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Lake Water Quality Measurement System at Situ Tekno using an ESP32-based Autonomous Surface Vehicle

SUTAN DIMAS AL FARIZI, DENNY DARLIS, ARIS HARTAMAN

Diploma of Telecommunication Technology, Telkom University, Indonesia
Email: dalfarizi68@gmail.com, dennydarlis@telkomuniversity.ac.id

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ABSTRAK

Situ Tekno yang berada di Universitas Telkom Bandung merupakan danau buatan dengan luas 5,788.51 m². Danau ini belum memiliki sistem pengukuran dan pemantauan kualitas air untuk menghindari terjadinya pencemaran. Pada penelitian ini telah diimplementasikan sebuah sistem pengukuran untuk mengetahui kualitas air menggunakan wahana permukaan otonom yang dikendalikan oleh ESP32 dan dilengkapi dengan sensor pengukuran yaitu sensor suhu, pH, kekeruhan dan oksigen terlarut. Data pengukuran kemudian ditampilkan pada platform IoT Blynk. Dari pengujian yang dilakukan, Oksigen terlarut di beberapa titik di Situ Tekno adalah 5 ppm hingga 8 ppm, pH sebesar 7 hingga 9, kekeruhan sebesar 207 hingga 427 NTU dan suhu air danau adalah 17°C hingga 20°C. Dari hasil pengukuran tersebut dapat disimpulkan bahwa kualitas air pada Situ Tekno dapat memenuhi standar kelayakan air danau dari Pemerintah Indonesia. Sistem ini dapat mengukur kualitas air danau di beberapa titik untuk pemantauan secara berkala secara waktu-nyata.

Kata kunci*: Wahana Permukaan Otonom, ESP32, Kualitas Air, Situ Tekno, Blynk*

ABSTRACT

Situ Tekno located at Telkom University Bandung is an artificial lake which is its area are 5,788.51 m². This lake does not yet have a water quality measurement and monitoring system to avoid pollution. In this study, a measurement system has been implemented to determine water quality at Situ Tekno using an autonomous surface vehicle controlled by ESP32 and equipped with measurement sensors, such as temperature, pH, Turbidity and dissolved oxygen sensors. Data then displayed on the Blynk IoT platform. From the tests carried out, the dissolved oxygen at several points in Situ Tekno was 5 to 8 ppm, pH of 7 to 9, turbidity of 207 to 427 NTU and water temperature of 17 to 20 ° C. From the results, it can be concluded that the water quality in Situ Tekno can meet the standards of lake water from the Government of Indonesia. The system can measure lake water quality at multiple points for periodic monitoring in real-time.

Keywords*: Autonomous Surface Vehicle, ESP32, Water Quality, Situ Tekno, Blynk*

1. INTRODUCTION

Water is one of the most needed necessities of life. In the absence of water, various life processes cannot take place **(Ishak, 2017).** From prehistoric times to the present, water has been a major driver in the development of human civilization. Not only that, as the most abundant substance, water forms an important part of ecosystems and invaluable natural resources. Although the content in pure water consists of only two atoms of Hydrogen (H) and one atom of Oxygen (O), water found in nature often contains additional substances that have dissolved or mixed in it **(Hamzah et al., 2022)**. The content contained in water depends on the water source and the surrounding environment. Situ is one of the water places commonly used by the community as a source for agriculture, animal husbandry, as well as daily consumption or other activities **(Pratama, 2021)**. In addition, it is part of a smaller aquatic ecosystem and can result from natural or man-made processes. Usually it is located in the lowlands and can be found in urban and rural areas. The quality of water in situ usually has a fairly high pH and turbidity value due to various human and natural activities **(Lopaa et al., 2014) (Ibrahima et al., 2021)**.

Situ Tekno is the final water conservation site of all areas at Telkom University which area are 5,788.51 m^2 **(Telkom University, 2023)**. This site is integrated with the green environmental management system and water resources around it in the framework of a green campus. However, at this time the water quality in Situ Tekno has not been well tested. This can be water pollution that can disturb the surrounding environment. To help the Telkom University community, monitoring using the right technology is needed to determine the quality of water in Situ Tekno.

