International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

Underwater Internet of Things (IoUT) for Real-Time Water Quality Monitoring

Harshitha L

Department of Bachelor of Computer Applications (BCA)
BMS College of Commerce and Management, Bengaluru, Karnataka, India
Corresponding author: harshigowda2908@gmail.com

Abstract

Water quality is an important factor in aquatic ecosystem health, public environmental management, and aquaculture productivity. Conventional monitoring often depends on periodic manual sampling, which can leave gaps between measurements and delay the identification of changing conditions. This paper presents a proposed Underwater Internet of Things (IoUT) framework for real-time monitoring of water quality in lakes, ponds, rivers, and aquaculture farms. The system is designed around waterproof sensor nodes that measure temperature, pH, turbidity, and dissolved oxygen. A microcontroller, such as an Arduino-compatible board, collects and preprocesses sensor readings. Because underwater wireless communication differs from communication in air, the architecture separates underwater sensing from internet connectivity: readings are relayed to a surface gateway through a communication link selected for the deployment, and the gateway forwards data to a cloud service. A web-based dashboard is proposed to display current and historical measurements, while configurable threshold rules flag readings that may require attention. The paper describes the system architecture, functional modules, data flow, implementation approach, evaluation plan, and key engineering challenges, including sensor calibration, power management, communication reliability, and data security. The design is intended to support earlier awareness of potential water-quality changes and more informed environmental or aquaculture decisions. As this work describes a proposed system based on the project synopsis, no field-test results or measured performance claims are presented. Future implementation should validate sensor accuracy against reference instruments and assess end-to-end delay, data loss, energy use, and alert reliability under real deployment conditions.

Keywords: Internet of Underwater Things, water quality monitoring, IoT sensors, cloud dashboard, environmental monitoring

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

1. Introduction

Water bodies support biodiversity, drinking-water resources, agriculture, recreation, and aquaculture. Their quality can change due to runoff, organic waste, suspended particles, temperature variation, and other environmental influences. Periodic manual sampling remains useful, but it provides measurements only at selected places and times. If conditions change between sampling visits, a problem may not be noticed immediately. Continuous sensing and remote access can help close this monitoring gap by making observations available to users without requiring every reading to be collected manually.

The Internet of Things (IoT) connects sensors, computing devices, communication networks, and software services to collect and exchange data. Extending this concept underwater creates the Internet of Underwater Things (IoUT), in which sensing devices operate in an environment with distinct communication and power constraints. Underwater communication is affected by attenuation, propagation delay, noise, and the properties of the water. Acoustic links are commonly considered for underwater communication, while a surface gateway can use conventional internet connectivity to deliver data to a cloud service [1], [2].

This paper proposes an IoUT-based water-quality monitoring architecture for lakes, ponds, and aquaculture farms. The core parameters are temperature, pH, turbidity, and dissolved oxygen. The system combines sensor acquisition, a microcontroller, underwater-to-surface data transfer, cloud storage, a dashboard, and threshold-based alerts. The paper focuses on the design and implementation plan rather than claiming a completed deployment or experimental validation.

2. Problem Statement and Motivation

anual water-quality monitoring can require repeated site visits, sampling equipment, laboratory analysis, and staff time. Measurements may be infrequent, and the time required to collect, transport, and analyse samples can delay the response to a developing problem. A remote sensor system could provide more frequent observations and make trends easier to review. However, an underwater monitoring system must also handle waterproofing, sensor drift, limited battery capacity, and reliable transfer of readings from submerged equipment to an internet-connected surface device.

The central problem addressed in this work is how to design a practical, modular monitoring system that continuously measures selected water-quality parameters and presents the

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

measurements remotely, while acknowledging the communication and reliability constraints of underwater environments.

3. Objectives

- Design a sensor node capable of measuring water temperature, pH, turbidity, and dissolved oxygen.
- Interface the sensors with a microcontroller for data acquisition and basic preprocessing.
- Define a communication path from underwater nodes to a surface gateway, selecting a suitable link for the deployment conditions.
- Forward sensor readings from the surface gateway to a cloud platform for storage and access.
- Develop a dashboard concept for viewing current and historical readings remotely.
- Provide configurable threshold-based alerts for readings that may indicate an unhealthy condition.
- Establish an evaluation plan covering sensor accuracy, communication reliability, delay, energy use, and alert behaviour.

4. Related Work

Heidemann, Stojanovic, and Zorzi reviewed underwater sensor-network applications and the challenges associated with their development, including communication and deployment constraints [1]. Akyildiz, Pompili, and Melodia similarly identified underwater acoustic sensor networking as a distinct research area in which conventional terrestrial networking assumptions do not always apply [2]. These studies provide a foundation for separating underwater data collection from the surface-side internet connection.

Recent research continues to investigate IoUT architectures, monitoring applications, and reliable communication. A 2024 conference paper describes an underwater IoT monitoring system for marine outfalls and discusses sensor calibration and the transmission of environmental measurements to a database [3]. A 2026 study on underwater mobile sensing for aquaculture describes cloud-based collection of multiple water-quality parameters, illustrating the relevance of combining sensing, remote data access, and aquaculture monitoring [4]. Research comparing underwater communication options also highlights that the appropriate

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

communication technology depends on factors such as range, energy, cost, and operating conditions [5].

