www.ijarp.com ISSN 2456-9992 Page: 01-07

International Journal Advanced Research Publications

Research Article

Volume: 02
Issue: 05

WATER QUALITY MONITORING RC BOAT

[1]Anoop Mishra, [2]Chinmay Chakravorty, [3]Suyash, *[4]Vaishnavi Sharma, [5]Dr.Abhimanyu Kumar Yadav

[1,2,3,4]UG Student, Department of Electronics and Communication Engineering, Babu Banarasi Das Institute of Technology and Management, Lucknow, U.P, India.

[5]Assistant Professor, Department of Electronics and Communication Engineering, Babu Banarasi Das Institute of Technology and Management, Lucknow, U.P, India.

Article Received: 24 March 2026, Article Revised: 14 April 2026, Published on: 04 May 2026

***Corresponding Author: Vaishnavi Sharma**

UG Student, Department of Electronics and Communication Engineering, Babu Banarasi Das Institute of Technology and Management, Lucknow, U.P, India..

DOI: https://doi-doi.org/101555/ijarp.3050

ABSTRACT

Water quality is a critical factor for environmental health, human consumption, and aquatic life. Monitoring water quality in remote, hazardous, or physically inaccessible water bodies is a challenging task when performed manually. This paper presents the design, development, and testing of a Bluetooth-controlled RC Boat equipped with a pH sensor and turbidity sensor for real-time water quality monitoring. The boat is built on a lightweight base frame powered by DC motors driven through a motor driver circuit, and is remotely controlled via a smartphone Bluetooth application. The system uses an Arduino UNO microcontroller as the central processing unit to collect sensor data and control motor operations. The boat can be navigated to areas where manual testing is risky or physically impractical, collect water quality data, and transmit it wirelessly to the user's smartphone. The proposed system offers a low-cost, portable, and effective solution for water quality assessment in industrial zones, lakes, rivers, and water treatment facilities. Key results show pH sensor accuracy within ±0.2 units, turbidity variation below 5%, Bluetooth range up to 15 m, and battery life of 45–60 minutes per charge.

KEYWORDS : Water quality monitoring, RC Boat, pH sensor, turbidity sensor, Arduino UNO, Bluetooth, DC motor, motor driver, HC-05, L298N.

INTRODUCTION

Water is one of the most essential natural resources on earth, and its quality directly impacts the health of ecosystems and human populations. With increasing industrialization, agricultural runoff, and urbanization, contamination of water bodies has become a growing global concern. Traditional water quality monitoring methods require trained personnel to physically collect water samples from potentially hazardous locations such as industrial effluent discharge zones, deep lakes, flooded areas, or chemically contaminated rivers. These manual methods are not only time-consuming but also pose serious safety risks to field workers.

The integration of embedded systems and wireless communication technologies has opened new possibilities for remote environmental monitoring. Unmanned surface vehicles (USVs) or RC boats equipped with sensors offer a practical solution for water quality assessment in areas that are difficult or dangerous to access by humans. These systems can be remotely controlled while continuously gathering and transmitting real-time data.

This project proposes a cost-effective, Bluetooth-controlled RC Boat integrated with a pH sensor and turbidity sensor, managed by an Arduino UNO microcontroller. The boat is designed to be operated via a smartphone application, allowing the user to navigate it to any desired location on a water body without physical presence at the site. The system provides real-time pH and turbidity readings, which are key indicators of water quality. A rack and pinion mechanism is used for steering control, while DC motors with a motor driver module provide propulsion. The system is lightweight, battery-operated, and designed for ease of use and rapid deployment.

This research demonstrates that affordable and portable water monitoring systems utilizing microcontrollers and wireless communication can significantly improve the safety and efficiency of environmental monitoring compared to conventional field-based methods.

MATERIALS AND METHODS

This section describes the system design, components, and working methodology employed in the development of the Water Quality Monitoring RC Boat.

