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Abstract

Purpose: To aim of the study was to analyze effect of influence of industrial emissions on air quality in manufacturing zones in United Kingdom.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Industrial emissions from manufacturing zones in the United Kingdom significantly contribute to air pollution, especially through the release of particulate matter (PM), nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs). These pollutants reduce air quality, increase health risks such as respiratory and cardiovascular diseases, and negatively affect surrounding communities and ecosystems. Although stricter environmental regulations and cleaner technologies have improved conditions in recent years, industrial areas still remain important sources of localized air pollution.

Unique Contribution to Theory, Practice and Policy: Ecological modernization theory, pollution haven theory & environmental Kuznets curve theory may be used to anchor future studies on the influence of industrial emissions on air quality in manufacturing zones in United Kingdom. This study contributes to practice by giving manufacturers, factory managers, environmental officers, and industrial zone managers practical guidance on how to reduce air pollution. This study contributes to policy by providing evidence that industrial emissions should be managed through strict, measurable, and enforceable air quality regulations.

Keywords: *Industrial Emissions, Air Quality, Manufacturing Zones*

INTRODUCTION

Air quality refers to the condition of the air in relation to pollutants such as particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and volatile organic compounds. Good air quality means pollutant levels are low enough to protect human health, ecosystems, visibility, and general environmental quality. In the United States of America (USA), air quality has improved over time, with national annual PM2.5 concentrations falling by 37% from 2000 to 2023, while nitrogen dioxide annual concentrations fell by 62% from 1990 to 2023. The United States Environmental Protection Agency also reported that direct PM2.5 emissions declined by 28% and sulphur dioxide emissions by 93% from 1990 to 2023. These trends show that developed economies can improve air quality through emission standards, cleaner technologies, monitoring systems, and enforcement (Kilpatrick, 2024).

The United Kingdom (UK) also shows an improving air quality trend, especially for fine particulate matter. Annual average PM2.5 concentrations at urban background sites declined from 12.4 µg/m³ in 2009 to 7.2 µg/m³ in 2023, the lowest recorded level. Roadside PM2.5 concentrations also declined from 12.8 µg/m³ in 2009 to 7.7 µg/m³ in 2023. In 2023, mean PM2.5 concentrations decreased by 12% compared with 2022 levels, showing continued progress in reducing particle pollution. This trend supports ApSimon (2023), who argue that future air quality improvement in the United Kingdom depends on integrated policies targeting PM2.5 emissions, population exposure, transport, domestic heating, and net-zero strategies.

In developing economies, air quality is often affected by rapid urbanization, industrial growth, traffic congestion, open burning, biomass fuel use, and weak pollution control systems. India provides a strong example because PM2.5 pollution remains high despite policy efforts such as the National Clean Air Programme. In 2023, India’s PM2.5 levels were reported to be about 11 times higher than the World Health Organization (WHO) annual guideline, while New Delhi recorded an annual PM2.5 concentration of 92.7 µg/m³. A peer-reviewed study of five Indian cities using daily PM2.5 data from 2014 to 2023 found significant negative trends only in New Delhi and Kolkata, meaning improvement was uneven across cities. This shows that air quality in developing economies may improve where targeted interventions exist, but progress is often slow and inconsistent due to population pressure, transport emissions, industry, and household fuel use (Gil-Alana & Carmona-González, 2025).

Brazil gives a second developing-economy example because its air quality challenge is shaped by urban emissions, agriculture, biomass burning, forest fires, and uneven monitoring coverage. A South American PM2.5 trend study reported that the highest PM2.5 concentrations were observed in the Amazon and Santiago, Chile, reaching 160.4 µg/m³ annually and 177.8 µg/m³ seasonally. However, the same study found significant PM2.5 reductions between 2003 and 2022 in parts of Brazil, especially the arc of reforestation, with reductions ranging from 0.5 to 10 µg/m³ per year. This means Brazil shows both progress and risk, since some areas are improving while fire-prone and deforestation-linked regions still experience serious pollution episodes. Therefore, developing economies need stronger air monitoring, forest protection, clean transport, industrial control, and public awareness to sustain air quality gains (Correia Filho, 2024).

