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Iot Based Industrial Pollution Monitoring System

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REVIEW ARTICLE

Abstract— This paper introduces a robust IoT-based industrial pollution monitoring system aimed at addressing the critical need for effective environmental management in industrial settings. By leveraging sensor networks and real-time data analytics, the system provides continuous monitoring of various pollutants emitted from industrial activities. The integration of IoT devices streamlines data collection, transmission, and analysis, offering timely insights for proactive decision-making. This system not only facilitates compliance with environmental regulations but also helps mitigate adverse impacts on surrounding ecosystems, thereby promoting sustainable industrial practices. The proposed solution underscores the importance of utilizing IoT capabilities to foster environmental sustainability and enhance the well-being of communities affected by industrial operations. Through continuous monitoring and immediate data processing, the system ensures that industrial pollution is kept within permissible levels, reducing the risk of environmental harm. Additionally, the real-time feedback loop allows industries to promptly address pollution incidents, preventing long-term ecological damage. Overall, this innovative approach demonstrates how advanced technology can be harnessed to achieve a balance between industrial development and environmental preservation, ensuring a healthier and more sustainable future for all.

Keywords- IoT , Industrial pollution, Monitoring system, Environmental sustainability, Real-time data, Sensor networks

INTRODUCTION

An IoT-based industrial pollution monitoring system represents a pivotal advancement in environmental sustainability and regulatory compliance. This innovative solution harnesses the power of interconnected devices to continuously monitor, analyze, and mitigate pollution levels within industrial settings. At its core, the system integrates a network of sensors strategically deployed throughout the facility to capture real-time data on various pollutants such as particulate matter, gases, and chemical emissions. These sensors, equipped with cutting-edge technology, measure pollutant concentrations with high accuracy and precision, providing invaluable insights into the environmental impact of industrial activities.

The cornerstone of this monitoring system lies in its seamless connectivity and data transmission capabilities. Through IoT-enabled devices, sensor data is swiftly transmitted to a centralized cloud-based platform, where it undergoes rigorous analysis and processing in near real-time. This instantaneous data aggregation allows for timely identification of pollution hotspots, abnormal emission patterns, and potential environmental risks. Furthermore, the integration of advanced analytics and machine learning algorithms empowers the system to predict pollution trends, detect anomalies, and optimize mitigation strategies proactively.[1]

One of the primary benefits of an IoT-based approach is its unparalleled scalability and flexibility. The system can be tailored to accommodate the unique needs and operational

specifications of any enterprise, whether it's a small-scale manufacturing facility or a large industrial complex. Additionally, the modular nature of IoT devices facilitates easy expansion and integration with existing infrastructure, minimizing deployment costs and operational disruptions. This scalability ensures that the monitoring system remains adaptable to evolving regulatory standards and industry best practices.

Moreover, the transparency and accessibility of real-time pollution data play a pivotal role in fostering environmental stewardship and corporate accountability. By providing stakeholders, including regulatory agencies, environmental activists, and local communities, with unrestricted access to

pollution metrics, the system promotes transparency and facilitates informed decision-making. This transparency not only enhances regulatory compliance but also fosters public trust and goodwill, positioning the organization as a responsible corporate citizen committed to environmental sustainability.

In addition to regulatory compliance and environmental stewardship, an IoT-based pollution monitoring system offers tangible economic benefits to industrial operators. By identifying inefficiencies, optimizing resource utilization, and minimizing emissions, the system enables cost savings through improved operational efficiency and reduced regulatory penalties. Furthermore, proactive pollution management helps mitigate the risk of costly environmental incidents, legal liabilities, and reputational damage, safeguarding long-term business viability and profitability.[2]

Looking ahead, the continued evolution of IoT technology holds immense promise for advancing environmental monitoring and sustainability efforts across industries. As sensor capabilities improve, data analytics become more sophisticated, and connectivity becomes ubiquitous, IoT-based solutions will play an increasingly integral role in mitigating pollution, conserving resources, and

fostering a more sustainable future. By embracing innovation and leveraging the transformative potential of IoT, industrial stakeholders can simultaneously enhance environmental performance, regulatory compliance, and operational efficiency, ushering in a new era of responsible and sustainable industrial practices.[4]

