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Analysis and Design of Integrated Waste Disposal System Information Based on Website

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Abstract. This study aims to design a website-based information system for waste management at the Integrated Waste Processing Site (TPST) in Siwalanpanji Village, Sidoarjo Regency. This system is designed to facilitate the recording and analysis of waste data, including recycled waste and waste disposed of at the Waste Processing Site (TPS). The method used is Rapid Application Development (RAD), which includes the stages of planning needs, design, construction, and testing using Black Box Testing. The results of this study are expected to improve the efficiency of waste management and support better decision making in waste management in the village.

Keywords: Information System, Waste Management, TPST, Website, RAD, Black Box Testing, Recycling

1 Introduction

Industrial development in Indonesia has had a significant impact on waste productivity levels. Here, the issue of waste management has become very important to address immediately [1]. In Sidoarjo Regency, strategic areas such as urban, tourism, agriculture, and business have large populations, which generate a large amount of waste. However, waste management services in this regency only cover about 38% of the total waste produced. The methods used to manage waste in this area include incineration (65.7%), collection and disposal to landfills (21.2%), other techniques (4.7%), direct disposal into rivers (3.4%), collection by informal collectors for recycling (1.5%), disposal to vacant land to decompose at 1.2%, and disposal to uncovered pits at 1.2%. This data shows that there is still waste management that has the potential to damage the environment, especially since only a small portion of the total waste is managed at landfills. Most of the waste, around 78.8%, is still not managed properly. [2].

Increasing waste production puts communities at risk. Therefore, to prevent household waste from accumulating, good waste management is necessary[3]. As a result, this can cause various additional problems such as health and environmental hygiene issues[4].

Law No. 18 of 2008 concerning Waste Management defines waste as the solid remains of human activities or natural products. The issue of waste management has become a major focus of the government[5].

Waste in Indonesia is classified into two types: household waste and non-household waste, each with its own characteristics[6]. There are two waste management systems in Indonesia, the first for household waste and waste with specific characteristics. The two main categories in waste management in Indonesia are household waste and waste with specific characteristics. The government is responsible for the management of specific waste, while waste reduction and treatment efforts are its responsibility[7]. Waste management in Indonesia involves several stages, starting with sorting based on type, quantity, and characteristics. The waste is then collected and taken to a processing site to change its characteristics, composition, and volume. The final stage is the safe return of waste or residue to the environment. The central and regional governments are responsible for funding waste management through the state budget and regional budgets[8].

Independent waste sorting by each family is one of the first steps towards effective waste management. Waste can be categorized into sellable waste and disposable waste. First, efforts are made to teach people that they can sort waste independently. To increase understanding and provide inspiration for sustainable economic opportunities for sustainable, group-based, independent, and networked waste management, it is very important to hold discussions about these waste sorting methods. One way to build awareness and obtain direct economic benefits from waste is by placing waste in trash bins[9].

One form of responsibility for consumption and production is sustainable waste management. Excessive consumption will inevitably produce waste, which has an impact on the current size of landfill sites. With

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sustainable waste management, the health impacts of open burning will be reduced. Waste that can be reused and recycled can generate economic potential for communities, which can help improve their economies.

Temporary Waste Disposal Sites (TPS) can be converted into Integrated Waste Management Sites (TPST) that apply the 3R principle: Reduce, Reuse, Recycle. These TPSTs function as more effective and efficient waste management centers. Activities at the TPST include transporting waste from its source to the TPST, sorting organic and inorganic waste, composting organic waste, and selling non-organic waste for recycling[10]. In order for the TPST to operate optimally, an institution is formed to be responsible for regulating the implementation of activities, including financial aspects and bookkeeping management. With structured and sustainable management, the TPST can be a solution to overcome waste problems and preserve the environment[11].

Based on the above information, the Integrated Waste Management Facility (TPST) implements a comprehensive waste management system with a primary focus on sustainable waste reduction[12]. The TPST receives waste from various sources, sorts it, and processes it using modern, environmentally friendly technology[10]. These efforts produce useful materials such as compost and recycled products, as well as residues that are safe for the environment[13].

