Automatic Clean Water Treatment System Using The Sugeno Fuzzy Method

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Abstract. All Water is the most important source in the human body, healthy water can help the metabolic processes in the body perfectly. Water used by humans must be in accordance with those set by the government (Permenkes RI number 492 of 2010, regarding the requirements and supervision of water quality). Clean water according to regulations issued by the government through the Indonesian Ministry of Health is having a PH value of 6.5 - 8.5, TDS (Total Dissolved Solid) a maximum of 500 mg / L, and a maximum turbidity level is 5 NTU (Nephelometric Turbidity Unit). In the process of managing dirty water into clean water, it must be done carefully so that the germs in the water are completely gone and the people who use them are free from all diseases. From the problems above, a clean water management system has been created. This system can read the value of water suitable for use or not. Water condition readings using PH sensor, TDS (Total Dissolved Solid) sensor and turbidity sensor (TSD 10). Data values from the sensor (input) are processed using fuzzy method as a logic to start the pump if the water value does not match the set point specified and display the sensor value on the LCD (Liquid Crystal Display). The results of the whole system were obtained an average error for the Sr-HCO4 sensor 1%, turbidity 2.12%, the TDS sensor 2.40% and the pH sensor 0.48%.

Keywords: Water treatment, TDS, turbidity, PH.

1. Introduction

The people in Indonesia are still faced with a number of quite complex problems and to date have still not been completely overcome [1], [2]. One of the problems faced is the low level of clean water services for the community. Clean water supply system is a national policy that aims to increase public access to quality water that is used every day. In this connection, it is necessary to supervise the quality of water distributed to the community by the water service provider [3]. This is important to do considering that various water borne diseases can arise from drinking and using water of a quality that does not meet health requirements. Utilization of water as a primary need makes water at the highest level of need [1],[4]. The water that is needed, of course, is clean and healthy water that has been designated as suitable water for use by the community. Consumable water must meet physical requirements, water must be clear or not turbid and have a TDS (Total Dissolved Solid) and PH value in accordance with government regulations [5]. Turbidity in water is usually caused by the presence of very fine clay grains, colored water means that it contains other substances harmful to health, a maximum turbidity value of around 5 NTU (Nephelometric Turbidity Unit) [6]. Water that feels acidic or salty indicates that the water quality is not good, water that has a high Total Dissolved Solid (TDS) value is usually rich in organic
compounds, with a maximum neutral TDS value of 500 mg/L. While the pH value that can be used by humans is 6.5 - 8.5.

From the problems above, a water management system was created automatically [7]. This system can read the value of water suitable for use or not. Reading the condition of the water using a PH sensor, TDS sensor (Total Dissolved solid) and turbidity sensor (TSD 10), the output of this tool is to display the value on the LCD (Liquid Cristal Display) and the pump will be active if the water value does not match the set point is not neutral to be returned to the initial shelter [8],[9]. Value data from the sensor (input) is processed using the fuzzy method as a logic to display values on the LCD (Liquid Cristal Display) and pump in order to get the desired output value [10].

2. Methods

a. Desain Hardware Pengolahan Air Bersih

Automatic water treatment equipment, namely the system has a height of 2 meters and a length of 2 meters, has four main processes. Namely the initial shelter process, filtering process 1, filtering process 2 and the process of reservoir or final storage [1],[3]. The initial collection process is collecting raw water from the river. In addition to this process, water level detection is also carried out to start the pump and open the water selenoid valve [5]. The second process is filtering 1, a process that aims to separate solid particles and colloids in liquid [8],[11]. The third process is the same as the second process [12]. In this process to do filtering using some natural material materials such as sand, gravel, zeloid stone, activated charcoal and palm fiber, and the last process is a reservoir which is a collection of clean water after several processes in water treatment [11]. In this process there are TDS sensors, turbidity sensors and PH sensors to detect water that is feasible or not to use.

![](https://example.com/image1.png)

**Figure 1.** Clean water treatment design

b. Turbidity Sensor Circuit Design

This picture can be seen in Figure 2. The Electronic Turbidity Sensor Circuit Scheme is designed. The working principle of this turbidity sensor is the compilation of the amount of light through the air, the amount of light through the material depends on the amount of impurities water [1]. Reducing the number of impurities, measuring light air samples, measuring turbidity sensors to calculate counting washing temperatures to mild turbidity [13]. This tool has 3 pins, namely Vcc, Gnd, and output pins. The output of this sensor research is the sensor value on the 16x2 LCD and water pump.

| Information |
|-------------|
| 1. Ultrasonic Sensor |
| 2. Faucet valve |
| 3. Container |
| 4. Filter 1 |
| 5. Filter 2 |
| 6. The final container |
| 7. Pump 2 |
| 8. TDS sensor |
| 9. Turbidity Sensor |
| 10. pH sensor |
| 11. Electronic Box. |
| 12. Pump 1 |
| 13. Support |
c. **TDS Sensor Circuit Design**

In picture 3 answers that the TDS sensor is a device that works based on the electrical working principle which has 2 stainless steel metals that accept the data in the test. Water has salt content in the ions it possesses - solute ions that can move [7],[14]. TDS sensors utilize properties where pure air is an insulator, but air which has dissolved material will turn into a conductor. TDS sensor has 3 pins, namely VCC, GND and output pins. The output of the sensors in this study consisted of a value sensor on a 16x2 LCD and a water pump [2].