LITERATURE REVIEW

In an industrial pollution monitoring system based on IoT (Internet of Things), a diverse array of sensors and components collaborate to provide thorough environmental surveillance. Sensors like the DHT11 for temperature and humidity, MQ3 for alcohol, MQ5 for LPG, MQ135 for air quality, and a pressure sensor provide real-time data on various pollutants and environmental conditions. These sensors are connected to a NodeMCU microcontroller, which processes the data and transmits it to the cloud via a WiFi module for remote monitoring and analysis. The system is powered by a dedicated power supply and incorporates isolators for safety. Depending on the pollution levels detected, the system can trigger actions through relays, such as activating an exhaust fan to vent harmful gases, or activating a sprinkler system to mitigate airborne pollutants. Additionally, voltage amplifiers may be employed to ensure accurate sensor readings. Overall, this integrated setup enables proactive pollution monitoring and control in industrial environments, contributing to a safer and healthier workplace and surrounding community.[3]

In their groundbreaking work, Saiye, Y.D. and colleagues (2020) pioneered an innovative approach to air quality surveillance, leveraging a sophisticated wireless sensor network. Their system not only facilitates real-time monitoring across diverse locations but also provides seamless access to data via smartphones, tablets, and other internet-enabled devices. This pioneering design incorporates an Arduino Uno, a WIFI module, and an MQ135 gas sensor, enabling precise tracking of airborne contaminants.

In their recent endeavor, Chourey, Pet al. (2022) introduced a cutting-edge IoT-driven approach to air pollution monitoring. Their system integrates MQ135, MQ7, and DHT11 gas sensors, each playing a crucial role in detecting various pollutants. These sensors interface seamlessly with the ESP32 module, which transmits the gathered data to the ThingSpeak web server for comprehensive analysis and visualization. Additionally, an alert mechanism, configured with a buzzer, ensures timely notifications in the event of deteriorating air quality, enhancing public awareness and safety.

Sunil Mahesh Pattar et al. (2018) conducted a comprehensive survey on the IoT-based air pollution monitoring system, revealing a concerning trend of escalating pollution levels over time. They attributed this surge to various factors including population expansion, intensified vehicular activity, rapid industrialization, and urban development, all

of which pose significant threats to human health by directly compromising air quality. In their solution, they introduced a pioneering IoT-driven Air Pollution Monitoring System, engineered to remotely monitor air quality through a web server. This system incorporates an alarm system that activates when pollution levels fall below preset thresholds, signaling the detection of hazardous gases like CO₂, smoke, alcohol, benzene, and NH₃. Additionally, it provides real-time monitoring of air components in parts per million (PPM) on both an LCD display and a specialized website, ensuring accessibility for users to monitor air quality conveniently via computers or smartphones in this forward-thinking IoT project.

In their groundbreaking study, Harsh Gupta and collaborators (2019) unveiled an innovative IoT-based air pollution monitoring system tailored for the unique challenges faced by smart cities. With urbanization on the rise globally, the livability of smart cities is increasingly scrutinized, particularly concerning air quality. Recognizing this pressing concern, the team devised a sophisticated IoT infrastructure aimed at continuously assessing the air quality index within urban centers. Their investigation led to the creation of an IoT-powered Air Quality Monitoring System tailored for smart cities. This system utilizes real-time data gathering through smart devices, facilitating in-depth analysis of its influence on urban residents. Essential metrics including temperature, humidity, carbon monoxide, LPG, smoke, as well as particulate matters such as PM_{2.5} and PM₁₀ levels, are diligently tracked using smart devices. To ensure widespread accessibility, an Android application disseminates the collected data globally, empowering individuals worldwide to stay informed about their city's air quality status.[5]

In a significant advancement, Harsh N. Shah and their team (2018) spearheaded the development of an IoT-based air pollution monitoring system, leveraging cutting-edge components including ATmega328P, ESP8266 Wi-Fi module, and an array of gas and environmental sensors such as MQ135, MQ6, LM35, and SY-H5220. Crafted for real-time air quality monitoring, this extensive system operates via a specialized web server. Its standout capability lies in issuing alerts upon detecting air quality deterioration below preset thresholds, signifying the existence of harmful gases like CO₂, smoke, alcohol, benzene, NH₃, and NO_x. Importantly, the system offers easily understandable visual representations of air quality measurements in parts per

million (PPM) on both an LCD display and a dedicated webpage, fostering effortless air pollution monitoring for heightened public consciousness and environmental guardianship.

