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Design of Tidal Height Monitoring Equipment Based on the Internet of Things For the Preservation of Mangroves at Kurnia My Darling Beach

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Abstract — **This study discusses the design of an Internet of Things (IoT)-based tidal height monitoring system applied to support the sustainability of mangrove ecosystems in the Kurnia My Darling Beach area. The tides of sea water are a critical factor that affects the growth and survival of mangrove plants. The monitoring system is designed using the Hc-Sr04 ultrasonic sensor to measure the water level in real-time, with data transmitted via the Nodemcu Esp8266 for remote monitoring. The methods used in the design include the needs analysis stage, system design, implementation, and testing. The test results show that the system can provide accurate data on sea level fluctuations with an error rate of less than 5%. The information produced can be used to optimize the management and conservation of mangrove ecosystems in the area. This system is expected to support mangrove conservation efforts by providing accurate and real-time data for better decision-making in mangrove area management.**

Keywords: Internet of Things, Sea tide monitoring, mangrove conservation

I. INTRODUCTION

Mangrove forests are an important component of coastal ecosystems that provide many ecological and economic benefits. However, mangroves in coastal areas often face threats from human activities and the impacts of climate change [1]. One of the efforts that can be made to preserve mangroves is to monitor the tidal dynamics of seawater around the ecosystem [2].

This study aims to design an Internet of Things based monitoring tool for tidal height to support mangrove conservation at Kurnia My Darling Beach. The Internet of Things (IoT) is a combination in a network connected to a machine, or other device that sends and receives data through a network connection. The Internet of Things (IoT) is a technology that connects to the internet, allowing for automated data exchange to execute specific commands[3]. This monitoring tool is designed to be able to collect and transmit real-time sea level data, so that it can help related parties in analyzing and planning appropriate mangrove conservation actions [4]. This study will consider several limitations of the problem, one of which is the use of ultrasonic sensors that are used as distance sensors[5] and the need for a tool that detects by sending data online with today's technology, namely the Internet of Things (IoT) so that information centers can transmit data accurately [6]

The research methodology used in this study is an experimental approach to design and test monitoring tools, as well as field studies to obtain tidal characteristics data at the study site. Based on the results of measurements with the designed tool, it is known that the tidal range in the Kurnia My Darling Beach mangrove ecosystem reaches 1.5. The tidal type in this location is a double daily mixture influenced by estuary geometry [1]

The application of the Internet of Things on this sea level monitoring tool allows real-time data collection and remote monitoring, making it easier to analyze the latest tidal patterns and their impact on mangrove ecosystems [7]. This 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 [7]. The designed system is still at the design stage and the simulation has not yet reached the implementation stage so there are no laboratory experiment results [8]

The information can be used as input in the preparation of more effective mangrove management and conservation strategies to improve mangrove conservation efforts in the region and ensure the sustainability of the mangrove ecosystem in the future.[9]

II. LITERATURE REVIEW

a. Mangrove Ecosystem Mangrove is an ecosystem that grows in coastal areas, especially in areas protected from large waves and strong tidal currents. Mangroves have unique adaptability to extreme environmental conditions such as high salt content, muddy sediments, and varying periods of seawater inundation[10]. The sustainability of mangrove ecosystems is highly dependent on tidal dynamics that affect nutrient distribution and salinity levels[11].
b. Tidal Sea Water Tidal waves are a phenomenon of rising and falling sea levels that are influenced by the gravitational force of the moon and the sun. Classification of four types of tides, namely diurnal, semi-diurnal, diurnal inclined mixture, and semi-diurnal inclined mixture[12]. Understanding tidal patterns is essential in the management of coastal ecosystems, including mangroves.
c. Internet of Things (IoT) The Internet of Things is a concept that allows various devices to connect to each other and exchange data over the internet. [13] defines IoT as a global network infrastructure that connects

physical and virtual objects through the exploitation of data capture and communication capabilities. In the context of environmental monitoring, it is explained that IoT can provide real-time data that is accurate and accessible from anywhere.

