ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1775

IoT-Integrated Multi-Sensor Floating Platform For Automated Water Quality Assessment

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Publication Date: 2026/08/06

Abstract: Water quality is the most important factor for aquaculture and drinking purposes. Water pollution is a major threat that affects the aquatic life and human's health. Conventional water quality methods use visual and physical testing to evaluates the probability of collected water sample. The solution of this problem is we proposed a manually floating platform for automated water condition sensing and detection system. It is an IoT based system that checks the quality of water in real-time. The proposed system uses an ESP32 microcontroller embedded with multiple sensors which are pH sensor, TDS (total dissolved solids) sensor, Turbidity sensor, Temperature sensor (DS18B20). These sensors continuously track the key parameters collected from multiple locations in the lakes or ponds. The ESP32 microcontroller reads the sensors values and determines whether the water is SAFE or NOT SAFE based on the predefined threshold values. The sensor acquired data is uploaded to Blynk IoT environment which is available for the users to check the water quality. The developed system yields a resource-optimized, energy-efficient and sustainable approach towards ecological parameter assessment. It can be deployed in lakes, ponds, aquaculture and for industrialization.

Keywords: *Aquaculture, Microcontroller, Sensors, Blynk IoT.*

How to Cite: Singam Aruna; Sujatha Kuna; Divya Sri Jami; Sai Veda Varshitha Kella; Srilalitha Patta; Navya Deepika Neredimilli (2026) IoT-Integrated Multi-Sensor Floating Platform For Automated Water Quality Assessment. *International Journal of Innovative Science and Research Technology*, 11(7), 3113-3119. https://doi.org/10.38124/ijisrt/26jul1775

I. INTRODUCTION

In contemporary times, water occupies an unparallel position among naturally occurring substances, serving as the foundation for human survival, aquatic life, industrial processes, agricultural productivity and ecological productivity and ecological sustainability. It plays a crucial role in maintaining biodiversity. Due to rapid urbanization, industrial waste discharge, sewage contamination, fertilizer and pesticides which are contaminated in the water has becomes a global issue and causes severe health problems and environmental deterioration. Conventional water quality monitoring depends on conventional sampling techniques and laboratory based analysis testing, which is insufficient in terms of time and lacks precision in measurements. This process requires man power which is very costly. To overcome these issues, advanced technologies like IoT facilitates live monitoring of water parameters and wireless access to environmental data.

This project presents the design and development of a cloud-integrated multi-sensor waterborne sensing unit capable of continuously evaluating aquatic parameters through a remotely navigable floating vessel, which is developed to measures the key parameters wirelessly. The proposed architecture is developed around an ESP32 microcontroller

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working in conjunction with four dedicated sensing elements namely pH sensor, a total dissolved solid sensor, a turbidity sensor and a temperature sensor all of which are carefully mounted on to a remotely controlled floating carrier to enable muti-point aquatic parameter evaluation. The ESP32 microcontroller establishes a wireless network interface, tracks the sensor values and uploads the sensors readings to Blynk IoT platform. It sends the alert notification through the Blynk whether the water is safe or not safe based on TDS values.

Along with monitoring, the Water bot consists of DC motors operated by an L298N motor driver module. By using Blynk application, the operator can move the boat forward, backward, right and left on the water surface. By utilizing these features, the system is capable of evaluating the quality of water at multiple locations without any need for human intervention. As a result of using Internet of Things technology, Blynk wireless communication, sensor detection, and robot mobility; Smart Water bot is a cost-effective, energy-efficient and intelligent solution for modern water quality management.

II. METHODOLOGY

The proposed system is a real-time operating water quality monitoring framework that uses the technology called Internet of Things (Iot). The system monitors the parameters of water like pH, turbidity, temperature and total dissolved solids (TDS). The system mainly uses an ESP32 microcontroller to collect data, compare the values of the parameters with the given threshold values and send this data wirelessly. Multiple sensors are used to capture water quality indicators. Each sensor works differently to convert water properties into signals. These signals are converted into data by the ESP32 and then cleaned up to ensure the accuracy. The data is then turned into units making it easy to analyze water quality.

