



## IoT-Based Real-Time Water Purity Monitoring and Alert System for Sustainable Shrimp Farming

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**ABSTRACT:** Shrimp farming is a rapidly growing aquaculture practice, where maintaining optimal water quality is essential for healthy shrimp growth and improved productivity. Conventional water quality monitoring methods rely on manual testing and periodic sampling, which often fail to detect sudden changes in critical parameters, leading to stress, disease, and economic losses. This research presents an Internet of Things based real-time water purity monitoring and alert system for sustainable shrimp farming. The proposed system continuously monitors essential water parameters such as pH, temperature, salinity, and turbidity using integrated sensors connected to a microcontroller unit. The collected data is transmitted wirelessly to a cloud-based platform, enabling real-time visualization and remote monitoring. Predefined threshold values are used to analyse the water conditions, and instant alert notifications are generated whenever the parameters exceed safe limits, allowing timely corrective actions by farmers. Experimental evaluation of the system demonstrates improved monitoring accuracy, reduced response time, and effective detection of abnormal water conditions when compared to traditional monitoring techniques. The results indicate that the proposed system minimizes shrimp mortality, reduces labour dependency, and enhances overall farm efficiency. The low-cost, scalable, and energy-efficient design of the system makes it suitable for both small-scale and large-scale shrimp farms. This work concludes that the implementation of real-time monitoring and alert mechanisms significantly supports sustainable aquaculture practices and contributes to smart farming solutions.

**Keywords:** IoT, Shrimp Farming, Water Quality Monitoring, Real-Time Alert System, Sustainable Aquaculture.

### 1. Introduction

Shrimp farming is one of the most important sectors of aquaculture due to its high economic value and growing global demand. The health, growth rate, and survival of shrimp are highly dependent on water quality parameters such as pH, temperature, salinity, and turbidity. Even slight deviations from the optimal range can cause stress, disease outbreaks, and significant financial losses. Therefore, continuous monitoring and timely

control of water quality are essential requirements for sustainable shrimp farming practices. Recent studies highlight that inadequate monitoring remains a major challenge in small and medium scale aquaculture farms.

Conventional water quality monitoring methods mainly rely on manual sampling and laboratory-based testing, which are time-consuming, labour-intensive, and incapable of providing real-time information. Such approaches often fail to detect

sudden changes in water conditions, resulting in delayed corrective actions and increased shrimp mortality. With the advancement of digital technologies, Internet of Things based solutions have emerged as an effective approach for real-time environmental monitoring in aquaculture systems. However, many existing IoT-based systems are either limited to monitoring fewer parameters or involve high implementation costs, making them less suitable for practical farm deployment.

To address these challenges, this work focuses on the design and implementation of a low-cost IoT-based real-time water purity monitoring and alert system specifically tailored for shrimp farming applications. The proposed system integrates multiple water quality sensors with a microcontroller and cloud-based platform to enable continuous monitoring, remote access, and instant alert generation during abnormal conditions. The main objective of this research is to improve monitoring efficiency, reduce response time, and support sustainable aquaculture management. The authors' contribution lies in developing an integrated, scalable, and farmer-friendly solution that enhances shrimp farm productivity while minimizing operational losses.

## 2. Recent Works

Recent advancements in aquaculture technology demonstrate a rapid increase in the adoption of Internet of Things (IoT) based solutions for real-time water quality monitoring in shrimp farming systems. The integration of smart sensors, wireless communication protocols, and cloud-based analytics platforms has transformed traditional aquaculture practices into more efficient and data-driven systems. Researchers across various countries have focused on designing low-cost, scalable, and intelligent monitoring frameworks to ensure optimal pond conditions and improve shrimp survival rates. However, while significant progress has been achieved, certain limitations remain in terms of system integration, automated

alert mechanisms, scalability, and cost-effectiveness.

One of the notable studies in this domain was conducted by Eso et al. (2024), who proposed an IoT-based water quality monitoring system specifically designed for Vannamei shrimp farming. The system incorporated multiple sensors to measure key parameters such as pH, temperature, and salinity, which are critical for shrimp growth and health stability. These sensors were integrated with a Node MCU ESP32 microcontroller, selected for its built-in Wi-Fi capability, low power consumption, and efficient data processing features. The primary objective of this system was to enable continuous real-time data acquisition and remote monitoring of shrimp pond conditions.

In their implementation, sensor data was transmitted using the Message Queue Telemetry Transport (MQTT) protocol, which is widely recognized for lightweight communication in IoT applications. The collected data was visualized through cloud-based platforms such as Thing Speak and Node-Red dashboards. Additionally, Telegram notifications were used to provide alerts when parameters exceeded predefined thresholds. The system demonstrated satisfactory accuracy levels, with sensor error rates reported below 5% after proper calibration procedures. This accuracy validation indicates that IoT-based sensing can effectively replace conventional manual testing methods for routine monitoring tasks.

