

## Water Quality Monitoring with Fuzzy Logic Control Based on Graphical Programming

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### Abstract

Water quality is the most important aspect to ensure success in various aspects of life, for example in the shrimp ponds. On a shrimp pond, water conditions are very vital because it has a very strict threshold. Unstable water conditions will affect growth and condition of shrimps, eat passion of shrimps, until their ability to survive greatly affect the survival of the shrimps. The percentage of farmers harvesting shrimps if the water did not have good conditions then the farmers will suffer significant losses if yields were not as expected, began from the amount of shrimp that was reduced due to death or the quality of the shrimp were judged from the size of the shrimp. So the authors wanted to do research on how to maintain the quality of the water in shrimp pond so that the water quality is maintained. To overcome this, we need to monitor water conditions based on the level of salinity and turbidity of water in order to stay in good condition. In this case, the researchers used fuzzy logic to monitor the amount of water quality and water volume. In this study only conducted water quality monitoring process but to do water changes to a certain condition still conducted manually. As well as the programming language used as the NI LabVIEW graphical programming with the application form to see monitoring of water quality so that water conditions are well preserved.

**Keywords:** salinity, turbidity, labview, fuzzy logic control, graphical programming

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### 1. Introduction

Water is the most important thing is in the aspects of life, such as households, farms, ponds, etc [1]. One of the vital water utilization was in the shrimp ponds. Water quality in shrimp ponds has an important role determine the success of the crop [2]. Poor water quality conditions will greatly affect the health of shrimps and farmers threatened with crop failure even if the pond water too clean, shrimps will not grow well. Some of the factors that affect the quality of water turbidity and salinity ponds. Several factors as determinants of water quality shrimps (Vannamei types for example) is the level of salinity of 19-25 ppt (part per thousand), while for the turbidity of 3-15 ppt. So the value of salinity and water turbidity should remain balanced.

Water that has low salinity was dangerous because it will decrease the oxygen that would cause the thin-crust shrimps, it usually occurs during the rainy season due to the increase in water flow due to the rain that has a high acid content. While salinity was too high will reduce their growth, this usually occurs during the dry season [3]. As shrinking water discharge but the amount of clay, organic [2] and inorganic compounds, plankton and other microorganisms strongly suspected as the cause of the water turbidity [4]. Turbidity of pond water greatly affect the growth shrimps, because if the water is not turbid, the sunlight absorbed in the water would be too much. This will cause the shrimp growth was not optimal, although the shrimp even though plankton need sunlight for growth [5].

Previous research conducted [6] on the use of NI LabVIEW to design instrumentation, this research only conducted for the instrumentation control system, but no algorithm / intelligent systems in this study. While further research conducted [7] was fuzzy logic implementation in LabVIEW, but was not implemented directly in hardware, but only on simulation for DC motors only. Meanwhile, according to Xie [5] very important to maintain the quality of the water in shrimp ponds. The fuzzy logic used to control the instruments directly through the exchange of

data and commands between input and output [8] as was done well in previous studies to monitor the irrigation channel.

Therefore it is necessary a system that can monitor water conditions in real time so that the farmer/user can monitor water quality at any moment and can replace or add water so that water quality maintained. The development of this system will be conducted in the form of hardware and software monitoring water quality using fuzzy logic control based on the level of salinity and water turbidity pond. Hardware that will be used was sensor salinity (salt), sensors turbidity (turbid), Arduino Mega microcontroller and LED indicators would implement with LabVIEW.

## 2. Research Method

This section describes the methods and hardware research procedures. How to use the sensor needs and design of fuzzy logic. Description of needs and their references so that the flow explanation of the system that can be used in Figure 1.

