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Drinking Water Quality Monitoring System

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Abstract

This study addresses the critical issue of drinking water contamination considering globalization and industrial development, emphasizing the paramount importance of ensuring safe water for public health and safety. Leveraging Internet of Things (IoT) technology, the paper explores the potential of IoT-enabled tools to detect and monitor contaminants in real-time, highlighting the need for innovative monitoring equipment capable of accurately measuring various water quality parameters. The urgency for affordable, portable, and precise monitoring tools capable of swiftly identifying a multitude of contaminants is underscored, along with the importance of standardized protocols and data formats for seamless integration with data analysis tools and IoT platforms. Addressing these challenges is essential to ensuring the provision of safe drinking water and mitigating the risk of waterborne illnesses globally. Additionally, the study provides a comprehensive analysis of water quality across various brands, focusing on pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), and temperature. The observed pH values fall within a narrow range, indicating neutral to slightly alkaline properties, meeting drinking water standards. TDS and EC values exhibit a broad spectrum, reflecting diverse mineral content, with lower values in brands sourced from treated tap water and higher values in natural mineral waters. Consistent water temperatures suggest controlled testing conditions. This data-rich analysis equips consumers with valuable insights to make informed choices based on preferences and health considerations.

1. Introduction

Safe drinking water is a necessity for human life. Water is a basic need for every life in this world. Ensuring drinking water quality is essential for human life because safe drinking water is a fundamental human right. Due to globalization and industrial development, our natural resources have been polluted drastically. Our water resources are getting contaminated daily, making it unsafe for every living thing. Human globalization and civilization have caused resources to be polluted. The responsibility to make everything correct falls into our hands. Monitoring the water quality in real-time is essential to ensure it is safe to consume. The revolution of IoT-based systems will be handy for us to monitor the water quality in real time and store the data to be processed. Various processes and studies can be made simultaneously using IoT-based systems. This report explores ideas about a water monitoring device using an IoT system to collect water contaminant readings. Drinking water quality is critical to public health and safety. Continuous monitoring of water quality parameters ensures safe drinking water for communities. Over the years, technological advancements have led to the development of various drinking water quality monitoring devices. This literature review explores the current research and development in drinking water quality monitoring devices, highlighting their key features, advantages, limitations, and prospects. 2 The Health Ministry (MOH) has introduced the Drinking Water Quality Act (DWQA) as a measure to further fortify protection against health hazards due to unsafe drinking water during the virtual celebration of World Health Day 2022 while pointing out the reality of having a lack of access to safe and adequate drinking water [1]. The National Drinking Water Quality Surveillance Program (NDWQSP) has managed to help raise the quality by ensuring the safety of drinking water provided to the public and monitoring the quality of water to reduce the incidence of waterborne diseases or illnesses [1]. WHO leads the global response to prevent water-related diseases and advises governments to bring development and standard regulations [2]. WHO has focused on implementing drinking water quality guidelines through the development of practical guidance.

2. Methodology

Fig. 1 shows the block diagram the process of the entire system, including the implementation of software and hardware. The hardware components used for this system are ESP8266, pH sensor, temperature sensor, ultrasonic sensor, and TDS sensor, which is used to measure and send the data. The ESP8266 will be mounted on NodeMcu base to provide 5V to all the connected sensors. 5V is recommended for the sensor to take precise and accurate reading. Meanwhile, Arduino IDE and Thingspeak are software systems that collect, store, and display all the data.

