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Design and Construction of a Prototype of a Water Clustering System at a Water Treatment Plant at an Airport Using an Esp 32 Microcontroller Based on the Internet of Things (IoT) and Fuzzy Logic

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ABSTRACT
Water quality in water treatment plants at airports is a crucial aspect that affects the health and service of passengers and airport operations. The author's goal is to create a prototype that will be able to collect and analyze water quality data with reference to the parameters of pH, water temperature, and water turbidity used. The data that has been taken from the three sensors will then be processed by the ESP32, which functions as a microcontroller and water quality controller by utilizing a 12V R385 DC pump, as well as monitoring data. Then the results of the sensor measurement monitoring data can be seen in the form of graphs on the Thingspeak website in real-time.

1. INTRODUCTION

Airports are facilities that are commonly used for landing and takeoff of aircraft. Flight service facilities, as well as other supporting infrastructure and facilities must be available at an airport. One of the important facilities at the airport is the clean water distribution process, therefore clean water is something that must be considered because later this clean water will be used for all activities at the airport and the water must be in a completely clean condition according to the regulations set by the Ministry of Health.

Airports produce various contaminants through maintenance activities, which can pollute water sources. Rainwater management is very important, because pollutants can enter the ground and surface water, requiring effective monitoring and remediation strategies, Sulej-Suchomska et al., (2024). Applying advanced methodologies to detect pollutants in airport runoff can improve water quality assessments, Sulej-Suchomska et al., (2024). Utilizing big data analytics can improve operational efficiency and service quality, including water management systems ("Enhancing Airport Business Services Using Big Data Analytics", 2022).

Controlling the pH of clean water is a fairly important step in maintaining good water quality in order to maintain the health and purity of the water. According to the Regulation of the Minister of Health No. 2 of 2023, most of the clean water used has a pH between 6.5 and 8.5 (Hasrianti, 2016). Then for the level of water turbidity around 3-5 NTU and for the temperature of the clean water itself ranges from 15-35 ° C. Water quality with a pH that is not higher or can also be lower can also indicate the presence of heavy metals or chemical pollution. pH measurements that want to be more accurate can use a pH meter.

Water quality processing at the water treatment plant at the airport is very important and requires supervision. When carrying out the first On the Job Training at Iskandar Airport, Pangkalan Bun, the clean water distribution process was carried out from pump suction from groundwater sources which were then collected in water tanks, after which they were immediately distributed to all terminal areas or the entire airport. In this process, there is still no further water treatment if the water conditions do not meet standards and there is still no monitoring of the pH value of the water, monitoring of turbidity and water temperature automatically, so that technicians take measurements manually and of course it is still ineffective. In these conditions, it is feared that the water that will be distributed to the terminal area will not be suitable, then it is feared that it will affect the airport service.

The water comes from groundwater, which may contain contaminants that require treatment before distribution, Fazal & Mataram, (2023). Technicians measure pH, turbidity, and temperature manually, which is inefficient and prone to error, Nugrahanik & Utomo, (2021). Poor water quality can cause health problems, as seen at other airports where water does not meet safety standards, Putri & Utomo, (2020). Airports must comply with environmental management standards to prevent pollution and ensure public safety, Sulej-Suchomska et al., (2024). The use of Polyvinylidene Fluoride (PVDF) membranes with additives such as Tin (IV) Dioxide (SnO_2) has shown promise in improving the efficiency of water treatment, Fazal & Mataram, (2023). Automatic Monitoring System: Implementing an automated system for real-time monitoring can improve the effectiveness of water quality assessment, Nugrahanik & Utomo, (2021).

Water that does not have clean quality standards can have a negative impact on human health and the environment in the surrounding area. An IoT-based water clustering system is a modern solution that uses advanced technology to provide efficient water management. There is a key component in this system, namely the use of IoT technology, this allows remote control and monitoring of various aspects of the system, including water quality and quantity. Seeing the need for water supervision in the clean water distribution system at this airport, the author has an idea to create a tool that can monitor and cluster water based on water pH, water temperature, and water turbidity based on IoT at the water treatment plant, so that water quality monitoring can be carried out automatically and efficiently.