In a groundbreaking initiative, Patil, P., along with their team (2017), developed an advanced IoT-centered system designed specifically for monitoring vehicle noise and pollution. Their meticulous work encompasses both hardware architecture and software implementation, offering comprehensive insights into the system's functionality. Leveraging IoT technology, they conducted rigorous performance verification, resulting in the creation of an intelligent environmental system adept at monitoring pollutants emitted by vehicles. This system not only detects pollution but also proactively alerts vehicle owners, prompting them to take corrective measures to mitigate environmental impact. Furthermore, pollution level data is transmitted to a centralized server for in-depth analysis. Environmental authorities benefit from this data-driven approach, enabling them to pinpoint vehicle registration numbers contributing to heightened pollution levels. Notably, the system boasts a low-cost, user-friendly design, suitable for deployment in diverse locations. Its superior accuracy and cost-effectiveness mark a significant improvement over traditional monitoring systems, heralding a new era of efficient pollution control measures.[6]

In their inventive initiative, Saha, A.K., and their collaborators (2018) introduced a cloud-based system controlled by Raspberry Pi to monitor air and sound pollution, incorporating temperature and humidity sensing capabilities facilitated by a Wi-Fi module. The authors stressed the importance of exercising control and vigilant monitoring to tackle rising pollution levels. Their study advocates for an IoT-based approach to monitor the Air Quality Index (AQI) and Noise Intensity in a given area. The system comprises four main modules: the Air Quality Index Monitoring Module, Sound Intensity Detection Module, Cloud-based Monitoring Module, and Anomaly Notification Module. Initially, the AQI is calculated based on the concentration of five specific air pollutants, followed by sound intensity detection using dedicated sensors. Subsequently, the Cloud-based Monitoring Module orchestrates data collection, leveraging the Raspberry Pi's Wi-Fi module for seamless transmission and enabling regular data analysis. Finally, the Anomaly Notification Module serves to alert users promptly in case of any detected issues, ensuring swift response and intervention as necessary.

Recent years have witnessed a transformative shift in air pollution monitoring, driven by advancements in wireless communication and sensor technologies. The emergence of the Internet of Things (IoT) has inaugurated a period of interconnected intelligent environments, facilitating smooth communication and cooperation among diverse devices. Leveraging this technological evolution, researchers have employed Raspberry Pi and IoT solutions to establish robust monitoring systems aimed at detecting dangerous gas leakages and assessing air quality, thus mitigating the risk of potential tragic incidents.[7]

METHODOLOGY

TheNodeMCUESP32, DHT11Temperature and Humidity Sensor,MQ3Alcohol,MQ135Gassensor,MQ5,PressureSensor,Blynk cloud,mobile app,Exhaust Fan are used to make our project. Fig 1



Fig1. An Elementary Architecture For Monitoring Industrial Pollution with IoT Integration

The ESP32 stands out as a multifunctional microcontroller and wireless communication module crafted by Espressif. Its array of benefits renders it a favored selection for diverse IoT (Internet of Things) endeavors. The ESP32 features a dual-core processor, which enables multitasking and efficient handling of multiple tasks simultaneously. The ESP32 is equipped with integrated Wi-Fi and Bluetooth functionalities, enabling seamless internet connectivity and device-to-device communication. Crafted with a focus on minimizing power consumption, the ESP32 is aptly suited for battery-operated devices and energy-conscious applications.

The ESP32 presents a cost-effective option when compared to certain microcontrollers possessing similar functionalities, rendering it an appealing selection for projects mindful of budget constraints. All sensors are affordable at low prices only, making it accessible for hobbyists, students, and projects with budget constraints. The MQ-3 sensor is versatile and can detect a variety of gases, including alcohol, ethanol, and smoke. This makes it suitable for applications related to breathalyzers, fire detection, and air quality monitoring. MQ sensors generally have a quick response time, providing timely detection of changes in gas concentrations. Blynk Cloud is a platform designed to simplify the development of IoT (Internet of Things) applications. Blynk allows for quick prototyping and testing of IoT applications. With a drag-and-drop interface, users can easily create interfaces for their projects, saving time during the development phase. Pressure sensors are designed to provide precise and accurate measurements of pressure. This

accuracy is crucial in applications where even slight variations in pressure can have significant consequences, such as in medical devices or industrial processes. Pressure sensors find applications in diverse fields, including automotive, aerospace, healthcare, industrial automation, and environmental monitoring. Their versatility allows them to be used in different environments and for various purposes.[8]