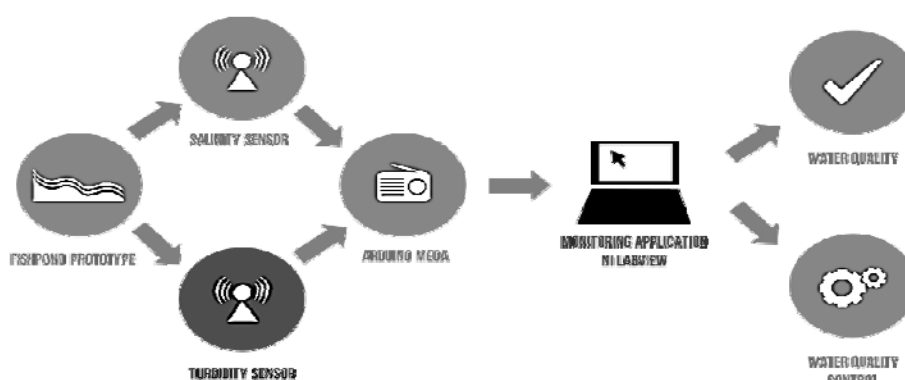


Figure 1. Hardware Block Diagram

This system will be made in the form of a prototype of a pool of water, where the water pools will be given two sensors, namely salinity sensor and turbidity sensor. Two of these sensors will provide an output voltage on the microcontroller. Microcontroller used is Arduino Mega. After Arduino gets the data from the sensor, then he will transmit the data to monitoring applications that have been created using LabVIEW. In such applications, the data of salinity sensors and sensor turbidity will be processed using fuzzy logic. So that the water quality data can be monitored quality. On the application of data obtained in real-time so that any slight change in water conditions, will be read in the monitoring system.

### 2.1. Sensor

Salinity and turbidity sensors used by the researchers generated data such as voltage output with a range of 0-5V. While the required data input form from the sensor is converted in the form of Part Per Thousand (ppt) to salinity and Nephelometric Turbidity Unit (NTU) with a range of 0-50ppt and 0-50ntu. To overcome this problem researchers apply Analog to Digital Conversion (ADC) [5, 9] as found in

Figure 2.

Based on

Figure 2, the data from the salinity sensor 0ppt 1,7v as default and 3.7V as the maximum value 50ppt after conversion. While turbidity sensor produces 0,3v as default Ontu and 1,3v maximum value 5ntu.

### 2.2. Fuzzy Logic Control

To control the quality of water needed two sensor data that has been obtained in the form Analog to Digital Conversion (ADC), then Membership Function and Rule Evaluation of Fuzzy Logic will be designed in LabVIEW. Fuzzy logic type used by researchers is the kind Center of Area (CoA) [10]. This function will determine the condition of the water because water

conditions a very vital in many aspects [11] A little water conditions was not precise will be harmful to living things in their environment. Therefore, Fuzzy models used by researchers is the Gaussian model. The membership functions used consisted of seven membership function for each input data. Fuzzy logic can be applied to give a specific value corresponding [12, 13], so in this application provided a feature to edit the membership functions.

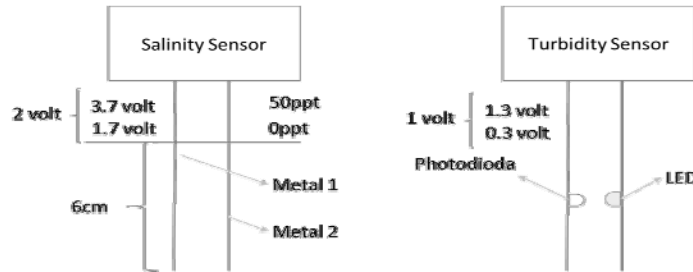


Figure 2. ADC Salinity and Turbidity Sensors

Users can edit the membership function by filling the array contained in the left column in Figure 3. Meanwhile, if you want to change the model of Fuzzy to which the user can press the button switch "Model" which located at the top left of the application. "Model" is available here for models from MF example gaussian, trapezoid or triangle. In the left column can be put restrictions into direct value of membership function, fuzzy logic functionality is already provided by LabVIEW so easy to implement.

