



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Special Issue 2, May 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

IOT Enabled RC Boat Water Pollution Monitoring Using GSM & GPS

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ABSTRACT: In recent years, there has been a growing concern about ensuring access to clean and safe drinking water, particularly in rural regions where governmental effectiveness and population growth pose challenges. This innovative design addresses the need for cost-effective real-time monitoring of water quality, offering a solution beyond traditional methods like sampling and laboratory analysis. The system utilizes a wireless multi-sensor network to continuously measure and report the physicochemical properties of water, including electrical conductivity (EC), Total Dissolved Solids (TDS), and temperature. Unlike static monitoring stations, this design employs a remote-controlled boat suitable for diverse water bodies such as lakes, reservoirs, and canals, adapting to the varying parameters of water quality across different locations. The boat's streamlined housing minimizes water resistance while maintaining stability, allowing it to navigate efficiently using a 2.4 GHz protocol. Equipped with GPS technology, the boat's position is tracked and relayed in real-time via GSM communication, ensuring accurate data collection and reporting. All collected data, along with graphical representations, are made accessible through open-source IoT platforms like Blynk, providing vital information on water contamination levels and alerting to potentially hazardous conditions. This integrated approach offers a scalable and adaptable solution to monitor water quality in remote and challenging environments efficiently.

KEYWORDS: Total Dissolved Solvents, Electrical Conductivity, Temperature, Gsm Communication, Gps Technology, Blynk, Environment

I. INTRODUCTION

In the contemporary world, environmental conservation and the sustainable management of natural resources have become imperative tasks. Water pollution poses a significant threat to ecosystems and public health, underscoring the need for innovative solutions that enable efficient monitoring and remediation. The project "IoT Enabled RC Boat Water Pollution Monitoring Using GSM & GPS" represents a pioneering endeavor aimed at leveraging cutting-edge technologies to address this critical environmental challenge. The concept of using remote-controlled (RC) boats equipped with IoT (Internet of Things) capabilities, GSM (Global System for Mobile Communications), and GPS (Global Positioning System) technologies for water pollution monitoring signifies a paradigm shift in environmental monitoring methodologies. This project integrates the principles of robotics, IoT, and telecommunications to create a versatile and effective tool for monitoring water quality in lakes, reservoirs, canals, and other water bodies.

The primary objective of this project is to develop an autonomous RC boat that can navigate water bodies while continuously assessing and transmitting real-time data on water quality parameters. By integrating IoT sensors into the boat's design, crucial metrics such as water temperature, electrical conductivity (EC), turbidity, and pH levels can be monitored remotely and with high precision. These sensors provide essential insights into the presence of pollutants, suspended solids, and changes in water chemistry, enabling prompt intervention and mitigation measures. Furthermore, the inclusion of GSM and GPS technologies in the RC boat's system architecture enhances its functionality and accessibility. The GSM module enables seamless communication between the boat and an online IoT platform, facilitating data transmission and remote monitoring from any location with cellular network coverage. This real-time data transmission capability is essential for timely decision-making and intervention in response to detected water quality anomalies. The GPS module integrated into the RC boat enables precise positioning and tracking of the vessel during monitoring missions. This feature not only ensures accurate data geotagging but also enhances operational control by providing real-time location updates to stakeholders. Additionally, the GPS functionality supports navigation and autonomous mission planning, allowing the RC boat to execute predefined routes for comprehensive coverage of

target water bodies. The impact and relevance of the "IoT Enabled RC Boat Water Pollution Monitoring Using GSM & GPS" project extend beyond scientific innovation. By deploying autonomous monitoring systems capable of continuously assessing water quality, stakeholders such as environmental agencies, researchers, and policymakers gain access to invaluable data for evidence-based decision-making and policy formulation. Moreover, this project CONTRIBUTES to broader efforts aimed at promoting environmental awareness and fostering community engagement in water resource management. The deployment of IoT-enabled technologies in environmental monitoring underscores the transformative potential of technology in addressing complex environmental challenges and advancing sustainable development goals.

