Automation of Water Treatment System with pH Sensors, Conductivity Sensors and Turbidity Sensors Based on Microcontroller

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***Abstract*— Water is main need for humans. People living around river use river water as consumsion, but majority of urban rivers are polluted. Polluted river water contains dissolved solids, unsTable water pH content and water turbidity. The government provides facilities used by residents to bathe, wash and defecate in residential areas with medium to high density, namely MCK. The MCK is close ± 2 meters close to the polluted river. Solution to this problem requires a water treatment tool that works automatically and can monitor the water content of the water treatment system based on water quality in accordance with PERMENKES No. 32 of 2017 which can monitor dissolved solids, turbidity and water pH. Officers can see the sensor reading process via website containing water quality content. Based on the results of tests carried out over 3 days, average water content in pH sensor was 6.77pH, conductivity sensor was 595.9ppm and tubidity sensor was 13.05NTU. The results of water content for three days are in accordance with standardization. Water treatment system is running well. Quality of Service testing for 3 days with an average delay of 0.0358s and packet loss of 0.48% is categorized as good.**

Keywords*— *Air, Delay, Packet Loss, Water Treatment, Website.

I. INTRODUCTION

One of human needs is water which is determined from river water. Humans use it as a daily necessity. However, the majority of river water in urban areas is polluted.

Polluted river water contains dissolved metal particles, unsTable acid-base content and turbid water which turns the water colored. River water pollution comes from humans themselves, such as waste disposal and laundry waste. Due to the case of polluted river water, the government has built public facilities that are shared by several families for bathing, washing and defecating in residential locations with medium to high density populations[1], namely MCK (Bathing, Washing and Toilet). One of the MCKs that has been built is located on Jl. Major General Sungkono RW. 02 District. Kedungkandang, Kel. Buring. The MCK uses a drilled well water source as deep as ± 25 meters and uses an electricity source from PLN. Local residents use it as a sanitation hygiene for their water.

Water for sanitation hygiene purposes is water of a certain quality that is used for daily purposes, the quality of which is different from the quality of drinking water [2]. When using well water in MCKs for local communities, it is necessary to pay attention to the level of water quality, so that residents avoid various diseases caused by water whose quality is not maintained.

Standardization of water that can be used by the community as a daily sanitation hygiene medium is stated in PERMENKES No. 32 of 2017 which contains water quality standards for sanitation hygiene media [3]. These standard standards are divided into several standard parameters, namely physical parameters [4], biological parameters [5] and chemical parameters [6]. The physical parameters contain water turbidity [7] with a maximum scale of 25 NTU and dissolved solids with a maximum scale of 1000 mg/l. For chemical parameters, one of them contains the acidity or alkaline level of water on a scale of 6.5 – 8.5 pH. If the water does not meet quality standards, a water treatment system is needed before it is distributed to residents for daily needs. There is no water content information on the MCK because the well in the MCK is very close to ±2 meters from the Amprong River, which according to the results of river water quality evaluations in the Malang area, the Amprong River is classified as lightly polluted [3]. So it is necessary to carry out research to determine the quality of the well water according to applicable regulations.

Given the problems, it is necessary to create a water treatment device that works automatically and can monitor the water content of the water treatment system based on water quality in accordance with applicable regulations. It can monitor physical parameters, namely, dissolved solids (Total Dissolved Solids) [8], water turbidity [9][10] and Water pH [11]. The water treatment automation process uses readings from a pH sensor which functions to measure the acidity or base level of water [12], a conductivity sensor which functions to measure the level of dissolved solids in water in mg/l units, and a turbidity sensor which functions to measure the level of water turbidity using the NTU scale. If the sensor detects that the well water does not meet standards, the water will be flowed through the water treatment process periodically until the sensor detects that the water meets standards. During the sensor reading process, residents can see it via a website that contains water quality content at any time so that residents don't worry about the water in the toilets they use for their daily needs.

