

## IOT BASED INDUSTRIAL HAZARD DETECTION WITH WIRELESS LOAD OPERATION

Hemadharshini S<sup>1</sup>, Lavanya M<sup>2</sup>, Madhumitha SC<sup>3</sup>, Ranjani M S<sup>4</sup>, Priya V<sup>5\*</sup>

<sup>1234</sup>UG Scholar-Dept CSE, Grt Institute of Engineering and Technology Tiruttani, India.

<sup>5\*</sup>Professor-Dept CSE, Grt Institute of Engineering and Technology Tiruttani, India.

[hemadharshini022@gmail.com](mailto:hemadharshini022@gmail.com), [layamunuswamy@gmail.com](mailto:layamunuswamy@gmail.com),  
[madhus004@gmail.com](mailto:madhus004@gmail.com), [ranjanirachu07@gmail.com](mailto:ranjanirachu07@gmail.com)

<sup>5\*</sup>Corresponding Author: [priya.v@grt.edu.in](mailto:priya.v@grt.edu.in)

### Abstract

Nowadays, industrial glaze plants and similar manufacturing environments operate under harsh and hazardous conditions where fluctuations in temperature, humidity, and the presence of toxic gases pose serious risks to worker safety and production quality. These conditions can lead to health hazards, equipment damage, and reduced operational efficiency if not monitored and controlled properly. To overcome these challenges, an IoT-based Industrial Hazard Detection System with Wireless Load Operation is proposed using embedded system and IoT technologies. A microcontroller is used as the central unit to interface with various sensors such as LM35 for temperature measurement, DHT11 for humidity monitoring, and MQ135 for detecting harmful gases. An LCD display is integrated to show real-time values of temperature, humidity, and gas levels locally. The sensor data is continuously monitored and transmitted via Wi-Fi using the MQTT protocol to a webpage, and is analyzed to identify abnormal or unsafe conditions. When hazardous gas levels or environmental imbalances are detected, the system automatically activates preventive mechanisms such as an exhaust fan to minimize risk. All the sensed data is transmitted to an IoT-based webpage, enabling real-time remote monitoring from anywhere. Additionally, a mobile-based wireless load control feature is implemented to allow safe operation of electrical loads without physical contact, the usage of these technique avoid to reduces the risk of electric

shock in high-humidity environments. The proposed system enhances industrial safety, reduces human intervention, minimizes errors, and improves overall efficiency through real-time monitoring, automation, and intelligent control, thereby ensuring a safer and more reliable industrial working environment.

**Keywords:** *Industrial IoT (IIoT), Sensor Networks, Hazard Detection, Automation, Remote Monitoring, Smart Control Systems.*

### 1. Introduction

In rapidly expanding industrial sectors across the world, maintaining safe and stable working environments has become an unavoidable challenge, particularly in industrial glaze plants where environmental conditions such as temperature, humidity, and hazardous gas Concentrations continu fluctuate. The concentrations concentration continuously fluctuate. The absence of efficient real-time monitoring systems often leads to operational inefficiencies that not only endanger worker health but also cause equipment damage, production downtime, and increased maintenance costs, creating a significant economic burden for industries. One of the primary reasons for this issue is the reliance on conventional monitoring methods that depend on periodic manual inspection rather than continuous surveillance, where environmental parameters are checked at fixed intervals regardless of actual real-time variations within the plant. Consequently, sudden increases in toxic gas levels or

