CHAPTER 4
ANALYSIS AND DESIGN

4.1. Analysis

Water quality is one of the important factors that need to be considered in maintaining ornamental fish, especially aquarium ornamental fish. Many cases of fish die because of not paying attention to the quality of the aquarium water. One reason people rarely pay attention to the quality of their aquarium water is being busy. Because it is busy, the aquarium water is not monitored and results in poor water quality. Therefore, this system made it easier to monitor aquarium water.

The optimal temperature range for the life and development of aquatic organisms ranges from 25 to 35^{o}C while the acidity level in the aquarium model is at pH 6.8-7.5 [7]. Table 1 results from testing the turbidity sensor, and the initial hypothesis of the relationship between water turbidity and the output voltage of the sensor can be taken. Where the smaller the output voltage, it shows the water has increased turbidity. From this explanation, conclusions can be drawn to determine the level of turbidity of the water. Voltage over 2 Volts is declared clean, Voltage is over 1 Volt and less than 2 Volts cloudy water, Voltage is less than 1 Volt very cloudy water [2].

Table 1: Water quality parameters for fish farming [2]

Level	Pengujian Tegangan (Volt)										Rata-Rata (Volt)
	1	2	3	4	5	6	7	8	9	10	
Level 1 (Air Bersih)	2,03	2,03	2,03	2,03	2,02	2,03	2,03	2,03	2,03	2,02	2,028
Level 2 (Air Keruh)	1,56	1,63	1,65	1,67	1,64	1,63	1,58	1,62	1,61	1,68	1,627
Level 3 (Sangat Keruh)	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,7	0,6	0,6	0,63

4.1.1. Fuzzy Algorithm

According to Muhammad Cholilulloh in his journal, he explains that: fuzzy logic is logic that represents fuzzy values, uncertainties, or partial truths. Fuzzy logic is an improvement over Boolean logic which only values 0 and 1. Fuzzy logic allows memberships to be marked between 0 and 1, black and white, and in linguistics, uncertain concepts such as few, half and many.

In this project, the fuzzy used is the Sugeno fuzzy. Because of the output of this algorithm there are no fuzzy numbers except in the form of constants or linear equations. Figure 1 describes the important stages in the fuzzy algorithm, namely fuzzification, inference, defuzzification and also a rule base to determine the membership function of each sensor.

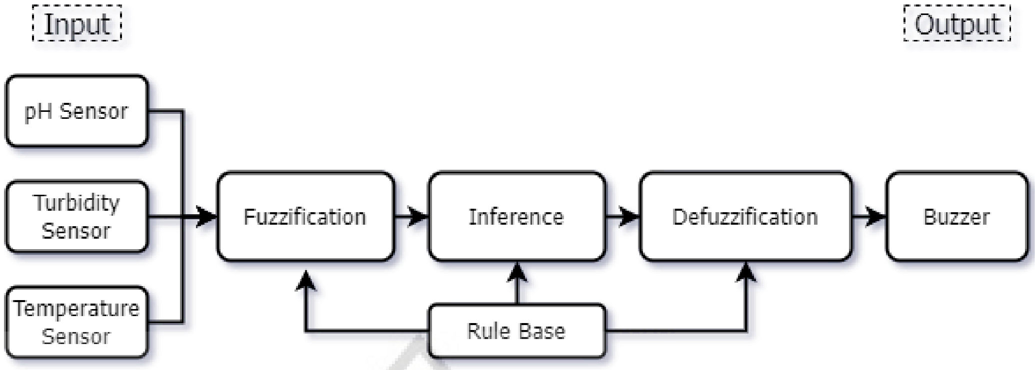


Figure 1: Fuzzy system block diagram

The first stage in the fuzzy algorithm is fuzzification. Fuzzification is changing the input as a firm value into a linguistic variable (fuzzy) using a membership function in the rule base. Next is inference, which is converting fuzzy input into fuzzy output (if-then) that has been determined in the rule base. Defuzzification is converting the results of the previous stage into an output that has a firm value using a predetermined membership function.

4.1.2. *Fuzzification*

1. ***Temperature membership variable***

The temperature variable has 3 sub-variables, namely cold, normal and hot. Cold conditions have a value of less than 25°C. Normal conditions have a value range of 25-35°C. While heat has a value of over 35°C.