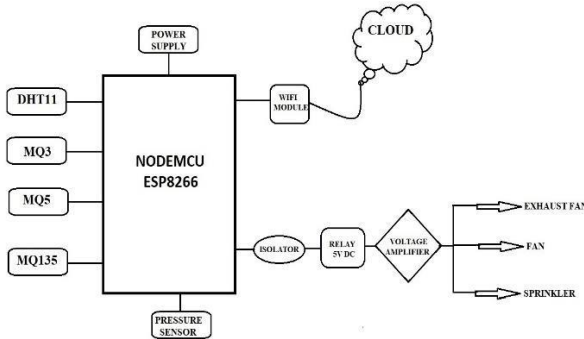


Fig .2: Illustrates The Functional Block Diagram.

Figure 2 showcases the proposed flowchart. The system overview process is categorized into seven (7) tiers. The initial layer involves loading essential libraries and defining pin configurations, while the second layer encompasses the measurement of environmental parameters using sensors. The third layer Describes about how NODEMCUESP36 Recieves data from sensors. The fourth layer Is the internet connectivity layer. The fifth layer Consists of blynk cloud and mobile app, The sixth layer Checks with the pollutantlevel in mobileApp, the seventh layer finally returns the output.[9]

Precise operation of our project

The procedure for efficient air quality monitoring unfolds in the following manner: Once hazardous gases such as carbon dioxide, benzene, and sulfur dioxide reach critical levels within the vicinity...

Different sensors like DHT11 measures the temperature and humidity levels, MQ3, MQ5, MQ135 measures the alcoholic and gaseous pollutant level and sends the information to the NODEMCUESP32, All the data of pollutants level will be transferred from esp32 to blynk cloud with the help of internet, Ultimately We will create one mobile application that accesses all the data from blynk cloud and compares it with normal pollutant called threshold value that is defined, if pollutant level is greater than the threshold range Then it alerts the user via notification , Simultaneously if the temperature exceeds more than threshold value then automatically Fan starts rotating thereby it absorves all the excess heat from industriy and similarly if dangerous gases is found excessively in the Industrial surrounding area, then An Exhaust Fan is provided that throws out all the dangerous Gases out to the industrial area.

The Mobile apps can provide real-time alerts about pollution levels, allowing users to receive immediate information about the air quality in their surroundings. This timely awareness is

crucial for individuals to take prompt actions to protect their health. By receiving alerts on their mobile devices, users can make informed decisions to avoid exposure to high pollution levels. This is particularly important for individuals with respiratory conditions, allergies, or other health concerns that may be aggravated by poor air quality. This is Final output which get displayed on thre user interface of user's mobile. Mobile apps can provide location-specific pollution data, helping users understand the pollution levels in their immediate vicinity. This localized information allows for more targeted responses and adjustments to activities based on the specific pollution conditions in their area[10] fig 3