Along with the development of technology, there are many innovative tools that are created to help problems or work in human life. One of them is the presence of Internet of Things (IoT) technology which is a concept on a device or device that is connected to the internet network continuously. IoT devices ranging from sensors as a medium for data retrieval, internet network access as access to sending data to servers and servers as a collector of information that received from the sensor for analysis. How IoT works follows commands or programming instructions that have been created and connected to connected devices. IoT consists of various devices equipped with technology and internet connectivity, so they can be connected to each other. Through this IoT device serves to collect data, transmit data through the internet or other networks and interact with users or other devices automatically or remotely **(Darustaman, 2023)**.

By considering the above problems, the author made a solution to overcome these problems through a study entitled "Lake Water Quality Measurement System Using ESP32-Based Autonomous Surface Vehicle". It is hoped that this study can make it easier for users to determine the criteria for the measured lake water quality.

2. RESEARCH METHOD

In this study, work will be carried out on the lake water quality measurement system in Situ Tekno which will use a ship. The ship used is the Autonomous Surface Vehicle (ASV) which can move at certain points according to paths determined before **(Syakir et al., 2023)**. The implementation of the lake water quality measurement system in Situ Tekno will be carried out in several stages **(Akbar et al., 2023)**. The flow diagram of the stages to be carried out can be seen in Figure 1.

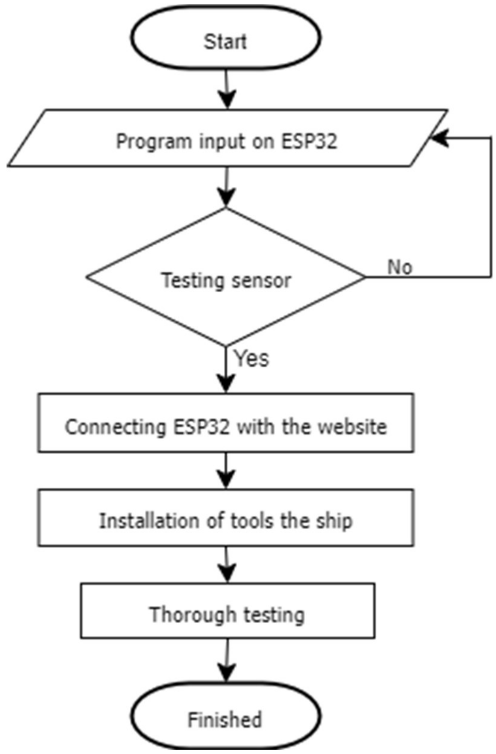

Figure 1. Flowchart of System Measurement Process

In Figure 1 will be explained the stages and flow of the planning process of the lake water quality measurement system which is carried out through several stages.

- The first stage, create a program using the Arduino software idea. Programs that have been created are included in ESP32.
- The second stage is to test the sensor to be used by comparing the measurement results using sensors to be used with measurement results using standard measuring instruments. This test uses 3 samples, namely water, orange ice and warm coffee. Data on the results of measurements that have been made using sensors that will be used and data on the results of measurements that have been carried out using standard measuring instruments will be recorded in Microsoft Excel. The data that has been recorded will be compared the results of both measuring instruments. If the measurement results of the sensor to be used with the measurement results of standard measuring instruments are far proportional , the program will be carried However, if the sensor measurement results used with the measurement results of standard measuring instruments are the same, it will proceed to the next stage.
- The third step isto connect ESP32 tothe website. The website used is Blynk. Blynk functions to be able to monitor measurement results remotely.
- The fourth stage is to install ESP32 and sensors that have been tested on ASV. The ESP32 is mounted in a plastic lunch box at the starboard rear of the ASV and sensors are installed in a jar behind the bottom of the ASV.
- The fifth stage is measuring the quality of lake water at Situ Tekno. These measurements are carried out at 20 different points. The results of measurements that have been made will be recorded.