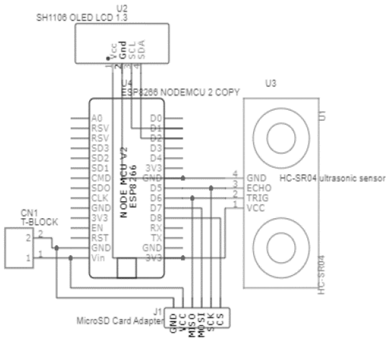
d. IoT-Based Monitoring System The development of IoT-based monitoring systems has been widely applied in various environmental fields. The research conducted shows the effectiveness of the use of ultrasonic sensors and microcontrollers in water level monitoring[14]. Meanwhile, [15] successfully developed an IoT-based water quality monitoring system that can provide data in real-time with a high level of accuracy.
e. Sensor Technology for Water Level Monitoring In water level measurement, various types of sensors have been developed. Demonstration of the use of the HC-SR04 ultrasonic sensor which has a high level of accuracy and low operating costs[16]. The combination of sensors with microcontrollers such as NodeMCU ESP8266 allows wireless transmission of data to a database that can be accessed online [17]).
f. Modern IoT Platform Data Processing and Visualization Systems have undergone significant developments in data processing and visualization capabilities. The integration of IoT platforms with cloud computing enables more complex data analysis and long-term data storage[18]. Real-time data visualization through interactive dashboards can improve monitoring and decision-making effectiveness[19].
g. Application of IoT in Environmental Conservation The use of IoT in environmental conservation efforts shows significant development. Recent research proves that IoT-based monitoring systems can increase decision-making accuracy in conservation area management by up to 85%[20]. Sharma and Kumar also reported on the successful implementation of IoT monitoring systems in the preservation of mangrove ecosystems in various coastal areas[21]

III. RESEARCH METHODOLOGY

The research was conducted using an experimental method. The stages of this research are six stages of research, namely:

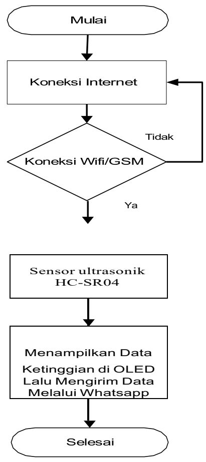
- Literature study on theories related to research on the manufacture of water level detection devices;
- Hardware design, including level sensor circuit design, microcontroller system circuit,
- Designing applications that are in accordance with the provisions of water level levels.
- Test and evaluate the tools that have been created
- Make a report on the results of the research from data collection and data processing and analysis.

Literature studies are carried out by reading journals, papers or books related to this research. This research was carried out at Kurnia My Darling Beach, Kota Pari Village, Pantai Cermin District, Serdang Bedagai Regency, North Sumatra Province. At the design stage, it is divided into two, namely hardware design and software design. In designing the hardware is carried out by determining the components to be used, some of the tools used are the NodeMCU ESP32 microcontroller, the HC-SR04 ultrasonic sensor, OLED, laptop, meter, and an 850 mAh Li-Po battery which has a voltage of 7.4 volts. This hardware can also transmit data automatically and in real-time



Picture. 1 Hardware Network Schematic

Then using the Thinkspeak application, a measuring device and sending tidal data will be designed and implemented. After being uploaded to the NodeMCU ESP8266 and the HC-SR04 sensor gets water level data, the microcontroller will look for a connection to the internet network to be connected to the WhatsApp application as a notification of warning information directly and quickly so that the measurement result data will be displayed automatically.

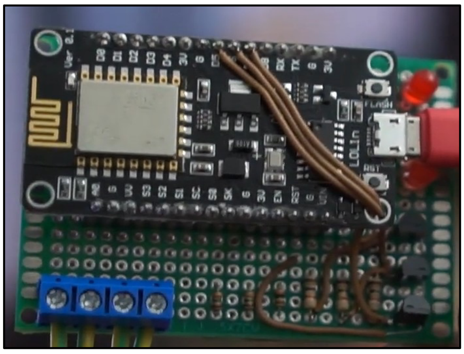


Picture. 2 Flowchart App

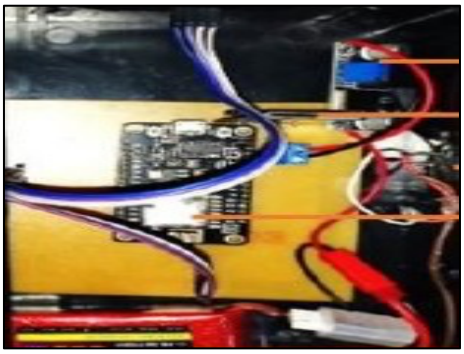
This tool produces data in the form of water level in cm from the water surface. The placement of the device is carried out in a place that is not directly affected by waves. The tools made are placed in the mangrove seedling planting area in an upright position so as not to be exposed to the waves directly. Data collection was carried out on August 17-18, 2024 because there will be a full moon and the highest tide will occur. The material used for this study is seawater in the tidal process. The research variable used in this study is the height of the sensor placement location, which is 2 meters from the LWL reference. The time of data collection as a manipulation variable is once every five minutes for 3 days. In the next step is system testing, it is very important to know if the designed tool is suitable and working properly. This is done by comparing the results of the appliance with the installed meter. If the results are not suitable, then further improvement is needed. If the results match, then data retrieval can begin.

