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# AIR QUALITY CONDITION OF ARTISANAL GOLD MINING SITES DURING THE DRY SEASON IN NIGER STATE, NIGERIA

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**Abstract**
This research examines the air quality condition of artisanal gold mining sites during the dry season in Niger State, Nigeria. The primary objective of the study is to analyze the air quality in the artisanal gold mining sites and to evaluate the impact of the seasonal weather conditions on air quality. The study also examines the causes of air pollution in the gold mining sites, the effects of air pollution on the local population, and the steps taken by the government to reduce air pollution. Data for the study were collected from secondary sources, such as meteorological records, air quality monitoring records, and reports from the Niger State Environmental Protection Agency. Primary data was collected through interviews with local stakeholders and gold miners. The data was analyzed using descriptive, inferential, and environmental monitoring statistical methods. The findings show that air quality in the artisanal gold mining sites was declining during the dry season due to lower precipitation and higher temperature. The results of this study contribute to the literature on air pollution in gold mining sites in the region and inform policy makers with regard to strategies for reducing air pollution in gold mining sites.

**Keywords:** Air quality, AGM sites and Dry season.

## Introduction

Globally, Artisanal Gold Mining (AGM) is a primary economic activity that has employed a great number of the human population with its attendant air, land and water pollution effects. Blacksmith Institute (2011) defines AGM as mining activity that uses undeveloped methods to extract and process minerals and metals on a small scale. Artisanal gold mining is a minor operation that is limited to non-mechanized exploration of mineral resources with a small-scale mining lease. AGM has played a critical role in the socio-economic development of poor regions of the world especially the developing countries (Balogun, 2001). This is because unemployment is high in these countries and illiteracy is on alarming rate. Many people indulge in AGM to have more income as it is more profitable than traditional agricultural practice (Owusu-Koranteng, 2008). The proliferation of AGM has negatively impacted on both cropland and pasture grounds to the rate of 0.4 and 0.8ha in 1970 and 0.2 and 0.5ha per capita in 2010 (European Environment-state and Outlook [EEO], 2010).

AGM in Africa has caused considerable environmental complications including chronic soil degradation, chemical contamination and air pollution (Owusu- Koranteng, 2008). The AGM activities are not without their attendant consequences; these include environmental risks, destruction to lithosphere, hydrosphere, atmosphere, biosphere and the ecosystem. Effects of AGM activities are connected to geological devastation and underground pollution in areas where they are carried out (Gerry *et al.,* 2001).

However, it is common knowledge that air pollution has caused intense disaster to man and the environment. The particulate matter and pollutants from AGM can cause difficulty in breathing, cardiac malfunctioning, sneezing and coughing, wheezing and general respiratory problems as well as eventual death. Furthermore, people react to air pollution differently depending on their level of exposure to the contaminants and genetic composition. Pollutants and toxins in the air can react to each other to form acid rain and ground level ozone. The product of such reaction can damage both fauna and flora species, especially trees, farm crops and agricultural livestock. Pollutants in the air on reaching the ground have the capacity to pollute water bodies which humans, plants and animals depend on for survival. Thus, AGM air pollution has the ability to destroy the economy of a place and cause loss of valuable resources yielding billions of revenues annually. Damages caused by air pollution could make people's productive energy to drop due to associated ailments (Gary *et al.*, 2009; Ghorani-Azam *et al.*, Loomis *et al.*, 2014).

In Asia, artisanal gold mining has devastated human lives and environment. According to a study conducted by Gunson and Marcello (2005) in China; it was discovered that mercury, coal and gold miners generate and emit hundreds of tons of mercury into the environment per annum. In China AGM usually adopts muller mills, which break down ores thereby increasing mercury contamination in the tailings and general environment. It was noted that more than 14 parts mercury can be lost in every part of gold recovered. Some gold mining operations are so crude, resulting to mercury vapor contamination. The study unveiled that only in 1997 alone; AGM emitted over 381 tons of mercury of which 226 tons were from gold mining.

In America, a study conducted by Camacho et al. (2016) unveiled that in a mining site located in Plazuela, in the municipality of Penamiller in the State of Queretaro; it was discovered that children, women and miners were heavily exposed to mercury when their urine samples were taken to the laboratory for analysis. Also, the study uncovered that there was high concentrations of mercury in soils and sediments of the community. This showed that AGM has the potential to contaminate both human health and environment if not put in proper regulation.

