IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Remote Monitoring Of Hazardous Environment Using Lora Network

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Abstract: Industrial environmental monitoring using LoRa technology enhances safety and efficiency by wirelessly tracking key parameters. The system uses sensors to monitor temperature, gas leaks, water flow, and pH levels, ensuring safe operations and water quality. Data from these sensors is processed by a microcontroller and transmitted using LoRa, known for its long-range, low-power communication. This allows reliable data transfer across wide industrial areas. The received data is displayed in real-time on a dashboard or LCD screen. Continuous monitoring enables quick detection of anomalies like gas leaks or temperature spikes. This smart system ensures rapid response and improved operational control over the hazardous environments in the industrial sites which helps to react quick from any environmental changes swiftly to save the people in the area from getting affected. By leveraging LoRa technology, this system ensures efficient and reliable monitoring, enhancing both safety and operational efficiency.

***Index Terms* - Component, formatting, style, styling, insert.**

I. INTRODUCTION

The project proposes a Remote Monitoring System for Hazardous Environments using LoRa Technology, which enables real-time transmission of critical environmental data such as gas concentrations, temperature, humidity, and smoke levels from the hazardous area to a centralized monitoring unit located at a safe distance. The system consists of a transmitter node equipped with various sensors and a LoRa module, which collects and transmits data wirelessly to a receiver node for display, alerting, and further analysis. By integrating LoRa communication into this monitoring system, the solution ensures robust, energy-efficient, and long-range connectivity, making it highly suitable for remote and risk-prone industrial applications. The implementation of this system can significantly enhance workplace safety, support preventive maintenance, and reduce response time in emergencies.

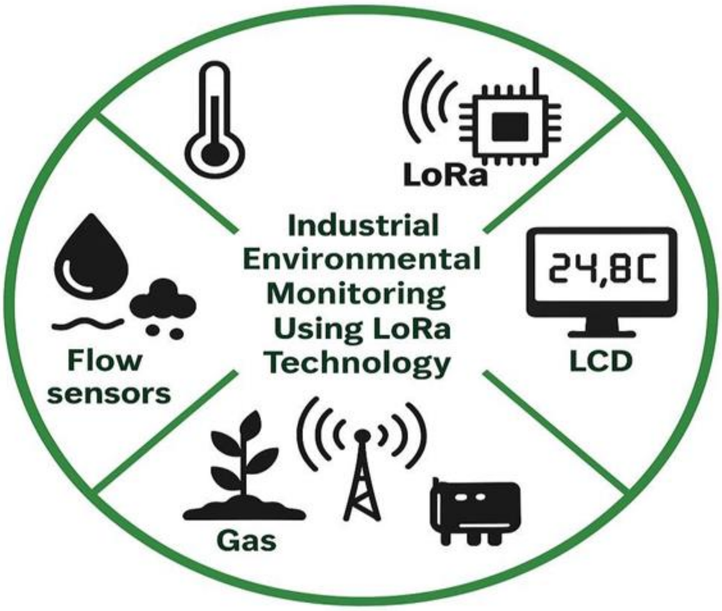
Industries have been a source of sustenance for humanity, evolving with technological advancements to improve efficiency and sustainability. Traditional industrial monitoring methods often suffer from limited coverage, delayed responses, and high energy consumption. The integration of LoRa technology with environmental sensors has transformed industrial monitoring by enabling real-time data collection, long-range communication, and energy-efficient operations. This approach ensures timely detection of anomalies, enhances safety, and improves overall process efficiency in industrial environments.

II. REVIEW OF LITERATURE

Several studies have explored IoT and LoRa applications in environment monitoring. **Augustin’s** research provides an in-depth analysis of LoRa WAN protocol, highlighting its ability to support multiple devices while maintaining low power consumption. It specifies that LoRa operates in the ISM band (e.g., 915 MHz in the US and 433 MHz in Asia). Adaptive Data Rate (ADR) optimizes power and data rate for energy efficiency. The study analyzed that the LoRa network supports both short- and long-range communication, emphasizing its benefit in scalable network architecture.

Z. Wang and S. Chen in their research discusses LoRa’s role in IoT across various electrical devices and smart infrastructure applications. It includes smart parking systems that enhance vehicle congestion management. The study shows that LoRa enables real-time fault detection in manufacturing plants and is cost-efficient. It also focuses on LoRa's use in industrial automation, particularly for monitoring and predictive maintenance.

Vasisht (2017): Vasisht explores the use of LoRa in precision agriculture through a system called Farm Beats. LoRa-based wireless sensors monitor soil moisture, temperature, and environmental factors, helping farmers make data-driven decisions. The system allows long-range connectivity without a centralized power grid, and its low power consumption ensures long battery life, making it suitable for continuous monitoring in rural areas.



Despite the advancements in industrial environmental monitoring, several challenges remain in achieving large-scale implementation. Factors such as initial setup costs, limited technical expertise among operators, and inconsistent connectivity in remote industrial areas can slow adoption. This work extends previous research by integrating real-time data logging, anomaly detection through predictive analytics, and automated alert systems to enhance monitoring accuracy and safety in industrial environments.