The system also has a decision-making part that uses set threshold values to classify water as safe or unsafe. The ESP32 sends the captured sensor readings to the Blynk Cloud ecosystem with the help of onboard wireless communication interface. This allows for dynamic data monitoring and remote access. The Blynk application also shows live data ,trends and status indicators promoting seamless interpretability for intended system users. The implementation involves integrating hardware developing firmware using the Arduino IDE and connecting to the cloud. It also involves testing under different to guarantee that the proposed unit is reliable, adaptable and streamlined for smart water quality management applications.

The system helps in managing the water quality as it is important for drinking water. This smart IoT based water quality system is a tool. Thus, this system sets a perfect example of using IoT for environmental monitoring as it shows how technology can help in protecting our environment.

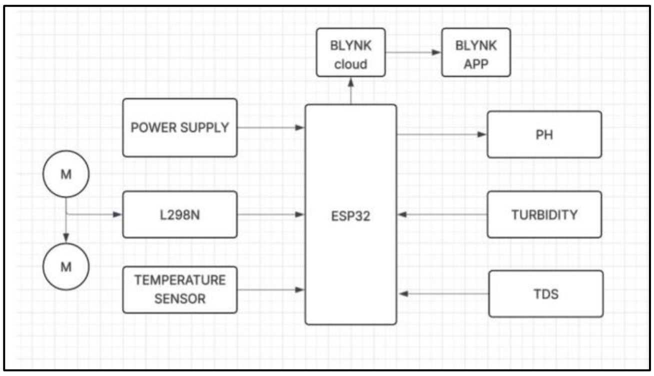

Fig 1 Block Diagram of Smart Water Bot

➢ *Water Quality Monitoring Parametrs*

In the proposed system we used four key parameters to checks the water quality. These parameters act as an indicator, providing key observations.

- *pH Parameter*

The pH parameter serves a fundamental function in portable water purposes and for aquaculture. It measures the activity of hydrogen ions and evaluates the acidity and alkalinity of water. The pH scale varies from 0 to 14 with 7 being neutral. The values below 6.5 is acidic and the values above 7 is basic or alkaline. According to WHO the pH range of pure water lies in between 6.5 to 8.5.

- *Total Dissolved Solids (TDS)*

TDS measures the concentration of dissolved inorganic salts as well as organic substances. The most common salts are calcium, magnesium, potassium, sodium all are cations and carbonates, nitrates, bicarbonates, chlorides which are anions. High TDS indicates high minerals are contaminated.

- *Turbidity Parameter*

Turbidity is an important indicator of suspended sediments in water which are existence of pathogens and bacteria. It measures the cloudiness, haziness of water. High turbidity indicates poor water quality.

- *Temperature Parameter*

Temperature is another key and fundamental characteristic that influences the metabolism of aquatic organisms, gas solubility and chemical reactions. When the temperature increases, the solubility of oxygen and other gases will decrease. Warm water has low oxygen for fish and another aquatic organism to survive. Another factor, conductivity also affected by the temperature parameters.

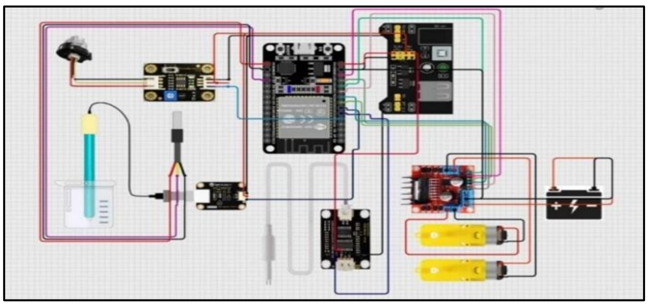
Fig 2 Circuit Diagram of Smart Water Bot