II. METHOD

A. System Plan

In Figure 1 regarding the block diagram the design has ESP32 microcontrollers [13][14]. The ESP32 microcontroller contains three sensors that will detect dissolved particulate elements in the water. These sensors are in the form of a pH sensor to detect the acid-base content of water, a Conductivity sensor to detect dissolved metal particles in water and a Turbidity sensor to detect water turbidity based on the color of the water. The first microcontroller will determine whether the water content after filtration produces water content that meets standardization or not. If the detection results show results that do not comply with standardization, the website display will show detection result data that does not comply with standardization and the data will be written in red and if the detection results show results that comply with standardization, then the website display will show the appropriate detection result data. with standardization and black data writing. These three sensors will also regulate the relay on the water pump [15]. If the detection results show results that are not in accordance with standardization, the water pump will turn on to channel the water in the tank to filtration which later, after the water has been filtered, will be returned back to the tank. If the detection results show results in accordance with standardization, the water pump will turn off. The results of the water content detection will be sent. The detection data with the help of the ESP32 microcontroller will be sent to the database via an access point which will later be displayed on the web in graphic form.

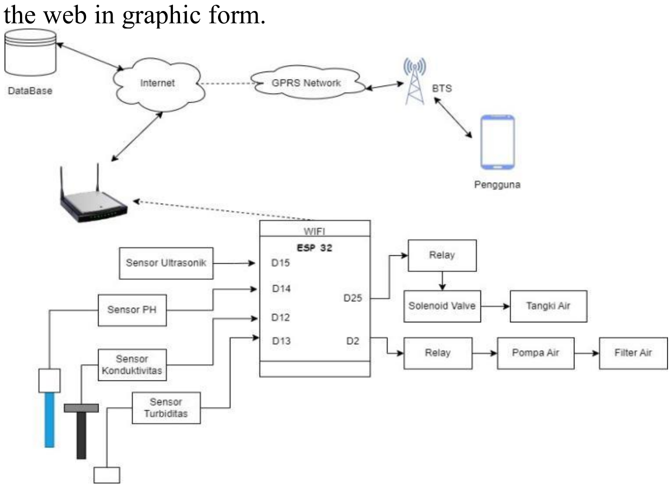

Figure 1. Diagram Block of System

The microcontroller also consists of a water level sensor, in this detector the water level sensor will be placed in the second tub / water tank in order to measure the volume of water, this water level sensor will be connected to the ESP32 microcontroller which is connected to the relay on the water pump. If the water volume in the water tank is ≤ 70 cm from the water tank, the water pump will turn on, and if the water level shows full, the water pump will automatically turn off. The water level sensor measurements will be displayed on the website.

B. Website Design Plan

The web design shown in Figure 2 is used to monitor water content. The monitoring data can be used by local residents and MCK cleaning staff to determine the water content. If the water content does not meet the established standards, the cleaning staff can turn off the water channel and check the condition of the water filter. In Figure 3 there is some information, namely:

1. There are 3 water content tabs with units of PH, NTU and PPM. When pressed, a graph will appear according to the selected water content.
2. There are data points for each change in the graph that can produce numbers.
3. Changes in graphs based on real time every minute.

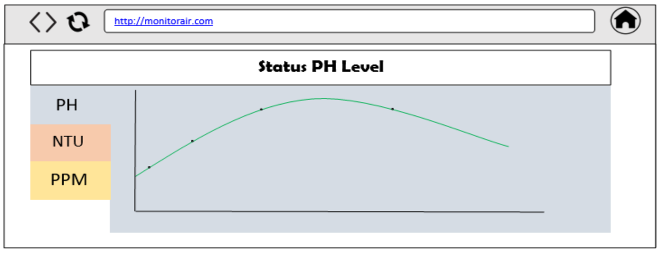

Figure 2. Website Appearance Design

C. System Testing Design

Figures 3 to Figure 5 show the system test design. The first box containing the pH sensor, Conductivity sensor and Turbidity sensor will be placed floating on the surface of the water. Meanwhile, the second box will be stuck behind the water tank cover. The first water filter is attached to the MCK wall and the second water filter is placed behind the water tank.

