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Koi Fish Pond Monitoring System Using IoT

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Abstract – *The process of collecting water parameter data for koi fish ponds is still done manually. Each parameter from the manually collected samples is tested one by one. This process is inefficient and can cause delays in decision making for koi fish farmers. If the manual testing reveals results that exceed the ideal threshold, it can have a negative impact on the fish. To address this issue, a koi fish pond water parameter monitoring system was designed using an automated method based on the Internet of Things. The sensors used in this study include an ultrasonic sensor, turbidity sensor, Total Dissolved Solids (TDS) sensor, and pH sensor. Based on the test results, when the values of the turbidity and TDS sensors exceed the set parameter limits of 40 NTU and 400 PPM, respectively, the system will activate the draining pump until the water level reaches the lower limit (10 cm), after which the filling pump will activate until the upper water level limit (18 cm) is reached. If the pH sensor value is below the lower limit set in the parameter, the system will activate the alkaline liquid pump to neutralize the pH to a value of 7. Conversely, if the pH sensor value exceeds the upper limit set in the parameter, the system will activate the acidic liquid pump to neutralize the pH back to 7. This automatic draining and filling system will stop working when the turbidity, TDS, and water level values fall within the parameters set in Blynk. The system also maintains the pond's water level at the upper limit set in the parameters.*

Keywords – *Arduino; IoT; Water Quality Parameters; Monitoring system; Fish farming.*

I. INTRODUCTION

HOME-based koi fish farming has enormous economic potential. From a business perspective, it is highly profitable because selling a single fish of good quality fetches a much higher price compared to fish for consumption. Additionally, even on limited land, it is possible to produce attractive ornamental fish, and the market is quite large [1]. The good selling price of koi fish directly impacts the economic development of the community, especially for koi fish breeders. The oldest koi organization, which is linked to Japan, once organized a koi fish competition with 4,476 fish entries, the largest in the history of koi fish competitions in Indonesia, with 614 participants [2].

Despite the large potential and public interest in koi fish farming, several challenges are faced by koi fish farmers. These challenges are closely related to key parameters in koi ponds that affect the growth and development of the koi themselves. These parameters include water temperature, pond water pH (Power of Hydrogen), Total Dissolved Solids (TDS), water clarity, ammonia content, nitrite and nitrate levels, and the lack of continuous monitoring of these parameters [3, 4].

With the presence of a monitoring system, critical pond parameters can be displayed as data, making it easier for farmers to observe these parameters directly [5, 6]. Controlling these key parameters is expected to help koi fish farmers become more effective and efficient in their farming process [7]. In the field, pond monitoring is still conducted manually. Samples are taken, and each parameter is tested one by one to obtain the data. This manual testing process can cause delays in decision-making. If the results of the manual test show that one of the pond parameters exceeds the acceptable threshold, it can negatively affect the growth and development of the koi fish in the pond. Inefficient water usage also frequently occurs in the field. With the limitations of manual pond parameter testing, home-based koi farmers often make decisions to drain 30-40% of the pond's capacity daily to avoid the hassle of dealing with increased ammonia, nitrite, and nitrate levels in the pond water [8–10].

Among all the critical pond parameters, three parameters were identified for further research as they greatly influence the growth and development of koi

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fish. These three parameters are water pH, the concentration of toxic substances in the pond related to water turbidity, and Total Dissolved Solids (TDS) in the water. Therefore, to achieve more accurate readings of these critical parameters, this study proposes using sensors that can read these parameters, including the analog Turbidity Sensor, analog pH Sensor Module, analog TDS Sensor Module, and an ultrasonic sensor to measure water depth.

II. Research Methods

In this research, the method was designed to integrate various hardware and software components to build an effective and efficient monitoring system. Each step in this method is explained in detail to ensure the accuracy of results and the achievement of research goals.

A system overview was created to provide a clear understanding of how all the components in the monitoring system work together. Figure 1 shows the overall system diagram of the koi pond parameter monitoring system based on the Internet of Things (IoT) [11, 12]. The system is built through the input process, where sensor readings are detected and controlled by an Arduino Mega microcontroller to operate the pump actuators for the water draining system and pH neutralization system [13, 14]. The IoT monitoring system reads the sensor data in the pond and sends it via Node MCU ESP8266 through the Blynk cloud server, which acts as the database, and the Blynk Android App as the interface, allowing the user to monitor the system via their Android smartphone.

