International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Internet of Things Enabled Water Quality Monitoring System

Kishan Kumar Ojha[1], Shraddha Agrahari[2], Nikhil Kumar[3], Ashutosh Kumar Singh[4]

[1,2,3,4]Department of ECE, Noida Institute of Engineering and Technology, Greater Noida, Uttar Pradesh, India

Abstract

This research introduces an advanced solution to address one of the most pressing environmental concern: water pollution. Contaminated water significantly contributes to various health issues in both humans and animals. If pollution is detected at its source and preventing measures are implemented promptly, critical situations can be averted, ensuring ecological balance. This system integrates an Arduino Mega microcontroller with multiple sensors, including a turbidity sensor for water clarity measurement, aTDS(Total Dissolved Solid) sensor for assessing dissolved particles, a pH sensor for acidity monitoring and a Dallas Temperature sensor for tracking the temperature of water.

The information from these sensors is fabricated by implementing the Random Forest machine learning algorithm , facilating the accurate analysis and anomaly detection. An LCD screen displays real-time sensor readings, while GSM module sends alerts when critical thresholds are exceeded. When pH values deviate beyond acceptable limits, the system activates an outlet water pump to remove affected water followed by an inlet pump to replenish clean water, ensuring continuous quality control. Operated via relays, the pumps function automatically baseed on sensor input. This efficient automated system provides continous monitoring the nature of water, encouraging healthier aquatic environment and reducing risk to life in such aquatic environment.

1. Introduction

1.1 Background

The increasing population leads to increased usage of water and reducing the availibility of good quality of water. The lack of strict regulatory enforcement exacerbates this issue, leading to severe water contamination from industrial discharge, agricultural runoff, sewage disposal, and urban waste. Other contributing factors include natural calamities such as floods and droughts, as well as limited public awareness and education regarding water conservation. Poor water quality results in the proliferation of diseases and disrupts ecosystems, ultimately hampers the societal progress and bring an imbalance toh the ecosystem.

Primary water pollutants include pathogens (bacteria, viruses, parasites), agricultural chemicals (fertilizers, pesticides, nitrates, and phosphates), industrial waste (pharmaceuticals, heavy metals, plastics), and radionuclides. While some contaminants visibly alter watercolor, others remain undetectable without precise monitoring tools.

1.2 Objectives

The objective of this project is to offer a real-time, automated solution for monitoring and maintaining standardized level of water in various aquatic environments. Traditional water quality management techniques rely on manual testing and basic automation, which often prove insufficient for real-time data analysis and timely interventions. This research presents an innovative system that enhances the efficiency and reliability of monitoring nature of water for aquaculture, fish tanks, including all water bodies.This research helps to find the root cause of water degradation which can be very benificial to resolve such an considerable problem

The core objectives include:

Ensuring Water Safety: Continuously monitoring key water parameters to prevent harmful conditions.

Real-Time Monitoring: Addressing the limitations of manual testing through continuous data collection and automation.

Automated Control and Intervention: Minimizing human intervention by enabling automatic pump operations based on real-time sensor input.

Anomaly Detection and Predictive Analysis: Employing machine learning to predict and detect water quality anomalies.

Cost-Effective and Scalable Design: Implementing a low-cost, scalable system using open-source hardware.

Remote Monitoring and Alerts: Utilizing GSM for real-time notifications, ensuring timely responses.

Enhancing Aquatic Health: Creating a stable environment for aquatic organisms by mitigating water quality issues.

