Sokoto Journal of Geographical Studies (SJGS)

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Prof. I. M. Dankani

Editor-in-Chief

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Sokoto Journal of Geographical Studies
Department of Geography
Faculty of Social and Management Sciences
Sokoto State University, Sokoto
P.M.B 2134, Along Birnin Kebbi Road, Sokoto State-Nigeria

Tel: 080-6950-1786 (Secretary Editorial Board)
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AMBIENT AIR QUALITY AND PUBLIC HEALTH RISK ASSESSMENT IN EKPOMA, EDO STATE, NIGERIA

Otabor-Olubor, E., Aghagboren, U. J., Balogun, V. S., Ibanga, O. A., Osakue, P. V. & Asikhia, M. O.

Department of Geography & Disaster Risk Management, Faculty of Social Sciences, University of Benin, Benin City

Corresponding Author's Email: ehiane.otabor-olubor@uniben.edu

Abstract *https://doi.org/10.65760/sjgs.v3.i1.2*

The effect of Air pollution on human health remains a major concern in the society. Poor air quality (AQ) is among the environmental change indicator that threatens human health and being the fourth leading cause of death worldwide. The aim of this study is to assess ambient air quality level in order to protect public health in Ekpoma, Edo State. The study examines the perception of the residents of Ekpoma on the level of Air pollution, sources, effects and the health implications associated with it. The study employed a cross-sectional survey and questionnaire was used to acquire data on the level of air quality and its accompanying effect on health and respondents were residents engaged in any source of livelihood in the study area. Also, geospatial techniques were used in mapping the Particulate Matter Index (PMI) in Ekpoma. Findings indicate that there is a significant awareness of air quality issues in the study area. It also revealed the dissatisfaction of the inhabitants with increasing level of air pollution in their domain due to socioeconomic and environmental factors. Health problems such as respiratory irritations, skin problems, wheezing and coughing were reported. The study recommends an overall modification in the attitude of residents to reduce pollution through the engagement of community leaders and critical stakeholders to encourage the adoption of cleaner practices alongside a comprehensive air quality monitoring system to enable a continuous and effective management of air pollution across the study area.

Keywords: *Air Quality, Pollution, Geospatial techniques, Particulate Matter and Public Health.*

Introduction

The importance of air quality for all humans and other creatures globally cannot be overemphasized, underscored by its inclusion in the UN Sustainable Development Goals (SDG 3 and 11). Air quality reflects the level of pollutants in the atmosphere such as $PM_{2.5}$, ozone, sulphur oxides, and nitrogen oxides; and determines the extent to which air remains safe for humans, animals, and ecosystems (WHO, 2018). Air pollution is the world's leading environmental health threat, responsible for about seven million premature deaths yearly, primarily due to outdoor $PM_{2.5}$ exposure (WHO, 2018, 2021).

In developing areas like Ekpoma, Edo State, research on knowledge, attitudes, and perceptions of air quality remains limited. Prolonged exposure to $PM_{2.5}$ and PM_{10} has been linked to respiratory, cardiovascular, and other systemic diseases (Giannadaki *et al*., 2016; Kampa & Castanas, 2007). With 92% of the global population exposed to air exceeding WHO particulate limits (Kirby, 2016), major sources such as industrial activities, power generation, and vehicular emissions continue to intensify urban pollution in Nigerian cities including Benin City, Warri, and Auchi (Balogun & Orimogunje, 2015). Air quality mapping thus provides essential spatial-temporal data for forecasting and policy decisions (Oyebanji *et al*., 2012).

This study adopts the Air Quality Index (AQI) and Environmental Monitoring (EM) frameworks. AQI offers standardized measurement and public awareness tools for managing pollution and predicting air conditions while EM systematically collects environmental data to detect trends and guide interventions (Kuklinska *et al*., 2015). The study focuses on atmospheric monitoring in Benin City, Ekpoma, and Auchi using both ground-based and satellite systems for effective, broad-scale air quality assessment.

Problem Statement/Objectives

Deteriorating air quality is one of the foremost ecological threats to public health globally, especially in sub-Saharan Africa (SSA). The global health cost of exposure to polluted air is estimated at about 8.1 trillion USD, with SSA recording higher death and hospitalization rates (World Bank, 2022). Nigeria, with over 200 million people and a heavy reliance on fossil fuels, ranks fifth among the most polluted countries, recording 70.4 $\mu g/m^3$ $PM_{2.5}$ exposure.