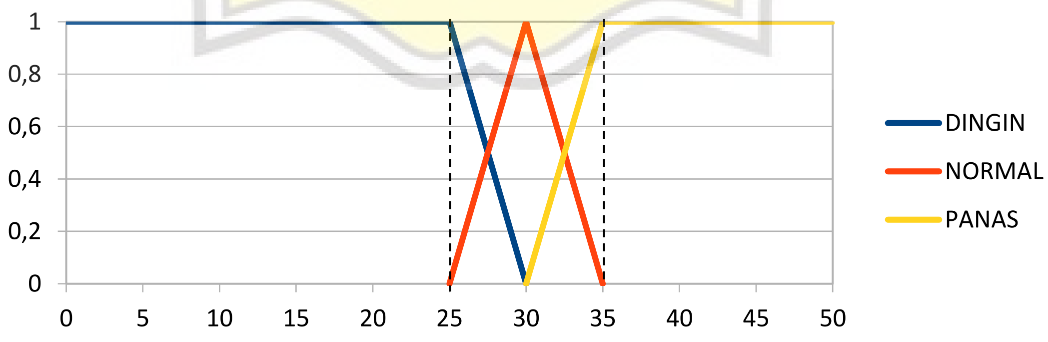


Figure 2: Temperature membership variable

The temperature membership function is formulated as follows:

$$\mu Dingin\ (x) = \begin{cases} 0; & x \geq 30 \\ \dfrac{30 - x}{30 - 25}; & 25 \leq x \leq 30 \\ 1; & x \leq 25 \end{cases}$$

$$\mu Normal\ (x) = \begin{cases} 0; & x \leq 25\ or\ x \geq 35 \\ \dfrac{x - 25}{30 - 25}; & 25 \leq x \leq 30 \\ \dfrac{35 - x}{35 - 30}; & 30 \leq x \leq 35 \end{cases}$$

$$\mu Panas\ (x) = \begin{cases} 1; & x \geq 35 \\ \dfrac{x - 30}{35 - 30}; & 30 \leq x \leq 35 \\ 0; & x \leq 30 \end{cases}$$

2. *pH membership variable*

The pH variable has 3 sub-variables, namely acid, neutral and alkaline. Acid has a value of less than 6.8. Neutral conditions have a range of values from 6.8 to 7.5. While for alkaline conditions, it has a value of over 7.5.

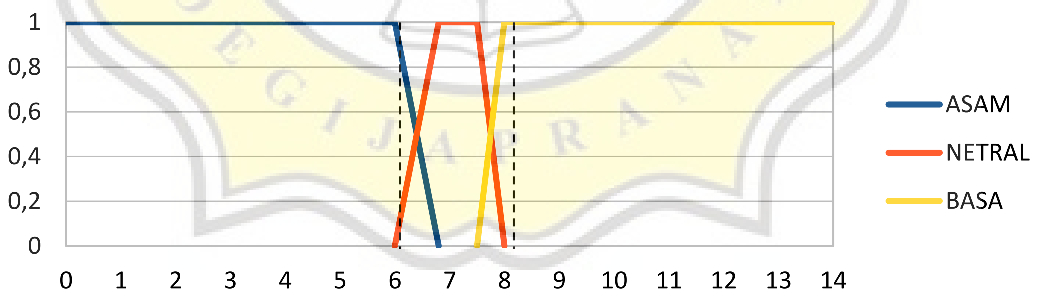


Figure 3: pH membership variable

The pH membership function is formulated as follows:

$$\mu Asam\ (x) = \begin{cases} 0; & x \geq 7 \\ \dfrac{7 - x}{7 - 6{,}8}; & 6{,}8 \leq x \leq 7 \\ 1; & x \leq 6{,}8 \end{cases}$$

$$\mu Netral\ (x) = \begin{cases} 0; & x \leq 6,8\ or\ x \geq 7,5 \\ \dfrac{x - 6,8}{7 - 6,8}; & 6,8 \leq x \leq 7 \\ \dfrac{7,5 - x}{7,5 - 7}; & 7 \leq x \leq 7,5 \end{cases}$$

$$\mu Basa\ (x) = \begin{cases} 1; & x \geq 7,5 \\ \dfrac{x - 7}{7,5 - 7}; & 7 \leq x \leq 7,5 \\ 0; & x \leq 7 \end{cases}$$

3. *Turbidity membership variable*

The next variable is turbidity, it has 2 sub-variables. Clear has a voltage value range of less than 2, and cloudy has a voltage value of over 2

