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Internet of Things Based Tidal Monitoring System at Kurnia My Darling Beach

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ABSTRACT

Internet of Things technology provides an effective solution to monitor real-time sea level changes remotely. This research aims to design and manufacture a sea level monitoring device based on NodeMCU ESP32 and HC-SR04 sensor where for 3 consecutive days the tide is monitored to exceed 130 cm above 10 am so that it has an impact on mangrove seedlings at Kurnia My Darling Beach. The results show that IoT-based sea level monitoring instrumentation tools have a high level of accuracy. The tool has been tested in real-time using ThingSpeak and can send notification notifications using WhatsApp. The results of monitoring for 3 days with this tool were obtained that the tide level exceeded the planted seedlings. It is hoped that in the future, this research will become a standard to make better tools that will be used for the purpose of monitoring mangrove seedlings so that the sustainability of mangrove forests can be maintained.

Keyword : IoT, NodeMCU, Mangrove Forest

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1. INTRODUCTION

The rapid development of technology in recent years has allowed various aspects of human life to become more computerized and connected (Akbar et al., 2019). One of the technologies that is becoming increasingly popular is the Internet of Things (Arifin & Rizal, 2023), which allows devices to exchange information with each other over the internet (Amir et al., 2018). The Internet of Things (IoT) is a technology that connects to the internet, allowing for automated data exchange to execute specific commands (Erika et al., 2024). This capability can be utilized in a variety of fields, including water level monitoring.

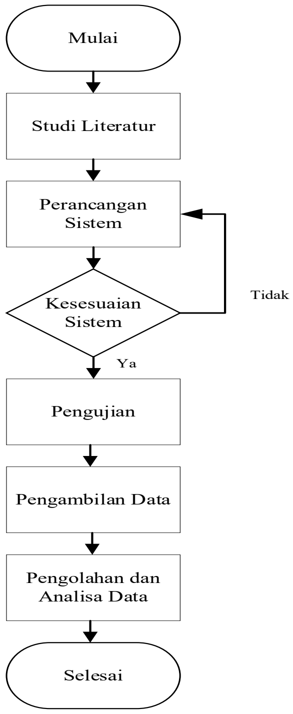
Several studies related to water quality monitoring have been carried out, such as the development of an IoT-based physical water quality monitoring system in PDAM (Yushananta, 2023), design and build a real-time PDAM water use control system based on Wemos and IoT (Diharja et al., 2021), as well as an IoT-based water turbidity monitoring system (Yushananta, 2023). However, unfortunately most of the research focuses only on water quality in general, while tidal monitoring of seawater, which is important for mangrove ecosystems, is still rarely studied.

The tides of sea water are natural phenomena that occur every day. Daily changes in sea level are important for various needs, such as port construction, coastal and offshore structures, cultivation in coastal areas, navigation, early warning systems for flash floods, as well as patterns of water mass movement and others. Therefore, real-time monitoring of sea level is very important to maintain the sustainability of mangrove ecosystems in coastal areas. This research will consider several limitations of the problem, one of which is the use of ultrasonic sensors which are distance sensors (Novelan et al., 2022)

In order to obtain information about the tides of sea water that is easily accessible and practical for everyone, this study created a sea level monitoring device based on the NodeMCU ESP32 microcontroller and the ultrasonic sensor HC-SR04. This tool allows data access through online storage. In its measurement system, the sensor is placed with a height of 2 meters, using the HC-SR04 sensor as a control variable. The value of sea level as a response variable. Several previous studies have been used as a reference in the design and implementation of this sea level monitoring system. The research used the HC-SR04 and Arduino Uno ultrasonic sensors, sent notifications via SMS, and stored the data on a Micro SD card, but the data could not be accessed in real-time via the internet (Dwi Agustin, 2022). The research uses water level sensors and NodeMCU ESP8266 by sending data via Telegram in the form of warning information, but cannot store the measurement results (Nanda et al., 2020). Furthermore, the study uses an ultrasonic sensor HC-SR04 and a NodeMCU ESP8266 by sending data through ThingSpeak software, but there is no LCD so that the observer cannot see the incoming data and warning information directly when a problem occurs (Dwi Agustin, 2022). This research aims to design and manufacture a sea level monitoring tool based on NodeMCU ESP32 and HC-SR04 sensor and integrate the system with IoT platform for continuous monitoring. The information can be used as input in the preparation of more effective mangrove management and conservation strategies to increase mangrove conservation efforts in the region and ensure the sustainability of mangrove ecosystems in the future (Wahyuni et al., 2024).