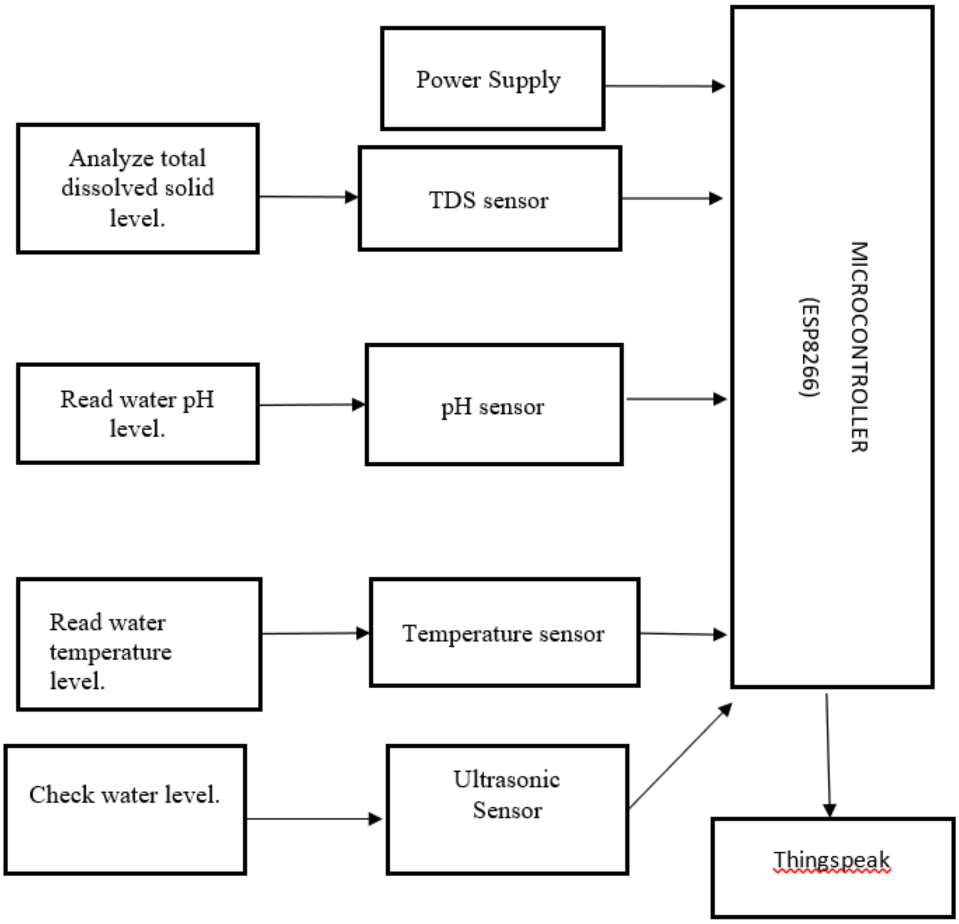


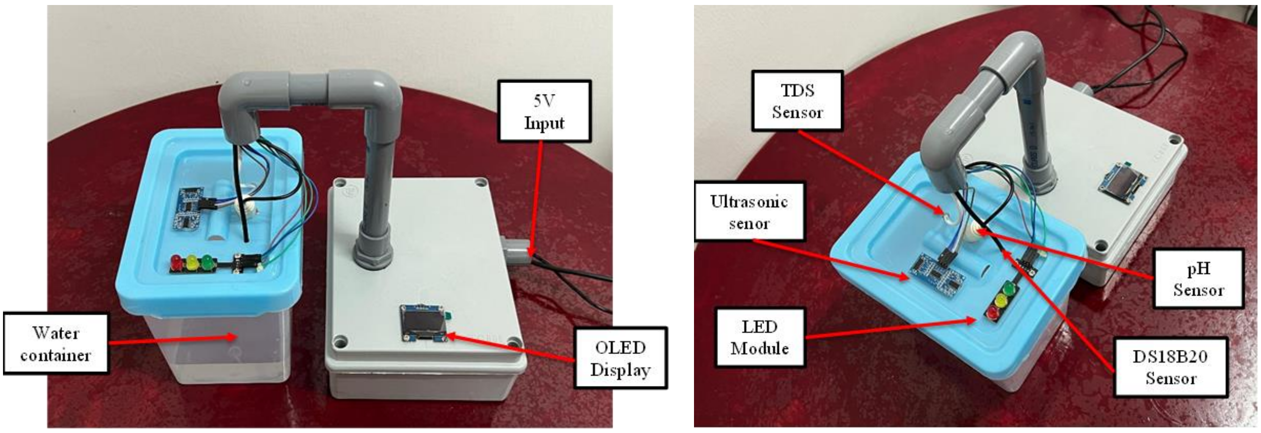
Fig. 1 *Block diagram of drinking water quality monitoring system*

Fig. 2 shows the flowchart for the system design. Firstly, the sensor will take the water level data from the ultrasonic sensor to start the whole process. If the water level does not pass the designated limit, the whole process will stop, and the red led light will start blinking. The led light is installed to notify the users about the water level in the container. This process helps to prevent damage to the pH sensor because absence of water in the probe for a long time may damage the probe. After checking the water level, the sensors will read all the parameters in the water. After collecting the data from the sensors, the average value will sent to the Thingspeak server to be displayed in graphical form. Meanwhile the readings also will be displayed on the oled display in a loop.

