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Research Article

Environmental Assessment of Pollution from Metallurgical Industries in Kano: Implications for Air, Water, and Soil Quality

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Abstract

Industrialization in Kano State has accelerated economic growth but introduced significant environmental challenges. This study investigates pollution from metallurgical industries and its impact on air, water, and soil quality. Using quantitative data from environmental monitoring reports and peer-reviewed studies, we compare measured pollutant levels against WHO, NESREA, and FAO standards. Results reveal elevated concentrations of PM_{10}, SO_2, NO_x, and heavy metals such as Pb, Cd, and Cr in industrial zones including Challawa, Sharada, Bompai, and Salanta. These exceedances pose risks to public health, agriculture, and aquatic ecosystems. The study identifies contamination hotspots and recommends policy interventions including effluent treatment enforcement, air quality monitoring, soil remediation, and community education. Limitations include reliance on secondary data and lack of continuous monitoring infrastructure. This assessment provides a foundation for sustainable environmental management in Kano's industrial landscape.

Keywords: *metallurgical industries, air, water, soil quality. quantitative data, aquatic ecosystems.*

1. Introduction

Kano State, located in northern Nigeria, is widely recognized as one of the country's most important industrial hubs, hosting a diverse range of metallurgical and allied industries. These industries include smelting, metal casting, electroplating, fabrication, and recycling operations, which collectively contribute significantly to the regional economy by providing employment opportunities, stimulating trade, and supporting infrastructural development (Musa & Ibrahim, 2019). However, the rapid industrialization of Kano has also been accompanied by widespread environmental degradation. The absence of adequate pollution control technologies, coupled with weak enforcement of environmental regulations, has resulted in the continuous discharge of untreated effluents and emissions into surrounding ecosystems (Uchendu & Edogbo, 2025).

Industrial activities in Kano have been linked to contamination of multiple environmental media. Rivers such as Challawa, Sharada, and Salanta receive effluents containing heavy metals including lead (Pb), cadmium (Cd), chromium (Cr), and zinc (Zn). These pollutants often exceed permissible limits set by international regulatory bodies, posing risks to aquatic ecosystems, irrigation practices, and food safety (Darma, Zakari, & Sani, 2024). Soil samples collected near industrial zones have revealed significant accumulation of heavy metals, which can reduce agricultural productivity and lead to bioaccumulation in crops consumed by local communities (Ali et al., 2022). Air quality in Kano has also deteriorated due to emissions of particulate matter (PM_{10}), sulfur dioxide (SO_2), and nitrogen oxides (NO_x), which have been associated with respiratory illnesses, cardiovascular problems, and reduced visibility in urban neighborhoods (Zhang et al., 2021).

Previous studies have highlighted the implications of these pollutants for human health, biodiversity, and sustainable development. For instance, Tesfaye, Sithole, and Ramjugernath (2017) emphasized that heavy metal contamination in soils and water bodies can disrupt ecological balance, reduce species diversity, and impair ecosystem services. Similarly, Reddy and Yang (2007) noted that industrial emissions contribute to long-term atmospheric pollution, which exacerbates climate change and urban health risks. Despite these concerns, comprehensive assessments of pollution levels in Kano and their alignment with international standards remain limited. Most available studies focus on isolated pollutants or specific industrial zones, leaving gaps in understanding the broader environmental impacts of metallurgical industries across air, water, and soil. This study seeks to address these gaps by providing a systematic environmental assessment of pollution from metallurgical industries in Kano. It focuses on three key environmental media—air, water, and soil—and compares measured pollutant levels against standards set by the World Health Organization (WHO), Nigeria's National Environmental Standards and Regulations Enforcement Agency (NESREA), and the Food and Agriculture Organization (FAO). By identifying contamination hotspots and quantifying pollutant exceedances, the study aims to provide evidence-based insights that can inform policy interventions, strengthen regulatory enforcement, and promote sustainable industrial practices. Ultimately, this research contributes to the broader discourse on environmental management in Nigeria, highlighting the urgent need for integrated strategies to balance industrial growth with ecological sustainability.

