ARCN International Journal of Sustainable Development
ISSN: 2384-5341. Volume 14, Issue 2, (February, 2025) pages 58 – 67
OTL: 2726-4-573-1-1426-1
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https://arcnjournals.org

Assessment of Air Pollutants from Marini Asphalt Plant in Maiduguri

Abubakar Muhammad Rufai[1], Emeadiong Samuel Akason[2], Zara Ali Lawan[3] and Grema Modu Bako[4]

[1&3]Department of Remedial of Science, Ramat Polytechnic Maiduguri, PMB 1070
[2]University of Maiduguri, Maiduguri Borno, PMB 1069
[4]Departments of Statistics, Ramat Polytechnic Maiduguri, Borno State, PMB 1070

Abstract: *This study investigated air pollutants emitted by the Marini Asphalt Plant in Maiduguri, Nigeria. Samples were collected using a Petri-dish with moist filter paper and analyzed using spectrophotometry and spectroscopic techniques. The results revealed high concentrations of heavy metals (Pb, Cd, Cr, Zn, Ni, Cu) and inorganic compounds (NO3-N), exceeding federal environmental standards. The study highlights significant environmental and health concerns, emphasizing the need for emission reduction measures.*

Keywords *Air Pollution, Asphalt Plant, Heavy Metals, Environmental Impact, Public Health.*

Introduction

Air pollution refers to the presence of harmful substances in the air that degrade air quality and pose threat to living beings and the environment. These pollutants include Particulate Matter, Carbon monoxide, Nitrogen oxides, and Ground ozone (Singh and Tripathi, 2021). According to World Health Organization (WHO) 2019, air pollution is responsible for approximately 7 million premature deaths worldwide, in spite of that, it's estimated over 114,000 Nigerian die prematurely each year due to air pollution. However, about 99% of the global population breaths air exceeding WHO air quality, low and middle in-come countries, particularly in Asia and Africa, bear the highest burden, and Nigeria is among the low in-income country.

Furthermore, global air report 2020 which summarizes the latest scientific understanding of air pollution around the world that about 4.5 million deaths were linked to outdoor air pollution and another 3.8 million deaths were caused by indoor air pollution. The production of asphalt mixtures in Marini plants represents a significant source of industrial emissions that raises growing concerns regarding public health and environmental quality (Movilla-Quesada *et al.,* 2021; Rodringuez-Martinez *et al.,* 2024). According to Zhang and Chen 2023; Wang, *et al,* (2021), These facilities, while essential for infrastructure development, release various air pollutants including Volatile organic compound (VOCs), Polycyclic aromatic hydrocarbon (PAHs), Particulate matter (PM2.5

and PM10), Sulfur dioxide (S02), and nitrogen oxides (NOX) during the heating and mixing processes of asphalt production.

In addition, from a human health perspective, exposure to these pollutants has been associated with various adverse health outcomes. Additionally, Thompson *et al*., (2023) study reports that the proximity of these plants to residential areas has emerged as a critical environmental health issue particularly in rapidly developing urban and suburban region. Recent epidemiological studies have demonstrated relationship between exposure to asphalt plant emissions and adverse health outcomes in neighboring communities (Li *et al.,* 2023; Anderson and Smith, 2022). These health effects ranges from acute respiratory symptom, and eye irritation to potentially more severe long term impacts on cardiovascular and pulmonary health (Miller 2022; Park and Lee 2022). Residents and communities near Marini asphalt plants may face increased risks of respiratory disease, cardiovascular problems, and other health issues related to chronic exposure to industrial air pollution. The occupational health risks for workers in these facilities are particularly significant, as they experience direct and prolonged exposure to these pollutants. The complex of pollutants emitted by Marini plants presents unique challenges for both exposure assessment and public health protection, as the synergistic effects of multiple contaminations remain inadequate understood (Tran *et al.,* 2023; Brown and Johnson 2022). The location of these facilities adds another dimension to the environmental impact, as air pollution can interact with Marini aerosols and affect air quality simultaneously; the environmental implications of these emissions are multifaceted (Tran *et al.,* 2023). Similarly, atmospheric deposition of pollutants can lead to soil contamination, affect vegetation growth, and contribute to ocean acidification when deposited in Marini waters (Movilla-Quesada *et al.,* 2021).