3. Results and Discussion

After all the sensors are completely installed in prototype of the drinking water quality monitoring system, the results and data analysis that have been collected are presented here. Fig. 3 shows multiple angles of the prototype. Each figure shows the model from a different perspective, providing a complete comprehension of its design and structure.

Fig. 2 *Flowchart of the system*



(a) (b)

Fig. 3 *(a) Front view and (b) side view of the prototype*

Table 1 *Water parameters reading measured with the prototype*

NO	Water Brand	Type of water	pH	TDS	EC	Temperature
1	Tap Water	-	7.61	61.13	50.00	29.6

2	Boiled Water	-	7.98	89.10	72.00	38.4
3	Distilled Water	Distillation	6.72	1.50	1.00	28.6
4	Sirma Natural Mineral Water	Spring water source	7.09	170.03	89.00	27.1
5	ANDA Natural Mineral Water	Groundwater	7.22	85.00	50.15	29.0
6	ANDA Drinking Water	Treated tap water supply	7.46	25.80	21.00	27.8
7	DASANI Natural Mineral Water	Groundwater	7.21	106.88	87.00	27.9
8	F&N Ice Mountain Drinking Water	Treated tap water supply	7.89	2.92	2.00	27.9
9	Summer Drinking Water	Treated tap water supply	7.78	7.58	6.00	28.3
10	Spritzer Natural Mineral Water	Groundwater	7.34	108.15	88.00	29.2
11	MOMA Drinking Water	Treated Tap Water supply	8.04	2.47	2.00	27.8
12	KK Natural Mineral Water (600ml)	Groundwater	7.40	100.80	82.00	27.8
13	KK Natural Mineral Water (305ml)	Groundwater	7.33	127.35	104.00	28.1
14	One 2 Drink Drinking Water	Treated Tap Water supply	7.88	2.40	2.00	28.3
15	Lotus Natural Mineral Water	Groundwater	7.42	65.70	53.00	27.9
16	Lotus Drinking Water	Treated Tap Water supply	7.86	7.05	6.00	28.3
17	Cactus Natural Mineral Water	Groundwater	7.22	111.90	91.00	28.1
18	Desa Drinking Water	Treated Tap Water supply	7.80	9.15	7.00	28.3
19	Alpine Natural Mineral Water	Groundwater	7.32	66.30	54.00	28.6
20	Blew Natural Mineral Water	Groundwater	7.36	97.50	79.00	28.1
21	Evian Natural Mineral Water	Groundwater	7.46	250.27	204.00	28.4
22	Dixy Natural Mineral Water	Groundwater	6.98	92.17	50.00	28.9
23	Desa Natural Mineral Water	Groundwater	7.02	127.72	70.00	29.1
24	Fuji Water Taman Melewar	Treated tap water supply	6.89	61.87	50.00	28.8
25	Energy Water Taman Melewar	Treated tap water supply	7.29	61.95	50.00	28.8
26	Miracle Hydrogen Taman Melewar	Treated tap water supply	7.38	63.15	52.00	28.8
27	Nucleus Nano Alkaline Taman Universiti	Treated tap water supply	6.87	74.25	60.00	29.9
28	Classic Taman Universiti	Treated tap water supply	6.76	100.72	82.00	30.6
29	Energy Taman Universiti	Treated tap water supply	6.96	69.45	56.00	30.6
30	DS MSR 3 Taman University	Treated tap water supply	6.93	64.28	52.00	30.4
31	Aqua Taman University	Treated tap water supply	6.97	66.45	54.00	31.8

The provided data in Table 1 offers a detailed insight into the water quality of various brands, encompassing essential parameters such as pH shown in Fig. 4, Total Dissolved Solids (TDS) shown in Fig. 5, Electrical Conductivity (EC) shown in Fig. 6, and temperature.

