www.ijbar.org
ISSN 2249-3352 (P) 2278-0505 (E)
Cosmos Impact Factor-5.86

ENHANCED IOT-BASED SYSTEM FOR REAL-TIME WATER QUALITY MONITORING

[1]Ms. Samreen Begum
Assistant Professor, Dept. Computer Science and Engineering
Vignan's Institute of Management and Technology for Women,Hyd.
email:samreen15101997@gmail.com

[2]Jella Vaidehi
UG Student, Dept. Computer Science and Engineering
Vignan's Institute of Management and Technology for Women, Hyd.
email:jellavaidehi18@gmail.com

[3]Ganji Varsha
UG Student, Dept. Computer Science and Engineering
Vignan's Institute of Management and Technology for Women, Hyd.
email:ganjivarsha18@gmail.com

[4]Kankanala Rohini
UG Student, Dept. Computer Science and Engineering
Vignan's Institute of Management and Technology for Women, Hyd.
email:rohinikankanala005@gmail.com

***Abstract*—Monitoring water quality has grown in significance in both urban and rural areas. This project presents a real-time Water Quality Monitoring System. A real-time water quality measurement system that monitors temperature, turbidity, and total dissolved solids (TDS)—among other important water parameters—was developed in this project using the ESP32 microcontroller. A turbidity sensor, a TDS sensor, and a DS18B20 temperature sensor are used by the system to gather data, which is then shown on an I2C LCD. Its compact size and energy-efficient design allow for continuous remote monitoring in a variety of environments, including homes, farms, and aquaculture. This creative approach improves safety, increases environmental awareness, and supports sustainable water management practices by doing away with the need for frequent human inspections. The ESP32 uses its integrated Wi-Fi to enable quick response in the event of anomalies, giving registered users instant email warnings. It may also be integrated into cloud storage and IOT dashboards for long-term study.**

Keywords: Cloud Storage, Continuous Monitoring, DS18B20 temperature sensor, Energy-efficient design, ESP32 Microcontroller, Remote Monitoring, TDS Sensor, Turbidity Sensor.

1. INTRODUCTION:

The significance of efficient water quality monitoring in a time when having access to safe and clean drinking water is a fundamental human right cannot be emphasized. Urbanization, industrialization, and environmental changes have made water supplies more susceptible to contamination than in the past. Because of this circumstance, creative ways to continuously check the quality of the water and guarantee its safety for human consumption are required. Conventional laboratory testing methods, which depend on field samples, are usually costly, time-consuming, and inadequate for making choice real time. The development of inexpensive, remote, real-time water monitoring devices has been made feasible by advancements in Internet of Things (IOT) technology in response to these problems. Microcontrollers with built-in Bluetooth and Wi-Fi, low power consumption, and connectivity to a variety of sensors, such as the ESP32, have become more and more popular.

The ESP32 is used in this project's proposed Quality Monitoring System to continually monitor three vital water parameters: temperature, total dissolved solids (TDS), and turbidity—all of which are important markers of water contamination. Temperature affects oxygen solubility and chemical reactions in water, turbidity measures the purity of the water, and TDS shows the quantity of dissolved ions or particles. A 0.96-inch I2C OLED screen is used for local monitoring, and the system uses a DS18B20 Temperature Sensor for precise temperature readings, a Turbidity Sensor to identify suspended particles, and a TDS Sensor to assess water conductivity and dissolved solids.

Simultaneously, the ESP32 determines whether sensor readings exceed predetermined levels, and if any abnormalities are found, it automatically sends the user an email notice via SMTP over Wi-Fi. This clever method guarantees prompt notifications and decision-making without requiring human oversight, which is especially helpful for small-scale companies, aquaculture farms, rural locations, and residential tanks where water quality monitoring is essential. Additionally, it has room to grow by integrating with the cloud for long-term analysis and data logging.