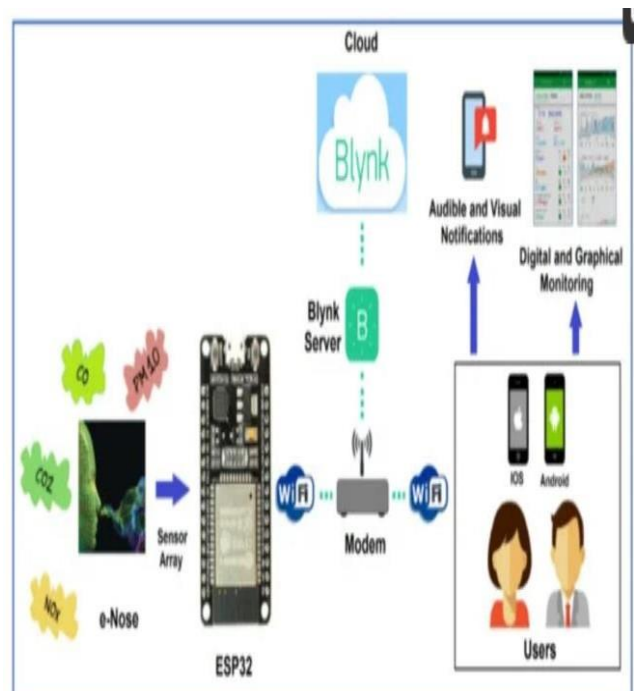


Fig. 3: Architectural Working Of Our Project

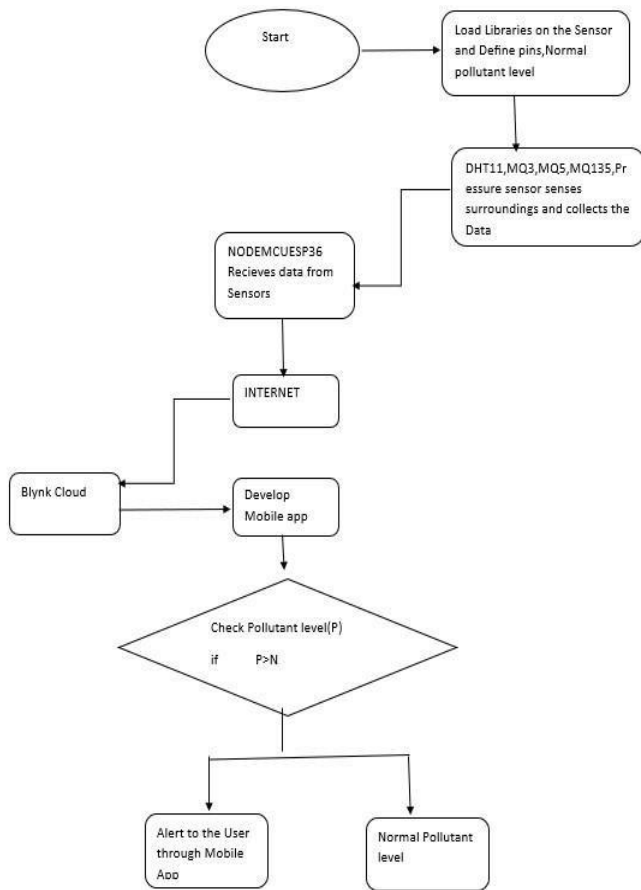


Fig 4. Flowchart Of Proposed System

Results And Discussions

The pollution concentration varies periodically . A comprehensive model has been developed incorporating sensors , interconnecting modules and the system is overseen by Central Processing Unit NodemCU . In this proposed study we have opted for pollutants as a input to measure . The primary factors we have taken into account in our study include temperature , humidity , gases which contains alcohol . First sensor is the DHT11 sensor to measure the Temperature .The another sensor is MQ3 sensor to measure Alcohol , Ethanol , Smoke . The another sensor is MQ5 sensor to measure LPG , Natural gas , Coal gas . The another sensor is MQ135 Ammonia , Sulphide , Benzene , CO2 . And the last one is pressure sensor which measures the force exerted by a fluid and it converts into an electrical signal. Communication protocols. Overall the integration with the Blynk streamlines the development , deployment and management of the pollution monitoring system , enhancing accessibility and user interaction fig 4