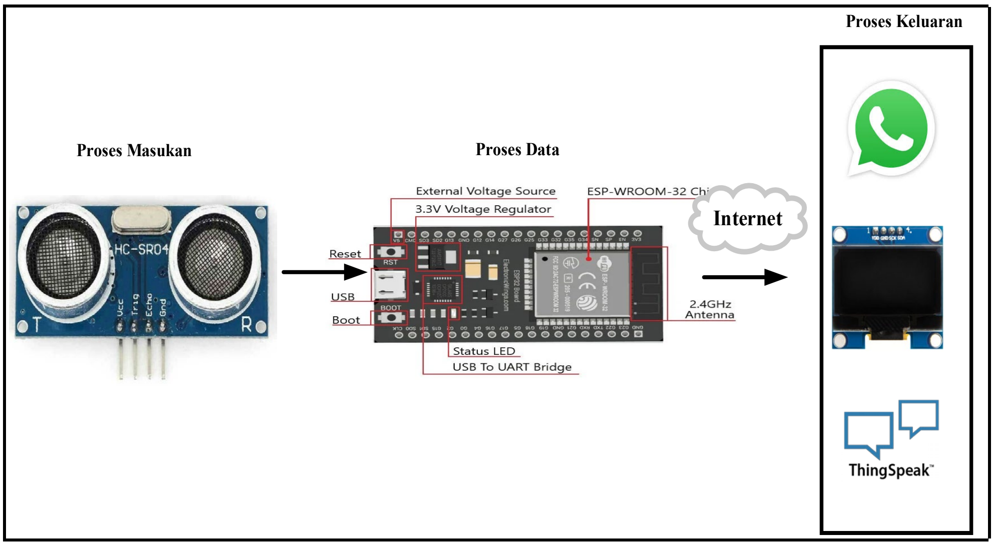
2. RESEARCH METHOD

This study was carried out at Kurnia My Darling Beach, which is located in Kota Pari Village, Serdang Bedagai Regency, North Sumatra Province, with a reference to mangove seedlings 130 cm above sea level. The appliance is placed in a place where it is not exposed to direct waves perpendicularly. The tool is made in the mangrove seedling planting area in a perpendicular position. Because the full moon and the highest tide are expected on August 19-21, 2024 in collecting data. This study was carried out using an experimental method. The necessary tools NodeMCU ESP32 microcontroller, HC-SR04 ultrasonic sensor, OLED, laptop, meter, and battery are some of the tools used. The ThingSpeak and WhatsApp apps serve as data storage and servers. The WhatsApp app serves as a direct and quick alert notification and ThingSpeak serves as a data server to store data. Seawater was used for this study. This study uses the ultrasonic sensor HC-SR04 as the control variable and the sensor height of the mangrove seedlings as high as 1.3 meters. Data was taken every five minutes for two days as a manipulation variable. This research is carried out in several stages of research, namely searching for literature, creating a system, testing, data collection, and then processing and analyzing data, At this stage, the researcher will conduct data analysis to find out the trend of sea level changes during the observation period. The data will be processed and interpreted to obtain conclusions regarding changes in sea level at the research site.