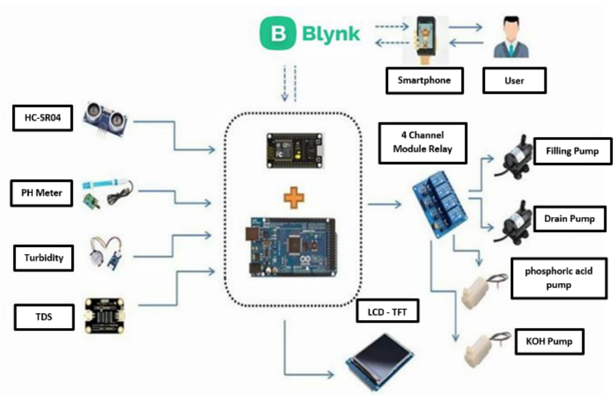

Figure 1: Overview of the entire system

The block diagram of the system is made to provide a simple visual representation of the main components and their interactions within the system. The block diagram used in the IoT-based koi pond parameter monitoring system is shown in Figure 2.

This monitoring system consists of several main components that work together. The power supply is used as the electrical source for the prototype. Meanwhile, the Arduino Mega acts as the brain of the system, running the entire process. The Node MCU ESP8266 is used to connect the Arduino Mega to the internet, enabling remote monitoring. Several sensors are used to measure the water conditions in the pond, such as the HC-SR04 ultrasonic sensor for water level measurement, the pH sensor for water acidity levels, the TDS sensor for total dissolved solids, and the turbidity sensor for water clarity. The relay functions as an electric switch between the Arduino and actuators such as the pumps used for water filling and draining, as well as for adding alkaline and acidic solutions like potassium hydroxide and phosphoric acid. Sensor values are displayed on the TFT LCD screen, while Blynk is used as the server connecting the smartphone and the wireless components on the Arduino and Node MCU ESP8266, allowing real-time monitoring and control [15–19].

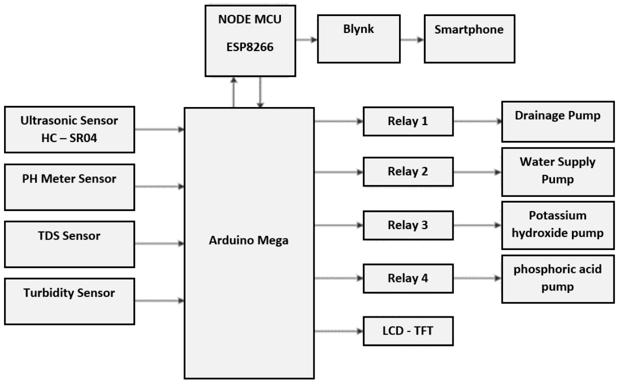

Figure 2: Block diagram of the system

i. *Designing of System Schematic*

The system schematic design involves the integration of Arduino Mega, Node MCU ESP8266, the turbidity sensor, TDS sensor, pH sensor, relay, and other integrated circuits. It also includes the design of the prototype model as a test medium and the design of Arduino Mega and Node MCU ESP8266 programming to ensure IoT connectivity [20]. The complete system schematic can be seen in Figure 3 below.