IoT systems use multiple sensors (e.g., pH, turbidity, temperature) connected to a microcontroller such as Arduino or ESP32 to continuously monitor water quality, Dubey et al. (2024). The collected data is transmitted wirelessly to a cloud platform or user interface, allowing for immediate access and analysis (Amirgaliyev et al., (2024), López-Munoz et al., (2024). Automated systems provide critical information for timely intervention, improving water management strategies, Amirgaliyev et al. (2024). Many systems feature intuitive dashboards that visualize data trends, making it easier for users to interpret water quality, Mourya et al. (2024). Despite the advantages, challenges such as sensor calibration, data security, and the need for robust infrastructure remain. These factors can affect the reliability and effectiveness of IoT-based water monitoring systems, requiring continued research and development to address these issues, Dubey et al. (2024).

So in connection with the above explanation, the author would like to submit a Final Project entitled "Design and Construction of a Prototype of a Water Clustering System at a Water Treatment Plant at an Airport Using an Esp 32 Microcontroller Based on the Internet of Things (IoT) and Fuzzy Logic."

2. LITERATURE REVIEW

2.1. Hardware

In making tools, the most important thing is the component devices, including the following:

1. Water pH Sensor

A Water pH Sensor is a sensor that functions as a measure of the acidity or alkalinity of water or solution. The working principle is to use a glass electrode to measure the amount of H_3O^+ ions in a solution. pH sensors often require periodic calibration to maintain accuracy. The pH sensor is based on the principle of measuring the amount of H_3O^+ ions in a solution using a glass electrode. When the pH electrode is immersed in a solution, ionization causes a change in voltage, which is converted into a pH value.

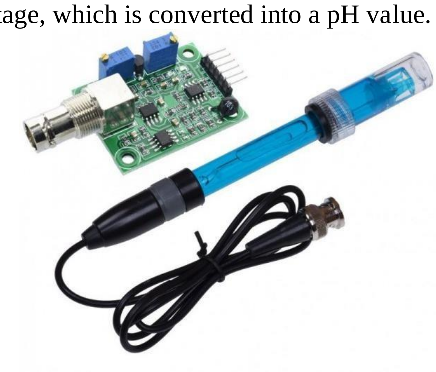

Figure 1. Water pH Sensor

2. Turbidity Sensor

A turbidity sensor is a sensor used to measure the turbidity or clarity of water or a solution. The more turbid the solution, the less light is reflected to the sensor. Turbidity sensors usually produce analog or digital voltage signals that can be processed by a microcontroller such as Arduino to display or store measurement data. Turbidity sensors can also be used in other applications, such as water treatment plants and the food industry.

Figure 2. Turbidity Sensor

3. DS18B20 Water Temperature Sensor

The DS18B20 water temperature sensor is a sensor that measures water temperature. Water temperature sensors are usually equipped with a waterproof probe that can be immersed in water to measure temperature. Commonly used water temperature sensors include thermistor sensors, RTD sensors, and LM35 sensors. Water temperature sensors measure changes in the resistance of the sensing element caused by changes in water temperature.

Figure 3. DS18B20 Water Temperature Sensor

4. ESP32

The ESP32 is a microcontroller module that offers low cost and power efficiency but still has very adequate features and performance. This module is equipped with two processors: one to handle Wi-Fi and Bluetooth networks, and another to run applications. In addition, the ESP32 also supports analog signal processing, various sensors, and digital input/output (I/O) devices.

Figure 4. ESP32

5. 12V R385 DC Pump

12V R385 DC pump is a type of water pump that is usually used to suck water and is usually used for mini aquariums, mini ponds, and others. In the 12V R385 DC pump, the roller or cylinder movement is usually driven by a DC motor, which produces a rotary motion to compress and push the liquid through the hose.

Corona is a phenomenon that occurs when the air around a conductor becomes ionized. This process releases charges that can cause dielectric breakdown in the air.

