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Oceanographic Parameter Measurement System Based on LoRA Communication Module

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Abstrak

Pengukuran parameter oseanografi dibutuhkan untuk mengetahui kondisi ekosistem yang ada pada wilayah perairan sehingga dapat menjadi dasar dalam melakukan kegiatan konservasi pada wilayah perairan laut. Pengukuran parameter fisik dan kimia yang digunakan masih dilakukan secara manual sehingga data yang diperoleh masih rentan terhadap kesalahan pengamatan. Pada penelitian ini dirancang sebuah sistem yang dapat melakukan pengukuran parameter oseanografi secara berkala. Sistem yang dirancang terdiri dari sensor suhu, sensor turbidity, sensor pH dan sensor TDS yang terintegrasi dengan perangkat mikrokontroler. Sistem terdiri dari dua bagian utama yaitu sensor node yang berfungsi sebagai transmitter dan gateway yang berfungsi sebagai receiver. Pengujian awal dilakukan dengan melakukan kalibrasi dan validasi data untuk setiap sensor yang digunakan. Pengujian selanjutnya dilakukan dengan menguji pengiriman data hasil pengukuran parameter oseanografi berupa pH air, salinitas, suhu air dan kekeruhan air dari sensor node ke gateway dengan menggunakan modul komunikasi LoRA Ebyte E220. Hasil pengujian menunjukkan bahwa data hasil pengukuran sensor node dapat dikirimkan ke gateway dengan pengaturan jarak antara perangkat sejauh 500 meter. Delay pengiriman data yang dihasilkan berada pada rentang 2-10 detik.
Kata Kunci: Oseanografi, Mikrokontroler, Sensor Node, Gateway, LoRA.

Abstract

Measurement of oceanographic parameters is needed to determine the condition of the ecosystem in the water area so that it can be the basis for carrying out conservation activities in marine waters. Measurement of physical and chemical parameters used manually which causes the data obtained is still susceptible to observational errors. In this study, a system was designed that can measure oceanographic parameters periodically. The designed system consists of a temperature sensor, turbidity sensor, pH sensor and TDS sensor integrated with a microcontroller device. The system consists of two main parts, a sensor node that has a function as a transmitter and a gateway that has a function as a receiver. Initial testing is done by calibrating and validating data for each sensor used. The next test was carried out by testing the transmission of data from the measurement of oceanographic parameters in the form of water pH, salinity, water temperature and water turbidity from the sensor node to the gateway using the LoRA Ebyte E220 communication module. The test results show that the sensor node measurement data can be sent to the gateway by setting the distance between devices as far as 500 meters. The resulting data transmission delay is in the range of 2-10 seconds.
Keywords: Oceanography, Microcontroller, Sensor Node, Gateway, LoRA.

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I. INTRODUCTION

Indonesia is a maritime country that has a large territorial waters. About 62% of Indonesia's territory is water. This makes the resources obtained from marine products a source of foreign exchange for the country which will have an impact on national development. In addition, the existence of abundant marine products will have an impact on the community's economy (Kambey et al., 2023) Therefore, the community must maintain the preservation of coastal and underwater ecosystems. Conservation is an effort made in the form of conservation of mangroves, seagrasses, coral reefs and other marine ecosystems. This activity will have a very important role in the sustainability of living things in the waters. The conservation activities carried out will refer to oceanography parameters (Handayani, 2022).

Oceanography is a science that discusses physical and dynamic phenomena and processes in seawater (Cahyadi &; Astiyani, 2021). The study of oceanography is divided into several parts including physical and chemical oceanography. Physical oceanography discusses physical parameters such as tides, temperature, depth, waves and ocean currents (Tanto et al., 2016). While chemical oceanographic discusses the salinity and pH conditions in waters.

To obtain data on physical and chemical parameters, by performing measurement methods manually using measuring instruments. Measurement of oceanographic data using tools such as GPS, current meters, scale poles for wave measurements, water quality checkers to measure temperature, salinity and pH (Jalil et al., 2020). The amount of data obtained by manual measurements is very minimal and not continuous. The available automatic measurement tools are still not affordable in terms of price (Fadly &; Dewi, 2016).

