RESEARCH ARTICLE OPEN ACCESS

ADVANCED SMART BOAT FOR WATER QUALITY MONITORING

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Abstract:

Water pollution monitoring boat has been designed to efficiently assess water quality in lakes, rivers, and reservoirs. Multiple sensors, including pH, turbidity, and temperature sensors, have been used to measure pollution levels and detect suspended particles. The boat is remotely controlled via Wi-Fi, allowing users to control it easily from their mobile devices. Motorized propeller system for propulsion and a servo motor for precise steering have been integrated. This setup ensures smooth navigation and flexibility in covering different areas of a water body. Collected sensor data is transmitted at regular intervals to an IoT server, ensuring continuous monitoring and easy access to water quality information. The effectiveness of the proposed system has been proved by deployment in three ponds in Chennai namely Lotus Pond Park Pallikarani, Chitlapakkam Pond and Madipakkam Pond. The results have shown that the Lotus Pond was the cleanest pond having average values of pH, TDS, and Turbidity were 7.96, 196.75 and 8.22 respectively. Madipakkam Pond have been found highly polluted pond having average values of pH, TDS, and Turbidity were 11.46, 718.41, and 23.12 respectively. The proposed system is also compared with recent water quality monitoring systems and achieves a higher score.

Keywords — **IoT, Smart Boat, Sensors, Water Pollution, Water Quality**

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I. INTRODUCTION

In the twenty-first century, technological advancement has accelerated, but pollution and global warming have also alarmingly increased. Our problems with the environment have led to a growing scarcity of drinkable water. In this case, real-time water quality monitoring faces a number of challenges, including the consequences of climate change, the strain on limited water supplies, and the expanding global population. Therefore, the development of more robust techniques for the real-time monitoring of water quality indicators is important.

One essential element of a balanced environment is the quality of the water. For a wide variety of plants and animals to survive, clean water is essential. Water quality is greatly impacted by human terrestrial activities, despite their initial apparent significance [1]. The city of Chennai has an abundance of natural resources. In the city of Chennai, 226 ponds have identified by Greater Chennai Corporation (GCC). Additionally, these ponds keep groundwater levels stable. Chennai likewise faces challenges in managing its water resources, namely pollution, industry growth, and excessive use of water resources. Difficulties include building new infrastructure, maintaining and running existing infrastructure, safeguarding the resource base from pollution and uncontrolled development that causes floods and droughts [2].

In the proposed work, a wireless acquisition system based on the Internet of Things for monitoring the water quality in ponds has been designed and proposed. The device uses three sensors to collect data from multiple pond areas. The pH, turbidity, and TDS data are collected from different ponds and are sent via ESP32 and are displayed in the mobile app. Three ponds in the city of Chennai have been used to test this device.

II. RELATED WORK

Numerous studies have shown that water quality monitoring methods have advanced significantly. Scholars have investigated new approaches and cutting-edge technology, such as complex sensor networks and Internet of Things (IoT) solutions. The goal of these initiatives is to address the pressing need for quick and effective assessment of water quality indicators. The development of water quality monitoring systems, their technological underpinnings, and the advancements made in understanding and resolving water quality issues are all covered in detail in this study's comprehensive review of the literature.

Das and Jain [3] presented a system using IoT to evaluate water quality instantly in 2017. They used temperature, conductivity, and pH sensors in their experiments, and they used a Zigbee module to transmit the data that the sensors collected. They also used a proximity sensor to be alerted whenever someone contaminated the water, and their device tracks the water's contamination in real time.

The creation of a water quality monitoring system using the Internet of Things was proposed by Daigavane and Gaikwad [4]. They added temperature, pH, turbidity, and flow sensors to the water monitoring system in order to accurately monitor the water's quality.

In 2017, Parameshwari et al. [5] suggested a technique for assessing the water's quality. They used temperature, pH, and turbidity sensors in addition to a level sensor.

Pasika and Gandla [6] presented an IoT-based water quality monitoring system in 2017. Sensors for pH, water turbidity, tank level, and ambient temperature and humidity were all incorporated into their suggested system. The sensors connected to a Microcontroller Unit (MCU), which processed the information before forwarding it to a PC. The examined data was sent to the cloud using an Internet of Things (IoT) ThingSpeak application, making it possible to remotely monitor the water quality in real time.

Bogdan et al. [7] suggested a low-cost water quality monitoring system in 2023. They created an inexpensive Internet of Things (IoT) system that tracks and reports on the quality of various water sources. A smartphone app controls the system, which is made up of an Arduino UNO board and several sensors. Most of the five water sources in a rural area that were monitored were found to be acceptable for human consumption, with the exception of one where the TDS levels were higher than the 500 ppm acceptable limit.

A water quality monitoring system was presented by Razman et al. [8] in 2023. They suggested an Arduino-based water quality monitoring and filtration device. They employed ThingSpeak for real-time tracking and Proteus software to simulate the design. The water quality metrics of tap, lake, and river water were compared.