Figure 5. 12V R385 DC Pump

6. 5VDC mini submersible water pump

A 5VDC mini submersible water pump is a type of water pump that is usually used to circulate small water in aquariums so that the water condition remains circulating. The working voltage for the mini submersible water pump is 5 VDC. This pump has a fairly small diameter so that it is easy to integrate into prototype projects.

7. Organic Light Emitting Diode (OLED)

Organic Light Emitting Diode (OLED) is a tool used as a medium to display information in the form of words or numbers so that it can be monitored via the OLED screen. In using OLED, it uses layer technology that uses organic light-emitting diodes to produce images. OLED will later be used as a medium to display information on the device with a size of 0.96 inches with 128x64 pixels

8. Relay

A relay is an electronic device that can connect or disconnect large currents with small currents, and a relay is a switch that operates based on the principle of electromagnetism when a weak current is passed through a coil with a soft iron core.

2.2. Software

1. ThingSpeak Website

ThingSpeak is an Internet of Things (IoT) platform that users can use to monitor and analyze data from various devices and sensors connected to the internet. This platform was developed by MathWorks. ThingSpeak offers cloud services for flexible and customizable sensor data management.

2. MATLAB Application

MATLAB (Matrix Laboratory), which can be used to organize and determine the rule base of several sensors used. In the control system to carry out the fuzzification process, which aims to obtain the value of the fuzzy, the application of the rule base, and the final result of data processing or deffuzification.

3. METHODOLOGY

3.1. Research Design

In the design of the research design for the Design and Construction of a Prototype of a Water Clustering System at a Water Treatment Plant at the Airport Using an Esp 32 Microcontroller Based on the Internet of Things (IoT) and compiling the research conducted. The ESP32 microcontroller was chosen because of its Wi-Fi capabilities and versatility in handling multiple sensors, making it ideal for IoT applications, Umami et al. (2024). This system combines pH, TDS, and turbidity sensors to monitor water quality parameters in real-time, sending data to a cloud platform for analysis, Yusri et al. (2024). The project followed an R&D methodology, including stages such as hardware integration testing, software integration testing, and system functionality testing to ensure all components work seamlessly, Umami et al. (2024). Leveraging a cloud computing platform, data collected from the sensors can be analyzed for trends and anomalies, improving decision-making in water management. Austin et al. (2024). The prototype was tested with various water samples, demonstrating high accuracy in monitoring water quality, with a deviation of ±0.5% compared to laboratory results, Yusri et al. (2024). The system can automatically adjust the water

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treatment process based on real-time data, improving efficiency and response time, Tundo et al. (2024). Below is a flowchart of the research stages we conducted:

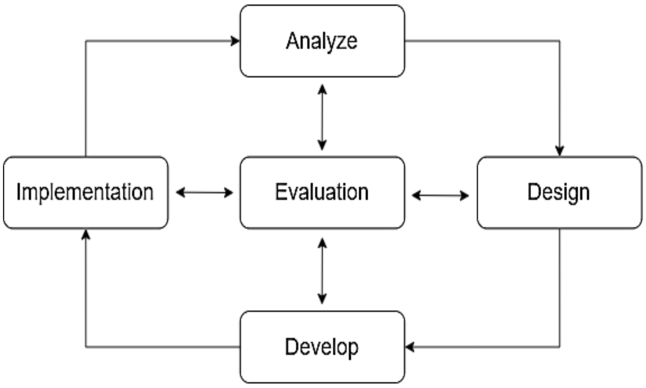

Figure 6. Research Desgin

3.2. Tool Design

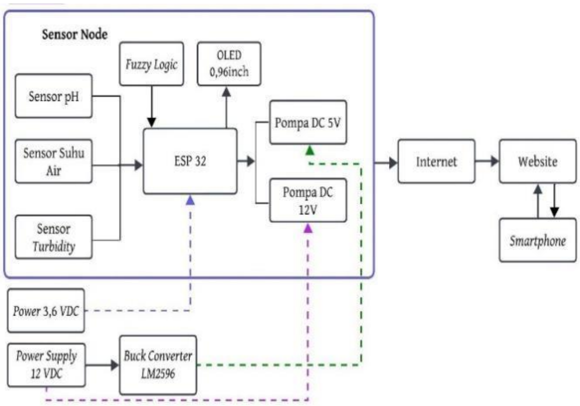

Figure 7. Tool Design Block Diagram

In the block diagram image above, it can be seen that there are three main processes that will be used as a reference for data collection. These processes are input, data processing, and output. In the input process, data is obtained through a pH sensor, which is used to measure the acidity or alkalinity of a liquid, a water temperature sensor to measure the temperature of the water, and a turbidity sensor to measure the turbidity or clarity of a liquid.