The goal of this project is to develop and put into place a thorough water quality monitoring system that can identify water quality parameters and use data analysis to assess water safety. Our goals in utilizing IoT technology are to improve environmental awareness, guarantee public safety, and support sustainable water management methods. In the end, our Internet of Things-based water quality monitoring system offers a creative way to protect one of the planet's most important resources.

2. LITERATURE REVIEW:

Nishan et al. [1] developed an IoT-based multi-level system for real-time water quality monitoring focused on industrial wastewater in Bangladesh. To improve spatial resolution, their system gathers data from three vertical water levels using an Arduino UNO microcontroller equipped with sensors for temperature, turbidity, pH, and total dissolved solids (TDS).

Real-time monitoring and analysis are made possible by the transmission of data via an HC-05 Bluetooth module and its presentation on a mobile application created with MIT App Inventor 2. Serious pollution was indicated by field tests conducted across industrial zones and the Buriganga River, which showed high pH (up to 10.90), elevated TDS (up to 487.81 ppm), and turbidity levels (up to 12.89 NTU). The report highlights how important IoT is for protecting the environment and advocates for scalable, sensor-rich platforms for proactive industrial use. The study emphasizes the critical role of IoT in environmental protection and calls for scalable, sensor-rich systems for proactive industrial wastewater management. Konde and Deosarkar [2] proposed an IoT-based smart water quality monitoring system (SWQM) utilizing FPGA technology for real-time, high-speed monitoring of multiple water parameters. Their system measures six key parameters: pH, turbidity, water level, temperature, humidity, and CO_2 using a suite of sensors interfaced with an Altera DE1-SoC FPGA board and transmitted wirelessly via Zigbee modules. The system employs VHDL and C programming for sensor integration and data processing, with output displayed in real-time on a Grafana dashboard via Python scripts. It supports continuous monitoring with low power consumption, high precision, and fast data refresh (every 5 seconds), making it suitable for large-scale deployments. The authors highlight the system's reconfigurability, modularity, and potential for expansion using WSN nodes, with future integration of IOT and cloud-based analytics for enhanced environmental monitoring.Pasika and Gandla [3] developed a cost-effective IoT-based smart water quality monitoring system that uses sensors to measure pH, turbidity, water level, temperature, and humidity. Their system integrates Arduino Mega and NodeMCU microcontrollers, with real-time data collected from sensors and uploaded to the ThingSpeak cloud platform via Wi-Fi (ESP8266). They implemented algorithms to process sensor data and visualize it through a serial monitor and a mobile application, enabling easy monitoring. The prototype was tested using real water samples from Hyderabad, and the system successfully recorded accurate and timely updates every 20 seconds. The authors suggest expanding the system to include additional parameters like dissolved oxygen, nitrates, and chlorine for broader environmental analysis. Sengupta et al. [4] developed a low-cost IoT-based water quality monitoring and control system that incorporates a Raspberry Pi with pH, turbidity, and temperature sensors. An ADC is used in the system to convert sensor data to a digital format, which is then processed by the Raspberry Pi, which regulates a solenoid valve to permit or prohibit water flow according to water quality. A relay-transistor mechanism controls the valve's functioning based on sensor readings, and real-time data is shown on a cloud platform, allowing authorities to monitor the system remotely. By letting only drinkable water enter homes, the device proved to be dependable when tested using both clean and polluted water samples. With future ambitions to incorporate biological sensors and multi-location deployment for improved coverage, it emphasizes on automation, cost-effectiveness, and real-time decision-making.

Geetha and Gouthami [5] presented an Internet of Things-enabled, real-time water quality monitoring system based on the TI CC3200 microcontroller with built-in Wi-Fi. Their system sends data to the Ubidots cloud for analysis and warnings while keeping an eye on vital metrics, including pH, turbidity, conductivity, and water level. For in-pipe home applications, it provides a small, economical, and power-efficient solution. A thorough analysis of relevant work is included in the publication, which covers sensor technologies, communication protocols, and microcontrollers used in earlier research. When water quality is above the WHO criteria, the system sends smartphone alerts, demonstrating accurate performance in experimental validation.

