

# Water Quality Level for Shrimp Pond at Probolinggo Area Based on Fuzzy Classification System

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**Abstract**—Since several years ago, vaname shrimp (*Litopenaeus Vannamei*) has been extensively cultivated in Indonesia because it has good business opportunities. In aquaculture activities, water quality is an important factor that dramatically impacts shrimp's survival and quality. Therefore, the farmer must know the water quality information for a satisfactory harvest. This study aims to develop a water quality monitoring system based on temperature, pH, salinity, and dissolved oxygen information. The data from sensors are sent to the cloud utilizing Internet of Things (IoT) technology and then classified by a fuzzy logic system. In order to help farmers easily know the water quality of their shrimp pond, four sensor data, including the result of classification from fuzzy logic, are sent to the phone. After a trial of the system, 100% of the data are successfully sent to the cloud (google spreadsheet). The system also successfully classified the level of water quality as the farmer's expectation. With this system, it is hoped that it can assist farmers in monitoring the water quality of shrimp ponds to improve the quality and quantity of shrimp.

**Keywords:** *fuzzy logic, google spreadsheet, internet of things, vaname shrimp, water quality*

## I. INTRODUCTION

Indonesia is the second-longest coastline globally after Canada, giving an excellent potential in aquaculture for Indonesia [1]. However, for inland aquaculture production, Indonesia is still under China, India and Cambodia [2]. By this paper, authors want to give contribution to increase the aquaculture production, especially shrimp cultivation.

One of shrimp production is located at Probolinggo, East Java Province. Probolinggo has an area of 56,667 km<sup>2</sup> with a coastline of 7 km<sup>2</sup> which is directly adjacent to the Madura Strait. Probolinggo has several competitive advantages as a place of investment in the marine and fisheries sector due to ease of access to resources, ease and openness of market access, support for adequate supporting infrastructure, support for regional spatial planning, and the availability of land for business unit development. Probolinggo has excellent potential in the fields of marine and fisheries, agriculture, animal husbandry and industry.

White-leg shrimp (*Litopenaeus vannamei*) is a cultivated commodity in Indonesia that is currently widely cultivated [3]. The White-leg shrimp belongs to the *Penidae* family and comes from the waters of Latin America. White-leg shrimp are known to have several specific advantages, including high adaptability to low temperatures, high tolerance to changes in salinity, relatively fast growth rate, increased survival rates and a broad production market [4].

One of the essential aspects of shrimp farming is water quality. However, many farmers still lack knowledge about how to measure and manage water quality. Water quality management is very important so that pond water conditions remain in optimal condition for the survival of shrimp being cultivated [5]. Water quality monitoring is necessary to improve the efficiency, accuracy, and precision of the data collected over the long term. Water quality can affect the health and stress levels of shrimp, so that poor water quality can cause disease [6]. Several parameters must be considered to treat white-leg shrimp pond water quality, such as dissolved oxygen (DO), pH, temperature, and salinity [7].

Kungvankij, et al. on behalf of The Food and Agriculture Organization of the United Nations (FAO) [8], in their book they state that water quality management is a major consideration in shrimp farming which has 6 important parameters, namely salinity, pH, DO, nitrogen, temperature and hydrogen sulfide (H<sub>2</sub>S). This is reinforced by research conducted by Mubarok, et.al [9] which uses 4 parameters to determine water quality, namely DO, temperature, pH and salinity. Where these four parameters are parameters that must be measured daily on a regular basis [10].

Fuzzy logic methods already used in many sector of life, such as in biomedical, used to stress detector based on temperature, GSR and heart rate parameters [11], acrophobia early detection based on heart rate and skin

resistance [12] also in food industry such as used to fruit rottenness detector [13], egg rottenness detector [14], and in aquaculture sector such as koi fish water quality identification system [15].

