IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, March 2026
Impact Factor: 8.2

Industrial Waste Water Management System Using IoT

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Abstract: *Industrial waste water management is important for environmental protection and industrial sustainability. Traditional systems do not provide real-time monitoring or quick response to water quality issues. This project presents an* ***IoT- Based Industrial Waste Water Management System*** *that continuously monitors parameters such as pH, turbidity, temperature, water level, humidity, and harmful gases using sensors connected to an ESP32 microcontroller. The collected data is transmitted to a cloud-based web application through Wi-Fi, where it is displayed in real time and alerts are generated when values exceed safe limits. The system reduces manual monitoring, improves accuracy, enhances operational efficiency, and provides a reliable and cost-effective solution for industrial waste water management*

Keywords: *Industrial waste water management*

I. INTRODUCTION

Industrialization has increased the generation of waste water, which can seriously harm the environment if not managed properly. Effective industrial waste water management is necessary to protect natural water resources and to follow environmental rules and regulations. Traditional waste water management systems mostly rely on manual testing and periodic monitoring, which are slow, less accurate, and cannot detect sudden changes in water quality.

The Internet of Things (IoT) provides a smart solution for these problems by enabling real-time monitoring and automatic data collection. In an IOT-based industrial waste water management system, sensors are used to measure parameters such as pH, turbidity, temperature, water level, humidity, and harmful gases. An ESP32 microcontroller processes this data and sends it to a cloud-based web application through Wi-Fi. This system allows continuous monitoring, instant alerts, improved decision-making, and better control of waste water treatment, making it more efficient and reliable than traditional methods.

II. METHODOLOGY

The system architecture is built around the ESP32 microcontroller, which acts as the central processing unit, collecting data from multiple sensors and transmitting it to a web-based interface. The main components of the system include:

Sensors:

- pH Sensor: Measures the acidity or alkalinity of the water, a critical factor in maintaining water quality. Turbidity Sensor: Monitors the cloudiness or clarity of the water, indicating the presence of suspended particles or contaminants.
- Ultrasonic Sensor: Detects the water level to prevent overflow and ensure an adequate supply.
- DHT11 Sensor: Measures temperature and humidity, which can affect water quality in storage and treatment processes.
- MQ2 Gas Sensor: Detects harmful gases such as methane and ammonia, ensuring safety in waste water treatment facilities.

• ESP32 Microcontroller: The ESP32 collects data from the sensors and uses its Wi- Fi module to send this data to a cloud-based database such as Google Firebase. The microcontroller also triggers a buzzer alert in case of critical conditions like gas leaks or extreme pH levels.
• Web Application: The web app visualizes real-time sensor data, sends alerts, and provides recommendations based on predefined thresholds. The user interface is designed to be responsive, ensuring easy access from both desktop and mobile devices.
• Alert System: The system is configured to trigger real-time alerts when any sensor reading crosses a critical threshold. Alerts are delivered via a buzzer system on-site and notifications on the web application.