The development of a system that can measure several oceanographic parameters automatically is a solution to overcome the above problems. The system to be designed will integrate data from several sensors that can perform measurements of multiple Oceanographic parameters. The sensors installed will be controlled through a Microcontroller device. Sensor data will be sent from sensor node (transmitter) to gateway (receiver) on mainland to observe sensor measurement results.

II. LITERATURE REVIEW

A. Oceanographic Parameters

Marine waters have various potentials and fisheries and marine resources are very abundant. Indonesia is the largest archipelagic country in the world which has a sea area of about 5.8 million km2 with a coastline length of 95,181 km. The potential of fisheries owned is a potential that can be utilized as a basis for national development (Munawaroh, 2019). To maintain the ecosystem in marine waters, an important aspect that needs to be studied is the suitability of the conditions of oceanographic physical-chemical parameters as an important factor in the growth of ecosystems in the waters. Several physical and chemical oceanographic parameters will be the object of this study, such as water temperature, water brightness / turbidity, water pH and salinity.

Temperature is one of the factors that greatly affect the existence and development of fish that live in water areas. If the temperature in the waters is too high, it will cause stress on the body of the fish. Good temperature standards for fish growth in water areas are in the range of 20oC – 30oC. Changes in water temperature are influenced by various weather conditions such as rainfall, wind speed, air temperature, solar intensity and air humidity (Abdullah, 2015).

The brightness of waters is a condition that indicates the ability of light to penetrate the water layer at a certain depth. In water areas, the level of brightness is very important for photosynthetic activity (Mainassy, 2017). Good brightness standards for coral reef growth are more than 5 meters deep (Rizal et al., 2016). Another factor affecting the brightness level is dissolved particles in the mud. Increased turbidity in the water will decrease the feeding efficiency of the organism.

Acidic or alkaline water conditions will endanger the survival of organisms. Because it will result in metabolic and respiratory disorders (Jalaluddin et al., 2014). Aquatic organisms have a high degree of sensitivity to changes in pH. Each organism has a tolerance limit of varying pH values. In general, the standard pH value is in the range of 7 - 8.5. Changes in pH values in water areas will affect biochemical processes (Makmur &; Fahrur, 2011). Increased pH in water areas occurs due to human activities, waste, organic and anorganic matter that pollute waters.

Salinity is one of the water quality parameters that needs attention in aquaculture activities in water areas because it is an important factor in the spread of organisms in water areas. This parameter has a direct influence on fish metabolic processes, especially osmoregulation processes that will have an impact on fish growth rates (Abidin, 2017). This process is an effort made by animals to control the balance of water and ions in the body and the surrounding environment (Syukri &; Ilham, 2016). Salinity standards for fresh water are in the range of 0-5 ppt, for brackish water 6-29 ppt and for seawater 30-40 ppt (Samy, 2020). The distribution of salinity in waters is influenced by various factors such as water circulation patterns, rainfall and river flow (Patty, 2013).

B. Sensor Data Acquisition with Microcontroller

Measurement of oceanographic parameters using sensors integrated with microcontroller devices has been carried out in recent years. Real-time measurement of water level is carried out using ultrasonic sensors. This measurement is carried out to monitor tidal conditions. (Pandiangan et al., 2016). Measurements related to oceanographic parameters are closely related to water quality. In several studies related to measuring freshwater quality for aquaculture in real-time, several oceanographic parameters became the main study. Research conducted by Hidayatullah, et al (2018) uses temperature, pH and turbidity as measurable parameters for water quality monitoring. The types of sensors used to perform measurements are shown in Table 1

Table 1. Sensors for Water Quality Measurement

Parameter	Satuan	Sensor
Temperature	oC	Temperature Sensor DS18B20
pH Value	-	pH Sensor (SKU: SEN0161)
Turbidity	NTU	Turbidity Sensor

