REAL-TIME IOT SYSTEM FOR DETECTION AND UV-BASED MITIGATION OF MICROBIAL CONTAMINANTS IN DRINKING WATER

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Abstract: An important feature of the solution is its ability to detect harmful bacteria in water and turn on UV light for instant disinfection. This approach ensures safe water use and meets the urgent need for clean water. This paper presents an Internet of Things (IoT) based water quality monitoring system designed to detect and solve pollution problems. The system uses state-of-the-art technology to protect public health and support sustainable water management. Water pollution is a major global problem that causes serious health hazards and loss of life.

Index terms: **Arduino; Water; Water quality; Ph; TDS; turbidity; temperature; UV light**

I. INTRODUCTION

One of the most vital resources for both national economic growth and personal health is water. It is essential not only for people but also for agriculture, industry, and all other living things. However, poor water resource management in highly populated regions causes serious problems like untreated sewage, population expansion pressures, climate change effects, and hazardous chemical releases, among other human activities. The situation is made worse on a global scale by problems like inequality, scarcity, and discrimination in water.

India, recognized as one of the crucial and fast-developing nations, encounters considerable challenges regarding water management. Given that 72% of the population in developing areas views water as essential for life, ensuring access to clean and safe water becomes vital. Contaminated water has a direct effect on human health, reducing the availability of safe drinking options and leading to various diseases. Although interventions have successfully reduced the incidence of waterborne diseases like dengue, cholera, and malaria in some regions, these continue to pose significant health risks in many areas. In India, a large number of infant fatalities are associated with water-related problems, with 70% of diarrhoea cases linked to poor water and sanitation practices. Tackling these issues demands effective management of water resources, fair access for all, and more stringent sanitation regulations to promote public health and sustainable growth.

II. LITERATUREREVIEW

Water quality plays a critical role in various applications, such as domestic water supply, agriculture, hydropower generation, and industrial processes. IoT and sensor-based systems have been extensively explored to ensure effective water quality monitoring. S. K.M. and S. R. M.S. [1] highlighted the development of a WSN and IoT-based monitoring system for evaluating key water parameters like pH and turbidity, enabling efficient and real-time monitoring. Johan et al. [2] demonstrated the use of IoT for water quality assessment in environmental monitoring, ensuring sustainability through continuous real-time data collection and analysis.

The use of IoT in industrial water quality monitoring has also been investigated. A study [3] focused on integrating temperature, pH, and turbidity sensors for industrial applications, ensuring accurate and timely water quality assessment. An ESP32-based water quality monitoring system [4] was proposed for safe drinking water management, utilizing IoT to monitor TDS and other water parameters. Furthermore, a cloud-integrated IoT solution [5] for water quality monitoring has been developed, allowing for remote data access and visualization in real time.

Real-time monitoring systems are increasingly used in IoT environments for precision and reliability. Deepthi N and Rahul R A [6] presented an IoT-based system to monitor water quality parameters, integrating multiple sensors for accurate data collection. Hitarth Patel et al. [7] proposed a wireless smart water quality monitoring system, capable of measuring turbidity and pH for agricultural and domestic water needs. Shruthi G R and Ritika Patil [8] highlighted a water quality monitoring system designed to address real-time challenges in rural and urban water management.

IoT has also been applied to aquaculture and river water quality monitoring. Wasana Boonsong. [9] developed a real-time IoT-based monitoring system for aquaculture ponds, ensuring water quality for aquatic organisms. Harshith Gowda K N [10] introduced "Water Sense," an IoT system for river water monitoring, capable of detecting contaminants and providing insights for better water management. M. Anin Manjusha [11] proposed an embedded system that integrates bacterial detection for drinking water, combining microbial sensing with IoT for enhanced safety and usability.

Together, these studies highlight how important IoT and AI-based systems are to transforming water quality monitoring and enabling them to be tailored to a range of uses, from industrial operations to drinking water management.

III. PROPOSED SYSTEM

In the current water quality monitoring framework, sensors like pH, turbidity, TDS, and temperature are employed to evaluate drinking water quality and identify possible bacterial contamination. Although these sensors successfully track water parameters, they do not offer a means to eradicate bacteria following the detection of contamination. To overcome this drawback, the suggested approach incorporates a UV light module into the system.

