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Development of Portable Water Quality Sampling Device for Water Dispenser Services

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Abstract

Clean water from water dispenser is important for human to ensure it safe to drink. This project present the development of a portable water quality sampling device for water dispenser services to address the lack of real-time water quality monitoring. Traditional laboratory based testing method are time-consuming and unsuitable for continuous monitoring. The main objective of this project is to develop a portable device that can read the foreign object in clear water with other related reading while integrating Internet of Things (IoT) for data managment and analysis. The system was developed using an ESP8266-based NodeMCU connected with multiple sensors and programmed using Arduino IDE, with real-time data transmission enabled through Wi-Fi to the Blynk and ThingSpeak platforms for monitoring and visualization. The evaluation was conducted by testing multiple samples from different water dispensers and the measured results were compared with standard laboratory reference values. The results indicate that the developed device is capable of providing stable, real-time water quality readings with acceptable accuracy and minimal deviation from reference standards. This innovative solution offers a cost-effective and reliable solution for real-time monitoring of water dispensers, and future work may focus on improving sensor calibration, expanding detection parameters, and enhancing system robustness for large-scale deployment.

1. Introduction

Access to safe and clean drinking water has always been a fundamental requirement for human health and well-being. The quality of drinking water directly influenced public health, regulatory compliance, and consumer confidence. Water dispensers were widely used in residential, commercial, and institutional environments due to their convenience. However, inadequate maintenance and filter degradation increased the risk of water contamination, making continuous monitoring essential to ensure water safety [1].

Traditionally, water quality monitoring relied on laboratory-based testing methods. These methods involved manual sampling, preservation, transportation, and chemical analysis using sophisticated equipment. Although laboratory testing provided high accuracy, it was time-consuming, costly, and unsuitable for real-time or on-site monitoring [2]. As a result, service providers faced difficulties in performing frequent inspections and detecting early-stage filter failures in water dispenser systems.

Recent scientific studies have highlighted the emergence of portable and IoT-based water quality monitoring systems. These systems integrated sensors with microcontrollers to measure key parameters such as pH, turbidity, temperature, and total dissolved solids (TDS) in real time [3]. The integration of Internet of Things (IoT) technology enabled remote data transmission, cloud-based storage, and continuous monitoring, offering a more efficient alternative to conventional approaches. However, many existing systems were either designed for large-scale water bodies or lacked portability and suitability for routine water dispenser servicing [4].

Despite these advancements, limited research focused specifically on portable water quality devices tailored for water dispenser services. Most existing solutions did not adequately address on-site usability, cost efficiency, and real-time data accessibility for service technicians. This gap highlighted the need for a compact and reliable monitoring tool capable of supporting routine maintenance activities.

Therefore, this study aimed to develop a portable water quality sampling device for water dispenser services. The objectives were to measure critical water quality parameters, including pH, turbidity, TDS, and temperature, to integrate IoT-based data management, and to evaluate the device's performance and accuracy through comparison with standard reference measurements.

2. Literature Review

Water quality monitoring was essential for ensuring safe drinking water and preventing health risks associated with contaminated supplies. Previous studies identified pH, turbidity, temperature, and total dissolved solids (TDS) as key indicators for assessing water quality and filtration performance [1]. Conventional laboratory-based testing methods were accurate but required manual sampling, specialized equipment, and long processing times, making them unsuitable for real-time or on-site monitoring [2]. Recent research introduced IoT-based water quality monitoring systems that integrated sensors with microcontrollers and wireless communication to enable real-time data transmission and cloud-based visualization using platforms such as ThingSpeak and Blynk [3]. Although these systems improved efficiency and reduced manpower requirements, most were designed for large-scale applications and lacked portability for routine water dispenser servicing, highlighting the need for a compact and field-deployable monitoring solution [4].

3. Methodology

The methodology section provides a detailed description of the project's execution, including a system block diagram, circuit design schematic and prototype design. These techniques enhance accountability and ensure the project's reproducibility, ensuring the project's success.

