such as limestone, gypsum, clay, sandstone, kaolin, bentonite, silica, barite, measurement stone, building aggregate, gravel, and dolomite. Due to their high aggregate content, these materials are frequently employed with concrete and asphalt plants for infrastructure development projects, including roads, bridges, dams, and housing. So many quarries exist in this very nation, thus generating substantial income and revenue for the economy and reducing poverty. Still, their environmental impact is being neglected by the authorities responsible for the establishment of these quarries and also by quarry owners and operators. Notably, Lameed and Ayodele (2010) identify quarrying, a process involving excavating or blasting rock with explosives, as a significant contributor to environmental challenges. These challenges encompass noise and vibration pollution, air and water contamination, and land degradation. Consequently, these disturbances have demonstrably negative impacts on the physical and biological aspects of the surrounding ecosystem. Moreover, the resulting blasting operation in this area is sometimes accompanied by incomplete detonation of the explosives, which causes the release of toxic gases into the atmosphere and pollutes the environment. Mabogunje (2008) and Lameed and Ayodele (2010) highlight the detrimental environmental impacts of quarrying activities. These impacts primarily stem from releasing dust particles laden with harmful pollutants like CO_2, NO_2, CO, and SO_2 into the surrounding air, water, and soil. These pollutants can harm plant and animal life through respiratory issues or indirectly by altering water and air quality. This also contributes to regional haze and escalates the prevalence of respiratory illnesses among nearby populations (Akinbode *et al*., 2010). Nartey *et al*. (2012) establish a significant correlation between air pollution from quarrying and mining operations and increased incidences of respiratory illnesses. Ojoawo *et al.* (2025) explained that scanty literature exists about the impact of noise on the environments, noise pollution comprises too loud, sudden, persistent and uninteresting sounds that become an assault to the body system, thereby incurring mental or physical harm. These impacts range from sleep disturbances to cardiovascular stress in humans, while also disrupting the natural breeding patterns of local wildlife (Babisch, 2014; Barlow *et al*., 2018). Despite the establishment of regulatory thresholds such as the National Environmental Standards and Regulations Enforcement Agency (NESREA) and the Nigerian Minerals and Mining Regulations (2011), a critical gap remains between policy and industry compliance. These findings aim to justify the adoption of sustainable mitigation strategies, such as the implementation of noise-dampening equipment and advanced dust suppression technologies to protect the surrounding ecosystem and community health. The study is centred on the environmental impacts of Kaidi quarry activities on Orogbangba communities, located in the Asa Local Government Area of Kwara State, Nigeria, at geodetic coordinates latitudes 8° 24′ 23″ N to 8° 24′ 20″ N and longitudes 4° 27′ 03″ E to 4° 26′ 59″ E. The Orogbangba Town, covering a total area of 2.83 sq. km, currently hosts less than 2000 inhabitants residing in 350 buildings. It comprises 13 communities, but the study was carried out on the most affected areas in the town, which are Passa, Ire Akari, Alubarika, and Company, as indicated in Figures 1a and 1b

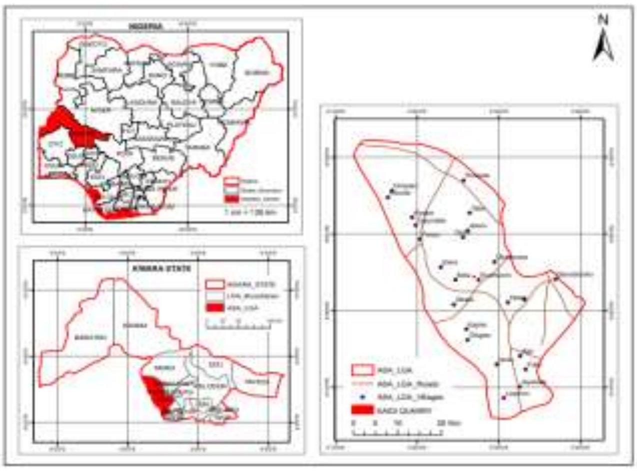


Figure 1a: Map showing Orogbangba Town and Kaidi Quarry in Asa Local Government, Kwara State.

