The 6th International Seminar on Science and Technology (ISST) 2020
July 25th 2020, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

IoT-based Automatic Fish Pond Control System

Fariza Halidatsani Azhra[1] and Chaerul Anam[2]
[1]Department of Industrial Engineering, Islamic University of Indonesia, Yogyakarta
[2]Department of Engineering, Islamic University of Indonesia, Yogyakarta
E-mail: farizazhra@gmail.com

***Abstract*—Aquaculture is a potential sector to be developed by the people of Indonesia considering that Indonesia's territory is dominated by the sea. Based on data released by the Directorate General of Aquaculture in 2015, the level of fish consumption projected increase up to 54.49 kg/capita/year. One important factor influencing the success of aquaculture is water quality. Some physical parameters to describe water quality include temperature, degree of acidity, dissolved oxygen and turbidity. The case of the death of thousands of fish in Cirebon due to hot temperatures reaching 36 degrees Celsius in November 2015 is one proof that monitoring and control of pond water quality has not been done properly. It will cause huge losses for fisheries. With research and development methods researcher design a tool called SENDAL IKAN. This tool has 7 sensors that can control water quality in fish ponds in real time from phone and can activate automatic responses directly and through applications on mobile phones if there is an indication that the water quality is outside normal limits. That way fish farmers will be easier to control and will not be too late to handle problems related to fish pond water quality.**

***Keywords*—Aquacultur, IoT, Sensor, Water Quality.**

I. INTRODUCTION

AQUACULTURE is an activity that conducts production in aquatic biota controlled containers [1]. Aquaculture is a potential sector to be developed by the Indonesian people considering that Indonesia's territory is dominated by the sea. Indonesia's total area is 7.9 million km^2 consisting of 1.8 million km^2 of land area and 3.2 million km^2 of territorial sea area [2].

In Indonesia, there are several types of fish that are popularly cultivated, including shrimp, milkfish, catfish, tilapia and grouper. Based on data released by the Directorate General of Aquaculture in 2015, the level of fish consumption increases from 40.9 kg/capita/year to 43.88 kg/capita/year in 2016. In 2019, this figure is projected to increase to 54, 49 kg/capita/year.

Based on data obtained from the Central Statistics Agency in 2017, the majority of each region in Indonesia has a high fish consumption category of more than 31.4 kg/capita. While the number of fish recommended for consumption by the Indonesian people is 22.5 kg per year [3]. The high number of fish consumption will be fulfilled if the success rate of aquaculture is also high.

One important factor influencing the success of aquaculture is water quality. Water quality measurement parameters can be seen from the physical quantities and chemical quantities. Physical characteristics include the whole solid material that is floating and dissolved, turbidity, color, odor, taste, and temperature (temperature) of water. The physical properties of water are related to the medium in which plants and animals live. Chemical quantities include pH, salinity, content of chemical compounds, and hardness [4].

In aquaculture, each type of fish requires water with different characteristics. In a study entitled Enlargement Technique of Tilapia (Oreochromis niloticus) in Freshwater Aquaculture Installation Pandaan, East Java, it is known that the measured water quality parameters are dissolved oxygen, temperature, pH, and brightness. The results showed that dissolved oxygen levels ranged from 4.00-6.50 mg/L, temperatures between 27-30ºC, pH 6.0-6.5, and brightness of 31 cm [5]. Monitoring water quality in aquaculture ponds is still mostly done manually and requires a long time [6]. In terms of fish farming, many farmers do not understand the factors that cause fish to die suddenly such as water turbidity, high water temperatures and the presence of toxic substances in pond water [7].

One of the cases caused by a mismatch in water quality is the case of the death of thousands of fish in Cirebon due to hot temperatures reaching 36 degrees Celsius in November 2015 [8]. This case is one proof that monitoring and control of pond water quality has not been done well. Likewise, in Bokesan Hamlet, water quality monitoring is still done manually so that it is very risky of crop failure due to problems that are not immediately addressed.

Based on the problems faced by fish farmers, an automatic system with novelty is designed that is able to monitor water quality in real time and can activate an automatic response if there are indications that the water quality is outside normal limits. This system uses a more complete sensor than previous studies with a total of seven sensors namely sensors pH, salinity, temperature, dissolved oxygen, conductivity, ammonia, and turbidity. This tool is also based on IoT (Internet of Things) that allows users to manage and optimize electronics and electrical equipment that uses the internet. That way the handling of problems that occur does not experience delays and the risk of crop failure due to abnormal water quality can decrease.