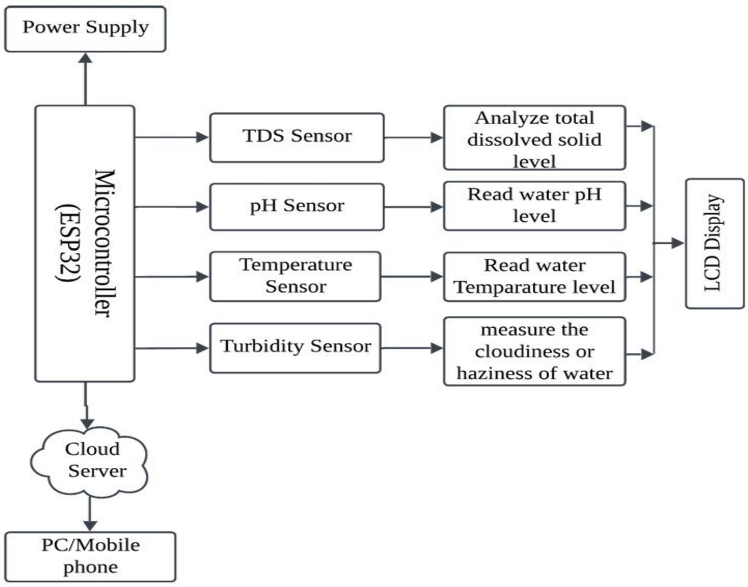


Fig. 1 *Block Diagram*

Fig. 1 showed the overall architecture and data flow of the developed system. The ESP32 microcontroller acts as the main processing unit and is powered by an external power supply. It interfaces with multiple water quality sensors, including Total Dissolved Solids (TDS), pH, temperature, and turbidity sensors, to measure key parameters related to water purity and safety. The acquired sensor data are processed by ESP32 to analyze the dissolved solid concentration, water pH level, temperature, and turbidity (cloudiness or haziness of water). The processed readings are displayed locally on an LCD for immediate on-site monitoring. Simultaneously, the ESP32 transmits the data wirelessly to a cloud server, enabling real-time data storage, visualization, and remote access via a PC or mobile device for continuous monitoring and analysis.

3.1 System Flowchart

Fig. 2 illustrates the operational sequence of the developed system from initialization to continuous monitoring.

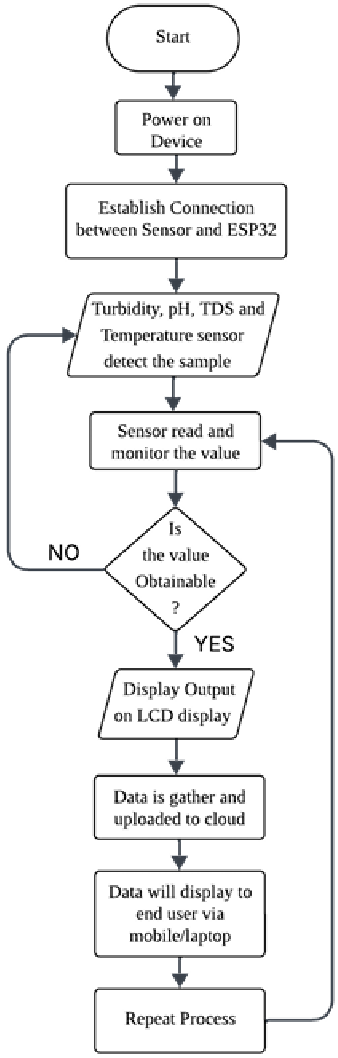


Fig. 2 *System Flowchart*

The process begins when the device is powered on, followed by the establishment of communication between the ESP32 microcontroller and the connected water quality sensors. The turbidity, pH, TDS, and temperature sensors then detect the water sample and acquire the corresponding parameter values. The ESP32 continuously reads and monitors the sensor outputs, and a decision process is performed to verify whether valid reading is obtained. Once valid data is confirmed, the measured values are displayed locally on the LCD for immediate user reference. The data are subsequently transmitted to the cloud platform for storage and further processing. Finally, the water quality information is displayed to the end user through a mobile or laptop interface, and the process is repeated to enable continuous real-time monitoring.

