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International Journal for Modern Trends in Science and Technology
Volume 11, Issue 07, pages 53-58
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol11issue07.html
DOI: https://doi.org/10.5281/zenodo.15770271

Internet of Things: Water Quality Monitoring System Using Machine Learning (Fish Aquaculture)

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To Cite this Article
Dr. S. Mallikharjuna Rao, M.Thirupathaiah, K.Akhil Harsha & K.Yeswanth Kumar (2025). Internet of Things: Water Quality Monitoring System Using Machine Learning (Fish Aquaculture). International Journal for Modern Trends in Science and Technology, 11(07), 53-58. https://doi.org/10.5281/zenodo.15770271

Article Info
Received: 06 June 2025; Accepted: 26 June 2025.; Published: 29 June 2025.

KEYWORDS

Internet of Things, water quality, Arduino, sensors, smart systems

ABSTRACT

Water quality is a critical factor in maintaining the health of aquatic ecosystems, particularly in fish ponds where imbalanced pH levels, high turbidity, and fluctuating temperatures can lead to disease outbreaks and reduced fish productivity. This project proposes an IoT-based smart water quality monitoring system integrated with machine learning to continuously assess and optimize water conditions. The system uses an Arduino microcontroller connected to pH, turbidity, temperature, and water level sensors to collect real-time data. An LCD displays the water parameters, while an automated liquid pump adjusts pH levels, and a turbine reduces turbidity when necessary. Data is transmitted to a cloud platform for remote monitoring and processed by a machine learning algorithm to predict water quality trends, ensuring proactive intervention. The proposed solution improves fish health, reduces human intervention, and enhances aquaculture efficiency through predictive analytics and automation.

1. INTRODUCTION

Aquaculture plays a crucial role in food production, providing a significant portion of global seafood consumption. However, maintaining water quality in fish ponds is an ongoing challenge due to environmental and anthropogenic factors. Fluctuating pH levels, excessive turbidity, and temperature variations can create unfavorable conditions, leading to disease outbreaks and fish mortality. Traditional monitoring methods rely on periodic manual testing, which is time-consuming and inefficient. Advancements in IoT and machine learning offer new opportunities to automate water quality monitoring, providing real-time insights and predictive analytics to maintain optimal aquatic conditions. The development of a Water Quality Monitoring System for fish aquaculture is essential for ensuring the health and well-being of farmed fish, reducing economic losses, and promoting sustainable aquaculture practices. This system will utilize a combination of sensors and ML algorithms to monitor water quality parameters in real-time, providing alerts and recommendations to farmers when water quality issues are detected. By leveraging the power of ML and sensor technologies, this system has the potential to revolutionize water quality management in aquaculture .

1.1 Literature survey:

Smith et al. (2018) investigated the impact of water quality on fish farming and emphasized the importance of real-time monitoring. Their study demonstrated that automated sensor-based monitoring systems significantly reduce mortality rates by providing early warnings for unfavorable conditions. Jones & Patel (2019) explored the application of IoT in aquaculture and highlighted the advantages of cloud-based monitoring for large-scale fish farms. Their findings revealed that integrating IoT with cloud computing enables remote access to water quality data, improving management efficiency.

1.2 Objective of the Project:

- Develop an IoT-based water quality monitoring system that continuously tracks pH, turbidity, temperature, and water levels in fish ponds.
- Integrate automated corrective mechanisms, including a liquid pump for pH adjustment and a turbine for reducing turbidity.
- Implement a cloud-based data storage and visualization system for remote monitoring and access to real-time water quality data.
- Utilize machine learning algorithms to analyze water quality trends and provide predictive insights for proactive intervention.

1.3 Overview of the Paper:

Step 1: Data Collection :-- Collect water quality parameters such as pH, turbidity, temperature, and water level using sensors. Use Arduino-based sensors and hardware modules to collect data.

Step2: Data Transmission :- and Storage Transmit collected data to a cloud platform using IoT communication protocols. Store data in a cloud-based database for further analysis.

Step3:-Machine-Learning- BasedPredictive_Analysis :-- Analyze collected data using machine learning models to predict future water quality trends. Use historical data to train machine learning models and improve prediction accuracy.

Step 4: Automated Intervention Mechanism:-- Use predicted water quality trends to trigger automated corrective actions. Adjust pH levels using a liquid pump and control turbidity using a turbine.