In another study conducted by Pratama & Taufiqqurrahman (2018), the parameters measured were temperature, pH and salinity. The measurement of these oceanographic parameters uses LM35 sensors, pH sensors and salinity sensors integrated with the ATMega16 Microcontroller device. The results of sensor data acquisition will be processed and separated and then sent to PCs / laptops on the ground in real time using serial communication. Then in research that has been conducted by Staudinger et al (2019), research was carried out by measuring pH parameters. This is in line with research conducted by Demetillo et al (2019) and Raihanto, et al (2021) who developed a prototype that can measure pH and TDS parameters using sensors integrated with microcontroller devices. Burke (2020) made oceanographic parameter measurements by observing temperature and dissolved oxygen parameters and Zhao (2020) also took TDS measurements integrated with GPS modules to inform water quality at certain locations. The limitation of the oceanographic parameter measurement system is that there is no system that integrates all types of sensors used in measuring physical and chemical parameters in water.

III. METHOD AND DESIGN

The research carried out is designing a real-time monitoring system for oceanographic parameters based on a Wireless Sensor Network. The results of this research will be used in carrying out conservation activities in marine areas. The block diagram of the system is shown in Figure 1. In this study, an oceanographic data measurement system was designed by utilizing sensors integrated with Microcontroller devices. The parameters measured in this study consisted of water salinity, water temperature, water turbidity level and water pH. This research consists of 3 stages, such as hardware design, software design and system testing. In hardware design, the tools and components used consist of ESP32, TDS sensors, pH sensors, DSB1820 temperature sensors and turbidity sensors. Software design for the EPS32 Microcontroller device is done using the Arduino IDE to give commands to the hardware that has been designed. The testing carried out in this study consists of several stages. The initial stage of testing is carried out by validating and calibrating sensors in the laboratory. This test is carried out by providing several levels of treatment on the parameters to be measured, such as pH, salinity, temperature and turbidity in several variations in water volume. Sensor readings are compared with measurement results with measuring instruments as a data validation process. The second stage of testing is carried out by testing a system that has been integrated with all sensor devices in marine waters. The data from the sensor acquisition will be processed using a microcontroller device to be displayed on the LCD device.