abnormal changes in humidity and temperature may go undetected until they escalate into serious safety hazards. Furthermore, manual operation of electrical loads in high-humidity environments aggravates the problem, as workers must physically interact with switches and control panels under moisture-prone conditions, thereby increasing the risk of electric shock. In critical situations, even a minor delay in detecting hazardous gases or electrical faults can have severe and life-threatening consequences. To overcome these challenges, the implementation of a dynamic and adaptive industrial monitoring and wireless load control system is imperative, as it enables continuous sensing, intelligent data processing, and automated response based on real-time conditions. By integrating temperature, humidity, and gas sensors with a microcontroller-based architecture such as the ESP32 and wireless communication modules, environmental parameters can be monitored dynamically and compared against predefined safety thresholds, allowing immediate activation of preventive measures such as exhaust fans when abnormal gas concentrations are detected. Additionally, a mobile-based wireless load control mechanism allows operators to switch electrical appliances ON or OFF remotely without direct physical contact, significantly reducing the probability of electric shock in high-humidity environments. The system can also transmit real-time data to a web-based platform for remote supervision, ensuring informed decision-making and timely intervention. Built upon the principles of the Internet of Things, this integrated framework can seamlessly align with modern smart industrial practices, leading to improved safety, reduced downtime, optimized energy consumption, enhanced operational efficiency, and better predictive maintenance of industrial equipment.

## 2. Related Work

Industrial safety and environmental monitoring have become essential in modern manufacturing environments due to the increasing use of automated systems and hazardous industrial processes. Gas leakage, environmental pollution, and equipment failure can lead to serious safety risks and production losses in industrial plants. Therefore, several research studies have focused on developing intelligent monitoring systems using wireless sensor networks and Internet of Things (IoT) technologies to detect hazardous conditions and improve workplace safety.

Wireless sensor networks have been widely used for detecting gas leakage in industrial environments. In a study conducted by Z. Yong et al., an indoor gas leakage source localization algorithm using distributed maximum likelihood estimation in sensor networks was proposed. The system deploys multiple gas sensors in indoor environments to continuously monitor gas concentration levels. Sensor nodes collect gas concentration data and transmit it to a processing system where algorithms analyze the information to determine the location of the gas leakage source. By using distributed estimation techniques, the system improves the accuracy and reliability of gas leak detection compared to traditional single sensor monitoring methods. This approach is particularly useful in industrial environments where early detection and precise localization of gas leaks are critical for preventing hazardous incidents and ensuring worker safety. [1]

Pipeline leakage detection is another important aspect of industrial monitoring systems. Hongwei Li et al. proposed a leakage detection method for HVAC pipeline networks based on pressure signal diagnosis. In their work, pressure sensors are used to continuously monitor pressure variations in pipeline networks used for heating,

ventilation, and air conditioning systems. By analyzing pressure signal patterns, the system can identify abnormal pressure changes that indicate leakage within the pipeline.

This method improves the efficiency of industrial monitoring systems and helps detect potential faults before they cause serious damage to equipment or infrastructure. The study demonstrates the importance of integrating intelligent monitoring techniques for maintaining safe and efficient industrial operations. [2]

The use of Internet of Things technology has significantly improved the capability of industrial monitoring systems. Zhu Qing and Li Yan-ping developed an IoT-based sensing system for mechanical assembly lines that enables real-time monitoring of industrial processes. In their system, sensors are installed on different components of the assembly line to collect operational data such as machine performance and environmental conditions. The collected data is transmitted through IoT communication networks to a centralized monitoring platform where it can be analyzed for abnormal conditions. This approach allows industries to monitor production systems more efficiently and detect potential problems early, thereby improving productivity and safety within manufacturing environments. [9]

Environmental monitoring within manufacturing industries is also an important research area. Han et al. proposed a wireless sensor network designed to monitor environmental quality in manufacturing industries. The system consists of multiple sensor nodes that measure environmental parameters such as temperature, humidity, and air quality. These sensors transmit data wirelessly to a central monitoring station where the information is processed and analyzed. The system enables continuous monitoring of environmental conditions

within industrial facilities and helps maintain safe working environments for employees. [11]

Gas leak detection systems based on wireless sensor networks have also been investigated by Spachos et al. They developed a gas leak detection and localization system using multiple gas sensors deployed throughout the monitoring area. Each sensor node measures gas concentration levels and transmits the data to a central system for analysis. The system uses algorithms to determine the presence and location of gas leaks based on sensor readings from different locations. This method improves the reliability of gas detection systems and provides an effective solution for monitoring hazardous gases. [13]