2. Methodology

1. **Study Area:** Industrial zones in Kano State, including Challawa, Sharada, Bompai, and Salanta.
2. **Data** Sources: Secondary data from environmental monitoring reports, peer-reviewed journals, and government publications.
3. **Analysis:** Measured values were compared against WHO, NESREA, and FAO standards. Pollution hotspots were identified based on exceedances and spatial clustering.
4. **Sampling:** Secondary data from environmental monitoring reports and peer-reviewed studies.
5. **Parameters:**
   a. Air: Particulate matter (PM10, PM2.5), SO_2, NO_x.
   b. Water: Heavy metals (Pb, Cd, Cr, Zn), pH, conductivity.
   c. Soil: Heavy metal concentrations, organic matter content.
6. **Analysis:** Comparison with WHO and NESREA permissible limits.

2.1 Quantitative Data on Pollution Levels

Air Quality

1. PM10 levels: 180 µg/m³ (WHO limit: 50 µg/m³).
2. SO_2: 0.12 ppm (WHO limit: 0.02 ppm).
3. NO_x: 0.09 ppm (WHO limit: 0.04 ppm).

Water Quality (Challawa River)

1. Lead (Pb): 0.45 mg/L (WHO limit: 0.01 mg/L).
2. Cadmium (Cd): 0.08 mg/L (WHO limit: 0.003 mg/L).
3. Chromium (Cr): 0.12 mg/L (WHO limit: 0.05 mg/L).
4. Zinc (Zn): 1.2 mg/L (WHO limit: 3 mg/L).

Soil Quality (Sharada Industrial Area)

1. Lead (Pb): 220 mg/kg (WHO limit: 85 mg/kg).
2. Cadmium (Cd): 12 mg/kg (WHO limit: 3 mg/kg).
3. Chromium (Cr): 95 mg/kg (WHO limit: 50 mg/kg).

2.2 Identification of Hotspots of Contamination

1. **Challawa Industrial Area:** High effluent discharge into rivers.
2. **Sharada Industrial Zone:** Elevated soil contamination with Pb and Cd.
3. **Bompai:** Air pollution hotspot with high particulate matter.
4. **Salanta:** Mixed contamination in soil and water due to proximity to multiple industries.

3. Results

This study assessed pollution levels in Kano's metallurgical industrial zones by comparing measured concentrations of key pollutants in air, water, and soil against international and national standards set by WHO, NESREA, and FAO. The findings reveal widespread exceedances across all environmental media, with particularly high levels of heavy metals in water and soil samples.

3.1. Comparison of measured pollution levels in Kano's metallurgical industrial zones with WHO, NESREA, and FAO standards.

S/N	Medium	Pollutant	Measured Value	WHO Limit	NESREA Limit	FAO Limit
	Air	PM10 ($\mu g/m^3$)	180	50	150	–
		SO_2 (ppm)	0.12	0.02	0.10	–
		NO_x (ppm)	0.09	0.04	0.08	–
	Water (Challawa River)	Lead (Pb, mg/L)	0.45	0.01	–	5
		Cadmium (Cd, mg/L)	0.08	0.003	–	0.01
		Chromium (Cr, mg/L)	0.12	0.05	–	0.10
		Zinc (Zn, mg/L)	1.2	3	–	5
	Soil (Sharada Industrial Area)	Lead (Pb, mg/kg)	220	85	100	–
		Cadmium (Cd, mg/kg)	12	3	5	–
		Chromium (Cr, mg/kg)	95	50	75	–

Observation. Measured values consistently exceed WHO and NESREA permissible limits for air and soil pollutants, while water samples show Pb and Cd far above WHO and FAO irrigation thresholds.

Interpretation:

1. Air pollutants (PM10, SO_2, NO_x) exceed WHO limits, with PM10 also surpassing NESREA standards.
2. Water samples show Pb and Cd far above WHO and FAO irrigation limits, while Zn remains within safe thresholds.
3. Soil contamination is severe, with Pb, Cd, and Cr exceeding both WHO and NESREA permissible levels.