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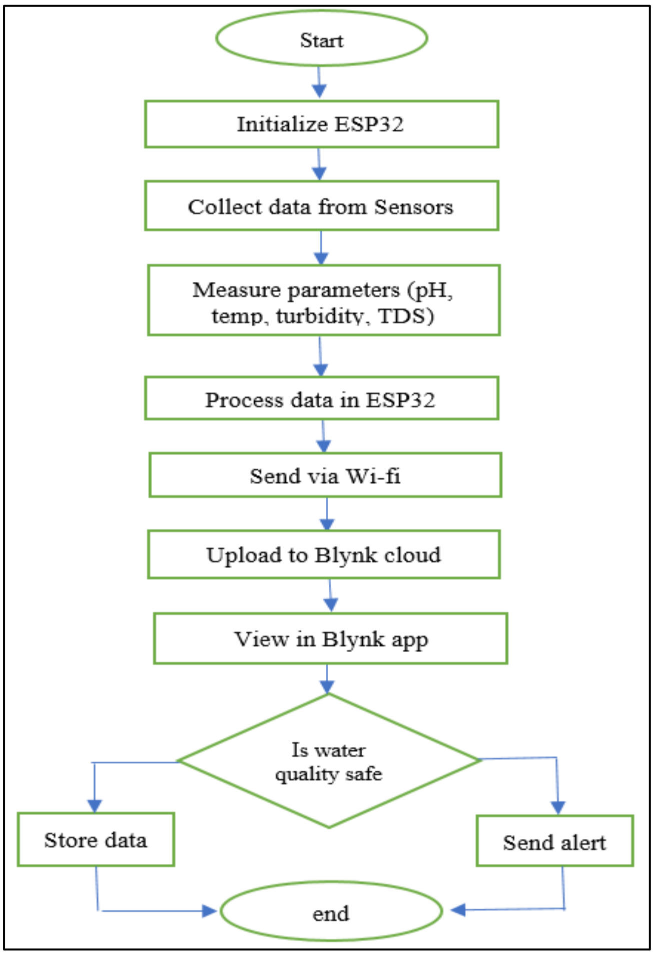

Fig 3 Operational Flow Chart of Smart Water Bot

III. COMPONENTS SPECIFICATION

➢ *ESP32*

ESP32 is the primary controller utilized in this project. It performs all functions that include acquiring data, processing it then uploading to the cloud. It has both the wi-fi and Bluetooth module features integrated in it; hence there will be no additional communication module required. The device operates on 3.3v and utilizes a dual-core, 32-bit microcontroller with a peak frequency of 240 MHz and it performs up to 600dmips (Dhrystone millions of instructions per second). Moreover, its reduced power utilization permits the chip to perform analog to digital conversion, calculations, and parametric boundary conditions during low power mode.

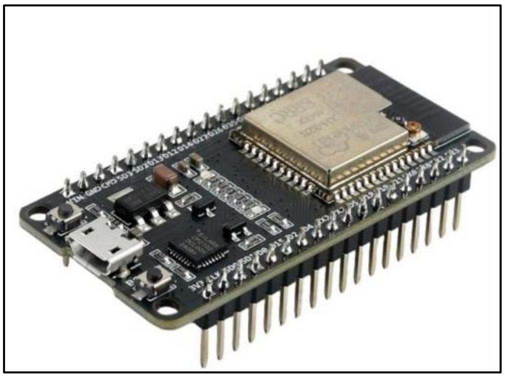
Fig 4 ESP32

➢ *pH Sensor*

A pH sensor is an analytical tool for the measurement of either the acid or base nature of the fluid. The acidity measurement continuum extends across a numerical range of 0-14, with 7 signifies ionic balance. Above 6.5 is basic or alkaline and below 6.5 is acidic. In technical terms, the pH sensor determines the ionized state of hydrogen ions present in the medium. Industrial pH sensors employ the glass electrode technique for the detection of the pH value. It requires a nominal excitation voltage of 5V.


Fig 5 pH Sensor

➢ *TDS Sensor*

The total dissolved solids sensing element quantifies the cumulative concentration of the dissolved inorganic and organic constituents present within an aquatic medium. If the TDS readings are high, then there will be higher impurities or minerals in water. The power requirements for this sensor vary from 3.3V to 5V, its measurement range lies between 0 and 1000 ppm. This can be applied to domestic water, hydroponic, aquaculture and for water quality monitoring. It measures in parts per million.

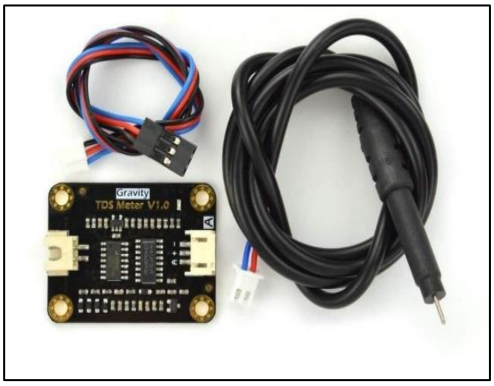
Fig 6 TDS Sensor

➢ *Turbidity Sensor*

The nephelometric operates by quantifying the degree of optical scattering induced by particulate matter dispersed within the aquatic medium. The elevated accumulation of the suspended and dissolved solids constituents throughout the examined water sample, the higher the turbidity level. Its power consumption is 5V. Moreover, its detection range varies between 0-1000 NTU. It offers both analog and digital signal output options. Its applications include water quality testing, sewage treatment, water purification and environmental

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research. It is measured in NTU Nephelometric Turbidity Unit.