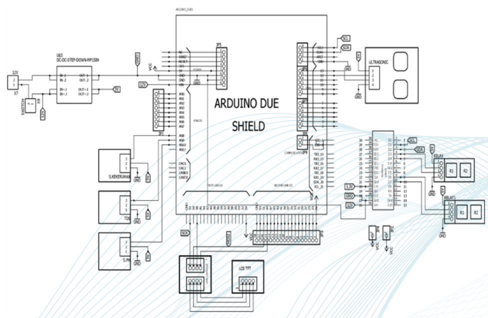

Figure 3: Control circuit schematic

ii. Software Design

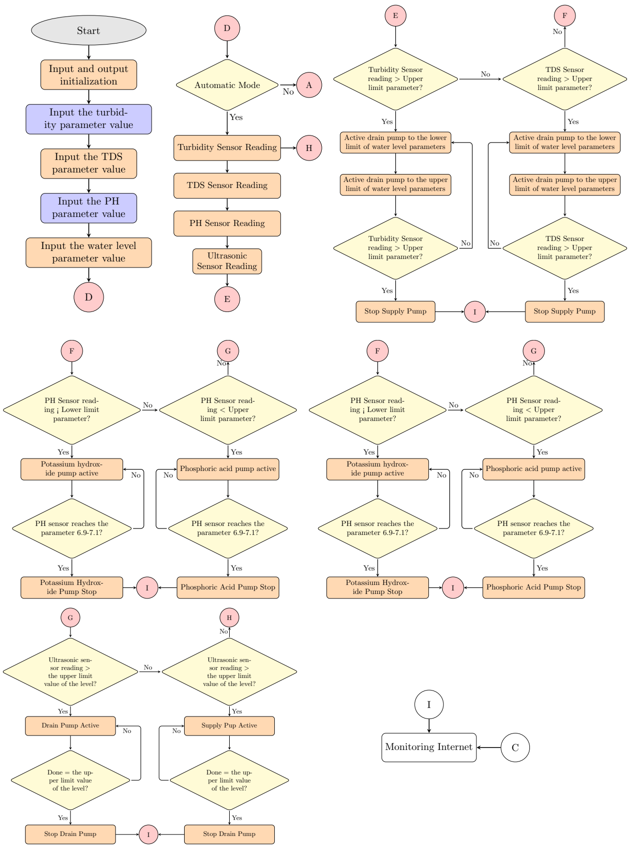

Figure 4: Flowchart of automatic system mode

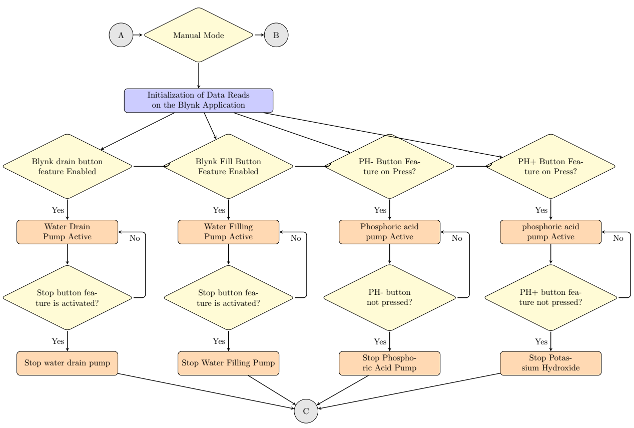

Figure 5: Flowchart for manual system

The system flowchart displays the steps or work processes in the system as a whole. It also outlines the sequence of each process within the system. The system designed uses two modes: automatic and manual system modes. The system flowchart can be seen in Figure 4.

The flowchart contains four parameters: the turbidity sensor for measuring water clarity, the TDS sensor for measuring the solid content in the koi pond water, and the pH sensor for detecting the pH level in the pond. The ultrasonic sensor is used to measure the water level parameter in the koi pond. Pumps are used as actuators for filling and draining the pond, as well as for delivering potassium hydroxide and phosphoric acid to neutralize the pH. The manual system flowchart can be seen in Figure 5 below:

The manual system flowchart is implemented for the water draining, water filling, phosphoric acid delivery, and potassium hydroxide delivery systems. The manual system is operated via the Blynk app on an Android device. To display the data generated by the system and connect it to the internet, an interface using an application called Blynk is required. The Blynk app acts as an Internet of Things interface, displaying on an Android smartphone. The Blynk interface can be seen in Figure 6 below:

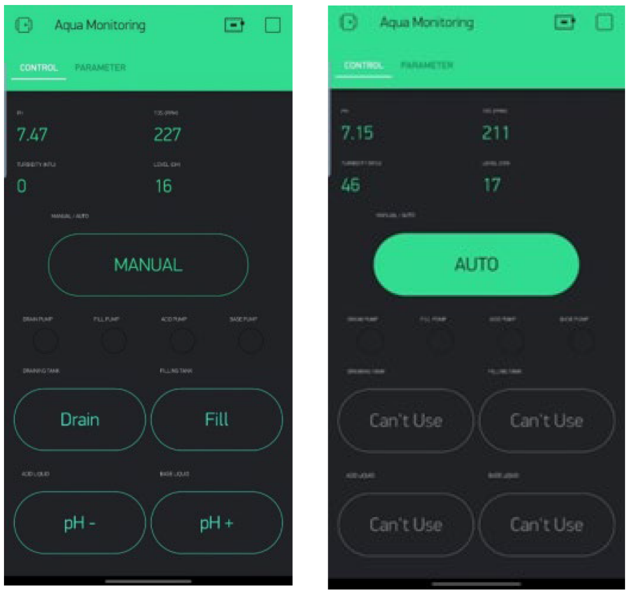

Figure 6: Blynk app interface on an Android smartphone

The Blynk app interface has two slides: the control slide and the parameter slide. On the control slide, users can choose between manual and automatic (Auto) system modes. The Blynk app also shows the sensor reading data parameters. Meanwhile, on the parameter slide, upper and lower limits can be set to control the automatic system. The parameter setting slide in Blynk can be seen in Figure 7 below.

III. Results and Discussion

i. System Prototype

In the overall testing, a prototype was used with the installed system. The prototype serves as an auxiliary work tool to closely simulate the real-life system operation. The prototype of this koi pond monitoring system uses an aquarium as the test medium. The results of the prototype development can be seen in the following

Figure 7: Parameter setting slide in Blynk

figure. The prototype results are shown in Figure 8 below.

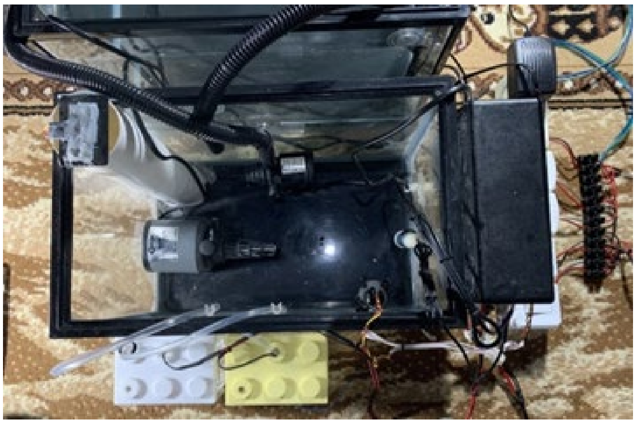

Figure 8: The prototype

ii. Automatic Mode Testing (Auto Mode)

The automatic mode testing involves testing the system that has been integrated with sensors and the microcontroller so that the designed output can function automatically. In this automatic mode testing, the parameters were set in advance to ensure that the system operates as intended.

The sensor parameters were previously set using the Blynk application to define the upper and lower sensor limits. For the TDS sensor readings, when the parameter value exceeds the preset upper limit (400 ppm), the system activates the draining pump, initiating the water draining system until the water level reaches the lower limit. Then, the system will activate the water filling system until the water level reaches the specified limit. The system will stop the draining and filling pumps once the TDS sensor reading falls below the specified parameter (400 ppm).

For the turbidity sensor readings, when the parameter value exceeds the preset upper limit (130 NTU), the system will activate the draining pump, initiating the water draining system until the water level reaches the specified lower limit (10 cm). Then, the system will activate the water filling system until the water level reaches the specified upper limit (18 cm). The system will stop the draining and filling pumps when the turbidity sensor reading falls below the specified parameter (130 NTU).

Figure 9: Status of water pool drain pump

From the results of the testing in the Table 2, it can be seen that the lower pH parameter limit is set at 6.7, and the upper pH parameter limit is set at 7.3. When the pH value falls below 6.7, the system will automatically activate the potassium hydroxide liquid pump to raise the pH value to the neutral pH level of 7 ± 0.1. When the pH value exceeds 7.3, the system will automatically activate the phosphoric acid pump to lower the pH value to the neutral pH level of 7 ± 0.1. When the pH value is between the lower and upper parameter limits, both the phosphoric acid pump and the potassium hydroxide pump will remain inactive.