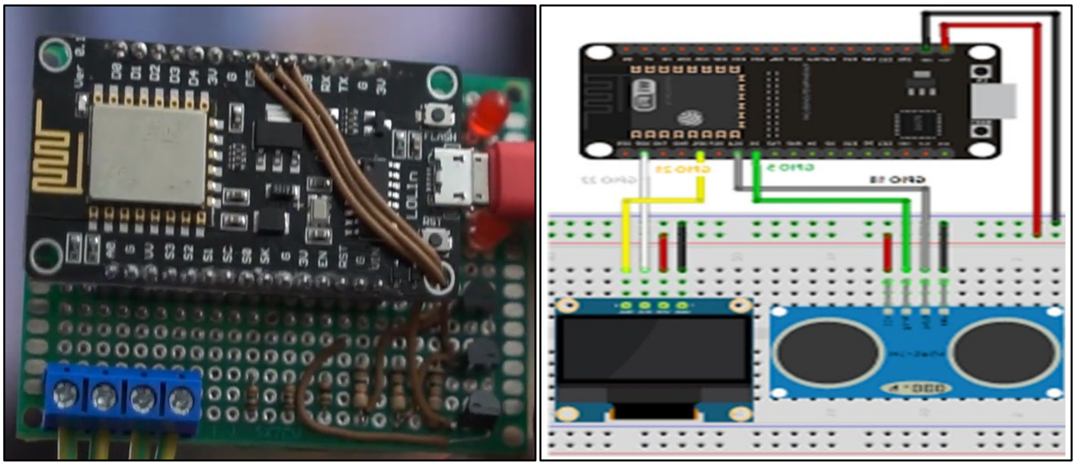


Picture. 1 Research Stages

In hardware design, the layout of all components and modules is arranged. The ESP32 NodeMCU is the information processing center of the HC-SR04 ultrasonic sensor and processed into information so that it can be sent to ThingSpeak as a sensor data storage medium, OLED that displays sea level values and WhatsApp as an early warning delivery medium. The design and implementation of programming in the NodeMCU ESP32 uses the C++ language on the Arduino IDE. The block diagram of the working process of the hardware and software of the seawater tide monitoring system is below.



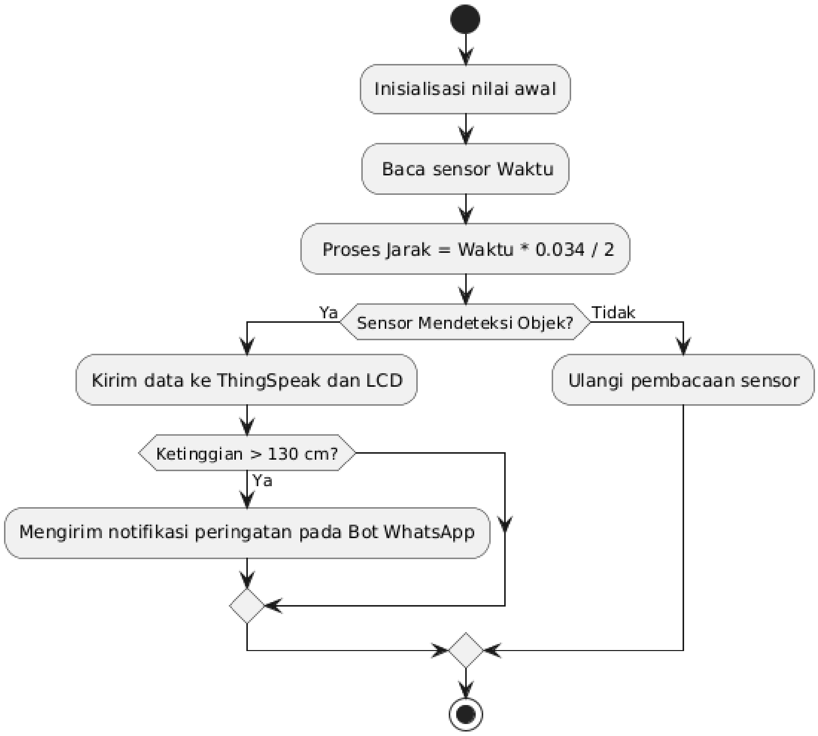
Picture. 2 Block Diagram



Picture. 3 Tool Range

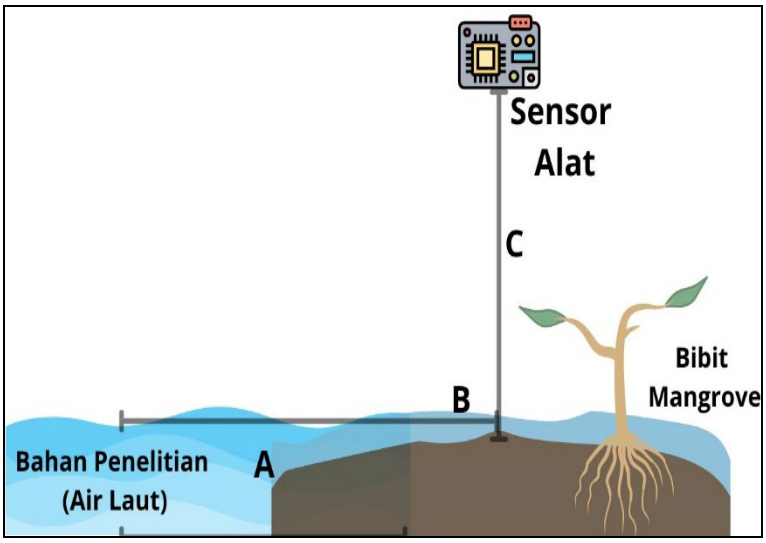
After creating the toolkit, the next step is to design a program on the software using the Arduino IDE application. Furthermore, the program will be applied to the design of the measuring instrument and the transmission of sea level data stored on the NodeMCU ESP32 microcontroller. Next, do programming that connects hardware systems, or hardware, with program system design. This includes integrating the channel ID code and Key API into the WhatsApp application which is uploaded into the Arduino programming IDE to monitor the application.