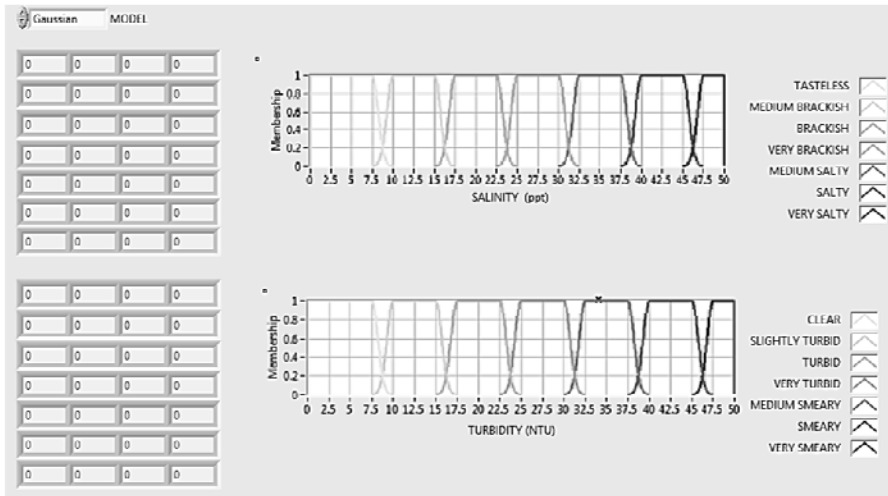


Figure 3. Fuzzy Logic Membership Function

**2.3. Analysis Methods**

Once the design of hardware and intelligent systems designed, the next step is to design the system software. System interface provided several features, among others, the first is the number of the membership function like in Figure 4. On the membership number is provided 3, 5 and 7, which serves to determine if the precision of the membership which is owned by the water located in the left column of the interface. The greater the number of membership function used, it increasingly details the value of the membership function processed by fuzzy logic. Then the second function is the result of sensor readings and output fuzzy logic located on the right column of applications.

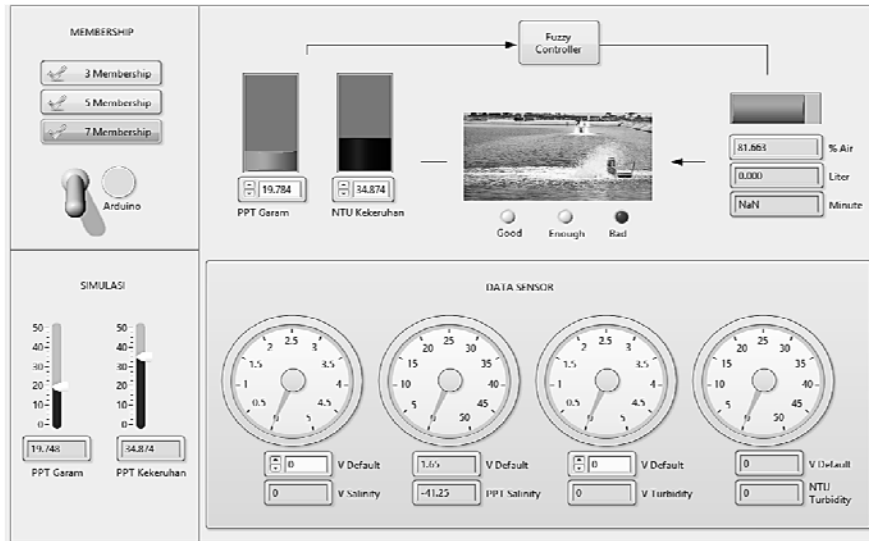


Figure 4. Application of Pond Water Quality Control

Based on Figure 4 the bottom right used to calibrate the sensor. In the picture, there are 4 circles, two circles used to calibrate the salinity of the sensor and then be used for calibration of turbidity sensors. So if performed in a swimming pool displacement smaller or larger, it is possible again to recalibrate. With this functionality will provide a lot of additional features for the system to work better and can be implemented on the condition of different pools.

**2.4. ADC Sensor Calibration**

Each sensor calibration ADC, to ensure whether the data obtained in accordance with a design that has been created. Based in

Figure 5 shows the ADC calibration salinity sensor produces an output voltage 1.5v default. For salinity sensor requires a long time, because of the influence of the water that soaked the foot sensor while the pool so large that it cause the readings less than the maximum.

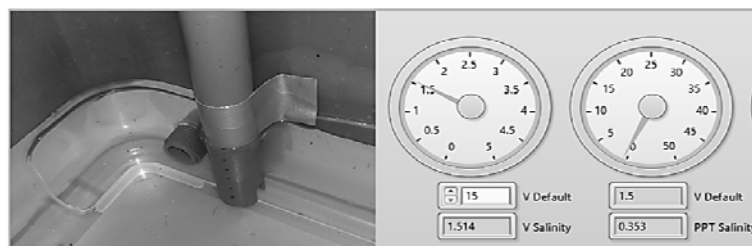


Figure 5. Salinity Sensor Calibration ADC

From Table 1, shows the results of ADC in accordance with the design of the system, but the time for the output of the sensor stable long enough salinity. To test seven samples requires 323 seconds or less than five minutes. Meanwhile, the turbidity sensor calibration tends to be more appropriate than the salinity sensor, although the default condition sensor able to changed easily.

There are in Figure 6 shows the results of the turbidity sensor calibration ADC produce output voltage 0,18v default.

Table 2, the test results of the turbidity sensor that produce different ADC values in accordance with the rise in the output voltage from the sensor. While the stable time of the

turbidity sensor indicates the total number of only 78 seconds or one minute by seven test samples.