With the advancement of IoT technology, several researchers have developed smart gas leakage detection systems with real-time alert mechanisms. Varma et al. proposed an IoT-based gas leakage detection and smart alerting system that continuously monitors gas concentration levels using gas sensors. When the detected gas concentration exceeds a predefined threshold value, the system automatically generates alerts and sends notifications to users through connected devices or monitoring platforms. This enables immediate response to hazardous situations and helps prevent accidents caused by gas leakage. The integration of IoT communication technology enhances the efficiency of monitoring systems by enabling remote supervision. [14]

From the analysis of the above studies, it is clear that IoT-based monitoring systems help detect hazardous gases and improve industrial safety. Therefore, the proposed system integrates gas sensing, environmental monitoring, and wireless load operation into a single IoT-based industrial hazard detection system to enable continuous real-time monitoring of environmental parameters and

provide faster detection of abnormal conditions. This helps industries to respond quickly.

### **3. Problem Of The Statement**

#### **1. Manual Environmental Monitoring**

In many industrial environments, environmental parameters such as temperature, humidity, and hazardous gas concentrations are monitored manually using conventional instruments. This method involves periodic checking rather than continuous observation, which creates significant delays in identifying abnormal or unsafe conditions. Sudden increases in toxic gases or extreme temperature variations may remain undetected until routine inspection is performed. Such delays increase the risk of accidents, health hazards for workers, and potential damage to machinery and infrastructure.

#### **2. Manual Operation of Electrical Loads in High-Humidity Areas**

Electrical appliances and industrial loads are often controlled manually through physical switches and control panels located within high-humidity environments. The presence of moisture increases electrical conductivity and significantly raises the risk of electric shock. Workers interacting directly with electrical systems under such conditions are exposed to serious safety threats, especially during emergencies or equipment malfunction, where quick action is required.

#### **3. Lack of Automation in Safety Control Systems**

The proposed AI-Enhanced Faculty Feedback System addresses these limitations by integrating structured ratings, aspect-based sentiment analysis, predictive modeling and visualization dashboards into a single advanced framework. By combining

statistical evaluation with machine learning-driven textual analysis, the system aims to provide comprehensive, unbiased and actionable insights. This integrated approach enhances transparency, supports faculty self-improvement and strengthens institutional accountability mechanisms in modern higher education environments.

#### **4. Absence of Real-Time Alert System**

There is no integrated real-time alert system to immediately inform workers or supervisors when environmental parameters exceed predefined safety thresholds. The absence of instant sound or light indicators prevents workers from evacuating high-risk areas during the critical first seconds of a hazard. In the event of gas leakage, excessive humidity, or abnormal temperature rise, delayed notification can result in severe consequences, including health complications, fire hazards, or production losses. Immediate alerts are essential to ensure prompt corrective action.

#### **5. Increased Safety Risks**

The combined impact of manual monitoring, lack of automation, lack of wireless load control and absence alerts leads to a higher probability of workplace accidents and equipment damage. It also reduces overall operational efficiency, as production processes may need to be halted due to unforeseen environmental issues. This not only affects worker well-being but also increases maintenance costs, energy consumption, and financial losses for the organization.

#### **4. Objective**

The objective of the proposed system is to develop an intelligent industrial safety monitoring system that continuously observes environmental parameters such as temperature, humidity, and harmful gas levels to ensure a safe working environment. The system uses sensors connected to the ESP32

to collect real-time data and detect abnormal conditions instantly. It also aims to automate safety responses such as activating exhaust fans and alerts when hazardous levels are detected. In addition, the system provides wireless load control and remote monitoring through IoT, reducing manual intervention and minimizing risks to workers while improving overall industrial safety and efficiency. Furthermore, the system enables continuous data monitoring through a web-based platform for better supervision and quick decision-making. It also helps in reducing accidents, protecting equipment, and maintaining a more reliable industrial environment.