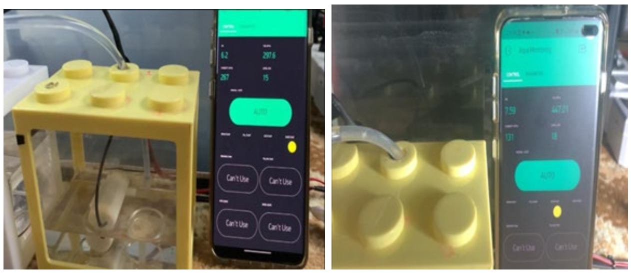

Figure 10: Status of Automatic Acid and Base Liquid Delivery

iii. Manual Mode Testing

This testing is conducted manually to implement the water draining and filling system in the pond, as performed

Table 1: Table of Automatic System for Draining and Filling in the Pond

TEST NO	PARAMETER SETUP IN BLYNK						WATER LEVEL (CM)	TURBIDITY (NTU)	TDS (PPM)	STATUS OF DRAINING PUMP RELAY MODULE	STATUS OF DRAINING PUMP	STATUS OF FILLING PUMP RELAY MODULE	STATUS OF FILLING PUMP
	WATER LEVEL (CM)		TURBIDITY (NTU)		TDS (PPM)								
	LOW LIMIT	UPPER LIMIT	LOW LIMIT	UPPER LIMIT	LOW LIMIT	UPPER LIMIT							
1	10	18	0	40	0	400	18	5	527	ON	ON	OFF	OFF
	10	18	0	40	0	400	10	5	518	OFF	OFF	ON	ON
	10	18	0	40	0	400	18	5	338	ON	OFF	OFF	OFF
	10	18	0	40	0	400	18	5	567	OFF	ON	OFF	OFF
2	10	18	0	40	0	400	10	5	540	OFF	OFF	ON	ON
	10	18	0	40	0	400	18	5	421	OFF	ON	OFF	OFF
	10	18	0	40	0	400	10	5	416	OFF	OFF	ON	ON
	10	18	0	40	0	400	18	5	312	OFF	OFF	OFF	OFF

(Table header: DRAINING AND FILLING PUMP (MODE AUTO))

Table 2: Table of Automatic Mode for Acid and Base Liquid Pumps

TEST NO	BLYNK PARAMETER SETUP (pH)		ADC VALUE (pH)	ACID PUMP RELAY MODULE STATUS	ACID PUMP STATUS	BASE PUMP RELAY MODULE STATUS	BASE PUMP STATUS
	LOW LIMIT	UPPER LIMIT					
1	6,7	7,3	6,2	OFF	OFF	ON	ON
			6,4	OFF	OFF	ON	ON
			6,7	OFF	OFF	OFF	OFF
2	6,7	7,3	7,7	ON	ON	OFF	OFF
			7,5	ON	ON	OFF	OFF
			7,3	OFF	OFF	OFF	OFF

(Table header: ACID AND BASE LIQUID PUMP (AUTO MODE))

by the user. The manual mode system is activated by changing the mode setting from Auto to Manual in the Blynk application. The Blynk app also features drain and fill options to operate the pond's water draining and filling systems. Additionally, there are pH- and pH+ features for lowering the pH level by delivering phosphoric acid and raising the pH level by delivering potassium hydroxide manually.

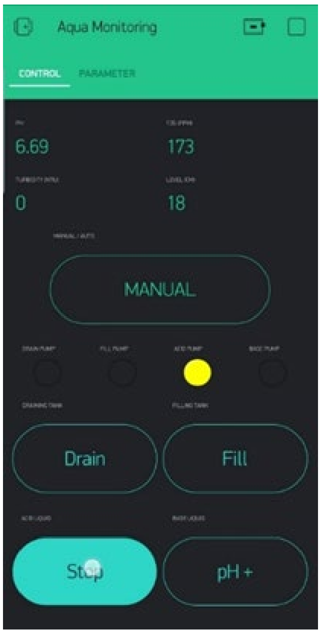

Figure 11: Manual mode in Blynk

Table 3 shows the results of the pond water draining system tests in manual mode. If the drain feature in the Blynk application is activated, the draining pump will turn on; conversely, if the stop feature in the Blynk application is activated, the draining pump will stop.