In Europe, in southern Ecuador, Hakan et al. (2009) studied environmental impact of small-scale and artisanal gold mining. It was noted that AGM caused serious damage to the air and water bodies in the sites. The AGM were found to generate harmful metallic substances, metalloids and cyanide into adjacent rivers and ambient air. In the river, the generated materials from AGM were not in water soluble forms only but as suspended particles and riverbed particles. Some of the pollutants from the mining sites were discharged to the air causing greater damage to the health of the people. This result identified general difficulty in achieving good environmental performance among small-scale miners. Thus, it suggested that Ecuadorian policy needed to develop to enable small scale and artisanal miners to become larger scale free from environmental pollution Hakan *et al.,* (2009).

In Africa, in Egypt a study was conducted by Abdelaal *et at.,* (2023) on emerging mercury and methylmercury contamination from new artisanal and small-scale gold mining along the Nile Valley, using remote sensing. The study established huge contamination of the water and air as connected to AGM sites. The study revealed that Hg contamination sources had interaction with their surrounding receptors. The Hg levels in amalgamation-tailing ponds were fourfold higher than USEPA's and eightfold the WHO's thresholds. This is an indication that some AGM sites have more contamination greater than international standards thereby affecting the living condition of the people. Small scale mining in Africa has also caused considerable environmental complications including chronic soil degradation, chemical contamination and air pollution (Owusu- Koranteng, 2008).

In Nigeria, the problem of AGM is non-regulation and lack of proper monitoring of the activities of miners. There is indiscriminate siting of mining business and activities which has resulted to intense air pollution and extreme contamination of water bodies. Thus, there is little or no understanding of when AGM has exceeded the tolerable pollution limit that could be harmful to miners and nearby neighborhood. Therefore, this study seeks to examine the air quality condition of AGM sites during the dry season in Niger State, Nigeria.

**Study Area**

Niger State space under study is located approximately within longitude 4'0"0 E and 7'30"0 E and latitude $8^0$30"0N and $11^0$30"0 N of the GM (Figure 1.1). Niger State is located at the south-eastern Guinea savannah in the North-Central