Globally, poor air quality remains a major environmental challenge, threatening health, economic growth, and poverty reduction. Nearly 99% of the world's population is exposed to unsafe air, with developing countries worst affected (WHO, 2021). Poor air quality ranks as the fourth leading cause of death after hypertension, malnutrition, and drug abuse (Rafaj and Amann, 2018), resulting in a global economic loss of 8.1 trillion USD, or 6.1% of GDP, in 2019 (World Bank, 2022).

In Southern Nigeria, particularly Edo State, ambient air quality continues to decline due to anthropogenic and socio-economic activities. However, limited empirical studies on air quality mapping and on public Knowledge, Attitude, and Perception (KAP) constrain policy development on pollution mitigation and adaptation.

The specific objectives of this study are to:

(i) ascertain the Knowledge, attitude and perception (KAP) of the causes of poor air quality and associated health risks in the study area.

(ii) examine the socio-economic, demographic and health status of residents of the study area.

(iii) evaluate the environmental concerns relating to air quality in the study area.

Materials and Methods

Study Area

The study was carried out in Ekpoma, Edo State as shown in figure 1 and is located in Esan West Local Government Area, in Edo Central Senatorial District. It lies between latitudes 6°28'0" N to 6°49'0" N and Longitudes 6°00'0" E to 6°13'0" E (Figure 1) with an estimated land Area of 502 km^2 and a population size of 125,842 persons which is projected to be 192,732 persons using the population growth rate of 2.78% (NPC, 2006). Ekpoma Town is of a humid tropical climate and possesses a tropical Savannah vegetation type, with an average annual temperature of 30.5°C and annual mean rainfall of 19.23mm (7.57 inches) (Odjugo *et al*., 2015). Rainfall in Ekpoma has a double peak with highest amount of rainfall in July and September and least rainfall in December. The highest yearly recorded temperature in Ekpoma is between 36°C and 38°C which is usually in the month of March (Odjugo *et al*., 2015). The people of Ekpoma are into educational, banking and agricultural activities amongst many others.