![Figure 2. Schematic of the Turbidity Sensor Electronic Circuit](image)

**Figure 2. Schematic of the Turbidity Sensor Electronic Circuit**

d. **Design of PH Sensor Circuits**

In the design of a PH sensor circuit, for more details, you can see in Figure 4 where the pH sensor is a device that works based on the working principle of the acidity of a solution [12]. The pH sensor will change the acidity or basicity of the solution. In this study, the pH sensor is used to measure the acidity and wetness values in clean water [3],[15].

![Figure 3. TDS Sensor Electronic Circuit Schematic](image)

**Figure 3. TDS Sensor Electronic Circuit Schematic**

e. **Design of the HC-SR04 Ultrasonk Sensor Circuit**

In figure 5 it can be explained that the ultrasonic sensor HC-SR04 is a sensor that can detect ultrasonic waves. Ultrasonic sensors take measurements of the physical properties of the sound waves primarily at the speed of propagation, reflection and sound wave doppler effects [6][9]. The results of the reflection of sound waves are used to interpret the existence (distance) of an object with a certain frequency. This sensor can be used to measure the distance of objects between 2 cm - 400 cm with an accuracy of 3 mm. In this study, ultrasonic sensors are used to fill water automatically in raw water reservoirs [9],[10]. The output of this sensor is a water pump that can be turned off automatically. This tool has 4 pins, namely Vcc, Gnd, Trigger, and Echo pins [13],[7]. Vcc pins for positive electricity and Gnd for grounding, Trigger pins for the signal output from sensors and Echo pins for capturing reflected signals from objects.
3. Results

The HC-SR04 ultrasonic testing sensor to the distance used to test the height of the air storage, the turbidity sensor for detecting turbidity in the air, the sensor for testing dissolved in water and the ph sensor to test the acidity value at the broadcast. Test tool stability and microcontroller program testing.

a) Testing the turbidity sensor calibration

Turbidity sensor calibration testing is done to get the value corresponding to the turbidity of the water, in this case, it is compared with a turbidity meter measuring instrument by taking as many as 5 kinds of samples with different turbidity values, obtained a table with an average error of 2.12.

| No | Measurement Tool (NTU) | Sensor reading (NTU) | Difference |
|----|------------------------|---------------------|------------|
| 1. | 0,00                   | 0,60                | 0,60       |
| 2. | 45,03                  | 46,05               | 1,02       |
| 3. | 98                     | 99,85               | 1,85       |
| 4. | 295                    | 300,02              | 5,02       |
|    | Total                  |                     | 8,49       |
|    | Average error          |                     | 2,12       |

b) TDS (Total Dissolved Solid) calibration testing

TDS (Total Dissolved Solids) sensor calibration testing is carried out to get the value that matches the actual TDS value, in this case, it is compared with the TDS meter by taking a sample of 5 types with different values, explained in the table. Obtained an average error of 2.40.

| No | Measurement Tool (PPM) | Sensor reading (PPM) | Difference |
|----|------------------------|---------------------|------------|
| 1. | 205                    | 207,02              | 2,02       |
| 2. | 396                    | 400,04              | 4,04       |
| 3. | 673                    | 676,06              | 3,06       |
| 4. | 1000                   | 1000,50             | 0,5        |
|    | Total                  |                     | 9,62       |
|    | Average error          |                     | 2,40       |

c) Testing the PH sensor calibration

PH sensor calibration testing is done to get the value that matches the actual pH value, in this case, it is compared with a ph meter by taking 3 different samples with different acidity values. Explained in the table. With an average error result of 0.48

| No | Measurement Tool | Sensor reading | Difference |
|----|------------------|----------------|------------|
| 1. | 5,23             | 5,82           | 0,59       |
| 2. | 7,28             | 7,69           | 0,41       |
d) Testing of HC-SR04 sensor calibration

The HC-SR04 sensor calibration test is carried out to get the value that matches the actual distance value, in this case, compared to the ruler. An average number of errors of 1 is obtained.

**Table 4. Testing HC-SR04 sensor**

| No | Set. Distance (cm) | Sensor reading (cm) | Difference |
|----|--------------------|---------------------|------------|
| 1. | 15                 | 15 - 16             | 1          |
| 2. | 25                 | 25 - 26             | 1          |
| 3. | 45                 | 45 - 46             | 1          |
| 4. | 60                 | 60 - 61             | 1          |
|    | **Total**          |                     | **4**      |
|    | **Average error**  |                     | **1**      |

Average error 0,48





e) Testing the Sugeno Fuego Method.

