
ASSESSMENT OF POLLUTION AND ITS ASSOCIATED RISKS TO PUBLIC HEALTH IN BAUCHI STATE, NIGERIA

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ABSTRACT

Environmental pollution remains a major public-health concern in many developing nations, including Nigeria, where poor waste management, urbanization, and industrialization continue to degrade air, water, and soil quality. This study assessed the levels of environmental pollution and its associated health risks among residents of Bauchi Local Government Area, Bauchi State. A cross-sectional research design was employed, combining field sampling, laboratory analysis, and structured questionnaires to collect data on pollution indicators and health outcomes. Air, water, and soil samples were analyzed for key

parameters including particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), heavy metals (lead, cadmium, and chromium), and microbial contaminants (E. coli and total coliforms). Findings revealed that concentrations of most pollutants exceeded World Health Organization (WHO) and Nigerian permissible limits, indicating significant environmental contamination. Health data showed a high prevalence of pollution-related diseases such as respiratory infections, diarrhoea, skin rashes, and eye irritation among residents living near dumpsites, roadsides, and industrial zones. Statistical analysis demonstrated a positive correlation between exposure to pollution and the incidence of these health conditions. The study concludes that environmental pollution in Bauchi LGA poses serious risks to public health, largely due to anthropogenic activities and weak environmental governance. It recommends the enforcement of environmental regulations, improved waste management systems, enhanced public awareness, and regular pollution monitoring. The findings provide a vital evidence base for policymakers and environmental health authorities to design effective interventions for pollution control and disease prevention in Bauchi State.

KEYWORDS: Environmental pollution, public health, Bauchi LGA, air quality, water contamination, heavy metals, Nigeria.

1. INTRODUCTION

1.1 Background of the Study: Environmental pollution is a major global determinant of public health, contributing to millions of premature deaths annually due to contaminated air, water, and soil World Health Organization (2023). In low- and middle-income countries, rapid urbanization, weak regulatory systems, inadequate infrastructure, and limited health-surveillance capacity intensify pollution-related disease burdens (World Health Organization, 2023).

In Nigeria, population growth, industrial and vehicular emissions, biomass fuel dependence, and ineffective waste-management systems create multiple exposure pathways. In northern regions such as Bauchi State, environmental degradation is further aggravated by deforestation and desertification, which increase dust levels, soil erosion, and reduce natural pollutant filtration (Pona et al., 2021). Bauchi LGA, characterized by dense settlements, commercial hubs, and peri-urban expansion, faces pollution sources including traffic emissions, small-scale industries, biomass fuel use, and poor waste disposal (BASEPA, 2024). Empirical evidence highlights rising vehicular carbon emissions (15–40% increases in certain corridors), dust and noise pollution from quarrying in areas such as Birshin Fulani, and

deforestation linked to illegal charcoal production (Daily Post, 2024; Buteh et al., 2023). Although environmental protection frameworks such as the Environmental Impact Assessment (EIA) Act exist, enforcement and monitoring remain weak, and local environmental data are limited. Drinking-water sources, particularly shallow wells and boreholes, are vulnerable to microbial and chemical contamination, as observed in similar Nigerian contexts (Adamu, 2022; Federal Ministry of Environment, 2022).

Air pollution from particulate matter (PM_{2.5}, PM₁₀), vehicle emissions, biomass smoke, and waste burning poses risks of respiratory and cardiovascular diseases (World Bank, 2020). Open dumping contributes to soil and groundwater contamination, methane emissions, and disease-vector proliferation (Haruna, 2020; EnviroNews Nigeria, 2024). Vulnerable groups—children, pregnant women, the elderly, and individuals with pre-existing illnesses—face heightened risks, including diarrhoeal diseases, pneumonia, and household air pollution effects (Isukuru et al., 2024).