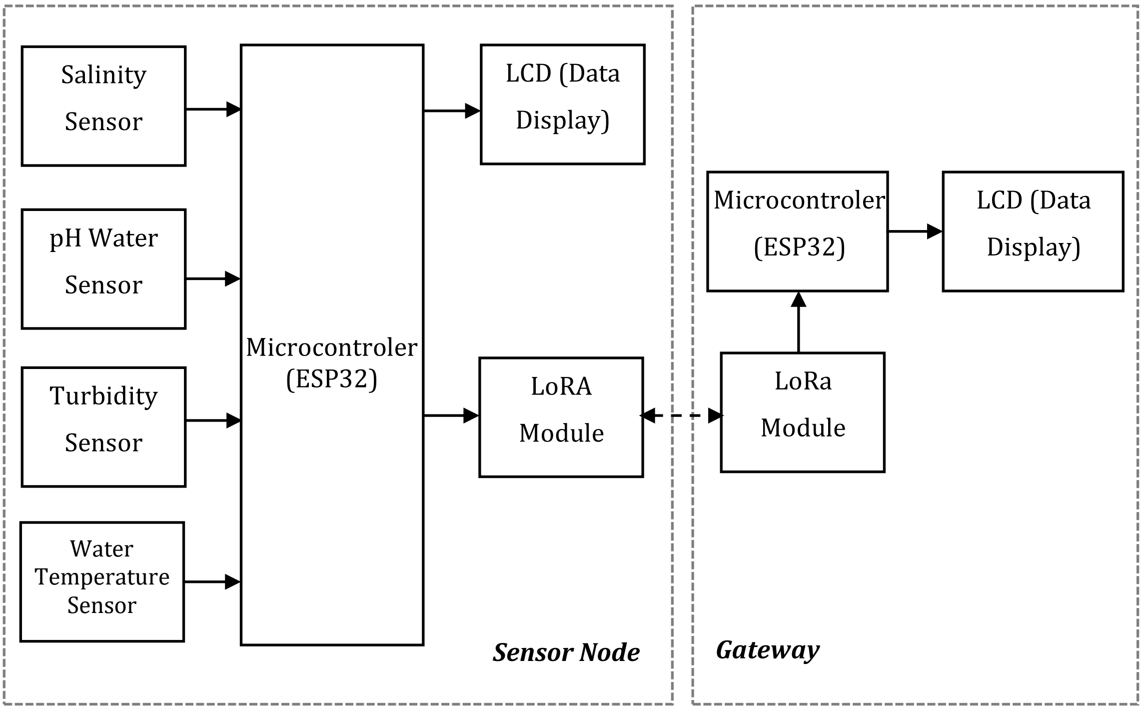

Figure 1. Block Diagram of Oceanographic Measurement System

IV. RESULTS AND DISCUSSION

The research conducted is the design of a real-time oceanographic parameter monitoring system based on Wireless Sensor Network and Internet of Things. The results of this research will be used in carrying out conservation activities in marine waters. Several physical and chemical oceanographic parameters will be the object of study, such as water temperature, water turbidity, water pH and salinity. The research carried out consists of two main stages. In the initial stage, the design of an oceanographic data measurement system was carried out by utilizing sensors integrated with Microcontroller devices (ESP32). The study begins with calibrating the sensor. Calibrated sensors are integrated with Microcontroller devices to measure oceanographic parameters. The data from the sensor acquisition will be processed through a microcontroller device displayed on the LCD layer and sent from the Sensor Node to the Gateway using the LoRA communication module as shown in Figure 2.

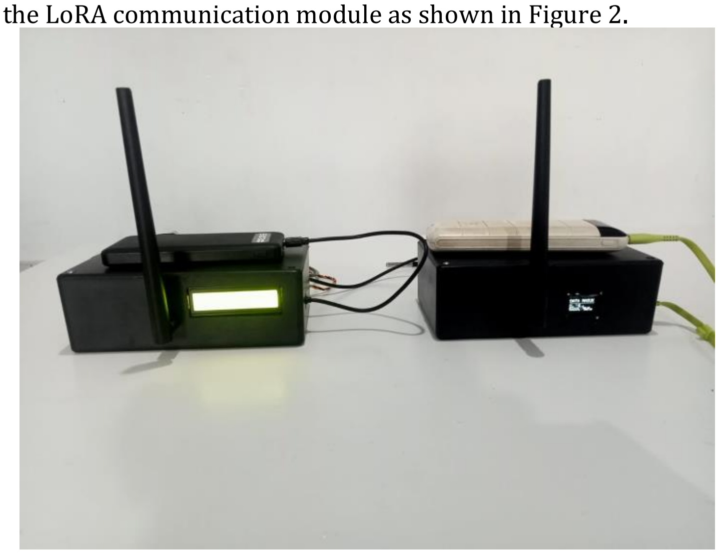

Figure 2. Sensor Node and Gateway Devices

A. Turbidity Sensor Measurement

Water turbidity measurement is carried out by providing several turbidity level treatments in water with various water volumes. In this test using coffee to provide turbidity treatment in water, coffee is given with 5 different doses. The volume of water used consists of 250 ml, 500 ml, 750 ml and 1000 ml. The turbidity level of water is measured using the Turbidity Sensor SEN0189-DFRobot. The sensor is able to detect changes in light intensity caused by particles in the water which are then processed by microcontroller devices (Iskandar et al., 2019). The measurement results are shown in Table 2.