Although the study successfully implemented real-time monitoring and alert notification, its scope was primarily focused on parameter observation and data transmission. The corrective actions still depended on manual intervention by farmers. Furthermore, the system monitored a limited set of parameters and did not incorporate advanced decision-support algorithms or predictive analysis models. The absence of integrated automation for pond management processes such as aeration control or water

exchange limits the overall system intelligence. Despite these constraints, the study significantly contributed to demonstrating the feasibility of IoT-based monitoring in shrimp farming environments.

Another recent study emphasized the development of an IoT-enabled aquaculture monitoring framework with a focus on affordability and accessibility for small-scale farmers. This research integrated pH, temperature, and turbidity sensors with wireless communication modules to provide real-time visualization of water conditions through a web-based dashboard. The primary aim of the study was to reduce dependency on laboratory-based water testing and enable farmers to remotely monitor pond health using smartphones or computers.

The system architecture included a microcontroller-based data acquisition unit connected to low-cost sensors. Data was transmitted through Wi-Fi modules to a centralized cloud server, where it was stored and displayed using graphical dashboards. The study demonstrated effective real-time performance, enabling continuous observation of environmental parameters. Farmers could monitor trends and historical data to analyze variations in pond conditions over time.

However, the proposed approach lacked a comprehensive alert mechanism capable of providing immediate notifications during critical deviations. While data visualization was achieved successfully, the absence of automated alert triggers reduces the system's proactive capability. Additionally, scalability challenges were identified when deploying the system across larger pond networks, as communication reliability and data management complexity increased. The study primarily focused on monitoring and visualization rather than intelligent decision-making support. Nevertheless, it highlighted the importance of cost-effective IoT solutions in improving aquaculture productivity.

Further research in the field has explored intelligent water quality management systems incorporating additional features such as dissolved oxygen monitoring, ammonia detection, and cloud-based analytics. Some studies proposed hybrid communication technologies combining GSM, LoRa, and Wi-Fi modules to enhance long-distance data transmission in rural aquaculture settings. These systems aimed to overcome connectivity limitations in remote areas where internet infrastructure is weak or unstable.

For instance, certain researchers designed IoT-based intelligent water management systems capable of performing threshold-based control actions. When water parameters exceeded safe limits, automated control mechanisms activated aerators or water pumps to restore balance. This advancement represents a shift from passive monitoring systems toward active control systems in aquaculture. However, such systems often involve higher implementation costs due to additional hardware components and control circuitry.

Another line of research explored cloud-based data analytics and predictive modeling techniques. Machine learning algorithms were applied to historical sensor data to predict potential water quality deterioration before it reached critical levels. Predictive models provide early warnings based on trend analysis rather than simple threshold comparison. While these systems demonstrate improved forecasting capability, they require large datasets and computational resources, which may not be practical for small-scale shrimp farms with limited technical expertise.

Despite the diversity of existing IoT-based aquaculture monitoring solutions, several common challenges remain. First, cost remains a significant barrier for widespread adoption, especially in developing regions where shrimp farming is often practiced by small and medium-scale farmers. Systems incorporating advanced

analytics, multiple sensors, and automated control mechanisms may become economically unfeasible.

Second, many systems prioritize monitoring functionality but do not fully integrate intelligent alert systems or automated responses. Real-time visualization alone is insufficient unless supported by immediate notifications and decision-support mechanisms. Third, long-term sensor reliability and calibration maintenance are frequently overlooked in experimental prototypes. Environmental exposure, biofouling, and sensor drift can affect measurement accuracy over time.

From the analysis of these studies, it is evident that IoT technology has significantly improved the capability of real-time water quality monitoring in shrimp farming. However, gaps exist in achieving a balanced combination of affordability, scalability, real-time alert generation, and system reliability. Some systems focus heavily on advanced features but compromise cost efficiency, while others emphasize low cost but lack comprehensive alert and decision-support mechanisms.

Building upon the strengths and limitations of existing works, the proposed research aims to integrate multi-parameter sensing with an efficient threshold-based real-time alert system in a cost-effective architecture. The objective is to provide a farmer-friendly solution that ensures timely detection of abnormal water conditions without requiring complex technical infrastructure. By combining accurate sensing, reliable wireless communication, cloud-based visualization, and automated alert notifications, the proposed system addresses both technological and operational challenges identified in previous research.