2. Literature Review

Several existing models focus on standarized level of water, yet they exhibit limitations in automation, scalability, and real-time analytics. This section reviews previous research on various approaches:

Key Features	Approach	Limitations
GSM Based Self Reliant Monitoring	Employs a GSM-enabled system such as the ALARM biosensor, which uses affordable sensors to track essential water parameters like temperature, pH, dissolved oxygen and TDS.	Not well suited for remote region lacking stable GSM connectivity, integrating multiple data streams for large-scale implementation can be complex.
Visual Analysis Using Fish Behaviour	Utilizes an image recognition system to monitor fish movements, analysing changes in behaviour as signs of variations in water quality using motion detection methods.	Effictiveness is reduced in murky water or water without aquatic life;demands substantial processing power and consistent environment condition for accuracy.
Smart Sensoring with Zigbee Communication Network	Utilizes intelligent sensor devices that communicate via zigbee protocols to collect and forward water quality data in real time to	Communication range is relatively short; performance may degrade in large monitoring areas or due to signal interference, limiting its

	central monitoring unit.	scalibility.
Distributed Wireless Sensor System	Implements a mesh of interconnected sensors using wireless communication(e.g Zigbee)to continuously gather and transmit environment data over extended periods.	Requires careful energy management to sustain long term operation; prone to issues like node failure, data overlap, and time synchronization among sensors.
Solar Powered Water Monitoring System	Combines photovolatic energy sources with monitoring units to support continuous water quality tracking in isolated locations without power infrastructure.	Heavily reliant on sunlight availability; power generation can fluctuate in cloudy regions or shaded environment, which may disrupt uninterrupted monitoring.

This table summarizes the aspects of the exisiting projects and the proposed project:

Aspects	**Exisiting Project**	**Proposed Project**
Automation Level	Limitted, some depends on manual testing or basic automated alerts.	Fully automated system with real time adjustments.
Data Processing Technique	Simple Threshold based alerts	Random Forest Machine Learning for precised detection.
Scalibility	Limitted due to dependencyon wired connection.	Scalable with cloud integration possibilities.
Communica-tion Technology	Zigbee, Bluetooth	GSM for real time remote monitoring
Application Scope	Mostly focused on fish farming and aquariums.	Expanded to hydroponics, water treatement plants,river bodies treatment.

3. Methodology

3.1 Research Approach

The study follows an **applied research** methodology, developing a practical, real-time solution for water quality monitoring.

3.2 Data Collection and System Components

Sensors: pH, turbidity, temperature, and TDS sensors for real-time data collection.
Microcontroller: Arduino Mega for sensor data acquisition and processing.
Machine Learning: Random Forest algorithm for anomaly detection and predictive analysis.
Communication Module: GSM for remote alerts and real-time monitoring.
Automation: Relays for automatic water pump activation based on sensor readings.
Cloud Integration: Data storage and visualization through cloud-based platforms.

3.3 Implementation Steps

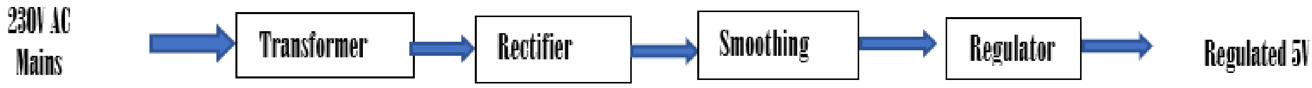
1. **Sensor Selection and Calibration** – Identifying appropriate sensors for key water quality parameters.
2. **System Design** – Developing an integrated architecture for data acquisition and analysis.
3. **Prototype Development** – Assembling hardware components and writing control algorithms.

4. **Field Testing** – Deploying the system in real-world settings and collecting data.
5. **Data Processing and Visualization**– Analyzing collected data to detect anomalies.
6. **User Interface Development** – Creating an accessible dashboard for stakeholders.
7. **Feedback and System Improvement** – Iterating the design based on user feedback.

4. List of Material Used

To implement the Internet of Things enabled water quality monitoring system the following components are utilized:

Power Supply



A step down transformer converts the 230V AC into 12V. The bridge rectifier is used to change alternating current to direct current. A capacitor is used to filter the AC ripples and gives to the voltage regulator.Finally the voltage regulator regulate the voltage to 5V and finally, a blocking diode is used for taking the pulsating waveform.

