

## Smart Mini Aquarium Monitoring System

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### Abstract

Pet ownership has been increasing steadily over the past 20 years, with freshwater fish now ranking as the third most popular pets after cats and dogs. Maintaining fish aquariums is a challenging task, requiring regular monitoring to ensure the health and well-being of the fish. This report explores the development and effectiveness of an advanced mini aquarium system designed to assist users in maintaining optimal aquarium conditions. The system leverages the ESP32 microcontroller and IoT technology to facilitate real-time communication between devices and users. Key water parameters, including pH and Total Dissolved Solids (TDS), are continuously monitored by sensors. The pH sensor measures the water's acidity and alkalinity, while the TDS sensor detects the total dissolved solids levels, indicating overall water quality. The collected data is transmitted wirelessly to users' smartphones via the Telegram application, allowing for immediate notifications about water conditions. This enables users to promptly address any issues, such as high nitrate levels or suboptimal pH, preventing fish health problems and potential fatalities. The project encompasses the design, implementation, testing, and evaluation of the aquarium system. Detailed analysis demonstrates the system's capability to maintain water quality efficiently, thereby enhancing fish care and simplifying aquarium maintenance. Additionally, the report discusses potential improvements and future developments for the system. By providing real-time data and alerts, the mini aquarium system aims to revolutionize aquarium management, making it more accessible and manageable for pet owners, ensuring the proper care and longevity of their fish.

## 1. Introduction

Fishkeeping is very popular but it's never going to be easy as the word is. It is a challenging job to take care of them as they are very sensitive to any changes in their surroundings [1]. This is because poor aquarium conditions will harm the fish. So, the aquarium tanks need to be properly set up and maintained. Specifically, when the water volume in the tank is small, key water parameters change very quickly. Therefore, it is critical to monitor water conditions closely and perform water changes faithfully for the mini aquarium tanks [2]. Then, unsafe water conditions, including high nitrates and less than ideal pH levels, can lead to a variety of health problems for your animals and plants. When fish are stressed and weak, they are more susceptible to ich and

other illnesses. Nowadays there are also systems that can monitor the water condition, but not all the time. From this problem, some system needs to be upgraded and used to resolve this issue.

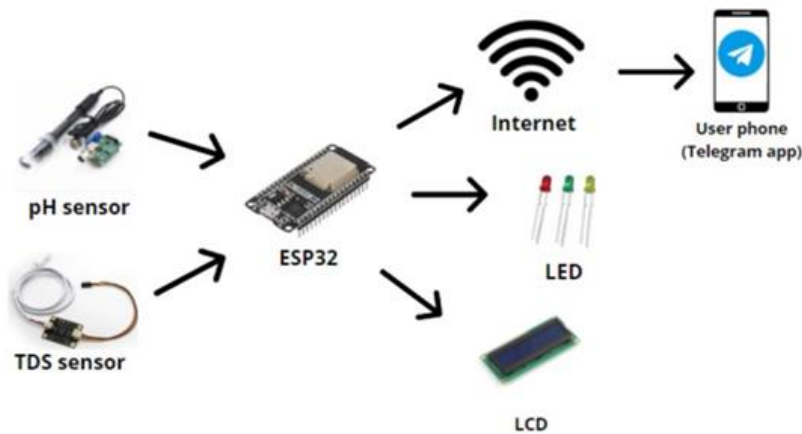
Table 1 highlights the various sensors and microcontrollers used in different aquarium monitoring systems. The level of IoT integration varies, with some projects using FishTalk servers, Server Thingspeak, or specific applications like Blynk. Key features include cost-effective sensors, real-time notifications, and comprehensive monitoring solutions, demonstrating significant advancements in aquarium monitoring technology. Each project aims to improve aquarium care and response, minimize the risk of making fatal mistakes that cause fish to die.

