Design of internet of things (IoT) based website for quality monitoring of home organic compost

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ABSTRACT

Waste is the residual product of human use that is often simply discarded and piled up, including organic household waste. The decomposition of organic waste causes unpleasant odors, environmental pollution, and becomes a breeding ground for disease-carrying animals. Therefore, composting is a necessary method that can be applied in households to manage organic waste with the aim of reducing and transforming it into beneficial products. In this modern era, a more efficient composting tool is needed, utilizing the Internet of Things (IoT) to monitor the composting process in real-time to produce compost that meets the Indonesian National Standard 19-7030-2004. This compost quality monitoring can be conducted both locally and remotely through a website integrated with the NodeMCU ESP32 microcontroller, which is connected to a Wi-Fi network to transmit data in real-time to a MySQL database for storage and management. Website testing at Wi-Fi distances of 5 meters and 10 meters from the device resulted in average response times of 31.943 ms and 31.444 ms, respectively, indicating that the website receives information with very good speed. 99.33% of all respondents agreed that the website met the friendly criteria in terms of both color and layout.

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1. INTRODUCTION

Waste in Indonesia is often simply discarded and piled up, particularly organic household waste, which has a high moisture content and quickly decomposes, producing unpleasant odors. Organic waste, such as leftover fruits and vegetables, can cause environmental pollution and become a breeding ground for disease-carrying animals when it decomposes. So far, waste has only been moved from the source to the final disposal site. Given this situation, it is necessary to start processing organic waste at the household level to convert it into more beneficial materials. One way to utilize this waste is through composting. Composting is the process of breaking down organic material into nutrient-rich compost that is beneficial for soil fertility. The production of compost fertilizer is generally still done manually, which requires a lot of energy. The composting process takes a considerable amount of time, around 2-3 months, until the compost is fully matured. Monitoring the maturity level of the compost is also done directly by visiting the composting site.

In this modern era, more efficient composting tools are needed by utilizing the Internet of Things (IoT) to make it easier to monitor the composting process in order to get better composting coolies. Compost quality standards can be said to be ideal if they meet the criteria standards as in SNI 19-7030-2004[1]. Some important parameters that must be considered such as temperature ranges from 35 C – 45 C, humidity ranges from 40% to 60%, good compost color generally has a dark chocolate or blackish color, a good compost smell is also not pungent but tends to smell the soil where the methane gas content is around 50% to 70% and the important parameter to pay attention to is the soil pH, which ranges from 6.8 to 7.49. If the compost meets these specifications, it can be said that the compost is feasible and good to use as a fertilizer to increase soil fertility. Thus, it is necessary to monitor the quality of compost by utilizing IoT monitored through the website will greatly help create maximum compost and can overcome the problem of household organic waste.

This research creates a composting product that is integrated with IoT where an object is equipped with technology such as sensors and software connected via the internet to exchange information. IoT works by using programming instructions that allow each command to automatically generate interactions between devices in both close and long distances[2]. This product has several sensors, namely the DHT22 sensor to measure air temperature and humidity, the MQ4 sensor to measure methane gas, the Soil pH sensor to detect pH levels, and the water level sensor to measure the level of liquid compost. The sensor has a number that will change according to the condition of the compost it detects. Therefore, a website is needed to monitor changes in temperature parameters, air and soil humidity, methane gas, soil pH and water level every day until it meets SNI standards. The website itself is a collection of information sharing displays that can be accessed online in the form of text, images, videos and other visuals[3]. Websites are often used for various purposes such as means of communication, finding sources of information, business platforms, entertainment and others.

Then to manage the data sent by the sensor, a reservoir is needed, namely a database. A database is a set of data in the form of a representation of tables that are managed in such a way and interrelated to make it easier for each user to find, store and delete information. In this study, a MySQL database is used to store and manage data and PhpMyAdmin as a tool to facilitate the operation of MySQL databases[4]. Integration between IoT, website and database creates an efficient system and makes it easy to monitor compost at various locations.