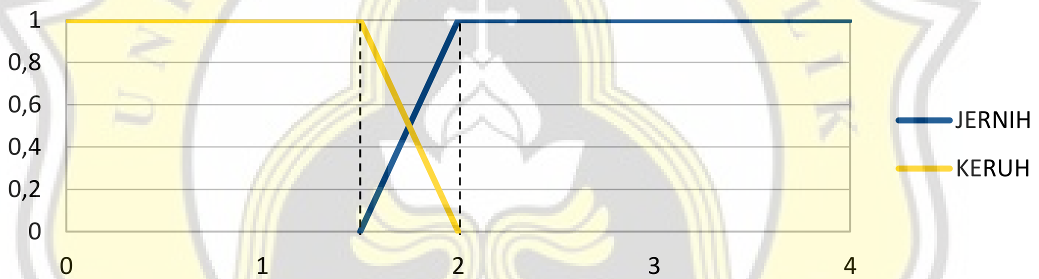


Figure 4: Turbidity membership variable

The turbidity membership function is formulated as follows:

$$\mu Jernih\ (x) = \begin{cases} 1; & x \geq 2 \\ \dfrac{x - 1,5}{2 - 1,5}; & 1,5 \leq x \leq 2 \\ 0; & x \leq 2 \end{cases}$$

$$\mu Keruh\ (x) = \begin{cases} 0; & x \geq 2 \\ \dfrac{2 - x}{2 - 1,5}; & 1,5 \leq x \leq 2 \\ 1; & x \leq 2 \end{cases}$$

4.1.3. Rule Base

The rule base is a set of rules as an if-then statement. Table 2 is the rule base for this system.

Table 2: Rule Base Table

Rule	Suhu	pH	Kekeruhan	Buzzer
R01	Dingin	Asam	Bening	On
R02	Dingin	Asam	Keruh	On
R03	Dingin	Netral	Bening	Off
R04	Dingin	Netral	Keruh	On
R05	Dingin	Basa	Bening	On
R06	Dingin	Basa	Keruh	On
R07	Normal	Asam	Bening	Off
R08	Normal	Asam	Keruh	On
R09	Normal	Netral	Bening	Off
R10	Normal	Netral	Keruh	On
R11	Normal	Basa	Bening	Off
R12	Normal	Basa	Keruh	On
R13	Panas	Asam	Bening	On
R14	Panas	Asam	Keruh	On
R15	Panas	Netral	Bening	On
R16	Panas	Netral	Keruh	On
R17	Panas	Basa	Bening	On
R18	Panas	Basa	Keruh	On

4.1.4. Defuzzification

Defuzzification is converting the results of the previous stage into an output that has a firm value using a predetermined membership function. The method to find the defuzzification value in fuzzy Sugeno uses Weight Average (WA). Below is the formula to calculate the value of defuzzification.

$$Output = \frac{(R1 * z1) + (R2 * z2) + (R3 * z3) + \cdots (Rn * zn)}{R1 + R2 + R3 + \cdots Rn}$$

Description:

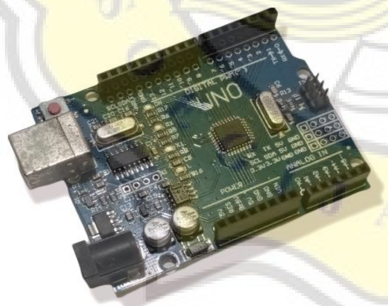
Rn = Rule value to … n

Zn = Rule output value to … n

4.2. Hardware

Figure 5 (a) shows Arduino Uno as the main component in making this system. Arduino Uno is a microcontroller board based on Atmega328p Arduino Uno is a microcontroller board based on Atmega328p. Arduino Uno It has 14 digital input/output pins, 6 of which can be used as PWM outputs, and 6 analog inputs. As a microcontroller, Arduino Uno can execute all program codes, including library code for calibrating each sensor and fuzzy algorithm library.

The DS18B20 sensor in figure 5 (b) which is a digital temperature sensor that has an internal 12-bit ADC. This sensor can read temperatures from -55 °C to +125 °C with precision and have an accuracy of +/-0.5 °C between -10 °C to +85 °C. This sensor uses a one wire communication protocol.