To start the program, you call the libraries for the NodeMCU ESP32 microcontroller, the HC-SR04 ultrasonic sensor, OLED, constants, and variable contents. The loop function reads the sensor data, converts it into a string variable, displays it to OLED, sends it to ThingSpeak, and sends WhatsApp alerts. The flow diagram of software and hardware system design is shown below.

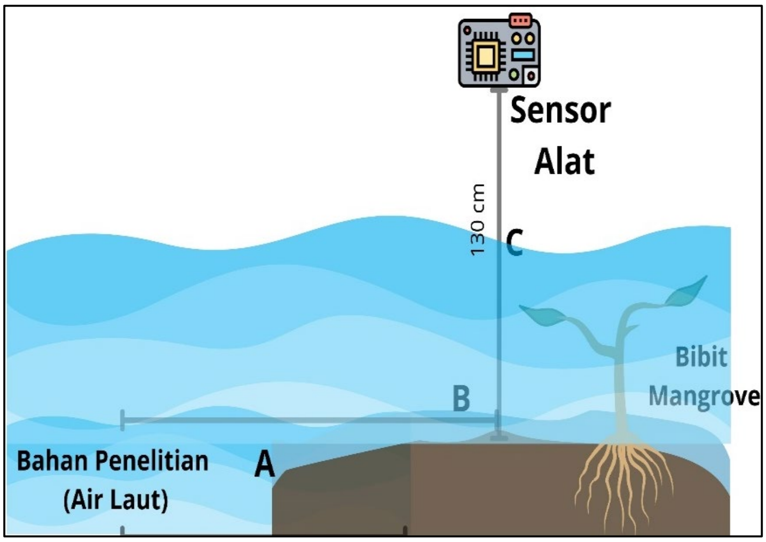


Picture. 4 Software System Design Flow Chart

The flow chart of the software system design system is shown in Figure 4. This tool can only work when connected to the internet. If the internet connection is disconnected, the appliance will stop working, and if it is disconnected for more than two minutes, it will automatically reset. The sensor will start measuring the sea water level once the device is connected to the internet and power source. After that, the reading results will be displayed on the OLED and sent to the ThingSpeak and WhatsApp users. Thus, sea level data will be displayed on the user's ThingSpeak in the form of tables and graphs, and the user's WhatsApp will receive an alert if the threshold of 130 cm is crossed. Figure 5 shows the location of the sea level detector and its measurement formula.



Picture. 5. Location of Monitoring Equipment When Receding



Picture. 6 Location of Monitoring Device When Installed

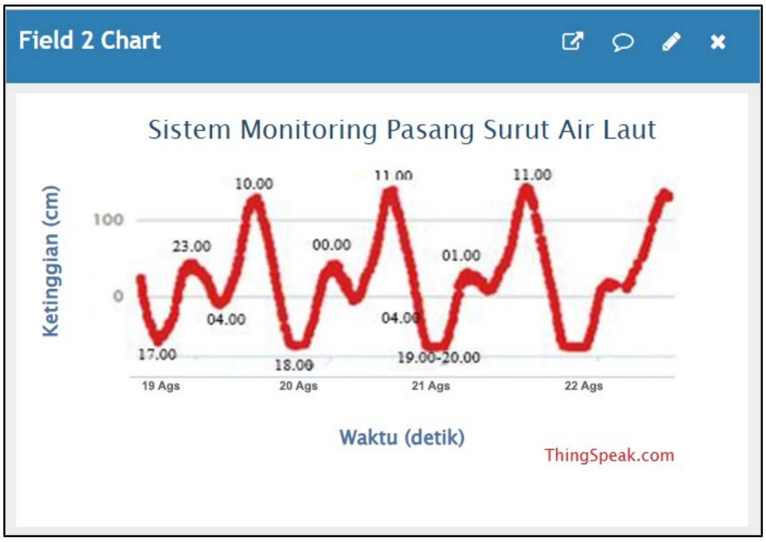
The measurement formula is (A) = B -C
Information:
A = Change in sea level (cm)
B = Distance from the LWL (Low Water Level) point or the lowest low tide to the sensor
C = Distance measured by the sensor (cm)