In Sub-Saharan economies, air quality is affected by industrial emissions, vehicle emissions, biomass fuel burning, waste burning, dusty roads, shipping activities, and weak monitoring systems. Nigeria provides a clear example because the annual average PM2.5 concentrations in 2019 was reported to be 14.1 times higher than the World Health Organization 2021 recommended concentration level. Lagos faces serious air quality pressure from traffic congestion, biomass fuel burning, shipping, trade, and manufacturing activities. A recent empirical study in four major manufacturing industrial zones in Nigeria found that particulate matter exposure was likely to pose negative health impacts, especially among vulnerable populations. This shows that poor air quality in Sub-Saharan manufacturing and urban zones is both an environmental and public health problem (Lala, 2025).

Kenya provides another Sub-Saharan example, especially through Nairobi, where air pollution is linked to transport, informal industries, unclean cooking fuels, waste burning, and urban growth. Nairobi's air pollution was linked to about 2,500 premature deaths in 2019, while 2023 average PM2.5 levels were about four times higher than the World Health Organization recommended level. This shows that even where emissions are lower than in heavily industrialized economies, exposure can still be harmful because of dense settlement patterns and weak pollution controls. State of Global Air also reports that while global PM2.5 exposure declined slightly from 2010 to 2019, populous countries in Sub-Saharan Africa experienced substantial increases over the same period. Therefore, Sub-Saharan economies require expanded air quality monitoring, cleaner transport, improved waste management, cleaner household energy, and stricter industrial regulation to reverse worsening air pollution trends (Lala, 2025).

Industrial emissions refer to pollutants released into the atmosphere from manufacturing processes, fuel combustion, boilers, generators, furnaces, chemical processing, transport activities, and raw material handling. Conceptually, industrial emissions influence air quality because they introduce harmful substances that change the natural composition of the air and reduce its safety for humans, animals, plants, and the environment. The first common industrial emission is particulate matter (PM2.5 and PM10), which includes fine dust, soot, smoke, and tiny particles released from factories, cement plants, metal works, and fuel-burning equipment. Particulate matter lowers air quality because it remains suspended in the atmosphere and can be inhaled, increasing respiratory and cardiovascular health risks, especially in manufacturing zones with high industrial concentration (Lala, 2025). The second common industrial emission is sulphur dioxide (SO_2), which is mainly released from burning sulphur-containing fuels such as coal, heavy oil, and diesel, and it worsens air quality by contributing to acid rain, haze, breathing problems, and environmental degradation (Salsabila, 2026).

The third common industrial emission is nitrogen oxides (NO_x), which are produced through high-temperature combustion in industrial boilers, furnaces, generators, and factory vehicles. Nitrogen oxides reduce air quality by contributing to smog formation, ground-level ozone, respiratory irritation, and poor visibility in manufacturing zones. The fourth common industrial emission is volatile organic compounds (VOCs), which are released from paints, solvents, petroleum products, chemical manufacturing, and petrochemical industries. Volatile organic compounds worsen air quality because they react with nitrogen oxides in sunlight to form ground-level ozone and can expose workers and nearby residents to harmful chemical pollutants, as shown in industrial corridor monitoring studies (Robinson, 2024). Therefore, particulate matter, sulphur dioxide, nitrogen oxides, and volatile organic compounds are key industrial emissions that negatively affect air quality by increasing pollution levels, reducing visibility, raising health risks, and weakening environmental sustainability in manufacturing zones (Liu, 2022).

Problem Statement

Manufacturing zones are important drivers of employment, industrial growth, and economic development, but they are also major sources of air pollution when industrial emissions are not properly controlled. Industrial processes release pollutants such as particulate matter (PM), sulphur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), smoke, dust, and chemical fumes into the atmosphere. These pollutants reduce air quality and expose workers, nearby residents, and surrounding communities to respiratory diseases, cardiovascular risks, eye irritation, reduced visibility, unpleasant odours, and general environmental degradation. Globally, air pollution remains a serious environmental health problem, with the World Health Organization (WHO) reporting that 99% of the world's population lives in places where air pollution levels exceed recommended guideline limits, while ambient and household air pollution were associated with 6.7 million premature deaths in 2019 (WHO, 2024). This shows that poor air quality is not only an environmental concern but also a major public health and sustainable development challenge.