Water quality decisions have been widely discussed by several researchers, such as water quality decisions for ex-mining shrimp ponds in Bangka Belitung using 3 parameters: pH, temperature and salinity. They used fuzzy logic Mamdani with 27 rules for their method to determine the level of water quality. This method is done under simulation program utilizing MATLAB software. The result is shown in the water quality scale of 0-100. The water quality is classified as “bad” if it has a value of <60, classified as “normal” if it has a value of 50-90, and classified as “good” if it has a value of >90. There are two types of simulation, one dynamic variable and two static variables, and one static variable and two dynamic variables are taken into observation. The simulation results show that a change in one dynamic variable can cause a decrease in water quality index to 70, and a change in the two dynamic variables can reduce the water quality index to 25.1 [16].

Another research done by Samura, et al. [17]. They monitor and control the water quality of tiger prawns which is implemented in miniature ponds in the form of plastic containers with 3 parameters i.e. temperature, salinity and turbidity. Fuzzy logic mamdani method is used in this research which is processed by NI MyRIO using the LABView program. In the monitoring process, comparing two types of membership function numbers used to know the water quality level with a comparison of error accuracy of 3.22 for 3 membership functions and error accuracy of 0.51 for 5 membership functions. So it can be said that the 5 membership functions are more accurate than 3 membership functions. In the control process, fuzzy logic is used to control the PWM rotational speed of each water pump including temperature pump, salinity pump and turbidity pump.

A portable pond water quality monitoring system was created to help aquaculture cultivators to monitor water quality parameters, then the data is processed using fuzzy logic to obtain water quality. These measured parameters will be stored in a google spreadsheet for further use in evaluating production achievements in the aquaculture sector, particularly shrimp production.

## II. SYSTEM DESIGN AND METHOD

In this research, authors divided the system into two blocks i.e., data acquisition module and fuzzy classification which is embedded in cloud system as shown in Figure 1. Data acquisition module that is shown by red dash line consist of four sensors i.e DO, pH, temp and EC, data acquisition unit, LCD and IoT device. This module collect data, display in LCD and send the data to cloud utilizing IoT device. Data are saved in the google spreadsheet where the fuzzy logic embedded as shown in Figure 1 inside blue dash line. In order to easily access the data, the

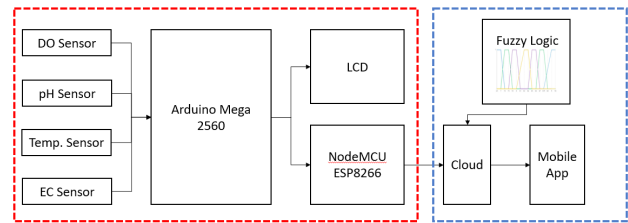


Figure 1. System block diagram

farmer is ask to register a google account. By doing this manner, farmer is easy to see the history of shrimp pond water quality on their smartphone.

In Figure 2a it is the external shape of the tool, while in Figure 2b it is the internal shape of the tool. In Figure 2b, it can be seen that there is an Arduino Mega 2560, NodeMCU ESP8266 and several sensors as shown in Figure 1 in the red dash line.

This research was carried out on a pond located in the coastal area of Probolinggo City, East Java as shown in Figure 3 with yellow colour.

### A. Data Acquisition Module

Data acquisition module consists of several parts i.e. sensing device, collecting data device, IoT device, and LCD.

Sensing device consists of four sensors, i.e:

- Dissolved Oxygen (DO) Sensor by Atlas Scientific, used to determine the dissolved oxygen content in water. The dissolved oxygen used is in part-per-million (ppm).
- Hydrogen Potential (pH) Sensor by Atlas Scientific, used to determine the acidity of the water.
- Temperature Sensor by Atlas Scientific, used to determine the temperature of the water. The temperature used is in Celcius degrees (°C).
- Electrical Conductivity (EC) Sensor by Atlas Scientific, used to determine the content of dissolved salts in water or salinity. The salinity used is in part per trillion (ppt).