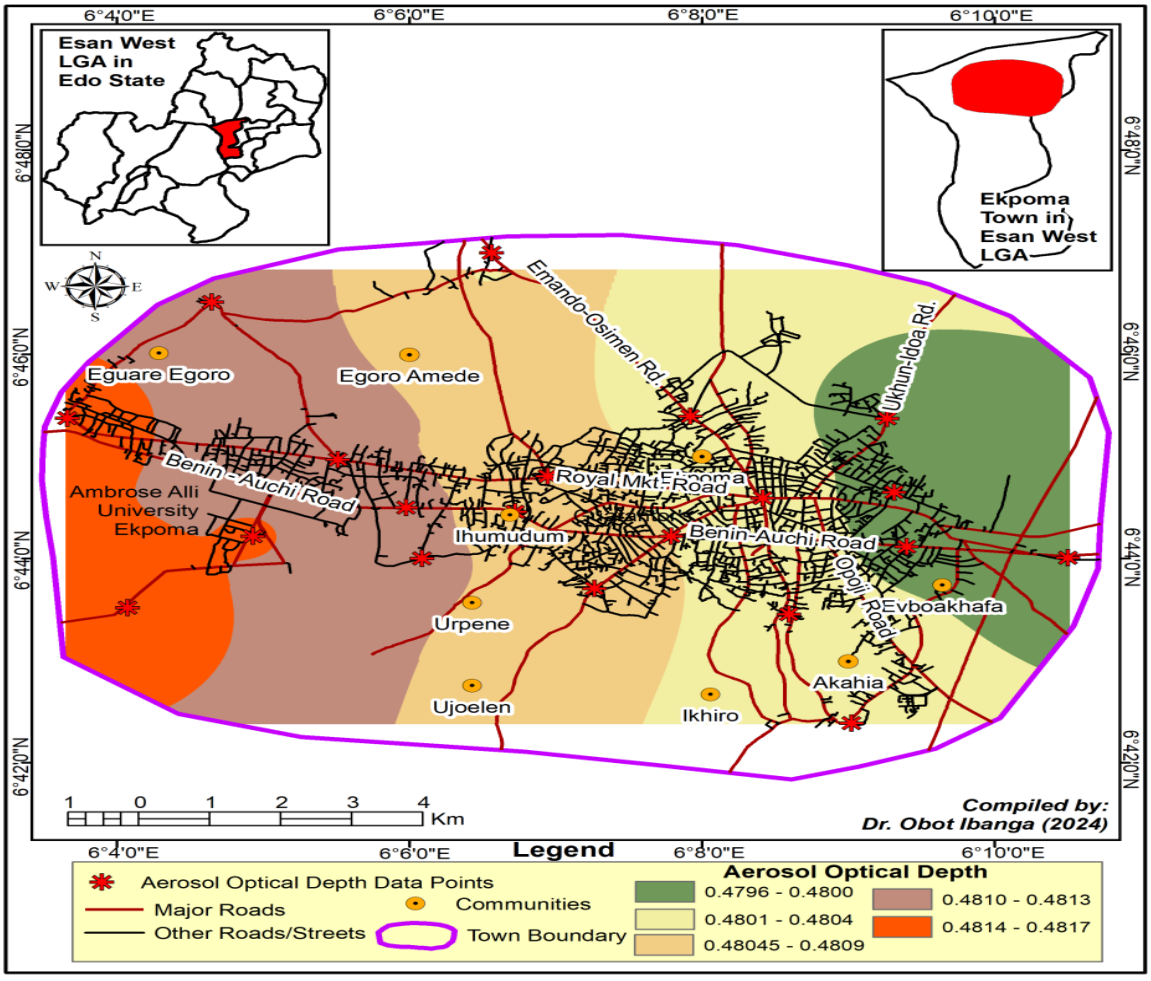

Figure 1: Ekpoma Showing Aerosol Optical Depth Data Extraction Points
Source: Compiled by the Researchers using Open Street Map Database (2024)

Sampling Framework and Sample Size Determination

Regarding the field survey, multi-stage, purposive and simple random techniques was used while the choice of respondents comprised of people residing and/or engaging in one form of livelihood activities in the study area. To arrive at the proposed sample size, 2006 population figures of the proposed selected towns were arithmetically projected to the end of 2022 using Edo State growth rate of 2.7%. This resulted in a population 192,732 people and using online sample size calculator at 95% confidence level and 3% margin of error, the sample size of 200 was achieved. Data was sourced from field survey, aided by well-structured questionnaires, personal observation and focus group discussion (FGD).

Air Quality Sampling Procedure and Analysis

A mixed research design integrating remotely sensed geospatial data and field surveys was adopted to achieve the objectives of the study and test its hypotheses. Two main datasets were utilized: ground-based $PM_{2.5}$ measurements and satellite-derived Aerosol Optical Depth (AOD) data obtained from Purple Air, NASA, and the Copernicus Atmosphere Monitoring Service (CAM) Emissions of Atmospheric Compounds and Compilation of Ancillary Data (ECCAD); and field survey data collected through structured questionnaires, personal observations, and focus group discussions (FGDs).

The AOD dataset contained monthly gridded temporal emission profiles from key anthropogenic sources such as energy production, residential combustion, industry, road transport, and agriculture. Data quality followed established research standards (Junker & Liousse, 2008; Höglund-Isaksson, 2012; Klimont *et al*., 2013). Gridded AOD files in NetCDF format were converted into raster layers, and site-specific numerical values were extracted in ArcGIS 10.8 using spatial coordinates (x, y). These were transferred to Microsoft Excel where $PM_{2.5}$ concentrations were computed using the equation proposed by van Donkelaar *et al*. (2012):

$$PM_{2.5} = AOD \times 46.7 + 7.13 \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad (1)$$

In this equation, 46.7 and 7.13 serve as empirical constants for estimation and Balogun *et al.* (2024) validated the predictability ability of this formula using ground-based PurpleAir Air $PM_{2.5}$ datasets with a resultant regression coefficient (R) of 0.99 at 2.75 standard error of the approximation.