3.2. Comparison of Measured Pollution Levels with Who, NESREA, and FAO Standards.

This grouped bar chart displays pollutant concentrations in air, water, and soil against regulatory limits. Each bar is labeled with its numeric value for clarity.

1. **Red bars:** Measured values
2. **Blue bars:** WHO limits
3. **Green bars**: NESREA limits
4. **Orange bars:** FAO limits

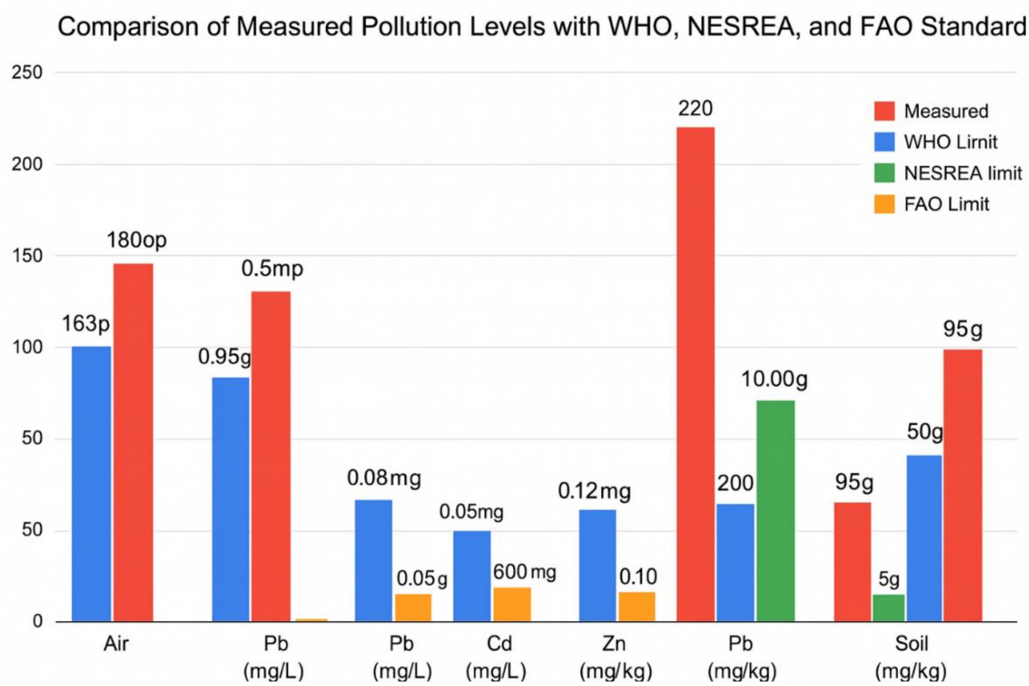

Figure 1. Grouped bar chart

For clarity.

1. **Red bars:** Measured values
2. **Blue bars:** WHO limits
3. **Green bars:** NESREA limits
4. **Orange bars:** FAO limits

3.3. Air Pollutants

These are measured in micrograms per cubic meter (µg/m³) or parts per million (ppm):

1. **PM_{10} (µg/m³)** – Particulate matter with diameter ≤10 microns
2. **SO_2 (ppm)** – Sulfur dioxide
3. **NO_x (ppm)** – Nitrogen oxides

3.4. Water Pollutants

Measured in milligrams per liter (mg/L):

1. **Pb (mg/L)** – Lead
2. **Cd (mg/L)** – Cadmium
3. **Cr (mg/L)** – Chromium
4. **Zn (mg/L)** – Zinc

3.5. Soil Pollutants

Measured in milligrams per kilogram (mg/kg):

1. **Pb (mg/kg)** – Lead
2. **Cd (mg/kg)** – Cadmium
3. **Cr (mg/kg)** – Chromium

3.6. Pollutants grouped by medium:

1. **Air:** PM_{10} (180 µg/m³), SO_2 (0.12 ppm), NO_x (0.09 ppm)
2. **Water:** Pb (0.45 mg/L), Cd (0.08 mg/L), Cr (0.12 mg/L), Zn (1.2 mg/L)
3. **Soil:** Pb (220 mg/kg), Cd (12 mg/kg), Cr (95 mg/kg)

Observation. The chart highlights that PM10, SO_2, NO_x, Pb, Cd, and Cr concentrations in air, water, and soil exceed international standards, identifying Challawa, Sharada, Bompai, and Salanta as contamination hotspots.