2. METHOD

2.1. Design System

The following is the system design that is generally used in this study.

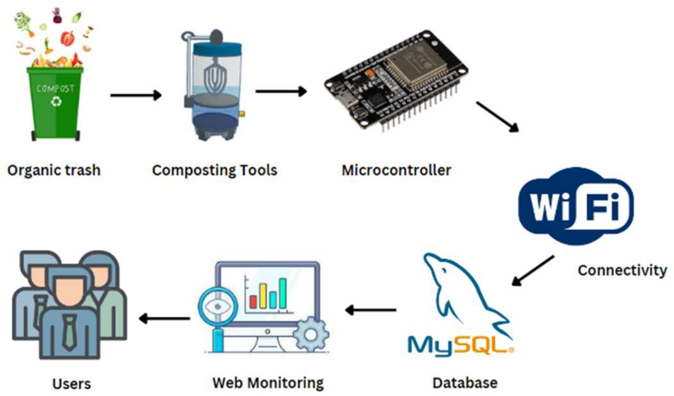

Figure 1 System Design

The overall working process of the system, as shown in Figure 1 above, begins with the insertion of organic waste, such as leaves or food scraps, into the composting device. This composting device is equipped with several sensors that detect predefined parameters such as temperature, soil moisture, methane gas, liquid compost water level, and soil pH contained within the device. The NodeMCU, acting as the microcontroller, collects data from the integrated sensors, including DHT22, soil moisture, MQ-4, water level sensor, and soil pH sensor. The data collected is processed by the NodeMCU through a Wi-Fi connection, enabling real-time data transfer from the composting device to the database. The data received from the NodeMCU is then stored in a MySQL database, covering all the parameters monitored by the sensors in the composting device. Subsequently, the data from the MySQL database is displayed on the monitoring website, allowing users to track the parameter values of the composting process. In this study, the author's focus is solely on the software.

2.2. Composting System

Here is a block diagram of a household-scale IoT-based composting system.

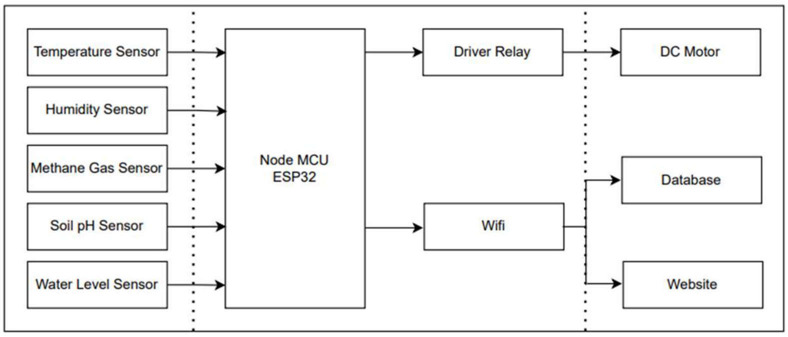

Figure 2 Composting System Blok Diagram

The overall system work can be seen in Figure 2 above, where the system will retrieve data during the composting process. The sensors are connected to the NodeMCU ESP32 to process data so that it can be sent in real-time to the website via Wi-Fi. The database and server are connected to each other to exchange information so that users can know the updated values of each of these sensors. Below are the hardware and software components that play crucial roles in the development and implementation of the system. The hardware serves as the physical foundation, providing the necessary processing power and connectivity, while the software facilitates the development, design, and functionality of the system. The following provides an overview of the hardware and software used in this study.