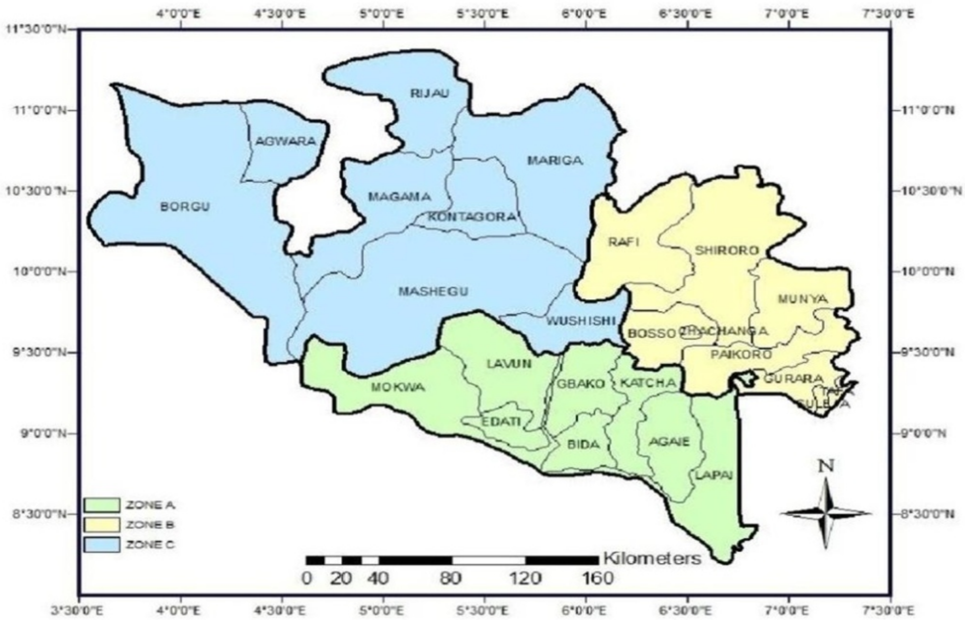


**Figure 1:** Study Area of Niger State showing Zones A, B, C
*Source: NIGIS, 2024*

**Table 1:** List of Sampled Locations

| S/N | AGM Location | LGA | Mineral | Northing | Easting |
|---|---|---|---|---|---|
| **Zone A (Niger South)** | | | | | |
| 1 | Afuwagi | Edati | Gold | 206293 | 1018791 |
| 2 | Kaniyan | Mokwa | Gold | 732437 | 1024554 |
| 3 | Kateregi | Katcha | Gold | 204022 | 1035008 |
| **Zone B (Niger East)** | | | | | |
| 4 | Koropan | Paikoro | Gold | 229326 | 1050208 |
| 5 | Shakwata | Shiroro | Gold | 240032 | 1066591 |
| 6 | Izom | Gurara | Gold | 290064 | 1021980 |
| **Zone C (Niger North)** | | | | | |
| 7 | Sabon Pegi | Mashegu | Gold | 755748 | 1102499 |
| 8 | Anfani | Magama | Gold | 718783 | 1139136 |
| 9 | Nassarawa | New Bussa | Gold | 663899 | 1097226 |

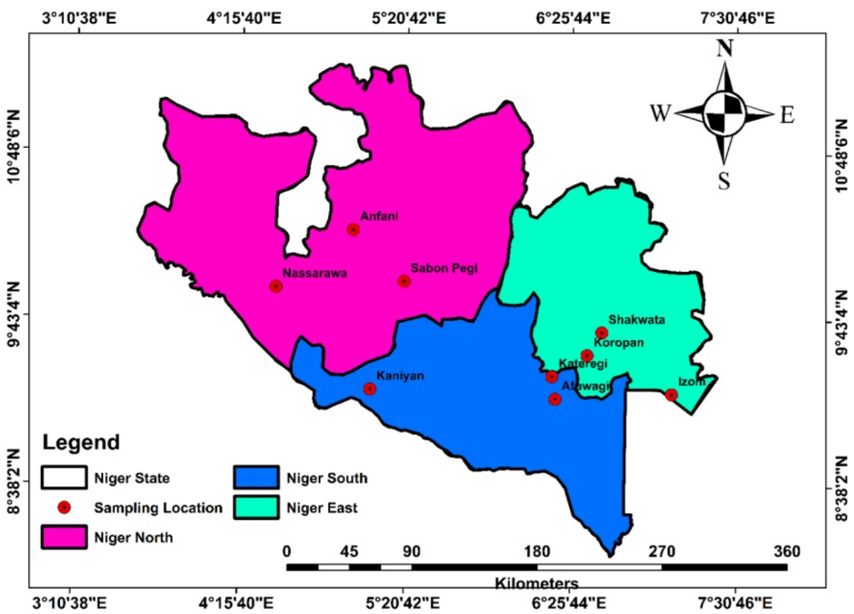


**Figure 2:** Locations of the Sampled AGM Sites

geopolitical zone of Nigeria. The State has boundary in the North with Zamfara State, West with Kebbi State, South with Kogi State, South West with Kwara State, North-East with Kaduna State and South-East with Federal Capital Territory (FCT). The State also has an international boundary with the Republic of Benin, the state has the largest land mass in Nigeria with approximately 76,363KM$^2$. Niger State is hosting the three Hydro-Electric Dams of Shiroro Hydro-Electric Dam; Kainji Hydro-Electric Dam and Jebba making it the power state of the country.

## Materials and Methods

The air quality primary data were directly retrieved from field observation and recording at various hourly interval in dry seasons. The air quality parameters that were collected were Particulate Matter ($PM_{2.5}$), Particulate Matter ($PM_{10}$), Nitrogen Oxide ($NO_x$) and Carbon Oxide ($CO_x$). Secondary data were sourced from journals and satellite remote sensing to ascertain the locations of AGM sites.

This study uses air quality detector instruments to take air quality data at nine selected AGM sites in the three zones (A, B and C) of Niger State. Zone A sites were Afuwagi, Kaniyan and Kateregi. Zone B sites were Chanchaga, Shakwatu and Izom. Zone C sites were Sabon Pegi, Nasarawa and Anfani (Table 1). Thus, 3 AGM sites were selected from each of the three zones of Niger State making it a total of 9 AGM sites (Figure 2). Also, air quality control sites were established to compare air quality characteristics or parameters with that of the AGM sites. The air quality parameters were pollutants of Particulate Matter ($PM_{2.5}$), Particulate Matter ($PM_{10}$), Nitrogen Oxide ($NO_x$) and Carbon Oxide ($CO_x$) respectively. The air pollutants were collected in different hours of the day such as at 0009 (Morning), 1200 (Afternoon) and 1700 (Evening).