1. Components Used

- **Arduino UNO:** Acts as the central microcontroller (ATmega328P). It processes incoming Bluetooth commands, controls motor driver outputs for movement, and reads analog data from pH and turbidity sensors simultaneously.
- **pH Sensor:** Measures the hydrogen ion concentration of the water sample. Outputs an analog voltage proportional to pH level (0–14 scale). Values below 7 indicate acidic water; above 7 indicate alkaline water.
- **Turbidity Sensor:** Measures the cloudiness of water caused by suspended particles. Outputs an analog voltage corresponding to turbidity level in NTU (Nephelometric Turbidity Units).
- **HC-05 Bluetooth Module:** Enables wireless serial communication (UART) between Arduino and the user's smartphone. Receives navigation commands from a Bluetooth controller app and transmits sensor data back.
- **DC Motors (x2):** Provide propulsion force for the boat. Controlled bidirectionally via PWM signals from the Arduino through the L298N motor driver for forward, backward, and turning movement.
- **L298N Motor Driver:** H-bridge motor driver IC. Amplifies low-power Arduino control signals to drive high-current DC motors in both directions independently.
- **Rack and Pinion Mechanism:** Converts rotational motor output to linear displacement for precise steering control of the boat's direction.
- **Rechargeable Battery (9V–12V):** Powers the entire system including Arduino, sensors, Bluetooth module, and DC motors, making the boat fully portable.
- **Base Frame / Hull:** Lightweight buoyant chassis that houses all electronic components securely above the waterline.
- **Copper Wires, Nuts & Bolts:** Used for all internal electrical connections and mechanical assembly of the boat frame.

2. System Design and Working Principle

The RC Boat operates by receiving navigation commands from a smartphone via Bluetooth. The user opens a Bluetooth controller application on their phone, pairs it with the HC-05 module on the boat, and uses on-screen directional buttons to control the boat. The HC-05 module transmits these commands as serial data to the Arduino UNO. Based on the received command (forward, backward, left, right, or stop), the Arduino sends appropriate PWM signals to the L298N motor driver, which drives the DC motors to produce the desired movement. The rack and pinion mechanism translates the motor output into steering action for directional control.

Simultaneously, the Arduino continuously reads analog voltage signals from the pH sensor and turbidity sensor mounted on the hull. These voltages are converted into meaningful water quality values — pH value (0–14) and turbidity level in NTU. The processed data is transmitted back to the smartphone via the HC-05 module and displayed in real time on the user's phone screen. This enables the operator to monitor water quality at any location the boat is navigated to, without physically entering or approaching hazardous water.

3. Experimental Procedure

1. The boat was assembled with all components mounted securely on the hull.
2. The Arduino UNO was programmed with motor control and sensor reading firmware.
3. HC-05 Bluetooth module was paired with a smartphone running a serial Bluetooth controller app.
4. The boat was tested in three environments: a still pond, a slow-moving stream, and a simulated contaminated water body.
5. pH calibration was performed using standard buffer solutions (pH 4.0, 7.0, and 10.0).
6. Turbidity was calibrated by comparing sensor NTU output against samples of known turbidity.
7. Navigation commands were issued from 2 m, 5 m, 10 m, and 15 m distances to measure Bluetooth range reliability.
8. Battery life was recorded from full charge until motor failure.
9. All sensor readings were recorded and compared with laboratory reference values for accuracy validation.

RESULTS AND DISCUSSION

Results

The Water Quality Monitoring RC Boat was successfully designed, assembled, and tested across multiple water body conditions including a still pond and a slow-moving river outlet. The boat demonstrated stable buoyancy, reliable Bluetooth-based control, and accurate sensor readings during all test runs.

- **pH Sensor Accuracy:** Average reading accuracy was within ±0.2 pH units when compared to laboratory reference values using standard buffer solutions (pH 4.0, 7.0, 10.0). This level of accuracy is acceptable for field monitoring applications.
- **Turbidity Sensor Performance:** Turbidity measurements were consistent across multiple trials with variation below 5%. Clear water registered low NTU values while intentionally muddied water samples produced proportionally higher NTU readings, confirming sensor linearity and sensitivity.
- **Bluetooth Communication:** The HC-05 module maintained stable communication with the smartphone at distances up to 12–15 meters in open water conditions. Command response latency averaged under 0.5 seconds across all test distances.
- **Navigation and Motor Control:** The boat navigated reliably in forward, backward, left, and right directions. The rack and pinion steering provided smooth directional control. DC motors delivered sufficient thrust for movement in both still and slow-moving water.
- **Battery Performance:** The rechargeable battery pack provided continuous operation for approximately 45–60 minutes per full charge, sufficient for practical field monitoring sessions.