Collecting data device use Arduino Mega 2560, IoT device utilizing NodeMCU ESP8266, while LCD using 16×2 characters.

### B. Fuzzy Classification System

After 4 parameter data successfully sent to cloud, the

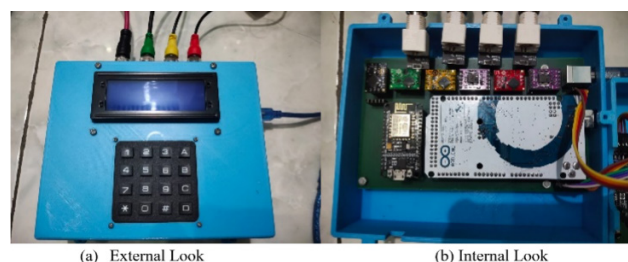


Figure 2. Hardware unit



Figure 3. Location of vaname shrimp pond

data is processed by fuzzy logic to generate the water quality level. For this purpose, authors propose fuzzy classification using Tsukamoto method as shown in Figure 4. By using fuzzy classification, it is possible to generate water quality level based on four parameters.

The inference system of the Tsukamoto fuzzy method forms a rule base in the form of "if-then". The first step in Tsukamoto's Fuzzy method is to create a fuzzy rule. The next step is to calculate the degree of membership according to the rules that have been made. After knowing the degree of membership of each fuzzy rule, the alpha predicate value can be determined by using fuzzy set operations.

The important thing before the design of fuzzy logic, intensive communication between author and farmer is conducted to adjust and determine the parameter in fuzzy logic such as membership function and rule base so the output of fuzzy logic will meet the requirement of farmer.

After the classification results are obtained, the farmers will verify the data for the feasibility of the next trial. For this purpose, authors must refer the standard data for shrimp cultivation. In this paper, authors utilize the result from other researches [3] [18] for generating membership function as shown in Table 1.

In this study, the authors represent the membership function input in the form of a trapezoidal curve. Where there are 3 types of functions to get the alpha predicate value, i.e a descending linear function, an ascending linear function and a trapezoidal function.

The descending linear function shown in Figure 5 is the fuzzy set starting from the area value with the highest degree of membership on the left side, then moving up to a lower degree of membership. A fuzzy membership degree function is called a descending linear function if it

Table 1. Standard optimal value of shrimp pond water parameters

Parameter	Optimum Values	Tolerance
DO	3 – 7.5 ppm	>3 ppm
Temperature	28.5 – 31.5°C	26 – 35°C
Salinity	15 – 25 ppt	0 – 35 ppt
pH	7.5 – 8.5	7 – 8.5

has 3 parameters, i.e a, b, c ∈ R, and is expressed by the following rule:

$$\mu(x;a,b,c) = \begin{cases} 1 & ;x < b \\ \frac{c-x}{c-b} & ;b \leq x \leq c \\ 0 & ;x > c \end{cases} \quad (1)$$

The ascending linear function shown in Figure 6 is the fuzzy set starting from the area value with the lowest degree of membership on the left side, then moving up to a higher degree of membership. A fuzzy membership degree function is called an ascending linear function if it has 3 parameters, i.e a, b, c ∈ R, and is expressed by the following rules:

$$\mu(x;a,b,c) = \begin{cases} 1 & ;x > b \\ \frac{x-a}{b-a} & ;a \leq x \leq b \\ 0 & ;x < a \end{cases} \quad (2)$$

The trapezoid function is a combination of two linear lines, with some points having absolute membership values. The Trapezoid Curve is shown in Figure 7.

For the first membership function, authors develop temperature membership function. The temperature parameters divided into four membership functions: good, medium, bad, and very bad. Temperature can be classified as "good" if it is 29.3-30°C, classified as "medium" if it is 26-29.3°C or 30-31°C, classified as "bad" if it is 25-26°C or 31-33°C, and classified as "very bad" if it is <25°C or >33°C. The temperature membership function is shown in Figure 8.

