Design and Implementation of Water Quality Monitoring System (Temperature, pH, TDS) in Aquaculture Using IoT at Low Cost

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ABSTRACT
This research aims to design and implement a water quality monitoring system in aquaculture that will be implemented in SME. Subang is a city which has a lot of potential fish farming in ponds, one of them is Rojo Koyo SMEs. The farmer has a problem, especially in the rainy season, mortality of fish increases and they don't know why this happens. This research aims to solve this problem by making a monitoring system to know the water quality in ponds at low cost because the system will be implemented in SME with small capital. Aquaponics system is an integrated system between fish farming and cultivation without soil. Aquaponics systems need continuous monitoring of water parameters to determine the suitability of the type of fish with the type of plant. The author has developed a low-cost IoT system that can monitor aquaponics system parameters such as temperature, pH and TDS via android platform. Hardware design using several integrated sensors is water temperature sensor type DS18B20, pH type SKU: SEN0161, sensor TDS type SKU: SEN0244. Android software design using C Language for programming. The author using an additional NodeMCU ESP8266 that can transmit data to a smartphone using an internet connection. Data can be accessed using Android with the Blynk app. The cost requirement to develop this device is low cost which is 83.79 USD. Components on the device are easily available in the market so that replacement parts can be done easily every 2-3 years

Keywords: *Monitoring, Water quality, Low cost, IoT.*

1. INTRODUCTION

Pond environment as an aquaculture media is an important way to support fish farming successfully. Pond environments consist of water, and soil in a fish enlargement process has degradation quality because several reasons increased waste derived from the rest of the feed, faces, and fish excretion [1]. Several parameters of water quality that can affect the growth and fish survival rate consist of temperature, dissolved oxygen, pH and water salinity. In this research parameters that have been used to determine water quality covers temperature, TDS and pH of water. Temperature and dissolved oxygen is a major factor that affect fish appetite, metabolism, and fish growth [2]. Water temperature is changed by sunlight radiation, air temperature, weather and location. Sun radiation is a major factor that affects fluctuation of water temperature. Sunlight heats water on the surface faster than in the dept. Water density decreases caused by temperature increase so the water in the surface and in the dept. can mix well. This will cause temperature stratification (thermal stratification) in the body water, which will form three layers of water namely epilimnion, hypolimnion and thermocline [3].

Another important parameter is pH value, pH value indicates the water neutral, base and acid. pH is a water quality dynamic variable and fluctuation throughout the day. In common water that is not affected by high biological activity, pH values rarely reach above 8.5 but in fish or shrimp ponds, water pH can reach 9 or more than 8.5 [4].

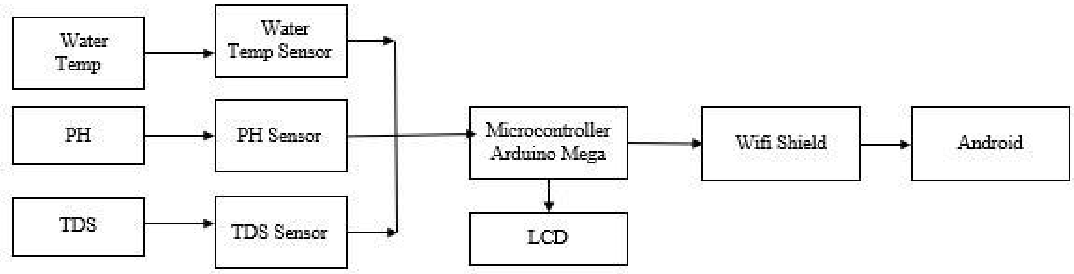

Figure 1. Block diagram water quality monitoring system

The problem in aquaculture cultivation is that water quality checks are still done directly and manually. Water quality is an important factor that has an impact on the success of aquaculture and the importance of continuous monitoring so monitoring systems have to be made to monitor water quality. Several research about monitoring systems was designed to develop wireless monitoring devices for water quality (temperature, pH and dissolved oxygen in the water) [5]. This system uses Chip STM32F103 to process data, Zigbee and GPRS to transmit data, power supply using solar cells and lithium cells. The research [6], development wireless monitoring system using wireless monitoring sensor EZ430-RF2500 type. To detect water quality (pH, temperature, and dissolved oxygen) can transmit short messages to the user (smart phone) via GSM. In [7] this paper contains a monitoring design system in aquaculture (pH, temperature and water flow) using Arduino, pH and water temperature set in range 6-7 and temperature between 25 ^{0}C-30 ^{0}C, notification message will be sent to smart phone via GSM. Research [8] containing development monitoring and control systems in aquaponics (pH, temperature and dissolved oxygen) this system using Arduino to transmit measurement parameter results to raspberry pi to record. all information displays in mobile application real-time. Another research is development monitoring system in aquaponics using Arduino and using LABVIEW program as a tool, monitoring system using GSM to display the data [9].