Despite growing awareness of these environmental health concerns, there exists a significant gap in the scientific literature regarding comprehensive assessments of Marini plants emissions and their specific public health implications (Li et al., 2024). While general studies on asphalt production facilities exist (Taylor and White, 2022; Mitchell et al., 2021), the unique operational characteristics of Marini plants and their emission profiles warrant dedicated investigation (Li et al., 2024). The expected result from this research is that pollutants in the study area will be identified and quantified. In addition; the presence of air pollutants and other heavy metals will be determined and compared with Federal Ministry of Environment (FMOE) and World Health Organization set standard for appropriate recommendation.

Study Area (Geographical and Climatic Characteristics of Maiduguri) Maiduguri, the capital and largest city of Borno State in northeastern Nigeria, is situated within the geographical coordinates of latitudes 11.50'N and longitudes 13.09’E. The city's elevation is approximately 320 meters (1,050 feet) above sea level, with a metropolitan area covering approximately 543 square kilometers. This expansive area encompasses both the urban core and its surrounding suburbs and metropolitan zone.

Climate and Weather Patterns: Maiduguri experiences a hot semi-arid climate, characterized by two distinct seasons: Dry season (October to May) Rainy season (June to September) The average annual temperature is around 28°C (82°F), with the hottest months being March to May, when temperatures often exceed 40°C (104°F). The cold and dry periods, known as "winter," occur in

November to January. Rainfall is concentrated between June and September, with an approximate annual rainfall of 650 mm. However, in rainy years, precipitation can start earlier than June or extend beyond September. This study focuses on some specific locations within Maiduguri, including:

- Marini Asphalt Plant: latitude 11°48'N and longitude 13°10'E
- Government Residential Area (GRA): latitude 11°48'N and longitude 13°10'E
- Fori Area latitude 11°8034'N and longitude 13°1794'E

These locations are significant to the study, as they represent areas with potential environmental impacts from the Marini Asphalt Plant's operations. Sampling Methodology for Atmospheric Air Pollutants (Dust). Atmospheric air pollutants (dust) were collected manually using Petri-dish with a moist filter paper on an elevated platform of about 2.5 meters' height without obstruction from the Marini Asphalt Plant. The same procedures were applied to the two adjoining communities of Fouri, and new GRA toward the Marini site, and the samples were collected at a height of 2.5 meters using the Petri-dish with moist filter paper for a period of one week.

Sampling Sites Selection

The sampling sites were selected to cover the emission originated from the Marini asphalt plant to the immediate surrounding communities. The selected sites are illustrated in Table 1.1, which includes:

Table 1.1 Site selected for the collection of samples

• Site 1: Marini Asphalt Plant (Source of emission)
• Site 2: Adjoining community (Fori)
• Site 3: Adjoining community Government Residential Area (New GRA)

Sampling Protocol

The sampling protocol involved the following steps:

a) Preparation of sampling equipment: Petri-dish, moist filter paper, and elevated platform.
b) Selection of sampling sites: Based on the proximity to the Marini Asphalt Plant and the direction of wind flow.
c) Collection of samples: Using the Petri-dish with moist filter paper on an elevated platform.
d) Storage of samples: Loaded filters were stored in sealed polythene bags to prevent contamination.

Laboratory Analysis

The loaded filters were transported to the laboratory for analysis using:

a) Smart Spectro: A spectrophotometer used to identify and analyze the concentration of pollutants.
b) Atomic Absorption Spectrometer (AAS): A spectroscopic technique used to analyze the concentration of heavy metals and other pollutants.