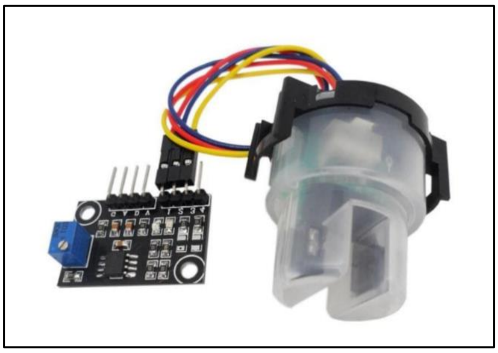

Fig 7 Turbidity Sensor

➤ *Temperature Sensor*

DS18B20 is a waterproof temperature that measure whether the water is hot or cold by detecting changes in physical properties. The temperature has a direct affect on the state of water as it is involved in chemical processes as well as affecting aquatic life. If the temperature increases, dissolved oxygen decreases which affects the aquatic life.

Fig 8 Temperature Sensor

➤ *L298N Motor Driver Module*

The L298N motor diver module regulates the rotational velocity directional orientation od DC actuator. Since ESP32 cannot operate independently due to absence of enough energy that can be used to drive the motors, the necessity for L298N lies in the aspect of acting as a means to enable both the components to work together. Its operational voltage ranges from 5V to 35V, with a control voltage of 5V, and a maximum output current of 2A.

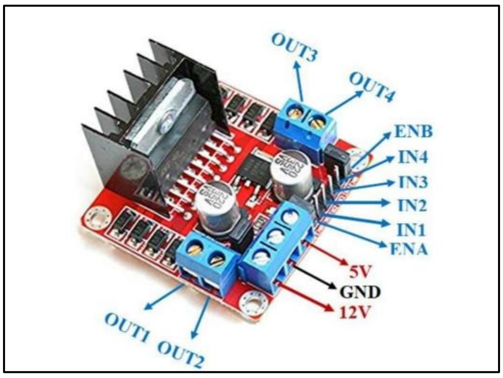

Fig 9 L298N Motor Driver Module

➤ *DC Motor*

DC motors are used for tasks like stirring water, circulating samples. DC motors work on 5V and rotate between the speed of 100 and 300 rpm. They have a small size, which consumes low power levels. These motors can be controlled easily using ESP32 microcontrollers.

Fig 10 DC Motor

➤ *Jumper Wires*

Connections from one component to another like sensors, motors, drivers, and microcontroller, will be made using jumpers. Jumpers can use either male-to-male or male-to-female pins depending on the need.

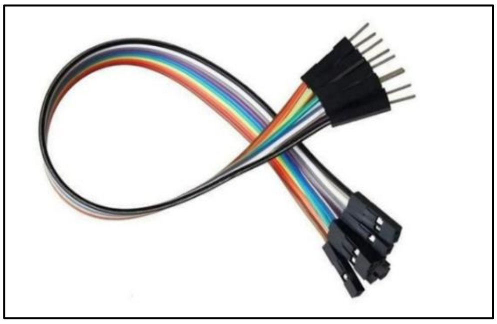

Fig 11 Jumper Wires

➤ *Power Supply*

The voltage regulation infrastructure assumes responsible for delivering consistent and stable electrical energy to all interconnected hardware contituents of the proposed framework, including ESP32, sensors and DC motors. For this project a stable and regulated power supply is required to maintain accuracy in sensor readings. Typically, a rechargeable battery or a regulated DC adapter is used. Proper power management helps prevent fluctuations.