Results and Discussion

Socio-Demographic Characteristics of Respondents, Analysis of the Knowledge, Attitude and Perception (KAP) on Air Quality and Associated Environmental Concerns.

This section deals with the analysis of the socio-demographic characteristics of respondents in the study area such as the age, sex, marital status, educational attainment, occupation, monthly income and religion. It also covers respondents' knowledge, attitude and perception (KAP) on air quality, as well as environmental concerns.

Table 1: Age Bracket by Sex of Respondents

Age Bracket of Respondents		Sex of Respondents		
		Male	**Female**	**Total**
Less than 18 years	Count	14	16	30
	% within Age Bracket of Respondents	46.7%	53.3%	100.0%
18-64 years	Count	96	63	159
	% within Age Bracket of Respondents	60.4%	39.6%	100.0%
65 and above	Count	7	8	15
	% within Age Bracket of Respondents	46.7%	53.3%	100.0%
Total	Count	117	87	204
	% within Age Bracket of Respondents	57.4%	42.6%	100.0%

Source: Author's Field Survey, 2024

The results in Table 1 display the percentage and sex breakdown of respondents. Out of 204 respondents, males constituted 57.4%, while females accounted for 42.6%. The majority (77.9%) were within the 18-84 years age bracket, followed by 14.7% which are respondents below 18 years while 7.4% were aged 65 years and above. This shows that majority of the individuals are adults and belong to the economically active age group and are likely exposed to daily outdoor and occupational air quality conditions. The higher proportion of male respondents suggests greater mobility and interaction with pollution sources which is relevant to assessing ambient air quality exposure in Ekpoma. The results align with similar demographic distributions in Nigeria where over 70% of respondents were within the active age bracket. (Adewale *et al*., 2024; Ibrahim *et al*., 2023).

Table 2: Current Health Status of Respondents

	Frequency	Percentage
Excellent	80	39.2
Very Good	81	39.7
Good	21	10.3
Fair	3	1.5
Poor	2	1.0
Cannot tell	17	8.3
Total	**204**	**100.0**

Source: Author's Field Survey, 2024

Table 2 shows the current health status of respondents in the study area. The majority (39.7%) rated their health as very good while 39.2% described it as excellent. About 10.3% and 8.3% rated their health as good and fair respectively and only 1.0% reported poor health. This distribution indicated that most respondents enjoy good health and is in line with the findings in Table 1 indicative of a relationship between the youthfulness of the population and the generally good health and vitality of the population. Adedeji and his colleagues also reported that although residents recognized air pollution from cement factories, over 60% rated their health as 'good' or 'very good'.

Table 3: Level of Awareness on Air Quality Issues

	Frequency	Percentage
Very well informed	**84**	**41.2**
Informed	**63**	**30.9**
Not well informed	**33**	**16.2**
Not informed at all	**14**	**6.9**
Cannot tell	**10**	**4.9**
Total	**204**	**100.0**

Source: Author's Field Survey, 2024

Table 3 presents the respondents' level of awareness of air quality issues in Ekpoma. The majority (41.2%) indicated they were very well informed while 30.9% reported being informed. About 16.2% were not well informed and the smaller proportion of 6.9% and 4.9% stated that they were not informed at all or could not tell. This indicated a generally high level of awareness of air quality issues among the respondents and may also reflect an increased public exposure and understanding of air quality concerns which is essential for promoting sustainable environmental practices in the area. This result is in line with the findings of Ajayi *et al.* (2023) who reported that 78.9% of respondents were aware of the haze from vehicle emissions and its adverse health effects in Lagos state. A similar study conducted in Southwest Nigeria showed that 54.4% of aware of indoor air pollution issues. (Ibrahim *et al*. 2025).

The findings of this research also show that most respondents (40.7%) believe the worst air quality in Ekpoma occurs in the afternoon, followed by the evening (29.4%), morning (10.3%), and night (6.7%). This pattern is attributed to increased daytime activities particularly heavy traffic and commercial operations which produce pollutants like smoke and dust. Additionally,

58.3% of respondents indicated that air quality is poorest during the dry/harmattan season, compared to 33.8% during the rainy season and 7.8% who said poor air quality can occur in any season. Overall, the findings highlight that Ekpoma experiences its worst air quality in the afternoons and during the dry/harmattan season due to intensified human and environmental activities.