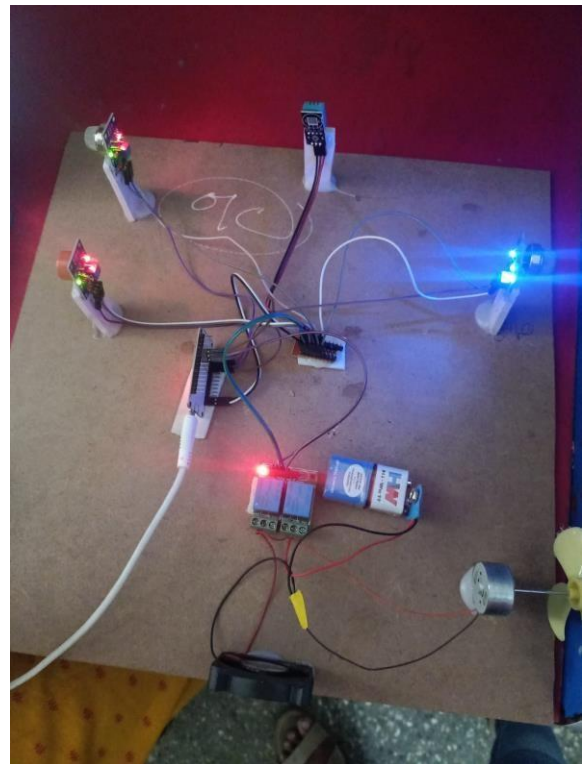


Fig 5. A Complete Hardware System Setup

Designing an IOT based Industrial pollution monitoring system involves selecting appropriate sensors for targeted pollutants ,calibrating them for accuracy and integrating them with IOT devices like Arduino . The sensors communicate data through we have incorporated communication protocols such as MQTT(Message Queuing Telemetry Transport) or HTTP(Hyper Text Transfer Protocol) for central server or cloud platform where processing algorithms analyze and aggregate the information . fig 5 The processed data is stored in databases like cloud for historical analysis and a user interface , such as web based dashboard , visualizes real-time pollution levels . Alert mechanisms notify stakeholders when predefined thresholds are exceeded , and power management and security measures , including encryption , are implemented . Regular maintenance , calibration checks and adherence to a security protocol ensuring system's reliability and efficiency in delivering a comprehensive industrial pollution monitoring system .[11,12]

In an IOT based Industrial pollution monitoring system connected to the blynk cloud , various sensors deployed in the industrial environment continuously collect data on parameters such as gas concentrations , particulate matter , temperature , humidity . The system integrates the Blynk library into its microcontroller , establishing a secure connection to the Blynk cloud for real-time data exchange . users configure a customized dashboard on the Blynk app or web interface , which is updated in real-time with the latest sensor data . The Blynk cloud processes and stores the data , providing historical analysis and trend monitoring . Users can set alerts based on predefined thresholds, receiving notifications if pollution levels exceed acceptable limits . The

platform also offers remote control capabilities and ensures data security through authentication and secure



Fig 6 .A Blynk App User Interface

NODEMCU serves as vital component in an IOT based industrial pollution monitoring system , facilitates the integration of pollution sensors and real time data acquisition . with its WIFI capabilities , NODEMCU connects to the internet , enabling the transmission of processed data to the central server or cloud platform for analysis . And also a WIFI module is required for real transmission data , enabling remote monitoring and seamless integration with cloud platforms . It facilitates quick and reliable communication , supporting timely decision making and comprehensive pollution control .And also it integrates isolators for safety , a 5v Dc relay to control high voltage devices based on pollution , and voltage amplifiers to enhance sensor signals connected to exhaust fans , regular fans and sprinklers , these components enable real time automation for workplace safety The system ensures electrical separation , accurate measurements and responsive actions to improve environmental conditions.[12] fig 6

Finally how they work together is the NODEMCU reads data from sensors using GPIO(General purpose Input/Output) pins . It processes this data and connects to the Blynk cloud through the WIFI module . The Blynk cloud enables you to create a user interface on a mobile app to control and monitor your devices . The power supply ensures that all components receive the required power for operation . and finally NODEMCU acts as the brain of the system , collecting data

from various sensors connecting to the internet through WIFI , and interacting with the Blynk cloud for remote monitoring and control .

Communication protocols . Overall the integration with the Blynk streamlines the development , deployment and management of the pollution monitoring system , enhancing accessibility and user interaction .

Conclusion

Industrial pollution presents significant hazards in various industries, necessitating continuous monitoring to ensure healthy workplace conditions free from contaminants. An IoT-based industrial pollution monitoring system maintains air quality in industrial settings and sends alert notifications to users' mobile devices. The implementation of such a system utilizing IoT technology is crucial for promoting sustainable and responsible industrial practices. This innovative approach enables real-time data collection, analysis, and reporting, empowering industries to proactively manage and mitigate their environmental impact. Over time, the adoption of these systems not only protects the environment but also enhances the reputation of industries committed to eco-friendly operations. As technology progresses, ongoing enhancements to the Industrial Pollution Monitoring System will further refine its effectiveness, contributing to a more sustainable and environmentally conscious industrial landscape. IoT devices inherently possess the capability to gather and transmit precise and timely data, enabling industries to proactively identify and address pollution sources. This approach not only reduces environmental impact but also enhances operational efficiency and minimizes the risk of regulatory non-compliance. The integration of IoT technologies facilitates seamless information flow, enabling stakeholders to make informed decisions and take prompt actions to address pollution incidents.

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