Discussion

The data obtained for a week in percentage were presented using a bar chart graph, highlighting the presence of pollutants originating from the Marini asphalt plant to the designated adjoining locations, such as Fouri and the government residential area (new GRA). These data outline potential variations in emissions from the Marini asphalt plant yard to the adjoining community, including Fori and new GRA, during a period of one-week. The data collection process involved sampling the air quality around the Marini asphalt plant, with a focus on the adjoining communities. The samples were analyzed for various pollutants, including heavy metals and inorganic compounds. The results were then compared to the reference standards provided by the Federal Ministry of Environment (FMoE). The samples results revealed the following elements as pollutants, with their concentrations, these includes, Cadmium, Nitrate Chromium, Zinc, Lead, Nickel, Copper, (NO_3-N), and Nitrogen. These data will provide valuable information in order to evaluate any potential environmental impact from the Marini emission to the adjoin communities. These data provide valuable information for evaluating the potential environmental impact of the Marini asphalt plant's emissions on the adjoining communities. The presence of these pollutants in the air the plant will poses a significant risk to human health and the environment. Therefore, it is essential to implement effective pollution control measures to minimize the environmental impact of the plant's operations.

Graphical Representation of Pollutant Concentrations

The graphical representation of the data collected from the plant's pollution control systems reveals important statistical patterns (Kumar et al., 2020). A bar chart graph provides a direct comparison between measured pollutant concentrations and the Federal Ministry of Environment standards over a period of one week (Federal Ministry of Environment, 2019). The results from the sample collected revealed several notable elements considered to be pollutants, these includes: Lead (Pb), Cadmium (Cd), Chromium (Cr), Zinc (Zn), Nickel, Copper (Cu), and Nitrate (NO_3-N). However, Cd, Cr, Ni, Cu and Zn are elements that are considered to be heavy metals whereas Nitrate (NO3-N) is considered to be Inorganic compounds (EPA, 2020). This graphical analysis provides strong visual evidence for regulatory compliance assessment (Kumar et al., 2020). The graph identifies specific areas requiring immediate attention in the plant's pollution control systems. The visualization effectively supports the numerical findings and helps identify priority areas for environmental management interventions (Sarkar et al., 2017). The varying bar heights in the graph immediately highlights areas of compliance and concern. The scale effectively captures both micro-concentrations (e.g., Mercury at 0.006 mg/L) and larger values (e.g., Nitrogen at 2.44 mg/L). This visualization enables stakeholders to quickly identify pollutants that exceed regulatory limits and prioritize actions plan (EPA, 2020).

However, the graph indicates a significant disparity in the concentration levels of various pollutants in the sample, with Cadmium showing the most prominent visual disparity (Kumar et al., 2018). The concentration value of Cadmium is 0.094%, which significantly exceeds the federal government standards. This is a concern, as Cadmium is a known carcinogen and can cause kidney damage and bone demineralization (Jarup & Akesson, 2009). Nitrogen, on the other hand, shows the largest absolute standard value but the smallest relative measured concentration. This suggests that while the standard allows for a high concentration of Nitrogen, the actual measured value is relatively low (Galloway et al., 2003). Similarly, study by Camargo & Alonso, (2006), reports that,

excessive Nitrogen levels can still contribute to eutrophication, leading to algal blooms and decreased water quality.

Copper, shows notably small measured values compared to its allowable limits, according to Taylor & Maher, (2010), even low concentrations of Copper can be toxic to aquatic life, causing damage to fish and other organisms. Therefore, Marini asphalt plant yard exceeds federal standards for five pollutants: Cadmium, Chromium, nitrate, lead, and Mercury. Chromium, a known carcinogen, can cause lung cancer and skin irritation (Kumar et al., 2018). Nitrate, a common pollutant in agricultural runoff, can contribute to eutrophication and decreased water quality (Camargo & Alonso, 2006). Lead, a neurotoxin, can cause developmental delays and cognitive impairment in children (Canfield et al., 2003). Mercury, a potent neurotoxin, can cause damage to the brain and nervous system, particularly in developing fetuses and young children (Clarkson & Magos, 2006). In conclusion, the results indicate significant environmental concerns related to the pollutants emitted by the Marini asphalt plant yard. These pollutants can have severe environmental and health impacts, and it is essential to implement measures to reduce their emissions and mitigate their effects.