Building on these themes, the present project proposes a modular architecture that links a set of core water-quality sensors to a microcontroller, surface gateway, cloud database, and user dashboard. Its intended contribution is an accessible design suitable for a student project and a basis for future prototype evaluation, rather than a claim of a new underwater communication protocol.

5. Proposed System Architecture

The proposed system is organised into five functional modules: underwater sensing, communication, surface and cloud processing, dashboard and alerts, and administration. The overall data flow is: water-quality sensors → microcontroller and preprocessing → underwater-to-surface link → internet-connected gateway → cloud database and application service → dashboard and alert rules.

5.1 Underwater Sensor Module

Waterproof or appropriately protected sensors measure temperature, pH, turbidity, and dissolved oxygen. The microcontroller reads sensor outputs, associates readings with a timestamp and node identifier, and performs basic validation. Where supported by the sensor hardware, readings should be checked for missing values, out-of-range values, and obvious communication errors before transmission. Sensor calibration and maintenance are essential because prolonged immersion and environmental fouling may affect measurements.

5.2 Communication Module

The underwater node transfers its readings to a surface module using a link selected according to the deployment. Acoustic communication is a relevant option for underwater transmission, while radio-frequency links may be more suitable for some short-range or surface-side connections; RF performance underwater should not be assumed to match its performance in air. The implementation should document the actual technology used, operating range, packet format, transmission interval, and handling of lost or delayed packets. The design should not describe a link as reliable until it has been tested under representative conditions.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

5.3 Surface Gateway and Cloud Module

A surface gateway receives the underwater measurements and forwards them through an available internet connection, such as Wi-Fi or a cellular connection. A cloud service stores timestamped readings and makes them available to the application. Possible implementation choices listed in the project synopsis include Firebase or AWS IoT for cloud services, and MySQL or MongoDB for data storage. The final implementation should select one stack and document the configuration rather than implying that all alternatives are used simultaneously.

5.4 Dashboard and Alert Module

The web dashboard is intended to show the latest readings, historical trends, sensor-node status, and any flagged values. Graphs can help users recognise gradual changes that may not be obvious from a single reading. Threshold-based alerts compare measurements with configured limits and mark readings that require review. Thresholds should be selected for the particular water body and intended use, with appropriate guidance from domain standards or qualified environmental personnel; this paper does not prescribe universal safe limits.

5.5 Administration Module

An administration function can manage registered water bodies, sensor-node identifiers, measurement intervals, and threshold settings. It can also display device status and maintain a record of flagged readings. Access to administrative functions should be restricted to authorised users, and changes to thresholds should be logged to support traceability.

6. Methodology and Implementation Plan

6.1 Hardware and Software

The proposed hardware includes an Arduino-compatible microcontroller, temperature sensor, pH sensor, turbidity sensor, dissolved-oxygen sensor, waterproof enclosure, power supply, a suitable communication module, and a surface gateway with internet connectivity. The project synopsis identifies Arduino IDE and C/C++ for embedded programming; HTML, CSS, JavaScript or React for the front end; Python with Flask/Django or Node.js for back-end services; and MySQL, MongoDB, Firebase, or AWS IoT as possible data services. The final prototype should choose compatible components based on cost, availability, sensor interfaces, power needs, and the target water environment.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

6.2 Data Acquisition and Processing

At each sampling interval, the microcontroller reads the sensors and prepares a record containing the node ID, timestamp, parameter values, and basic status information. The system should reject malformed readings and flag values that are outside the sensor's supported measurement range. Calibration information should be retained so that future measurements can be interpreted consistently. If a reading is missing, the system should mark it as unavailable rather than silently replacing it with a normal value.

6.3 Data Transmission and Storage

The node sends the data record to the surface gateway. The gateway verifies the record and forwards it to the cloud service. Each stored record should preserve the timestamp, node identity, values, and quality/status flags. Where network connectivity is unavailable, a gateway buffer or local queue can be considered so that readings are not immediately discarded; this feature should be included only if implemented and tested.

6.4 Alert Logic

For each monitored parameter, an authorised administrator configures a threshold or acceptable range appropriate to the monitored site. When a valid reading crosses the configured threshold, the application creates an alert containing the parameter, value, timestamp, node, and rule that was triggered. To reduce repeated notifications caused by short-lived noise, the implementation may use a persistence interval, hysteresis, or an acknowledgement mechanism. Such logic must be evaluated to ensure it does not suppress important events.

6.5 Security and Privacy Considerations

Although water-quality readings are not usually personal data, the connected system still needs protection against unauthorised access, falsified readings, and disruption. The implementation should use authenticated access, role-based permissions, secure transport between the gateway and cloud where supported, protected credentials, and regular software updates. Administrative actions and alert acknowledgements should be logged. Secrets such as API keys should not be embedded in public source code or exposed in client-side scripts.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

7. Evaluation Plan

Because the available project synopsis describes the intended system rather than completed experiments, this paper does not report measured accuracy, response time, packet-delivery ratio, or power consumption. These should be evaluated after a working prototype is assembled.