Figure 3. Water Turbidity Level Measurement with Turbidity Sensor

Table 2. Results of Water Turbidity Level Measurement with Turbidity Sensor

Turbidity Treatment Rate	Water Volume (ml)	Voltage (Volt)	Turbidity Value (NTU)
1	250	4.04	560
	500	4.05	558
	750	4.07	458
	1000	4.09	390
2	250	4.00	689
	500	4.02	624
	750	4.02	624
	1000	4.04	558
3	250	3.86	1118
	500	3.93	909
	750	4.01	657
	1000	4.02	624
4	250	3.75	1424
	500	3.93	909
	750	4.01	657
	1000	4.01	659
5	250	3.73	1477
	500	3.89	1030
	750	3.98	816
	1000	4.00	685

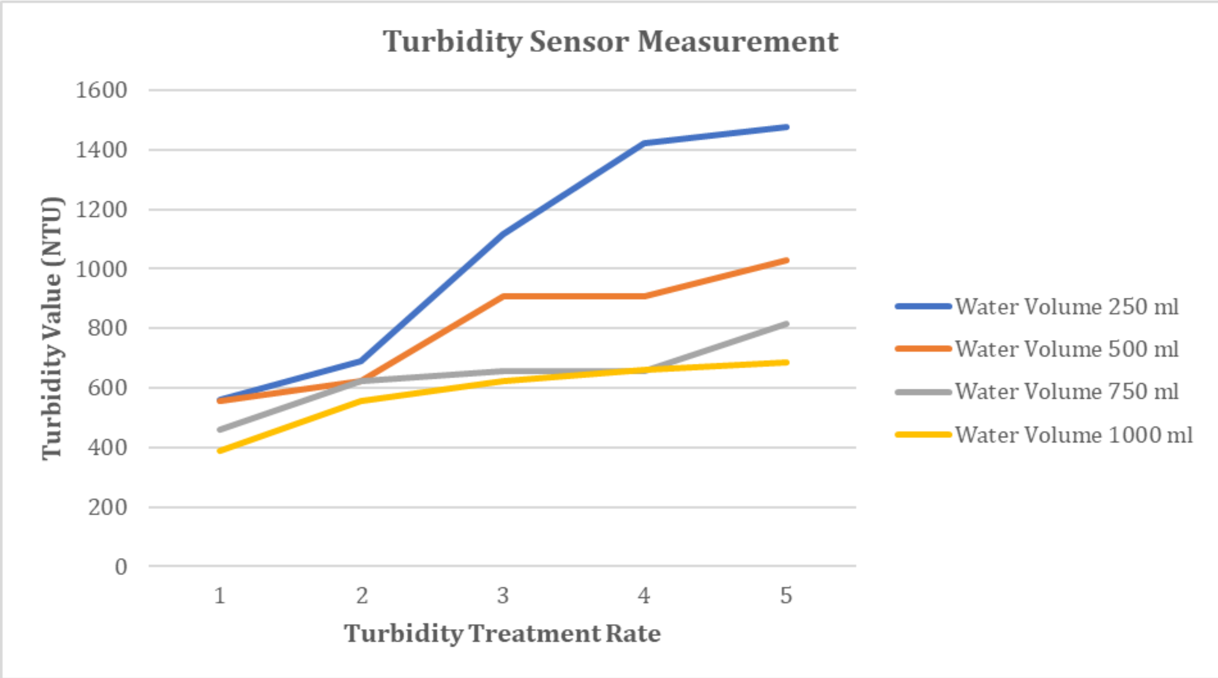

Figure 4. Results of Water Turbidity Level Measurement with Turbidity Sensor

The test results show that the higher the level or level of turbidity treatment (dose of coffee) given, the resulting voltage value is smaller and the turbidity value (NTU) is greater. At the same turbidity treatment level, the value of the water turbidity reading produced by the sensor (NTU value) gets smaller the larger the volume of water given.

B. TDS Sensor Measurement (Salinity)

Water salinity level measurement is carried out by providing several salinity level treatments in water with various water volumes. In this test using salt to provide salinity level treatment in water, salt is given with 5 different doses. The volume of water used consists of 250 ml, 500 ml, 750 ml, 1000 ml and 1500 ml. The salinity level of water was measured using a TDS Sensor SEN0244- DFRobot. The sensor can measure conductivity in water. An increase in the concentration of ions present in the water will cause the conductivity value to increase. The conductivity will be read by a sensor probe that will convert into a voltage value (Hakimi et al., 2021). The measurement results are shown in Table 3.