Figure 1b: Modified Google Map Showing the Satellite Imagery of Orogbangba Town and Kaidi Quarry Site in Asa Local Government Area of Kwara State.

Materials and Methods

The study was conducted in Orogbangba Town, Kwara State, Nigeria, specifically targeting the residential area most proximal to the Kaidi Quarry. Based on preliminary site observations and a random sampling technique, three residential zones were identified as the most impacted: Passa, Ire Akari, and Alubarika. These settlements span a linear distance of 1.29 km from the quarry epicentre, as shown in Figure 2.

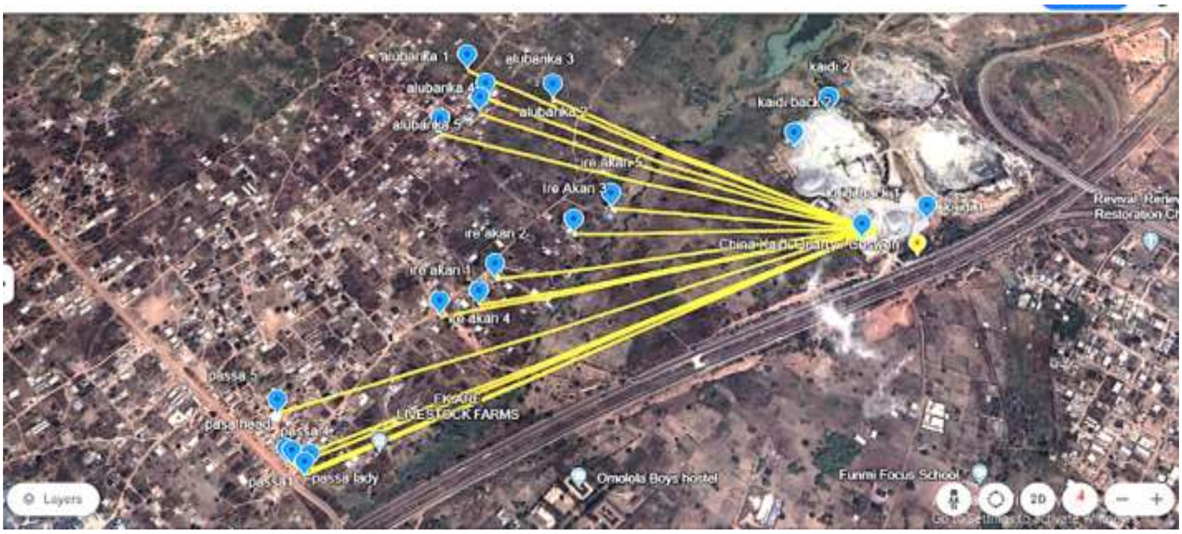


Figure 2: The Aerial Satellite View showing a buffer of 1.29km distance from the quarry site with Adjoining residents

Sampling Frame and Locations

Environmental monitoring was assessed across fifteen (15) distinct sampling locations distributed across the four cardinal points surrounding the quarry (north, south, east, and west). The sampling grid covered a radius of 1.29 km, with the closest station (W-1) located at 0.54 km and the furthest (SW-2) serving as a peripheral control node.

Table 1: Sampling Locations and Coordinates of the Affected Areas in Orogbangba Community of Kwara State, Nigeria

Station ID	Cardinal Direction	Settlement Area	Proximity to Source (m)	Monitoring Purpose
NW-1	North-West	Passa (Core)	150m	Direct emission/Blasting impact
NW-2	North-West	Passa (Outer)	950m	Extended settlement impact
W-1	West	Ire Akari	350m	Intermediate dispersion
SW-1	South-West	Alubarika	600m	Primary residential exposure
SW-2	South-West	Alubarika (Outer)	1,290m	Maximum extent of study radius

As detailed in Table 1, specific monitoring nodes included high-risk directions such as NW-1, NW-2, W-1, SW-1, and SW-2. These locations were selected to capture:

1. Immediate Impact Zone: Locations closest to the drilling and blasting pits (NW-1, W-1).

2. Dispersion Zone: Locations within the residential neighbourhoods of Passa and Alubarika (SW-1, NW-2).
3. Peripheral/Buffer Zone: Locations at the 1.29 km boundary (SW-2) to establish the extent of pollutant decay.