The upgraded system functions by persistently tracking water quality using the current sensors and assessing the presence of bacterial contamination based on the gathered information. Upon detecting contamination, the system automatically triggers the UV light, which purifies the water by disrupting bacterial DNA, thereby ensuring its safety for consumption. Furthermore, the system offers immediate feedback through an IoT interface, notifying users about the water quality and the disinfection process. This method not only monitors but also proactively eradicates bacteria, providing a more thorough and effective solution for guaranteeing safe drinking water.

IV. IMPLEMENTATION

In this section, the detailed implementation of the water quality monitoring system is explained in form of block diagram as shown in Fig. 1.

In Fig. 1, the main blocks are:

- Wi-Fi Module- This module is used for IOT connection, the module used here is ESP8266.
- 16X2 LCD - LCD is used to display the sensor data real time values.
- UV Light - UV light purifies water by destroying harmful microorganisms without using chemicals.
- Arduino Atmega328P - This is the microcontroller board. Atmega328 is the microcontroller and Arduino Nano board issued.
- Temperature sensor – To analyze the water temperature LM35 is used.
- Turbidity Sensor- To note the values of turbidity sensor
- PH sensor- to give values of PH in water
- TDS - Total Dissolved Solids are analyzed using this module.

These modules are combined together to form the water quality system using IOT.

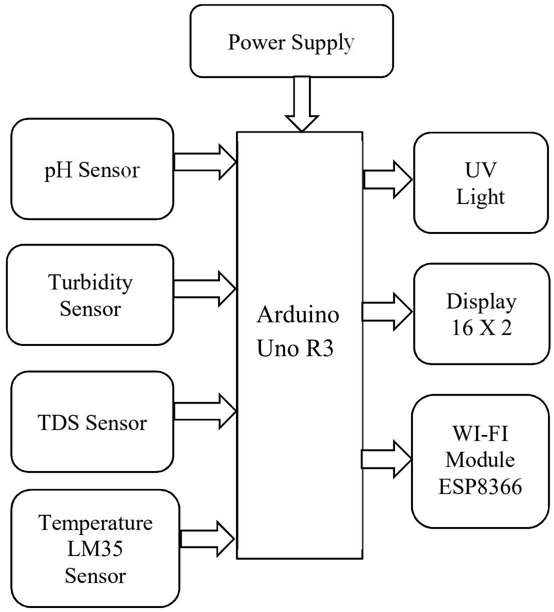

Fig. 1. Block Diagram Representation of Water Quality with implementation of IOT

For IOT implementation Blynk server is used. Arduino IDE is used for programming the microcontroller. Arduino Software Programming language is used for coding.

V. RESULTS

The IoT-enabled microbial contamination detection system effectively monitored and evaluated the quality of drinking water using a variety of sensors, such as pH, turbidity, TDS (Total Dissolved Solids), and temperature sensors. These sensors gathered data continuously, which was then sent to a cloud-based platform for real-time monitoring and evaluation. The system successfully detected potential microbial contamination by identifying irregularities in water quality metrics. A shift in pH levels from the ideal range (6.5–8.5) indicated a possible contamination event, while elevated turbidity levels suggested the presence of suspended particles, which are often linked to microbial proliferation. High TDS readings further supported the possibility of contamination, as they indicated an excessive amount of dissolved substances in the water. Furthermore, temperature fluctuations had a significant impact on microbial activity, with higher temperatures occasionally being associated with higher microbial presence.

The system used UV sterilization as a treatment technique to address microbiological contamination. By comparing water samples taken before and after UV exposure, it was verified that UV radiation is effective at getting rid of bacteria. The outcomes showed a notable decrease in microbial activity, proving that the sterilizing procedure effectively eliminated dangerous microorganisms. Additionally, real-time data transfer to a cloud platform was made possible by the integration of IoT technology, allowing users to obtain water quality metrics remotely. When contamination levels were surpassed, the system also automatically sent out alarms, enabling prompt action to preserve safe drinking water standards.