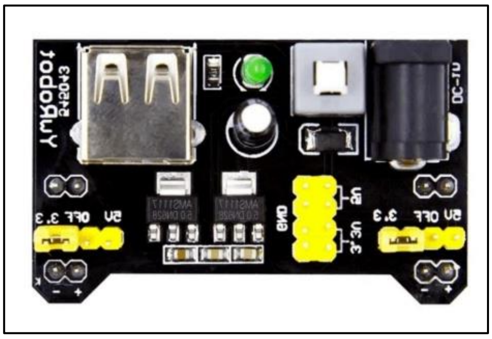

Fig 12 Power Supply

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➢ *Lithium-Ion Battery*

The Lithium-ion batteries are used to supply the entire system with power in a portable form. The nominal usually voltage of this type battery is usually 3.7 volts and can be used in series or parallel connection depending on the power requirements of the system. This application can widely used in remote applications.

Fig 13 Li-Ion Battery

➢ *Software Implementation*

Its software implementation aims to acquire, process, visualize and monitor data remotely in real time. Serving as the computational nucleus of the proposed architecture is the ESP32 microcontroller, sensor interfacing code, and the Blynk cloud based infrastructure. The ESP32 microcontroller is firmware-configured using the Arduino IDE, where embedded C/C++ code is developed to acquire data from several sensors, comprising electrochemical pH, optical turbidity, thermometric and total dissolved solid sensing elements. The output given by each sensor is in the form of analog or digital values, which are then calibrated by relevant calibration formula to get the actual physical values. For instance, pH value is deduced from pH, scale, whereas turbidity is quantified based on NTU using light scattering concepts. On the user interface side, the Blynk IoT platform has interactive widgets like gauges, graphs, and status indicators that check the physicochemical integrity of aqueous environment. The implemented unit shows a status message like “SAFE” OR “NOT SAFE” based on the pre threshold values. This helps the users quickly figure out how the water is doing. The platform also let users see historical data, which lets them look at trends over different time periods. This makes it easier to make decisions and make sure that monitoring is always effective. Alert notifications also sent to the respected mail through Blynk.

IV. RESULTS AND DISCUSSION

➢ *Hardware Setup*

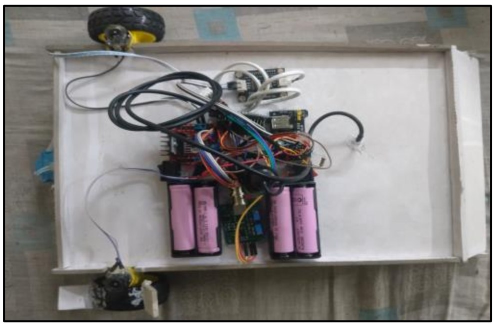

Fig 14 Hardware Setup

The above figure is a prototype to the Smart water bot. The hardware setup consists of ESP32 microcontroller, four sensors which are pH, turbidity, total dissolved solids, temperature, DC motors, power supply unit, L298N motor driver module and Li-Ion batteries. The ESP32 microcontroller serves as the central computational governing element. The hardware components are interfaced with the ESP32 microcontroller using both continuous and discrete signal pins to evaluate the data correctly. The pH, turbidity, total dissolved solids and temperature sensors are connected to analog input pins (GPIO134, GPIO135, GPIO132 and GPIO4) of the ESP32. A voltage regulation unit is deployed to deliver stable electrical energy to ESP32, sensors and motor driver.

A rechargeable lithium-ion energy cell supplies uninterrupted electromotive power to the developed architecture. The ESP32 microcontroller is powered via its VIN pin with a regulated 5V supply, and its on-board 3.3V regulator supplies lower-powered components. The temperature and TDS sensors operate at 3.3V, while the pH and turbidity sensors require 5V for optimum performance. Voltage levels are controlled to ensure that no damage occurs to the microcontroller’s ADC pins, and all components are grounded to ensure that they have signal integrity and function properly.

➢ *Blynk IoT*

The Blynk cloud surveillance interface is used to examine and visualize the water quality parameters in an instantaneous manner. The ESP32 embedded controller transmits to the cloud continuously collects all sensors readings and displayed on a mobile dashboard. The values of temperature, TDS, turbidity, and pH are depicted by circular gauge widgets in the interface for an enhanced visual representation.

Fig 15 Safe Condition

The image showcases the recorded values show a temperature, turbidity, pH, and TDS. Also, a system status indicator is included for a general water quality assessment, as per predefined threshold conditions, shown as SAFE. The system also users to view the water quality status in real-time.