II. METHODS

A. Method of Collecting Data

1) Literature Study

Literature study is carried out with study research ever conducted by previous researchers with sourced from books, journals, proceedings which is relevant. Also learned about the main devices related to this research design.

2) Observation

The method is to do direct spaciousness observations for get the real problem in fish farming. The observation was carried out in Bokesan, Sindumartani Village, Sleman,

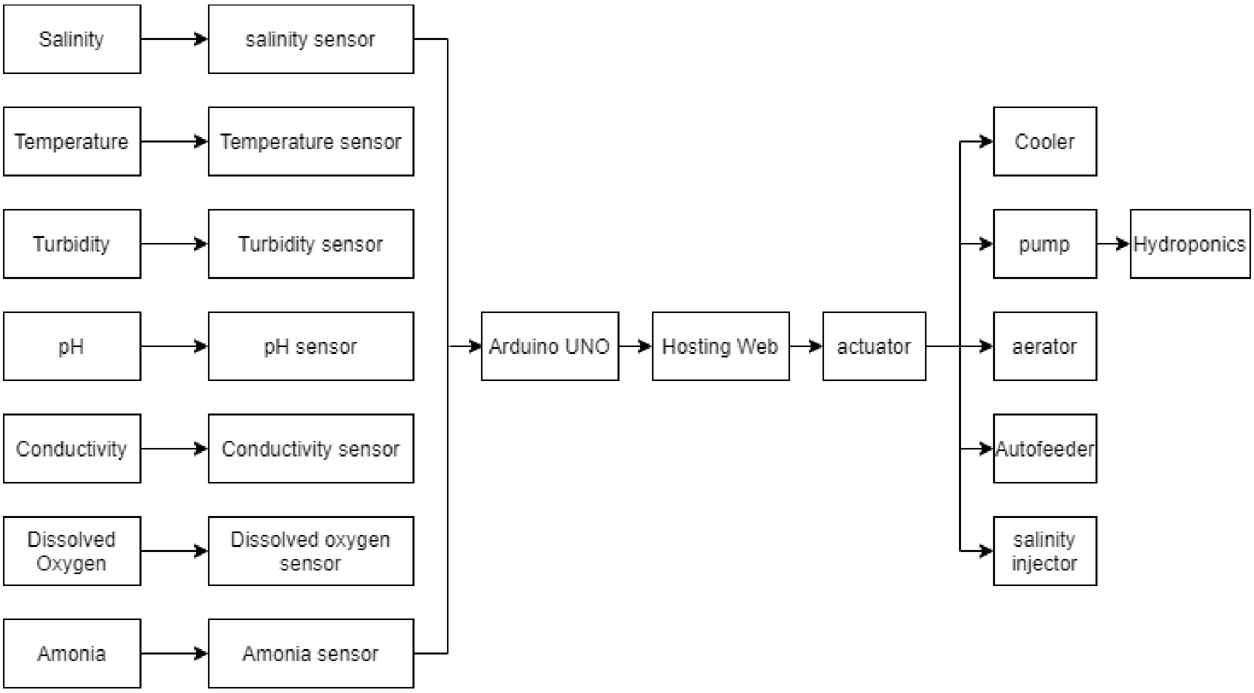

Figure 1. System design diagram.

Special Region of Yogyakarta.

3) Device Design

This method begins by designing the concept from the description of the problems that have been obtained from field observations and then proceed with making the device suitable with goals to be achieved.

B. System Planning

System planning monitoring water quality in freshwater fish ponds uses Arduino. The design of this monitoring system consists of hardware and software design.

1) Hardware

In Figure 1, the sensors will be installed in a fish pond and connected to a microcontroller for later processing and the results displayed on the screen. The screen installed in the fish pond will display several menus including, calibration to change the sensor catches into general units, set point to set the maximum limit of the value of each allowed indicator, monitoring to display the value of each indicator in real time, and control to activate the actuator on the appliance.

Actuators function to control several indicators in response if there are indications that water quality is beyond normal limits. Actuators can be activated automatically or manually. This tool is also connected to the application that can be installed on mobile phones so that users can control water quality even if they are far from fish ponds. Actuators mounted on the device include:

1. Cooling, in response if the water temperature is high.
2. Pump, to drain water from a pond to hydroponics.
3. Airator, to add oxygen in the pool.
4. Autofeeder, to feed fish automatically
5. Salinity injectors, in response if water salinity is not normal.