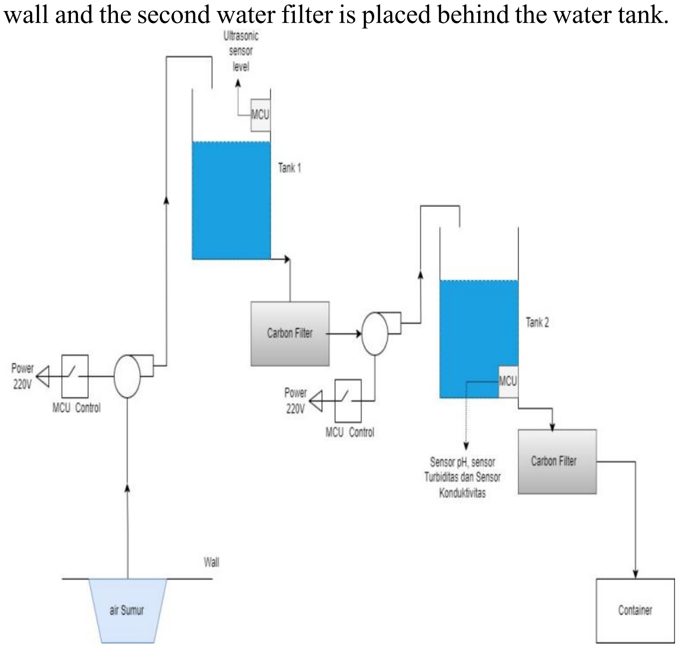

Figure 3. System Testing Block Diagram

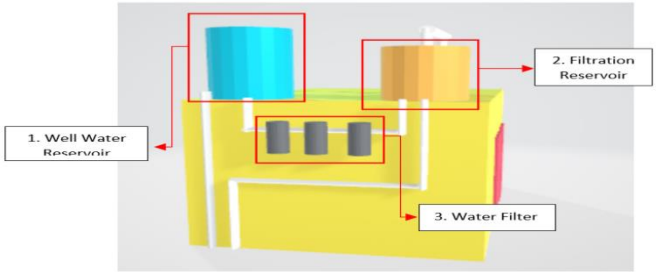

Figure 4. System Design Side View

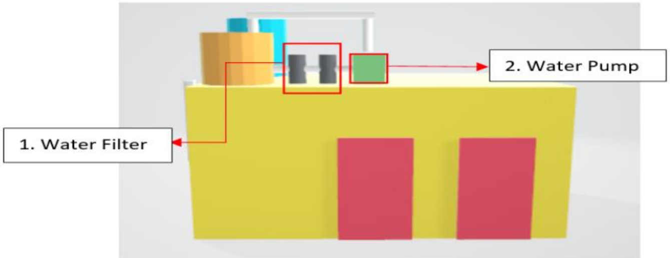

Figure 5. System Design Side Front

III. RESULTS AND DISCUSSION

A. Placement of Sensor Hardware

The pH, Turbidity and Conductivity Sensor Hardware is designed to control water filtration and measure water content. The hardware is placed according to Figure 6.

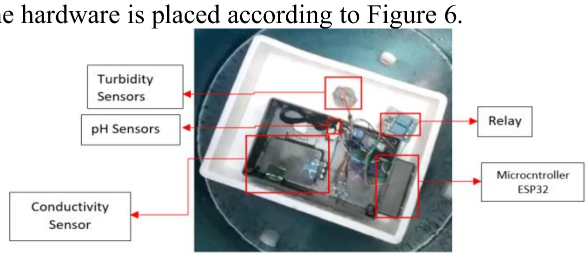

Figure 6. Placement of pH, Conductivity and Turbidity Sensors

Figure 7 shows that the distance sensor (ultrasonic) is placed on the lid of the water tank so that the sensor is easy to measure the height of the water surface and minimizes the distance sensor (ultrasonic) from being exposed to water because the distance sensor (ultrasonic) is not resistant to water. The relay connected to the distance sensor (ultrasonic) is used to close or open the electric current in the solenoid valve. If the distance sensor (ultrasonic) measures the height of the water surface with a result of less than 75cm, then the sensor will provide information to the ESP32 to open the relay so that the solenoid valve opens and fills the water tank until the distance sensor (ultrasonic) measures the water surface height to reach 75cm.