## 5. Proposed System

The proposed system represents a smart and efficient approach to improving industrial safety in glaze plants by integrating IoT technology with automated hazard detection and wireless load control. The core functionality of the system revolves around continuous real-time monitoring of environmental parameters such as temperature, humidity, and harmful gas levels using sensors connected to the ESP32. The microcontroller collects and analyzes the sensor data and compares it with predefined safety threshold values to determine whether the industrial environment is operating under safe conditions. When abnormal situations such as gas leakage, excessive temperature rise, or high humidity levels are detected, the system immediately triggers safety mechanisms including buzzer alerts, activation of exhaust fans, and automatic control of electrical loads through relay modules. These automated responses help in reducing the exposure of workers to hazardous environments and prevent possible damage to industrial equipment. In scenarios where all environmental parameters remain within safe limits, the system continues monitoring and periodically uploads real-time data to a web-

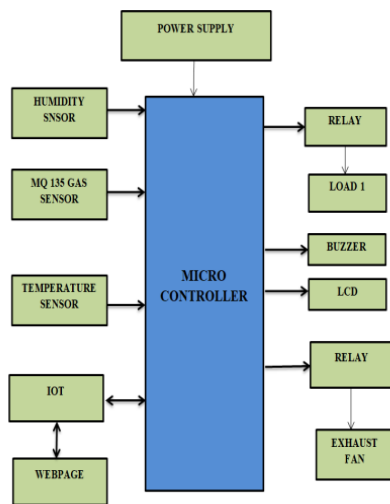
based dashboard using the MQTT communication protocol, enabling supervisors to observe plant conditions remotely. The integration of wireless load control also allows operators to switch electrical appliances ON or OFF through a mobile or web interface without physically interacting with switches, which is particularly useful in high-humidity environments where the risk of electric shock is high. By combining real-time sensing, automated decision-making, and remote monitoring capabilities, the system significantly enhances industrial safety, improves operational reliability, and reduces the need for constant manual supervision.

**Advantages:** Immediate detection of hazardous environmental conditions helps prevent accidents and protects workers' lives by enabling quicker response to potential threats. The automated activation of safety devices reduces equipment damage, prevents

## 6. Architecture Diagram

The proposed system is designed to continuously monitor environmental conditions within the industrial plant to ensure worker safety and efficient operation. Data is collected from various sensors that measure parameters such as temperature, humidity, and harmful gas concentration in the surrounding environment. These sensor readings are transmitted to the ESP32, where the collected data is processed and compared with predefined safety threshold values. Based on this analysis, the system determines whether the industrial environment is operating under normal or hazardous conditions. If abnormal conditions such as gas leakage, high temperature, or excessive humidity are detected, the system immediately activates safety mechanisms including buzzer alerts and exhaust fans to reduce potential risks. The processed environmental data is also transmitted to an IoT web dashboard using the

MQTT protocol, allowing supervisors to monitor the plant conditions remotely. Additionally, the system supports wireless load control, enabling users to operate electrical devices remotely through the web interface. Through continuous monitoring, automated hazard detection, and remote accessibility, the proposed system enhances industrial safety, reduces manual intervention, and improves overall operational efficiency.



**Fig.5.1: Architecture Diagram**

## 7. Implementation

### 7.1 Sensor Data Acquisition Module

The Sensor Data Acquisition Module is responsible for continuously collecting environmental parameters from the industrial plant using dedicated sensors. The LM35 temperature sensor measures the surrounding temperature, the DHT11 sensor monitors humidity levels, and the MQ135 sensor detects the presence of harmful gases in the air. These sensors operate in real time to ensure continuous monitoring of environmental conditions within the industrial workspace. The collected analog and digital signals are transmitted to the ESP32

microcontroller for further analysis and processing. This module forms the foundation of the system by providing accurate and timely environmental data required for hazard detection and safety control.