The system in Figure 2 was designed by installing seven sensors with the consideration that the more parameters used, the analysis and decision making would be closer to valid. The parameter includes:

a. Salinity sensor use two electrodes are used which function to provide injection of current into the water. Current flows through water, where salt water is a strong electrolyte that can conduct electric current. Electric current that flows are proportional to the conductivity of salt water, meaning that if the salinity value is high, then the conductivity value is also high.
b. Water temperature is a controlling factor for aquatic life, controlling the rate of metabolic activity, reproductive activity and life cycle. If the flow temperature increases, decreases or fluctuates too broadly, metabolic activity can increase, slow down, even not function.
c. Turbidity is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in water. A low turbidity level indicates a healthy and functioning ecosystem. However, higher turbidity levels cause several problems with the flow system.
d. pH is an important limiting chemical factor for aquatic life. If the water in the stream is too acidic or basic, H^+ or OH^- ion activity can disrupt the biochemical reaction of aquatic organisms by injuring or killing aquatic organisms. Waters generally have a pH value between 6 and 9, depending on the presence of dissolved substances derived from bedrock, soil and other materials in watersheds.
e. Conductivity, this module consists of a sensor module circuit and a TDS sensor signal conditioning circuit. The workings of the circuit are started with the sine wave generation by the Wien Bridge Oscillator circuit with a 5.3 kHz oscillation frequency and then amplified by a large non-reversing amplifier based on the magnitude resistance value obtained from the conductivity sensor output. The AC signal that occurs is converted into a DC

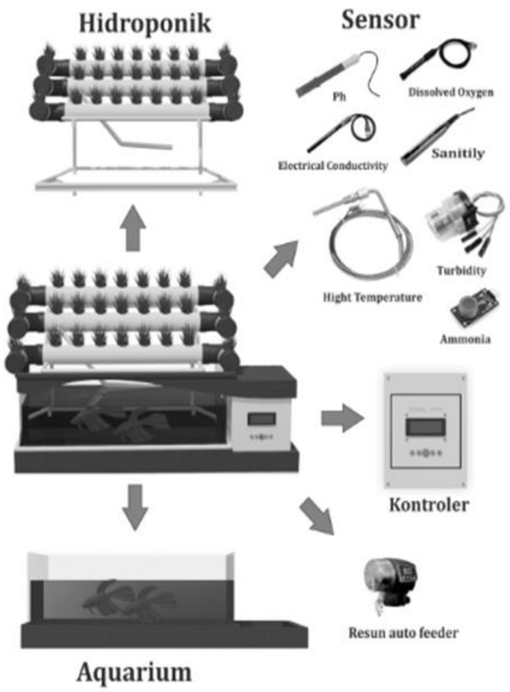

Figure 2. System scheme.

signal to be processed by a microcontroller via the AC to DC signal converter circuit.

f. The dissolved oxygen sensor is part of an electrochemical sensor in which the reaction of oxygen gas with an electrolyte solution produces an electrical signal of a magnitude proportional to the amount of oxygen concentration

g. Ammonia can be detected with MQ-135 sensor. This sensor consists of an aluminum tube surrounded by silicon and at the center there are electrodes made of aurum where there is a heating element. When the heating process occurs, the coil will be heated so that the ceramic SnO_2 becomes a semiconductor or as a conductor so that it releases electrons so when ammonia is detected by the sensor and reaches the aurum electrode the sensor output MQ-135 will produce an analog voltage.

2) *Software*

Software is used to manage programs on the system. Data captured by the sensor will be converted into data with a standard unit so that it is easy to read. Software is also used to carry out automatic responses when there are indications of parameter mismatch, set the normal limits of each parameter, turn on the indicator, and others. the software used to carry out the program is Arduino UNO (Figure 3).

III. RESULT AND DISCUSSION

A. *Water Quality Monitoring*

Water quality monitoring in this system determined through seven parameters namely salinity, ammonia, conductivity, dissolved oxygen, temperature, pH and turbidity of water. Analog data from the sensor is changed to digital data and the data is read by microcontroller. This system can activate automatic response if the parameters are not normal.