2.1 Block Diagram of ASV's Measuring and Propulsion System

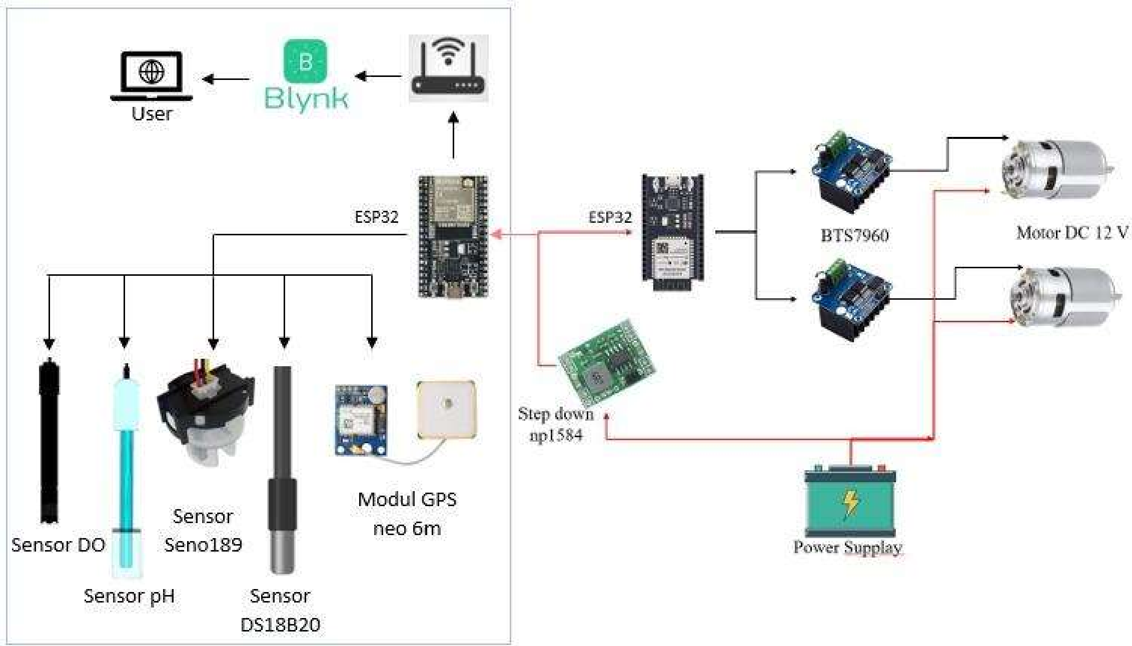

Figure 2. Block Diagram of ASV's Measurement and Propulsion System

Figure 2 is the block diagram of the ASV's measuring and propulsion system. On the left is the measurement system and on the right is the ASV's drive. The measurement system is divided into 2 parts, namely tools and dashboards. A web-based platform designed for admins, where admins can manage data information and access dashboards. The information on the dashboard is DO value, pH value, turbidity value and temperature value **(Prasetya, 2022)**. The tool has one microcontroller, namely ESP32 **(Pradana, 2019)**. The tool serves to measure lake water quality which displays 4 indicators, namely DO, pH, turbidity and temperature. The measurement system has several components to support its working system, namely DO, pH, turbidity and DS18B20 sensors. At the right ASV drive design has BTS7960, the right R_PWM on pin D32, the right L_PWM on pin D33, and R_L_EN on pin D25. On the left side of the ASV, there is BTS7960, the left R_PWM on pin D26, L_PWM left on pin D27, and R_L_EN on pin D25. There is a system where the propulsion of the ASV will move around the pool. The Esp32 will give orders to the BTS7960 to drive the dc motor as a propulsion for the ASV to move forward, the ASV to turn left, the ASV to turn right. In this system, a 12V power supply is needed as a power provider for dc motors, ESP32 ASV drives and ESP32 measurement systems. To provide power to ESP32, it takes a step down mp1584 as a voltage converter from 12V to 5V.

2.2 Water Quality Measurement System Design

In designing a water quality measurement system using Arduino programming language, namely C ++. Arduino IDE is software used to create programming sketches, compile andupload into microcontroller memory.