The next process is the data processing process obtained through the ESP 32 from the sensor. The working process of this tool is that the sensor node will read the actual conditions that occur in real time. The sensor node itself consists of a pH sensor, a DS18B20 water temperature sensor, and a turbidity sensor. The data obtained from the sensor node will be processed through the ESP 32 which here has a role as the main brain in reading and processing data from the sensor.

The next process is the output process where the data obtained through the three sensors and processed by the ESP 32 will be used as input for fuzzy logic. From the results of the sensor data measurements, it will be clustered or divided into three membership functions, which include water pH (acidic, normal, alkaline), DS18B20 water temperature (cold, normal, hot). Then for the turbidity sensor, it will be used to monitor the turbidity of the water. Furthermore, from the two sensor values that are used as sensor data, it will be clustered or divided into three membership functions, the fuzzification process will be carried out to obtain a fuzzy value with an output range of 0 - 1. After grouping the data using fuzzy logic, it can be controlled or acted upon if there is a mismatch in the pH and water temperature conditions. Then after getting the value of the water pH and water temperature, the action taken is the DC 12V R385 pump will turn on to control so that the water conditions remain stable, neither acidic nor alkaline, and there is a 5V mini submersible water pump that is used as water circulation when acidic or alkaline liquids enter, the water is quickly evenly distributed because there is water circulation. After data processing and control using fuzzy logic, the data will be sent via the internet network, then the data will be displayed on a website that can also be accessed via a smartphone, so that users or authorized parties will be able to monitor the condition and information about the clean water processing process in real time. On the OLED installed on the sensor node, there is also information displayed, so for the information system on this tool it is displayed on the website and OLED (Organic Light Emitting Diode).

4. RESEARCH RESULTS AND DISCUSSION

4.1. Analysis

At this stage, it begins with analyzing the potential of the problem, identifying tools, and thinking about the tools to be developed. In making this tool, researchers found problems, namely the ineffectiveness of monitoring the pH value of water, monitoring the turbidity and temperature of water automatically before the water is distributed, so that technicians take measurements manually and of course it is still not effective. In these conditions, it is feared that the incompatibility of the water that will be distributed to the terminal area and the entire airport will affect the airport service.

4.2. Design

After the analysis stage is carried out, the next step is for the author to carry out the planning stage (design) of the tool to be produced. Making a reference for the placement of components and installation of the tool to be produced. This phase is a framework before developing the tool. The framework in question is the component used to make the final assignment tool.

At this design stage, the designed system circuit will be implemented on the printed circuit board (PCB). The PCB design of the circuit can be shown in the figure below.

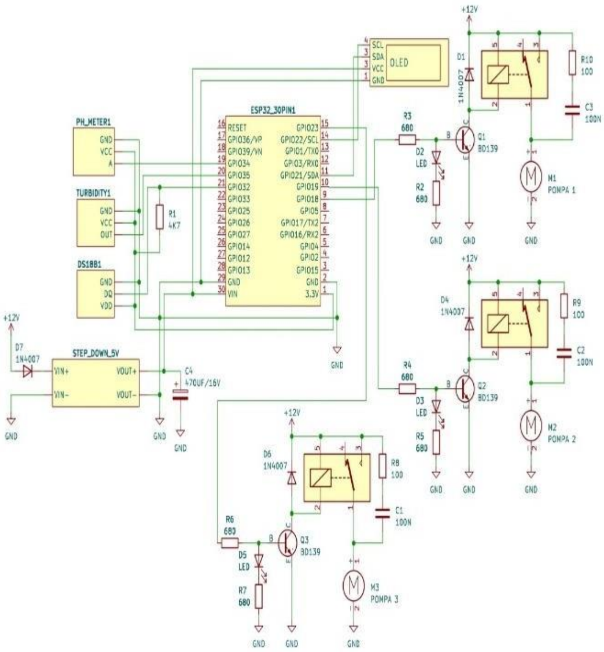

Figure 8. Wiring Hardware System Circuits

4.3. Development

The development stage is the stage where the design or system plan that has been made previously will be realized to become the desired product. At this development stage, what has been designed at the design stage will begin to be actualized into a tool that meets expectations.