Arduino Mega

The The Arduino Mega 2560 is a microcontroller board based on the ATmega 2560. It has 54 digital input/ output pins out of which 14 can be used as PWM(Pulse Width Modulation) outputs and 16 analog inputs. 4 UARTs(Hardware Serial Ports) , a 16Mhz crystal oscillator ,a USB connection, power jack , an ICSP header, and reset button. It contains everything needed to support the microcontroller , simply connect it to the PC with USB cable or power it with AC to DC adapter or battery to get started.

Turbidity Sensor

A turbidity sensor is a device used to mesure the cloudiness or haziness of the liquid by detecting the presence of the suspended particles. It is based on the principle of scattering of light . Usually infrared or laser goes through the liquid the rays deviates from their original path upon striking an particle in liquid. The higher the concentration of particles, the more light is scattered indicating greater the turbidity. It is used to detect the pollutants, sediments or other contaminants that produces imact on the clarity of water.-

TDS Sensor

A TDS (Total Dissolved Solids) sensor is a device used to mesure the concentration of dissolved solids in liquid. These dissolved solids include minerals, salt , metals and all organic matter that can effect the quality of the water. The TDS value is an important indicator of water purity as high level of dissolved solids can lead to the contamination or poor quality of water.It plays a pivotal role in preventing health risks due to the contamination of water

pH Sensor

The pH Sensor helps to measure the acidity and alkalinity of the water within the range of 0-14.It works by assessing the hydrogen ion activity in the water.

Dallas Temperature Sensor

The Dallas Temperature Sensor is called that because it was originally made by a company name Dallas Semiconductor, he name stuck with the product.It is commonly known as DS18B20. This sensor measures the temperature and converts it into digital signal so no need to connect and extra circuits.There is a small thermometer chip that converts temperature into digital signals. It uses single wire to send and receive data. The sensor has unique serial number so multiple sensors can be connected without any confusion.

GSM Module

GSM(Global System for Mobile) Module with other technology is a part of evolution of wireless telecommunication. SIM900A GSM Module is the smallest and the cheapest module for GPRS/GSM communication with the use of mobile sim. It works on 900 and 1800MHz frequency band and allow user to send or receive mobile calls and SMS.

Relay

A relay is a automatic switch that helps in controlling the high current using the low current signal.In the proposed project we have used 5v relay so the range of relay varies from 0-5V.

LCD

LCD is Liquid Crystal Display, it is a device which do not transmit any light to display characters, animations , vedios etc. LCD consists of millions of pixels made of crystals which are arranges in rectangular grid. It uses fluorescent tubes to lighten the picture. Eache pixel is provided with the backlight. Each pixel has a red, green and blue sub pixels that can be turned on and off.

Buzzer

The Buzzer is also called as Piezo, this device generates alarming sound. It is a digital component which is connected to the digital outputs and it generates sound when the output is high.

AC Water Pump

An AC Water Pump uses alternate current (AC) electricity for the motion of water across the system. It comes in multiple sizes and capacities ranging from small low power pump to high capacity high power pump.

5. Use Case Applications

The system is applicable in various real-world scenarios:

- **Fish Farming:** Ensuring optimal water conditions for fish health and growth.
- **Aquariums:** Monitoring and maintaining water quality in public and private aquariums.

- **Hydroponics:** Regulating nutrient-rich water conditions for plant growth.
- **Water Treatment Facilities**: Enhancing efficiency in water purification processes.
- **Pond and Lake Management:** Preventing pollution and ensuring ecological stability.

6. Challenges and Solutions

- **Sensor Accuracy:** Frequent calibration and industrial-grade sensors enhance precision.
- **Power Supply:** Solar-powered backups ensure continuous operation.
- **Data Transmission**: Multi-network support (GSM, LoRa, ZigBee) improves connectivity.
- **Maintenance Issues:** Self-cleaning sensors and predictive maintenance optimize performance.
- **Computational Limitations:** Cloud-based processing enhances machine learning capabilities.
- **User Accessibility:** Mobile and web-based dashboards simplify data interpretation.

7. Future Scope

- **IoT and Cloud Integration** for large-scale monitoring.
- **Advanced AI Models** for improved predictive analytics.
- **Renewable Energy Sources** for sustainable operation.
- **Expanded Scalability** to cover larger water bodies.
- **Mobile and Web Applications** for improved accessibility.