Data were analyzed by applying descriptive statistics of simple mean, range, matrices, tables, charts and plates. The Analysis of Variance (ANOVA) statistical tool was engaged to ascertain variation in air quality condition across different hours of the day, variation in air quality condition across different AGM sites and ascertain difference in air quality between wet and dry seasons respectively.

## Air Quality condition of AGM Sites during the Dry Season

During the dry season, the site with the highest concentration of $PM_{2.5}$ was Izom (37μg/m$^3$) as shown in Table 3. This was seconded by Sabon Pegi (25μg/m$^3$) and Anfani (25μg/m$^3$) respectively. The AGM site with the least $PM_{2.5}$ concentration was Kateregi (30μg/m$^3$) during the dry season. Thus, the AGM site with the highest concentration of $PM_{10}$ was Nassarawa (55μg/m$^3$), seconded by Sabon Pegi (54μg/m$^3$) and thirdly by Izom (52μg/m$^3$) and Afuwagi (52μg/m$^3$) respectively. The site with the least $PM_{10}$ was Kateregi (40μg/m$^3$). Also, the highest concentration of CO was noticed in the AGM site of Afuwagi (6.19μg/m$^3$), seconded by Koropan (5.48μg/m$^3$) and thirdly by Sabon Pegi (5.43μg/m$^3$). The AGM site with the least concentration of CO during the dry season was Shakwata (4.46μg/m$^3$). However, the AGM site with the highest concentration of $NO_x$ was Anfani (0.58μg/m$^3$); this was seconded by Shakwata (0.48 μg/m$^3$) and thirdly by Koropan (0.47μg/m$^3$) and Anfuwagi (0.47μg/m$^3$) respectively. The AGM site with the lowest concentration of $NO_x$ was Izom (0.32μg/m$^3$). The concentration of air pollutants at different sites was as a result of the severity of mining activities, nature of chemical composition and climatic parameters that were operational at a particular period.

**Table 3:** State of Air Quality across the AGM Sites during the Dry Season

| AGM Site | $PM_{2.5}$ (μg/m$^3$) | $PM_{10}$ (μg/m$^3$) | CO (μg/m$^3$) | NOx (μg/m$^3$) |
|---|---|---|---|---|
| Afuwagi | 33 | 52 | 6.19 | 0.47 |
| Kaniyan | 33 | 43 | 5.06 | 0.43 |
| Kateregi | 30 | 40 | 4.83 | 0.43 |
| Koropan | 34 | 47 | 5.48 | 0.47 |
| Shakwata | 34 | 44 | 4.46 | 0.48 |
| Izom | 37 | 52 | 4.99 | 0.32 |
| Sabon Pegi | 35 | 54 | 5.43 | 0.43 |
| Anfani | 35 | 51 | 5.19 | 0.58 |
| Nassarawa | 31 | 55 | 5.52 | 0.45 |

*Source: Researcher's Field Work, 2023*

The result showed that the highest concentration of $PM_{2.5}$ was Izom (37μg/m$^3$), it was discovered that air pollutants were lower during the wet season when compared with that of the dry season. This was due to the transportation of pollutants from the north-eastern desert regions which had accelerated particles concentration during the dry season. The study showed that $PM_{2.5}$ contributes to at least 70% of the particulate matter pollution throughout the year which was highest during the dry season (January and February). It therefore suggested that people with chronic respiratory issues should be guided during these critical months of the year (January and February).

## Conclusion and Recommendations

Results of the investigation indicated that $PM_{2.5}$, $PM_{10}$ and Nitrogen Oxide ($NO_x$) have the highest concentration in the evening except $CO_x$. The state of air quality across the various AGM sites during the dry seasons shows that they vary in different sites. The study shows that greater number of AGM sites have exceeded the World Health Organization (WHO) standard limits for atmospheric gas pollution. Some of the AGM sites have Unhealthy air quality health index, indicating that miners in the sites would likely have respiratory symptoms in children and elderly, especially those with asthma and other lung diseases. Also, the spatial distribution of AGM sites showed that miners in the northern part of the state received the highest concentration of pollution dosages. It is recommended that indiscriminate mining activities should be avoided and there should be buffer zone between AGM sites and inhabitable human neighborhood in order to minimize the air pollution hazards to the people.

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