Socio-economic challenges, informal settlements, weak land-use planning, and low environmental awareness further compound pollution exposure in Bauchi LGA. Despite recent government interventions addressing localized crises such as the Birshin Fulani pollution issue, comprehensive LGA-level data linking environmental exposure to health outcomes remain lacking (The Cable, 2023).

Therefore, this study is timely and necessary to generate localized evidence through field assessment, mapping, and health-risk estimation, thereby supporting targeted interventions, policy formulation, and sustainable environmental health management in Bauchi LGA.

1.2 Research Gap: Existing literature confirms strong links between environmental pollution and adverse public health outcomes in Nigeria; however, most studies remain narrow in scope and rarely integrate multiple pollution pathways within a unified analytical framework, limiting understanding of cumulative risks and weakening policy responses (Pona et al., 2021). In Bauchi LGA, research is fragmented and often focused on single media such as air or water, with limited evidence on combined exposure patterns and seasonal variability (Muhammad, 2025). Inadequate access to modern environmental monitoring equipment further constrains data accuracy, while weak enforcement of existing environmental laws at state and local levels due to resource limitations reduces policy effectiveness (FME, 2022). These gaps highlight the urgent need for comprehensive, LGA-level assessments that integrate environmental measurements with health data to generate actionable, localized evidence.

Additionally, public health systems lack structured environmental surveillance mechanisms, as many health facilities do not routinely collect or analyze pollution-related disease data. Integrating environmental indicators into health information systems would strengthen monitoring, support early detection of emerging threats, and improve preventive planning World Health Organization (2023). A comprehensive assessment of pollution and associated health risks in Bauchi LGA is therefore essential to bridge knowledge gaps, enhance environmental governance, inform evidence-based interventions, and support Nigeria's national and international health and environmental objectives.

2.0 RESEARCH METHODOLOGY

2.1 Study Area: The study was conducted in Bauchi Local Government Area, the administrative headquarters of Bauchi State located in the northeastern region of Nigeria between latitude 10°18'N and longitude 9°49'E. Bauchi LGA covers an area of approximately 3,687 square kilometers and experiences a tropical climate characterized by a rainy season from May to October and a dry season from September to December, 2025 with annual rainfall ranging from 700 mm to 1,000 mm and an average temperature of 28°C. The area has a projected population of about 700,000 people based on 2023 estimates by the National Population Commission (NPC, 2023). Major sources of pollution in the LGA include unregulated waste disposal, vehicular emissions, industrial effluents, and open burning of refuse. The growing population, rapid urbanization, and poor environmental management practices make Bauchi LGA suitable for assessing the extent of pollution and its health implications.

2.2 Target Population: The target population for this study comprises residents of Bauchi Local Government Area, especially those living near pollution-prone zones such as dumpsites, industrial clusters, busy motor parks, and densely populated neighborhoods. The study were also include health workers, environmental officers, and municipal waste management personnel who possess professional insight into local environmental and health challenges. The population encompasses adults, adolescents, and children who are potentially exposed to environmental pollutants through air, water, or soil. Health records from selected hospitals and primary health care centers was reviewed to identify common pollution-related illnesses such as respiratory infections, diarrheal diseases, and dermatological conditions prevalent in the area.

2.3 Research Design: This study adopted a cross-sectional descriptive research design that integrates both quantitative and qualitative methods to assess pollution levels and their associated health risks in Bauchi Local Government Area (LGA) of Bauchi State. The design enables the collection of environmental and health-related data simultaneously, allowing the researcher to describe and analyze existing relationships between pollution exposure and public health outcomes within the community. Quantitative data was obtained from laboratory analyses of air, water, and soil samples, while qualitative data was collected using structured questionnaires and key informant interviews to capture community perceptions and experiences regarding environmental pollution. This mixed-method design ensures triangulation of data and enhances the validity of the findings by linking objective environmental measurements with subjective health perceptions (Creswell & Creswell, 2018).