DISCUSSION

The results validate that the proposed system achieves its core objective of providing safe, remote, and real-time water quality monitoring. The pH sensor accuracy (±0.2 units) and turbidity consistency (<5% variation) are comparable to results reported by Chowdary and Suresh [1] and Joshi and Verma [5], confirming that Arduino-based sensor systems are reliable for field monitoring. The Bluetooth control range of 12–15 m is consistent with findings by Gupta and Sharma [4], demonstrating that HC-05-based communication is practical for small-scale water vehicle applications.

The dual-sensor approach (pH + turbidity) allows simultaneous monitoring of two critical water quality parameters in a single deployment, offering an advantage over single-parameter systems reviewed in the literature. The low cost and portability of the system make it accessible to institutions and monitoring agencies with limited budgets. Compared to the IoT-based systems described by Patel and Mehta [3], this system prioritizes simplicity and ease of deployment over cloud connectivity, which is appropriate for short-range, operator-attended monitoring tasks.

Limitations include the Bluetooth range constraint of approximately 15 m and the absence of GPS geo-tagging for location-stamped readings. These can be addressed in future iterations through GSM/IoT upgrades, as discussed in the conclusion.

CONCLUSION

This paper presented the design and development of a Bluetooth-controlled RC Boat for real-time water quality monitoring using pH and turbidity sensors managed by an Arduino UNO microcontroller. The system successfully demonstrated reliable Bluetooth-based navigation via smartphone, accurate dual-parameter water quality sensing, and stable operation across multiple water body environments. Key performance metrics include pH accuracy within ±0.2 units, turbidity variation below 5%, Bluetooth range up to 15 m, response latency under 0.5 seconds, and battery life of 45–60 minutes per charge.

The proposed system offers a safe, low-cost, and portable alternative to conventional manual water sampling in hazardous, remote, or physically inaccessible water bodies. It demonstrates that affordable microcontroller-based hardware combined with wireless communication can effectively replace field-based manual monitoring for key water quality parameters.

Future enhancements may include the integration of a GPS module for geo-tagged readings, additional sensors such as dissolved oxygen and temperature probes, IoT-based cloud data logging using ESP8266/ESP32, autonomous obstacle-avoidance navigation, and solar power for extended battery-free operation. These additions would significantly expand the system's applicability for large-scale environmental monitoring programs.

ACKNOWLEDGEMENTS

The authors would like to express sincere gratitude to Dr. Abhimanyu Kumar Yadav, Assistant Professor, Department of Electronics and Communication Engineering, Babu Banarasi Das Institute of Technology and Management, Lucknow, for his invaluable guidance, continuous support, and expert supervision throughout this project. The authors also acknowledge the Department of Electronics and Communication Engineering, BBDITM, for providing the laboratory facilities and resources required to complete this work.

REFERENCES

1. R. Chowdary and P. Suresh, "Autonomous Water Quality Monitoring System Using Arduino," International Journal of Engineering and Technology, vol. 8, no. 3, pp. 112–118, 2019.

2. S. Kumar and A. Rao, "Design of an Unmanned Surface Vehicle for Water Quality Monitoring," Journal of Environmental Science and Technology, vol. 12, no. 5, pp. 245–252, 2020.
3. B. Patel and S. Mehta, "IoT-Based Water Quality Monitoring for Industrial Applications," International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), vol. 10, no. 2, pp. 56–62, 2021.
4. T. Gupta and M. Sharma, "Bluetooth-Controlled Robotic Boat for Environmental Monitoring," International Journal of Robotics and Automation, vol. 9, no. 1, pp. 34–40, 2020.
5. N. Joshi and K. Verma, "A Review on Water Quality Monitoring Techniques and Smart Sensing Systems," International Research Journal of Engineering and Technology (IRJET), vol. 9, no. 4, pp. 1021–1028, 2022.
6. Surati, S., Hedaoo, S., Rotti, T., Ahuja, V., & Patel, N. (2021). "Pick and Place Robotic Arm: A Review Paper," International Research Journal of Engineering and Technology (IRJET), 8(2), 2121–2129.