IV. RESULT

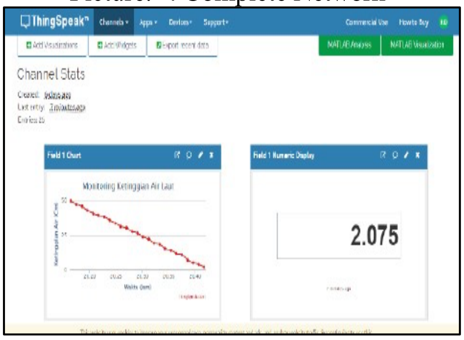
This seawater tide monitoring device is placed on a 20 x 30 cm panel box. Measurement data is displayed on the OLED and ThingSpeak web, as shown in Figures 3, 4 and 5.



Picture. 3 NodeMCU Network ESP8266



Picture. 4 Complete Network



Picture. 5 ThingSpeak app view

The data from the water level measurement will be displayed on OLED and ThingSpeak in cm from the water surface and will be forwarded to WhatsApp for real-time reporting.

Picture. 6 Thinkspeak Display on Smartphone

In this study, data was taken using a simple prototype using a water bath with a depth of 50 cm, data was taken with a time span of 1 minute with a height manipulation of 2 cm, which was then compared with a bar measuring instrument so that data was obtained on the table.

Table. 1 Monitoring tool test result data
The tides of sea water

Water Height on Meter (cm)	Height of Water on the Tool (cm)	Error (%)
50	49,855	0,290
48	47,283	1,494
46	45,911	0,193
44	44,126	0,286
42	43,369	0,878
40	39,585	1,037
38	38,313	0,824
36	35,998	0,005
34	33,665	0,985
32	31,316	2,137
30	30,206	0,687
28	27,766	0,836
26	26,600	2,306
24	23,718	1,175
22	22,244	1,109
20	19,662	1,690
18	17,713	1,594
16	15,747	1,581
14	14,286	2,042
12	12,022	0,183
10	10,204	2,040
8	7,837	2,037
6	5,900	1,667
4	4,030	0,750
2	2,075	3,750
Err Rata - Rita		1,263

Table 1 shows that this tool can well measure water levels in a height range of up to fifty centimeters. As indicated by the HC-SR04 sensor specification, this tool can measure distances ranging from two centimeters to forty centimeters with a range accuracy of three millimeters and the lowest error value of 0.005% and the highest error of 3.75% with an average delay interval of 1.263%. From the error values obtained, some results due to the high sensitivity of the sensor, the results of measuring the height of the tool with the bar may vary. The best sensors are placed in a stable place and with an angle of 150 cm. The data obtained will be transmitted to ThingSpeak via the internet network with the recorded data, with a delay interval of 15-19 seconds, relying on WiFi to send data to thingspeak. When conducting research, the measurement data will be displayed on ThingSpeak. In order for the tool to measure altitude and send data in real-time properly, the internet connection must be ensured to be in a stable condition so that there are no obstacles in sending data.

V. DISCUSSION

The seawater tide monitoring device designed with NodeMCU ESP8266 and HC-SR04 sensor was successfully made and worked well. The collected data is sent to ThingSpeak over the internet with a delay of 15 seconds. In this experiment, this tool was used to measure the water level in the range from 2 to 50 cm with a height manipulation of 2 cm. The average error value of the device is 1.263% recorded on the tidal monitor of sea water. In order for the device to measure altitude well and send data in real time, the internet connection must be stable.

REFERENCES

[1] N. R. Prasetiawan *et al.*, "PUMMA (Cheap Measuring Device for Water Level) performance for water level monitoring of mangrove ecosystem in Pangandaran," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 925, no. 1, 2021, doi: 10.1088/1755-1315/925/1/012060.

[2] D. Akbar, Mariani, W. E. Yudiatmaja, and Edison, “Governance of mangrove restoration and conservation to climate change resilience in Bintan Island,” IOP Conf. Ser. Earth Environ. Sci., vol. 824, no. 1, 2021, doi: 10.1088/1755-1315/824/1/012048.

[3] W. Erika, A. R. Firmansyah, and M. R. Sukri, “Design and Building of an Automated Lighting Control System for Rooms Based on Internet of Things (IoT),” *J. Inf. Technol. Comput. Sci. Electr. Eng.*, vol. 1, no. 3, pp. 96–99, 2024.

[4] P. Yushananta, G. C. Putri, S. Widyawati, and A. P. Sari, "Application of Internet of Things Based Water Physical Quality Monitoring System on PDAM," Link, vol. 18, no. 1, pp. 22–28, 2022, doi:10.31983/link.v18i1.8379.