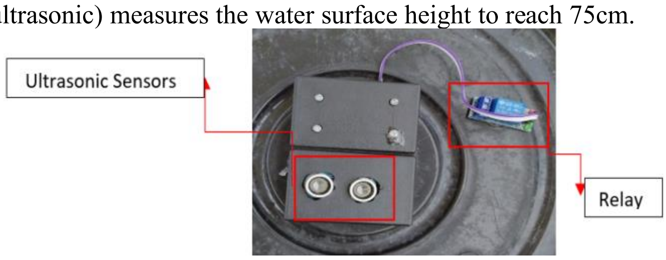

Figure 7. Placement of Distance Sensors and Relays

B. Water Treatment System Test Results

In testing the water treatment system, 3 sensors are used to detect water content, namely the PH sensor, conductivity sensor and turbidity sensor. The three sensors have different functions, including, the PH sensor in this test can measure acid or alkaline levels in water, the conductivity sensor functions to measure dissolved solids in water, and the Turbidity sensor functions to measure turbidity in water. The PH, Conductivity and Turbidity sensors are connected to the ESP32 microcontroller and there are relays. The use of the ESP32 is as a microcontroller that will process data from PH sensor readings, Conductivity sensors and Turbidity sensors. The results of data processing will be sent to the server and displayed on the website.

The relay in this system is triggered by the reading results of the three sensors that detect water content. The relay will be active if one of the sensors or the three sensors detects a discrepancy in water content with the standardization of drinking water. The relay will turn off if all three sensors detect the water content in accordance with consumption water standards.

TABLE I
WATER TREATMENT SYSTEM TESTING RESULTS FRIDAY 7/23/2021

No	Day	Time	PH (pH)	Conductivity (ppm)	Turbidity (NTU)	Water Pump
1	Friday 7-23-2021	10:38	7.12	355.1	9	Off
2		10:43	6.24	422.4	10	Off
3		10:48	6.12	647.2	12	On
4		10:53	6.52	551.5	8	On
5		10:58	7.31	300.8	8	Off
6		11:03	7.20	278.1	7	Off

TABLE II
WATER TREATMENT SYSTEM TESTING RESULTS SATURDAY 7/24/2021

No	Day	Time	PH (pH)	Conductivity (ppm)	Turbidity (NTU)	Water Pump
1	Saturday 7-24-2021	13:22	7.42	322.4	9	Off
2		13:27	7.13	526.7	9	Off
3		13:32	7.01	861.9	18	Off
4		13:37	6.37	911.3	15	On
5		13:42	6.93	745.6	14	Off
6		13:47	7.11	552.2	10	Off

TABLE III
WATER TREATMENT SYSTEM TESTING RESULTS SUNDAY 7/25/2021

No	Day	Time	PH (pH)	Conductivi (ppm)	Turbididty (NTU)	Water Pump
1	Sunday 7-25-2021	08:59	7.21	422.3	10	Off
2		09:04	6.86	713.1	15	Off
3		09:09	6.37	897.6	19	On
4		09:14	6.09	1021.5	26	On
5		09:19	6.55	792.4	19	On
6		09:24	6.84	404.2	17	Off

C. Quality of Service (QoS) test result

QoS (Quality of Service) testing aims to determine the quality of the water and electrical power management system network at the MCK. The QoS parameters measured include delay and packet loss. The following are the QoS test results:

Delay Testing

This delay test aims to determine the time required for data to travel the distance from source to destination. The time used for this test was 3 days of data collection.

Data collection in Table 4 was carried out using Wireshark software, testing by opening the website and then running Wireshark software. Then the data will appear according to Figure 8.