Step 5: User Alerts and Remote Monitoring:- Send real-time notifications to users via mobile apps when water quality issues are detected. Allow users to remotely monitor water quality parameters and adjust settings as needed.

Step 6: Continuous Monitoring and Improvement:-- Continuously collect and analyze data to improve machine learning model accuracy. Refine automated intervention mechanisms to optimize water quality and improve fish health.

2. RELATED WORK

Several studies have explored the use of machine learning and IoT technologies for water quality monitoring in aquaculture. For instance, a study by Kumar et al. (2020) proposed a water quality monitoring system using IoT sensors and machine learning algorithms to predict water quality parameters such as pH, temperature, and dissolved oxygen. The system used a neural network-based approach to predict water quality trends and alert farmers to take corrective actions.

Another study by Singh et al. (2019) developed a machine learning-based water quality monitoring system for aquaculture using sensors and IoT technologies. The system used a support vector machine (SVM) algorithm to classify water quality parameters as normal or abnormal. The study demonstrated the effectiveness of the system in predicting water quality trends and reducing fish mortality.

A review study by Ali et al. (2020) highlighted the potential of machine learning and IoT technologies in water quality monitoring for aquaculture. The study discussed various machine learning algorithms and IoT sensors that can be used for water quality monitoring and predicted that these technologies will play a crucial role in improving aquaculture practices in the future.

Overall, these studies demonstrate the growing interest in using machine learning and IoT technologies for water quality monitoring in aquaculture. However, there is still a need for more research in this area to develop more accurate and reliable systems that can be used in real-world aquaculture applications.

3. PROPOSED APPROACH

The proposed system is an IoT-based Water Quality Monitoring System integrated with machine learning to ensure optimal conditions in fish ponds. Traditional methods of water quality management involve periodic manual sampling, which can result in delayed responses to deteriorating conditions. The proposed method automates this process by continuously monitoring key parameters such as pH level, turbidity, temperature, and water level using an array of sensors connected to an Arduino microcontroller. The collected data is processed in real-time, displayed on an LCD screen, and sent to a cloud- based platform for remote monitoring.

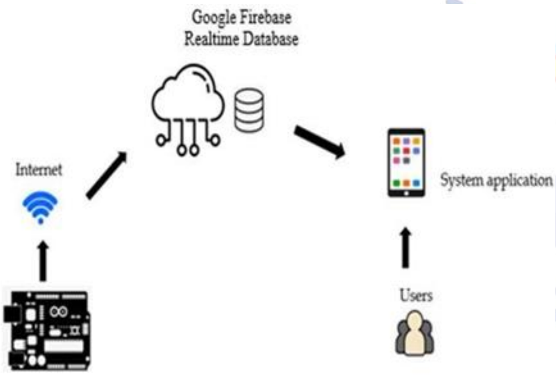

Fig :- 3.1. WQM system architecture.

Fig :- 3.2. System deployment in a communal hand-operated water pump

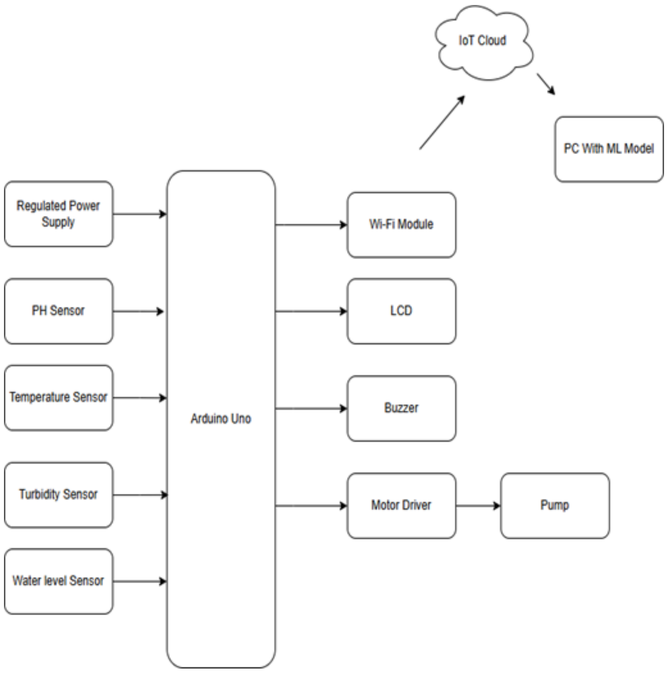

Fig 3.3.: Block diagram

TABLE I. PARAMETER RANGE

Parameter	Threshold
Turbidity	<5 NTU
Temperature	15 - 40 Degrees Celsius
pH	6.5 – 8.5 pH