[5] M. Amin and M. S. Novelan, "Intelligent System of Water Faucet Control Using Arduino Microcontroller and Ultrasonic Sensor," J. Nas. Technol. and Jar., vol. 4, no. 2, 2020.

[6] M. S. Novela, R. S. Hardinata, and R. P. N. Dwi, "Design of Flood Detection System Using Ultrasonic Sensors and Nodemcu," in Proceedings of the National Seminar on Social, Humanities, and Technology, 2022, pp. 32–38.

[7] H. Hanifadinna, "Design of Water Level Monitoring on Raw Water Tank with Nodemcu-Based Ultrasonic Sensor in Sungai Kupang Mill," J. Vocational Technol. Ind., vol. 4, no. 2, pp. 01–08, 2022, doi: 10.36870/jvti.v4i2.304.

[8] H. Herdianto, S. Efendi, and H. Hafni, "Design and Build an Internet of Things-Based Lake Water Quality Data Monitoring and Acquisition System," in *Proceedings of the National Seminar on Information Science Research (SENARIS)*, 2022, pp. 36–44.

[9] R. S. Hardinata, W. Fitriani, N. Mayasari, H. Kurniawan, L. F. Ayu, and E. Hariyanto, "DESIGNING ROOM DOORS USING ANDROID-BASED INTERNET OF THINGS (IOT)," Publisher of Tahta Media, 2023.

[10] Rahman et al., “Mangrove ecosystems in Southeast Asia region: Mangrove extent, blue carbon potential and CO2 emissions in 1996–2020,” *Sci. Total Environ.*, vol. 915, p. 170052, 2024, doi: https://doi.org/10.1016/j.scitotenv.2024.170052.

[11] D. A. Friess et al., “Mangroves give cause for conservation optimism, for now.,” Feb. 2020, England. doi: 10.1016/j.cub.2019.12.054.

[12] Y. Mei, F. Jing, Q. Lu, and B. Guo, “Experimental study on power characteristics of a horizontal-axis tidal turbine under pitch motion,” Ocean Eng., vol. 307, p. 118184, 2024, doi: https://doi.org/10.1016/j.oceaneng.2024.118184.

[13] Y. Khan, M. Su’ud, M. Alam, S. Ahmad, A. (Ayassrah), and N. Khan, “Application of Internet of Things (IoT) in Sustainable Supply Chain Management,” Sustainability, vol. 15, p. 694, 2022, doi: 10.3390/SU15010694.

[14] M. M. Rahman, N. Alam, S. Ullah, and M. Rahman, “The Prospects and Challenges of Internet of Things (IoT)-based Public Healthcare System in Bangladesh,” BUFT J. Bus. Econ., Vol. 5, 2024, Doi: 10.58481/BJebe/2403.

[15] M. Kumar, T. Singh, M. Maurya, A. Shivhare, A. Raut, and P. K. Singh, “Quality Assessment and Monitoring of River Water Using IoT Infrastructure,” *IEEE Internet Things J.*, Vol. Pp., P. 1, 2023, Doi: 10.1109/Geot.2023.3238123.

[16] S. Chen, H. Xu, D. Liu, B. Hu, and H. Wang, “A Vision of IoT: Applications, Challenges, and Opportunities With China Perspective,” IEEE Internet Things J., vol. Volume: 1, p. Page(s): 349-359, 2014.

[17] Z. Wang, J. Li, S. Yang, X. Luo, D. Li, and S. Mahmoodi, “A lightweight IoT intrusion detection model based on improved BERT-of-Theseus,” Expert Syst. Appl., vol. 238, p. 122045, 2024, doi: https://doi.org/10.1016/j.eswa.2023.122045.

[18] D. B. Patel, R. Tripathi, and N. Goel, “IoT an Overview: Advantage, Disadvantage and Applications,” Int. J. Comput. Appl. Technol. Res., vol. 10, pp. 119–122, 2021, doi: 10.7753/IJCATR1005.1003.

[19] I. Rodríguez-Rodríguez, M. Campo-Valera, J. V. Rodríguez, and A. Frisa-Rubio, "Constrained IoT-Based Machine Learning for Accurate Glycemia Forecasting in Type 1 Diabetes Patients," *Sensors*, vol. 23, no. 7, 2023, doi: 10.3390/s23073665.

[20] I. Martínez Ruiz, "Is IoT monitoring key to improve building energy efficiency? Case study of a smart campus in Spain," 2024. doi: 10.31224/3524.

[21] A. Sharma, P. Gogoi, S. Kumar, and A. Mohan, "Revolutionizing Home Automation with Iot: An Arduino-Based System for Enhanced Control," SSRN Electron*. J.*, pp. 1–6, 2024, doi: 10.2139/ssrn.4485336.