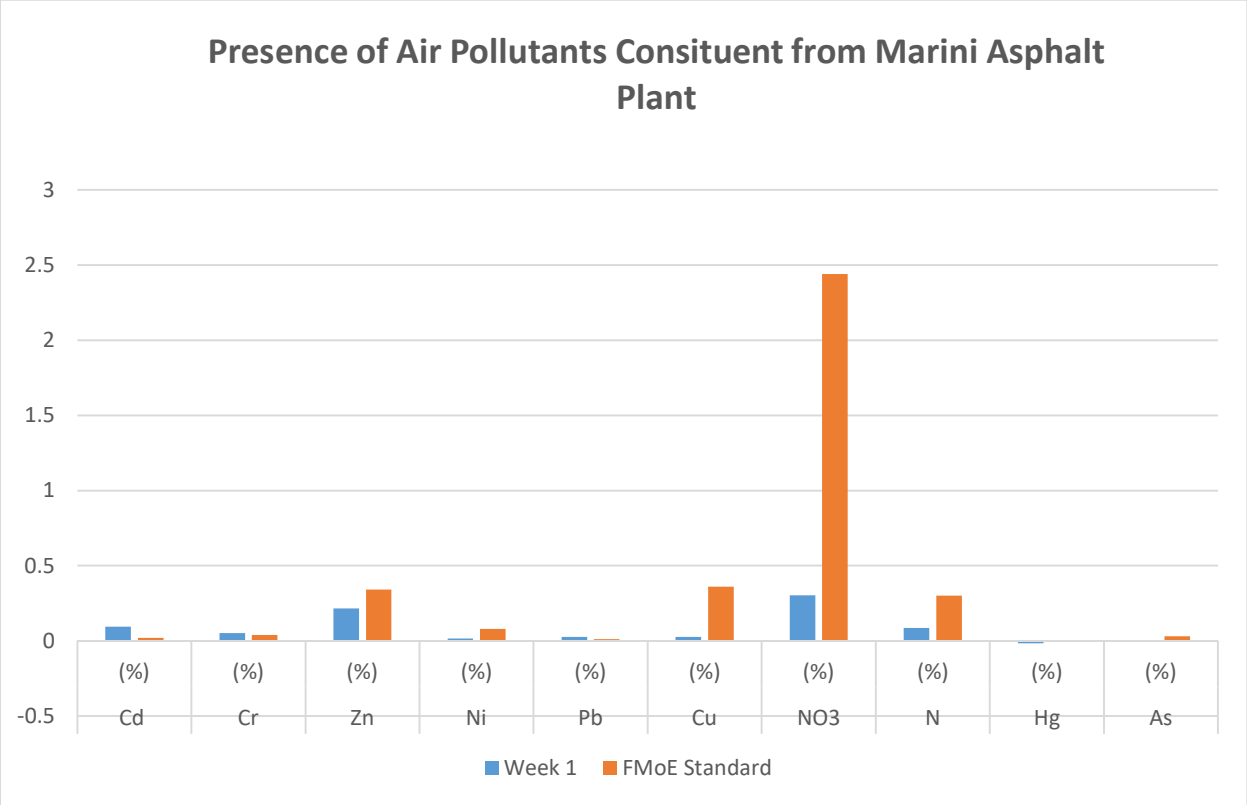

Fig (1a) graph of sampled pollutants and federal ministry environment standards for one week period