With the large volume of data that needs to be managed by those responsible for waste management, if the management process is carried out manually, it can cause a number of problems such as damage to data storage media, a high risk of data loss, and the need for a long time to search for historical data. This can reduce overall efficiency.[14]

Currently, information technology is undergoing rapid development. Driven by the increasing availability of high-speed internet access throughout Indonesia, this phenomenon has led to widespread changes in people's behavior, especially in theof use information technology. The use of information technology is now widespread in various sectors, including in efforts to address waste issues.

Currently, the data entry and analysis methods for waste management at the 3R TPST Sidoresik Siwalanpanji Sidoarjo Campus still use conventional methods. Therefore, systematic data recording and analysis are needed to track the journey of waste from receipt to the recycling stage or delivery to the final disposal site. This step is expected to simplify the process of recording and analyzing waste management data, which was previously done manually at the TPST 3R Sidoresik Siwalanpanji Sidoarjo Campus.

Previous research on waste management in an area has produced several approaches, such as the development of web-based application systems, Java desktop, and Android applications [4].

Based on the problems and literature studies, research was proposed to analyze and develop a design for a website-based Integrated Waste Management Information System in Siwalanpanji Village, Sidoarjo Regency[16]. The system is expected to assist the Siwalanpanji Village government in recording and analyzing centralized waste management so that it can be used as material for evaluation and decision-making support.

2 Research Method

The research method using Rapid Application Development (RAD) aims to develop systems quickly through intensive collaboration between developers and users[17]. In the context of this study, the RAD method was used to build a website-based information system for the Integrated Waste Management Site (TPST). The following is an explanation of the stages of the RAD method:

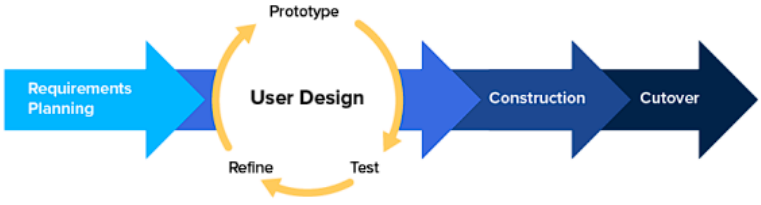

Figure 1. RAD Method Ahmad Munawir and Nurhasan Nugroho 2023

2.1 Requirements Planning

This stage involves discussions between developers and users to determine the main requirements of the system. In this study, this stage was carried out through interviews and observations at the TPST to understand the waste management process, the data required, and the problems faced by users[17].

2.2 User Design

The system was designed with short iterations, allowing for rapid changes based on user input. The use of diagrams such as Data Flow Diagrams (DFD) and Entity-Relationship Diagrams (ERD) helped illustrate the data

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flow and relationships between entities in the system[18].

2.2 Prototype Development (*Construction*)

This stage involves creating an initial prototype of the information system. The prototype is tested and evaluated directly by users (administrators and TPST officers) to ensure that the system functions meet their needs. The login page, dashboard, and features such as inputting incoming and outgoing waste data are part of the prototype.

2.3 Testing and Integration (*Custover*)

The system is thoroughly tested to ensure its functionality meets requirements. If deficiencies are found, revisions are made quickly. This stage ensures the integration of system components runs smoothly.

Once the system is complete and approved by users, it is implemented in the work environment. Maintenance continues by updating the system based on new requirements or user input.

This method is suitable for projects such as website-based waste management because it allows for the development of a system that is specifically tailored to the needs of TPST.

3 Results and Discussion

3.1 Requirements Design

The requirements design phase is the first step in developing a system using the Rapid Application Development (RAD) approach. At this stage, the focus is primarily on activities aimed at determining, recording, and validating system requirements for the smooth development of the desired system. The activities carried out at this stage are described below:

A. Identifying Requirements
   a. Identifying business and technical requirements caused by problems at the Integrated Waste Management Facility (TPST) in Siwalanpanji Village.
   b. Discussing with stakeholders such as TPST workers, managers, and the villagers themselves to understand the existing waste management system and the challenges they face.
   c. Define the types of data that will be needed, including the amount of waste received, the recycling process, and the amount of waste sent to the final disposal site.