The second input is the power of hydrogen (pH). The pH parameters divided into four membership functions: good, medium, bad, and very bad. pH can be classified as "good" if it is 8.0-8.5, classified as "medium" if it is 7.5-8 or 8.5-8.7, and classified as "bad" if it is 7-7.5 or 8.7-8.8, classified as "very bad" if it is <7.0 and >9.0. The pH membership function is shown in Figure 9.

The third input is dissolved oxygen. The DO parameters

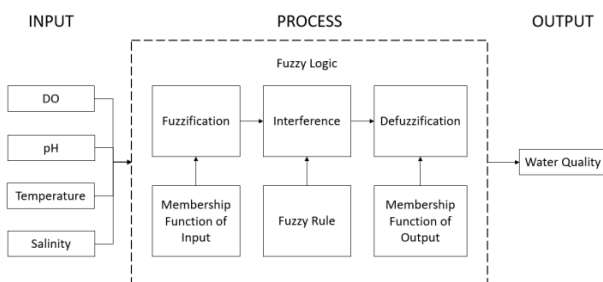


Figure 4. Fuzzy logic block diagram

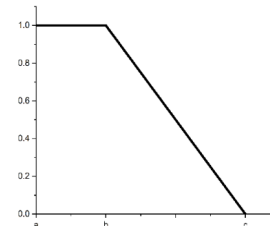


Figure 5. Descending linear curve

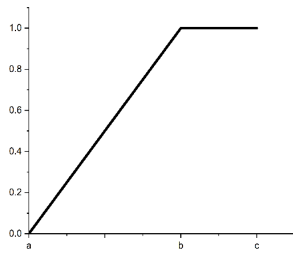


Figure 6. Ascending linear curve

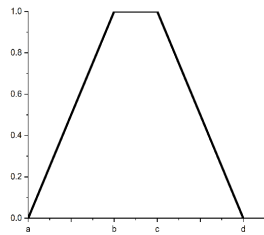


Figure 7. Trapezoid curve

divided into four membership functions: good, medium, bad and, very bad. DO can be classified as “good” if it is >6.5 ppm, classified as “medium” if it is 4.75-6.5 ppm, classified as “bad” if it is 2.75-4.75 ppm, and classified as “very bad” if it is <2.75 ppm. The DO membership function is shown in Figure 10.

The fourth input is salinity. The salinity parameters divided into four membership functions: good, medium, bad and very bad. Salinity can be classified as “good” if it is worth 17-25 ppt, classified as “medium” if it is worth 10-17 ppt or 25-30 ppt, classified as “bad” if it is 4-10 ppt or >30 ppt, and classified as “very bad” if it is <4 ppt. The salinity membership function is shown in Figure 11.

For testing each parameter, the  $\alpha$ -predicate is taken from membership function of its parameter. Then, the largest  $\alpha$ -predicate value is taken to determine the status of the parameter. The input data for fuzzy logic testing is in the form of random data to generate the status of each parameter as shown in Table 2.

After getting the  $\alpha$ -predicate for each parameter, it will be compared to the rule base. There are 80 rule bases in

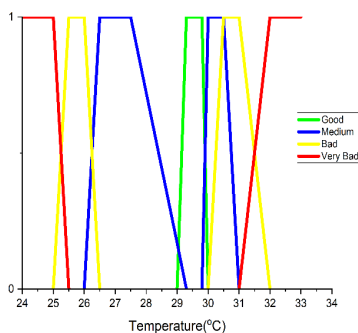


Figure 8. Membership function of "Temperature"

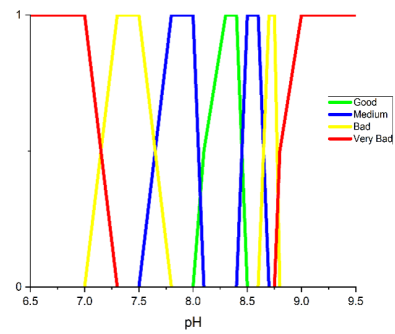


Figure 9. Membership function of "pH"

Table 3 that are created and will get the value of each rule to be defuzzified.