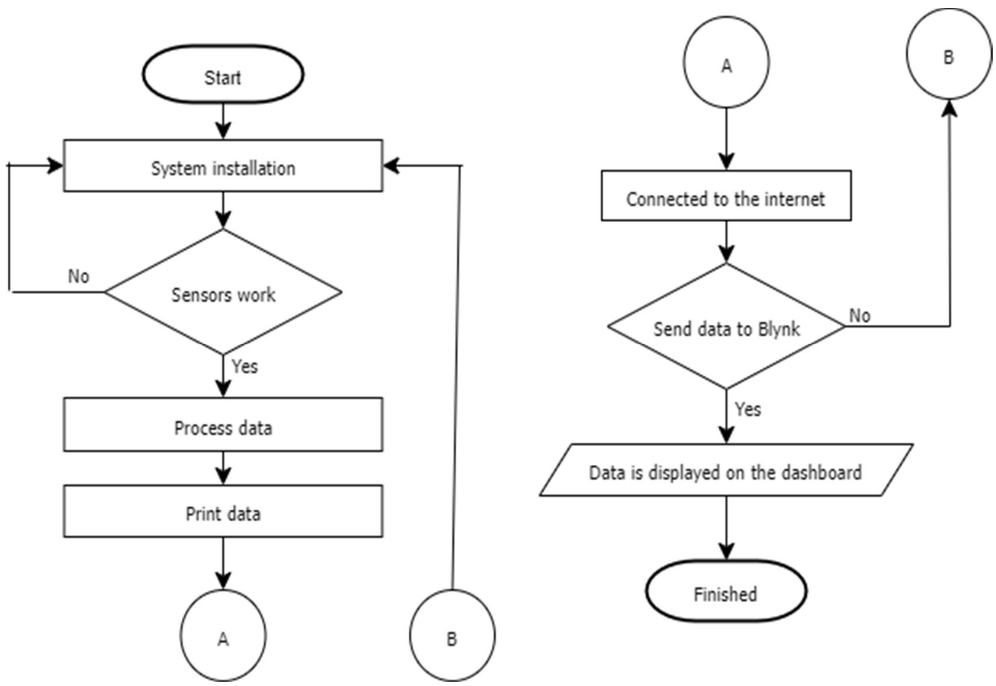

Figure 3. Flowchart of The System

Figure 3 is a flowchart made for the implementation stage of the water quality measurement system on ASV. Several stages are carried out to run the measurement system, as follows.

1. The system starts first.
   In this case the ESP32 is given a voltage of 5V to run the system.
2. Initialize the system.
   In this case the initialization of the system, which serves to hold data in memory where it holds data values that can change, pins connected from the component to ESP32 are detected, access to connect to the computer, entering the library of the component used and Wi-Fi username and password.
3. If the sensor is working, then the sensor will take data at a certain point.
   It uses 4 sensors namely DO sensor, pH sensor, turbidity sensor and DS18B20 sensor.
4. If the sensor does not work, then it does not retrieve data.
5. Processing data that has been obtained
   In this case, the data obtained is processed using existing formulas. The formula created is different for each indicator.
6. Print data
   In this case, the processed data will be printed on the serial monitor.
7. Connect to the internet
   In this case ESP32 is connected to the internet through a router that has internet data. Once connected to the internet ESP32 gets an IP.
8. Send data to Blynk
   In this case, the already processed data is sent to blynk. Data is submitted based on a pre-created blynk database.
9. If the data is not sent to blynk, then the data does not exist in the blynk database.
10. Data displayed on the dashboard
    In this case, the data is displayed on the dashboard in the form of numbers and graphs.