3.2 Circuit Design

Fig. 3 shows the complete circuit schematic of the developed system, showing the interfacing between the ESP32 microcontroller and the water quality sensors. The ESP32 functions as the central processing and communication unit, received input signals from the turbidity sensor, total dissolved solids (TDS) sensor, pH sensor, and temperature sensor through the appropriate analog and digital input pins. Signal conditioning modules are used to ensure stable and accurate sensor readings. An OLED LCD display is connected to the ESP32 via the I²C communication interface to provide real-time local visualization of the measured water quality parameters. The pH sensor module includes an external probe and interface circuit for voltage regulation and signal amplification. The power supply section provides the required operating voltages to all components, ensuring stable system operation. This circuit design enables simultaneous data acquisition, local display, and wireless transmission of water quality data for real-time monitoring and analysis.

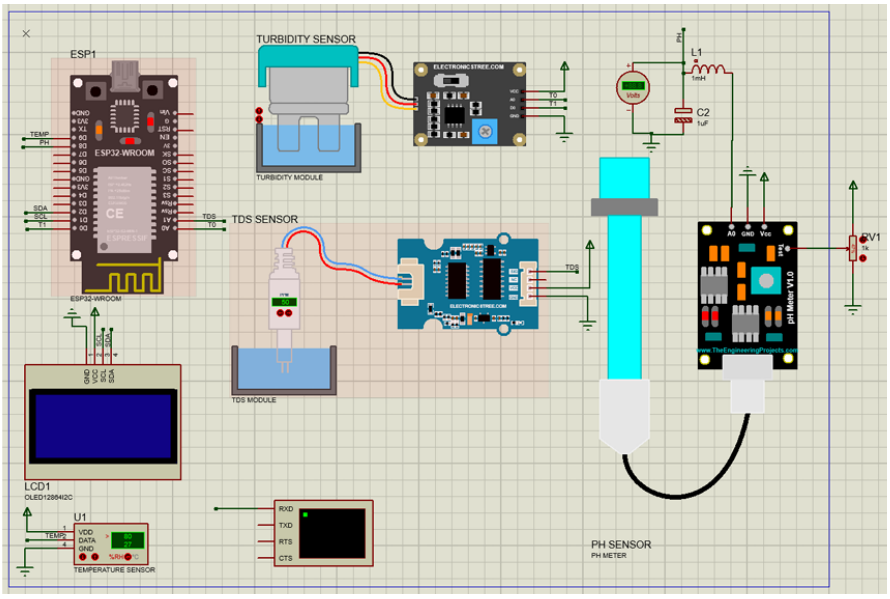


Fig. 3 *Circuit Design on Proteus*

3.3 Prototype Design

Based on Fig. 4, the proposed system is built using low-cost and commercially available components to ensure practicality and portability. The main hardware elements include an ESP8266 NodeMCU microcontroller as the central processing and communication unit, a pH sensor for acidity/alkalinity measurement, a Total Dissolved Solids (TDS) sensor for dissolved mineral concentration, a turbidity sensor for water clarity assessment, and a temperature sensor for thermal monitoring. All electronic components are housed within a protective enclosure to prevent environmental exposure.

(a) **(b)**

Fig. 4 *Prototype Design*

4. Results and Discussion

The performance of the developed portable IoT-based water quality monitoring device was evaluated through experimental testing using different water samples, including tap water and commercial water dispensers. The system successfully measured key water quality parameters, namely pH, total dissolved solids (TDS), turbidity, and temperature, and displayed the results in real time on the LCD as well as on the cloud platform. The ESP32 maintained stable communication with all sensors, and continuous data transmission to the cloud server was achieved without interruption.

(a) (b) (c)

Fig. 5 *(a) Coway Dispenser (b) Tap Water Dispenser (c) Alkoh Water Dispenser*

Fig. 5 shows the overall performance comparison indicates distinguishable water quality characteristics among Coway, tap water, and Alkoh water. Normalized average data show that Coway water consistently recorded lower TDS and turbidity values, Alkoh water exhibited higher pH and TDS levels, while tap water remained at intermediate levels across all measured parameters. These variations reflect the different treatment processes applied to each water source, where Coway emphasizes filtration efficiency, Alkoh focuses on mineral enrichment, and tap water represents standard municipal treatment. The clear differentiation among water sources confirms the device's capability to accurately compare water quality performance, fulfilling the objective of evaluating multiple water dispensers using a portable IoT-based monitoring system.