2.4 Sample Size Determination: The sample size was determined using the Fisher's formula (2008) for estimating sample size in cross-sectional studies:

$$n = Z^2 \times p(1 - p) / d^2$$

Where:

= desired sample size

= standard normal deviation corresponding to 95% confidence level (1.96)

= estimated prevalence of HPV infection from previous studies (assumed 0.30 or 30%)

= margin of error (0.05)

$$n = (1.96)^2 \times 0.30(1 - 0.30) / (0.05)^2 = 322.7$$

After adjusting for a 10% non-response rate, the final sample size will be approximately 355 participants. This sample is considered adequate to ensure sufficient statistical power to detect significant associations between STI history and HPV infection within the target population.

2.5 Ethical Considerations: Ethical approval was obtained from the Bauchi State Ministry of Health Research Ethics Committee, and permission was sought from relevant local authorities before commencing data collection. Participants will be provided with detailed information about the purpose and procedures of the study and their rights to voluntary participation. Written or verbal informed consent was obtained before administering questionnaires or interviews. Confidentiality was maintained through the use of codes instead of personal identifiers, and collected data was stored securely and used solely for academic

purposes. Environmental sampling was followed safety and regulatory guidelines to prevent harm to participants or the environment.

2.6 Sampling Techniques: A multistage sampling technique was employed for this study. In the first stage, five wards was randomly selected from the total wards in Bauchi LGA. In the second stage, four communities was randomly chosen from each selected ward, making a total of 20 communities. In the final stage, systematic random sampling was used to select households within each community, with one eligible respondent chosen per household. For environmental sampling, a purposive sampling approach was used to select pollution hotspots such as dumpsites, industrial areas, and residential neighborhoods near waste accumulation points. This combination of random and purposive sampling ensures that the study captures both general population exposure and site-specific pollution risks.

2.7 Data Collection Instruments: The data collection process will utilize structured questionnaires, environmental sampling, and key informant interviews (KIIs). The questionnaire were consist of sections on socio-demographic characteristics, knowledge and perceptions of pollution, exposure pathways, and self-reported health effects. It was interviewer-administered in both English and Hausa languages to accommodate literacy differences. Environmental samples include were air, water, and soil analyses. Air quality was measured using portable PM_{2.5} and PM₁₀ sensors, while water samples from wells, boreholes, and streams were analyzed for physicochemical and microbiological parameters following WHO (2023) standards. Soil samples from dumpsites and nearby residential areas were tested for heavy metals using Atomic Absorption Spectrophotometry (AAS). KIIs was conducted with environmental health officers, community leaders, and waste management officials to obtain expert insights and contextual information about pollution challenges in Bauchi LGA.

2.8 Validation and Reliability of Instruments: The research instruments were undergo validation and reliability testing to ensure accuracy and consistency of data collection. Content and face validity were established through expert review by professionals in environmental science and public health from Galaxy College of Health Technology, Bauchi. A pilot study were conducted in a nearby community not included in the main study to test the questionnaire's clarity, comprehensiveness, and language appropriateness. Data from the pilot test were analyzed using Cronbach's Alpha to assess internal consistency, with a

reliability coefficient of 0.70 or higher considered acceptable (Tavakol & Dennick, 2011). Based on pilot findings, necessary modifications were made to refine the instruments before actual field data collection.

2.9 Data Analysis: Collected data was analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics such as means, frequencies, and percentages were used to summarize socio-demographic characteristics, pollution awareness, and environmental parameters. Inferential statistics including Chi-square tests and Pearson correlation analysis were employed to examine associations between pollution exposure and health outcomes, with significance established at $p < 0.05$. Laboratory results for air, water, and soil quality were compared against WHO and NESREA permissible limits to assess compliance and pollution severity. Qualitative data from KIIs was analyzed using thematic analysis, identifying recurring themes and patterns related to pollution sources, community perceptions, and health implications.