(a)

(b)

Figure 5: (a) Arduino Uno and (b) DS18B20 Temperature sensor

Figure 6 is the turbidity sensor. This sensor is used to detect turbidity in water. This sensor uses the light emitted by the LED, which is then the result of the reflected light which will be read by the sensor. So that the higher the level of turbidity of the water that will be detected, the level of light reflection received will be less, and vice versa.

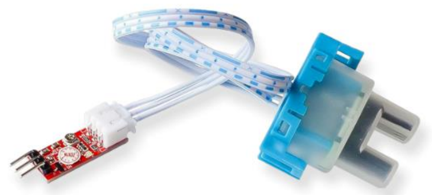
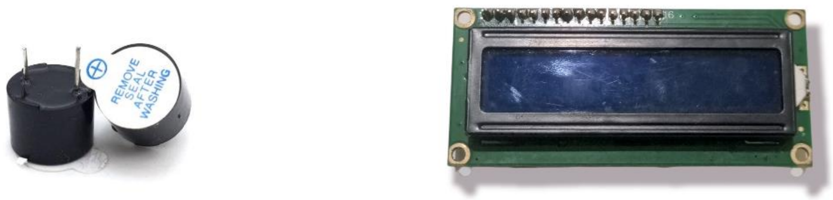


Figure 6: Turbidity Sensor

SEN0161 or the pH sensor module in figure 7 serves to detect the pH level of the water, where the output is an analog voltage. So, converting the reading value must be entered into the formula in the program code that is made. The fundamental working principle of the pH meter is that it is on the sensor probe as a glass electrode by measuring the number of $H3O+$ ions in the solution. The tip of the glass electrode is a layer of glass 0.1 mm thick, which is round (bulb). This pH sensor has an analog voltage output from 0 to 3 Vdc with an input power supply of 3.3–5.5 Vdc [6].

Figure 7: SEN0161 pH Sensor

Figure 8 (a) is an active buzzer that is used as a notification that the aquarium water is getting dirty and the water is ready to be replaced. While in Figure 6 (b) it is a 16x2 LCD to display the data read by the sensor.



(a) **(b)**

Figure 8: (a) Active Buzzer and (b) LCD 16x2

4.3. Design

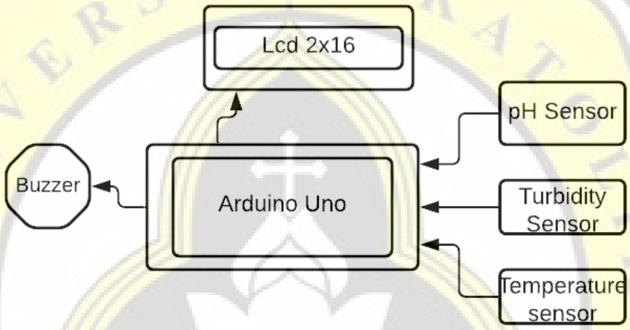


Figure 9: Block diagram

Figure 9 explains that this system uses Arduino Uno as a system that will control several components, such as pH sensor, temperature sensor, turbidity sensor, buzzer and LCD. The LCD will display the water condition as data from the sensor readings. The buzzer will activate if the water condition is less or more than a predetermined value.