2.3 Wiring Diagram

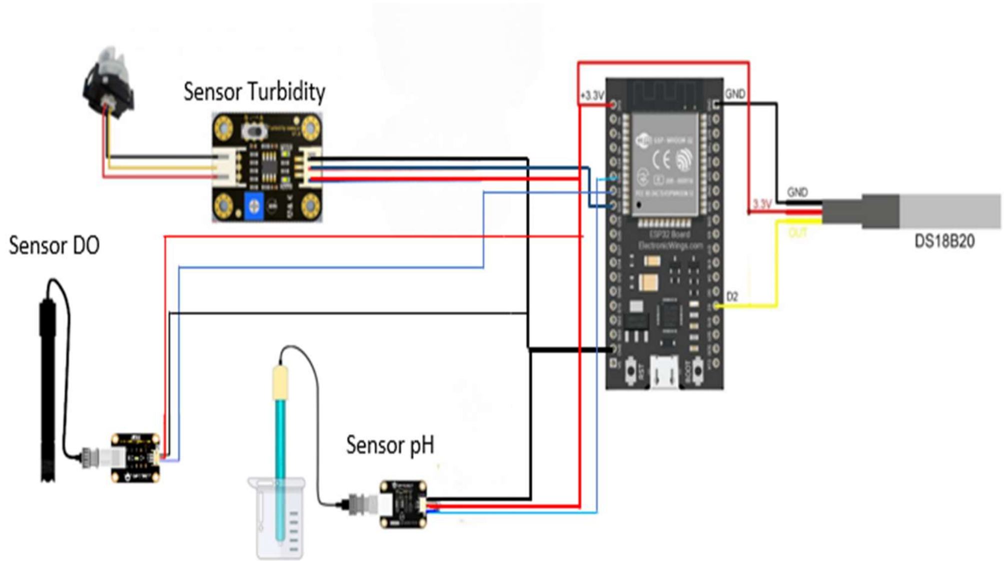

Figure 4. Wiring Diagram of Lake Water Quality Measurement System

Figure 4 is a wiring diagram of several components used in lake water quality measurement systems. It can be seen that each pin contained in the component is connected to ESP32. The following is an explanation of the wiring of each component.

1. The Dissolved Oxygen sensor connected to the Signal Converter Board has 3 pins namely VCC, AO and GND. The AO data pin is connected to pin 32 while the VCC and GND are connected to the ESP32 voltage source.
2. pH sensors connected to pH Signal Conversion have 3 pins namely VCC, AO and GND. The AO data pin is connected to pin 35 while the VCC and GND are connected to the ESP32 voltage source
3. The Turbidity Sensor connected to the Turbidity Probe Module has 3 pins, namely VCC, OUT and GND. The OUT data pin is connected to pin 33 while the VCC and GND are connected to the ESP32 voltage source
4. DS18B20 sensor which has 3 pins namely VCC, Data and GND. The data pin is connected to pin 2 while the VCC and GND are connected to the ESP32 voltage source.

2.4 Lake Water Quality Standards

Lake water quality testing measures 3 indicators, namely pH, turbidity and temperature. These 4 indicators have proper lake water standardization based on Annex VI of Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management **(Indonesia, 2021).**

a. Water pH = 6 – 9
b. Water Temperature = Dev 3
c. DO = ≥ 3 mg/L

2.5 Calibration

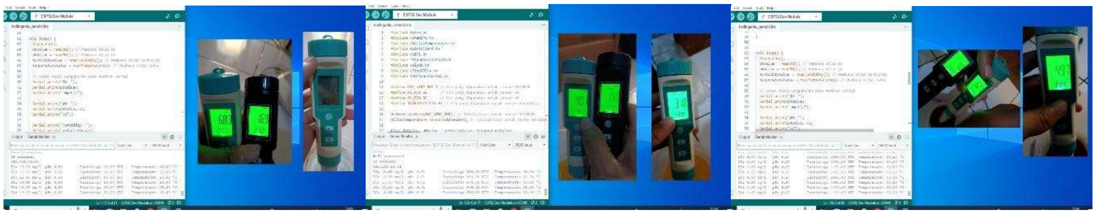

Figure 5. Sensor Calibration Process

In Figure 5 is calibrate the sensor using 3 sampels. The samples used are water, orange juice and warm coffee. Calibration is done by comparing the measurement reading using sensors to standard measuring instruments JADPES C600 7in1 multifunction water quality tester and DO9100 Dissolved Oxygen Analyzer tester. Measurements are made 25 times per sampel. Data from measurements that have been carried out using sensors will be used and data from measurements that have been carried out using standard measuring instruments will be recorded and averaged. The average of the two data points was compared. If the two data are far proportional, a reprogram will be carried out on the sensor to be used; however, if the two data are equally compared, the sensor is declared ready to be used for testing in lake water. The average value data for calibration can be seen in graphical form in Figure 6.