Table 1. ADC Salinity Sensor Calibration Results

No.	V Default (v)	Sensor Voltage (v)	ADC Salt (ppt)	Stable Period (t)
1	1,5	1,51	0,35	41
2	1,5	2,12	15,78	45
3	1,5	2,23	18,48	47
4	1,5	2,97	36,85	51
5	1,5	3,11	40,41	45
6	1,5	3,27	44,45	50
7	1,5	3,33	45,92	44
Total				323

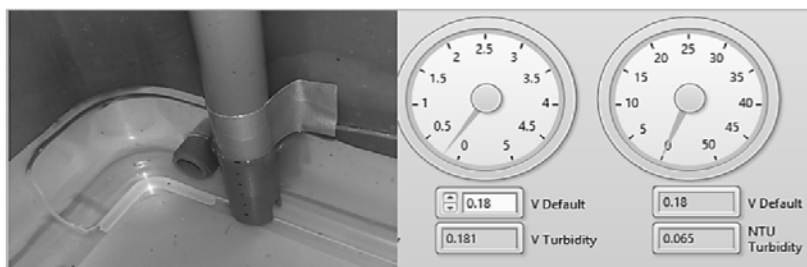


Figure 6. ADC Turbidity Sensor Calibration

Table 2. Results of ADC Calibration Turbidity Sensor

No	V Default (v)	Sensor Voltage (v)	ADC Salt (NTU)	Stable Period (t)
1	0,18	0,18	0	11
2	0,18	0,21	1,53	12
3	0,18	0,31	6,68	11
4	0,18	0,53	17,70	10
5	0,18	0,70	26,03	13
6	0,18	0,88	35,61	10
7	0,18	1,03	41,60	11
Total				78

### 3. Result and Analysis

Based on the results of the design to implementation, testing for sensor calibration has been done but have not been tested to perform testing of fuzzy logic that has been designed. The purpose of this test is to assess the level of success, failure, and deficiencies of the system that has been designed.

#### 3.1. Pond Water Quality Control

In this test scenario, testing was conducted by comparing the results of water quality through LED indicator software and hardware after water conditions deemed to be replaced was conditioned in accordance with the control output of the system. Error obtained from the scheme is not great only 0.62 only can be seen in Table 3. Error results obtained from testing the sensor inputs to the membership function that has been made.

Table 3. Error Output Model Fuzzy

No	PPT	NTU	m0	m1	m2	e
1	5,8	9,2	70,1	70,1	70,1	0
2	11,7	13,8	39,8	39,8	39,8	0
3	16,8	18,9	40,7	40,7	40,7	0
4	21,8	25,2	70,1	70,1	70,1	0
5	28,1	31,5	81,7	81,9	84,8	3,1
Average						0,62

The next stage of the test scenario was to determine the sensor data. Sensor data are given at random or random until the LED indicator lights up in the three conditions "Bad", "Enough", and "Good" to see the results of the monitoring of each of these conditions. The total volume of water that must be replaced will appear at the output of the monitoring system. Because this study only monitoring, water change performed manually.

Based on the test results in Table 4, the whole experiment produces good water quality, although the percentage of the input or volume of water each a different membership. In tests, the percentage or volume of water affects the length of time on testing. The worse the quality of the water, the longer duration required to change the water until the water of good quality. Here is photographic evidence of poor quality water test start from water in critical condition until the water in good condition for shrimp pond.

Table 4. Water Quality Test Results

No	p0	p1	a0	volume	h0	h1	a1	s	
1	4,7	46,6	Bad	96	3,9	41,4	2,7	Good	357
2	34,8	24,2	Enough	39	1,6	37,3	5,9	Good	60
3	39,7	3,0	Good	24	1,0	40,9	2,0	Good	48
Time Total (s)								465	

The actual water conditions can be seen Figure 7, while in the program interface, the measurement results are contained in Figure 8. in the image shows that the water conditions "Bad". At the top right column shows the number of liters of water that must be replaced in order to be good or incoming water conditions "Good" or at the center of the image.