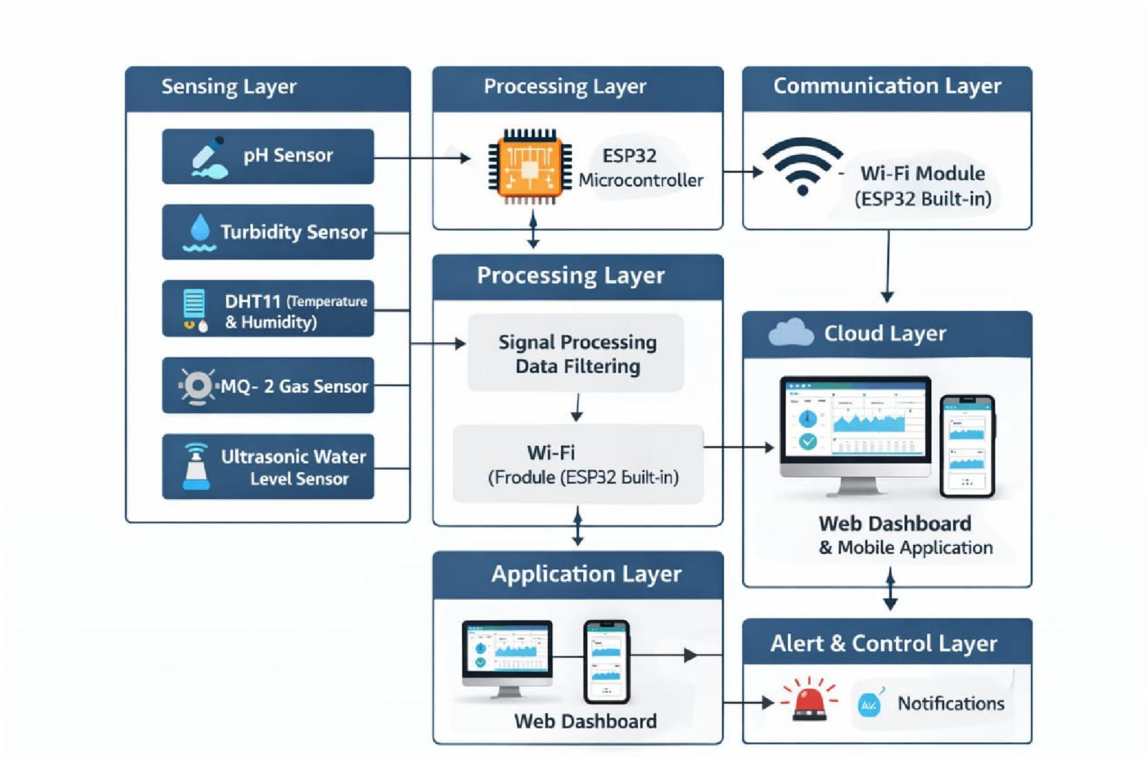

Fig.1 IOT based industrial waste water management system Architecture.

III. SYSTEM OVERVIEW

The IoT-Based Industrial Wastewater Management System is designed to monitor and manage industrial wastewater in real time. It uses sensors to measure critical parameters such as pH, water level, and chemical concentration, and sends this data to a microcontroller. The system can display the readings on an LCD and a cloud dashboard, enabling industries to track wastewater quality continuously. Alerts are generated automatically if any parameter exceeds safe limits, allowing immediate corrective action. This automated approach reduces manual monitoring, ensures compliance with environmental regulations, and promotes sustainable water management.

1. Objective Definition

• Define the goals of integrating IoT, such as real-time monitoring, predictive maintenance, or process optimization.
• The primary objective of an IoT-based industrial wastewater management system is to enhance the efficiency, monitoring, and treatment of wastewater, ensuring compliance with environmental regulations while minimizing operational costs.

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2. System Architecture

• Sensors: Deploy IoT sensors to measure parameters like pH, temperature, turbidity, dissolved oxygen, and chemical concentrations.

• Connectivity: Establish a network (e.g., Wi-Fi, LoRaWAN, cellular) to connect sensors and devices to a central system.

• Data Processing: Utilize edge computing or cloud platforms to process and analyze data from sensors.

3. Data Acquisition and Analysis

• Real-time Monitoring: Implement continuous data collection for immediate insights into wastewater characteristics.

• Data Analytics: Use machine learning algorithms to identify patterns, detect anomalies, and predict system performance.

4. Automated Control Systems

• Integrate IoT with control systems to automate responses based on real-time data (e.g., adjusting chemical dosing or flow rates).

• Use actuators to manage valves, pumps, and other equipment based on sensor data.

5. User Interface and Dashboards

• Develop user-friendly dashboards for operators and managers to visualize data, monitor system performance, and receive alerts.

• Incorporate mobile access for on-the-go monitoring and control.

6. Functionality

• Real-Time Monitoring: Continuous tracking of wastewater parameters allows for immediate detection of anomalies or deviations from set thresholds.

• Data Analytics: Historical and real-time data analysis using machine learning to optimize treatment processes, predict equipment failures, and enhance resource management.

• Automated Alerts: Notification systems that alert operators to any critical changes in water quality or system performance, facilitating timely interventions.

• Regulatory Compliance: Automated reporting tools that help ensure compliance with local environmental regulations through accurate data collection and documentation.

7. System Components

• IoT Sensors: Devices that monitor various parameters such as pH, turbidity, chemical oxygen demand (COD), temperature, and flow rate in real time.