1. Hardware

The hardware used in this study is as follows.

a. NodeMCU ESP32
- Prosesor: Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, operating at 160 or 240 MHz.
- Memory: 520 KB SRAM.
- Wireless connectivity: Wi-Fi 802.11 b/g/n
- Working current: 80mA average
- Voltage: 2.2V – 3.6V

b. Laptop HP Pavilion 13-bb0062TU
- Processor: 11th Gen Intel Core i5-1135G7
- Memory: 8 GB DDR4
- Storage: 512 GB
- Graphics Card: Intel® Iris® Xe Graphics

2. Sofware

The software used in this study is as follows.

a. Visual Studio Code (IDE)
Visual Studio Code is a popular Integrated Development Environment for software development[5].

b. Hyper Text Markup Language (HTML)
Hyper Text Markup Language is a markup language used to create website pages and display information in internet browsers [6].

c. Framework CSS
Cascading Style Sheet is a programming language used to arrange the layout and appearance of HTML to make it more attractive[7].

d. JavaScript
JavaScript sets logic such as validation to make the website look more dynamic, execution errors occur in the browser window[8].

e. Hypertext Preprocessor (PHP)
Hypertext Preprocessor is a scripting language that is often used to create dynamic websites by inserting them directly into HTML[9].

f. Boostrap
Boostrap is a CSS framework library built for front-end website development[10].

g. XAMPP

XAMPP is a software package consisting of several open source software useful for developing and testing websites locally on personal computers. XAMPP can be run on various operating systems such as Windows, Mac OS and Linux[11].

h. MySQL
MySQL is a type of database that functions as a data storage[12].

i. PhpMyAdmin
PhpMyAdmin is used as a tool to facilitate the operation of MySQL database[12].

j. Website Hosting
Website hosting functions to turn a local website into a public so that it can be accessed online[11].

2.3. Delay Parameter Calculation

The way to find out the quality of a website is to measure the delay of the website. Delay is the time it takes for the sender to deliver a package from the time the package arrives in the system to the time it is finished being transmitted[13]. If the delay value is smaller, the quality will also be better, as can be seen in Table 1 below based on the Telecommunication and Internet Protocol Harmonization Over Network (TIPHON) standard. The delay calculation this time uses the Wireshark application. The following is the formula for calculating the delay using Wireshark.

$$\text{Delay Average} = \frac{\text{Total delay}}{\text{Total recieving package}} \quad (1)$$

Table 1 Delay Category

Latency Category	Big delay (ms)	Index
Very Good	<150 ms	4
Good	150 – 300 ms	3
Currently	300 – 450 ms	2
Bad	>450 ms	1

2.4. Alpha Testing

Alpha is the first letter in the Greek alphabet. Alpha testing is so named because it is the first phase of testing conducted after the software has been developed but is not yet ready for public release[14]. Alpha testing is used to identify bugs and ensure that all components of the website are functioning correctly. The author conducted testing by evaluating the functionality of each button and observing the sensor parameter values that fluctuate every few seconds as predetermined.

2.5. Beta Testing

Beta is the second letter in the Greek alphabet. Beta testing is so named because it is the second phase of testing conducted after the software has passed alpha testing and is considered stable enough to be tested by external users[14]. Beta testing is used to gather feedback from respondents who have accessed the website, providing valuable insights into their satisfaction with the website.

2.6. Flowchart Website

The flowchart in Figure 3 above illustrates the website design process. When the NodeMCU ESP32 sends data to the database, the program performs a check. If the specifications fall below the set thresholds temperature < 30°C, humidity < 40%, methane gas < 50%, soil pH < 6.8, and water level < 10 cm, the parameter values on the website will be displayed in yellow. If the specifications meet the set values temperature 35-45°C, humidity 40-60%, methane gas 50-60%, soil pH 6.8-7.49, and water level 10 cm, the parameter values on the website will be displayed in blue. If the specifications exceed the set thresholds temperature > 70°C, humidity > 60%, methane gas > 70%, soil pH > 7.49, and water level > 10 cm, the parameter values on the website will be displayed in red. The data displayed on the dashboard represents real-time values sent from the server connected to the database.