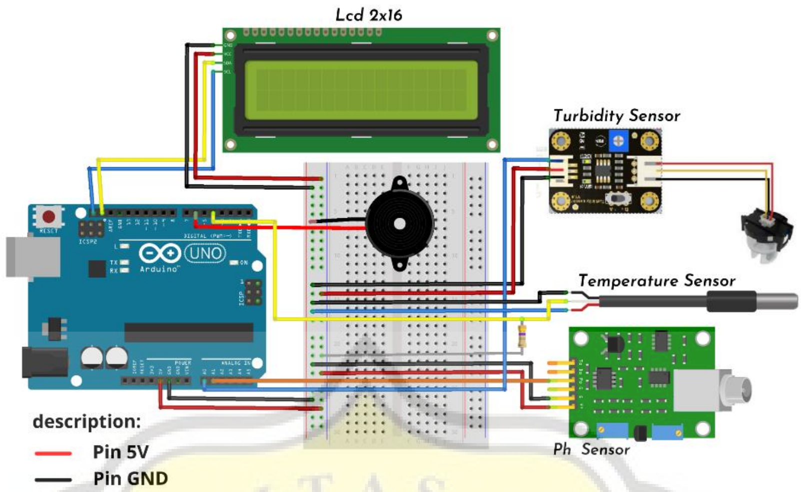


Figure 10: Hardware circuit sketch

Figure 10 is a complete overview of the prototype used in this project. The circuit comprises Arduino Uno as a microcontroller. Use a breadboard to connect the 5V voltage pins and the GND pins of the Arduino to each sensor. Cable with red colour is the cable connected to the 5V pin on the breadboard, while the cable with black colour is the cable for the GND pin. On a 16x2 LCD, connect the GND pin and the 5V pin to the breadboard. Then for the SDA pin (yellow cable) connect it to the SDA pin on the Arduino, as well as the SCL pin (blue) connect it to the SCL pin on the Arduino.

The next component is the buzzer. There are 2 pins on the buzzer, the GND pin which is connected to the GND breadboard and the 5V pin which can be connected to the 5V pin on the Arduino or can also be connected to the digital pin. In this project, the 5V buzzer pin is connected to pin 6. The turbidity sensor has 3 pins, the GND and 5V pins which are connected to the breadboard, then there is a digital output pin which is connected to pin A0 on the Arduino.

Next sensor is the temperature sensor. Temperature sensor has 3 pins namely, GND pin (black), DQ (data, yellow), VDD (blue). The GND pin and the VCC pin are joined and connected to the GND pin on the breadboard. The DQ pin is connected to the Arduino pin 4 via a 4.7k resistor connected to the 5V pin. The pH sensor has 6 sensors, but only 3 pins are used GND, VCC and Po pins. Just like the other sensors, the GND and VCC pins are connected to the breadboard, then the Po pin is connected to the A1 pin on the Arduino. Figure 11 is the final stage after all parts such as sensors and Arduino are assembled into one part.

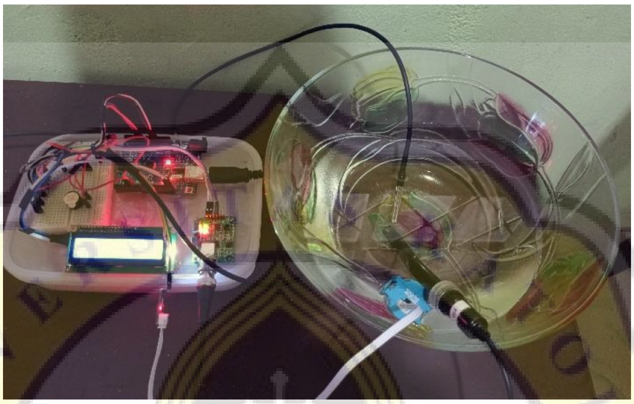


Figure 11: Hardware circuit

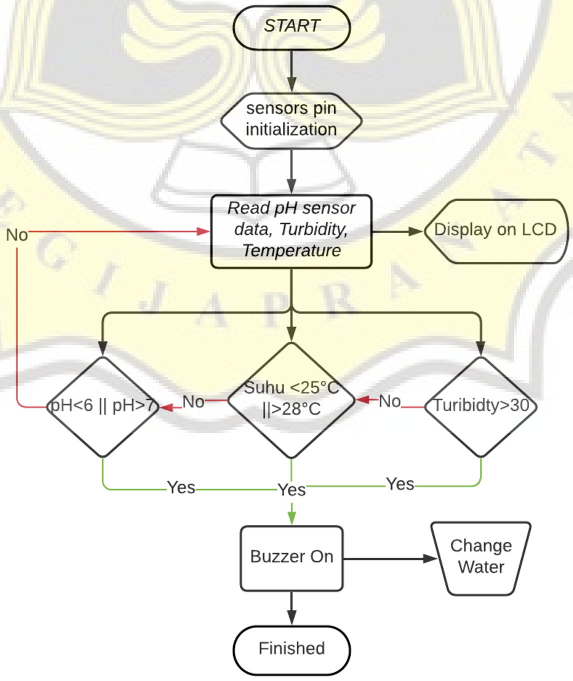


Figure 12: Flowchart

Figure 12 describes the flow of this system. Starting from the initiation of all sensors, then the sensor reads the content in the water, such as temperature, pH and turbidity. Then the data from the sensor is displayed on a 16x2 LCD. If the value of the water content is less or exceeds the predetermined value, the buzzer will sound to remind the owner to immediately change the water. And as a last act, the owner will change the water.