• Data Transmission Modules: Communication technologies (e.g., Wi-Fi, LoRa, or cellular) that facilitate the transfer of data from sensors to the cloud or local servers.

• Cloud Platform: A centralized system for data storage, processing, and analytics, enabling real-time visualization and decision-making.

• User Interface: Web and mobile applications that provide operators with dashboards for monitoring, control, and alert notifications.

8. Challenges

• Data Security: Ensuring the protection of sensitive data transmitted over networks.

• Integration: Seamlessly integrating IoT technologies with legacy systems can be complex.

• Maintenance: Regular maintenance of sensors and IoT devices is essential to ensure accuracy and reliability.

DOI: 10.48175/IJARSCT-31638

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System Features:

• Real-Time Monitoring: Continuous tracking of water quality parameters (e.g., pH, turbidity, temperature, dissolved oxygen) using IoT sensors.

• Remote Access and Control:

Enables operators to monitor and control systems from anywhere, using mobile or web applications.

• Automated Alerts and Notifications:

Sends alerts for any deviations from normal operating conditions, such as exceeding pollutant thresholds.

• Predictive Maintenance:

Uses data from sensors to predict equipment failures and schedule maintenance, reducing downtime.

• Energy Management:

Monitors energy usage across treatment processes to optimize consumption and reduce costs.

• Compliance Tracking: Automatically collects data for regulatory reporting and compliance, ensuring adherence to environmental standards.

Implementation:

1. Overview

The IoT-Based Industrial Wastewater Management System is an advanced solution designed to monitor, analyze, and manage wastewater from industrial processes efficiently. Utilizing IoT sensors, real-time data analytics, and automated controls, this system ensures compliance with environmental regulations while optimizing water treatment processes.

Installation and Preparation:

1. Project Planning and Requirement Analysis

1.1. Define Objectives and Scope

• Set Goals: Understand the specific needs of the wastewater management system. For example:

• Monitoring and managing wastewater quality and flow. Optimizing chemical use and energy consumption.

• Complying with regulatory standards for discharge water quality. Providing real-time data for better decision making.

1.2. Identify Key Performance Indicators (KPIs)

1.3. Budget and Resource Planning

• Budget: Allocate resources for sensors, actuators, communication infrastructure, cloud services, and labor.

• Team Setup: Assemble the necessary personnel (e.g., engineers, IT specialists, technicians, operators).

2. System Design and Component Selection

2.1. Selection of IoT Devices and Sensors

• Water Flow Meters: For measuring the volume and rate of wastewater flow.

• Chemical Sensors: To monitor parameters like pH, dissolved oxygen (DO), turbidity, and contaminants (e.g., nitrates, oil, heavy metals).

• Temperature and Pressure Sensors: To track temperature variations and pressure in pipes or tanks.

• Toxin/Contaminant Sensors: Specialized sensors for detecting pollutants such as hydrocarbons or heavy metals.

• Automated Dosing Equipment: For chemical dosing based on sensor data.

• Communication Devices: Gateways, routers, and wireless communication technologies (e.g., Wi-Fi, LoRa, Zigbee) for transmitting sensor data.

• Edge Computing Devices: For local data processing and ensuring smooth data flow between sensors and the cloud.

2.2. Network and Connectivity Setup

• Wireless Network Infrastructure: Choose the appropriate communication protocols (e.g., Wi-Fi, Zigbee, LoRaWAN) depending on the size of the plant and sensor requirements.

• Cloud Platform: Select a suitable IoT cloud platform to store, process, and visualize data (e.g., AWS, Azure, or a custom IoT platform).

• Data Security: Ensure encryption and secure communication protocols to protect data transmission.

2.3. Design the Data Architecture

• Data Flow: Map out how data will be collected, transmitted, and analysed (e.g., sensors → gateway → cloud → dashboard).

• Dashboard and Analytics: Design a dashboard for monitoring wastewater quality, system health, and generating real time insights.

• Reporting Tools: Plan for automated compliance and operational reports, which should be readily accessible to stakeholders.

3. Installation of Hardware Components

3.1. Install IoT Sensors

• Positioning of Sensors:

o Install flow meters at the entry and exit points of wastewater treatment processes.

o Position chemical sensors in critical areas such as tanks, treatment units, or water discharge points. o

Install temperature, pressure, and contaminant sensors at relevant locations.