4.3.1. Hardware manufacturing

Figure 9. Overall Tool View

Description:
1. Power Supply
2. OLED
3. ESP32
4. Buck Converter LM2596
5. Relay
6. Water pH sensor
7. Turbidity sensor
8. Water temperature sensor DS18B20
9. DC pump 12V R385 (as a PH UP pump)
10. DC pump 12V R385 (as a PH Down pump)
11. Mini submersible water pump 5VDC
12. Aquarium as a testing place

4.3.2. Software manufacturing

a. Arduino IDE Application

Arduino IDE is software that is commonly used to program or upload a code that was previously designed on the ESP 32. Arduino IDE allows users to write code using the C/C++ programming language that can be run on the Arduino microcontroller.

b. MATLAB (Matrix Laboratory) Application

In the process of making this Final Project tool to launch the program that has been programmed on Arduino, MATLAB (Matrix Laboratory) is also needed, which can be used to set and determine the rule base of several sensors used, namely the pH sensor and the DS18B20 water temperature sensor, which can be used in the control system to carry out the fuzzification process, which aims to obtain the value of the fuzzy, the application of the rule base, and the final result of data processing or deffuzification.

c. Thingspeak Website

In its application, the prototype of this tool will later use the Thingspeak website, which of course is connected to the ESP 32 with an internet network that is used for monitoring the sensor. The use of this website makes it very easy to monitor remotely because it is connected via an internet device and can be accessed by users via a previously registered smartphone.

4.4. Implementation

In this implementation stage, a tool trial is carried out as a real step to apply the tool that we have made and implemented into the object/field used. There are several tests in this stage, which will later be used as data to indicate that the tool that has been made is working and functioning properly.

a. Water PH Sensor Testing

Testing is carried out using neutral water, acidic liquids, and alkaline liquids. Testing is carried out by inserting the pH sensor into a 30 cm aquarium filled with water. This is done with several trials using different water to ensure whether the sensor conditions are appropriate or not when taking measurements.
The results of the water pH sensor measurements will be displayed on the OLED screen that has been installed on the hardware that the author designed, and to further ensure the accuracy of the data from the sensor, the author also uses litmus paper to determine the pH value of a liquid. The actual water pH sensor testing process can be seen.

Figure 10. Water pH Sensor Testing Process and Measurement Results Displayed on the OLED Screen

Table 1. Results of water pH sensor testing

Test	Liquids	Water pH Sensor Results	Litmus Paper Results	Descriptions
1	Acid Liquid	4,9	5,0	Acid
2	Acid Liquid	5,0	5,0	Acid
3	Acid Liquid	5,1	5,1	acid
4	Standard Water	7,2	7 ,1	Neutral
5	Standard Water	7,4	7,2	Neutral
6	Standard Water	7,1	7,1	Neutral
7	Alkali Liquid	9,5	9,6	Alkali
8	Alkali Liquid	9,8	9,7	Alkali
9	Alkali Liquid	9,4	9,6	Alkali

Based on the results of the measurement data obtained from the air pH sensor, it can be seen that the sensor can work as desired. In this experiment, the author used litmus paper as a comparison between the measurement results using the sensor and using litmus paper. The results obtained were that the difference between the two experiments was not too far from the measurement results.

b. Testing the DS18B20 Air Temperature Sensor

The sensor test was carried out by inserting the DS18B20 Water Temperature Sensor into a 30 cm aquarium filled with air. This was done by several trials using air that had different temperature levels to ensure whether the sensor conditions were appropriate or not when taking measurements.