### 7.2 Microcontroller Processing Module

The Microcontroller Processing Module uses the ESP32 as the central control unit of the system. It receives real-time input data from all connected sensor and processes the information based on predefined threshold values. The ESP32 compares sensed environmental parameters with safe operating limits to determine whether any abnormal condition exists. If deviations are detected, it generates appropriate control signals to activate alerts or safety mechanisms. Additionally, the microcontroller manages communication between different modules, ensuring synchronized operation and efficient system performance.

### 7.3 Hazard Detection & Alert Module

The Hazard Detection & Alert Module identifies unsafe conditions such as excessive temperature, high humidity, or elevated gas concentration. When any environmental parameter exceeds its predefined safety limit, the system immediately activates an alert mechanism, such as a buzzer, to warn workers about potential danger. Simultaneously, automatic corrective actions—like turning on an exhaust fan—are triggered to reduce hazardous conditions. This module ensures rapid response to industrial threats, minimizing risks to both workers and equipment.

### 7.4 Wireless Load Control Module

The Wireless Load Control Module enables remote operation of electrical appliances using the built-in Wi-Fi capability of the ESP32. Through a smartphone or web-based

IoT interface, users can send commands to control industrial loads without physically interacting with switches. The ESP32

processes these commands and controls the relay module to switch devices ON or OFF accordingly. This wireless mechanism significantly reduces the risk of electric shock, especially in high-humidity environments, while also improving operational convenience and flexibility.

### 7.5 IoT Communication Module

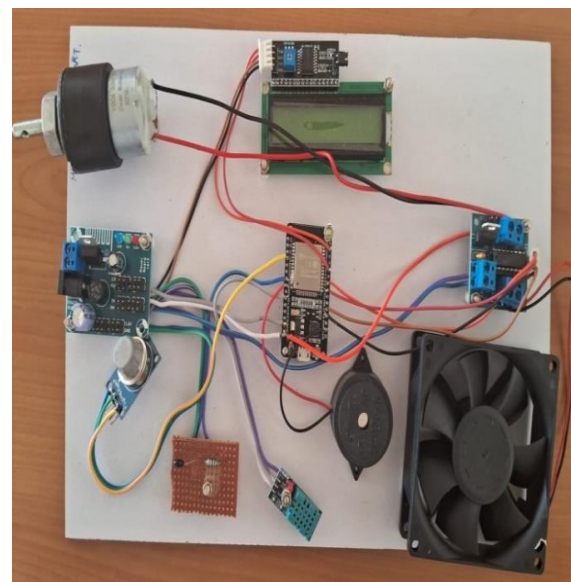
The IoT Communication Module is responsible for sending all sensor data to a web-based dashboard for remote monitoring. Environmental readings such as temperature, humidity, and gas levels are transmitted in real time using the MQTT protocol. This allows supervisors to view plant conditions from anywhere through an internet connection. The module ensures continuous data updates, supports data storage for future reference, and helps in taking quick decisions to maintain industrial safety and efficiency.

### 7.6 Power & Actuator Control Module

The Power & Actuator Control Module provides a stable and regulated power supply to all system components, ensuring proper functioning of the sensors, ESP32 microcontroller, and communication units. It distributes appropriate voltage levels required for low-power electronic components and high-power industrial loads. This module also includes relay units and motor driver circuits to control high-voltage devices such as exhaust fans, motors, and alarms. The relay acts as an electrically operated switch, allowing safe isolation between low-voltage control circuits and high-voltage loads. By ensuring proper power regulation and safe switching operations, this module enhances system reliability, protects components from damage, and maintains overall operational safety.

## 8. Experimental Results

The result discussed demonstrates the successful implementation and reliable operation of the IoT-based hazard detection and wireless load control system driven by an ESP32 microcontroller. Continuous data acquisition from the sensor network accurately captured real-time fluctuations in environmental parameters, including temperature, humidity, and harmful gas concentrations. During simulated hazardous conditions, the system exhibited minimal latency in processing these inputs and identifying threshold anomalies. Upon detecting a breach, the ESP32 autonomously executed its predefined safety protocols without fail, successfully activating localized buzzer alerts, engaging exhaust fans and wireless load control to ensure worker safety and maintain a secure industrial environment.