Figure 5. Water Salinity Measurement with TDS Sensor

Table 3. Water Salinity Measurement Results with TDS Sensor

Salinity Treatment Rate	Water Volume (ml)	Voltage (volt)	Salinity Value (ppm)
1	250	2.3	1125
	500	2.14	988
	750	1.76	724
	1000	1.49	575
	1250	1.31	491
	1500	1.16	428
2	250	2.3	1125
	500	2.3	1121
	750	2.22	1044
	1000	2.05	913
	1250	1.86	784
	1500	1.7	686
3	250	2.3	1125
	500	2.3	1125
	750	2.3	1125
	1000	2.29	1108
	1250	2.21	1040
	1500	2.11	957
4	250	2.3	1125
	500	2.3	1125
	750	2.3	1125
	1000	2.3	1125
	1250	2.29	1112
	1500	2.23	1057
5	250	2.3	1125
	500	2.3	1125
	750	2.3	1125
	1000	2.3	1125
	1250	2.3	1125
	1500	2.29	1116

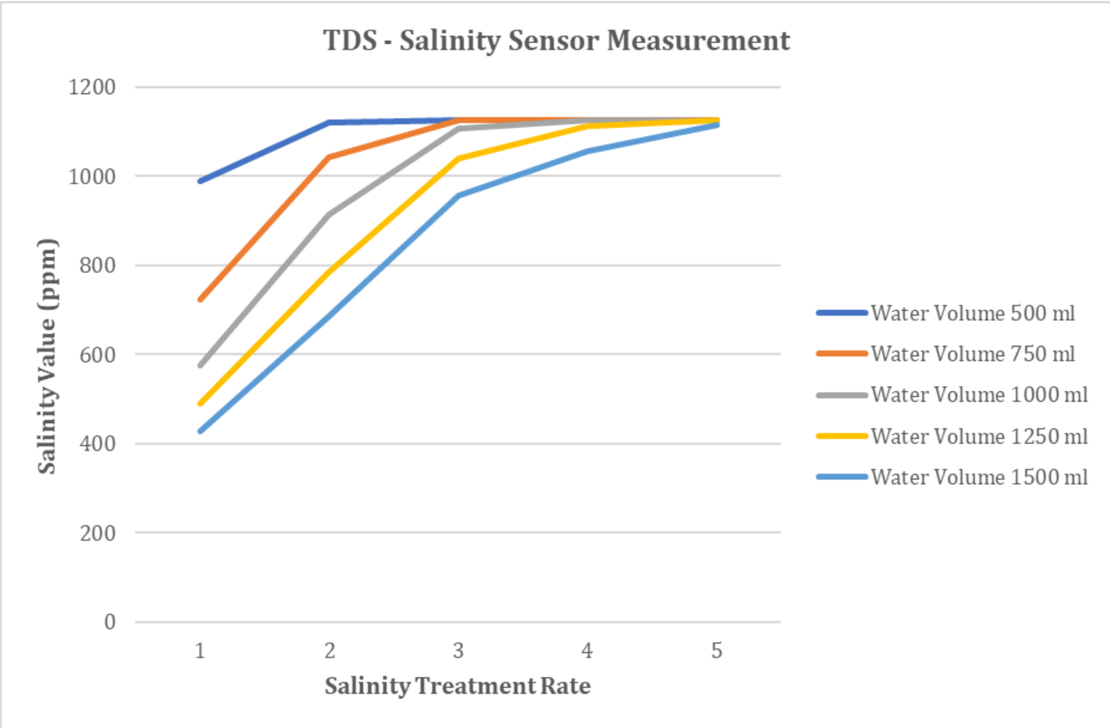

Figure 6. Water Salinity Measurement Results with TDS Sensor

The measurement results show that the higher the salt content given, the greater the voltage value produced and the salinity value (TDS sensor reading) in ppm units is greater. At the same level of salt content treatment, the salinity reading value of the water produced by the sensor gets smaller the larger the volume of water given.