The sensor reading results will generate its accuracy value, which then takes into account the accuracy of the tool and the average error, and then generates the value that is considered correct from the manual record. Accuracy calculations are carried out to determine the accuracy of conventional measuring instruments. The tool can be used if the difference is still within the tolerance limit and in accordance with the accuracy characteristics of the ultrasonic sensor used.

Testing is carried out in the field after producing accurate readings. Testing was carried out at Kurnia My Darling Beach. The test was carried out for 3 days, from August 19 to 21, 2024, to be precise. The test was carried out by installing a device in the mangrove seedling area around Kurnia My Darling Beach. The sea level is recorded once every three minutes. Overall equipment performance is monitored during the testing process, including battery life used, OLED display, and results sent via ThingSpeak and WhatsApp. The data generated by this tool consists of sea level in centimeters from the lowest sea level. This data is displayed quantitatively every five minutes for two days of high tide and two days of low tide. In addition, an alert will appear in the WhatsApp application if the water level exceeds the threshold of 130 cm. After the data was processed, the results were analyzed so that conclusions could be drawn from this study.

3. RESULTS

The first tool test was carried out from August 19, 2024 WIB to August 21. In the figure below is the data that has been recorded in the test with a minimum sea level of -67 cm on August 19 at 19.00-20.00 WIB and a maximum sea level of 140 cm on August 21, 2024 at 11.00



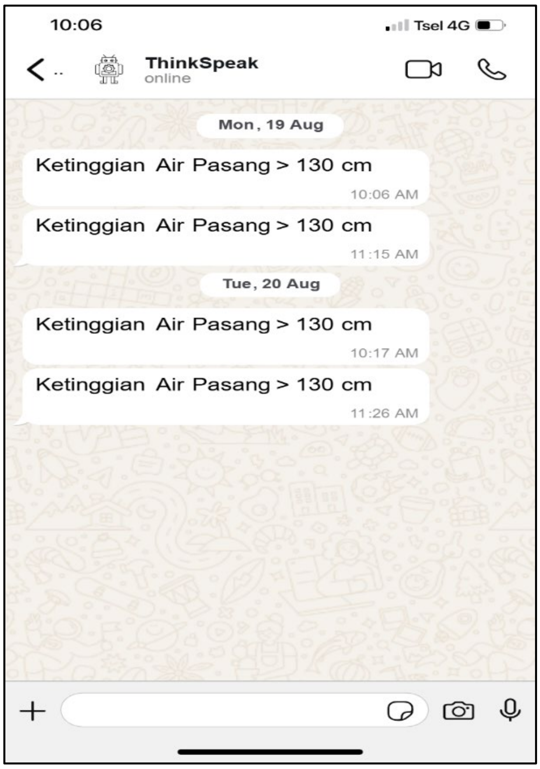
Picture. 7 Data Graph for Aug. 19 – 22

One of the factors that can affect the performance of the HC-SR04 sensor is weather changes. According to weather data from bmkg.go.id, on August 19-21, 2024 at 16.00-21.00 WIB, the air temperature in the Kurnia My Darling Beach area is in the range of 27.2-26.4°C with an air humidity value in the range of 87-94%. The temperature in the system affects how quickly or slowly sound waves travel through the air (F. F. Haryani, 2016). Therefore, changes in the level of signal strength that the sensor sends and receives can affect the accuracy of distance measurements. Humidity also affects the performance of the HC-SR04 sensor. Changes in humidity have more effect on the performance of ultrasonic sensors. Sensor accuracy will decrease if the humidity conditions are high which is more than 90% (Luomala & Hakala, 2015). The high average error value is also caused by the fact that the data from the IoT-based sea level monitoring instrument is not uploaded properly, which means that there is some data lost in the study using the HC-SR04 sensor. In addition to natural factors, internet network disruptions also affect the performance of IoT-based sea level monitoring devices. The location of the device has an unstable internet connection or data that causes the data to not be uploaded continuously. Internet connections based on GSM networks in these areas are still difficult or often down. This can lead to degradation of network quality or even connection failure.