Similarly, graph (1b) representing the Fori, the results of the sample and concentration level, the concentrations of these pollutants change over the week. However, some of these pollutants such as Copper, Nitrate and Cadmium concentration exceed the federal standards, demonstrating potential environmental concern associated with the emissions from the asphalt plant site to the adjoin community. Copper is an essential micronutrient, but excessive levels can be toxic, the

elevated copper concentrations in the environment can cause harm to aquatic life, plants, and microorganisms (EPA, 2020). Copper can also accumulate in the food chain, posing a risk to human health through consumption of contaminated fish and shellfish (WHO, 2011). In addition, Nitrates are a common water pollutant that can cause eutrophication, leading to excessive algae growth and depletion of oxygen in water bodies (EPA, 2019). Elevated nitrate levels in drinking water can also pose health risks, particularly for infants, and pregnant women, by causing methemoglobinemia (CDC, 2020). Similarly, Cadmium is a known human carcinogen and can cause kidney damage, bone demineralization, and other health problems (ATSDR, 2019). According to World Health Organization (2010) Environmental exposure to cadmium can occur through inhalation of contaminated air, ingestion of contaminated food or water, or dermal contact with contaminated soil.

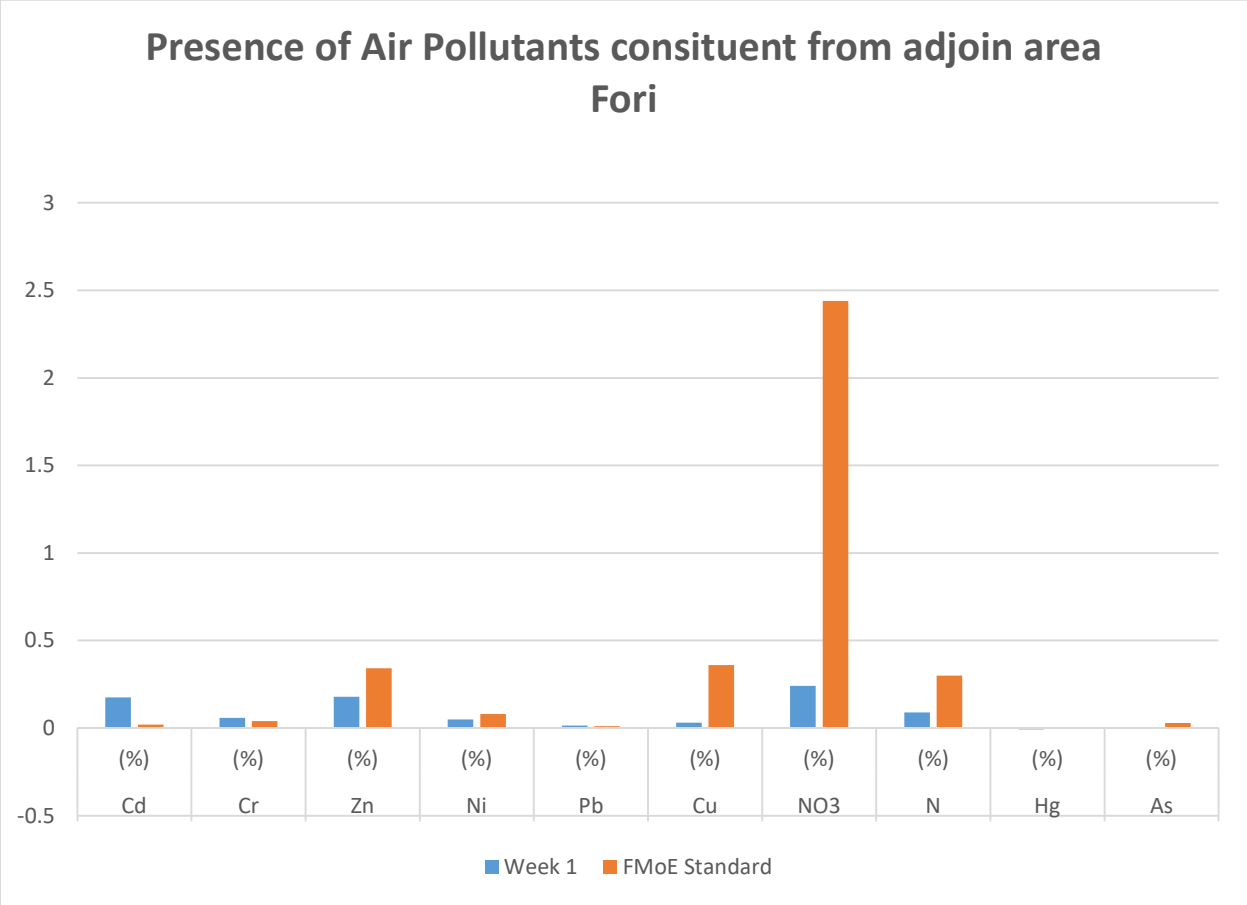

Fig 1b graph of sampled pollutants and federal ministry environment standards for one week period.