**Table 1** Comparison table for each previous work

Article	Sensor	Microcontroller	IoT
1) FishTalk: An IoT-Based Mini Aquarium System [1]	<ul style="list-style-type: none"> <li>• DO sensor</li> <li>• Temperature sensor</li> <li>• pH sensor</li> <li>• EC sensor</li> <li>• Water level sensor</li> <li>• TDS sensor</li> </ul>	<ul style="list-style-type: none"> <li>• Arduino UNO</li> <li>• ESP8266 ESP-12F</li> <li>• ROHM IoT Kit</li> <li>• MediaTek LinkIT Smart 7688 DUO</li> </ul>	FishTalk Server
2) IoT Based Automated Fish Tank Monitoring System [2]	<ul style="list-style-type: none"> <li>• Temperature sensor</li> <li>• Ultrasonic sensor</li> </ul>	<ul style="list-style-type: none"> <li>• ESP8266</li> </ul>	Mobile App
3) <i>Monitoring Kualitas Air Aquarium Berbasis Internet of Things</i> [3]	<ul style="list-style-type: none"> <li>• Temperature sensor</li> <li>• TDS sensor</li> <li>• pH sensor</li> </ul>	<ul style="list-style-type: none"> <li>• NodeMCU</li> </ul>	Server Thingspeak
4) Aquarium Monitoring System via IOT [4]	<ul style="list-style-type: none"> <li>• Temperature sensor</li> <li>• pH sensor</li> <li>• Ultrasonic sensor</li> </ul>	<ul style="list-style-type: none"> <li>• ESP8266 NodeMCU</li> </ul>	BlynkApps
5) Smart Aquaculture using Internet of Things (IoT) [5]	<ul style="list-style-type: none"> <li>• pH level</li> <li>• Temperature sensors</li> </ul>	<ul style="list-style-type: none"> <li>• NodeMCU ESP322</li> </ul>	Cayenne Platform
6) Smart Aquarium using IoT [6]	<ul style="list-style-type: none"> <li>• Temperature sensor</li> <li>• pH sensor</li> <li>• Turbidity sensor</li> </ul>	<ul style="list-style-type: none"> <li>• ESP8266 Wifi Module</li> <li>• Arduino UNO</li> </ul>	IoT Platform

## 2. Methodology

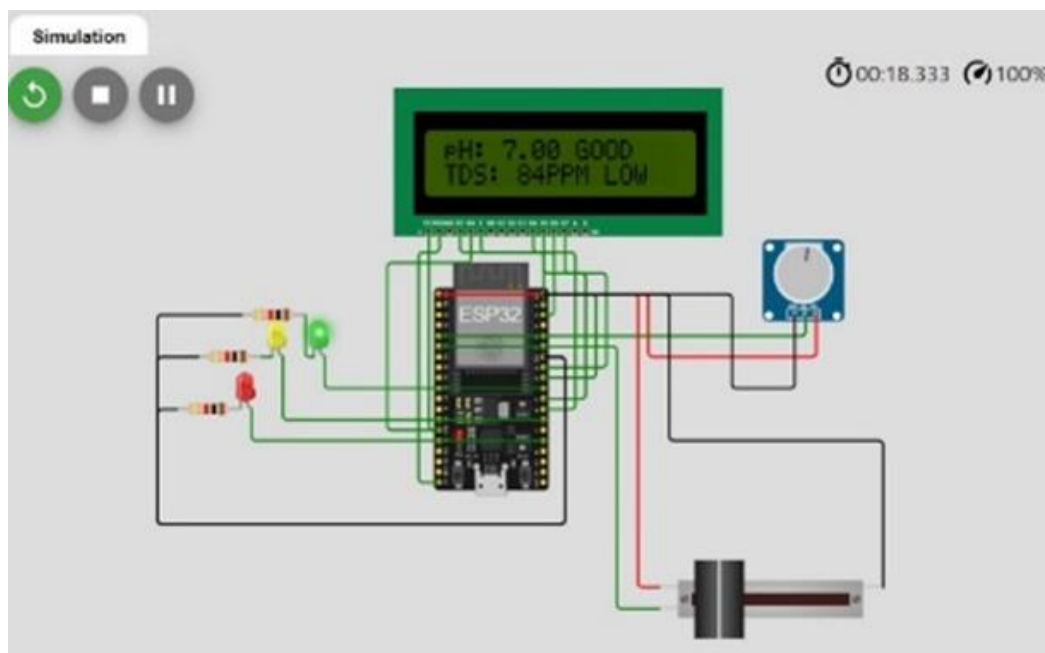
Figure 1 shows the block diagram of this project aquarium monitoring system, which has 2 inputs, pH sensor and TDS sensor. The ESP32 is used as the microcontroller in this system. Other than that, the output of this system is the LED will light up, and the LCD will display the value input; due to the IoT, the Telegram application is used in this system.