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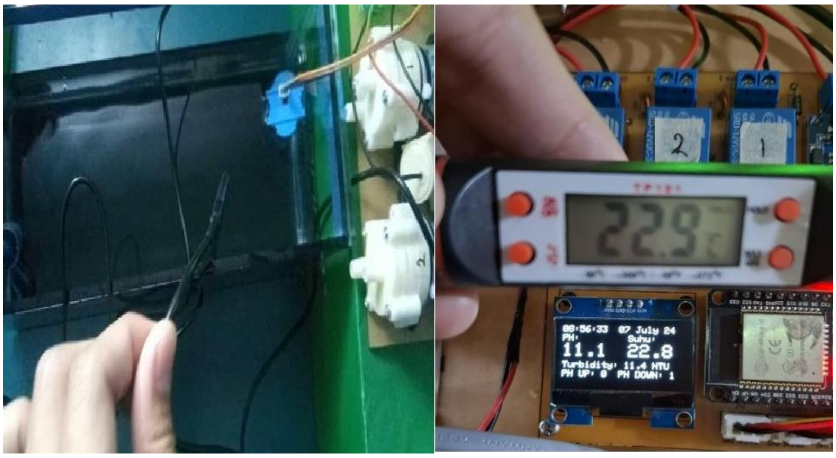

Figure 11 . DS18B20 Water Temperature Sensor Testing Process and Measurement Results Displayed on the OLED Screen

Table 2. DS18B20 Water Temperature Sensor Test Results

Test	Liquids	DS18B20 Water Temperature Sensor Measurement Results (°C)	Thermometer Measurement Results (°C)
1	Cool	22,8	22,9
2	Cool	23.6	23,8
3	Cool	23,2	23.4
4	Normal	29,6	29,5
5	Normal	28,4	28,6
6	Normal	29,8	29,6
7	Hot	31,7	31,8
8	Hot	32,6	32,8
9	Hot	34,4	34,5

Based on the results of the measurement data obtained from the DS18B20 Water Temperature Sensor, it can be seen that the sensor can work as desired. In this experiment, the author used a thermometer as a comparison between the measurement results using the sensor and using a thermometer. The results obtained were that the difference between the two experiments was not too far in the measurement results.

c. Turbidity Sensor Testing

Turbidity Sensor testing was carried out by inserting the Turbidity Sensor into a 30 cm aquarium filled with water. This was done with several trials to ensure whether the sensor conditions were appropriate or not when taking measurements.

The results of the turbidity sensor measurements will be displayed on the OLED screen that has been installed on the hardware that the author designed. The actual turbidity temperature sensor testing process can be seen.

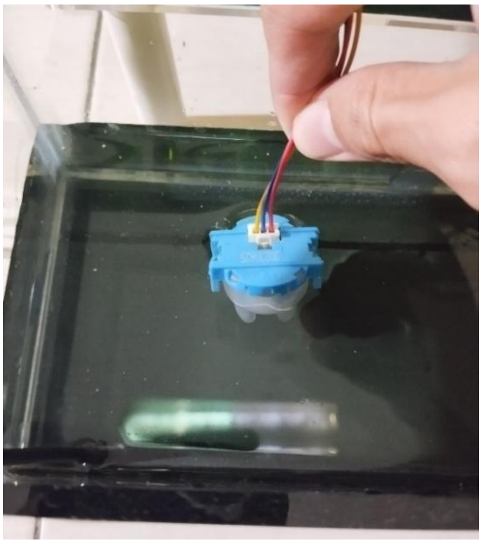

Figure 12. Turbidity Sensor Testing Process and Measurement Results Displayed on the OLED Screen

Tabel 3. Turbidity Sensor Test Results

Test	Liquids	Turbidity Sensor Measurement Results (NTU)
1	Acid Liquid	16,3
2	Acid Liquid	16.5
3	Acid Liquid	16,6
4	Air Standart	8,5
5	Air Standart	8,7
6	Air Standart	8,8
7	Standard Water	17,8
8	Standard Water	17,1
9	Standard Water	19,1

Based on the results of the measurement data obtained from the turbidity sensor, it can be seen that the sensor can work as desired. In taking this data, the author conducted several experiments using several different liquids in order to determine the level of turbidity of the liquid sample. In taking the turbidity sensor data, the author did it together with taking the water pH sensor.

d. System Integration Testing

In practice, all the sensors used can work as expected. After all the sensors used have been integrated, the system can read the water pH quality data, the water temperature data used, and the turbidity of the water. Then for the other components, they can work well too, and the MATLAB application used to set the fuzzy logic set point and the Thingspeak Website used to monitor remotely are also able to display data in real time.