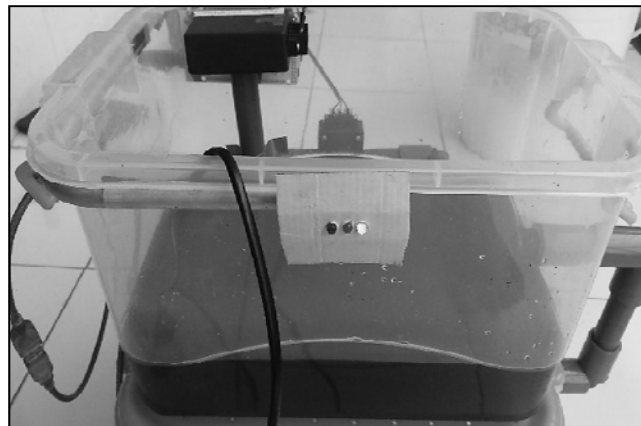


Figure 7. Water Condition Before controlled

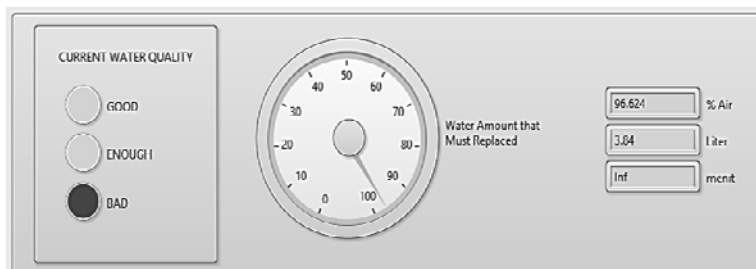


Figure 8. Water Condition In Monitoring Systems Before controlled

The initial condition of water in Figure 8, the water conditions before controlled "Bad", the color looks very intense water, thus fall into the category of "bad". In addition to the LED indicator lights up on the left side of the application, which means poor water conditions and should be replaced until the water quality to be good. Figure 8 is a representation of the data processing system taken from the water in Figure 7 is seen that the water very turbid.

The condition of the water after is replaced or supplemented with other water conditions in Figure 9, then testing the system. The water conditions after controlled well, the color looks on the dark water becomes clearer than the water condition in Figure 8. In addition to monitoring the application, show increased salt and lower ppt NTU turbidity which indicates that water conditions are better than ever. Black LED indicator lights up on the application, which means good water conditions have changed like in Figure 10.

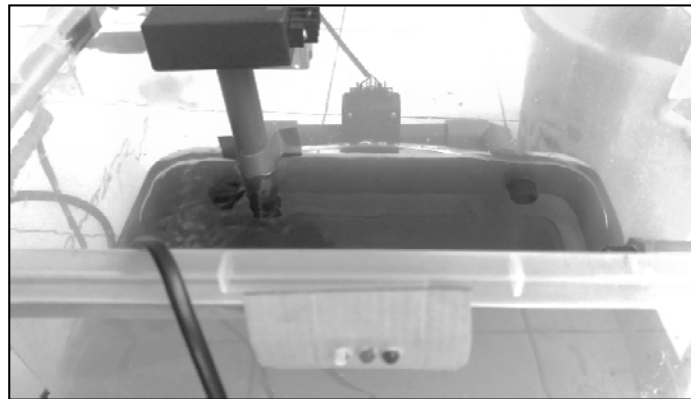


Figure 9. Water Condition after Controlled

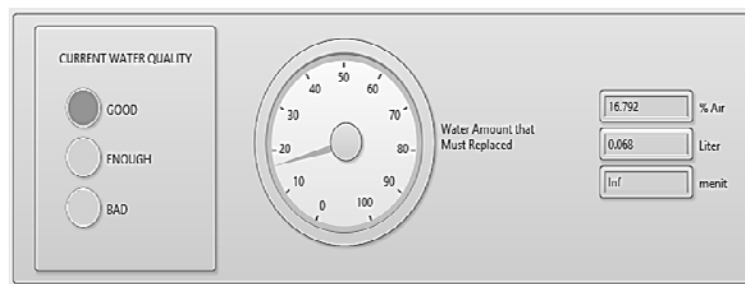


Figure 10. Water Indicator In Monitoring Systems After Controlled

The upper left column in Figure 10, black colored indicators move to the indicator "Good" which means indicates that the water quality is good. At the top center of the image also shows the condition of the water that must be replaced smaller than in Figure 8. This shows that the system has been run in accordance with what was expected earlier.

#### 4. Conclusion

This system has made a good communication between the sensor, microcontrollers and LabView working in accordance with the wishes. LabVIEW provides features fuzzy logic designers fairly easy to applied by the user. But fewer problems with sensor because the water input does not directly read fast, it takes a long time to read with appropriate water quality. This relates to the process of mixing water intake when given a particular input quality water and wait for the water and the water feedback from the system.

For future research could be added to this system in the control system. Mixing water is not performed manually but using a motor that can get in the flow of water according to need so

that no manual process. as well as water mixing process can be done more quickly if added to accelerate the process of mixing water. In addition, factors that affect the water quality of the pond there are two, namely salinity and turbidity, so there are two input flow of water to the control system.

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