III. METHODOLOGY

We have built a new wireless system for the water quality monitoring system that uses the Arduino Uno and ESP32 microcontroller. This state-of-the-art device is made to deliver accurate remote measurements of key water quality parameters, including pH, turbidity, and total dissolved solids (TDS). The device uses three different sensors to gather data from multiple areas around the pond. One major benefit of this technology is that it may be integrated with an aquatic boat. The accuracy of the overall water quality measurement is increased by this integration, which enables the collection of thorough samples from both the pond's margins and centre. Using the ESP32, the suggested water quality monitoring system measures the pond's pH, turbidity, and TDS levels and sends the data to the mobile app. The framework of the suggested water quality monitoring system is depicted in Figure 1. Three ponds in Chennai have been used to test this work, namely Lotus Pond Park Pallikarani, Chitlapakkam Pond and Madipakkam Pond.

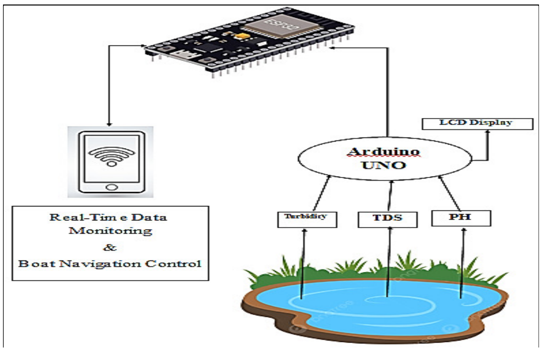


Fig. 1 Proposed Framework to detect quality of water in Ponds

A. *Parameter Used to detect Quality of Water*

Three parameters have been used in this experiment to assess the water quality. Each parameter plays a distinct role in evaluating different aspects of water quality, leading to a more thorough and in-depth understanding of its characteristics.

1) **pH parameter:** The pH value is important because it indicates the amount of hydrogen ions in water. Water's acidity or alkalinity is determined by measuring its pH value. The pH of pure water is 7, while values below and above 7 denote acidity and alkalinity, respectively. The range of the pH scale is 0 to 14. According to WHO guidelines, drinking water should have a pH between 6.5 and 8.5.

2) **Turbidity:** A measurement of turbidity indicates how many invisible suspended particles are present in the water. Because it signifies that there is less particles present in the water, a lower degree of turbidity is a sign of cleaner water. A higher risk of waterborne illnesses like cholera and diarrhea is linked to higher turbidity levels.

3) **Total Dissolved Solids (TDS):** Total dissolved solids in water are measured by TDS. These consist of both organic and inorganic compounds, minerals, salts, metals, cations, and anions. TDS is often expressed as mg/L or ppm. Water quality can be monitored by checking TDS levels because high levels can indicate pollutants and have an impact on taste, odour, and suitability for industrial and drinking use.

B. *Component Utilized*

1) ***ESP32:***

The ESP32 is a single-chip combination chip that utilizes TSMC's ultra-low power 40 nm technology. It operates at 2.4 GHz Wi-Fi connectivity and has Bluetooth 4.2 connectivity.

2) ***Arduino UNO:***

The Arduino Uno is an 10-bit microcontroller board with an ATmega328P, 14 digital I/O pins, 6 analog inputs, and USB programming support.

3) ***LCD Display***: The LCD is a type of flat panel display which uses liquid crystals in its primary form of operation.

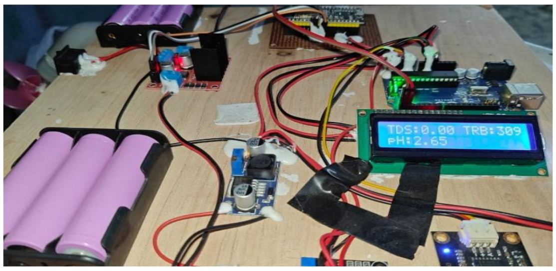
4) ***Gear Motor:*** The gear motor is a mechanical system consisting of an electric motor and a gearbox containing a series of gears. It operates in 1000rpm

5) ***Motor Driver:*** The L298N Motor driver is an electronic device that can change motor attributes by amplifying current followed by input signals

6) ***Buck Converter:*** The buck converter, as a step-down converter, is a popular topology in power electronics that converts a higher input voltage to a lower output voltage

7) ***Battery:*** The 3.7-volt batteries provide an excellent energy-to weight ratio, meaning they store a substantial amount of power relative to their size.