3. METHODOLOGY:

3.1 System Architecture:

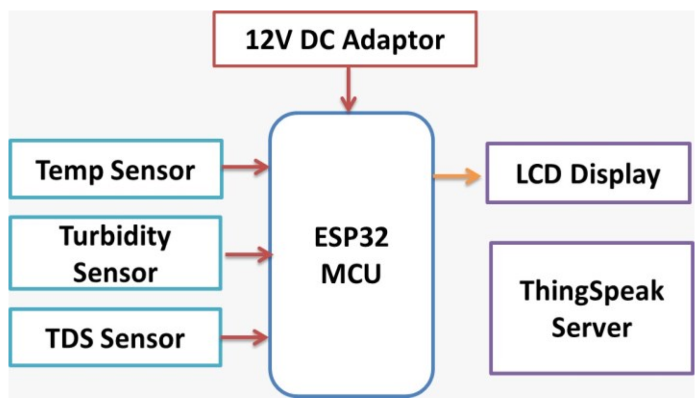

Fig 3.1 System Architecture

Overview of System:

A water quality monitoring system that is powered by a 12V DC adaptor is depicted in the diagram. This configuration ensures effective operation by giving the different components a steady power source. The ESP32 Microcontroller Unit (MCU), the system's primary component, acts as the central processing unit, regulating the outputs and overseeing the gathering of data from numerous sensors. Real-time water quality parameter monitoring and data analysis are prioritized in the design.

Sensors and Data Collection:

The system employs three primary sensors. The temperature sensor determines the water's temperature, which affects biological activity and chemical reactions. The turbidity sensor measures the water's clarity, which may be a sign of silt or pollutant levels. Last but not least, the Total Dissolved

Solids (TDS) sensor gauges the amount of dissolved solids in the water, offering information about possible pollutants and general water quality. The ESP32 MCU receives data from each sensor and processes it.

Data Display and Processing:

The ESP32 MCU processes the data collected by the sensors, interpreting the results and getting them ready for display and further action. Users can quickly view water quality measures thanks to the system's LCD display, which shows data in real-time. For quick evaluations and decision-making in a variety of applications, including aquaculture and environmental monitoring, this visual feedback is essential.

Data Communication and Remote Monitoring: The entire system can be remotely monitored via the ThingSpeak server alongside the local display. The ThingSpeak platform is capable of receiving processed data via the ESP32 MCU, permitting users to view and examine data remotely over the internet. This feature increases the usefulness of the monitoring system by allowing users to monitor changes in water quality over time, get warnings for any irregularities, and make choices based on up-to-date information.

Algorithm:

- **Step 1:** ESP32 reads turbidity, TDS, and temperature.
- **Step 2:** Values are compared against set thresholds.
- **Step 3:** If any value crosses the threshold, an SMTP email alert is triggered.
- **Step 4:** All values are displayed live on the OLED screen.
- **Step 5:** The system repeats the process continuously.

4. EXPERIMENTAL RESULTS :

The Water Quality Monitoring System was designed to continuously monitor critical parameters of water, namely temperature, total dissolved solids (TDS), and turbidity, using appropriate sensors interfaced with an ESP32 microcontroller. The experimental phase involved immersing the sensor module in different water samples and observing the output on both the OLED screen and via email alerts.

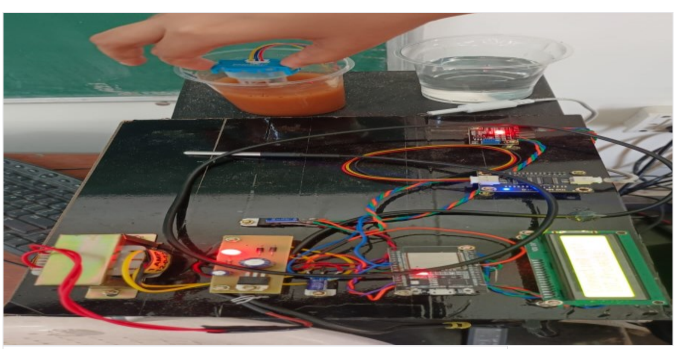

Fig 4.1 Checking Water Quality

Threshold Used for Alerts:

- Temperature – Max Safe = 35C
- TDS – Max Safe = 500ppm
- Turbidity – Max Safe = 5NTU

Parameter	Sensor Output	Condition	Remarks
Temperature	27.6 C	Room temperature Water	Within safe range
TDS	420 ppm	Water with added salt	Approaching the upper safety threshold
Turbidity	6.3 NTU	Slightly muddy water	Exceeded safe turbidity threshold
System Status	**Unsafe**	Based on threshold logic	Triggered email alert

Table 1: Water Parameters

The **OLED Display** provided real-time visual output of all sensor readings, making the system user-friendly for local monitoring.

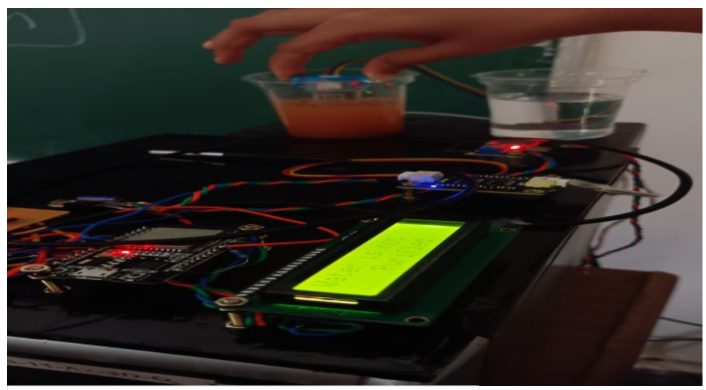

Fig 4.2 Water is not purified

When thresholds were breached, an **email alert** was sent using Wi-Fi and SMTP protocols — a feature particularly useful for remote or unattended water sources.

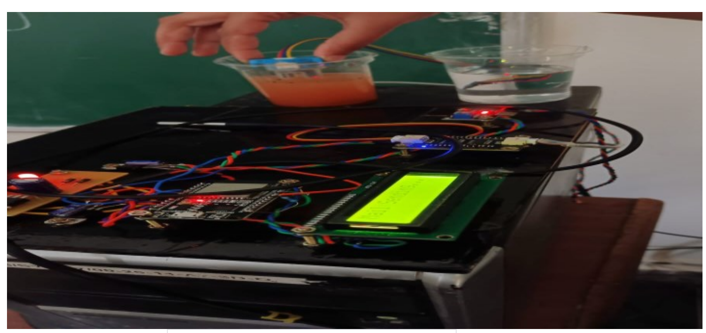

Fig 4.3 Sending Alert Mail

The response time for data refresh and alert generation was typically under 5 seconds, indicating fast system reaction and reliable performance. The User will receive the Alert Email.

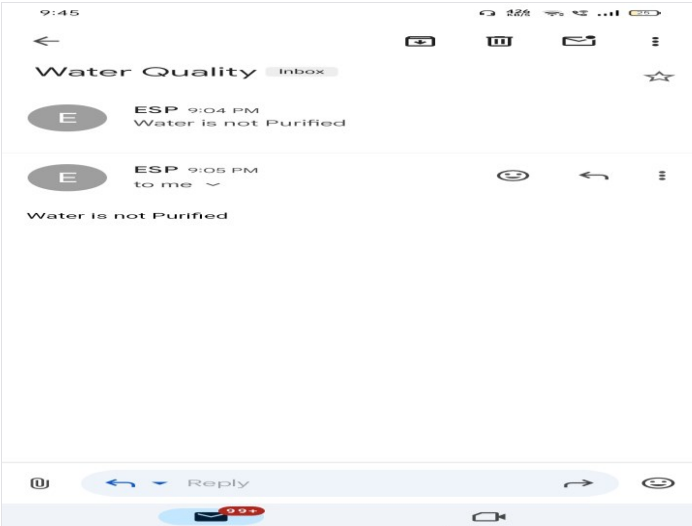

Fig 4.4 Alert mail received by user

The successful detection of anomalies (like high turbidity) and the immediate triggering of alerts validate the system's real-world applicability. It offers a low-cost, energy-efficient, and portable solution to a problem traditionally addressed with expensive lab equipment. Furthermore, its modular design means it can be upgraded to include cloud storage, mobile app interfaces, or additional sensors (like pH or heavy metals).