Table 3: Table of Manual Mode Draining System

TEST NO	TEST TIME INTERVAL (s)	INPUT SIGNAL FROM BLYNK	RELAY MODULE STATUS	PUMP VOLTAGE (V)	PUMP STATUS	BLYNK DRAIN TEST LED STATUS
1	0,45	ON	ON	220	ON	ON
2	0,54	OFF	OFF	0	OFF	OFF
3	0,55	ON	ON	220	ON	ON
4	0,33	OFF	OFF	0	OFF	OFF
5	0,29	ON	ON	220	ON	ON
6	0,30	OFF	OFF	0	OFF	OFF

(Table header: MANUAL DRAIN TANK PUMP)

Table 4: Table Filling system in manual mode

TEST NO.	TEST TIME INTERVAL	INPUT SIGNAL FROM BLYNK	RELAY MODULE STATUS	PUMP VOLTAGE	PUMP STATUS	BLYNK FILLING TANK LED STATUS
1	0,43	ON	ON	220	ON	ON
2	0,45	OFF	OFF	0	OFF	OFF
3	0,3	ON	ON	220	ON	ON
4	0,56	OFF	OFF	0	OFF	OFF
5	0,52	ON	ON	220	ON	ON
6	0,7	OFF	OFF	0	OFF	OFF

(Table header: MANUAL FILLING TANK PUMP)

Table 4 shows the results of the pond water filling system tests in manual mode. If the fill feature in the Blynk application is activated, the filling pump will turn on; conversely, if the stop feature in the Blynk application is activated, the filling pump will stop. Table 5 shows the results of the acid liquid delivery system tests in manual mode. If the pH- feature in the Blynk application is activated, the acid pump will turn on to lower the pH level; conversely, if the pH- feature in the Blynk application is not activated, the acid pump will remain inactive. Table 6 shows the results of the base liquid delivery system tests in manual mode. If the pH+ feature in the Blynk application is activated, the base pump will turn on to raise the pH level; conversely, if the pH+ feature in the Blynk application is not activated, the base pump will remain inactive.

Table 5: Table of Manual Mode Acid Liquid Delivery System

MANUAL ACID LIQUID PUMP						
TEST NO.	TEST TIME INTERVAL	INPUT SIGNAL FROM BLYNK	RELAY MODULE STATUS	PUMP VOLTAGE	PUMP STATUS	BLYNK ACID PUMP LED STATUS
1	0,56	ON	ON	4,92	ON	ON
2	0,75	OFF	OFF	0	OFF	OFF
3	0,76	ON	ON	4,92	ON	ON
4	0,63	OFF	OFF	0	OFF	OFF
5	0,51	ON	ON	4,92	ON	ON
6	0,53	OFF	OFF	0	OFF	OFF

Table 6: Table of Manual Mode Base Liquid Delivery System

MANUAL BASE LIQUID PUMP						
TEST NO.	TEST TIME INTERVAL	INPUT SIGNAL FROM BLYNK	RELAY MODULE STATUS	PUMP VOLTAGE	PUMP STATUS	BLYNK BASE PUMP LED STATUS
1	0,63	ON	ON	4,86	ON	ON
2	0,64	OFF	OFF	0	OFF	OFF
3	0,73	ON	ON	4,86	ON	ON
4	0,75	OFF	OFF	0	OFF	OFF
5	0,59	ON	ON	4,86	ON	ON
6	0,59	OFF	OFF	0	OFF	OFF

IV. Conclusion

The system in this prototype is divided into two modes: manual and automatic. In manual mode, draining, filling, and the addition of acid and base liquids can operate smoothly without issues. In automatic mode, the system can perform pond water draining and filling, as well as pH neutralization, according to the design specifications within the defined parameter limits. The system is also capable of maintaining the pond's water level at the upper limit of the specified water level parameters

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