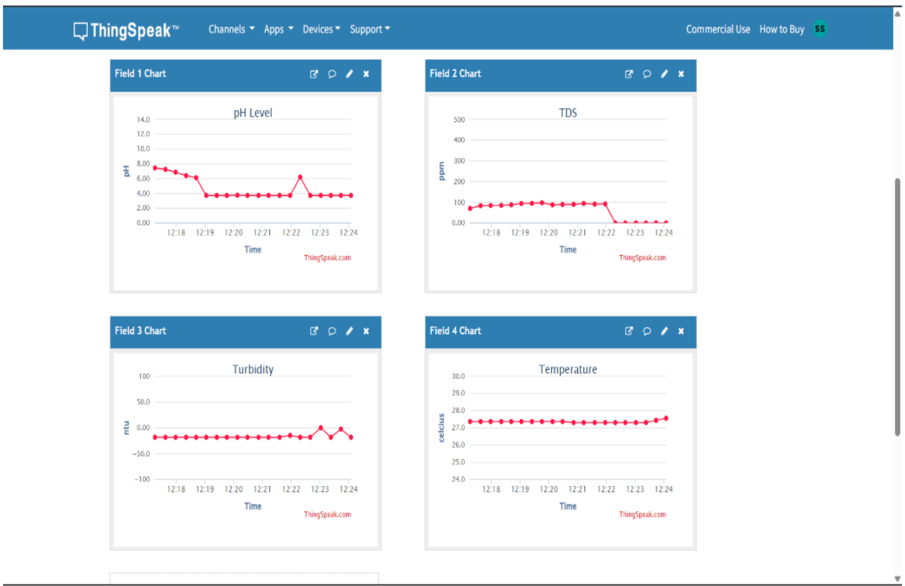
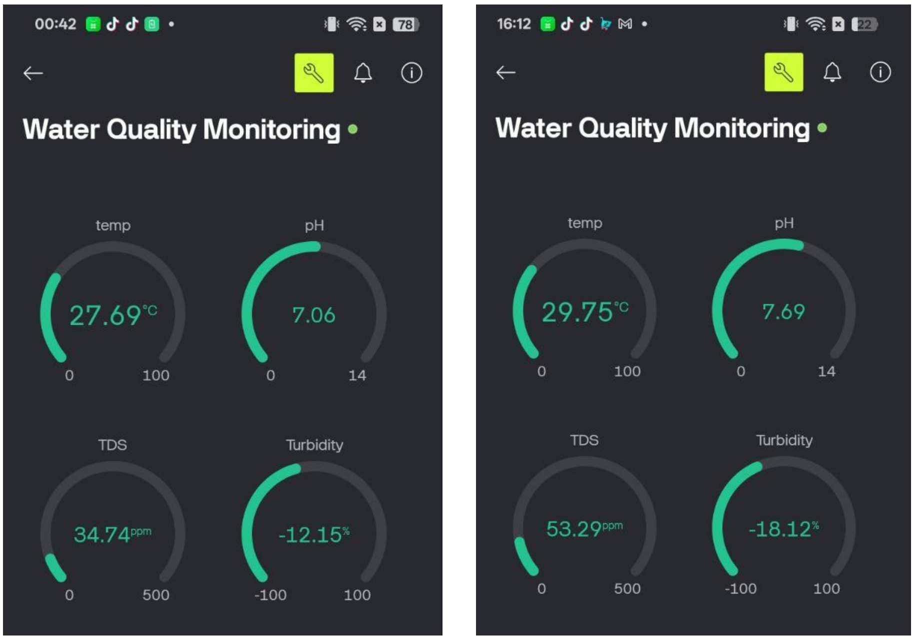