**Figure 1** Block diagram of smart mini aquarium monitoring system

Figure 2 shows the flowchart of this system, there are three conditions in this flowchart. The first condition is about the pH value and the second condition is about the TDS value. The last condition is about the comparing the value of two sensor and this will indicate using the LED.

Figure 3 is a preliminary test for this project, Wokwi software was used for making this preliminary test. Initial tests for a prototype aquarium monitoring incorporating potentiometer use as a substitute for pH and TDS sensor, red, yellow and green LEDs, LCD, and using a ESP32 as a microcontroller with Wokwi simulation software, aim to evaluate the effectiveness of these components in detecting and warning of possible flood events, evaluating its response and integration, and identify any issues for refinement in the simulated environment.



**Figure 3** Preliminary test using Wokwi

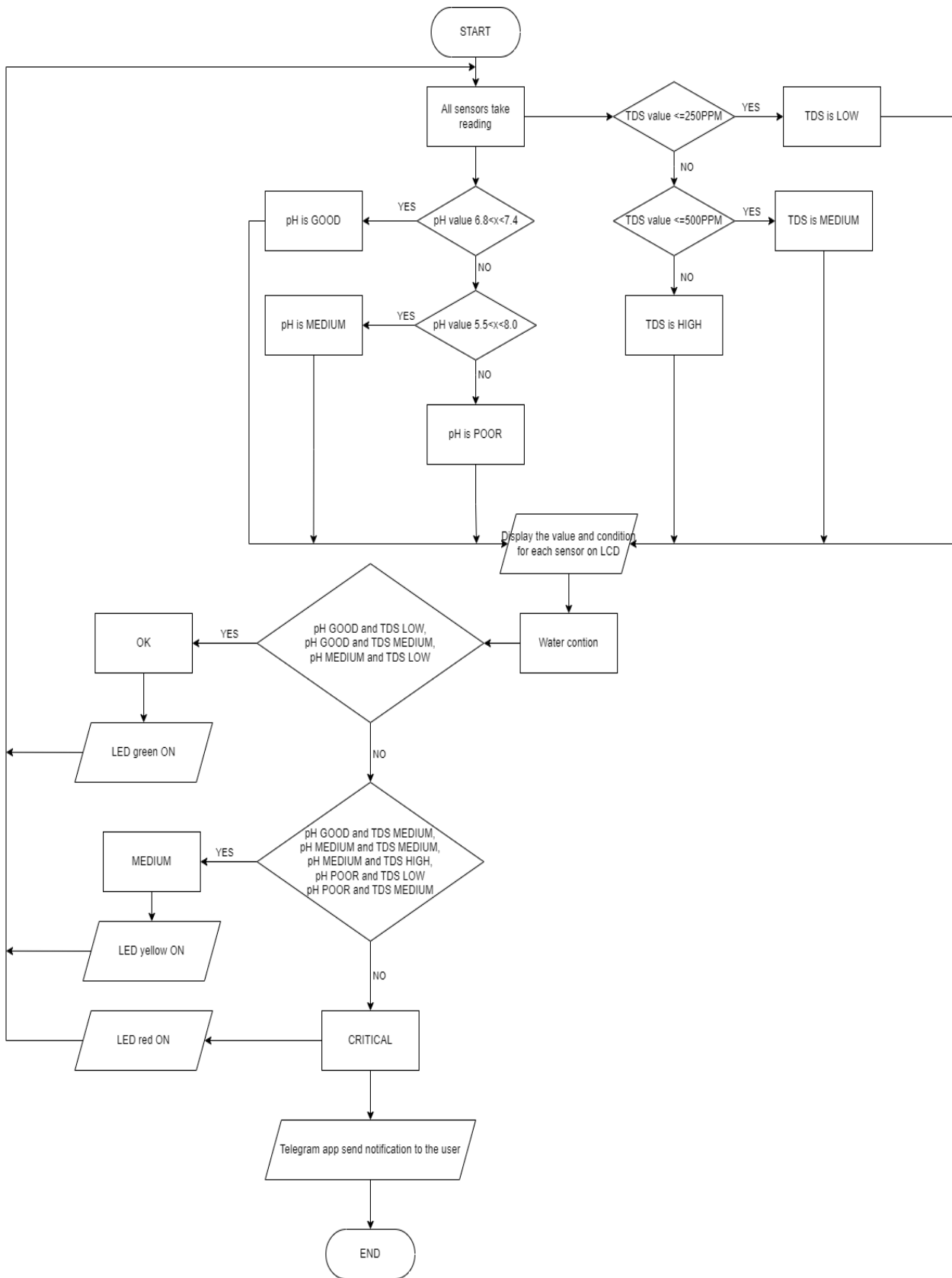
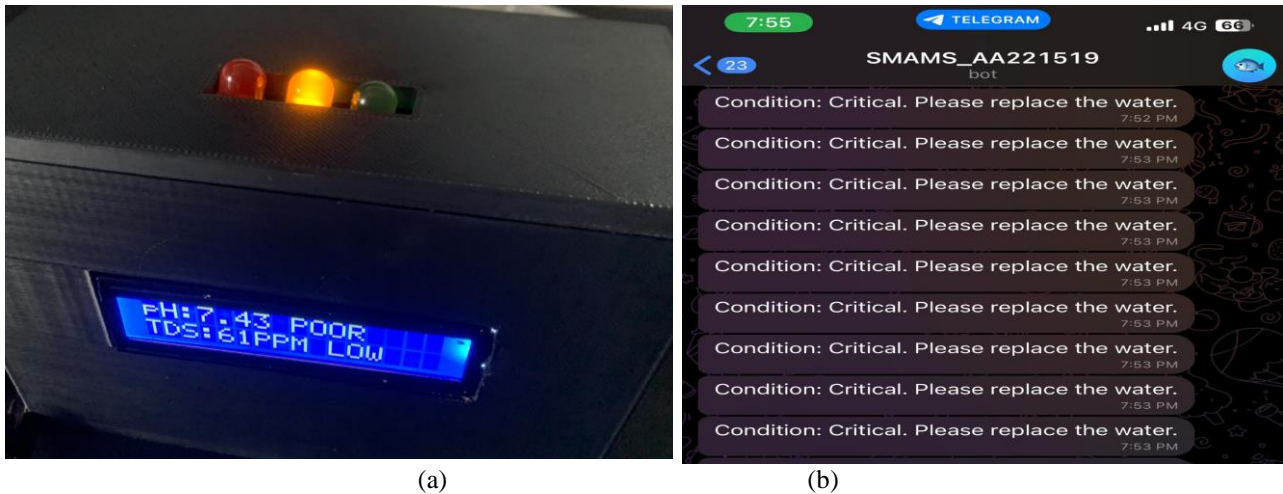


Figure 2 The flowchart of smart mini aquarium monitoring system

### 3. Results and Discussion

Figure 4 Shows the indicator for the LCD, LED and the message from the telegram for the completed system. The indicator part of the aquarium monitoring system includes an LCD, LED and a Telegram messaging service, both essential for providing real-time alerts about water condition. The LCD displays real-time data of the value based on pH and TDS sensors. The LED indicates the condition of water in aquarium. Telegram messaging sends real-time aquarium care alerts to users' smartphones, ensuring critical information is received even away from the LED.



**Figure 4** Indicator for (a) LCD, LED and (b) Telegram

Table 2 shows the LED detect on type of condition from pH and TDS value. The system being described is designed to respond to value of pH and TDS readings. There are several conditions of pH and TDS sensor. For green LED detect, the condition is must pH is good and TDS is low, pH is good and TDS is medium, and pH is medium and TDS is low. For yellow LED detect, the pH is good and TDS is High, both pH and TDS is medium, pH is medium and TDS is high, pH is poor and TDS is low, and pH is poor and TDS is medium. For red LED detect, the condition for pH is poor and TDS is high.