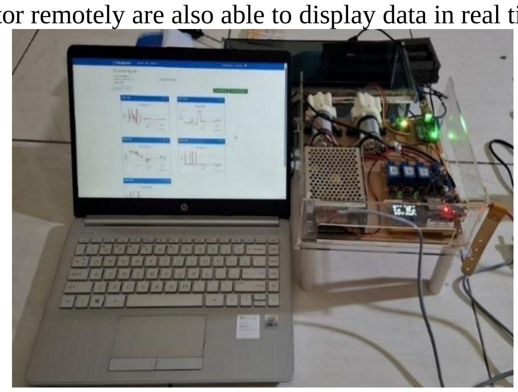

Figure 13. System Integration Testing

ISSN : 3032-2642

Table 4. System Integration Test Results

Initial Conditions	Water PH			Fluid Added		Amount of Fluid Added (ml)
	PH Meter	*Website Thingspeak*	Results	Acid	Alkali	
Acid	6,2	6,2	6,7	-	✓	1
	2,9	2,9	7,5	-	✓	5
	5,1	5,1	7,1	-	✓	3
Neutral	6,7	6,7	6,7	-	-	-
	7,5	7,5	7,5	-	-	-
	7,1	7,1	7,1	-	-	-
Alkali	8,7	8,7	7,9	✓	-	1
	10,2	10,2	8,2	✓	-	3
	13,4	13,4	7,6	✓	-	5

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Based on the experiment, data collection, and discussion, it can be concluded from this final project that:

1. A tool has been created to monitor water quality conditions in the Water Clustering System at the Water Treatment Plant based on the Internet of Things (IoT). The process of the tool's working system is able to monitor the condition of water pH quality, water temperature levels, and turbidity levels in the water. After the data is read by the sensor, the data will appear on the Thingspeak website and can be viewed by registered users.
2. Based on the experiments carried out, the tool is able to control water quality conditions well. The sensor performance also runs well in obtaining water quality data by considering the parameters of the water pH sensor, DS18B20 water temperature sensor, and turbidity sensor. In the design of this tool, the Mamdani Fuzzy Logic Method was successfully used, which can make firm decisions using ESP 32 as a microcontroller and the MATLAB application to regulate and analyze virtually by entering water pH and temperature parameters as input monitoring variables for the water status clustering system. The output process of the Mamdani Fuzzy Logic Method is 2 DC 12V R385 pumps, which function to add pH-lowering and increasing fluids so that the water condition remains neutral.
3. By using the Thingspeak web server, data sent by the sensor can be displayed in real-time and, of course, must be registered first in order to access data from the Thingspeak web server.

5.2. Recommendations

The author has several recommendations for future tool development so that it can be further improved. Here are some suggestions that are proposed:

1. In testing the tool, it is expected to always pay attention to sensor recalibration; this needs to be done so that when taking measurements, the results are appropriate and optimal.
2. In further research, it is expected to pay more attention to sensor selection, especially focusing on the selection of water pH sensors. It is necessary to use a better type of sensor so that it is more accurate in determining the pH level in water.
3. In further research, it is expected to add an automatic draining system to the reservoir so that water that has settled on the bottom of the surface can be drained cleanly so that the water quality is maintained.
4. The water clustering system in this water treatment plant is expected to be added with several more sensors in further research to be more precise in determining the quality of water suitable for use.
5. Based on the test results on the website, for further research, it is expected to develop several additional features that are more detailed so that they can control water quality through the website in detail and in real-time.