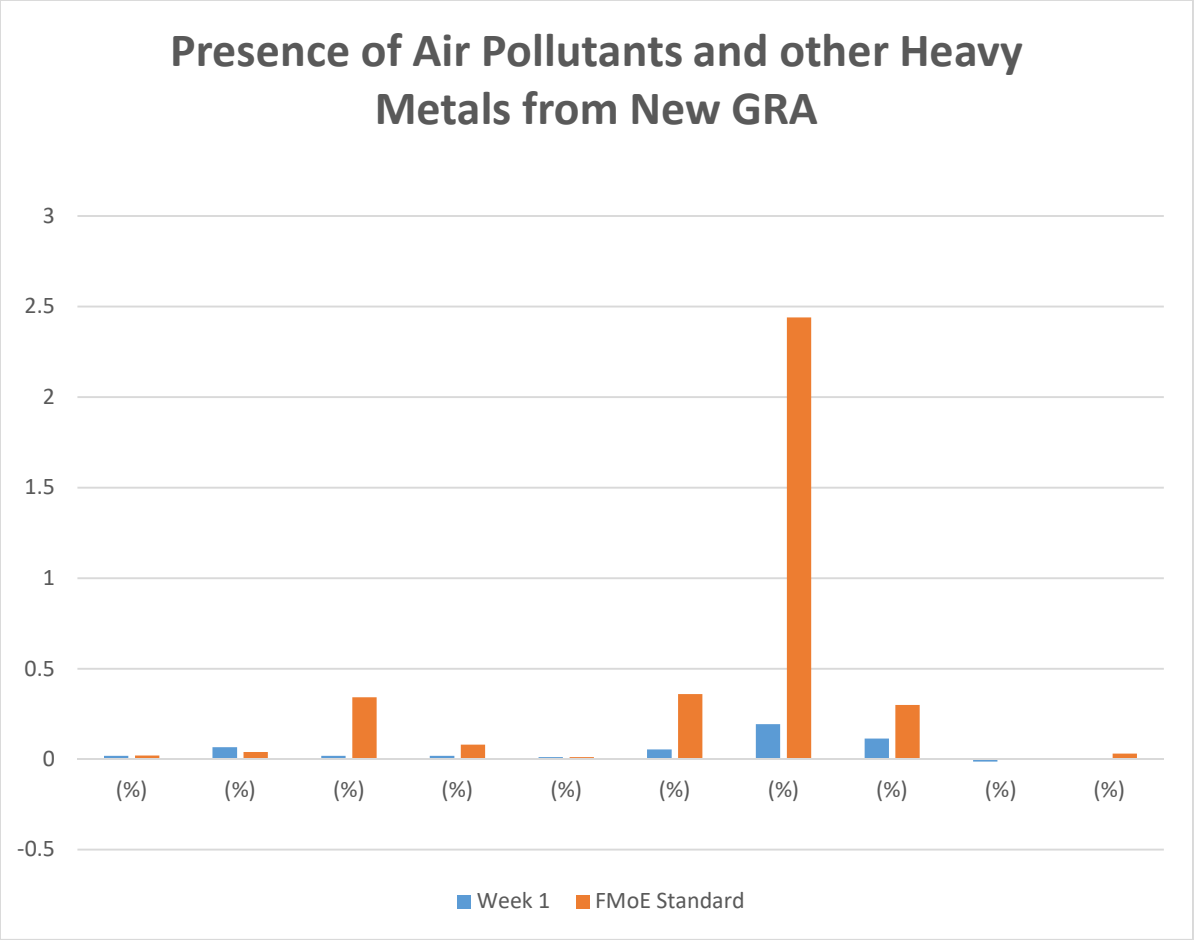

Fig 1c graph of pollutants sampled concentration and federal ministry environment standards for one-week period.

Graph (1c) represents the sample results from the adjoining environment of the Government Residential Area (New GRA) in Maiduguri. The data reveal that some concentration values, such as Nitrate and Copper, exceed the Federal Ministry of Environment standards in certain orders (FMoE, 2019). These results indicate potential concerns regarding emissions from the asphalt plants to the New GRA location. The concentrations of these substances fluctuate across the sampling week, indicating potential variations in emissions (Kumar *et al.,* 2020). The excessive levels of Nitrate and Copper in the environment can have severe environmental and health implications. Nitrate pollution can lead to eutrophication in water bodies, causing harmful algal blooms and depletion of dissolved oxygen (EPA, 2020). In addition, Copper toxicity can harm aquatic life, causing damage to fish and other organisms (Gaetke *et al.,* 2014). The emissions from the asphalt plants can also pose health risks to the residents of New GRA. Exposure to excessive levels of Nitrate and Copper can cause: Respiratory problems, such as asthma and bronchitis (Kumar et al., 2020).Neurological damage, including cognitive impairment and neurodegenerative diseases (Grandjean *et al*., 2010). Cancer, as both Nitrate and Copper has been classified as potential carcinogens (IARC, 2012). By contrasting the sample values with the FMoE standards, the table allows for an assessment of whether the emissions meet established air quality guidelines

(FMoE, 2019). The results indicate that the asphalt plant emissions exceed the regulatory standards, highlighting the need for improved pollution control measures.

Conclusion