The HC-SR04 sensor works on the principle of wave reflection, but sometimes the reflected waves produced are not suitable, resulting in less than optimal measurement results, so when installing the sensor, the position of the sensor must be considered so that the reflected waves produced are accurate (Yakob et al., 2019). To detect the presence of an object, ultrasonic waves are reflected on the object. Because the material properties of a material have different levels of ultrasonic wave reflection, the resulting reflection will result in a different number of pulses received by the sensor (F. F. Haryani, 2016). This error value can be understood because the test is carried out in the field so that there are natural factors that can interfere such as waves or water waves as well as the presence of household waste that passes through and hits the sensor.

In addition, the use of breadboards for electronic circuits has some limitations, such as the nature of impermanent circuits, allowing for circuits that are not properly connected. The use of too many jumper wires can also affect the readings because the jumper wires have resistance to the material. Furthermore, faults in electronic circuits are caused by electromagnetic radiation from other adjacent circuit elements, power supply cables, loose connections, and so on. Therefore, it is recommended to assemble electronic circuits using PCBs. The circuit is assembled directly on the PCB to reduce errors generated when using the breadboard. PCBs have a much better ability to support current flow compared to breadboards. This is because the path on the PCB is wider so that it can carry more current. On the other hand, a breadboard can only channel less current capacity to the circuit because its components are connected using jumper wires. PCBs are capable of supporting and connecting circuits mechanically as well as electrically, while breadboards only support mechanically (Yahya & Ihlas, 2020).

The design of the IoT-based sea level monitoring tool that has been developed is also equipped with notifications. When the sea level exceeds 130 cm, the tool will automatically send a notification notification via WhatsApp as seen in figure 8. The sensor in this tool can detect changes in sea level, thus providing a warning that the water level has passed the height of mangrove seedlings. Thus, preventive measures can be taken immediately by planting taller mangrove seedlings. The existence of this tool can help a little in anticipating changes in sea level.



Picture. 8 Notifications on Whatsapp

Data obtained through the internet network often experiences delays in transmission. This is due to the dependence on the internet network via GSM which is not strong enough, so there is data that is recorded late. To ensure that the measuring instrument can measure sea level and transmit data in a timely manner, it is necessary to ensure that the internet connection is in a stable condition so that there are no obstacles in data transmission.

The Internet of Things Based Tide Monitoring System at Kurnia My Darling Beach using NodeMCU ESP32 and HC-SR04 sensor was successfully created and could function properly, and the data obtained was transmitted via the internet network to the ThingSpeak website with a notification to Whatsapp. In this experiment, the tool was used to measure the water level in a range above 130 cm. In order for the device to measure altitude and send data in real time properly, the internet connection must be ensured to be in stable condition. The monitoring of high tides is related to the planting of mangrove seedlings which are deliberately made for the preservation of the Kurnia My Darling Beach area in Kota Pari Village. In the future, mangrove preservation can be used for tourism in the village, not only for environmental conservation (Rizal et al., 2024). So that on a large scale it increases the number of visitors to Pari City Village (Ritonga et al., 2022)

4. CONCLUSION

This tool is designed for the Internet of Things Based Tidal Monitoring System at Kurnia My Darling Beach which is connected to the ThingSpeak website. This system is able to send notifications if the sea level exceeds 130 cm through the WhatsApp application. In addition, this system can also work continuously and can be connected to various electronic devices such as computers, laptops, and smartphones, making it more practical and easy to use. The main components of this tidal monitoring system include water sensors to measure water level height, NodeMCU communication modules to send data to servers, and notification systems that will provide a signal when the water level has exceeded a specified level.

The results of the 72-hour test of the sea level monitoring device showed that the waveform of the water level was almost similar, although there were some data with significant value differences. This can be caused by various factors, such as the influence of the weather, internet network, use of breadboards, sensor position, as well as the possibility of waves or water waves that exceed the measurement range and objects such as household waste that hit the sensor**.**

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