Table 4: Major Sources of Air Pollution

	N	Minimum	Maximum	Mean	Std. Deviation
Household cooking	204	1	3	1.81	.746
Fuel-powered generating set	204	1	3	1.19	.470
Emissions from vehicles	204	1	3	1.21	.513
Emissions from industries/factories	204	1	3	1.67	.792
Dust from the ground	204	1	3	1.11	.400
Bush burning	204	1	3	1.49	.719
Burning of refuse	204	1	3	1.27	.606
Pollen	204	1	3	1.88	.897
Valid N (listwise)	204				

Source: Author's Field Survey, 2024

Table 4 shows the major sources of air pollution in the study area. Pollen, household cooking and emissions from industries/factories are the most prominent sources of air pollution given their mean score and standard deviation of 1.88, 0.897; 1.81, 0.746 and 1.67, 0.792 respectively. Emissions from vehicles, fuel-powered generating set and bush burning are other significant sources of air pollution in Ekpoma. Burning of refuse, and dust from the ground were the least significant sources of air pollution in the study area according to respondents. Similar research showed that 74.26% of Nigeria depend on traditional fuel. (Abubakar *et al.,* 2024).

In terms of respondents' experience of irritation in the eyes, nose or throat due to exposure to poor air quality, 71.1%, consisting of the majority of respondents affirmed their experience of irritation due to exposure to poor air quality with 23.0% stating that they have not had such experience as seen in figure 6. It can be deducted from the above that while the majority of respondents have experienced irritation of the eyes, nose or throat due to exposure to poor air quality, a significant proportion of the study population have not experienced such irritation. Poor air quality has also been proven to exacerbate respiratory issues such as asthma.

Table 5: Level of Concern About the Impact of Climate Change on Air Quality

	Frequency	Percentage
Extremely concerned	22	10.8
Very concerned	96	47.1
Moderately concerned	49	24.0
Slightly concerned	29	14.2
Not at all concerned	8	3.9
Total	**204**	**100.0**

Source: Author's Field Survey, 2024

Table 5 shows the respondents' level of concern on the impact of climate change on air quality. The high level of concern among respondents in Ekpoma regarding climate change and air quality with 47.1% being "very concerned" and 10.8% being "extremely concerned" is consistent with empirical research in Nigeria showing rising awareness of environmental risks. For example, rural farmers in southwestern Nigeria reported 72.8% recognition of climate change (Ayanlade *et al*., 2018), while a study in Lagos showed that air pollution and climate change were increasingly treated as interconnected public health challenges (Komolafe *et al*., 2014). These findings support the interpretation that the population in Ekpoma is not only aware of air quality issues, but views climate change as a significant factor in future ambient air-quality risk.

Table 6: Level of Concern About the Impact of Solid Waste Management on Air Quality

	Frequency	Percentage
Extremely concerned	53	26.0
Very concerned	106	52.0
Moderately concerned	26	12.7
Slightly concerned	14	6.9
Not at all concerned	5	2.5
Total	**204**	**100.0**

Source: Author's Field Survey, 2024

Table 6 shows that the majority of respondents (52.0%) were very concerned and 26.0% extremely concerned about the effect of solid waste management on air quality, while only 2.5% were not at all concerned. This indicates high environmental awareness among residents. This result is consistent with findings from Ogun and Lagos States where household surveys similarly report high public awareness of waste-management failures and concern about open dumping and burning as drivers of air and health hazards (Olukanni *et al*., 2020; Etim *et al*., 2024).

Table 7: Level of Concern About the Impact of Bush Burning on Air Quality

	Frequency	Percentage
Extremely concerned	19	9.3
Very concerned	122	59.8
Moderately concerned	37	18.1
Slightly concerned	17	8.3
Not at all concerned	9	4.4
Total	**204**	**100.0**

Source: Author's Field Survey, 2024

Table 7 presents respondents' level of concern about the impact of bush burning on air quality in the study area. 59.8% of respondents were very concerned and 9.3% extremely concerned about the impact of bush burning on air quality, while only 4.4% expressed no concern. This underscores public recognition of bush burning as a key pollution source. Similar studies in Cross River and Benue States show that respondents recognise smoke, vegetation loss and soil degradation as outcomes of bush burning (Ambe *et al*., 2014; Ezihe *et al*., 2020).