The findings of this study highlighted significant environmental and public health concerns associated with emissions from the Marini Asphalt Plant in Maiduguri. The analysis of air pollutants revealed elevated concentrations of heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), zinc (Zn), nickel (Ni), and copper (Cu), as well as inorganic compounds like nitrate (NO3-N), exceeding the regulatory limits set by the Federal Ministry of Environment (FMoE) and the World Health Organization (WHO). These pollutants pose serious health risks, including respiratory issues, cardiovascular diseases, and neurological impairments, especially for workers and nearby residents. Additionally, the environmental implications, such as soil contamination and potential water pollution, further emphasize the need for stringent pollution control measures. To mitigate these risks, it is essential to implement improved emission control technologies, regular environmental monitoring, and strict regulatory enforcement to ensure air quality standards are maintained and public health is safeguarded.

Recommendation

To mitigate the environmental and health risks posed by emissions from the Marini Asphalt Plant in Maiduguri, it is essential to implement stringent pollution control measures. The adoption of advanced emission control technologies, such as baghouse filters and scrubbers, should be prioritized to reduce particulate matter and heavy metal discharge. Regular environmental monitoring and air quality assessments should be conducted to ensure compliance with regulatory standards set by the Federal Ministry of Environment (FMoE) and the World Health Organization (WHO). Additionally, the establishment of buffer zones and green belts around the plant can help in minimizing pollutant dispersion. Public awareness campaigns and health surveillance programs should be initiated to educate workers and local communities on potential risks and preventive measures. Lastly, policymakers must enforce stricter industrial regulations and promote sustainable asphalt production practices to protect both environmental and public health.

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