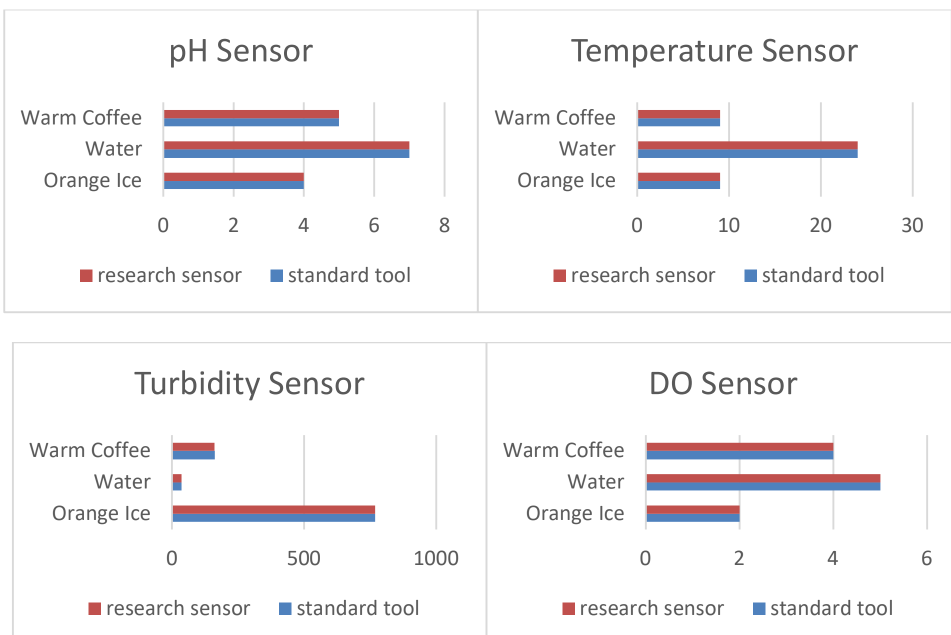

Figure 6. Comparison of Average Value on between used Sensors and Standard Meter

2.6 Implementation of the System

Figure 7 Shows the implementation of a lake water quality measurement system using ASV. The ASV used uses Styrofoam as the basic material on the hull and has a length of 94 cm and a width of 67 cm. The ESP32 is mounted in a plastic lunch box at the starboard rear of the ASV and sensors are installed in a jar behind the bottom of the ASV. When the ASV move along pre-defined path and stop in one measurement points, the sensors will measure several water paramater simultaneously and send the data to Blynk IoT platform. Then the ASV move along defined path. Data from the ASV will be sent to Blynk IoT platform using wifi network in its communication range from wifi router around the lake.

Figure 7. Implementation of the System

3. RESULTS AND DISCUSSION

In testing the lake water quality measurement system using ASV that have been made in previous studies as a means. In this test, measuring thequality of lake water in Situ Tekno. Lake water quality has four indicators, namely dissolved oxygen, turbidity, temperature and pH. The test was conducted for 2 days to retrieve test data. The data that has been obtained from this measurement will be analyzed to provide an understanding of the condition of lake water quality in Situ Tekno. The test has been carried out at 20 different points located in Situ Tekno which can be seen in Figure 8.