Before entering the defuzzification process, there is an implication process which is used at this stage is the MIN function, namely by taking the smallest membership value between elements in the fuzzy set in one rule as the  $\alpha$  value of water quality. The result of the function of the implications of each rule is called  $\alpha$ -predicate or can be written  $\alpha$ .

$$\alpha_i = \mu_{A \cap B} = \min(\mu_{A_i}[x], \mu_{B_i}[x]) \quad (3)$$

where:

$\alpha_i$ : the minimum value of the degree of membership in the i-th rule

$\mu_{A_i}[x]$ : the degree of membership of the fuzzy set A on the i-th rule

$\mu_{B_i}[x]$ : the degree of membership of the fuzzy set B on the i-th rule

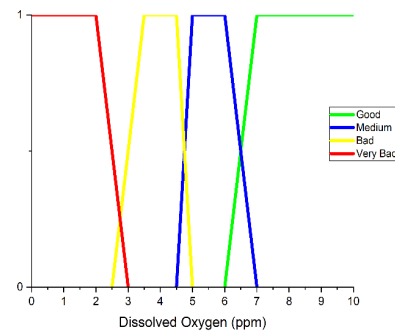


Figure 10. Membership function of "DO"

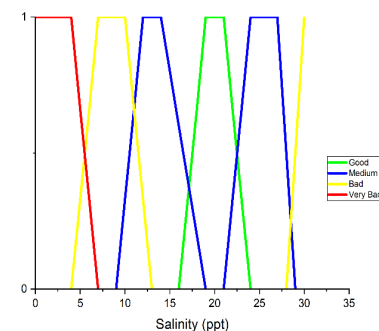


Figure 11. Membership function of "Salinity"

Table 2. Status of each parameter

Parameter	Value	Score				Status
		Good	Medium	Bad	Very Bad	
pH	8.1	0.67	0.33	0	0	Good
DO	6.8	0.8	0.3	0	0	Good
Salinity	24	0.6	0.3	0	0	Good
Temperature	28.5	0.59	0.41	0	0	Good

The output of this system is water quality level. The level of water quality is represented by the numbers 0-100. The water quality index is classified as “very bad” if the level is under 40, classified as “bad” if the level is 35-60, classified as “medium” if the level is 55-80, and classified as “good” if the level is >80. The water quality membership function is shown in Figure 12.

After knowing the  $\alpha$  value of the water quality, the next step is to know the  $z_i$  value. To find out the  $z_i$  value, refer to Figure 12 with the following formula:

Good :

$$z_i = 25\alpha_i + 75 \tag{4}$$

Medium :

$$z_i = 10\alpha_i + 55 \text{ and } z_i = 80 - 15\alpha_i \tag{5}$$

Bad :

$$z_i = 10\alpha_i + 35 \text{ and } z_i = 60 - 15\alpha_i \tag{6}$$

Very Bad :

$$z_i = 40 - 40\alpha_i \tag{7}$$

As shown in Table 2, the  $\alpha$  value can be obtained from the column score/good where in these column it has 0.67 for pH, 0.8 for DO, 0.6 for salinity and 0.59 for temperature. Based on these number, all of parameters are in good condition, giving good result for water quality classification, as shown in Table 3. Based on equation (3), the minimum number of those parameter must be chosen yielding 0.59 as the  $\alpha$  value. If a horizontal line is drawn from  $\alpha = 0.59$ , this line will cross several classification lines shown in Figure 12. Since the classification result is “good”, the horizontal line will cross “good” line indicated by green line. Then, using equation (4) will get the  $z_i$  result is 89.75.

