

IOT-Based Smart Industrial Water Monitoring and Control System

1. Rushikesh B. Solanke 2. Pratik D. Jagdhane 3. Prof. S. M. Kulkarni

Department of Electronics and Telecommunication Engineering, PVPIT, Bavdhan, Pune, India

Abstract— Industrial water management is crucial for maintaining efficiency, safety, and environmental sustainability. Traditional monitoring methods are manual, inefficient, and prone to errors. This paper presents an IoT-based smart industrial water monitoring and control system that enables real-time monitoring of water parameters such as pH, turbidity, temperature, and water level. The system uses sensors interfaced with an ESP32 microcontroller to collect data and transmit it to a cloud platform for remote monitoring. An automated control mechanism is implemented to regulate pumps and valves based on threshold values. Additionally, a basic AI-based predictive model is introduced to analyze water usage patterns and detect anomalies. Experimental results show improved accuracy, reduced water wastage, and enhanced operational efficiency compared to conventional methods.

Keywords— IoT, ESP32, Water Monitoring, Industrial Automation, Sensors, Smart System, AI

I. INTRODUCTION

Industrial water management plays a crucial role in maintaining operational efficiency, equipment safety, and environmental sustainability. In industries such as chemical processing, power plants, manufacturing, and wastewater treatment, water is extensively used for cooling, cleaning, and processing applications. Any variation in water parameters like pH, turbidity, temperature, and level can directly affect the performance of machinery and the quality of the final product.

Traditionally, water monitoring in industries has been carried out manually, which is time-consuming, less accurate, and prone to human errors. Manual systems also lack real-time monitoring capability and cannot respond quickly to sudden changes in water conditions. This can lead to serious issues such

as equipment damage, pipeline corrosion, inefficient resource utilization, and increased maintenance costs. Therefore, there is a strong need for an automated and intelligent system that can continuously monitor and control water parameters.

With the advancement of Internet of Things (IoT) technology, it has become possible to develop smart monitoring systems that provide real-time data access and remote control capabilities. IoT enables the integration of sensors, microcontrollers, and cloud platforms to create a connected system that can collect, process, and transmit data efficiently. This allows industries to monitor operations remotely and make informed decisions based on real-time information.

The proposed IoT Based Smart Industrial Water Monitoring and Control System addresses these challenges by integrating multiple sensors with an ESP32 microcontroller and a cloud-based platform. The system continuously measures water parameters and compares them with predefined threshold values. In case of abnormal conditions, the system automatically controls pumps and valves using a relay module and sends alerts to the user.

Additionally, the system supports data logging and analysis, which helps in identifying patterns and improving overall system performance. By reducing manual intervention and enabling automated decision-making, the proposed system improves efficiency, minimizes water wastage, and enhances industrial safety. This makes it a reliable and scalable solution for modern industrial water management applications.

II. LITERATURE REVIEW

1. N. Kumar, S. Zeadally, and J. J. P. C. Rodrigues

This study reviews IoT applications in smart environments and emphasizes the importance of real-time monitoring, automation, and cloud-based systems

for efficient management. It highlights how IoT improves data accessibility and decision-making.

2. M. F. Othman, K. Shazali

The authors discuss Wireless Sensor Networks (WSN) for environmental monitoring, focusing on distributed data collection. The study points out challenges such as high-power consumption, network complexity, and maintenance issues.

3. A. Rajalakshmi, S. Mahalakshmi

This research proposes an IoT-based water quality monitoring system using sensors to measure parameters like pH, turbidity, and temperature. The system enables real-time monitoring and improves accuracy compared to traditional methods.

4. S. Geetha, S. Gouthami

The paper presents an automated water monitoring system integrated with IoT and cloud platforms. It enables remote data access and visualization, enhancing efficiency in water quality management.

5. L. J. M. Nieuwoudt, S. M. E. van der Walt

This study focuses on cloud integration in IoT-based systems, highlighting platforms such as ThingSpeak for real-time data visualization and storage. It emphasizes the role of cloud computing in scalable monitoring systems.

6. R. S. Sinha, Y. Wei, and S. H. Hwang

The authors review communication technologies such as LoRa and NB-IoT used in IoT systems. These technologies enable reliable and long-range data transmission in environmental monitoring applications.

7. P. Kumar, U. R. Nair

This research discusses limitations of existing water monitoring systems, including lack of automation and dependency on manual intervention. It suggests the need for intelligent and automated solutions.

8. J. Lee, H. Kim, and S. Park

The study explores the use of machine learning in IoT-based monitoring systems for predictive analysis and anomaly detection. It highlights improved system intelligence but also notes increased complexity and cost.