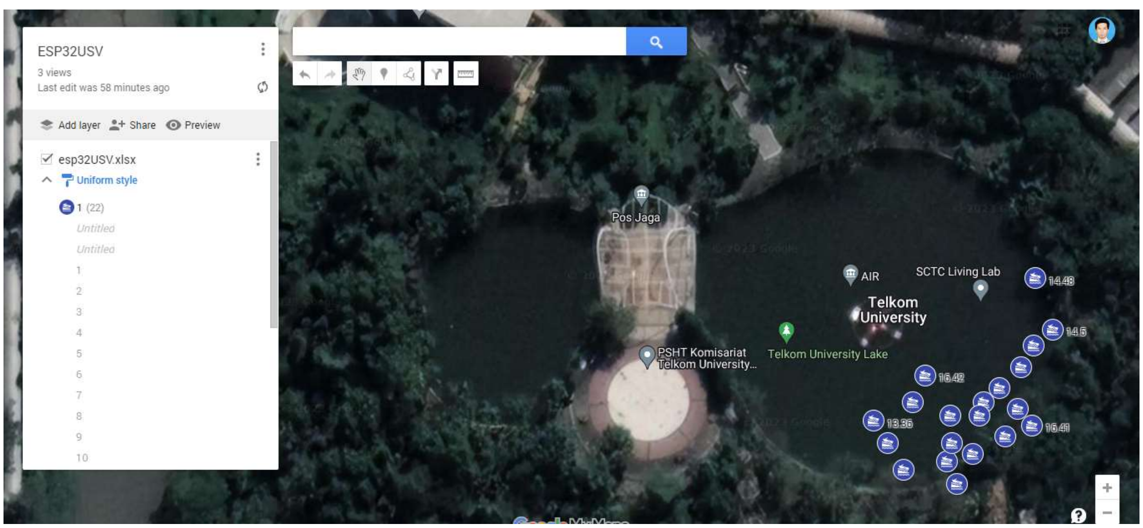

Figure 8. Map of ASV Point Measurement

Based on the test data in Table 1, it can be known the value of 4 indicators of lake water quality in Situ Tekno, namely the DO value of 5-8 ppm, pH value of 7-9, turbidity value of 207-427 NTU and temperature value of 17-20 °C.

Table 1. Test Results Data at Situ Tekno

Test	Test Date	Testing Time (WIB)	Lake Water Quality Testing				Coordinate Point
			DO (ppm)	pH	Turbidity (NTU)	Temp (°C)	
1	21-07-2023	14.48	8	7	237	17	-6.972961, 107.631913
2	21-07-2023	14.50	8	7	237	17	-6.973043, 107.631941
3	26-07-2023	09.41	6	8	320	20	-6.973068, 107.631910
4	26-07-2023	09.48	6	8	260	20	-6.973103, 107.631890
5	26-07-2023	09.52	6	8	275	20	-6.973137, 107.631855
6	26-07-2023	09.55	6	9	320	20	-6.973159, 107.631830
7	26-07-2023	09.56	6	9	320	20	-6.973181, 107.631776
8	26-07-2023	10.18	5	8	207	20	-6.973159, 107.631716
9	26-07-2023	10.39	6	9	320	20	-6.973254, 107.631770
10	26-07-2023	10.56	6	8	371	20	-6.973267, 107.631701
11	26-07-2023	10.58	6	8	427	20	-6.973224, 107.631675
12	26-07-2023	13.36	5	9	217	20	-6.973189, 107.631652
13	26-07-2023	14.15	6	9	209	20	-6.973214, 107.631864
14	26-07-2023	16.35	5	8	218	17	-6.973181, 107.631823
15	26-07-2023	16.36	5	8	215	17	-6.973242, 107.631812
16	26-07-2023	16.37	5	8	213	17	-6.973290, 107.631786
17	26-07-2023	16.38	5	8	216	17	-6.973224, 107.631779
18	26-07-2023	16.41	5	8	214	17	-6.973196, 107.631907
19	26-07-2023	16.42	5	8	216	17	-6.973116, 107.631735
20	26-07-2023	16.42	5	8	207	17	-6.973170, 107.631885

Data on Table 1, sent to Blynk IoT platform in real-time using Wi-Fi network provided by router nearby directly as shown on Figure 9. The signal quality became one of an important factor to guarantee the data send to the IoT platform in real-time.