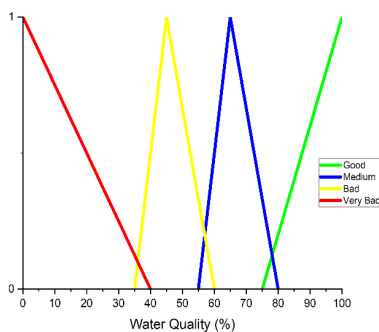


Figure 12. Membership function of water quality level

After that, a defuzzification process will be carried out to obtain the percentage of water quality. The defuzzification method used in this study is the weighted average method, which is obtained by the following formula as shown in (8):

$$Z = \frac{(a1 * z1) + (a2 * z2) + \dots + (an * zn)}{a1 + a2 + \dots + an} \tag{8}$$

### III. RESULT AND DISCUSSION

Based on studies in introduction section, authors interest to bring four parameters as shown in Table 4, for leveling water quality using fuzzy classification system.

#### A. Fuzzy Logic System

The fuzzy logic system is done by combining the possibilities that exist by using parameter data to determine the status of each parameter and the percentage of its water quality. To verify whether fuzzy logic created in this system is correct, several parameter, i.e sensor sensing value are randomly created. These parameter are then processed by fuzzy classification system and confirmed by farmer. Based on this test, all result produced by fuzzy classification system are meet the expectation of farmer. Table 5 shows some samples of defuzzification which is verified by farmers.

In the real measurement, data acquisition module with the sensor is placed in the pond. Ten days experiment was carried out. The data is taken from the pond morning and evening as shown in Table 6.

On the 14th and 15<sup>th</sup> of June, there was an anomaly in the DO data which looked very high, above 10ppm. The anomaly is caused by human error, where the sensor has not been properly calibrated before measurement on that day.

DO values tend to be lower in the morning than in the afternoon due to algae activity that produces oxygen during the day and consumes oxygen at night. The activity of these algae will also affect the pH parameters towards alkaline, so that the pH measurement during the day is higher than the pH in the morning. As for changes in temperature due to exposure to sunlight which affects the temperature of the water itself. Salinity values tend to be stable because usually salinity is strongly influenced by rainfall, while in June there is almost no significant rainfall.

#### B. Testing of Data Delivery, Data Storage and Data Processing on Google Spreadsheet

This test is carried out to test the flow of data from the data acquisition tool to google spreadsheet as the data storage area and also to ensure the data is processed with fuzzy logic so that the results are in the form of water quality.

Figure 13 shows the parameter data stored on a google spreadsheet. The first and second column contains the date



Table 3. Fuzzy classification rule base

DO	pH	Temperature	Salinity	Classification
Good	Good	Good	Good	Good
Good	Good	Good	Medium	Good
Good	Good	Medium	Good	Good
Good	Good	Medium	Medium	Medium
Good	Good	Bad	Good	Medium
Good	Good	Bad	Medium	Medium
Good	Good	Very Bad	Medium	Bad
Good	Medium	Good	Good	Good
Good	Medium	Good	Medium	Good
Good	Medium	Medium	Good	Medium
Good	Medium	Medium	Medium	Medium
Good	Medium	Bad	Good	Bad
Good	Medium	Bad	Medium	Medium
Good	Bad	Medium	Good	Bad
Good	Bad	Medium	Medium	Bad
Good	Bad	Very Bad	Good	Bad
Good	Bad	Very Bad	Medium	Very Bad
Good	Very Bad	Very Bad	Good	Very Bad
Good	Very Bad	Very Bad	Medium	Very Bad
Medium	Good	Good	Good	Good
Medium	Good	Good	Medium	Good
Medium	Good	Medium	Good	Medium
Medium	Good	Medium	Medium	Medium
Medium	Good	Bad	Good	Bad
Medium	Good	Bad	Medium	Medium
Medium	Medium	Good	Good	Medium
Medium	Medium	Good	Medium	Medium
Medium	Medium	Medium	Good	Medium
Medium	Medium	Medium	Medium	Medium
Medium	Medium	Bad	Good	Medium
Medium	Medium	Bad	Medium	Bad
Medium	Bad	Good	Good	Medium
Medium	Bad	Good	Medium	Bad
Medium	Bad	Medium	Good	Bad
Medium	Bad	Medium	Medium	Bad
Medium	Bad	Bad	Good	Bad
Medium	Bad	Bad	Medium	Bad
Medium	Very Bad	Very Bad	Good	Very Bad
Medium	Very Bad	Very Bad	Medium	Very Bad