III. RESEARCH METHODOLOGY

3.1 System Architecture The proposed smart monitoring system comprises IoT-based sensors, a long-range-based communication, This system entails a comprehensive approach to monitor the industrial environment safety. The core components of the system include

- **Sensors**: A network of sensors, including temperature sensor, gas sensor, pH sensor and water-flow sensor, collect real-time environmental data.
- **LoRa Connectivity**: The sensor data is transmitted through wireless LoRa transmitter to the LoRa receiver and thereby it is displayed in the monitor to ensure smart monitoring.

- **Node MCU Model**: The system employs a Node MCU model which a microcontroller that has an in-built wi-fi module for transmission of data wirelessly.
- **Display:** The data that is received from the LoRa transmitter is collected by the LoRa receiver and then the data is displayed on monitor.
- **Working Principle**: The working principle of the project is the long-range communication of data collected from the input sensors to the output sensors.

3.2 LoRa Integration The implementation of LoRa S services enhances the efficiency and scalability of the smart monitoring system. The LoRa transmitter model collect the data from the Sensors connected at the input end and the data is then transmitted to the receiver end through the long-range LoRa transmission using the LoRa transmitter at transmission and LoRa receiver at Receiver Sections respectively which ensures the communication is enhanced for a very long range.

IV. RESULTS AND DISCUSSION

The system was tested by using various elements like different gases that are made as input to the gas sensor and the changes the data received at the receiver side of the system are noted as outputs and tested the system in different temperatures to make sure the results by the temperature sensor as input are accurate and the pH sensor is also tested by providing different pH valued liquids such as water , lime water, salt water and other liquids with different pH and finally the flow sensor is tested by placing it in water flowing at different flow speeds .

Comparative analysis of the smart monitoring also includes the monitoring of quality of air or water depending on the inputs given by system and is calculated using:

$$\text{Normalized Value: } \frac{\text{Current Value} - \text{Min Acceptable}}{\text{Max Acceptable} - \text{Min Acceptable}}.$$

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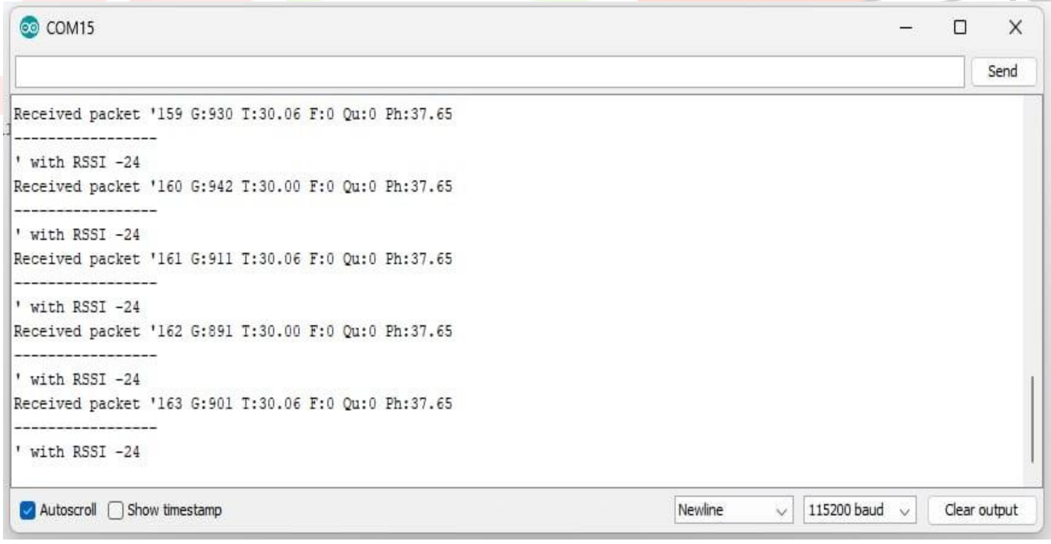

Further refinements in model accuracy and sensor precision can enhance the system's efficiency. Future work includes the data transmission from a long-range including more sensor data inputs and the output accuracy.

The Data that is received from the industrial area provides workers in industrial areas with real-time insights in their fields, enabling proactive decision- making. Workers and management of industries could track water levels, temperature fluctuations, and gas changes in air, allowing timely interventions. The LoRa-based long-range communication ensured seamless data accessibility and prevented data loss. Additionally, it helps in monitoring of environment from long range by the managers of industrial area so that they can ensure atmost safety to the workers.

V. Conclusion and Future Scope

This paper presents a smart industrial monitoring system integrating LoRa, Node MCU, and IOT to enhance precision monitoring. The system enhances long-range monitoring, provides accurate environmental monitoring, and enables real-time environmental monitoring. By leveraging Node MCU the data can be transmitted wirelessly and it enhances the communication for a very long range.

1.1 Future Scope:

1. Enhanced Data Analytics:

a. Incorporate machine learning algorithms for predictive analysis of hazardous conditions.

b. Develop anomaly detection systems to identify unusual patterns in sensor data.

2. Integration with IoT Platforms:

a. Extend the system to integrate with cloud-based IoT platforms for remote monitoring and control.

b. Enable real-time alerts via SMS or mobile apps for critical conditions.

3. Improved Sensor Network:

a. Add more sensors to monitor additional parameters like air quality (e.g., PM2.5), soil health, or radiation levels.

b. Optimize sensor placement for better coverage in large or complex environments.

By these we can get to know that it has a vast future scope and the project can evolve into a comprehensive solution for intelligent environmental monitoring, contributing significantly to industrial safety, disaster prevention

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