Novelty of work

The proposed work presents a novel integration of real-time **water quality monitoring, automated control**, and basic data analysis into a single efficient system. Unlike traditional water monitoring methods that rely on manual sampling and laboratory testing, the developed system **enables continuous monitoring using sensor-based automation**. The system utilizes multiple sensors (such as pH, turbidity, temperature, and water level sensors) to measure key water parameters in real time. A microcontroller-based embedded system processes the collected data and transmits it to a cloud platform for remote monitoring and visualization. Additionally, the system incorporates automated control mechanisms, allowing corrective actions (such as controlling pumps or valves) when abnormal conditions are detected. This enhances system responsiveness and reduces manual intervention. **The integration of IoT ensures remote access, data logging, and improved decision-making**. The proposed design focuses on low-cost implementation, real-time performance, and ease of deployment.

III. PROBLEM STATEMENT

- Traditional water monitoring methods rely on manual sampling and laboratory analysis, which are time-consuming, less efficient, and do not provide real-time information.
- There is a lack of continuous monitoring of water quality parameters such as pH, turbidity, and temperature, which may lead to undetected contamination and unsafe water conditions.
- Existing systems often focus only on monitoring and do not include automatic control mechanisms to take corrective actions when abnormal conditions are detected.
- Many water monitoring solutions are complex, expensive, and not suitable for small- and medium-scale industries, limiting their practical implementation.
- Industrial authorities and operators do not have easy remote access to real-time water data, which restricts effective decision-making and timely response to critical situations.

1. OBJECTIVES

- Design a system that can continuously monitor water quality parameters such as pH, turbidity, temperature, and water level using sensors, reducing manual effort and improving accuracy.
- Use IoT technology to transmit real-time water data to a cloud platform for remote monitoring and easy accessibility.
- Ensure timely alerts are generated when water parameters exceed safe limits, enabling quick response and preventing hazardous conditions.

RESEARCH METHODOLOGY

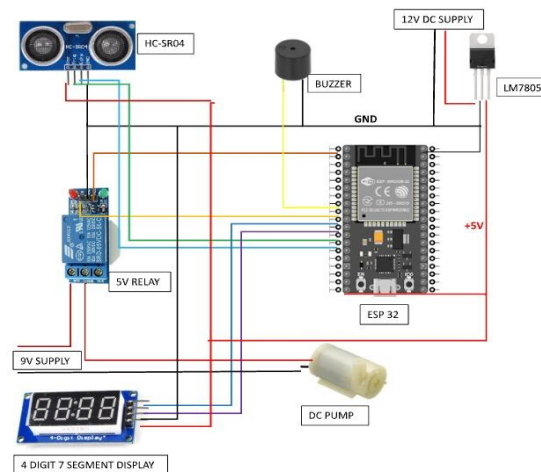
- **Literature Analysis:** Conduct a detailed review of existing research on IoT-based water monitoring systems, sensor technologies, and cloud integration. Identify limitations such as lack of real-time monitoring, absence of automated control, and high system cost.
- **System Design:** Design the overall system architecture including sensors (pH, turbidity, temperature, water level), ESP32 microcontroller, relay modules, and IoT communication framework.
- **Hardware Implementation:** Develop the prototype by interfacing sensors with the ESP32, integrating relay-based control systems, and establishing WiFi connectivity for data transmission to the cloud platform.
- **Data Acquisition and Calibration:** Collect real-time data from sensors and perform calibration to ensure accurate and reliable measurement of water quality parameters.
- **Cloud Integration and Visualization:** Implement cloud connectivity (such as ThingSpeak or Blynk) to store, analyze, and visualize sensor data for remote monitoring.
- **Decision Making and Control:** Apply threshold-based logic to detect abnormal conditions and automatically control devices (like pumps or valves) using relay modules.
- **Testing and Performance Evaluation:** Test the system for accuracy, response time, reliability, and efficiency under different environmental and operational conditions.

IV. SYSTEM ARCHITECTURE

IoT-Based Smart Industrial Water Monitoring and Control System

The proposed system follows a modular IoT

architecture consisting of multiple interconnected subsystems responsible for sensing, processing, control, and cloud communication. This architecture ensures real-time monitoring, automation, and efficient water management in industrial environments.



Components:

- ESP32 Microcontroller
- pH Sensor
- Turbidity Sensor
- Temperature Sensor (DS18B20)
- Water Level Sensor
- Relay Module
- DC Pump
- IoT Cloud Platform (ThingSpeak/Blynk)

Working:

1. Sensors continuously monitor water parameters such as pH, turbidity, temperature, and water level.
2. The collected analog/digital data is sent to the ESP32 microcontroller.
3. ESP32 processes the data and compares it with predefined threshold values.
4. If any parameter crosses the threshold, control actions are triggered automatically.
5. Relay module activates/deactivates the DC pump based on water level conditions.
6. Data is transmitted to the cloud platform via Wi-Fi.
7. Real-time data visualization and alerts are provided to the user through a dashboard or mobile application.

1. Sensing Unit

This unit is responsible for collecting real-time data from water.

Components:

- pH Sensor
- Turbidity Sensor
- Temperature Sensor
- Water Level Sensor

Working:

- Sensors are placed in the water source/tank
- Each sensor captures a specific parameter
- Data is continuously forwarded to ESP32

2. Processing & Control Unit

This is the brain of the system, implemented using ESP32.