5. CONCLUSION:

In conclusion, real-time water quality monitoring has advanced significantly with the creation of the Quality Measurement System utilizing the ESP32 microcontroller. Turbidity, TDS, and temperature sensors are all included in the system, which offers a reliable way to identify hazardous water conditions. While the email alert feature provides a dependable means of communication for customers to stay informed even when they are not physically there, the incorporation of an OLED display guarantees instant visual feedback. This two-pronged strategy encourages prompt decision-making to resolve any emerging water quality concerns while also improving user participation.

Additionally, this Internet of Things-based strategy significantly lowers operating expenses by reducing the number of staff required for conventional monitoring systems. Because of its versatility, it can be used in a wide range of urban and rural contexts, especially in fields like irrigation, residential water supply, and fish aquaculture. Future developments may provide more reliability and effectiveness, emphasizing its importance as a vital tool for safeguarding the environment and human health.

6. FUTURE SCOPE:

Future improvements to the Internet of Things-based water quality monitoring system might incorporate cutting-edge technologies like artificial intelligence (AI) and machine learning (ML) to anticipate possible problems with the water quality before they arise. The system could be expanded to monitor a wider range of pollutants, including heavy metals and harmful chemicals, making it more applicable in industrial and environmental monitoring. Additionally, introducing solar-powered sensors would enhance the system's sustainability, especially in remote or rural areas where power availability is limited. Another enhancement could be improving data visualization through more sophisticated dashboards or mobile applications, providing real-time alerts and recommendations. Lastly, the system could be made more scalable, allowing for deployment across multiple locations and integrating with smart city infrastructure for broader environmental management.

REFERENCES:

[1].R.K. Nishan et.al, "Development of an IOT- based multi-level system for real-time water quality monitoring in industrial wastewater", Springer Access, 2024

[2].S.Konde, S.Deosarkar, "IOT based water quality monitoring system, in: Proceedings of the 2nd International Conference on Communication & Information Processing (ICCIP)", 2020

[3].S.Pasika, S.T.Gandla, "Smart water quality monitoring system with cost-effective using IoT", Heliyon ,2020

[4].B. Sengupta , S. Sawant , M. Dhanawade , S. Bhosale , "Water quality monitoring using IoT", Int. Res. J. Eng. Technol. 6 (2019)

[5].S. Geetha, S. Gouthami, Internet of things enabled real time water quality monitoring system, Smart Water 2 (1) (2016)

[6].M. Chatterjee, "IoT-Based Water Monitoring System," IEEE Sensors Journal, 2019.

[7].S. Patil, "Water Quality Alert via GSM," IJERT, Vol. 9, 2020.

[8].B. K. Singh, "Smart Water Monitoring Using Raspberry Pi," Elsevier Procedia Computer Science, 2021.

[9].Raut, N. Rathi, "ESP8266-Based Water Quality System," IRJET, Vol. 9, Issue 3, 2022.

[10].G. Sharma, "Cloud-Based Smart Water Monitoring, " Springer Smart Innovations, 2023.

[11].L. Zhang, "Wireless Sensor Networks for Water Monitoring," IEEE Access, 2020.

[12].H. Lee, "Real-Time Water Quality in Aquaculture," MDPI Sensors, 2021.

[13].V. Kumar, "Monitoring Turbidity and TDS Using IOT," IJERA, Vol. 11, 2021.

[14].P. Das, "Email Alert System for Contamination," IJRTE, Vol. 8, 2020.

[15]. D. Bose, "ESP32-based Smart Water Monitor," Elsevier Environmental Tech, 2022.