C. pH Sensor Measurement

Water pH level measurement is carried out using two buffer solutions, namely pH 4.01 and pH 7.01. The sensor used in this study was the SEN0161-DFRobot pH sensor. A pH sensor is a sensor that functions to determine the degree of acidity of water which is then converted into a voltage value (Hariyadi et al., 2020). The sensor readings are compared with the pH meter readings. Tests are carried out in several times to observe the level of accuracy of the sensor. The measurement results are shown in Table 4.

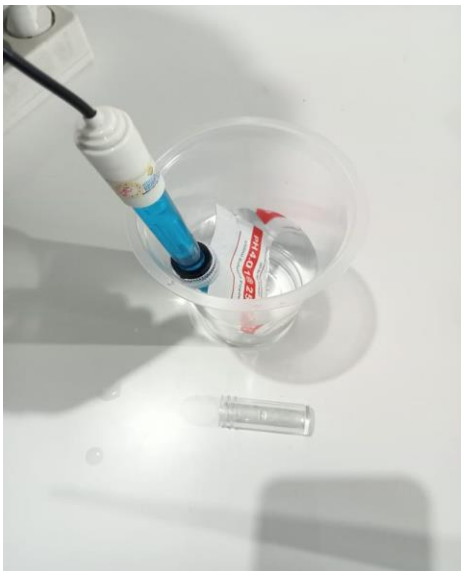

Figure 7. Water pH Measurement with pH Sensor

Table 4. pH Sensor Readings

pH Calibration Solutions	Sensor Reading			pH Meter
	Testing	Voltage (volt)	pH Value	
4.01	1	1.03	3.90	3.35
	2	1.02	3.84	
	3	1.03	3.89	
	4	1.02	3.84	
	5	1.03	3.89	
	6	1.02	3.86	
	7	1.03	3.90	
	8	1.03	3.87	
	9	1.04	3.92	
	10	1.04	3.91	
7.01	1	1.98	7.20	6.33
	2	1.98	7.20	
	3	1.99	7.24	
	4	1.99	7.25	
	5	2.00	7.28	
	6	2.00	7.28	
	7	2.01	7.30	
	8	2.01	7.32	
	9	2.01	7.32	
	10	2.02	7.35	

The measurement results of the pH sensor showed that using buffer 4.01 the sensor reading results in an average pH value of 3.88 with an error value of 15.88%. The test results with a buffer of 7.01 resulted in an average pH value of the sensor reading of 7.27 with an error value of 14.91%.

D. Temperature Sensor Measurement

Water temperature measurement is carried out using a DS18B20 temperature sensor. This sensor is a waterproof sensor. This sensor has an output in the form of digital data with an error accuracy rate of ±0.5°C. The detectable water temperature is in the range of -10°C to 85°C (Aritonang et al,m 2021). Tests were conducted using several water samples with varying temperatures. Validation of sensor measurement results is carried out using a thermometer. The measurement results are shown in Table 5.

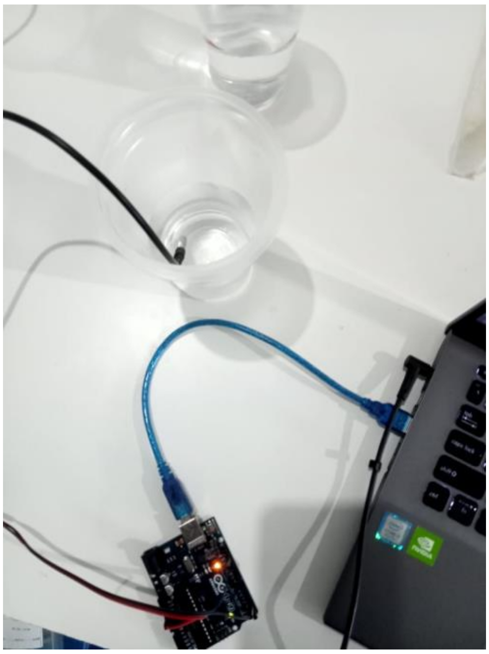

Figure 8. Water Temperature Measurement with Temperature Sensor

Table 5. Temperature Sensor Measurement Results

Water Sample	Sensor Readings (°C)	Thermometer Readings (°C)	Percentage of Error Values
1	18.94	19.3	1.87
2	25.0	25.19	0.75
3	25.6	25.62	0.08
4	25.9	26.37	1.78
5	27.9	27.62	1.01