Temporal and Spatial Variations in $PM_{2.5}$ Concentration in Major Cities in Edo State

The pattern and trend of $PM_{2.5}$ concentration in Ekpoma, Edo State Nigeria from 2012 to 2023 was evaluated. Detailed evaluation of the results shows a number of fascinating features about $PM_{2.5}$ concentration in this town. Describing the air quality indicator descriptively in Table 8, it could be seen that the mean concentration of $PM_{2.5}$ in the study period (2012-2013) in Ekpoma was 24.43µg/m^3 with Standard Deviation (SD) 2.51µg/m^3.

Table 8: Descriptive Statistics of $PM_{2.5}$ Concentration in Ekpoma, Edo State

Statistics	Ekpoma
Mean	24.430
Standard Deviation	2.5143
Variance	6.322
Range	7.1
Minimum	21.4 (2013)
Maximum	28.5 (2017)
Coefficient of variation (%)	10.29
Number of years	12

Data Analysis by the Researchers (2024)

$PM_{2.5}$ concentrations in Ekpoma ranged from 7.2 µg/m³ (CV = 10.29%) with peak and minimum annual values of 28.5 µg/m³ (2017) and 21.4 µg/m³ (2013) respectively. Monthly variation revealed the highest concentration in February (52.44 µg/m³) and the lowest in July (12.19 µg/m³), reflecting seasonal influences where precipitation in the wet season reduces particulate levels. These patterns align with Adeyemi *et al*. (2021), Levi-Okoli *et al*. (2021), and Wang *et al*. (2023), who similarly observed lower $PM_{2.5}$ levels during wet seasons and dissolution effects of rainfall on particulate matter.

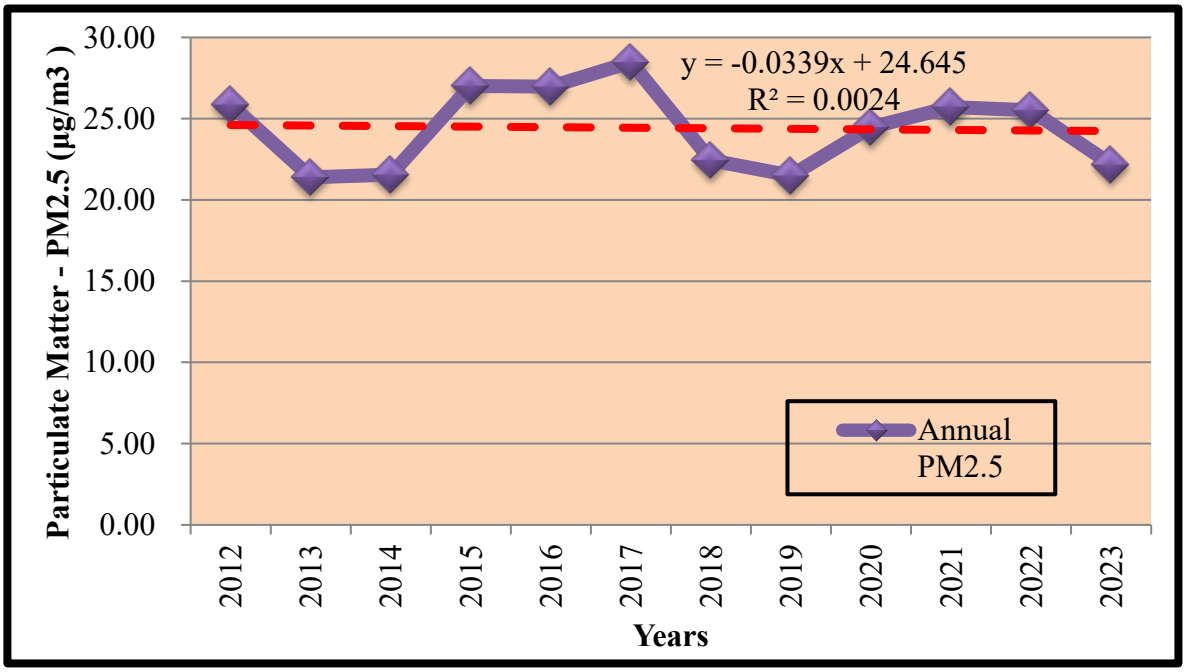

Figure 2: Annual Trends of $PM_{2.5}$ Concentration in Ekpoma
Source: Data Analysis by the Researchers (2024)