3. RESULTS

3.1 Socio-Demographic Characteristics of Respondents: A total of 422 respondents participated in the study across selected wards and communities within Bauchi LGA. The majority (56.2%) were male, while 43.8% were female, with a mean age of 34 years ($SD = 10.5$). Most respondents (62%) had attained at least secondary education, while 18% had no formal education. The predominant occupation was trading (30%), followed by civil service (25%), and artisanship (20%), while 15% were students and 10% were unemployed. About 70% of respondents reported living within 500 meters of dumpsites, major roads, or industrial areas. The demographic distribution reflects a population at risk of environmental exposure due to residential proximity to pollution sources and occupational engagement in informal or outdoor work, similar to findings by Pona et al. (2021) and Buteh et al. (2023).

3.2 Sources and Types of Pollution in Bauchi LGA: Respondents identified multiple sources of pollution within their communities. The most frequently mentioned were open waste dumping (82%), vehicle emissions (75%), and open burning of refuse (68%), followed by industrial discharge (42%) and poor drainage (37%). Field observations confirmed the prevalence of unregulated waste-disposal sites, stagnant wastewater channels, and clusters of informal auto-mechanic workshops generating oil and metal residues. These findings align with the reports by Usman (2017) and Haruna (2020), which highlighted inefficient solid-

waste management and poor environmental regulation in urban Bauchi. The combination of domestic, industrial, and vehicular pollutants contributes to cumulative environmental degradation and public health risks.

3.3 Air Quality Assessment: Air-quality measurements conducted across 20 sampling sites revealed significant variations in pollutant concentrations. The mean concentration of PM_{2.5} was 67 µg/m³, while PM₁₀ averaged 125 µg/m³, both exceeding the WHO (2023) recommended limits of 15 µg/m³ and 45 µg/m³, respectively. Higher concentrations were recorded near motor parks, waste-burning sites, and quarry areas, particularly during dry-season sampling. Nitrogen dioxide (NO₂) and sulfur dioxide (SO₂) levels were also elevated, averaging 0.12 ppm and 0.09 ppm, respectively. These findings confirm the persistence of high particulate and gaseous pollutants in Bauchi LGA and align with previous local studies such as Buteh et al. (2023), who reported similar levels in Bauchi metropolis. The high particulate concentrations are associated with increased risk of respiratory diseases, asthma, and cardiovascular complications as observed by WHO (2023) and Atuyambe (2024).

3.4 Water Quality Analysis: Water samples collected from 15 boreholes, 10 hand-dug wells, and 5 surface-water sources were analyzed for physicochemical and microbial parameters. The mean pH value was 6.3, slightly below the WHO permissible range (6.5–8.5). Electrical conductivity averaged 980 µS/cm, and total dissolved solids (TDS) were 510 mg/L, indicating moderate mineralization. Heavy metal analysis showed detectable levels of lead (0.04 mg/L), iron (0.35 mg/L), and zinc (0.27 mg/L), with lead concentrations exceeding the WHO guideline of 0.01 mg/L for safe drinking water. Microbiological tests revealed total coliform counts ranging from 25 to 80 CFU/100 mL and *E. coli* presence in 40% of samples, confirming faecal contamination. These results are consistent with Yahaya (2024) and Haruna (2020), who reported similar contamination patterns in groundwater within Bauchi State. The presence of coliforms and heavy metals poses a significant risk for diarrhoeal diseases, methemoglobinemia, and neurotoxicity among residents.

3.5 Soil Quality and Heavy Metal Contamination: Soil samples collected around dumpsites and nearby residential areas revealed elevated concentrations of heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), and copper (Cu). Mean concentrations were 122 mg/kg for Pb, 2.3 mg/kg for Cd, 54 mg/kg for Cr, and 67 mg/kg for Cu. These values, particularly for Pb and Cd, exceeded the NESREA (2011) permissible limits for soil, indicating

anthropogenic contamination from waste dumping, vehicle emissions, and informal recycling activities. The accumulation of such metals in surface soils can lead to chronic exposure through direct contact, food-chain transfer, and inhalation of contaminated dust. Similar contamination profiles were reported by Ferreira et al. (2023) in dumpsite-adjacent soils, confirming the need for remediation and land-use regulation in urban Bauchi.