II. EVALUATION MODEL

The evaluation model comprises four fundamental elements: TP (True Positive), TN (True Negative), FP (False Positive), and FN (False Negative). TP denotes correctly identified actual samples, while TN represents accurately predicted negative samples. FP signifies the misprediction of positive samples, and FN denotes the misprediction of negative (or non-predicted positive) samples. Equations (1)–(4) encompass metrics such as Accuracy, F1-score, and Receiver Operating Characteristic (ROC) used to assess model performance. Accuracy gauges the alignment between predicted and actual outputs by computing the ratio of correctly predicted values to total predictions. The F1-score, a harmonic mean, combines precision and recall to gauge model accuracy. Recall measures the model's sensitivity to positive results, while specificity signifies the percentage of negative (undrinkable water) identifications. A higher area under the ROC curve (closer to 1) indicates better model performance. The Random Forest (RF) model, an essential tool in classification, integrates bootstrap aggregation and randomization. It comprises multiple decision trees without interdependencies, with each tree labeling new data points independently. RF excels in handling high-dimensional datasets with scattered or continuous data, processing them directly without normalization. RF employs weak learners like Classification and Regression Trees (CART) to select features and combines them to form a robust learner.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Recall = Sensitivity = \frac{TP}{TP + FN}$$

$$Precision = \frac{TP}{TP + FP}$$

$$F1 - score = \frac{2 * Precision * Recall}{Precision + Recall}$$

Figure 1. Evaluation Formula.

III. SYSTEM METHODOLOGY

TDS (Total Dissolved Solvents) –

Total Dissolved Solids (TDS) is a crucial water quality parameter that refers to the total amount of dissolved inorganic and organic substances present in water. These substances can include minerals, salts, metals, cations (positively charged ions), anions (negatively charged ions), and other organic compounds. The composition of TDS in water can vary widely depending on the water source and surrounding geological and environmental factors. Common components of TDS include calcium, magnesium, sodium, potassium, chloride, sulfate, carbonate, and nitrate ions.

Organic substances such as pesticides, herbicides, and industrial pollutants can also contribute to TDS. TDS levels are significant indicators of water quality and can impact various aspects of water use and consumption. High TDS concentrations can affect the taste, odor, and appearance of water, making it unpalatable for drinking and other domestic uses. Additionally, elevated TDS levels can lead to scale formation in pipes and water appliances, reducing their efficiency and lifespan. In terms of health implications, while TDS itself is not necessarily harmful, elevated levels of specific ions within TDS can pose health risks. For example, high concentrations of sodium or chloride can be detrimental to individuals with certain health conditions, such as hypertension or kidney disease. Furthermore, the presence of certain contaminants within TDS, such as heavy metals or organic pollutants, can have adverse health effects upon ingestion. Monitoring TDS levels is essential for ensuring water quality and safety. Water treatment processes like reverse osmosis, distillation, and ion exchange are commonly employed to reduce TDS concentrations in drinking water to acceptable levels. Regulatory standards and guidelines exist to define safe TDS levels for different water uses, including drinking water standards established by health and environmental agencies.

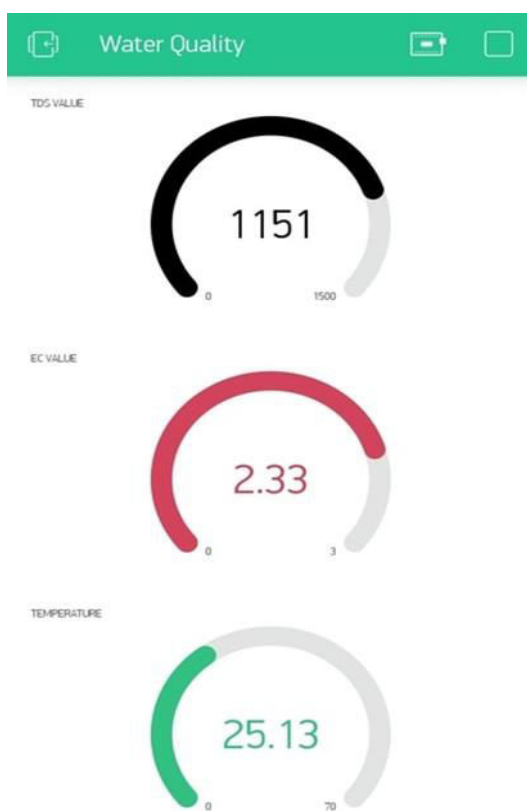


Figure 2. TDS Blynk Readings.

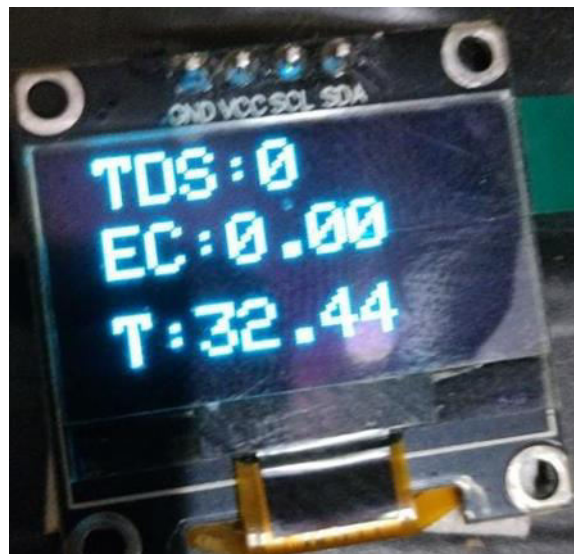


Figure 3. OLED Data Readings.