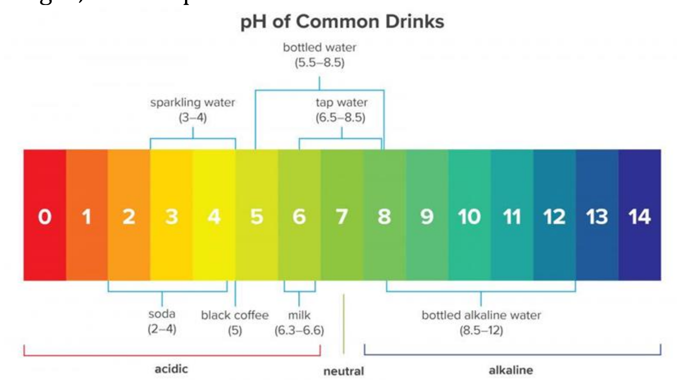


Fig. 4 *pH level in water*

Notably, the pH values across all brands fall within a relatively narrow range from 6.72 to 8.04, indicating that the tested waters are generally neutral to slightly alkaline, meeting standard expectations for drinking water. The TDS values exhibit a broad spectrum, spanning from 1.5 to 250.27 ppm, with distilled water showcasing the lowest TDS and natural mineral waters like Evian and Spritzer displaying higher values. This variation underscores the diverse mineral content in the tested waters. The EC values follow a similar trend, reflecting the concentration of ions in the water. The consistent water temperatures, ranging from 27.1 to 31.8 degrees Celsius, suggest careful testing under controlled conditions. The analysis reveals those brands like Distilled Water and ANDA Drinking Water from treated tap sources present lower TDS and EC values, potentially appealing to those seeking purified water. In contrast, natural mineral waters like Evian and Spritzer, with higher TDS and EC values, may attract consumers interested in the potential health benefits associated with elevated mineral content. Overall, this data-rich analysis provides a comprehensive understanding of the nuanced differences in water quality among the tested brands, enabling consumers to make informed choices based on their specific preferences and health considerations.

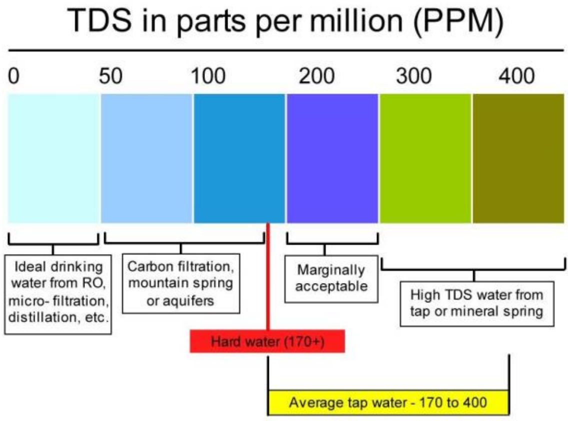


Fig. 5 *Total dissolved solids level by WHO*

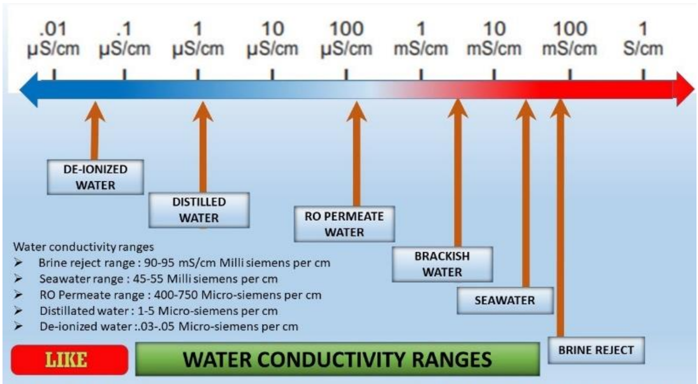


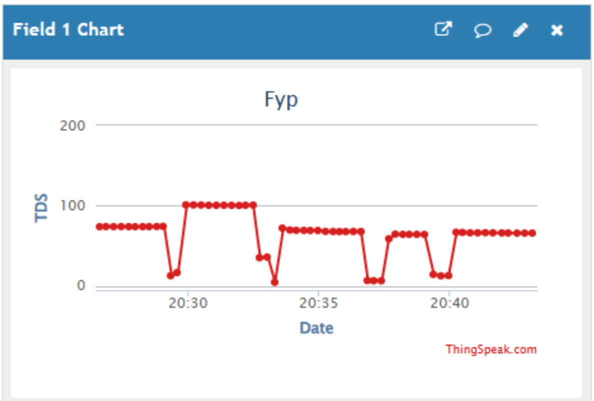
Fig. 6 *Electrical conductivity level set by WHO*