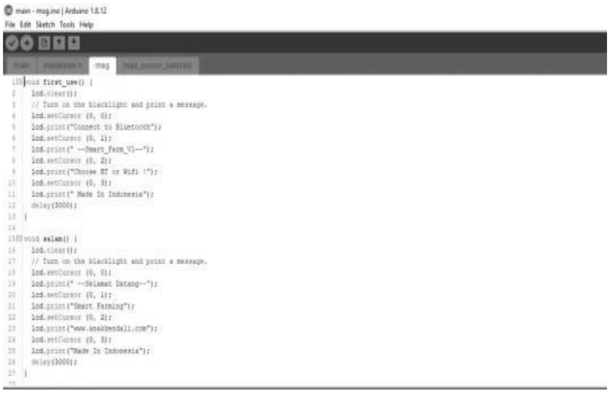

Figure 3. Arduino interface.

Table 1.
Temperature sensor accuracy

Temperature Sensor (°C)		Termometer		Error temperature sensor (%)	
1	2	1	2	1	2
28,8	28,8	29,1	29,1	1,03	1,03
28,8	28,8	29	29	0,69	0,69
28,5	28,5	29	29	1,72	1,72
29	28	29,1	29,1	0,34	3,78
28,9	29	29	29	0,34	0,00
Average				0,83	1,44
Accuration (%)				99,17	98,56

B. *Arduino Microcontroller*

This system uses an arduino microcontroller, using arduino software for calibration to convert sensor catches into general units. This tool is also connected to the application that can be installed on mobile phones so that users can control water quality even if they are far from fish ponds.

C. *Parameter Test*

The parameter test is used to determine whether the sensor used in the study has results that are in accordance with the parameter measurement tool in general. Parameter testing is done by looking at the level of accuracy of each parameter. Testing is done with two samples. Number one represents the fish pond water sample and number two represents the well water sample.

D. *Temperature Sensor Testing*

Temperature sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of temperature sensor can be seen in the Table 1.

E. *pH Sensor Testing*

pH sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of pH sensor can be seen in the Table 2. From the Table 2, the accuracy between sensor and pH meter is 98,01% for fish pond water sample and 98,58% for well water. It means the accuration is high, and the sensor can be used in the system.

F. *Dissolved Oxygen Sensor Testing*

Dissolved oxygen sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of dissolved oxygen sensor

Table 5.
pH sensor accuracy

pH sensor		pH meter		Error pH sensor (%)	
1	2	1	2	1	2
7,1	7,3	7	7,2	1,43	1,39
7,2	7	7,1	7	1,41	0,00
7,3	7,2	7,1	7	2,82	2,86
7,1	7	7,1	7	0,00	0,00
7,3	7,2	7	7	4,29	2,86
Average				1,99	1,42
Accuration (%)				98,01	98,58

Table 6.
Dissolved oxygen sensor accuracy

DO sensor (ppm)(mg/L)		DO meter		Error DO sensor (%)	
1	2	1	2	1	2
5,8	5,5	6	5,5	3,33	0,00
5,8	5,5	6	5,5	3,33	0,00
5,7	5,7	6,2	5,5	8,06	3,64
5,9	5,7	6	5,6	1,67	1,79
6,1	5,5	5,8	5,7	5,17	3,51
Average				4,31	1,79
Accuration (%)				95,69	98,21

Table 7.
Salinity sensor accuracy

Salinity Sensor (%o) (ppt)		Refraktometer		Error salinity sensor (%)	
1	2	1	2	1	2
3	2	3	3	0,00	33,33
3	3	3	3	0,00	0,00
3	3	3	3	0,00	0,00
4	4	3	3	33,33	33,33
3	3	3	3	0,00	0,00
Average				6,67	13,33
Accuration (%)				93,33	86,67

can be seen in the Table 3. From the Table 3, the accuracy between sensor and DO meter is 95,69% for fish pond water sample and 98,21% for well water. It means the accuration is high, and the sensor can be used in the system.

G. Salinity Sensor Testing

Salinity sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of salinity sensor can be seen in the Table 4. From the Table 4, the accuracy between sensor and Refraktometer is 93,33% for fish pond water sample and 86,67% for well water. It means the accuration is high, and the sensor can be used in the system.

H. Ammonia Sensor Testing

Ammonia sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of ammonia sensor can be seen in the Table 5. From the Table 5, the accuracy between sensor and Spektrofotometer is 84,17% for fish pond water sample and 85,33% for well water. It means the accuration is high, and the sensor can be used in the system.

I. Conductivity Sensor Testing

Conductivity sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of conductivity sensor can be seen in the Table 6.