Despite the existence of environmental regulations and emission standards in many countries, air quality in manufacturing zones remains poor due to weak enforcement, outdated technologies, high dependence on fossil fuels, poor maintenance of industrial equipment, inadequate monitoring systems, and limited investment in cleaner production. Recent empirical evidence shows that industrial activities significantly affect air quality, especially in areas with high industrial concentration and low technological upgrading (Liu, 2022). Similarly, studies in manufacturing industrial zones have shown that particulate matter pollution, especially PM2.5 and PM10, remains a major concern because it can spread beyond factory boundaries and affect both workers and nearby communities (Lala, 2025). This means that industrial emissions do not only affect the immediate factory environment but also surrounding residential, commercial, and public spaces.

The problem is further complicated by the fact that many manufacturing zones lack reliable air quality monitoring systems capable of measuring pollution levels regularly and accurately. Without consistent monitoring, it becomes difficult for regulators, factory managers, workers, and communities to know the level of exposure or the effectiveness of emission control measures. Studies have shown that direct and technology-supported monitoring can reveal pollution patterns that may be missed by general estimates or irregular inspections (Robinson, 2024; Salsabila, 2026). In addition, industrial air pollution has been linked to increased respiratory and cardiovascular health risks in industrial regions, confirming that poor air quality affects both environmental quality and human wellbeing (Kim, 2025; Sadykanova, 2025). Therefore, there is a need to examine the influence of industrial emissions on air quality in manufacturing zones in order to generate evidence that can guide cleaner production, stronger emission control, improved monitoring, better enforcement, and sustainable industrial development.

Theoretical Review

Ecological Modernization Theory

Associated with Joseph Huber, Arthur Mol, and Gert Spaargaren, argues that industrial development and environmental protection can be achieved together through cleaner technology, innovation, regulation, and institutional reform. Its relevance to the study is that manufacturing zones can reduce emissions and improve air quality by adopting cleaner production systems, emission-control equipment, renewable energy, and stronger environmental management practices. Recent studies support the view that technology and industrial modernization can improve environmental outcomes when properly supported by policy and regulation (Julkovski, 2021).

Pollution Haven Theory

Associated with Walter and Ugelow, argues that industries may move or operate in areas with weak environmental regulations because compliance costs are lower. Its main theme is that poor regulation can encourage pollution-intensive industries, leading to increased industrial emissions and declining air quality. This theory is relevant because manufacturing zones with weak monitoring, poor enforcement, and limited penalties may experience higher emissions from factories, boilers, generators, furnaces, and production processes. Recent evidence shows that weak environmental control can attract or sustain pollution-intensive industrial activity, thereby worsening environmental quality (Zhang, 2023).

Environmental Kuznets Curve Theory

Developed from the work of Simon Kuznets and later applied to environmental issues by Grossman and Krueger, argues that pollution increases during early industrial growth but may decline after income, technology, and regulation improve. Its relevance is that manufacturing zones may first experience poor air quality as industrial activity expands, but emissions can later reduce when firms adopt cleaner technologies and governments enforce stronger air quality standards. The theory helps explain the changing relationship between industrialization and pollution over time. Recent studies continue to test this theory in relation to industrialization, economic growth, energy use, and environmental degradation (Acaroğlu, 2023).

Empirical Review

Liu, Su, Gu, Tian, and Li (2022) determined how industrial concentration, industrial structure, and technological development affect urban air quality. The study focused on 284 prefecture-level cities in China. The researchers used the Air Quality Index (AQI) as the main indicator of air quality. The methodology involved geospatial analysis and spatial econometric modelling. Specifically, the study applied spatial Durbin models to examine direct and spillover effects of industrial patterns on air quality. The findings showed that industrial activities significantly influenced air quality in cities. The study found that areas with heavy industrial concentration experienced poorer air quality. It also found that the effect of industrial emissions depended on the type of industry and the level of technological upgrading. Cities with cleaner technologies had better air quality outcomes than cities relying on traditional heavy industries. The study further showed that industrial pollution can spread beyond the original manufacturing zone to nearby areas. This means that air pollution from manufacturing zones may affect surrounding urban communities. The study recommended cleaner industrial transformation, improved spatial planning, and technological upgrading. It also recommended that governments should control the location and density of polluting industries. Therefore, Liu (2022) showed that industrial emissions and industrial structure are important determinants of air quality in manufacturing zones.