This research aims to produce a monitoring design system. That has been used to measure water quality (water temperature, pH and TDS) in aquaculture with low cost of implementation and fish farming. To make the operators easier to monitor water quality in real time, which can impact on the success of aquaculture. This research used a design method that was divided into hardware design, software design and cost analysis of water quality monitoring system.

2. RESEARCH METHODOLOGY

2.1. Hardware Design

Hardware designed by choosing electronics components and sensors that have good quality and reliability. Monitoring system can monitor water temperature, pH and TDS at aquaculture so several sensors needed and related components. Block diagram hardware for monitoring water quality can be seen in Figure 1.

In Figure 1, it can be seen water quality monitoring system using electronic component and sensor such as: Arduino mega, water temperature sensor type DS18B20 with accuracy ±0.5 ^{0}C [10], pH sensor type SKU: SEN0161 with accuracy ±0,1 pH (25 ^{0}C) [11], TDS sensor type SKU: SEN0244 with accuracy ±10% FS (25 ^{0}C) [12] completely with NodeMCU ESP8266 as a wi-fi shield that can access via android [13]. The data from the water temperature sensor, pH sensor and TDS sensor will be accepted, processed and calculated automatically by the microcontroller. Then the data will display on screen. There is a SD card processed by a microcontroller to save data every 5 seconds. Moreover, the data can be accessed by android via the internet. Hardware in the monitoring design system is as shown in Figure 2.

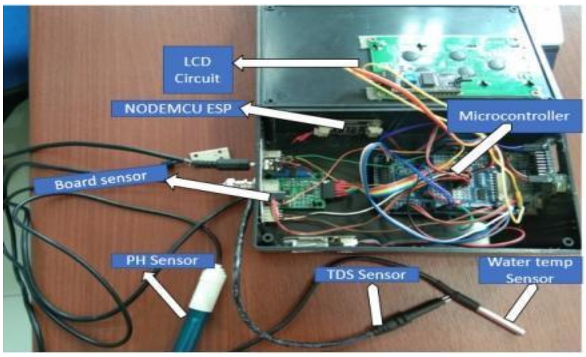

Figure 2 Electronics system and sensor

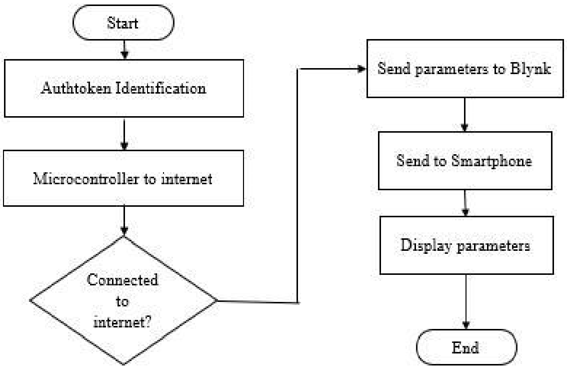

Figure 3. Flow diagram communication device to Blynk

2.2. Software Design

In this research software needed to turn on the hardware, microcontroller Arduino Mega using C language. The output of the sensor is analog voltage and digital will be processed by microcontroller and will display on screen and will be sent to NodeMCU ESP8266 to display on android. Data can be accessed using android via the internet. To access the applications needed authentication, so users can access system aquaponics that connect with application Blynk.

```
//--------sensor dallas-----------------
 sensors.requestTemperatures();
   suhu = sensors.getTempCByIndex(0);
//-----------TDS----------------------
    gravityTds.setTemperature(temperature);
    gravityTds.update();
    tdsValue = gravityTds.getTdsValue();
//------------P H ---------------------
 for(int i=0;i<10;i++)
 {
  buf[i]=analogRead(analogInPin);
  delay(10);
 }
 for(int i=0;i<9;i++)
 {
  for(int j=i+1;j<10;j++)
   {
   if(buf[i]>buf[j])
    {
    sementara=buf[i];
    buf[i]=buf[j];
    buf[j]=sementara;
    }


  }
 }
 avgValue=0;
 for(int i=2;i<8;i++)
 avgValue+=buf[i];
 float pHVol=(float)avgValue*5.0/1024/6;
 float pHValue = -5.70 * pHVol + 21.50; //21.34
if ((unsigned long)(currentMillis - previousMillis) >= interval
  logfile.print(suhu);
  logfile.print(", ");
  logfile.print(", ");
  logfile.print(tdsValue);
  logfile.print(", ");
  logfile.print(pHValue);
  logfile.print(", ");
  logfile.flush();
  Serial.println("Menyimpan data");
  previousMillis = millis();
 }
  root["a1"] = suhu; //suhu air
  root["a4"] = tdsValue; //tds
  root["a5"] = pHValue; //pH
  root.printTo(Serial);
  char auth[] = "0V3knrChciPpunVmrnmJdOS0LPcGXLg_";
  char ssid[] = "Andromax-M3Z-9538";
  char pass[] = "38305369";
  Serial.begin(9600);
  while (!Serial) continue;
  Blynk.begin(auth, ssid, pass);
  timer.setInterval(10000L, dataMega);
  StaticJsonBuffer<1000> jsonBuffer;
  JsonObject& root = jsonBuffer.parseObject(Serial);
  data1 = root["a1"]; //suhu air
  data4 = root["a4"]; //tds
  data5 = root["a5"]; //pH
```