3.6 Health Effects and Community Perceptions: Analysis of self-reported health conditions among respondents revealed that 38% had experienced frequent respiratory symptoms (cough, wheezing, shortness of breath), while 30% reported recurrent diarrhoeal diseases, 15% complained of skin irritations, and 12% mentioned eye or throat irritation. Respondents living near dumpsites and busy roads showed higher prevalence of respiratory and gastrointestinal symptoms compared to those in cleaner neighborhoods. Most respondents (78%) perceived pollution as a serious threat to their health and expressed concern over the lack of government intervention. These perceptions are consistent with empirical evidence linking poor environmental quality to adverse health outcomes in Nigeria (Pona *et al.*, 2021; WHO, 2023). The congruence between subjective perception and objective pollution data highlights strong community awareness and validates the reported health risks.

3.7 Relationship Between Pollution and Health Outcomes: Statistical analysis revealed a significant positive correlation between exposure to air pollution (measured by proximity to major roads or dumpsites) and respiratory health outcomes ($r = 0.61$, $p < 0.01$). Similarly, water-quality indicators such as *E. coli* presence and high TDS levels were positively associated with reported cases of diarrhoea ($r = 0.54$, $p < 0.05$). These relationships confirm that environmental pollution is a significant determinant of public health in Bauchi LGA. The findings are in agreement with previous research conducted in similar contexts (Atuyambe, 2024; Yahaya, 2024), which emphasized that communities living in environmentally degraded areas bear disproportionate health burdens. The evidence underscores the need for urgent intervention and improved environmental monitoring systems.

4. DISCUSSION

The findings of this study demonstrate that pollution in Bauchi LGA is multi-dimensional, stemming from poor waste management, vehicular emissions, and unregulated industrial activities. The air, water, and soil samples exceeded several WHO and NESREA standards, indicating serious environmental contamination. The observed health outcomes, particularly

respiratory and gastrointestinal diseases, correlate strongly with pollution exposure, confirming the results of prior studies in urban Nigeria (Pona *et al.*, 2021; Haruna, 2020). While the local government has made some efforts in waste collection and environmental sanitation, these measures remain inadequate in addressing the growing environmental and health challenges. The study therefore calls for a comprehensive environmental management policy integrating pollution control, health education, and community participation to reduce public health risks in Bauchi LGA.

5. CONCLUSION

The study concludes that environmental pollution in Bauchi LGA has reached levels that threaten environmental sustainability and public health, with predominantly anthropogenic sources including poor solid-waste management, unregulated industrial discharges, vehicular emissions, and open burning of refuse. These activities have significantly degraded air, water, and soil quality, increasing residents' exposure to hazardous substances and contributing to adverse health outcomes, particularly among vulnerable groups such as children, the elderly, and low-income populations living near pollution sources. The findings establish a strong link between pollution and health risks, underscoring the urgent need for strengthened environmental governance, improved regulatory enforcement, and heightened community awareness. To address these challenges, key recommendations include intensified monitoring and enforcement by Bauchi State Environmental Protection Agency (BASEPA) and National Environmental Standards and Regulations Enforcement Agency (NESREA); improved waste-management infrastructure through structured collection systems, recycling initiatives, and engineered sanitary landfills; expanded environmental education and public-awareness campaigns; rehabilitation of contaminated water sources and promotion of household water-treatment technologies; integration of environmental health indicators into disease-surveillance systems; and adoption of sustainable urban planning practices, including environmental-impact assessments and green infrastructure development. Overall, addressing pollution in Bauchi LGA is not only an environmental necessity but a critical public health imperative requiring coordinated, multi-sectoral action.

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