Nakhjiri and Kakroodi (2024) analyzed how industrial activities contribute to air pollution in clustered manufacturing areas. The study also aimed to predict air pollution patterns using multi-source data. The methodology involved spatial analysis, industrial activity data, pollution measurements, and predictive modelling. The researchers examined the relationship between industrial location and air quality conditions. The findings showed that industrial clusters were major contributors to poor air quality. Areas with high industrial concentration recorded higher levels of air pollution. The study found that emissions from manufacturing activities were more serious where industries were closely located. It also found that pollution was influenced by industrial type, production intensity, and location. The findings suggest that manufacturing zones can become pollution hotspots when emission control is weak. The study recommended integrated air quality monitoring systems in industrial zones. It also recommended better industrial zoning to separate highly polluting industries from sensitive areas. The researchers further recommended the use of predictive technologies to support pollution control. The study is relevant because it shows that industrial planning is directly linked to air quality management. Therefore, Nakhjiri and Kakroodi (2024) demonstrated that controlling industrial emissions requires both monitoring and proper spatial organization of manufacturing zones.

Lala, Vincent, Adesina, Popoola, Odejobi, and Sonibare (2025) assessed particulate matter pollution and its health risks in selected industrial zones. Particulate matter refers to tiny particles in the air that can harm human health when inhaled. The study focused on particulate matter with a diameter of 2.5 micrometres or less (PM2.5) and particulate matter with a diameter of 10 micrometres or less (PM10). The methodology involved air quality monitoring, spatiotemporal analysis, dispersion modelling, and non-carcinogenic health risk assessment. The researchers collected air pollution data from four major manufacturing zones. The findings showed that particulate matter levels were a major concern in the selected industrial zones. The study found that industrial activities contributed significantly to particulate matter pollution. It also found that workers and nearby residents were exposed to possible health risks. The findings showed that vulnerable groups such as children, older people, and people with respiratory conditions may be more affected. The study linked particulate matter pollution to poor air quality in manufacturing zones. It recommended stricter control of industrial emissions. It also recommended continuous air quality monitoring in manufacturing areas. The researchers further recommended stronger government enforcement of environmental regulations. Therefore, Lala (2025) showed that industrial emissions in manufacturing zones can reduce air quality and increase public health risks.

Kim (2025) examined whether exposure to pollutants from industrial complexes affects chronic respiratory diseases among local residents. The study focused on communities living near industrial complexes. The methodology used population cohort data and exposure assessment techniques. The researcher examined the relationship between industrial air pollutants and respiratory health outcomes. The findings showed that residents around industrial complexes were exposed to air pollutants linked to respiratory problems. The study found that air pollution from industrial complexes may increase chronic respiratory disease risks. It also showed that the effect of industrial emissions can extend beyond factory boundaries. This means that nearby communities may suffer from pollution even if they do not work inside the factories. The findings confirmed that industrial emissions are both an environmental and public health concern. The study recommended stricter industrial emission control. It also recommended wider exposure monitoring zones around industrial complexes. The researcher further recommended stronger protection measures for communities living near manufacturing areas. The study is relevant because it connects industrial emissions, air quality, and human health. Therefore, Kim (2025) showed that improving air quality in manufacturing zones requires protecting both workers and surrounding residents.

Sadykanova, Kumarbekuly, and Yessimbekova (2025) examined the impact of air pollution on morbidity in industrial areas of East Kazakhstan. The purpose of the study was to determine the relationship between pollutant emissions and disease patterns in industrial regions. Morbidity refers to the occurrence of disease or illness within a population. The study focused on the health effects of air pollution in areas affected by industrial activities. The methodology involved correlation and regression analysis. The researchers used pollutant emission data and morbidity indicators covering the period from 2014 to 2023. The findings showed that industrial air pollution was associated with increased public health risks. The study found that air pollutants contributed to respiratory and cardiovascular disease patterns. It also showed that industrial regions with higher pollution levels experienced greater health burdens. The findings suggest that poor air quality in manufacturing and industrial zones can directly affect community wellbeing. The study recommended stronger environmental regulation in industrial areas. It also recommended regular air quality monitoring and emission reduction measures. The researchers further recommended health-based air quality policies. The study is relevant because it shows that air quality management should be linked to disease prevention. Therefore, Sadykanova (2025) demonstrated that industrial emissions influence both environmental quality and public health outcomes.