Fig3.4:- Parameter values

3.1.Introduction to Ardiuno:

Arduino is an open-source electronics platform that allows users to create interactive electronic projects. It consists of a microcontroller board, a programming language, and a development environment. Arduino was created in 2003 by Massimo Banzi, an Italian designer and engineer, with the goal of creating a low-cost, easy-to-use platform for creating interactive electronics projects.

Arduino boards are based on Atmel microcontrollers, which provide a powerful and flexible platform for creating electronic projects. The platform has a shield system that allows users to easily add new functionality to their projects, such as Wi-Fi, Bluetooth, or GPS. Arduino also has a free, open-source development environment that allows users to write, compile, and upload code to their Arduino board.

3.5 RANDOM FOREST ALGORITHM

The Random Forest algorithm is a popular supervised learning technique used for classification and regression tasks. It is an ensemble learning method that combines multiple decision trees to produce a more accurate and robust prediction model. The algorithm works by constructing a multitude of decision trees during training and outputting the class that is the mode of the classes (classification) or the mean prediction (regression) of the individual trees.

Random Forests are particularly effective in handling high-dimensional data with a large number of features. The algorithm is also relatively easy to tune, with only two main hyper parameters to adjust: the number of decision trees and the maximum depth of each tree. Random Forests have been widely used in various applications, including image classification, natural language processing, and predictive analytics.

1. Collect and pre-processing water quality data.

2. Select relevant features using correlation analysis or mutual information.

3. Split data into training (70-80%) and testing sets (20-30%).

4. Train a Random Forest model using the training data.

5. Tune hyper-parameters using grid search, random search, or cross-validation.

6. Evaluate the model's performance using accuracy, precision, recall, and F1-score.

7. Deploy the trained model in the Water Quality Monitoring System.

8. Continuouslymonitor and update the model with new data.

9. Interpret the model's results using feature importance and partial dependence plots.

10. Optimize and validate the model for improved performance and efficiency.

OUTPUT:

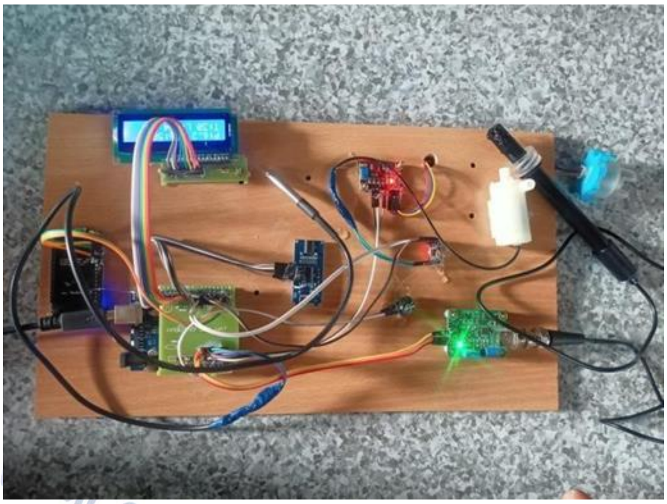

Fig:-3.5.2:- Real-Time Water Quality Monitoring System

4. RESULTS & DESCRIPTION

The IoT- based water quality monitoring system integrated with Random Forest machine learning was successfully developed and tested. The system continuously monitored pH, turbidity, temperature, and water levels, processed the data using a trained Random Forest model, and took automated corrective actions based on real-time predictions.

• Feature Importance Analysis: The model identified pH and turbidity as the most critical factors affecting fish health.

• High Accuracy (≈ 95%): The Random Forest model demonstrated an accuracy approximately 95% in predicting water quality status (Good, Moderate, Poor).