• Power Supply: Ensure each sensor has a reliable power supply. This could involve a direct connection to the plant's electricity grid or using batteries (for wireless sensors).

• Wiring and Mounting: Install the necessary wiring or mounting brackets, ensuring secure and stable sensor placement.

3.2. Install Communication Gateways

• Placement: Position the gateways close to sensor clusters to reduce transmission distance and ensure reliable data transfer to the cloud.

• Connectivity Check: Ensure the gateways have reliable communication with the sensors, as well as a stable internet connection for cloud data transmission.

3.3. Install Control Equipment and Automation Systems

• Automated Dosing Units: Set up pumps and dosing units for adding chemicals like coagulants or disinfectants based on sensor readings.

• Control Valves and Pumps: Install automated valves and pumps that can be controlled based on real-time system data (e.g., flow rates, wastewater quality).

• Power Backup: Set up backup power solutions like UPS systems to ensure uninterrupted operation during power outages.

4. System Integration and Configuration

4.1. Sensor Calibration

• Calibrate Sensors: Test and calibrate sensors to ensure accurate readings. This may involve using known reference solutions for chemical sensors or flow calibration devices.

• Ensure Sensor Accuracy: Ensure the sensors' range and accuracy meet the requirements of the wastewater management system.

4.2. Network Configuration

• Connect Sensors to Gateways: Ensure that all sensors are properly paired with communication gateways for data transfer.

• Check Connectivity: Verify wireless network connections and ensure that the gateways can successfully communicate with the cloud platform.

• Set Data Transmission Intervals: Configure the data collection frequency for each sensor, depending on the criticality of the parameter being monitored.

4.3. Cloud Platform and Dashboard Setup

• Configure Cloud Integration: Set up the IoT cloud platform to receive data from the gateways, store it, and process it for analysis.

• Build Dashboards: Develop and configure dashboards that display real-time data on key parameters like flow rate, chemical levels, wastewater quality, and system performance.

• Set Alerts and Notifications: Set up automatic alerts for parameters that exceed predefined thresholds, such as pH levels or flow rates.

• Generate Reports: Configure automated compliance reports for regulators and internal stakeholders.

5. Testing and Validation

5.1. Functional Testing

• Sensor Testing: Test all sensors and equipment to ensure they are functioning correctly and transmitting accurate data.

• System Integration Testing: Test the integration of all components, from sensors to cloud storage and dashboards. Ensure smooth data transmission and proper system response.

5.2. Pilot Run and Debugging

• Pilot Testing: Run the system for a short period (e.g., 1-2 weeks) under controlled conditions to identify any potential issues.

• Troubleshooting: Monitor system behavior during the pilot phase. If any issues are identified (e.g., incorrect data readings, network failures), make the necessary adjustments.

• Data Validation: Ensure that the data is being recorded accurately in the cloud and displayed correctly on the dashboards.

6. Training and Handover

6.1. Operator Training

• User Training: Train the operational staff on how to use the system, interpret data, respond to alerts, and maintain the hardware.

• Dashboard Training: Provide training on how to use the visualization dashboard, analyze trends, and generate reports.

6.2. Documentation

• User Manuals: Provide documentation detailing system operation, maintenance, and troubleshooting procedures.

• Maintenance Schedule: Create a maintenance plan, specifying routine tasks such as sensor calibration, cleaning, and software updates.

6.3. Final Handover

• Final Inspection: Perform a final inspection and verification to ensure that everything is working as expected.

• Client Handover: Provide all relevant documentation and ensure that the client is comfortable operating the system.

7. Ongoing Maintenance and Support

7.1. Remote Monitoring

• Continuous Monitoring: Use cloud-based platforms to monitor the system's performance remotely and offer continuous support.

• Regular System Updates: Periodically update the system software and firmware to ensure the system is running optimally.

7.2. Performance Optimization

• Review Analytics: Continuously analyse the data to identify patterns and improve system efficiency.

• Optimize Chemical Dosing: Fine-tune the chemical dosing process to further reduce costs and improve treatment efficacy.

IV. RESULT

Mobile Application: A dedicated mobile application was developed to provide easy access to real-time monitoring data and alerts from the industrial wastewater treatment system.