TABLE IV
TEST RESULT ARE DELAYED FOR 3 DAYS

Testing to-	Delay Test		
	Friday	Saturday	Sunday
1	0.000000	0.034724	0.034808
2	0.015198	0.034735	0.034831
3	0.015596	0.034741	0.052731
4	0.015609	0.034757	0.052731
5	0.015834	0.034757	0.052731
6	0.034680	0.034767	0.052731
7	0.034680	0.03477	0.052731
8	0.034680	0.034783	0.052772
9	0.034680	0.034783	0.052785
10	0.034680	0.034798	0.052785
Rata - Rata	0.0235637	0.0347615	0.0491636

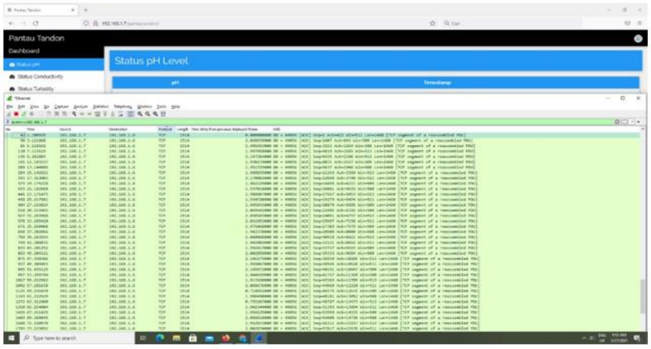

Figure 8. Wireshark Packet Data View

Data collection was carried out for 3 days in accordance with system testing. Based on Table 4.23, a delay in system testing of 3 days has been obtained. Data was taken for 10 sample packages, where then all packages for 3 days were calculated on average per day. From the package calculation results, it was found that the average package on Friday, 7-23-2021 was 0.0235637 seconds or 23ms, on Saturday, 7-24-2021 it was 0.0347615 seconds or 34ms and on Sunday 7-25-2021 it was 0.0491636 seconds or 49ms. The smaller the delay time, the better the quality of data transmission, minimal information delays.

D. Packet Loss Testing

Packet Loss is a parameter to describe lost packets, this can be influenced by congestion on the network. The following is a short procedure for calculating packet loss.

Wireshark will display a graph as in Figure 9, then click on the option to display packet loss and save it in CSV format.

Open the file that has been saved in CSV format then add up all packets and TCP Errors.

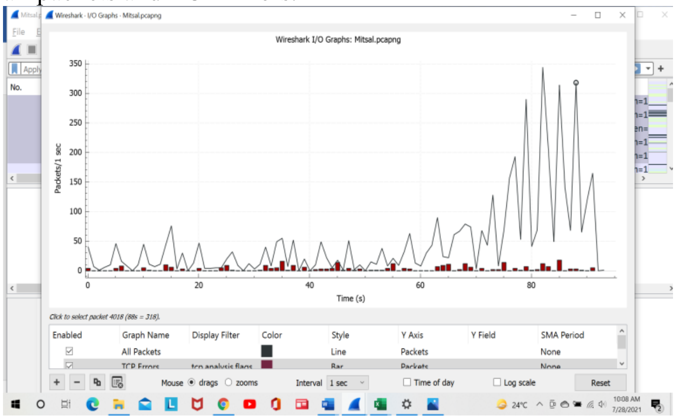

Figure 9. I/O Graph Display

TABLE V
PACKET SEND AND TCP ERROR

Interval Start	All Packets	TCP Error
0	40	4
1	7	0
2	1	0
3	6	0
4	10	0
5	46	4
6	16	8
7	8	0
8	0	0
10	40	4

By using the Equation 1, you can calculate packet loss at each locker against time and operator. So we get the packet loss results:

$$Packet\ loss\ (\%) = \frac{20}{4665} x100\% = 0.48\% \quad \text{.................................(1)}$$

The results of the calculations that have been carried out show that the packet loss value obtained during testing was 0.48%. This value shows that the packet loss value obtained is low. The value of 0.48% falls into the good category value range.

IV. CONCLUSION

Based on this research article, the standardization of the water treatment system must be determined by the parameters pH, dissolved solids and turbidity designed by researchers in order to obtain well water content results in accordance with Health Meter regulations, PERMENKES No. 32 of 2017 concerning water quality requirements and supervision. There is a filter to reduce the water content before the water enters the reservoir and there is a further filter if the water content in the second reservoir does not comply with water standards based on readings of the pH sensor, Conductivity sensor and Turbidity sensor.

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