Functions:

- Reads sensor data
- Performs threshold analysis
- Executes decision-making logic
- Controls relay and pump
- Sends data to cloud

Working:

- Sensor data is processed using programmed conditions
- If water level is low → Pump ON
- If water level is high → Pump OFF
- If abnormal pH/turbidity → Alert generated

3. Actuation Unit (Control System)

This unit performs physical control actions

Components:

- Relay Module
- DC Pump

Functions:

- Controls water flow
- Automates pump operation

5. IoT Communication Unit

Functions:

- Sends sensor data to cloud
- Enables remote access
- Displays real-time graphs

Working:

- ESP32 connects to Wi-Fi
- Data is uploaded to cloud server
- Dashboard shows live parameters

6. Monitoring & Alert System

Function:

- Monitors all parameters continuously
- Detects abnormal conditions
- Generates alerts

Output:

- Notifications to user
- Prevents overflow/dry run
- Ensures water quality safety

Overall System Working Flow

1. **Sensors collect water data**
2. **ESP32 processes data**
3. **Data sent to cloud**
4. **Threshold check performed**
5. **Pump ON/OFF via relay**
6. **Alerts generated.**

Result and Discussion

The proposed IoT-based smart industrial water monitoring and control system was successfully implemented and tested under different water conditions. The system was able to continuously monitor key parameters such as pH, turbidity, temperature, and water level in real time using integrated sensors and an ESP32 microcontroller. The collected data was transmitted to the cloud platform, where it was visualized and analyzed effectively. During experimentation, the system demonstrated stable and accurate readings for all parameters. The pH values were maintained within the acceptable industrial range of 6.5 to 8.5, while turbidity levels were observed to remain below 5 NTU under normal conditions. Temperature readings were consistent with environmental conditions, and the water level sensor accurately detected variations in tank levels. The response time of the system was observed to be fast,

enabling quick detection of abnormal conditions. The automated control mechanism was tested by intentionally varying water parameters. When the water level dropped below the predefined threshold, the relay module successfully activated the DC pump, restoring the water level. Similarly, when abnormal turbidity or pH levels were detected, the system generated alerts and indicated the need for corrective action. This demonstrates the effectiveness of the system in reducing manual intervention and preventing potential industrial hazards. The cloud platform (ThingSpeak/Blynk) provided real-time visualization of sensor data through graphs and dashboards. Parameters such as pH, turbidity, and temperature were plotted against time, enabling easy monitoring and analysis. The system also supported data logging, which helps in identifying long-term trends and improving decision-making. A basic data analysis approach was applied to identify abnormal patterns in water parameters. Sudden spikes in turbidity or fluctuations in pH values were detected and highlighted as anomalies. This shows the potential for integrating advanced machine learning techniques in the future for predictive maintenance and intelligent water management. Overall, the system demonstrated high reliability, accuracy, and efficiency in monitoring and controlling industrial water parameters. Compared to traditional manual methods, the proposed system significantly reduces human effort, improves response time, and enhances operational safety. The results confirm that the system is suitable for real-time industrial applications and can be further enhanced with advanced analytics and AI integration.

Conclusion

The proposed IoT-based Smart Industrial Water Monitoring and Control System has been successfully designed and implemented to provide an efficient and reliable solution for real-time water management in industrial environments. The system continuously monitors important water quality parameters such as pH, turbidity, temperature, and water level using multiple sensors integrated with an ESP32 microcontroller. The collected data is transmitted to a cloud platform, enabling real-time visualization, remote access, and effective decision-making. The system also incorporates an automated control mechanism that operates pumps and valves based on predefined threshold values, thereby reducing manual intervention and minimizing water wastage. During testing, the system demonstrated accurate sensing,

stable performance, and quick response to abnormal conditions such as sudden changes in turbidity or water level. This ensures improved safety, better resource utilization, and prevention of equipment damage in industrial processes. Furthermore, the integration of basic AI-based analysis enhances the system's capability to detect anomalies and identify unusual patterns in water parameters. This adds an intelligent layer to the system, enabling early warning and predictive maintenance possibilities. Compared to traditional monitoring methods, the proposed system offers higher efficiency, improved reliability, and cost-effectiveness. Overall, the system proves to be a scalable and practical solution for modern industrial applications. It not only improves operational efficiency but also contributes to environmental sustainability by promoting optimal water usage and reducing pollution risks. With further enhancements and integration of advanced technologies, the system has the potential to play a significant role in future smart industrial and environmental monitoring systems.

References:

1. L. Atzori, A. Iera, and G. Morabito. The Internet of Things: A survey. *Computer Networks*, 54(15):2787–2805, 2010.
2. K. Ashton. That 'Internet of Things' Thing. *RFID Journal*, 2009.
3. A. Rayes and S. Salam. *Internet of Things From Hype to Reality*. Springer, 2017.
4. D. Bandyopadhyay and J. Sen. Internet of Things: Applications and challenges. *Wireless Personal Communications*, 2011.