8.Conclusion

The proposed *IoT-enabled Water Quality Monitoring System* provides an innovative, automated approach to maintaining water quality. By leveraging multiple sensors, machine learning, and real-time alerts, the system effectively addresses the limitations of traditional water quality assessment methods. With automation and predictive analytics, it ensures a safer and healthier aquatic environment, making it an ideal solution for various applications.

9. REFERENCES

1. S. Chowdhury and S. Ahmed, “A comprehensive review of IoT-driven systems for monitoring water quality,” *J. Environ. Manage.*, vol. 305, Art. no. 113390, 2022, doi: 10.1016/j.jenvman.2021.113390.
2. H. Zhao and X. Li, “Implementing real-time water quality analysis using IoT combined with machine learning methods,” *Environ. Sci. Pollut. Res.*, vol. 30, no. 2, pp. 321–335, 2023, doi: 10.1007/s11356-022-22471-4.
3. A. Almeida and J. Silva, “Exploring the incorporation of IoT in water quality surveillance: Present challenges and upcoming possibilities,” *Sensors*, vol. 23, no. 5, p. 2341, 2023, doi: 10.3390/s23052341.
4. K. Patel and R. Singh, “An IoT-enabled intelligent system for monitoring water quality: A real-world case evaluation,” *IEEE Internet Things J.*, vol. 9, no. 6, pp. 4567–4575, 2022, doi: 10.1109/JIOT.2021.3090980.
5. A. Das and A. Ghosh, “Designing and deploying a cloud-integrated framework for monitoring water quality,” *J. Water Resour. Prot.*, vol. 14, no. 4, pp. 289–301, 2022, doi: 10.4236/jwarp.2022.144018.
6. P. K. Sahu and R. Maji, “Sustainable water quality oversight through advanced IoT technologies,” *Environ. Technol. Innov.*, vol. 29, Art. no. 102792, 2023, doi: 10.1016/j.eti.2022.102792.

7. S. Mishra and N. Sahu, “Evaluating IoT's role in environmental applications with emphasis on water quality: A review,” *Int. J. Environ. Res. Public Health*, vol. 20, no. 8, p. 1234, 2023, doi: 10.3390/ijerph20081234.
8. A. S. Rao, S. Martial, J. Gubbi, and M. P. Swami, “A cost-efficient and self-sustained system for continuous water quality assessment,” in *Proc. IEEE Conf.*, 2013, pp. 14–19.
9. C.-L. Lai and C.-L. Chiu, “Utilizing image analysis for an automated water quality inspection framework,” in *Proc. IEEE Conf.*, Jul. 2011, pp. 1856–1861.
10. N. A. Cleote, R. Malekian, and L. Nair, “Development of intelligent sensor technology for dynamic water quality tracking,” *IEEE Sensors J.*, vol. 13, no. 9, Sep. 2014.
11. A. Patawala, N. Bansode, and Y. Bhong, “A smart city solution for managing water resources via IoT,” *Int. J. Adv. Res. Ideas Innov. Technol.*, vol. 3, no. 2, 2017. [Online]. Available: https://www.ijariit.com/manuscripts/v3i2/V3I2-1252.pdf
12. D. He and L.-X. Zhang, “Deploying WSN-based solutions for water quality monitoring,” *Inst. Mech. Electron. Inf., China Univ. Geosci. (Wuhan)*, Wuhan, China, 2012.
13. A. M. Kulkarni and S. M. Turkane, “Solar energy-powered monitoring of water parameters using a wireless sensor network,” *Dept. E&TC, P.R.E.C., Loni, Univ. Pune*, Loni (MH), India, 2013.
14. N. S. Haron, M. K. B. Mahamad, I. A. Aziz, and M. Mehat, “A wireless sensor network setup for remote assessment of water quality,” in *Proc. 8th WSEAS Int. Conf. Electron., Hardw., Wireless Opt. Commun.*