Procedure and Field Protocol

Using a random sampling technique, the most affected areas by the Kaidi Quarry in the Orogbangba Town are Passa, Ire Akari, and Alubarika, with the longest length of 1.29km, as shown in Figure 2.

Quantitative data collection methods: Subjective data were collected through field surveys; 250 structured questionnaires were administered to residents to assess their perceptions of environmental impacts. Semi-structured interviews were also conducted with residents, quarry workers, and local authorities to explore experiences, concerns and mitigation strategies. A handheld Global Positioning System (GPS) Garmin GPSMAP 64s was positioned at each of the 15 sampling stations (NW-1 to SW-2), ensuring that every air and noise reading was linked to precise Northing and Easting coordinates for subsequent GIS mapping.

Quantitative data collection methods: Objective data were collected through handheld calibrated ToxiRAE (Pro electrochemical sensor) to measure CO, NO_2, and SO_2 concentrations in parts per million (ppm) at each sample location at 3-hour intervals across 15 georeferenced sampling nodes (0.54 km to 1.29 km for gaseous emissions (CO, NO_2, and SO_2) over a period of 10 weeks and noise levels were monitored in decibels (dBA) using ATP 901A dosimeters during the same period.

Analytical Procedures

The data collected over the 10-week monitoring period were subjected to three analytical approaches to ensure the statistical significance and spatial accuracy of the findings regarding air and noise pollution.

Statistics Analysis: This was generated through IBM SPSS Statistics software to summarise and characterise air and noise pollution data collected. These measures included central tendency (mean, median) and dispersion (range, standard deviation) to provide a foundational understanding of the data distribution.

Geospatial Analysis: This was generated through Geographic Information Systems (GIS) software to map pollution hotspots and spatial patterns of pollutant dispersion. The geospatial data about air quality and noise levels were utilised. The spatial estimation of pollutant concentrations and noise levels within a 1.5km radius of the Kaidi quarry industry of Orogbangba Town enables the creation of detailed maps that visually represent the spatial distribution of these parameters throughout the study area. Spatial analysis identified pollution hotspots around the quarry site, indicating areas of high environmental risk.

Comparative Analysis with Regulatory Standards: The air quality and noise level data were subjected to comparative analysis, and the results contrasted with measured values against established environmental standards promulgated by authoritative bodies such as the World Health Organization (WHO) and the Federal Ministry of Environment (FMEnv's) standards

Results and Discussion

Impact of Quarry Activities on Air Quality and Noise Level

Air quality assessment of the study *area*:

Table 2: Mean Gaseous Concentrations vs. Ambient Air Quality in Nigeria (Regulatory Limit)

				Parameters					
Location Code	Northing	Easting	Interval(m)	CO (ppm)Before	CO (ppm) after	NO_2 (ppm) Before	NO_2 (ppm) After	SO_2 (ppm) Before	SO_2 (ppm) After
NW-1	82426	42635	0.77km	12	03	0.005	0.40	0.01	0.80
NW-2	82427	42628	0.99km	07	02	0.009	0.38	ND	0.70
W-1	82418	42641	0.54km	22	02	0.010	0.65	0.01	1.05
SW-1	82408	42635	0.86km	14	02	ND	0.41	ND	0.85
SW-2	82357	42625	1.29km	03	02	ND	0.25	ND	0.65
Regulatory Limit FMEnv’s				10 – 11.4	50 - 250	10		0.04 - 0.06	O.01
Regulatory Limit WHO				10	50			0.04	0.02