Figure 2 showed a slight annual decline in Trend analysis (0.033 µg/m³) in Ekpoma, with notable fluctuations; an increase of 5.46 µg/m³ (2014–2015) and a decrease of 6.05 µg/m³ (2017–2018). Conversely, Auchi exhibited a significant upward trend (0.457 µg/m³ per year), marked by an increase of 28.33 µg/m³ (2017–2018) and a sharp decline of 30.11 µg/m³ (2019–2020), suggesting spatial differences in pollution dynamics across the two urban areas.

Particulate Matter $PM_{2.5}$–based Air Quality Index Maps in Ekpoma, Edo State

The $PM_{2.5}$-based Air Quality Index (AQI) maps for Ekpoma from 2012 to 2023 reveal largely moderate pollution levels across the town. In 2012, 97.91% of the town recorded an AQI of 80 (Moderate, 51–100), with 2.09% in the eastern flank classified as Good (0–50). From 2013 to 2018 and 2021–2023, the AQI exhibited a mostly homogeneous distribution, maintaining a Moderate classification, with yearly averages of 69 (2013), 71 (2014), 82 (2015–2016), 84 (2017), 71 (2018), 80 (2021–2022), and 71 (2023). Slight spatial variations were observed in 2019 (AQI 69–71) and 2020 (AQI 76–78), yet overall pollution levels remained Moderate. These patterns indicate persistent moderate air pollution in Ekpoma over the decade, with limited spatial disparities.