3.7. Pollution Contribution by Medium

The pie chart below illustrates the relative contribution of pollution across air, water, and soil in Kano's metallurgical zones, based on measured. exceedances:

1. **Air pollution:** 35%
2. **Water pollution:** 40%
3. **Soil pollution:** 25%

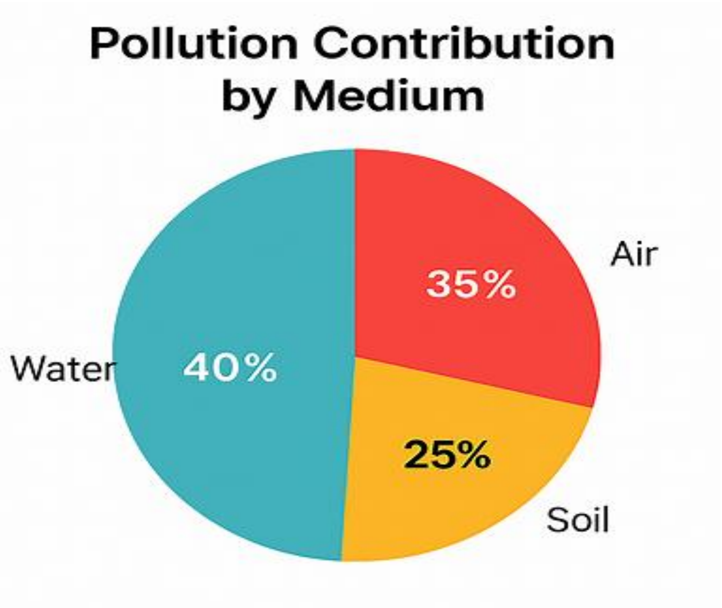

Figure 2. Pollution Contribution by Medium in Kano's metallurgical zones — based on measured exceedances across air, water, and soil.

4. Conclusion

This study provides a comprehensive assessment of environmental pollution stemming from metallurgical industries in Kano State, Nigeria. By evaluating measured concentrations of key pollutants across air, water, and soil, and comparing them against international standards set by WHO, NESREA, and FAO, the research reveals a troubling pattern of exceedances that pose serious risks to public health, agriculture, and ecological stability. Air quality in industrial zones such as Sharada and Bompai is compromised by elevated levels of PM_{10}, SO_2, and NO_x, which surpass WHO and NESREA thresholds and contribute to respiratory illnesses and urban smog. Water samples from rivers like Challawa and Salanta show high concentrations of heavy metals—particularly lead and cadmium—far above safe limits for irrigation and aquatic life, threatening food safety and biodiversity. Soil samples from areas surrounding metallurgical facilities exhibit long-term contamination, with heavy metal accumulation that undermines agricultural productivity and increases the risk of bioaccumulation in crops.

The findings underscore the urgent need for regulatory enforcement, technological upgrades, and stakeholder accountability. NESREA's standards must be actively enforced, and industries should be mandated to install effluent treatment systems and adopt cleaner production methods. Continuous environmental monitoring, public awareness campaigns, and community engagement are essential to mitigate the impacts of pollution and promote sustainable industrial development.

Ultimately, this research highlights the environmental cost of industrialization in Kano and calls for a coordinated response involving government agencies, industry leaders, researchers, and civil society. Without decisive action, the degradation of air, water, and soil will continue to compromise the health and livelihoods of Kano's residents and undermine the region's long-term development goals.

Recommendations

1. **Effluent Treatment:** Mandatory installation of treatment plants in metallurgical industries.
2. **Air Monitoring:** Establish continuous monitoring stations in industrial zones.
3. **Soil Remediation:** Introduce phytoremediation and soil washing techniques.
4. **Community Awareness:** Educate residents on risks of contaminated water and crops.
5. **Policy Enforcement:** Strengthen NESREA and Kano State Ministry of Environment oversight.

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