**Table 2** Detection of LED colour

Condition	pH sensor	TDS sensor	LED (Detect)		
			Green	Yellow	Red
Good	Good	Low	✓	✗	✗
Good	Good	Medium	✓	✗	✗
Good	Good	High	✗	✓	✗
Medium	Medium	Low	✓	✗	✗
Medium	Medium	Medium	✗	✓	✗
Medium	Medium	High	✗	✓	✗
Poor	Poor	Low	✗	✓	✗
Poor	Poor	Medium	✗	✓	✗
Poor	Poor	High	✗	✗	✓

In State conditions: -

- pH value= 0 – 5.4 & 8.1 – 14 (POOR)
- 5.5 – 6.7 & 7.5 – 8.0 (MEDIUM)
- 6.8 – 7.4 (GOOD)
- TDS value= 0 – 250 (LOW)
- 251 – 500 (MEDIUM)
- 500 > (HIGH)

Table 3 shows the time taken by indicator to produce an output. The table shows how different indicators react to signals from two sensors across six trials. All the trials use pH and TDS sensors. For trial 1-2 is focused on green LED detect, trial 3-4 for yellow LED detect and trial 5-6 for red LED detect. As we see, the telegram response on LED red only. For the LCD, the output value from the pH sensor takes 1 second and TDS sensor takes 17.83 seconds. All LED responses in 1 second. On average, Telegram takes 4.5 seconds to response. This test shows the system response effectively to notify the users.

**Table 3** Time for indicator produces an output in second (s)

Trial	LCD		LED			Telegram
	pH sensor	TDS sensor	Green	Yellow	Red	
1	1	18	1	-	-	-
2	1	18	1	-	-	-
3	1	18	-	1	-	-
4	1	18	-	1	-	-
5	1	19	-	-	1	4
6	1	16	-	-	1	5
Average	1	17.83	1	1	1	4.5

In State Trial= 1-2 (LED green detect)  
3-4 (LED yellow detect)  
5-6 (LED red detect)

#### 4. Conclusion

This project developed an advanced mini aquarium system using ESP32 microcontroller technology and IoT concepts to provide real-time monitoring of essential water parameters like pH and Total Dissolved Solids (TDS). The system's sensors continuously collect data, which is wirelessly transmitted to user's smartphones via the Telegram app, allowing for immediate notifications and timely interventions. By simplifying maintenance tasks and reducing the risk of fish health issues due to poor water conditions, this system enhances fish care and makes aquarium upkeep more efficient and accessible for pet owners, offering a promising solution and paving the way for future advancements.

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#### Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of the paper

#### Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Muhammad Faiq Mughis; **data collection:** Muhammad Faiq Mughis; **analysis and interpretation of results:** Muhammad Faiq Mughis; **draft manuscript preparation:** Muhammad Faiq Mughis;. All authors reviewed the results and approved the final version of the manuscript.

#### References

- [1] K. Dinesh, M., "IoT Based Automated Fish Tank Monitoring System," *Int. Res. J. Mod. Eng. Technol. Sci.*, vol. 4, pp. 2135-2140, 2022.
- [2] Y.-B. Lin, H., "FishTalk: An IoT-Based Mini Aquarium System," *Natl. Chiao Tung Univ.*, vol. 7, pp. 35457-35469, 2019.
- [3] B. S. Kusumaraga, S., "Monitoring Kualitas Air Akuarium Berbasis Internet of Things," *Program Studi Teknik Elektro, Universitas Muhammadiyah Sidoarjo*, vol. 1, 2021.
- [4] A. S. Shamshulbahrin, Dr., "Aquarium Monitoring System via IOT," *Univ. Kuala Lumpur Br. Malaysian Inst.*, vol. 10, pp. 13-16, 2022.
- [5] N. binti Halim, B., "Smart Aquaculture using Internet of Things (IoT)," *Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer, Universiti Teknikal Malaysia Melaka*, pp. 77-78, 2021.

- [6] F. A. Z. Shaikh, U., "Smart Aquarium using IoT," *Int. J. Res. Appl. Sci. Eng. Technol. (IJRASET)*, vol. 10, no. 3, pp. 151-156, 2022.