Salsabila, Aly, Hustim, Harusi, Dinanti, and Pala'langan (2026) estimated and validate air pollutant concentrations in an industrial manufacturing zone. The study focused on pollutants such as particulate matter with a diameter of 10 micrometres or less (PM10), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO). The methodology combined satellite-based estimation and ground-based validation. The researchers used Landsat 8 satellite imagery to estimate pollutant concentrations. They also collected ground measurements from 41 monitoring points. The findings showed that satellite-based monitoring can help identify air pollution patterns in industrial areas. The study found that cement production activities contributed to measurable pollution levels. It also showed that remote sensing can support air quality monitoring where ground stations are limited. The findings suggest that manufacturing zones require both modern monitoring technology and physical field measurements. The study recommended combining satellite data with ground monitoring systems. It also recommended regular monitoring of cement and manufacturing zones. The researchers further recommended using air quality data to guide emission management. The study is relevant because many manufacturing zones lack adequate monitoring infrastructure. Therefore, Salsabila (2026) showed that technology-based monitoring can improve understanding and control of industrial emissions.

Robinson (2024) conducted an empirical study in Southeastern Louisiana's petrochemical industrial corridor in the United States of America (USA). The purpose of the study was to measure ambient ethylene oxide concentrations around industrial production and end-use facilities. Ethylene oxide is a hazardous industrial air pollutant used in some chemical and manufacturing processes. The study focused on a petrochemical corridor with many industrial facilities. The methodology involved high-spatial-resolution mobile monitoring. The researchers used real-time air monitoring equipment to collect pollution data across a 75-kilometre industrial corridor. The data were aggregated at 500-metre resolution to show pollution variation across space. The findings showed measurable ethylene oxide concentrations around industrial facilities. The study found that direct monitoring can reveal pollution patterns that may not be fully captured by modelled estimates. It also showed that hazardous industrial emissions can vary greatly across short distances. The findings suggest that communities near petrochemical and manufacturing corridors may face uneven exposure to industrial pollutants. The study recommended improved industrial air monitoring. It also recommended stronger reporting of hazardous emissions by industrial facilities. The researchers further recommended targeted emission reduction around high-risk industrial zones. Therefore, Robinson (2024) showed that direct measurement of industrial emissions is important for improving air quality management in manufacturing corridors.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low-cost advantage as compared to field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

FINDINGS

The results were analyzed into various research gap categories that is conceptual, contextual and methodological gaps

Conceptual Gap

The reviewed studies show that industrial emissions affect air quality, but most of them focus on specific pollutants, specific industries, or specific outcomes rather than providing a broad conceptual link between industrial emissions and air quality in manufacturing zones. For example, Lala (2025) focused mainly on particulate matter, Salsabila 2026) focused on pollutants such as particulate matter with a diameter of 10 micrometres or less (PM10), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO), while Robinson (2024) focused on ethylene oxide in a petrochemical corridor. This creates a conceptual gap because air quality in manufacturing zones is influenced by a wider combination of emissions, including smoke, dust, gases, chemical fumes, fuel combustion, production-process emissions, and transport-related emissions. Therefore, the current study can fill this gap by examining industrial emissions more broadly and linking them to overall air quality indicators in manufacturing zones.

Contextual Gap

The reviewed studies were conducted in different industrial contexts, including industrial clusters, cement production areas, petrochemical corridors, industrial complexes, and broad city-level industrial structures. However, many of them do not focus specifically on ordinary manufacturing zones where several small, medium, and large factories may operate together and release mixed emissions into the same environment. For instance, Liu (2022) examined 284 Chinese cities using industrial patterns, while Kim (2025) focused on health outcomes among residents near industrial complexes, and Sadykanova (2025) examined morbidity in industrial areas. These contexts are useful, but they do not fully explain how daily emissions from manufacturing activities such as boilers, generators, furnaces, raw-material processing, chemical use, and factory transport affect air quality within manufacturing zones. This creates a contextual gap that the current study can address by focusing directly on manufacturing zones as production environments where air pollution is shaped by factory operations, technology use, fuel sources, emission control systems, and regulatory compliance.