In summary, the evolution of IoT-based water quality monitoring systems demonstrates promising progress toward smart aquaculture. However, sustainable shrimp farming requires not only real-time monitoring but also intelligent alert generation, scalability, ease of use, and economic

feasibility. The proposed work contributes to this growing body of research by offering an integrated and practical solution that aligns with the needs of modern shrimp farming environments.

### **3. Proposed Work Explanation**

The proposed solution introduces a comprehensive IoT-based real-time water purity monitoring and alert system designed to enhance sustainable shrimp farming through continuous environmental observation and intelligent decision support. The system is developed to overcome the limitations of conventional manual monitoring methods, which often fail to detect sudden fluctuations in water quality parameters. In shrimp farming environments, maintaining stable water conditions is essential because even minor deviations in pH, temperature, salinity, or turbidity can negatively affect shrimp growth, immune response, and survival rate. Therefore, the proposed system focuses on providing uninterrupted monitoring, rapid analysis, and immediate alert generation to ensure timely corrective action and prevent economic losses.

The system operates by integrating multiple water quality sensors within the shrimp pond to continuously measure critical environmental parameters. Each sensor is carefully selected to ensure accuracy, durability, and compatibility with embedded systems. The pH sensor measures the acidity or alkalinity of water, which directly influences shrimp metabolism and biochemical reactions. The temperature sensor continuously tracks water temperature, as shrimp are highly sensitive to thermal variations that affect oxygen solubility and feed conversion efficiency. The salinity sensor monitors salt concentration, which is crucial for maintaining proper osmotic balance within shrimp bodies. The turbidity sensor measures water clarity and suspended particles, helping detect contamination, excess feed waste, or organic matter accumulation. These sensors work simultaneously to provide a complete picture of pond water quality conditions.

The collected sensor data is transmitted to a microcontroller unit that acts as the central processing component of the system. The microcontroller performs real-time data acquisition and applies calibration algorithms to convert raw sensor signals into standardized engineering units. This ensures consistent and reliable measurement interpretation. The system incorporates predefined threshold values based on recommended water quality ranges for shrimp farming. The microcontroller continuously compares real-time sensor readings with these threshold limits to determine whether the water conditions remain within safe operational boundaries. By implementing this evaluation process at the edge level, the system significantly reduces response time compared to traditional methods that rely solely on periodic observation or cloud-side analysis.

Once processed, the data is transmitted wirelessly to a cloud-based platform using internet connectivity. The communication mechanism is designed to be energy-efficient and reliable, ensuring uninterrupted data flow from the pond to the cloud server. The cloud platform stores real-time and historical data, enabling long-term trend analysis and performance evaluation. Farmers can remotely access the monitoring dashboard through smartphones or computers, allowing them to supervise pond conditions without being physically present at the farm site. The dashboard presents parameter values in graphical and numerical formats, improving clarity and ease of understanding.

A key feature of the proposed solution is its automated alert mechanism. When any parameter exceeds the predefined safe range, the system immediately generates an alert notification. This instant warning enables farmers to take corrective actions such as adjusting aeration systems, replacing water, or applying necessary treatments. Unlike conventional systems that function primarily as passive data loggers, the proposed system actively supports decision-making by

transforming raw sensor readings into actionable alerts. This proactive approach reduces the risk of shrimp stress, disease outbreaks, and mortality caused by delayed intervention.

The proposed system is designed with scalability and cost-effectiveness in mind. The modular architecture allows additional sensors to be integrated in the future, such as dissolved oxygen or ammonia sensors, without major structural changes. The use of widely available microcontrollers and low-cost sensors ensures that the system remains affordable for small and medium-scale farmers while still being suitable for large commercial farms. Energy efficiency is also considered in the design to enable long-term continuous operation with minimal maintenance requirements.

Furthermore, the system enhances farm management efficiency by reducing labor dependency and human error. Manual testing often involves inconsistent sampling intervals and subjective interpretation of results. In contrast, the automated IoT-based solution provides consistent, objective, and continuous monitoring. The availability of historical data on the cloud platform supports analytical decision-making, enabling farmers to identify seasonal patterns or recurring water quality issues. This contributes to improved planning and optimized resource utilization.

Overall, the proposed solution represents a significant advancement in smart aquaculture technology. By integrating real-time sensing, embedded processing, wireless communication, cloud-based visualization, and automated alert generation into a unified framework, the system provides a reliable and intelligent water purity monitoring platform. It not only improves productivity and profitability in shrimp farming but also supports sustainable aquaculture practices by ensuring environmental stability and efficient resource management. The implementation of this solution demonstrates how IoT technology can transform traditional shrimp farming into a

modern, data-driven, and resilient agricultural system capable of meeting future food production demands.