**Fig.8.1. Project Kit**

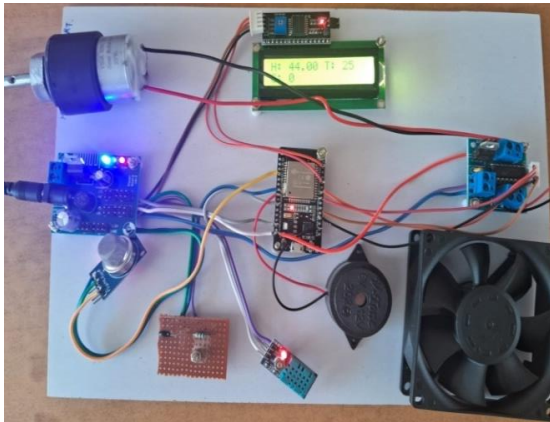


Fig.8.2. LCDdisplay output

#	HUMIDITY STATUS	TEMPERATURE STATUS	GAS STATUS	Date & Time	Action
1	humidity: 45.00	T:36TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:52	[Action]
2	humidity: 45.00	T:39TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:44	[Action]
3	humidity: 44.00	T:40TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:41	[Action]
4	humidity: 44.00	T:41TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:38	[Action]
5	humidity: 44.00	T:42TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:34	[Action]
6	humidity: 44.00	T:43TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:30	[Action]
7	humidity: 44.00	T:44TEMPERATURE ABNORMAL	G:0	2026-03-05 11:18:27	[Action]

Fig.8.5. Temperature abnormal status

#	HUMIDITY STATUS	TEMPERATURE STATUS	GAS STATUS	Date & Time	Action
1	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:21	[Action]
2	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:18	[Action]
3	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:15	[Action]
4	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:11	[Action]
5	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:08	[Action]
6	humidity: 44.00	T:25TEMPERATURE NORMAL	G:0	2026-03-05 11:16:05	[Action]
7	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:02	[Action]

Fig.8.3. Sensor data monitoring

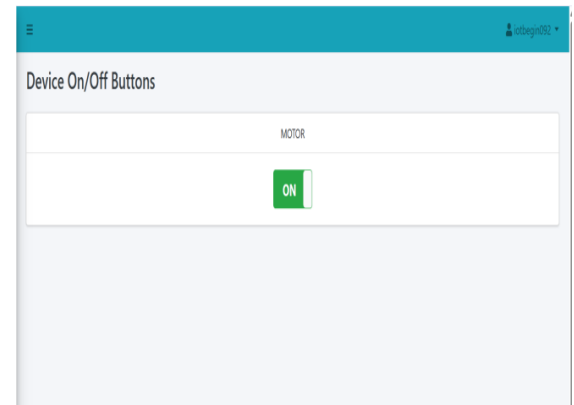


Fig.8.6. Wireless Load

#	HUMIDITY STATUS	TEMPERATURE STATUS	GAS STATUS	Date & Time	Action
1	humidity: 43.00	T:25TEMPERATURE NORMAL	G:37GAS NORMAL	2026-03-05 11:17:51	[Action]
2	humidity: 43.00	T:25TEMPERATURE NORMAL	G:97GAS ABNORMAL	2026-03-05 11:17:43	[Action]
3	humidity: 43.00	T:25TEMPERATURE NORMAL	G:36GAS NORMAL	2026-03-05 11:17:40	[Action]
4	humidity: 43.00	T:25TEMPERATURE NORMAL	G:100GAS ABNORMAL	2026-03-05 11:17:37	[Action]
5	humidity: 43.00	T:25TEMPERATURE NORMAL	G:0	2026-03-05 11:17:26	[Action]
6	humidity: 44.00	T:25TEMPERATURE NORMAL	G:0	2026-03-05 11:17:01	[Action]
7	humidity: 44.00	T:24TEMPERATURE NORMAL	G:0	2026-03-05 11:16:58	[Action]