B. Collecting Data and Information
   a. Conducting fieldwork to obtain factual data on waste management at TPST, Integrated Waste Management Facilities.
   b. Conduct interviews to explore the specific needs of users of the system.
   c. Conducting direct observations of waste management practices to determine workflows and potential efficiencies that can be improved.

C. Documenting Requirements
   a. Documenting the identified requirements into the System Requirements Specification (SRS) document.
   b. This document includes a description of functional requirements: for example, features for entering waste data and so on. And non-functional requirements such as system performance, information safety and security, and system availability.
   c. Mapping of user requirements: administrators, for example, officers or several people from the village who are waiting for reports on what is being done with waste and its management.

D. System Requirements Analysis
   a. Conducting an analysis of the documented information requirements to validate the requirements in terms of system development objectives.
   b. Identify and prioritize the identified requirements in terms of their level of importance and potential benefits for the targeted end users.
   c. Conducting a technological feasibility study to ensure that requirements can be met with the available tools and materials.

E. Needs Validation
   a. Provide stakeholders with an overview so that they can validate that all requirements described in the document have been addressed and that no relevant issues have been overlooked.

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b. Conduct meetings or presentations to allow relevant parties such as TPST officials and administrators to provide their comments.
c. Modify or supplement requirements.

3.2 Iterative System Design (*User Design*)

The application design at this stage includes the development of visual elements and user interfaces designed to support ease of use and efficiency in system operations. Researchers utilize visual approaches and diagrams to explain the relationships between system elements and the interactions between actors and the system as a whole. Some of the main components at this stage are:

A. System Layout and Structure Design

User interface design begins with the creation of wireframes that describe the layout and structure of each page in the waste management information system shown in Figure 2. These wireframes include:

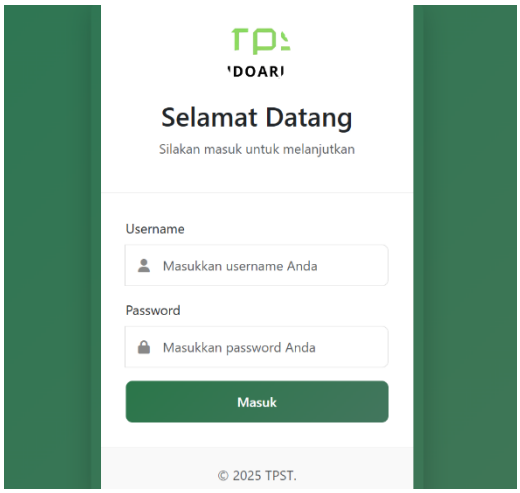

Figure 2. First view

a. The login page for administrators and officers.
b. The main dashboard displays data such as the amount of incoming waste, recycled waste, and outgoing waste.
c. A simple and intuitive data input form.

B. Use Case Modeling with UML

To illustrate the interaction between actors and the system, researchers used a UML-based use case diagram (see Figure 5). This diagram identifies two main actors:

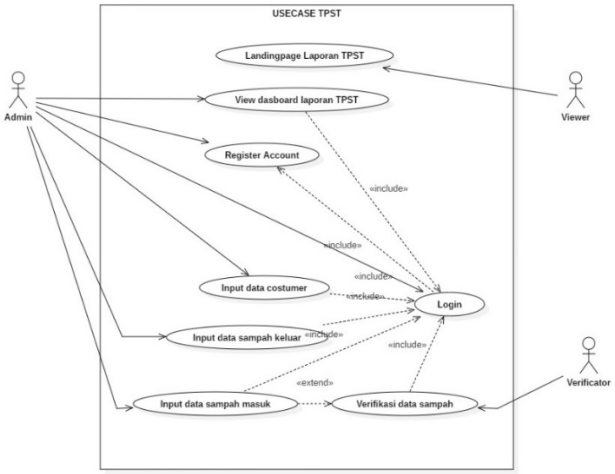

Figure 3. Use Case

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Administrator, responsible for managing user access and monitoring reports. Officer, tasked with inputting data on incoming, outgoing, and recycled waste. This diagram provides a clear visual representation of the system's main functions and the roles of each actor, facilitating communication between developers and users.