Source: FMH 2008

High-resolution data captured via the ToxiRAE Pro sensor at 3-hour intervals over the 10-week study period indicate that Carbon Monoxide (CO) peaked at 22 ppm at the Western station (W-1, 0.54 km), exceeding the WHO 8-hour safety threshold of 10 ppm by more than 120%. More alarming are the concentrations of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2), which reached 0.65 ppm and 1.05 ppm, respectively. The mean concentrations of pollutants were: carbon monoxide (CO) of 5.2 ppm (exceeding the WHO 2015 limit of 4.4ppm), nitrogen dioxide (NO_2) of 1.8 ppm (exceeding the FMEnv 2008 limit of 0.05 ppm), and sulphur dioxide (SO_2) of 2.1ppm (exceeding the WHO limit of 0.5ppm). The results revealed that, within each sample, the NO2, SO2, and CO concentrations in the air exceeded the maximum permissible limit (FMEnv's 2008), and, for WHO 2015, almost all parameters exceeded the allowable limit at each sample location. This persistent presence of toxic gases established that the Orogbangba community is a high-risk zone for chronic respiratory illnesses. Figures 3a and 3b, 4a and 4b, and Figure 5a and 5b show the spatial kriging interpolation model, which revealed the concentration of SO_2, NO_2 and CO measured before and after operational hours. The areas with average concentration are indicated in yellow. The red area shows higher concentrations of SO_2, NO_2 and CO emissions, and these established that SO_2, NO_2 and CO pollutants in the communities of Orogbangba town. Table 2 shows mean gaseous concentrations vs. ambient air quality in Nigeria (regulatory limit) that host communities have a high tendency to environmental pollution.

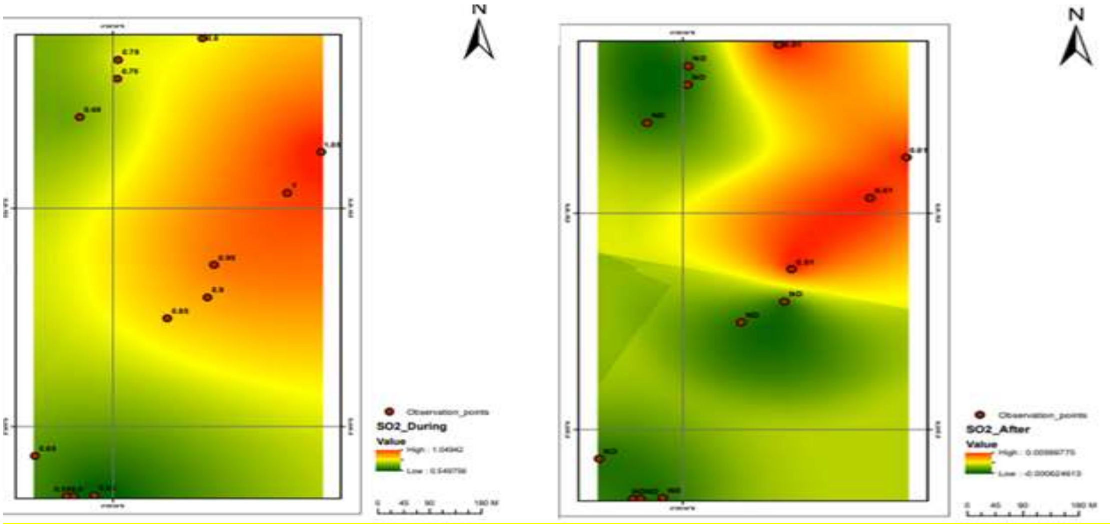


Figure 3a: Spatial Kriging Interpolation of SO_2 (sulphur dioxide) concentration in air at Orogbangba community during Kaidi quarry Operation
Figure 3b: Spatial Kriging Interpolation of SO_2 (sulphur dioxide) concentration in air at Orogbangba community after Kaidi quarry Operation.