Fig.8.4. Gas Sensor abnormal status

Row	Humidity	Temperature	Gas	Date & Time
43	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
44	humidity: 41.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
45	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
46	humidity: 42.00	T:32TEMPERATURE ABNORMAL	G:0	3/3/2026 11:45
47	humidity: 42.00	T:32TEMPERATURE ABNORMAL	G:0	3/3/2026 11:45
48	humidity: 42.00	T:32TEMPERATURE ABNORMAL	G:0	3/3/2026 11:45
49	humidity: 42.00	T:34TEMPERATURE ABNORMAL	G:0	3/3/2026 11:45
50	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
51	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
52	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
53	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:45
54	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
55	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
56	humidity: 48.00	T:32TEMPERATURE NORMAL	G:55GAS ABNORMAL	3/3/2026 11:46
57	humidity: 48.00	T:32TEMPERATURE NORMAL	G:84GAS ABNORMAL	3/3/2026 11:46
58	humidity: 48.00	T:32TEMPERATURE NORMAL	G:55GAS ABNORMAL	3/3/2026 11:46
59	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
60	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
61	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
62	humidity: 48.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
63	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
64	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
65	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
66	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
67	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
68	humidity: 42.00	T:32TEMPERATURE NORMAL	G:0	3/3/2026 11:46
69	humidity: 42.00	T:25TEMPERATURE NORMAL	G:0	3/3/2026 11:46
70	humidity: 42.00	T:25TEMPERATURE NORMAL	G:0	3/3/2026 11:46
71	humidity: 42.00	T:25TEMPERATURE NORMAL	G:0	3/3/2026 11:47
72	humidity: 42.00	T:25TEMPERATURE NORMAL	G:0	3/3/2026 11:47
73	humidity: 42.00	T:25TEMPERATURE NORMAL	G:0	3/3/2026 11:47

Fig.8.7. Sensor data download

## 9. Conclusion & Future work

In conclusion, this project represents a significant step toward creating a safer, smarter, and more efficient industrial working environment through the integration of IoT and automation technologies. By leveraging intelligent sensing devices and the powerful processing capability of the ESP32, the system continuously monitors critical environmental parameters such as temperature, humidity, and gas concentration in real time. The implementation of automated hazard detection ensures that abnormal conditions are identified instantly and appropriate safety measures are activated without human delay. Furthermore, the incorporation of wireless load control and IoT-based remote monitoring using the MQTT enhances operational safety, minimizes manual intervention, and reduces the risk of electrical accidents. The seamless combination of real-time monitoring, automated response, and smart communication marks a substantial advancement in industrial safety systems. Beyond its technical implementation, this project contributes toward building a reliable industrial infrastructure that prioritizes worker safety, operational efficiency, and sustainable industrial growth.

### Future Enhancement:

In future work, the system can be enhanced by integrating advanced data analytics and Artificial Intelligence (AI) techniques to predict potential hazards before they occur based on historical sensor data. The safety threshold mechanism can be further refined using adaptive and quantified risk assessment models for more accurate hazard classification. Integration with cloud storage, mobile notification systems, and additional industrial-grade sensors can further expand the scalability, intelligence, and reliability of the proposed system.

## Reference

- [1] Z. Yong, Z. Liyi, H. Jianfeng, B. Zhe and Y. Yi, "An indoor gas leakage source localization algorithm using distributed maximum likelihood estimation in sensor networks," Springer - Journal of Ambient Intelligence and Humanized Computing, vol. 10, pp. 1703–1712, November 2017.
- [2] Hongwei Li, Haoyang Li, H. Pei and Z. Li, "Leakage detection of HVAC pipeline network based on pressure signal diagnosis," Springer - Building Simulation, vol. 12, pp. 617–628, June 2019.
- [3] Q. Han, P. Liu, H. Zhang, and Z. Cai, "A Wireless Sensor Network for Monitoring Environmental Quality in the Manufacturing Industry," *IEEE Access*, vol. 7, pp. 80764–80773, June 2019. DOI: 10.1109/ACCESS.2019.2920838.
- [4] Knowles W, Prince D, Hutchison D, et al. A survey of cyber security management in industrial control systems[J]. International journal of critical infrastructure protection, 2015, 9: 52-80.
- [5] Sankalp Raghuvanshi, Kalpana Singh, "Light Fidelity: The Future of Data Communication," International Journal of Engineering Research & Technology, 2020,9.
- [6] R. Mahendran, "Integrated Li-Fi (Light Fidelity) For Smart Communication through Illumination," IEEE International Conference on Advanced Communication Control and Computing Technologies (ICACCCT), 2016, 53-56.