Geographical Gap

The reviewed empirical studies were conducted in China, Iran, Nigeria, South Korea, East Kazakhstan, Indonesia, and the United States of America (USA). Although these studies provide useful evidence, their findings may not be fully applicable to other manufacturing zones because air quality conditions vary according to industrial structure, enforcement capacity, technology levels, energy sources, urban planning, and climate conditions. For example, China's large industrial cities may differ from Nigerian manufacturing zones, Korean industrial complexes, Indonesian cement zones, and United States petrochemical corridors. This means that evidence from one geographical setting cannot automatically be generalized to another location without considering local industrial practices and environmental regulation. Therefore, a geographical gap exists because there is still need for location-specific evidence on how industrial emissions influence air quality in the selected manufacturing zone of the proposed study.

CONCLUSION AND RECOMMENDATIONS

Conclusions

In conclusion, industrial emissions have a significant influence on air quality in manufacturing zones. Emissions from factories, boilers, generators, furnaces, vehicles, and production processes release pollutants such as particulate matter, sulphur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, and greenhouse gases into the atmosphere. When these emissions are not properly controlled, they contribute to poor air quality, respiratory health risks, environmental degradation, unpleasant odours, reduced visibility, and contamination of the surrounding environment. This shows that air pollution in manufacturing zones is not only an environmental issue but also a public health, workplace safety, and sustainable development concern.

Therefore, improving air quality in manufacturing zones requires strong emission control measures, cleaner production technologies, regular monitoring, proper maintenance of industrial equipment, and strict enforcement of environmental regulations. Manufacturing firms should adopt cleaner fuels, install pollution control equipment, train workers on environmental safety, and comply with air quality standards. Government agencies and local authorities should also strengthen inspections, enforce penalties for non-compliance, and encourage industries to adopt sustainable production practices. The study concludes that reducing industrial emissions is essential for creating healthier manufacturing zones, protecting nearby communities, improving environmental quality, and promoting sustainable industrial development.

Recommendations

Theory

This study contributes to theory by strengthening the understanding of how industrial emissions influence air quality in manufacturing zones. It supports Ecological Modernization Theory by showing that industrial growth and environmental protection can be achieved together through cleaner technologies, innovation, and better regulation. The study also contributes to Pollution Haven Theory by helping explain how weak environmental controls can allow industries to continue emitting harmful pollutants, especially in areas where enforcement is limited. In addition, the study contributes to Environmental Kuznets Curve Theory by examining whether industrial development initially worsens air quality before cleaner technologies and stronger policies improve environmental outcomes. Therefore, the study links industrial activity, environmental regulation, technological improvement, and air quality into one useful framework for understanding pollution control in manufacturing zones.

Practice

This study contributes to practice by giving manufacturers, factory managers, environmental officers, and industrial zone managers practical guidance on how to reduce air pollution. It shows that air quality can be improved when firms control emissions at the source instead of waiting to manage pollution after it has already affected communities. The findings can help industries develop practical emission reduction plans, including cleaner fuel use, machine maintenance, installation of filters, improved ventilation, and continuous pollution monitoring. The study also provides guidance for industrial zone managers to coordinate shared pollution control efforts among firms located in the same manufacturing area. In practice, the study encourages manufacturers to treat air quality management as part of operational efficiency, worker safety, corporate responsibility, and long-term business sustainability.

Policy

This study contributes to policy by providing evidence that industrial emissions should be managed through strict, measurable, and enforceable air quality regulations. Policymakers can use the study to strengthen emission standards for manufacturing firms and require regular reporting of air pollutants. The study can also guide the establishment of mandatory air quality monitoring stations in manufacturing zones. Environmental agencies should introduce inspection schedules, penalties for non-compliance, and incentives for industries that adopt cleaner technologies. The study further supports the need for zoning policies that separate highly polluting industries from residential areas, schools, hospitals, and markets. Therefore, the study provides a policy foundation for cleaner industrial development, improved public health, and sustainable manufacturing zones.

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