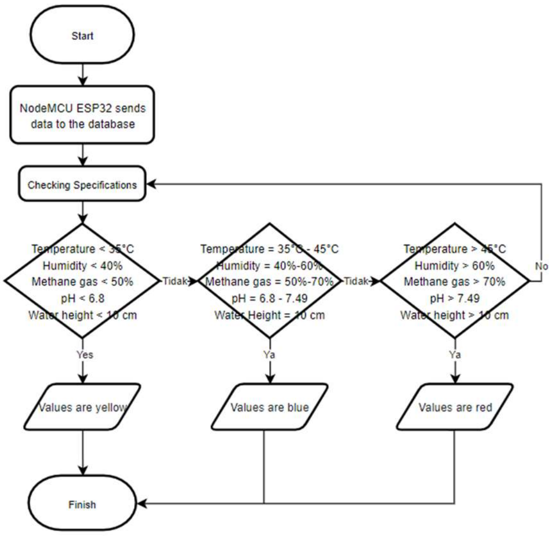

Figure 3 Flowchart Website

2.7. Layout Planning

In the process of creating website pages, the author uses Bootstrap to provide a more attractive layout. The website below has been hosted on the internet along with its database so that it can be accessed by other devices.

a. Login

The flow of users in accessing the website is to authenticate the account on the login page first before using the monitoring feature on the website. The login page display is as follows.

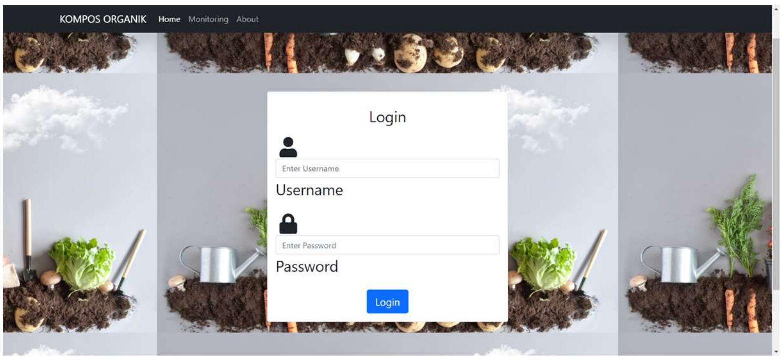

Figure 4 Login Display

Figure 4 above shows the website login display, where if you enter the appropriate username and password, the login will be successful. However, if you enter a username and password that is different from the one that has been predetermined, the login will fail.

b. Home

After successfully logging in, you will be directed to the home page. Where on this page users can use every feature on the composer website.

Figure 5 Home Display

Figure 5 above shows the main view of the website which contains the home, monitoring and about menus. The home display will be integrated on the main page, then if you press the monitoring menu, it will be directed to the monitoring information display, while the about menu will be directed to the display containing detailed information about compost specifications. Then if you click the logout button, you will be directed to the login menu. This main display also has a monitoring check button which will also be directed to the monitoring information display if clicked.

c. Monitoring

The monitoring page of the website is used to make it easier for users to monitor the quality of compost.

Figure 1 Monitoring Menu

Figure 6 above shows a monitoring display that contains information about the values of compost processing, for example such as temperature, humidity, methane gas, soil pH, and liquid compost water. If the parameters have not been met, the value will be blue, but if the parameters have been met, the value will be red.

d. Information

The information page on this website is useful for finding out parameters related to the quality of compost.

Figure 2 Information Display

Figure 7 above is a compost information display that contains information about compost parameters, namely temperature, humidity, compost color, methane gas, and soil pH so that users can also know the important things about compost processing.

3. RESULTS AND DISCUSSION

3.1 Delay Testing

This delay test aims to determine the quality of the network and analyze the time it takes to transmit and receive data between the device and the server.

Table 2 Delay with a Wi-Fi distance of 5m

Testing phase	Delay (ms)
1	35,296
2	26,821
3	36,660
4	37,007
5	23,931
Average	31,943

From the results of Table 2 above, it shows that the average delay is 31.943ms, this number is included in the category of very good delays.