Sugeno fuzzy testing method aims to apply the fuzzy method in decision making which will later be used as the output of clean water treatment equipment according to sensor input data. By using the rules - rules or rules that are set.

**Table 5. Base rules**

| Rule | Condition | and | then | Conclusion |
|------|-----------|-----|------|------------|
| 1    | turbidity J and TDS BK and PH AS | then | H    |
| 2    | turbidity J and TDS BK and PH NE | then | M    |
| 3    | turbidity J and TDS BK and PH BA | then | H    |
| 4    | turbidity J and TDS CU and PH AS | then | H    |
| 5    | turbidity J and TDS CU and PH NE | then | M    |
| 6    | turbidity J and TDS CU and PH BA | then | H    |
| 7    | turbidity J and TDS BU and PH AS | then | H    |
| 8    | turbidity J and TDS BU and PH NE | then | H    |
| 9    | turbidity J and TDS BU and PH BA | then | H    |
| 10   | turbidity J and TDS BU and PH NE | then | H    |

**Note:** J: Clear, US: Acid, B: Clean, NE: Neutral, K: Turbid, BA: Wet, BK: Good, BU: Bad, CU: Enough, M: Dead, H: Alive

Sugeno fuzzy method testing with mathematical calculations. In testing the value of the turbidity sensor 3.4 NTU, TDS 424 sensor and pH 6.1 sensors are used

- Sensor Turbidity = 3.4 NTU is included in the clear and clean membership.
  \[ \mu(x)[\text{Clean}] = \frac{5 - x}{5 - 3} = \frac{5 - 3}{2} = 0.6 \]
  \[ \mu(x)[\text{murky}] = \frac{x - 3}{5 - 3} = \frac{3.4}{2} = 0.4 \]

- Sensor TDS = 424 included in good and sufficient membership.
  \[ \mu(x)[\text{enough}] = \frac{500 - x}{500 - 424} = \frac{76}{44} = 0.44 \]
  \[ \mu(x)[\text{Bad}] = \frac{x - 330}{424 - 330} = \frac{94}{194} = 0.55 \]

- Sensor pH = 6.1 Included in acid membership

6.1 = 1

[R1] if turbidity is turbid, sufficient TDS AND pH of THEN acid

Output = 80

\[ Z = 80 = \frac{(a1+Zt)+a2-Zt+a3+Zt}{a1+a2+a3} = \frac{(0.2-80)+(0.44-80)+(1-80)}{0.2+0.44+1} = \frac{16+35.2+80}{164} = \frac{131.2}{164} = 80 \]
Conclusion: From the manual calculation the result is 80 and the result of the Matlab application calculation is 80.

f) Testing the fuzzy response to the sensor
This test aims to determine the performance of the sensor system, the sensor will members distance obtained water value will be sent to the microcontroller to obtain the expected output. The test results will be proven by mathematical calculations manually, whether the fuzzy method in the program in accordance with the calculation. Fuzzy output response test results. The value of the sensor will be displayed on the LCD (Liquid Crystal Display).

| No | TDS  | PH   | Turbidity | Pump Output |
|----|------|------|-----------|-------------|
| 1  | 451  | 6,87 | 1,50      | Die         |
| 2  | 329  | 6,96 | 0,00      | Die         |
| 3  | 325  | 7,80 | 2,82      | Die         |
| 4  | 320  | 7,50 | 4,20      | Die         |
| 5  | 496  | 7,94 | 6,68      | Life        |
| 6  | 560  | 7,43 | 8,80      | Life        |
| 7  | 421  | 7,50 | 4,90      | Life        |
| 8  | 369  | 7,65 | 4,98      | Life        |
| 9  | 359  | 7,30 | 6,50      | Life        |
| 10 | 416  | 8,10 | 2,11      | Die         |

Based on the results of testing the response output in table 4.8 that the tool works in accordance with the existing algorithm programmed Arduino Mega 2560 and in accordance with the desired. The fuzzy algorithm in the program is in accordance with the output. If the turbidity sensor, the TDS (Total dissolved solid) sensor, and the pH sensor detect according to the ranges in the membership function, the microcontroller will process the fuzzy program to match the expected output.

4. Conclusion
Based on the design, implementation, experiment tools and the results obtained can be concluded. The results of this study can create the use of dirty water into water that is suitable for use, the results of testing all sensors are feasible to use, this is evidenced by the value in the sensor testing table in compare with the manufacturer's gauge, the output of the sensor changes the water pump and the results of the whole system get an average error for the sensor sr-HC04 1%, turbidity 2.12%, sensor TDS 2.40% and pH sensor 0.48% . In future studies, the output of turbidity sensors, TDS sensors, and pH sensors can be changed using other methods. As well as adding other sensors to perfect the clean water quality requirements according to the Republic of Indonesia Minister of Health Regulation.

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