Fig. 6 *Water parameter data on ThingSpeak channel*

Fig. 6 illustrates the real-time monitoring results presented in the ThingSpeak dashboard which demonstrated the system's capability to continuously acquire and transmit multi-parameter water quality data via an IoT platform. The pH graph shows a clear transition from near-neutral values to more acidic conditions, indicating the sensor's responsiveness to changes in water composition, while the TDS readings initially remain stable before dropping significantly, reflecting variations in dissolved solid concentration during the testing period. Similarly, the turbidity plot demonstrated small but noticeable fluctuations, confirming the system's sensitivity to foreign material presence in the water, whereas the temperature remains relatively stable, validating that observed changes in other parameters are not caused by thermal effects. These synchronized trends across all four parameters verify reliable sensor integration, stable data transmission, and effective cloud visualization, thereby supporting the project objective of incorporating IoT-based data management for accurate water quality analysis and performance evaluation across different water conditions.



(a) **(b)**

Fig. 7 *(a) Readings from Coway Dispenser (b) Readings from Tap Water dispenser*

Fig. 7 shows the Blynk mobile dashboard results illustrated real-time water quality measurements obtained from two different water sources, demonstrating the system's effectiveness in on-site monitoring and comparison. The displayed parameters show measurable variations in pH, TDS, turbidity, and temperature between the samples, where the first reading from Coway indicates slightly higher temperature, pH, and TDS values, suggesting increased mineral content and dissolved solids, while the second reading from Tap Water exhibits lower values across these parameters, reflecting comparatively cleaner or less mineralized water. Despite these differences, turbidity levels for both samples remain within a low and stable range, indicating minimal suspended foreign particles. The consistent and responsive visualization of sensor data through the mobile IoT interface confirms reliable wireless data transmission and user-friendly monitoring, thereby supporting the project objective of integrating IoT-based data management for effective water quality assessment and comparative analysis across multiple water sources.

4.1 Analysis on measured data

Based on the averaged measurements obtained from multiple samples, Coway water exhibited a relatively stable pH level closer to neutral-to-slightly alkaline conditions, with lower Total Dissolved Solids (TDS) and turbidity values compared to the other sources. Tap water recorded moderate pH and TDS values, while Alkoh water showed a comparatively higher pH and TDS level. Turbidity measurements were lowest for Coway water, followed by tap water, whereas Alkoh water demonstrated higher turbidity fluctuations. Temperature readings across all samples remained within a narrow range, with Alkoh water consistently presenting slightly lower values due to its cooling system.

Table 1 *Average water quality parameters for three water dispensers*

Parameter	Tap Water	Coway	Alkoh
pH	7.60	7.78	7.08
TDS	61.86	59.17	77.21
Turbidity	-2.00	-18.07	2.09
Temperature	29.43	29.59	15.86

As shown in Table 1, the average water quality parameters were obtained from five samples for each type of water dispenser. The observed differences can be attributed to the treatment processes applied to each water source. The lower TDS and turbidity values in Coway water indicate effective multi-stage filtration, which removes dissolved solids and suspended particles more efficiently. Tap water, although treated at the municipal level, still retains moderate dissolved minerals, explaining its intermediate TDS and turbidity values. In contrast, Alkoh water's higher pH and TDS suggest mineral enrichment intended to produce alkaline water, which increases dissolved mineral concentration. The temperature variation further confirms the operational characteristics of the dispensers, where Alkoh water is dispensed at a lower temperature compared to ambient tap and Coway water. The experimental results demonstrate that the proposed device is capable of reliably measuring key water quality parameters in real time. The system provides consistent readings, effective IoT integration, and practical portability, making it suitable for routine inspection of water dispenser systems.

5. Conclusion

Overall, a portable IoT-based water quality sampling device for water dispenser applications was successfully developed and evaluated. The system integrates pH, TDS, turbidity, and temperature sensors with an ESP8266 microcontroller for real-time data acquisition and wireless transmission. Experimental results demonstrate stable and repeatable measurements within acceptable drinking water standards across multiple water sources. The developed device offers a practical, low-cost, and reliable solution for routine water quality inspection in water dispenser services. The outcomes of this work indicate strong potential for deployment in maintenance operations and quality assurance processes, while providing a scalable foundation for future enhancements such as automated calibration, additional sensing parameters, and improved enclosure integration.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

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Journal

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