Fig 16 Not Safe Condition

The image showcases the NOT SAFE condition as pH <7, TDS>300ppm, turbidity>50 NTU.

➢ *Mail from Blynk*

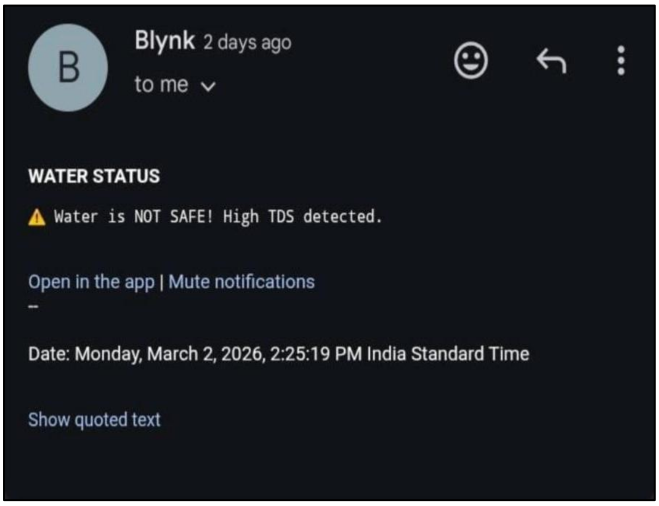

Fig 17 Mail from Blynk

Alert notification sent to the respected mail from Blynk. This automated email alert serves to inform the user about the status of the water. If any parameter exceeds the safe limits, an alert will be sent to the respected mail instantly to facilitate the prompt action.

➢ *Alert Notification from Blynk*

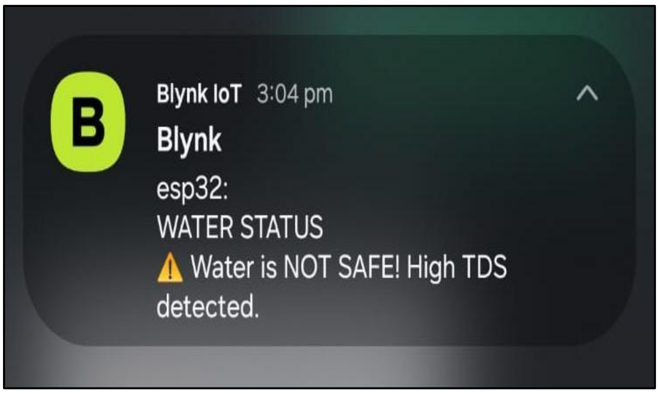

Fig 18 Alert Notification from Blynk

Users receive this notification in real time via push buttons on their smartphones. The notification contains values for all criteria being measured as well as a status value of SAFE OR NOT SAFE. Users can take action without manually monitoring on a continuous basis.

➢ *Applications*

- Industries can check waste water discharge for compliance with environmental safety requirements prior to discharge.
- With this system, municipal corporations can check the quality of water in pipes and storage tanks.
- Continuously monitoring biological parameters maintains the desired quality of water for aquatic organisms.
- It is used for agricultural and irrigation Monitoring to maintain soil health and crop health.
- This system supports IoT-based environmental management in Research and Smart City applications.

➢ *Advantages*

- Easy installation & Maintenance
- Automation and reduced human intervention
- Reliability and continuous monitoring
- Instant alert notifications
- Energy efficiency

V. CONCLUSION

The current investigation has successfully a wireless interconnected heterogenous sensor embedded hydrological module dedicated to perpetual observation of aquatic attributes spanning acidic equilibrium measurement, optical clarity assessment, ionic solid quantification, thermometric characterization which provides significant information of the water condition with instant alerts. Manual operating platform minimizes cost and complexity while maintaining accuracy in data collection. The proposed system reduces the man power to check manually and collecting water samples.

ACKNOWLEDEMENT

We extend our deepest gratitude towards our esteemed scholarly advisor Dr. S. Aruna, Associate professor, for giving us advice, and being a great mentor throughout the project. Her helpful suggestions, support, and willingness to share at every step have been important in shaping our work and completing our project i.e. “IoT INTEGRATED MULTI-SENSOR FLOATING PLATFORM FOR AUTOMATED WATER QUALITY ASSESSMENT”.

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