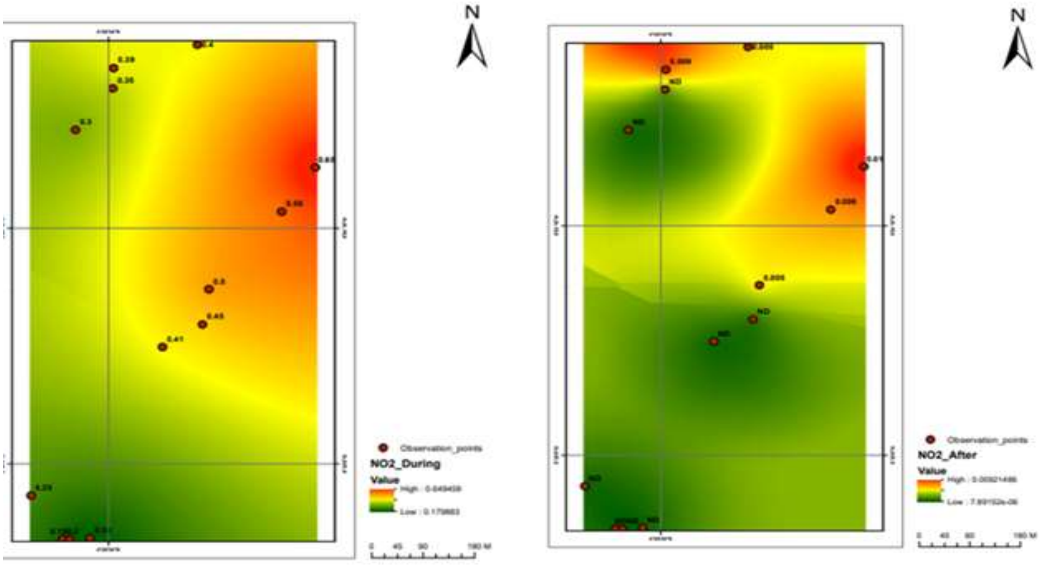


Figure 4a: Spatial Kriging Interpolation of NO_2 (nitrogen dioxide) concentration in air at Orogbangba community during Kaidi quarry Operation
Figure 4b: Spatial Kriging Interpolation of NO_2 (nitrogen dioxide) concentration in air at Orogbangba community after Kaidi quarry Operation.