Table 2.
Ammonia sensor accuracy

Amonia Sensor (ppm)		Spektrofotometer		Error Ammonia Sensor (%)	
1	2	1	2	1	2
0,8	0,5	0,8	0,6	0,00	16,67
0,7	0,7	0,9	0,5	22,22	40,00
0,7	0,6	0,9	0,6	22,22	0,00
0,7	0,6	0,8	0,6	12,50	0,00
0,7	0,7	0,9	0,6	22,22	16,67
Average				15,83	14,67
Accuration (%)				84,17	85,33

Table 3.
Conductivity sensor accuracy

Conductivity Sensor (µs/cm)		Conductivity Meter		Error Conductivity Sensor (%)	
1	2	1	2	1	2
139	130	138	139	0,72	6,47
128	135	138	138	7,25	2,17
129	137	137	138	5,84	0,72
130	128	139	139	6,47	7,91
133	128	138	138	3,62	7,25
Average				4,78	4,91
Accuration (%)				95,22	95,09

Table 4.
Turbidity sensor accuracy

Turbidity sensor (JTU)		Turbidimeter		Error tubidity sensor (%)	
1	2	1	2	1	2
50	46,8	48	49	4,17	4,49
45,6	51,2	48	49	5,00	4,49
51,2	52,1	49	48	4,49	8,54
47,7	50	48	49	0,62	2,04
48,5	50,3	50	48	3,00	4,79
Average				3,46	4,87
Accuration (%)				96,54	95,13

From the Table 6, the accuracy between sensor and conductivity meter is 95,22% for fish pond water sample and 95,09% for well water. It means the accuration is high, and the sensor can be used in the system.

J. Turbidity Sensor Testing

Conductivity sensor testing is carried out on two different types of water namely fish pond water samples and well water samples. The result of conductivity sensor can be seen in the Table 7. From the Table 7, the accuracy between sensor and turbidimeter is 96,54% for fish pond water sample and 95,13% for well water. It means the accuration is high, and the sensor can be used in the system.

IV. CONCLUSION

The conclusion of this research is water quality monitoring in this system determined through seven parameters namely salinity, ammonia, conductivity, dissolved oxygen, temperature, pH, and turbidity of water. Analog data from the sensor is changed to digital data and the data is read by microcontroller. This system can activate automatic response if the parameters are not normal. This system uses an arduino microcontroller, arduino software will calibration to convert sensor catches into general units. This tool is also connected to the application that can be installed on mobile phones so that users can control water quality even if they are far from fish ponds. From the testing data, the sensor test results show good accuracy on each parameter. The accuracy on all parameter test is more than 80%, so the sensor is accurate and can be use in system.

ACKNOWLEDGMENT

The researchers would like to thank the permission given by the Head of Sindumartani Village to make observations at the Bokesan tourism village in this study.

REFERENCES

[1] Sahfitri, I. A., "Potensi Pengembangan Budidaya Perikanan," *in Budidaya Perikanan FIKP UMRAH Journal*, 2018, pp. 1-12.

[2] Susanto, & Munaf, D., *Komando dan Pengendalian Keamanan dan Keselamatan Laut: Berbasis Sistem Peringatan Dini*. Jakarta: Gramedia Pustaka Utama, 2015.

[3] Andriani, Y., *Budidaya Ikan Nila*. Yogyakarta: Deepublish, 2018.

[4] Agustiningsih, E. D., "Perancangan Perangkat Monitoring Kualitas Air pada Kolam Budidaya berbasis Web Localhost," in *Umrah Journal*, 2016, pp. 1-15.

[5] Salsabila, M., & Suprapto, H., "Enlargement Technique of Tilapia (Oreochromis niloticus) in Freshwater Aquaculture Installation Pandaan, East Java," in *Journal of Aquaculture and Fish Health*, 2018, pp. 118-123.

[6] Pramana, R. (2018). Perancangan Sistem Kontrol dan Monitoring Kualitas Air dan Suhu Air Pada Kolam Budidaya Ikan," In *Jurnal Sustainable: Jurnal Hasil Penelitian dan Industri Terapan*, 2018, pp. 13-23.

[7] Hidayatullah, M., Fat, J., & Andriani, T. (2018). "Prototype Sistem Telemetri Pemantauan Kualitas Air Pada Kolam Ikan Air Tawar Berbasis Mikrokontroler," in *Positron Journal*, 2018, pp. 43-52.

[8] Lintang, E., & Firdaus, I. N., "Sistem Monitoring Kualitas Air Pada kolam Ikan Berbasis Wireless Sensor Network Menggunakan Komunikasi Zigbee" in *UMK Journal*, 2017, pp. 145-152.