REFERENCES

[1] Amirgaliyev, B., Kozbakova, A., Kozbakova, A., Омарова, П., Merembayev, T., Омарова, П., Amirzhan, K., Merembayev, T., & Amirzhan, K. (2024).

Development and experimental study of an intelligent water quality monitoring system based on the internet of things. *Bulletin of Electrical Engineering and Informatics*, *14*(1), 761–773. https://doi.org/10.11591/eei.v14i1.8864

[2] Austin, C., Mulyadi, M., & Octaviani, S. (2024). Implementasi IoT dengan ESP 32 Untuk Pemantauan Kondisi Suhu Secara Jarak Jauh Menggunakan MQTT Pada AWS. *Jurnal JE-UNISLA: Electronic Control, Telecomunication, Computer Information and Power System*. https://doi.org/10.25170/jurnalelektro.v15i2.5141

[3] Dubey, S. K., Sanghvi, A., Yadav, P., Balmiki, A., & Bansode, S. M. (2024). *To Implement the IoT Based Water Quality Monitoring and Analysis with Using Blockchain Technology*. 1–6. https://doi.org/10.1109/acroset62108.2024.10743893

[4] *Enhancing Airport Business Services Using Big Data Analytics* (pp. 104–127). (2022). IGI Global eBooks. https://doi.org/10.4018/978-1-6684-5959-1.ch005

[5] Fazal, M. R., & Mataram, A. (2023). Polyvinylidene fluoride membranes with tin (iv) dioxide (sno2) additives: enhancing water treatment for airport eco green. *Journal of Airport Engineering Technology*, *3*(2), 68–74. https://doi.org/10.52989/jaet.v3i2.100

[6] López-Munoz, M. A., Torrealba-Meléndez, R., Arriaga-Arriaga, C. A., Tamariz-Flores, E. I., López-López, M., Quirino-Morales, F., Muñoz-Pacheco, J. M., & Lopez-Marcos, F. (2024). Wireless Dynamic Sensor Network for Water Quality Monitoring Based on the IoT. *Technologies (Basel)*. https://doi.org/10.3390/technologies12110211

[7] Mourya, A. S., Verma, A., Harod, A., & Siddiqui, J. A. (2024). *Advancing Water Quality Monitoring: A Comprehensive IoT-Based Approach for Safety Measurement*. 98–101. https://doi.org/10.1109/ic2sdt62152.2024.10696125

[8] Nugrahanik, R., & Utomo, B. C. (2021). *Implementation of water supply supervision in class 1 port health office in juanda airport working area, surabaya*. *16*(2), 253–263. https://doi.org/10.20473/IJPH.V16I2.2021.253-263

[9] Putri, J. F., & Utomo, S. W. (2020). *Brief Description of Catering Service's Food and Water Qualities in Soekarno-Hatta International Airport*. *1*(1). http://ijesm.pepsili.or.id/index.php/IJESM/article/download/16/5

[10] Sulej-Suchomska, A. M., Szumińska, D., de la Guardia, M., Przybyłowski, P., & Polkowska, Ż. (2024). Airport Runoff Water: State-of-the-Art and Future Perspectives. *Sustainability*. https://doi.org/10.3390/su16188176

[11] Tundo, T., Setiawan, K., & Aula, R. F. (2024). Penerapan IoT dengan Algoritma Fuzzy dan Mikrokontroler ESP32 dalam Monitoring Penyiraman. *Jurnal Indonesia : Manajemen Informatika Dan Komunikasi*, *5*(3), 2915–2924. https://doi.org/10.35870/jimik.v5i3.977

[12] Umami, N. R., Prihastono, P., & Puspitacandri, A. (2024). *Rancang Bangun Sistem Pengontrol PH Air Minum dari Water Treatment Kapal Menggunakan Micro Controller ESP 32*. *2*(4), 174–187. https://doi.org/10.61132/globe.v2i4.595

[13] Yusri, M., Maulita, Y., & Sembiring, H. (2024). *Penerapan IoT dalam Monitoring dan Pengendalian Kualitas Air*. https://doi.org/10.62951/repeater.v2i4.250