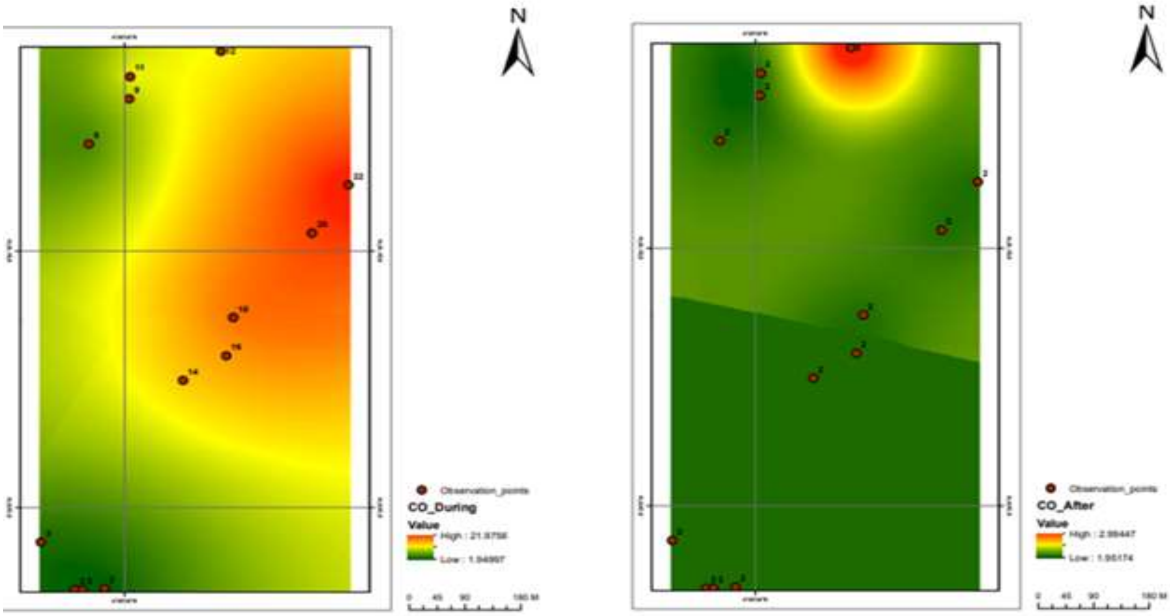


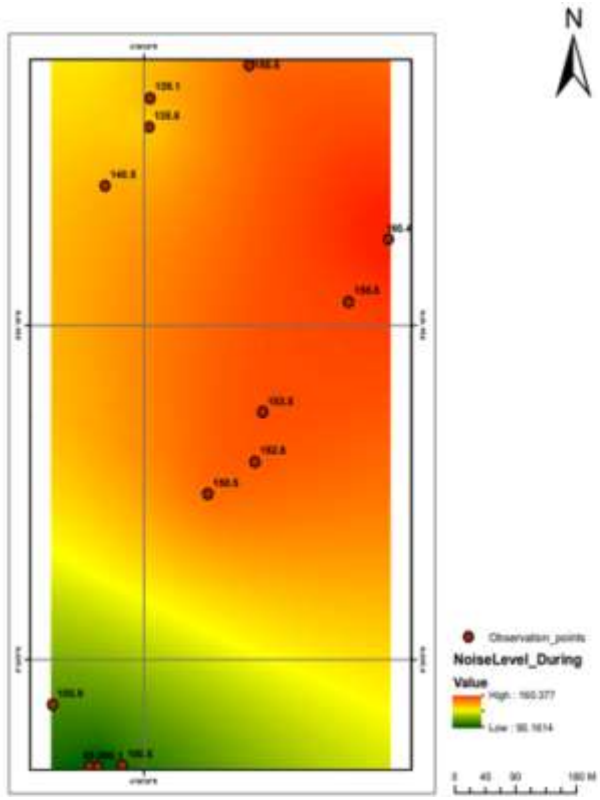
Figure 5a: Spatial Kriging Interpolation of CO (carbon monoxide) concentration in air at Orogbangba community during Kaidi quarry Operation
Figure 5b: Spatial Kriging Interpolation of CO (carbon monoxide) concentration in air at Orogbangba community after Kaidi quarry Operation

Noise level of the study area:

Table 3: Noise Level Recorded during operational hours for the affected part of the study area

Location Code	Northing	Easting	Interval(km)	Noise Level (dB)
NW-1	82426	42635	0.77	95.0
NW-2	82427	42628	0.99	94.0
W-1	82418	42641	0.54	90.0
SW-1	82408	42635	0.86	87.0
SW-2	82357	42625	1.29	85.0

During peak operational hours, noise levels at stations W-1(0.54 km) and NW-1 (0.77 km) peaked between 85 dBA and 95 dBA, the noise level measured is above the maximum permissible limit of 70dB in the daytime, as compared to the NESERA standard, which confirms that the Kaidi Quarry is the sole driver of acoustic toxicity in the region. These values indicate a pervasive breach of the National Environmental (Noise Standards and Control) Regulations. The assessment conducted over the 10-week monitoring period demonstrates that Kaidi quarry operations generate high-intensity noise and ground-borne vibrations that exceed both environmental comfort and structural safety thresholds. Figure 6 a and b shows the spatial kriging interpolation of the concentration of noise level during and after the operational hours. The results were shown in 'stretched colour', red represents the higher concentration, the light red represents the average concentration, and the yellow represents the lower concentration. The red colour shows the effect of Noise pollution generated during the quarry operations and the impact of the kaidi quarry on the immediate communities, which established the negative environmental impact of the quarry on the communities in Orogbangba Town. Table 3 shows the comparison results that the host communities have a high tendency towards Noise pollution.