Figure 2 shows the proposed water quality monitoring system. Figure 2(a) shows the components used in the proposed work and Figure 2(b) shows the working model of the proposed work. Figure 3 shows the flowchart of the working principle of the proposed work



(a)

(b)

Fig. 2 (a), (b) Proposed Water Quality Monitoring System

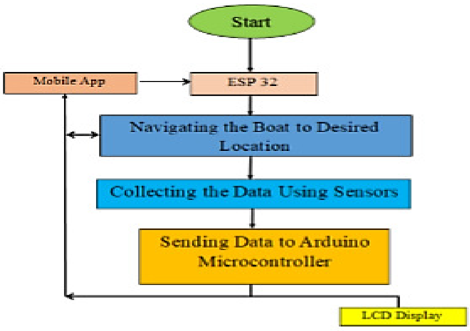


Fig. 3 Flowchart of the water monitoring system

C. ESP32-Boat App

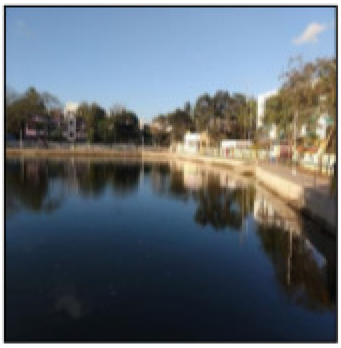
The Android app, called''ESP32_Boat'' is designed to display real-time in an accurate way. This app serves to display remote data and indicating the online state of the device. Figure 4 shows the logo of the mobile app.

Fig. 4 Logo of the mobile App

D. Deployment

The proposed water quality monitoring system has been used to measure water quality in three ponds, namely Lotus Pond Park Pallikarani, Chitlapakkam Pond and Madipakkam Pond. Figure 5 shows the deployment of the proposed water quality monitoring system in different ponds. At each pond, pH, TDS, and Turbidity data are collected and sent to the mobile app.

(a)



(b)

(c)

Fig. 5 (a) Lotus Pond (b) Chitlapakkam Pond (c) Madipakkam Pond

In all the three ponds, the proposed water quality monitoring system has been deployed and tested to collect and analyse the average of sensor values as shown in Table 1. Following are the standard values of pH, TDS, and Turbidity for drinking water

- pH - 6.5-8.5
- TDS - 50-600 ppm
- Turbidity - < 50 ntu

TABLE I

AVERAGE SENSOR VALUES

Pond Name	pH	TDS	Turbidity
Pond 1	7.96	196.75	8.22
Pond 2	8.96	685.18	33.89
Pond 3	11.46	718.41	23.12

The main advantage of the proposed approach is the reduction of manual effort. It is cost effective compared to the traditional water testing models

CONCLUSIONS

The balance of the environment depends on the quality of the water. A diverse environment depends on clean water. Water purity must be checked and maintained to safeguard the intricate web of life that depends on it since it is crucial to ecosystem resilience and health. Using Arduino (ESP32) microcontrollers have been used to create an efficient wireless water quality monitoring system based on the Internet of Things (IoT). This gadget was created especially for ponds and allows for real-time measurements of turbidity, pH, and Total Dissolved Solids (TDS). Using the suggested water quality monitoring system, the analysis revealed that the Lotus Pond exhibited the highest level of cleanliness having average values of pH, TDS, and Turbidity were 7.96, 196.75 and 8.22 respectively. Madipakkam Pond have been identified as the highly polluted pond having average values of pH, TDS, and Turbidity were 11.46, 718.41, and 23.12 respectively.

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ACKNOWLEDGMENT

We would like to show our heartfelt gratitude to our Head of Department, P Sridhar for his constant encouragement and great assistance in the scripting of this paper. His valuable suggestions, patience, and motivation have been very important in creating this work. Without his effort and hard work, this success would not have been possible. Thank you for being our constant source of inspiration.

REREFERENCES

[1] Dong, J., Wang, G., Yan, H., Xu, J., & Zhang, X. (2015). A survey of smart water quality monitoring system. Environmental Science and Pollution Research, 22, 4893-4906.

[2] Hemdan, E. E. D., Essa, Y. M., Shouman, M., El-Sayed, A., & Moustafa, A. N. (2023). An efficient IoT based smart water quality monitoring system. Multimedia tools and applications, 82(19), 2882728851.

[3] B. Das and P. C. Jain, ‘‘Real-time water quality monitoring system using Internet of Things,’’ in Proc. Int. Conf. Comput., Commun. Electron. (Comptelix), Jul. 2017, pp. 78–82, doi: 10.1109/COMPTELIX.2017.8003942.

[4] V. V. Daigavane and M. A. Gaikwad, ‘‘Water quality monitoring system based on IoT,’’ Adv. Wireless Mobile Commun., vol. 10, no. 5, pp. 1107–1116, 2017. Accessed: Apr. 28, 2021. [Online]. Available: http://www.ripublication.com.

[5] M. Parameswari and M. B. Moses, ‘‘Efficient analysis of water quality measurement reporting system using IOT based system in WSN,’’ Cluster Comput., vol.22, no.5,pp. 12193–12201, Sep.2019, doi:10.1007/s10586017-1581-1

[6] S. Pasika and S. T. Gandla, ‘‘Smart water quality monitoring system with cost-effective usingI oT,’’ Heliyon, vol.6, no.7, Jul.2020, Art.no.e04096, doi: 10.1016/j.heliyon.2020.e04096 .