Table 3 Delay with a Wi-Fi distance of 10m

Testing phase	Delay (ms)
1	28,795
2	32,361
3	34,682
4	31,974
5	29,408
Average	31,444

From the results of Table 3 above, it shows that the average delay is 31.444 ms, this number is included in the category of very good delay.

3.2 Alpha Testing

Here are the results of the alpha tests that have been carried out.

Table 4 Alpha Testing

No	Testing	Test Case	Expected Result	Status
1	Go to the website page	Accessing website links	Displaying a login page	Yes
2	View the home page	Enter your username and password	Successfully logged in	Yes
3	View the monitoring page	Click the monitoring button	Successfully view the monitoring page	Yes
4	View the compost information page	Click the About button	Successfully viewed the compost information page	Yes
5	Return to the home menu	Click the home button	Successfully return to the home page	Yes
6	Log out of the home page	Click the logout button	Successfully exit the home page	Yes

From the results of Table 4 of the test above, the test has met the criteria and is in accordance with expectations, so it can be concluded that all components are running well.

3.3 Beta Testing

The following are the results of beta testing that has been carried out with 50 respondents and 6 questions.

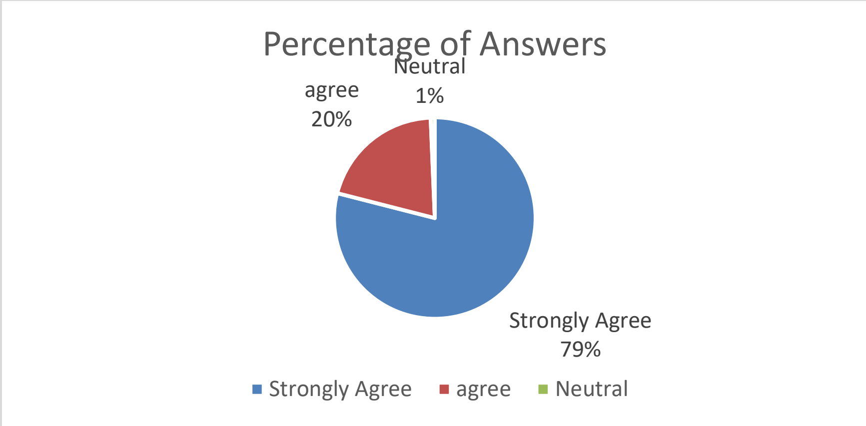

Figure 8 Beta Testing Percentage

In Figure 8 above, it can be seen that the percentage of answers is strongly agreed at 79%, then agreed by 20% and neutral by 1%.

Table 5 Beta Testing

No	Question	Strongly Agree	Agree	Neutral
1	Is the website attractive (user friendly)	80%	20%	-
2	Does the website look make it easier for users to monitor the composting process	74%	26%	-
3	Is the website easy to operate?	76%	24%	-
4	Does the display of information on the website make it easier for users to know the quality of the compost	82%	16%	2%
5	Does color marking on the monitoring result values help users identify specifications met/not?	76%	22%	2%
6	Is the operation on the website easy to remember?	86%	14%	-
	Average	79%	20.33%	0.66%

From the results of Table 5 above, an average percentage of 99.33% of all respondents agreed that this website has met the criteria of friendliness both in terms of color and layout. From the research can be concluded that the display of the composter website makes it easier for users to monitor the process during composting.

4. CONCLUSION

This study resulted in a website that allows real-time monitoring of the composting process from anywhere using a device, eliminating the need for periodic checks at the composting site. The website functions as expected and operates efficiently. Based on delay testing, the average delay was 31.943 ms at a Wi-Fi distance of 5 meters and 31.444 ms at 10 meters, both of which meet the Telecommunication and Internet Protocol Harmonization Over Network (TIPHON) standard of very good, being under 150 ms. The difference in delay is attributed to interference from various sources, such as walls and other equipment. Additionally, Wi-Fi signal quality diminishes as the distance between the NodeMCU ESP32 and the router increases. Furthermore, alpha testing concluded that each function of the website performs well, and beta testing revealed that 99.33% of respondents agreed that the website facilitates the monitoring of compost quality effectively.