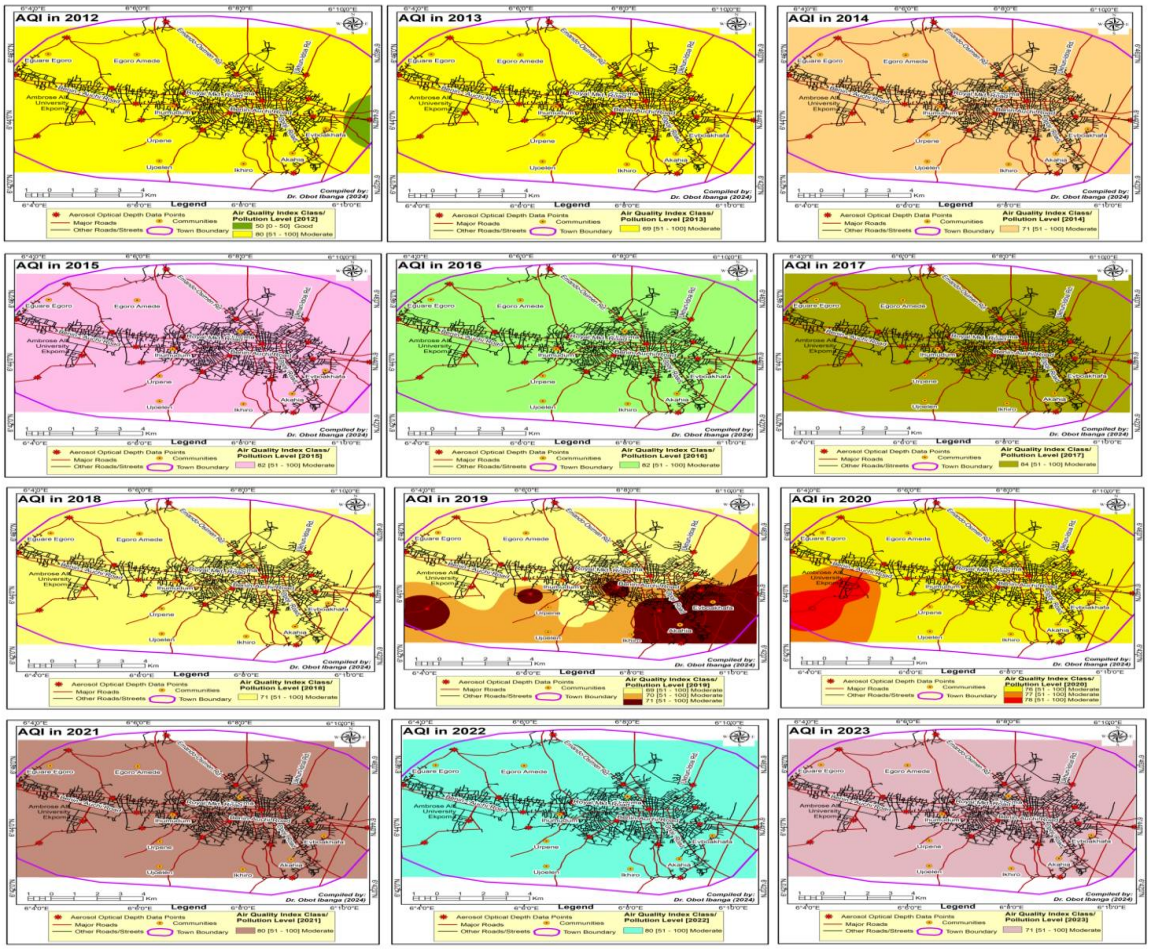

Figure 3: Particulate Matter $PM_{2.5}$-BasedAir Quality Index Maps in Ekpoma Town (2012- 2023)

Survey data in Ekpoma align with AQI patterns, with 81.4% of respondents reporting pollution at home or work. Moderate pollution was noted by 34.8%, while 61.7% were dissatisfied with air quality. Major pollution sources include pollen, household cooking, industrial emissions, vehicle emissions, generators, and bush burning, especially during the dry/harmattan season.

Conclusion and Recommendations

This study evaluated ambient air quality and public health risks in Ekpoma, Edo State, aiming to examine pollution, associated health risks, and identify gaps for interventions. The population is predominantly young (17–64 years), with most reporting relatively good health despite high awareness of air pollution. Respondents noted the worst pollution occurs in afternoons and the dry season, and many felt air quality has remained the same or worsened over the past year.

Major pollution sources include pollen, industrial emissions, household cooking, vehicle emissions, generators, dust, bush burning, and refuse burning. Health impacts reported were eye, nose, and throat irritation, wheezing, coughing, chest tightness, skin problems, and exacerbation of existing conditions. Many respondents avoid outdoor activities or rely on medications during poor air quality. Concerns about sanitation, hygiene, climate change, and waste management highlight the interconnectedness of environmental factors, emphasizing the need for targeted interventions, policy measures, and community engagement to improve air quality and public health in Ekpoma.

The following recommendations are provided to address the issues surrounding Ambient Air Quality and Public Health Risk in Ekpoma, Edo State:

1. To effectively address air pollution and improve air quality, a comprehensive monitoring system is essential to continuously assess pollutant levels across the town. Identifying pollution hotspots allows authorities to prioritize interventions and allocate resources effectively. Stricter regulations should control industrial emissions, vehicular pollution, and other major sources, while collaboration with industries, transport agencies, and urban planners can promote emission control and cleaner technologies. These measures are crucial for reducing pollutants and enhancing overall air quality in the city.
2. Raising awareness of air pollution's health impacts is vital. Integrating air quality education in schools and engaging communities through workshops and campaigns empowers residents to make informed choices, benefiting both health and the environment.
3. Investing in green infrastructure projects is paramount to mitigate air pollution and improve overall air quality. Initiatives such as urban green spaces, tree planting programs, and the promotion of green building designs can help absorb pollutants and reduce their impact on the environment. Green spaces and planting of trees should be encouraged in order to keep the air clean and healthy.
4. Renewable fuel and clean energy production such as the use of solar energy, wind and geothermal should replace fossil fuels and others. This will go a long way in reducing the rate of air pollution and the release of toxins to the atmosphere.
5. Enhancing healthcare capacity, implementing early warning systems, and fostering partnerships with NGOs and government agencies are key to effectively managing air pollution-related health risks.
6. The Government and Private sector should promote electric vehicles, public transit, cycling, and renewable energy can reduce emissions, improve air quality, and support public health.

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