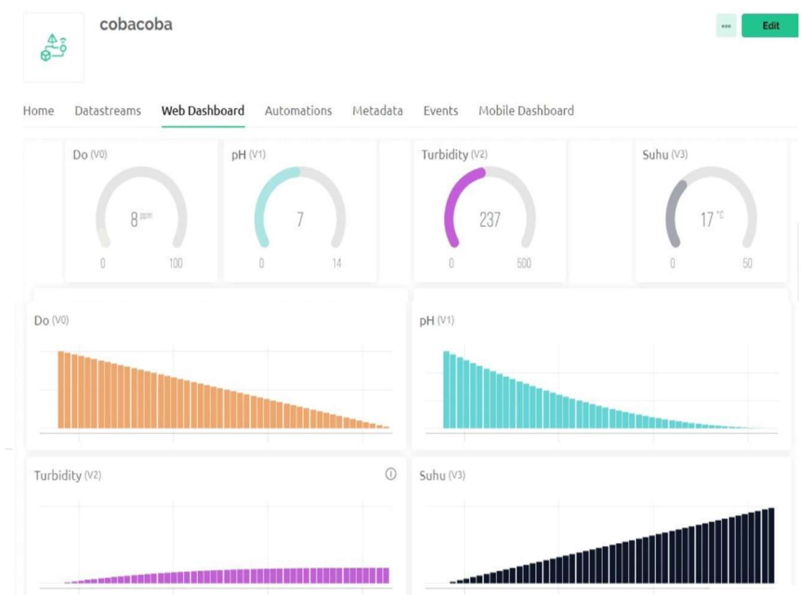

Figure 9. Data Displayed on Blynk IoT platform

In Figure 9 is a display of data on the blynk that has been sent automatically. Data that is in blynk can be stored for 1 week. Data that has passed 1 week will be automatically deleted by the blynk. The data displayed is in the form of measurement results in the form of numbers and graphs and coordinates in the form of numbers.

Table 2. Performance Comparison with Previous Studies

Turbidity (NTU)	Temp (°C)	pH	DO (ppm)	Method
-	Normal +2	6-9	5-7	Lake Water Quality Assessment in University Selangor Bestari Jaya Campus **(Baharim et al., 2022)**
-	26-30	5-7	-	Temperature and pH Quality Of Catfish Pond Water **(Sinaga, 2023)**
-	25,5-28,2	6,8 - 8,2	7,41-7,77	Study on water physical-chemical parameters around fish culture areas in Lake Tondano, Paleloan Village, Minahasa Regency **(Tatangindatu et al., 2013)**
207-427	17-20	7-9	5-8	lake water quality in Situ Tekno **(proposed)**

In this study, water quality comparisons were also carried out with previous research methods as shown in Table 2. It can be analyzed that in this study the average pH, temperature and DO were almost the same in each study.

4. CONCLUSION

In this study, a system has been designed for measuring lake water quality in Situ Tekno using ESP32-based Autonomous Surface Vehicle.Based on the results of the test design and analysis that has been carried out, several conclusions can be stated that, Based on the system design, the system uses ESP32 as its microcontroller to read water quality in the form of temperature from DS18B20 Sensor, pH value from pH meter Sensor, turbidity value from turbidity sensor, DO (Dissolved Oxygen) value from DO meter Sensor and read data will be sent to the Blynk platform. From the results of implementation and testing, the lake water quality system that measures 4 indicators, namely DO (Dissolved Oxygen), pH, turbidity and temperature are carried out as many as 20 different points in Situ Techno who uses ASV. Based on the analysis of the results of lake water quality testing in Situ Tekno, DO values of 5-8 ppm, pH values of 7-9, turbidity values of 207-427 NTU and temperature values of 17-20 ° C. From this statement, it can be concluded that the water quality at Situ Tekno can meet the standards of the Government of the Republic of Indonesia and the measurement system can measure the quality of lake water at several points that cannot be monitored by humans and the system is considered more efficient and effective for regular monitoring and can be monitored in realtime.

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