- [7] R. A. Ramlee, M. A. Othman, M. H. Leong, M. M. Ismail and S. S. S. Ranjit, "Smart home system using android application," *Information and Communication Technology (ICoICT), 2013 International Conference of, Bandung, 2013*, pp. 277-280.
- [8] M. Asadullah and A. Raza, "An overview of home automation systems," *2016 2nd International Conference on Robotics and Artificial Intelligence (ICRAI), Rawalpindi, 2016*, pp. 27-31, doi: 10.1109/ICRAI.2016.7791223.
- [9] ZHU Qing, LI Yan-ping. The Design of sensing system of mechanical assembly line based on Internet of things [J]. *Information Technology & Informatization*, 2018, 225(12):133-136.
- [10] KANG Cheng-bo, YANG Hui-bin, YAN Juan, et al. Remote Control and Monitoring System Based on IOT Industrial Robots[J]. *Control and Instruments in Chemical Industry*, 2019, 046(005):367-3.
- [11] Macaulay T, Singer B L. *Cybersecurity for industrial control systems: SCADA, DCS, PLC, HMI, and SIS[M]*. Auerbach Publications, 2016.
- [12] N. A. Pantazis, S. A. Nikolidakis, and D. D. Vergados, "Energy-Efficient Routing Protocols in Wireless Sensor Networks: A Survey," *IEEE Communications Surveys & Tutorials*, vol. 15, no. 2, pp. 551–591, 2013.
- [13] P. Spachos, L. Song, and D. Hatzinakos, "Gas Leak Detection and Localization System Through Wireless Sensor Networks," *11th Annual IEEE Consumer Communications and Networking Conference*, 2014.
- [14] A. Varma, S. Prabhakar, and K. Jayavel "Gas Leakage Detection and Smart Alerting and Prediction Using IoT," *International Conference on Internet of Things and Applications (IOTA), IEEE*, 2017.
- [15] J. Yoon, H. Kim, and S. Park, "Smart IoT Safety Platform for Accident Prevention in Industrial Environments," in *Proc. ACM Int. Conf.*, 2024, pp. 210-215..
- [16] U. Ejaz, W. Ramon, P. Jeol, and M. Blessing, "IoT for Hazard Detection and Worker Safety Monitoring," *International Journal of Engineering Research and Applications*, vol. 15, no. 1, pp. 45-52, Jan. 2025.
- [17] M. N. A. Ramadan, S. Hassan, and A. El-Sayed, "Real-Time IoT-Powered AI System for Industrial Air Quality Monitoring," *Journal of Environmental Monitoring Systems*, vol. 12, no. 3, pp. 201-210, 2024.
- [18] T. Sepanosian, R. Kumar, and L. Das, "IoT-Enabled Multi-Agent System for Hazard Detection in Construction Sites," *Procedia Computer Science*, vol. 235, pp. 150-158, 2025.
- [19] Z. Woźniak, P. Nowak, and K. Kowalski, "Integrated Hazard Detection System Using Machine Learning and IoT," *Sustainability*, vol. 17, no. 23, pp. 10584-10592, 2025.
- [20] C. L. Kok, M. Tan, and J. Lee, "Energy-Efficient IoT-Based Hazard Detection System Using ESP32-CAM," *Sensors*, vol. 25, no. 6, pp. 1761-1770, 2025.