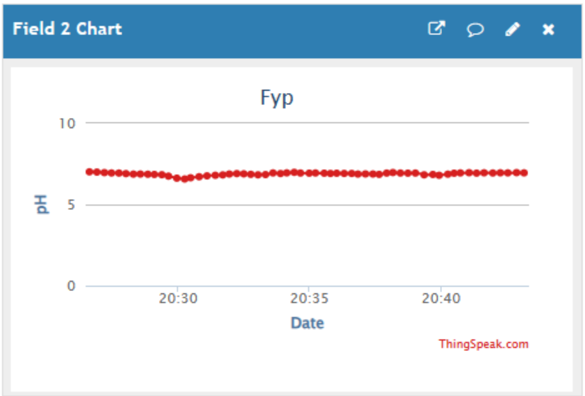
4. Analysis

Three types of water have been used for testing the prototype. Mineral water, treated tap water, and filtered water were used to test the function of the prototype. These sources are commonly used in daily life. Mineral water, sourced from natural underground springs, is known for its rich mineral content, including calcium and magnesium [3]. It is often considered a clean and pure option with potential health benefits, though it can be pricier and raises environmental concerns due to packaging. Treated tap water, commonly supplied by municipalities, undergoes processes like chlorination for safety [4]. It is widely accessible, affordable, and regulated, but some may find its taste less appealing. Filtered water, achieved through various methods, offers a compromise. It improves taste, eliminates impurities, and is environmentally friendly, though it requires initial investment and maintenance. Choosing between mineral, treated tap, and filtered water depends on personal preferences, health considerations, and environmental awareness. Regular water quality testing is crucial, regardless of the chosen source.

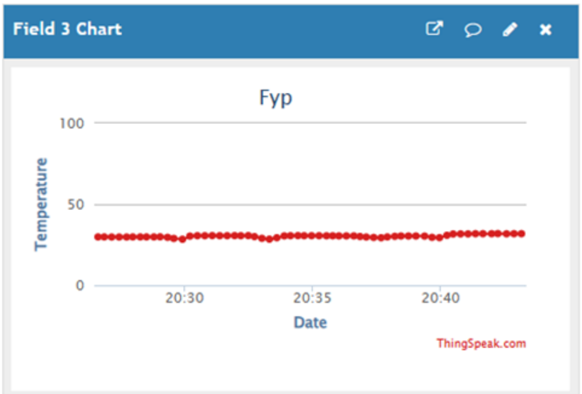
5. Thinkspeak Analysis

Thingspeak has been used for IOT construction for this work. This IoT platform has been designed and developed to monitor the water quality level using the prototype. Thingspeak has been chosen to have access to show the results in real-time and store the data in the cloud. The data collection can be monitored from any place at any time for further analysis. The screenshot of collected data from the thingspeak show and data analysis in the MIT application has been attached. MIT application has been developed to be user-friendly and can help users monitor the water quality readings through their mobile application. The collected data are shown in Fig. 7.





(a) (b)



(c)

Fig. 7 *(a) TDS reading in Thingspeak (b) pH reading in Thingspeak (c) Temperature reading in Thingspeak*

6. Conclusion

In conclusion, implementing the drinking water quality monitoring system marks a significant stride in safeguarding the safety and cleanliness of water for human consumption. This innovative system offers real-time insights into critical parameters like Total Dissolved Solids (TDS), pH, and temperature by integrating cutting-edge hardware and software applications. By incorporating this system into water quality management practices, individuals can proactively monitor and analyze their drinking water, fostering a safer environment for humans and wildlife.

The system's real-time capacity to measure TDS, pH, and temperature is pivotal in ensuring accurate and timely water quality assessments. With enhanced accuracy and minimal delay in data transmission, users can trust immediate and reliable information about their drinking water. Rigorous testing conducted on the TDS sensor further validates the precision of the collected data, instilling confidence in the system's performance.

Furthermore, the ongoing development of standardized protocols and data formats is crucial for seamless integration with data analysis tools and IoT platforms, enhancing the system's effectiveness and accessibility. By addressing these challenges, we bolster our capacity to provide safe drinking water and mitigate the risk of waterborne illnesses, ultimately safeguarding public health and safety for both present and future generations. To further enhance the system's effectiveness, it is recommended to focus on continuous improvement through updates and enhancements, foster collaboration among stakeholders, raise public awareness and education, expand the monitoring network to underserved areas, and integrate the system with water treatment facilities. By implementing these recommendations, the monitoring system can play a pivotal role in ensuring access to safe drinking water and promoting a healthier environment for both present and future generations.

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Conflict of Interest

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

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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