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REFERENCES

[1] “Standar Nasional Indonesia Spesifikasi kompos dari sampah organik domestik Badan Standardisasi Nasional.”

[2] F. Susanto, N. Komang Prasiani, and P. Darmawan, “Implementasi Internet of Things dalam Kehidupan Sehari-hari,” Online, Apr. 2022.

[3] N. S. Aziz, N. S. Sulaiman, W. N. I. T. M. Hassan, N. L. Zakaria, and A. Yaacob, “A Review of Website Measurement for Website Usability Evaluation,” in *Journal of Physics: Conference Series*, IOP Publishing Ltd, Jun. 2021. doi: 10.1088/1742-6596/1874/1/012045.

[4] U. Siregar, T. Sitakar, and S. Haramain, “Pengembangan database Management system menggunakan My SQL,” *SAINTEK: Jurnal Sains, Teknologi & Komputer*, vol. 1, no. 1, pp. 8–12, Jan. 2024.

[5] A. Farras, A. Diharja, and A. Fanrian, “Pelatihan HTML Dan CSS Dasar Menggunakan Visual Studio Code Di SMK Setia Bhakti,” *APPA: Jurnal Pengabdian kepada Masyarakat*, vol. 1, no. 4, pp. 200–204, Dec. 2023.

[6] M. Tabrani, H. Priyandaru, and Suhardi, “Sistem Informasi Manajemen Berbasis Website pada UNL Studio dengan Menggunakan Framework Codeigniter,” Jan. 2021.

[7] F. Rifandi, Adriansyah Tri Viqi, and Kurniawati Rina, “Website Gallery Development Using Tailwind CSS Framework,” 2022.

[8] Hardianto, R. Rosnelly, L. Wahyuni, and G. M. Anggraini, “Impelemtasi Javacript dalam Pembuatan Web Sederhana,” *CORAL (Community Service Journal)*, vol. 2, no. 1, pp. 116–123, 2022.

[9] A. Yudha and M. Elfatiha, “Sistem Informasi Penjadwalan Ruang Kelas Perkuliahan Bebasis Web Menggunakan Waterfall Model pada Institut Bisnis Muhammadiyah Bekasi,” *Jupiter: Journal of Computer & Information Technology*, vol. 2, no. 2, pp. 2998–3129, Aug. 2021.

[10] J. Mawansyah, L. Mulyadi, S. Hidayat, and W. Maranatha, “Build a Construction Management Application Based on PHP, JavaScript, CSS, MySQL, and Bootstrap,” 2020.

[11] A. E. Yanuar and M. A. Senubekti, “Perancangan Aplikasi Penjualan Online Berbasis Website (Studi Kasus : Bakso Emsa),” *Jurnal Nuansa Informatika*, vol. 16, no. 1, Jan. 2022, [Online]. Available: https://journal.uniku.ac.id/index.php/ilkom

[12] R. Fajar Ramadhani and R. Mukhaiyar, “Penggunaan Database Mysql dengan Interface PhpMyAdmin sebagai Pengontrolan Smarthome Berbasis Raspberry Pi,” *Jurnal Teknik Elektro Indonesia*, vol. 1, 2020.

[13] D. Aditya Rachman, Y. Muhyidin, and M. Agus Sunandar, “Analysis Quality of Service of Internet Network Fiber to the Home Service PT. XYZ using Wireshark,” *Jurnal Informatika dan Teknik Elektro Terapan*, vol. 11, no. 3, pp. 2830–7062, Sep. 2023.

[14] T. Menora, C. H. Primasari, Y. P. Wibisono, T. A. P. Sidhi, D. B. Setyohadi, and M. Cininta, “Implementasi Pengujian Alpha dan Beta Testing pada Aplikasi Gamelan Virtual Reality,” 2023.