The system was able to trigger timely alerts in

Extended Sensor Range: Additional sensors such as Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) sensors can be incorporated to provide more accurate water quality monitoring.

Energy Efficiency: Solar-powered water being discharged. Additionally, dynamic sensors could be introduced to reduce the recommendations based on sensor data allowed energy consumption of the system, operators to optimize the treatment process, particularly in remote or off-grid areas. leading to efficient use of chemicals and filtration systems.

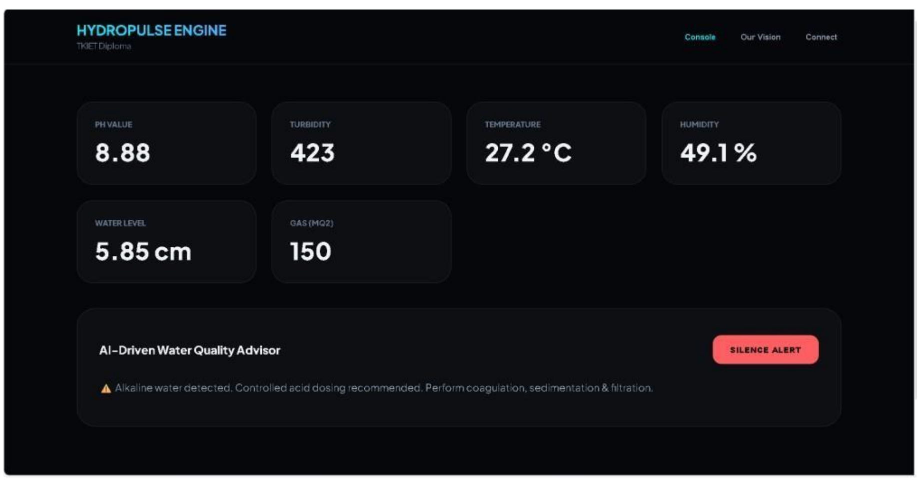

Fig. 1 (Real time water quality monitoring interface)

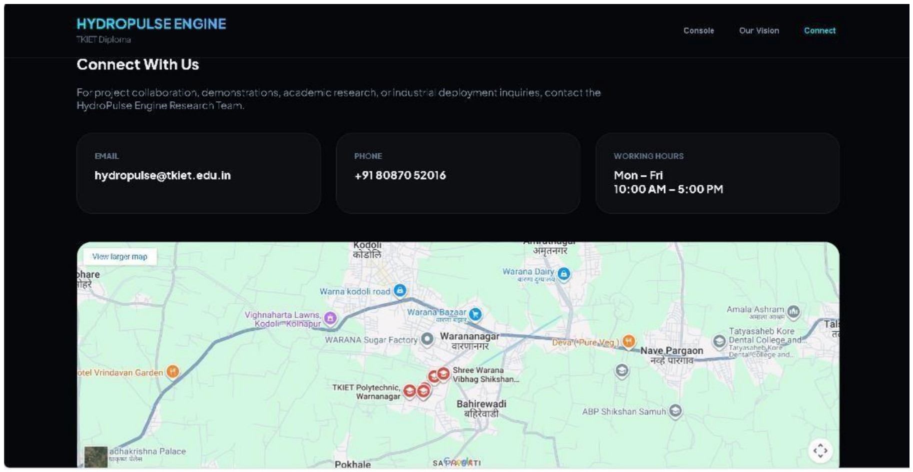

Fig. 2 (Geographic visualisation of wastewater monitoring points)