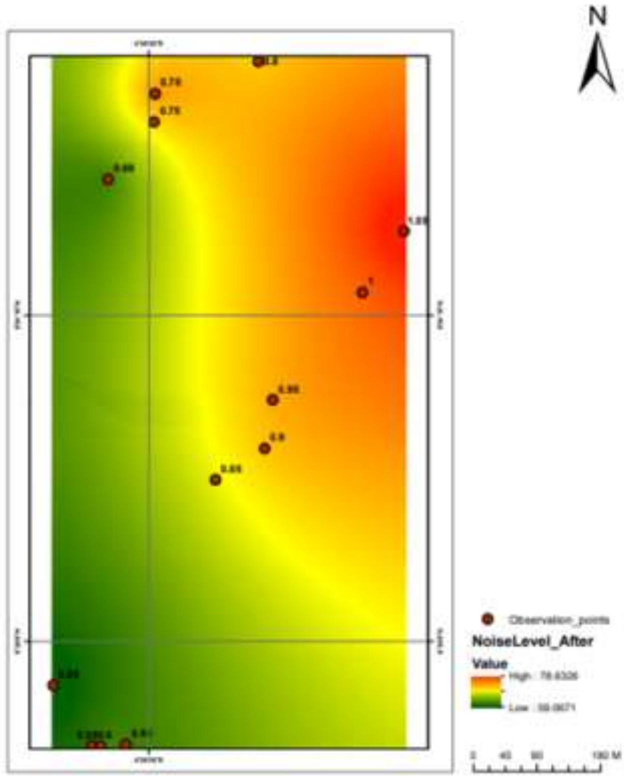


Figure 6a: Spatial Kriging Interpolation of Noise Level Concentration at Orogbangba community during Kaidi Quarry Operation
Figure 6b: Spatial Kriging Interpolation of Noise Level Concentration at Orogbangba Community after Kaidi Quarry Operation

Conclusion

With air and noise pollutants continuously surpassing WHO, FMEnv, and NESREA safety thresholds, this study demonstrates that Kaidi Quarry operations in Orogbangba, Kwara State, are the main causes of serious environmental degradation. Residents of Passa, Ire Akari, and Alubarika are at serious risk for respiratory, auditory, and psychological problems due to atmospheric concentrations of CO (5.52 ppm), NO_2 (0.65 ppm), and SO_2 (1.05 ppm), as well as noise levels that peak at 95 dBA. According to spatial analysis, pollutants continue to exist at dangerous levels even within a 1.29 km radius, endangering public health and causing structural damage to nearby buildings.

Recommendation

The following measures are recommended for quarry operators, regulators, and the Kwara State Government to mitigate the adverse impacts on air quality and noise levels. The quarry management should adopt wet drilling techniques and install high-pressure water sprinklers at crushing points and along haulage roads to minimise the suspension of particulate matter and associated gaseous pollutants before they become airborne. The act of implementing delayed-action detonators and electronic blasting systems can significantly reduce the peak ground vibrations and the incidence of "flying rocks" that lead to structural damage in Passa and Ire Akari.

This study confirms that even at 1.29 km, air quality remains non-compliant with WHO standards. It is recommended that NESREA should enforce a minimum 1.5 km mandatory buffer zone between active blasting faces and residential settlements in Kwara State to ensure pollutant decay. The strategic tree planting of species with high foliage density around the 1.5 km perimeter should be mandatory to act as a natural noise absorber and dust filter. NESREA and the Ministry of Mines and Steel Development should conduct quarterly monitoring audits of ambient air and noise levels at the Orogbangba site to ensure continuous compliance. The Kwara State Ministry of Health should establish a respiratory and auditory health surveillance program for Orogbangba residents.

The Environmental agencies responsible for mining activities should ensure that the Kaidi Quarry Company updates its Environmental Management Plan (EMP) to include a decommissioning and restoration plan, ensuring that the land is rehabilitated once extractive activities cease.

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