Overall, the findings support the effectiveness of an Internet of Things-based approach in identifying and reducing drinking water microbiological contamination. This strategy offers an automated, real-time, and affordable way to guarantee safe and clean drinking water by utilizing sensor-based monitoring, cloud connectivity, and UV sterilization. In order to improve the system's capacity to detect pollution patterns and streamline water purification procedures, future developments may use artificial intelligence (AI) for predictive analysis. Furthermore, adding more sophisticated microbial detection methods, like biosensors, could increase precision and dependability even more, strengthening the system's ability to protect the public's health.

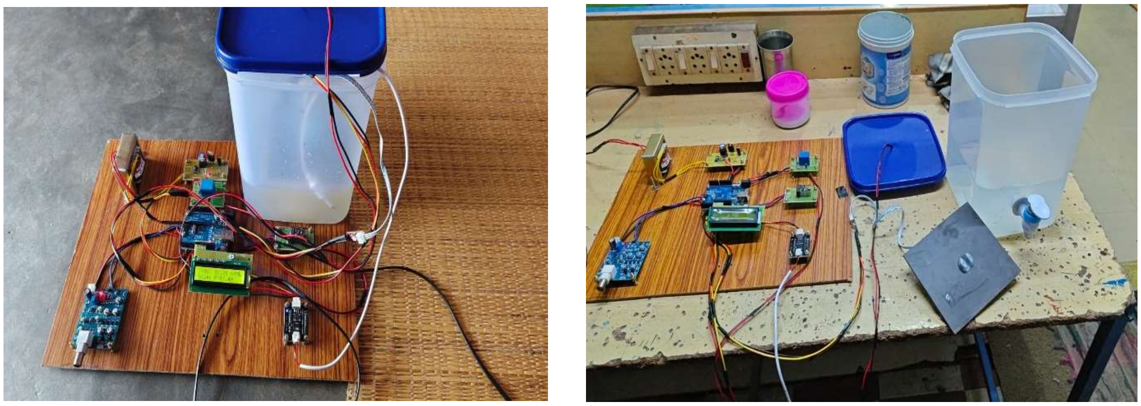

Fig.2 Hardware Output Water Quality with implementation of IOT

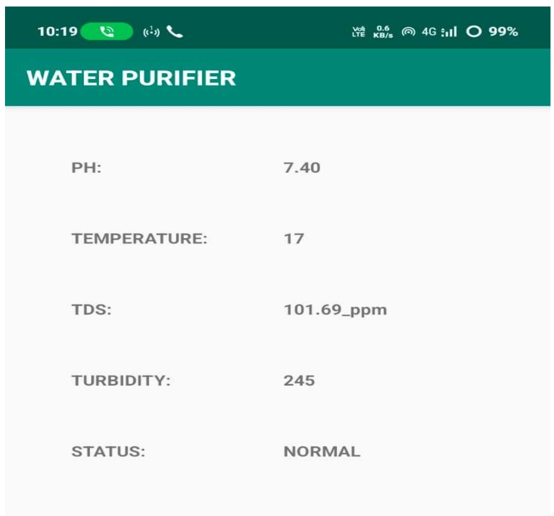

Fig.3 Water Quality Sensor Data in Application

VI. CONCLUSION

The development of an IoT-based system for detecting and eliminating microbial contamination in drinking water proves to be a significant step toward ensuring water safety and public health. By integrating pH, turbidity, TDS, and temperature sensors, the system effectively monitors critical water quality parameters in real-time. Abnormalities in these parameters were successfully used as indirect indicators of microbial contamination, allowing early detection and intervention. The incorporation of UV light as a disinfection mechanism demonstrated strong efficiency in neutralizing microorganisms, significantly improving the quality of contaminated water samples.

Furthermore, the use of IoT technology enabled seamless data transmission, remote monitoring, and alert generation, making the system both smart and user-friendly. This approach reduces the need for manual testing and provides continuous oversight, especially valuable in areas lacking regular water quality checks. Overall, the project validates the practicality, accuracy, and efficiency of using a sensor-based, IoT-enabled water monitoring system with integrated sterilization.

Future enhancements could include the use of AI or machine learning for predictive analysis, integration with mobile apps for user interaction, and the inclusion of biosensors for direct microbial detection to further improve precision and expand its applications.

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