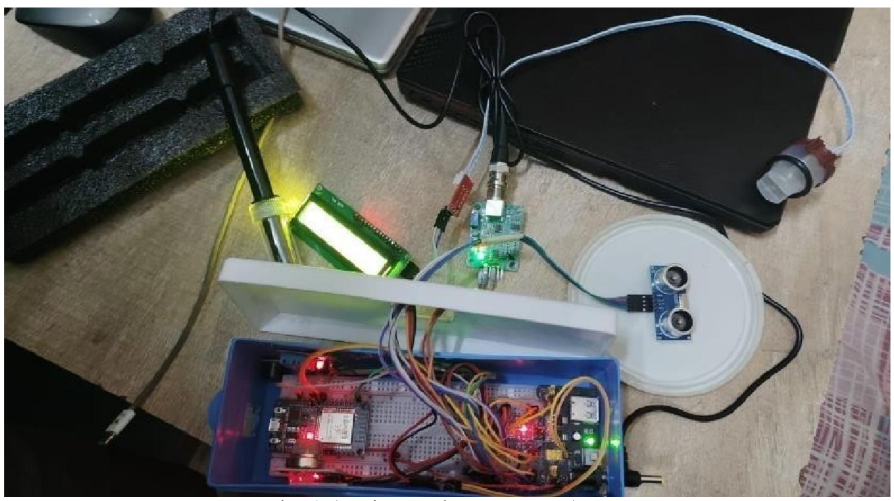

Fig. 3 (Main Hardware system)

Fig. 4 (Digital real time display)

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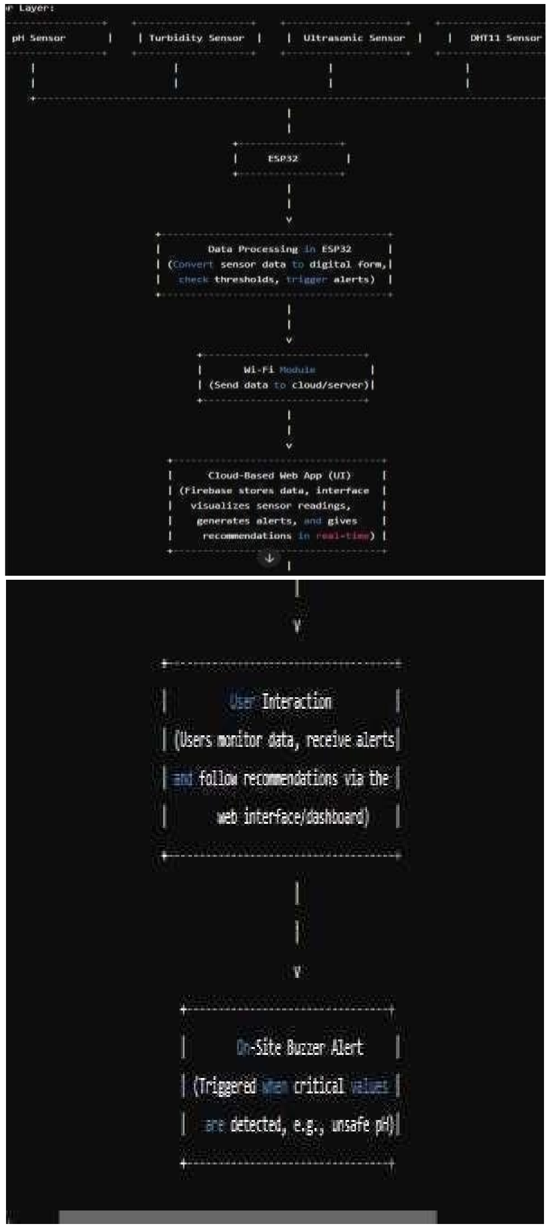
Dataflow:

The system follows a structured data flow that ensures real-time monitoring and response.

• Data Collection: The sensors (pH, turbidity, ultrasonic, DHT11, MQ gas) continuously measure water quality parameters. This data is transmitted to the ESP32 microcontroller.



• Data Transmission: The ESP32 microcontroller processes the sensor data and transmits it via Wi-Fi to a cloudbased database & Google Firebase).

• Data Processing: The web application pulls real-time data from the cloud and visualizes it on a dashboard for the user. Alerts are generated if the data crosses critical thresholds.

• User Interaction: The user can interact with the web interface to view real-time data, receive alerts, and follow dynamic recommendations for corrective actions.

• Action: Based on the system's recommendations, operators can take corrective measures (e.g., adding chemicals to adjust pH, applying filtration to reduce turbidity).

V. APPLICATIONS

1. Manufacturing Industries

Monitors and treats wastewater from textile, chemical, pharmaceutical, and food processing plants.

Ensures compliance with environmental regulations by tracking pH, turbidity, and chemical discharge levels.

2. Power Plants

Manages cooling tower wastewater by monitoring chemical levels and temperature.