The measurement results using water samples showed that the lowest error value was obtained by the 3rd water sample with an error value of 0.08%. The average error rate obtained in temperature sensor testing is 1.1 %

E. Data Transmission from Sensor Node to Gateway

At this stage, testing of sending data from the sensor node to the gateway is carried out. Sensor node is a device that is integrated with sensors and sends data from measurement of oceanographic parameters through the LoRA communication module placed in the waters. A gateway is a land-based device that receives data from oceanographic parameter measurements displayed on OLED devices. The test is carried out by sending sensor reading data from the sensor node to the gateway by changing the distance between the two devices.

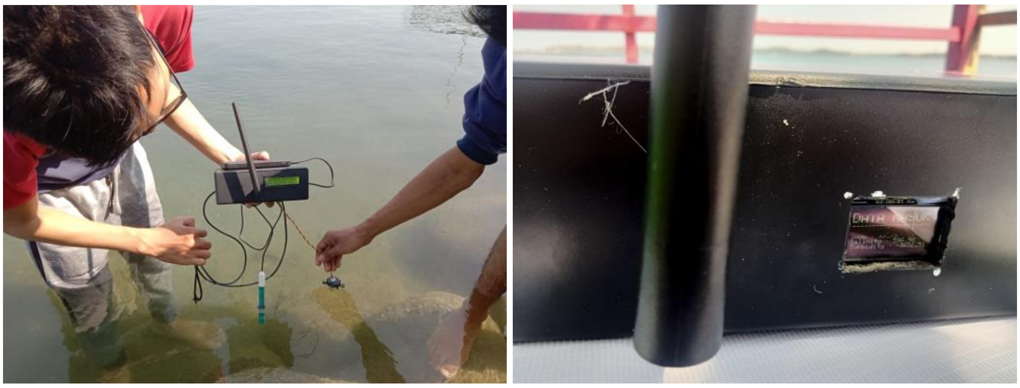

Figure 9. Testing Data Transmission in Water

The test was conducted with the maximum distance between the sensor node and the gateway is 500 meters. The test results show that sensor reading data can be sent to the gateway device displayed on the OLED screen. Data transmission delay of about 2-10 seconds.

The development of a real-time oceanographic parameter measurement system is carried out by utilizing several types of sensors integrated with microcontroller devices. In previous research conducted by Staudinger, et al (2019), a system designed to observe pH parameters in water. While the research conducted by Burke, et al (2020), the system designed only observed the parameters of Dissolve Oxygen and water temperature. In another study conducted by Pratama & Taufiqqurrahman (2018), the parameters measured were temperature, pH and salinity. The development of monitoring devices that have been designed and tested allows sensor reading data to be sent from devices in water areas to devices on land. This system can reduce observation errors in the measurement of oceanographic parameters carried out manually with the help of measuring instruments. The process of taking oceanographic data can be more efficient because measurement data can be stored properly.

V. CONCLUSION

The designed oceanographic parameter measurement system consists of a turbidity sensor, pH sensor, TDS sensor and temperature sensor integrated with the ESP32 microcontroller device. The sensor used has been calibrated and validated in the laboratory. The results of turbidity and TDS sensor testing show that the higher the level of treatment given, the greater the turbidity value (NTU) and salinity (ppm) produced. pH sensor readings show an average error value of about 15%. Tests performed on temperature sensors resulted in an error value of 1.1%. Sensor data is transmitted from the sensor node to the gateway using the LoRA Ebyte E220 communication module and tests are performed at a maximum distance of 500 meters. The test results show that the sensor measurement data on the sensor node is the same as that displayed on the gateway with a delivery delay of up to 10 seconds. The development of a real-time oceanographic parameter measurement can reduce measurement errors in oceanographic parameter measurements. The process of taking oceanographic data can be more efficient because measurement data can be stored periodically according to specified time intervals without having to measure directly in the water areas throughout the day.

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