Figure 4 Program used in the aquaponic system

2.3. Concept of Architecture System

In this research software needed to turn on the hardware, microcontroller Arduino Mega using C language. The output of the sensor is analog voltage and digital will be processed by microcontroller and will display on screen and will be sent to NodeMCU ESP8266 to display on android. Data can be accessed using android via the internet. To access the applications needed authentication, so users can access system aquaponics that connect with application Blynk.

The system can function and work well, the system needs synchronization between hardware and software. As shown in Figure 1, communication needed so the data can access using android platform via internet. To access application authentication users needed so users can access aquaponics systems that connect with application Blynk. The steps are as shown in Figure 3. The list program with C programming is as shown in Figure 4. The Blynk system application and the LCD can be seen in Figure 5.

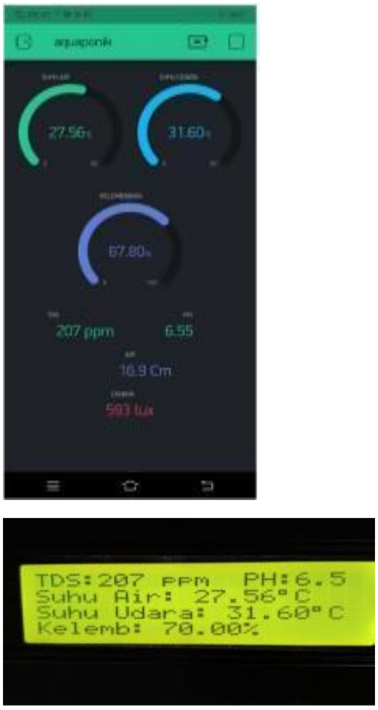

Figure 5 Monitoring system display at Blynk android (top) and the LCD display (bottom)

Figure 6 Implementation monitoring system at aquaculture pond

3. RESULT AND DISCUSSION

3.1. Implementation Monitoring System in Aquaculture

Water quality monitoring system can implementation at aquaculture, system can read water temperature, TDS and pH water aquaculture implementation are done 10 times in 5 hours-time period, between 8 AM to 1 PM GMT+7 using sensor experiment (Figure 6) and the data of the reading are as shown in Table 1.

3.2. Cost Analysis

The advantage of using this device is that the user or owner can observe water conditions without having to be in the cultivation location. In addition, the overall cost of producing the device is very low, so it can be used in any area, including rural areas. The component parts in the device are easily available so that replacement of spare parts can be done easily every 2-3 years. The cost analysis of the monitoring device prototype is shown in Table 2. According to table 2 to design this system only costs 83.79 USD, cheaper than [14].

Table 1. Sensors reading for water temperature, pH dan total dissolve solid (TDS)

Reading Number	Temp (C)	pH	TDS (ppm)
1	25.37	6.74	27.11
2	25.41	6.88	27.70
3	25.44	6.97	27.75
4	26.04	6.99	27.88
5	26.37	7.02	28.24
6	26.41	7.07	28.24
7	26.98	7.12	28.44
8	27.11	7.34	28.87
9	27.98	7.61	28.87
10	28.12	7.9	28.89

4. CONCLUSION

In this research a water quality monitoring system has been done (water temperature, pH, and TDS) in aquaculture, with a low cost around 83.79 USD. This device is completed with a water temperature sensor, pH, TDS. Integrated sensors can monitor remotely using an android platform so water quality can be monitored without on the site. The advantage of a real time monitoring system via smartphone brings success for fish farming. Water parameter data record and save in the memory card so can be reference and feedback for business owner to determine appropriate water quality.

Table 2. Cost analysis of the device prototype

No	Components	Quantity	Unit	Price ($)	Total Price ($)	Useful life (year)
1	Temperature sensor DS18B20	1	piece	1.38	1.38	2
2	pH sensor SKU: SEN0161	1	piece	13.79	13.79	2
3	TDS sensor SKU: SEN0244	1	piece	11.72	11.72	2
4	Jumper cable	1	set	1.38	1.38	3
5	LCD (I2C 20X4 character)	1	piece	6.90	6.90	2
6	Arduino Mega	1	piece	6.90	6.90	3
7	NodeMCU v3 CH340G ESP8266	1	piece	4.83	4.83	3
8	Modem Wifi	1	piece	20.69	20.69	3
9	MicroSD card	1	piece	5.17	5.17	3
10	SD card shield Arduino	1	piece	3.45	3.45	3
11	Power Supply	1	piece	3.45	3.45	3
12	Box panel	1	piece	4.14	4.14	3
	Total Cost				83.79	

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