Optimizes water reuse and recycling for sustainable operation.

3. Mining & Metallurgy

Tracks heavy metal contamination in wastewater.

Helps in safe disposal and treatment of toxic effluents.

4. Municipal and Urban Wastewater Treatment Plants

Enhances the efficiency of sewage treatment by automating monitoring and control.

Predicts equipment failures and optimizes maintenance schedules.

VI. FUTURE ENHANCEMENT

In the future, the IoT-based Industrial Waste Water Management System can be improved by integrating AI and machine learning for predictive analysis of wastewater patterns and chemical levels. Cloud-based monitoring and a mobile application can enable real-time remote access and alerts. Advanced sensors and automated control of valves and pumps will enhance efficiency, while data analytics can help optimize treatment processes. Additionally, modules for wastewater recycling and resource recovery can promote sustainability and water conservation.

VII. CONCLUSION

The IoT-based Industrial Waste Water Management System provides an effective and automated solution for monitoring, controlling, and optimizing industrial wastewater treatment. By using real-time sensors to track parameters like pH, TDS, turbidity, temperature, and chemical contaminants, the system ensures water quality compliance and reduces environmental pollution. Automation and remote monitoring minimize human intervention and enable timely corrective actions, while data analytics allow trend analysis and process optimization. With future enhancements such as AI-based predictive analysis, cloud monitoring, mobile applications, and resource recovery modules, the system can further improve operational efficiency, promote sustainability, and contribute significantly to water conservation and environmental protection.

VIII. DISCUSSION

The IoT-based Industrial Waste Water Management System is designed to address the critical challenge of monitoring and managing industrial wastewater efficiently. Traditional wastewater management methods often involve manual sampling, periodic lab testing, and delayed responses to contamination, which can lead to environmental hazards and regulatory non-compliance. By integrating IoT sensors, this system allows real-time monitoring of key water quality parameters such as pH, TDS, turbidity, dissolved oxygen, and temperature, providing immediate data for accurate decision-making

The system's automation capabilities ensure that pumps, valves, and treatment units can be controlled automatically based on sensor readings, reducing human error and improving treatment efficiency. Additionally, cloud-based monitoring and mobile app integration make it possible to access data and receive alerts remotely, enabling industrial managers to respond promptly to abnormal conditions. This connectivity also supports data logging and analytics, which can be used to identify trends, optimize processes, and plan preventive maintenance

REFERENCES

[1] Kumar, A., & Sinha, A. K. (2018). "Internet of Things (IoT) for wastewater treatment systems: A comprehensive review." Journal of Water Process Engineering, 23, 305-317. doi: 10.1016/j.jwpe.2018.04.015.

[2] Malik, S., & Jain, V. (2021). "An IoT-enabled real-time water quality monitoring system for sustainable development in industrial wastewater management." Sustainable Water Resources Management, 7(4), 1-12. doi:10.1007/s40899-021-00520-9.

[3] Manogaran, G., Thota, C., & Lopez, D. (2017). "A hybrid approach for big data processing of IoT-based industrial waste water treatment." IEEE Transactions on Industrial Informatics, 13(2), 507-515. doi:10.1109/TII.2016.2600504.

[4] Mehmood, Z., & Rafiq, M. (2022). "Implementation of IoT-based systems in wastewater management for enhanced treatment processes." Water Science and Technology, 85(10), 3021- 3035. doi:10.2166/wst.2022.021.

[5] Patil, M. B., & Jadhav, R. D. (2019). "IoT in wastewater management for industrial applications: Real-time monitoring and control." Journal of Environmental Management, 234, 345-354. doi: 10.1016/j.jenvman.2019.01.071.

[6] Bhatia, R., & Kaur, M. (2020). "IoT-Based Smart Water Management System: A Review." International Journal of Advanced Research in Engineering and Technology (IJARET), 11(3), 227-239.

[7] Ramesh, M., & Chandrasekaran, S. (2021). "Real-Time Monitoring of Industrial Wastewater Using IoT and Cloud Based System." Journal of Water Process Engineering, 41, 101963.

[8] Patel, H., & Joshi, D. (2019). "IoT-Based Water Quality Monitoring System for Smart Cities." IEEE Access, 7, 65458-65467.