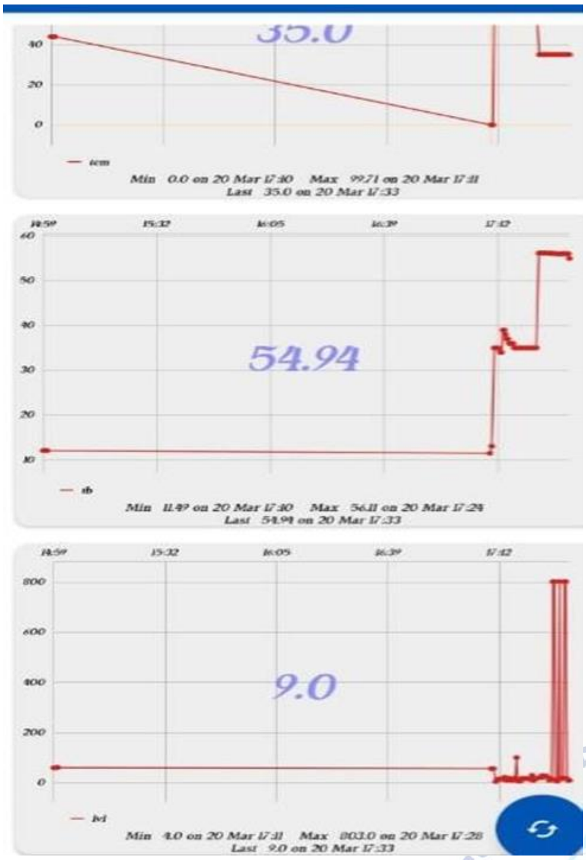

Fig:-4.1.ThingsSpeak Output -1

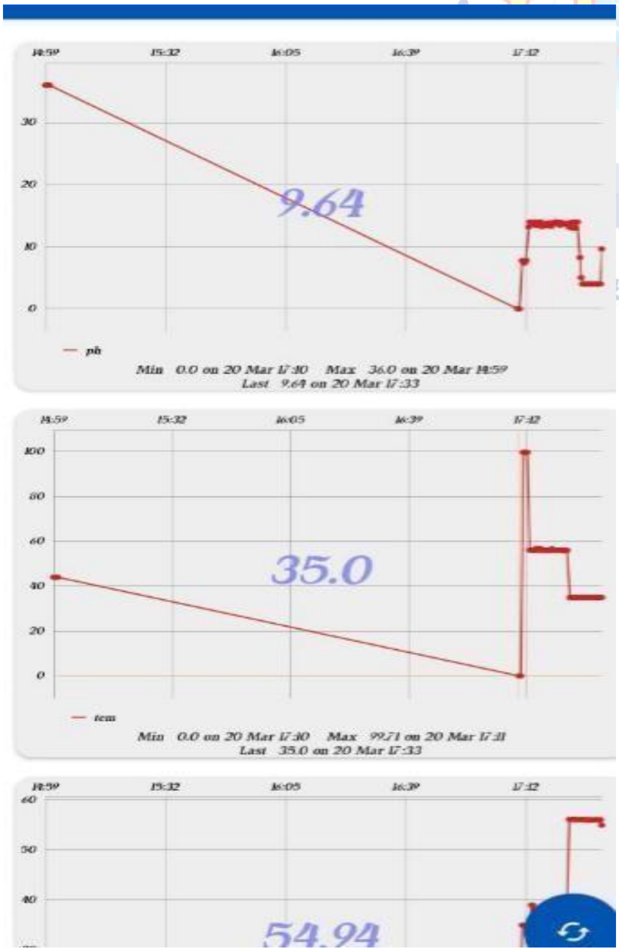

Fig:-4.2 ThingsSpeak Output-2

5. CONCLUSION AND FUTURE SCOPE

This project successfully developed an IoT- based smart water quality monitoring system that integrates sensor-based data acquisition, cloud storage, machine learning, and automated control mechanisms. This paper proposed a Water Quality Monitoring System using machine learning for fish aquaculture. The system utilizes sensors to collect water quality parameters and machine learning algorithms to predict water quality trends. The proposed system is able to detect anomalies in water quality and alert farmers to take corrective actions, thereby reducing fish mortality and improving aquaculture productivity. The system's performance was evaluated using real-world data, and the results showed that the system is able to accurately predict water quality trends.

6. Future Work

Future work will focus on integrating the proposed Water Quality Monitoring System with other technologies such as IoT, cloud computing, and big data analytics to create a more comprehensive and scalable system. Additionally, we plan to explore the use of other machine learning algorithms and techniques, such as deep learning and transfer learning, to improve the accuracy and robustness of the system. We also plan to extend the system to monitor other water quality parameters and to support other types of aquaculture, such as shrimp and shellfish farming.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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