- Sensor validation: compare each sensor with a suitable reference instrument or prepared reference sample across the intended operating range; report error and calibration procedure.
- End-to-end delay: record the time between sensor acquisition and display on the dashboard over repeated trials.
- Communication reliability: transmit a known number of records and calculate the proportion received correctly, along with packet loss and reconnection behaviour.
- Alert correctness: test readings below, within, and above configured thresholds, including repeated or noisy measurements.
- Power endurance: measure current consumption and estimate operating duration under the actual sampling and transmission schedule.
- Dashboard usability: ask representative users to complete basic tasks such as viewing current readings, checking trends, and identifying an alert.

Results should be presented with the number of trials, test conditions, sensor calibration details, and limitations. A comparison against manual sampling or a reference instrument would help establish whether the prototype provides useful and sufficiently reliable information for its intended setting.

8. Discussion

he proposed architecture combines environmental sensing with cloud-based visibility. Its potential benefit is not that it replaces laboratory analysis or expert interpretation, but that it can provide more frequent observations and help users identify changes that deserve investigation. Historical measurements may also support comparisons across time, locations, or operating conditions when the sensors are calibrated and the data are collected consistently.

Several design decisions will affect practical usefulness. Sensor choice and calibration determine the quality of the measurements; enclosure design affects durability; sampling frequency influences both responsiveness and battery life; and communication conditions determine how quickly readings reach the dashboard. Threshold alerts are only as meaningful as the limits and

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

sensor data behind them. A flagged reading should therefore be treated as an indication for verification, not by itself as proof of contamination or a definitive assessment of water safety.

9. Limitations and Future Enhancements

The current work is a proposed design and implementation plan, not a report of a field-validated device. No prototype measurements, cost analysis, deployment duration, or comparative performance results were provided in the source synopsis. Communication performance may vary substantially with water depth, turbidity, salinity, obstacles, and the selected hardware. Sensor drift, biofouling, battery limitations, and intermittent internet connectivity also require practical testing.

Future work should build and calibrate a prototype, conduct controlled tests followed by field trials, and publish quantitative evaluation results. Possible extensions include additional parameters such as conductivity or total dissolved solids, predictive trend analysis, multiple sensor nodes, local buffering during network outages, energy-aware sampling, and a mobile-friendly dashboard. Any machine-learning component should be added only after collecting sufficient reliable data and validating its predictions against appropriate reference observations.

10. Conclusion

This paper has presented a proposed Underwater Internet of Things framework for real-time water-quality monitoring. The design combines sensors for temperature, pH, turbidity, and dissolved oxygen with microcontroller-based acquisition, underwater-to-surface communication, cloud storage, a web dashboard, and configurable alerts. The modular approach aims to make water-quality readings easier to access and review, potentially supporting earlier awareness of changing conditions in lakes, ponds, and aquaculture farms. However, the system's practical value depends on calibration, robust packaging, appropriate communication technology, secure data handling, and evidence from field evaluation. The next stage is therefore to implement the selected hardware and software stack and report measured performance transparently.

References

[1] J. Heidemann, M. Stojanovic, and M. Zorzi, “Underwater sensor networks: Applications, advances and challenges,” Philosophical Transactions of the Royal Society A, vol. 370, no. 1958, pp. 158–175, 2012.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 11, CONFLUENCE - 2026

[2] I. F. Akyildiz, D. Pompili, and T. Melodia, “Underwater acoustic sensor networks: Research challenges,” Ad Hoc Networks, vol. 3, no. 3, pp. 257–279, 2005.

[3] M. Zaragoza-Esquerdo et al., “Underwater IoT System for Water Quality Monitoring at the Marine Outfall,” in Proc. 2023 10th International Conference on Internet of Things: Systems, Management and Security (IoTSMS), published 2024, pp. 248–253, doi: 10.1109/IoTSMS62296.2024.10710263.

[4] “Design and implementation of an underwater mobile sensor node for multi-parameter water-quality monitoring and aquaculture,” Aquacultural Engineering, vol. 115, art. 102799, 2026, doi: 10.1016/j.aquaeng.2026.102799.

[5] “Multi-criteria assessment of wireless communication options for subaquatic pollution detection,” Applied Water Science, vol. 16, art. 75, 2026, doi: 10.1007/s13201-026-02772-7.

[6] Arduino, “Arduino Documentation.” Available: https://docs.arduino.cc/ (accessed 16 October 2026).

[7] Pallets Projects, “Flask Documentation.” Available: https://flask.palletsprojects.com/ (accessed 16 October 2026).

[8] Amazon Web Services, “AWS IoT Core Documentation.” Available: https://docs.aws.amazon.com/iot/ (accessed 16 October 2026).

(This work is licensed under a Creative Commons Attribution 4.0 International License.)