#### 4. Results and Discussion

The proposed IoT-based water purity monitoring and alert system was evaluated to assess its effectiveness in real-time monitoring, alert generation, and practical applicability in shrimp farming environments. The system demonstrated stable performance in continuously monitoring key water quality parameters such as pH, temperature, salinity, and turbidity, with reliable data transmission to the cloud platform. The real-time visualization of parameters enabled continuous observation of pond conditions, which is critical for early detection of unfavorable environmental changes.

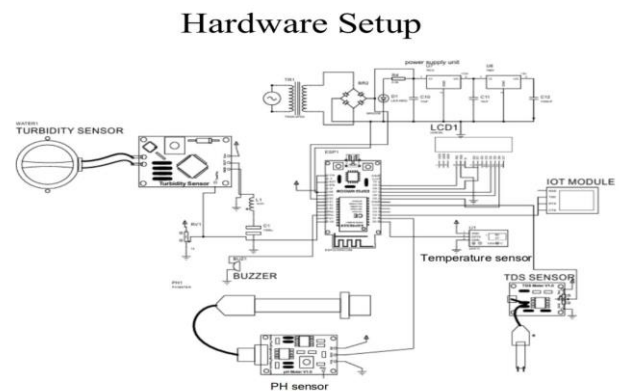
One of the significant outcomes of the proposed system is the reduction in response time compared to conventional manual monitoring methods. By implementing threshold-based condition evaluation at the edge level, the system was able to generate instant alerts during abnormal parameter variations. This proactive alert mechanism allows farmers to take timely corrective actions, thereby minimizing shrimp stress and reducing the risk of mortality. Unlike traditional systems that function primarily as data loggers, the proposed work emphasizes decision support through automated alert generation, which enhances its practical usefulness.

The monitoring accuracy and system reliability were observed to be consistent with recent IoT-based aquaculture monitoring studies, while the integration of multiple parameters into a unified platform improves situational awareness for farm management. Compared to recent works that focus mainly on monitoring limited parameters or rely heavily on manual intervention, the proposed system offers a more comprehensive and farmer-friendly solution by combining real-time monitoring, cloud visualization, and alert functionality within a low-cost architecture. This

integration highlights the novelty of the proposed work in addressing both technological and operational challenges in shrimp farming.

Furthermore, the system’s modular design supports scalability and adaptability to different farm sizes and environmental conditions. The use of wireless communication and cloud-based access ensures remote monitoring without requiring constant physical presence at the farm site. This addresses a major challenge faced in aquaculture practices, particularly in remote and resource-constrained regions.

Overall, the results indicate that the proposed system effectively enhances water quality management by transforming raw sensor data into actionable insights. The combination of real-time monitoring, automated alerts, and remote accessibility demonstrates the system’s potential to improve productivity, reduce operational losses, and support sustainable shrimp farming practices in line with recent advancements in smart aquaculture technologies.



**Figure 1:** (IoT-Based Real-Time Water Purity Monitoring and Alert System for Sustainable Shrimp Farming)

**Table 1:** Water Quality Parameters for Shrimp Farming

Parameter	Range	Unit
pH	7.5 – 8.5	pH
Temperature	26 - 32	°C
Turbidity	30 - 80	NTU
Salinity	10 - 25	ppt

## 5. Conclusion

This work presented an IoT-based real-time water purity monitoring and alert system designed to support sustainable shrimp farming by enabling continuous observation of critical water quality parameters. The proposed system successfully integrates sensors for monitoring pH, temperature, salinity, and turbidity with a microcontroller and cloud-based platform to provide real-time data visualization and instant alert notifications. The major outcome of this research is the significant reduction in monitoring delay and human dependency when compared to conventional manual methods, allowing farmers to respond quickly to unfavorable water conditions and thereby reduce shrimp stress and mortality. The system improves overall farm management by converting raw sensor data into actionable information that supports timely and informed decision-making.

The importance of this work lies in its practical applicability and cost-effective design, making it suitable for adoption in both small-scale and large-scale shrimp farms. By enabling remote access to water quality information, the system reduces the need for constant on-site supervision and contributes to efficient resource utilization. The proposed solution is highly relevant to modern aquaculture practices, where maintaining stable water quality is a persistent challenge due to environmental variability. The system can be applied not only in shrimp farming but also in fish farms, aquaculture research facilities, and other smart farming environments that require continuous water quality monitoring.

Despite its advantages, the system has certain limitations, including dependence on reliable internet connectivity and the need for periodic sensor calibration to maintain long-term accuracy. Future improvements may include the integration of additional water quality sensors, predictive analysis for early risk detection, and automated control of farm equipment. These enhancements

can further improve system reliability and move toward fully automated smart aquaculture solutions.

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