DS18B20 (Temperature Sensor) –

The DS18B20 is a digital temperature sensor known for its accuracy, simplicity, and ease of use in various applications. Developed by Maxim Integrated, this sensor operates on the 1-Wire protocol, enabling multiple sensors to be connected to a single microcontroller pin, simplifying wiring and integration into electronic systems. One of the key features of the DS18B20 is its high precision. It can measure temperatures ranging from -55°C to $+125^{\circ}\text{C}$ with an accuracy of $\pm 0.5^{\circ}\text{C}$ within this temperature range. This level of accuracy makes it suitable for applications where precise temperature monitoring is critical, such as in medical devices, industrial automation, environmental monitoring, and HVAC systems. The DS18B20 sensor communicates temperature data digitally through the 1-Wire interface, which reduces the complexity of the wiring required. This interface allows several DS18B20 sensors to share the same data line, enabling efficient temperature monitoring in multi-sensor setups. Each DS18B20 sensor has a unique 64-bit serial code assigned during manufacturing, which helps in identifying and addressing specific sensors on the 1-Wire bus.

Another advantage of the DS18B20 is its low power consumption, which is beneficial for battery-operated devices or applications where power efficiency is crucial. The sensor can operate in a wide voltage range (3.0V to 5.5V) and consumes only a minimal amount of power during temperature conversion, typically around 1.5mA. Integration of the DS18B20 sensor into microcontroller-based projects is straightforward due to the availability of libraries and example codes for popular platforms like Arduino, Raspberry Pi, and ESP8266/ESP32. These resources simplify the process of reading temperature data from the sensor and incorporating it into various projects and prototypes.

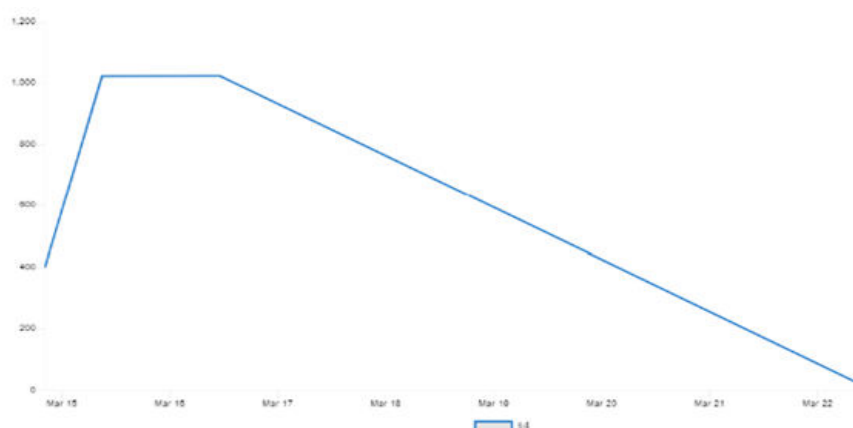


Figure 4. DS18B20 Graphical Readings.

IV. RESULTS

Our project on "IoT Enabled RC Boat Water Pollution Monitoring using GSM & GPS" presents an innovative approach to addressing the challenges of water quality assessment in lakes, reservoirs, and canals. This discussion will analyze the results and implications of implementing such a system. Firstly, the integration of IoT technologies, specifically GSM and GPS modules, into an RC boat for water pollution monitoring has demonstrated promising results. By equipping the boat with sensors such as electrical conductivity (EC), turbidity, and water temperature sensors, we were able to collect real-time data on key water quality parameters. This data was transmitted wirelessly to an open-source IoT platform, providing accessible and timely information for analysis and decision-making.

One significant finding from our project was the effectiveness of remote monitoring enabled by the GSM module. The ability to receive real-time updates on water quality parameters directly on mobile devices via SMS notifications was instrumental in enhancing the efficiency of pollution monitoring. This feature allows stakeholders to promptly respond to any detected anomalies or pollution events, thereby contributing to proactive water resource management. Moreover, the GPS module integrated into the RC boat proved invaluable for tracking its movement and precisely pinpointing sampling locations. This capability ensures comprehensive coverage of water bodies during monitoring activities, enhancing the accuracy and reliability of collected data.