and time. Then, columns 3, 4, 5, 6 are the data obtained from the data acquisition module. Then, columns 7, 8 are data processing results using fuzzy logic classification system in *Appscript*.

#### IV. CONCLUSIONS

In this study, authors build a water quality classification system using a fuzzy logic classification model. The parameters used have been discussed with the farmers in

Table 3. Fuzzy classification rule base (cont.)

DO	pH	Temperature	Salinity	Classification
Bad	Good	Medium	Medium	Bad
Bad	Medium	Good	Good	Medium
Bad	Medium	Good	Medium	Bad
Bad	Medium	Medium	Good	Bad
Bad	Medium	Medium	Medium	Bad
Bad	Medium	Bad	Good	Bad
Bad	Medium	Bad	Medium	Bad
Bad	Medium	Very Bad	Good	Very Bad
Bad	Medium	Very Bad	Medium	Very Bad
Bad	Bad	Good	Good	Bad
Bad	Bad	Good	Medium	Bad
Bad	Bad	Medium	Good	Bad
Bad	Bad	Medium	Medium	Bad
Bad	Bad	Bad	Good	Bad
Bad	Bad	Bad	Medium	Bad
Bad	Very Bad	Very Bad	Good	Very Bad
Bad	Very Bad	Very Bad	Medium	Very Bad
Very Bad	Medium	Medium	Medium	Very Bad
Very Bad	Bad	Good	Good	Bad
Very Bad	Bad	Good	Medium	Very Bad
Very Bad	Bad	Medium	Good	Very Bad
Very Bad	Bad	Medium	Medium	Very Bad
Very Bad	Bad	Bad	Good	Very Bad
Very Bad	Bad	Bad	Medium	Very Bad
Very Bad	Very Bad	Good	Good	Very Bad
Very Bad	Very Bad	Good	Medium	Very Bad
Very Bad	Very Bad	Medium	Good	Very Bad
Very Bad	Very Bad	Medium	Medium	Very Bad
Very Bad	Very Bad	Bad	Good	Very Bad
Very Bad	Very Bad	Bad	Medium	Very Bad
Very Bad	Very Bad	Very Bad	Good	Very Bad
Very Bad	Very Bad	Very Bad	Medium	Very Bad

the hope that the output produced by the system will be in accordance with the standards or wishes of the farmers. There are 4 parameters that are classified into 4 categories which will be processed to obtain a water quality that is

Table 4. Comparison of water parameter for determining water quality level

Parameter	[13]	[14]	Current Research
DO	-	-	✓
pH	✓	-	✓
Temperature	✓	✓	✓
Turbidity	-	✓	-
Salinity	✓	✓	✓
Pond	Real	Miniature	Real
Status	Simulation	Real	Real

Table 5. Fuzzy logic validation output

DO	pH	Temperature	Salinity	Percentage	Classification	Validation
8.65	8.25	27.5	24	83.42	Good	✓
8.1	8.35	27.3	22	81.89%	Good	✓
7.6	8.4	27	22	70%	Medium	✓
4.3	8.4	27	22	63.92%	Medium	✓
4.1	7.9	26.7	25	52.76%	Bad	✓
3.7	8.1	26.5	27	45.53%	Bad	✓
2.6	8.9	27	22	24%	Very Bad	✓
2.3	8.9	27	22	16%	Very Bad	✓