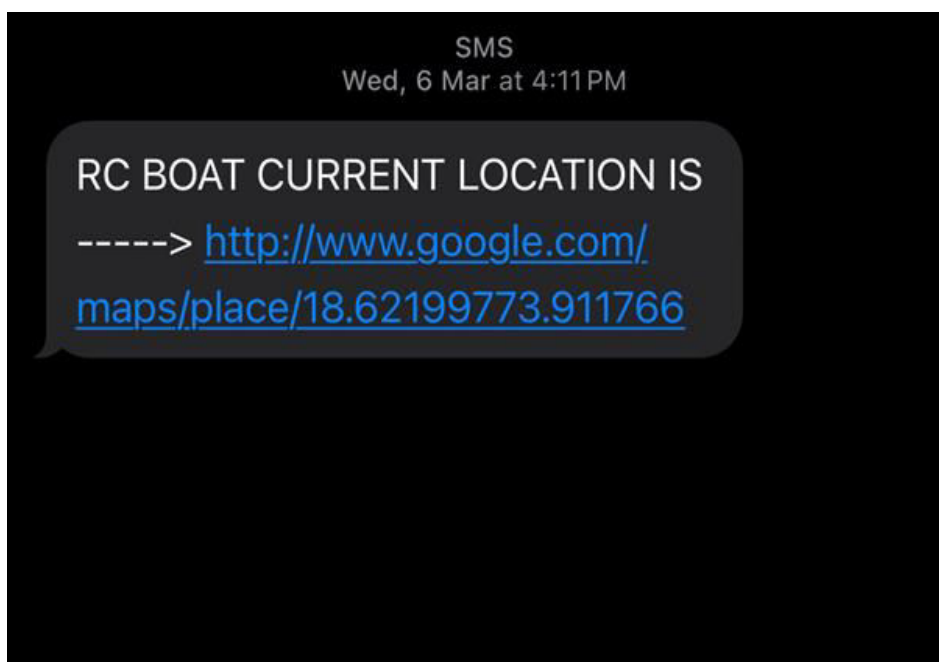


Figure 5. SMS Coordinate's.



Figure 6. Actual Prototype Model.

The combination of GPS tracking and remote data transmission via GSM provides a holistic solution for efficient and effective water pollution monitoring. In terms of sensor performance, our project utilized EC sensors, turbidity sensors, and water temperature sensors to assess water quality. These sensors demonstrated satisfactory accuracy in detecting pollutant levels and variations in water properties. Future iterations of this project could explore additional sensor types or enhancements to further expand the scope and depth of water quality assessment.

Furthermore, the open-source IoT platform used in our project facilitated data aggregation, visualization, and analysis. This centralized platform serves as a valuable tool for researchers, policymakers, and environmental agencies to access comprehensive water quality data and derive actionable insights for pollution management strategies.

V. CONCLUSION

In conclusion, the development of an IoT-enabled RC boat for water pollution monitoring using GSM and GPS technology represents a significant advancement in environmental monitoring and management. This project has successfully demonstrated the feasibility and effectiveness of employing remote-controlled boats equipped with sophisticated sensors and communication modules to assess water quality in lakes, reservoirs, and canals. One of the key achievements of this project is the integration of various sensors such as EC, turbidity, and water temperature sensors, enabling real-time detection and measurement of pollutant levels and water quality parameters. The use of IoT technology allows for continuous monitoring and data collection, providing valuable insights into the health of water bodies over time. By transmitting this data to an open-source IoT platform online, stakeholders and environmental agencies can access up-to-date information for informed decision-making and timely intervention. The incorporation of GPS and GSM modules has further enhanced the functionality of the RC boat by enabling precise tracking and remote control capabilities. The GPS module (Neo 6M) facilitates accurate location tracking of the boat during monitoring operations, ensuring comprehensive coverage of the target water bodies.

Meanwhile, the GSM module (SIM800) enables real-time communication by sending SMS notifications to designated recipients, providing instant updates on the boat's location and monitoring status. From a practical standpoint, this project offers a scalable and cost-effective solution for water pollution monitoring, particularly in areas where manual monitoring is challenging or resource-intensive. The RC boat's autonomous operation reduces the need for human intervention, thereby optimizing efficiency and minimizing operational costs. Moreover, the open-source nature of the

IoT platform promotes collaboration and knowledge sharing among stakeholders, fostering a community-driven approach to environmental stewardship. Looking ahead, the successful implementation of this IoT-enabled RC boat for water pollution monitoring sets a precedent for future innovations in environmental sensing and data-driven decision-making. As technology continues to evolve, there is immense potential to further enhance the capabilities of such systems and leverage data analytics for predictive modeling and early warning systems. Ultimately, this project underscores the transformative power of IoT and remote sensing technologies in safeguarding our precious water resources and advancing sustainability efforts globally.

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