Table 6. The pond's data for 10 days

Date	Time	DO	pH	Temperature	Salinity
14/06/2019	12:50	14.75	8.14	27.31	24
	15:08	14.44	8.32	27.57	23
15/06/2019	6:54	47.95	7.98	26.09	22
	15:17	8.74	8.35	27.33	23
16/06/2019	6:56	8.27	7.96	26.25	23
	14:59	8.46	8.6	27.66	24
17/06/2019	6:52	7.65	9.07	25.74	22
	14:44	8.57	8.68	27.54	23
18/06/2019	6:47	7.66	8.04	25.64	22
	14:54	8.78	8.7	27.02	23
19/06/2019	6:47	7.06	8.06	25.36	21
	14:59	9.11	8.84	26.95	23
20/06/2019	6:55	6.12	8.09	25.19	21
	14:53	7.48	8.67	26.66	22
21/06/2019	6:52	7.16	7.93	24.76	20
	14:49	8.75	8.84	26.76	23
22/06/2019	6:50	6.33	8.02	25.08	21
	14:50	9.11	8.86	27.01	23
23/06/2019	6:51	6.7	8.1	25.38	21
	14:26	9.11	8.09	26.89	25

classified into 4 categories.

From the experimental results, it can be seen that the classification results are in accordance with the expectations of farmers. Fuzzy logic that is placed in the cloud can run well, because the output on the spreadsheet is in accordance with the results that have been discussed.

For further development, authors will carry out measurement and analysis in different places. To see if the system being built will work in a different geographic location, authors will do the same case in a different location.

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Data		DissolvedOxygen	Temperature	pH	Salinity	WaterQuality	
Date	Time	Value	Value	Value	Value	Percentage	Classification
6/14/2019	12:50	14.75	27.31	8.14	24.00	84.22	Good
6/14/2019	15:08	14.44	27.57	8.32	23.00	83.42	Good
6/15/2019	6:54	47.95	26.09	7.98	22.00	60.18	Medium
6/15/2019	15:17	8.74	27.33	8.35	23.00	83.42	Good
6/16/2019	6:56	8.27	26.25	7.96	23.00	63.19	Medium
6/16/2019	14:59	8.46	27.66	8.6	24.00	74.33	Medium
6/17/2019	6:52	7.65	25.74	9.07	22.00	60.76	Medium
6/17/2019	14:44	8.57	27.54	8.68	23.00	64.01	Medium
6/18/2019	6:47	7.66	25.64	8.04	22.00	61.38	Medium
6/18/2019	14:54	8.78	27.02	8.7	23.00	52.83	Bad
6/19/2019	6:47	7.06	25.36	8.06	21.00	60.08	Medium
6/19/2019	14:59	9.11	26.95	8.84	23.00	45.33	Bad
6/20/2019	6:55	6.12	25.19	8.09	21.00	52.76	Bad
6/20/2019	14:53	7.48	26.66	8.67	22.00	62.68	Medium
6/21/2019	6:52	7.16	24.76	7.93	20.00	60.00	Medium
6/21/2019	14:49	8.75	26.76	8.84	23.00	45.33	Bad
6/22/2019	6:50	6.33	25.08	8.02	21.00	53.24	Bad
6/22/2019	14:50	9.11	27.01	8.86	23.00	45.53	Bad
6/23/2019	6:51	6.7	25.38	8.1	21.00	61.38	Medium
6/23/2019	14:26	9.11	26.89	8.09	25.00	74.00	Medium

Figure 13. Parameter data storage on Google Spreadsheets

Pengelola Dana Pendidikan (LPDP) through the Program Pendanaan Program Riset Keilmuan Terapan Tahun 2021 based on contract number: 0761/D6/KU.04.00/2021 between the Direktorat Jenderal Pendidikan Vokasi, Kementerian Pendidikan, Kebudayaan, Riset dan Teknologi Republik Indonesia and Politeknik Elektronika Negeri Surabaya.

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