C. Prototype Development

A prototype was created to provide an initial overview of the final product to be developed. This prototype includes the visual design of the login page, dashboard, and data input page. Feedback from stakeholders was used to refine the prototype until an approved design was achieved.

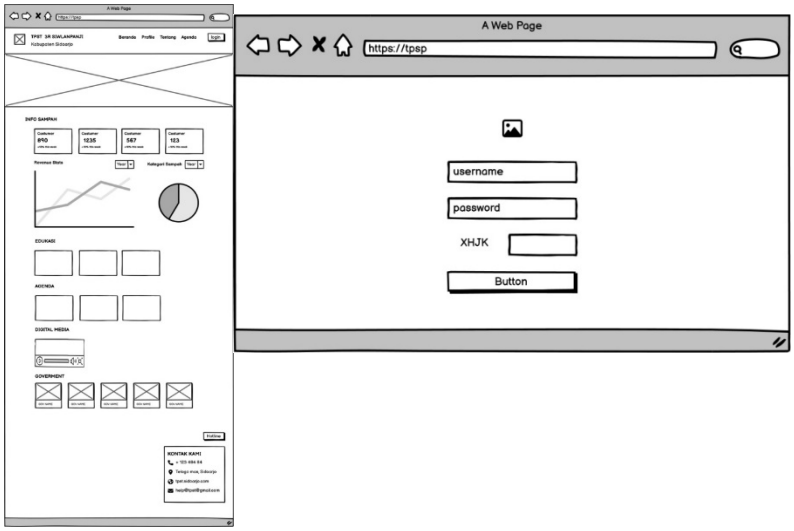

Figure 4. *Login* Page and *Viewer*

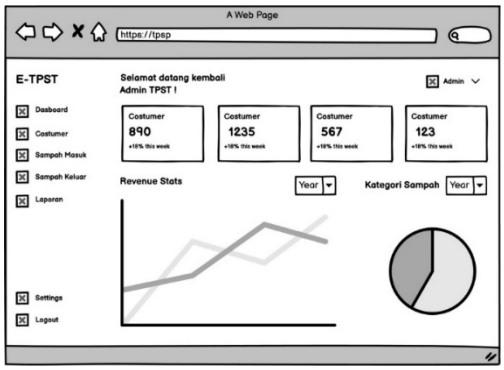

Figure 5. Administrator Dashboard Page

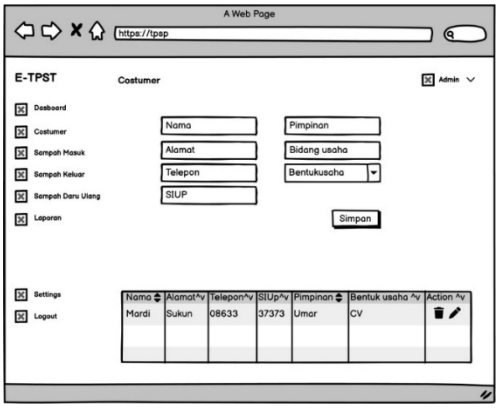

Figure 6. Customer Admin Officer Page

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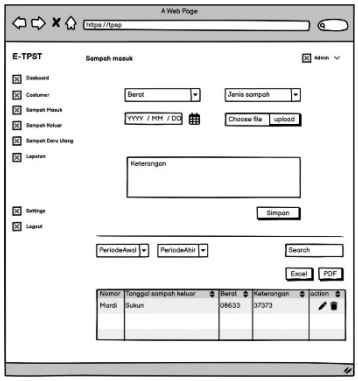

Figure 7. Administrator Trash In Page

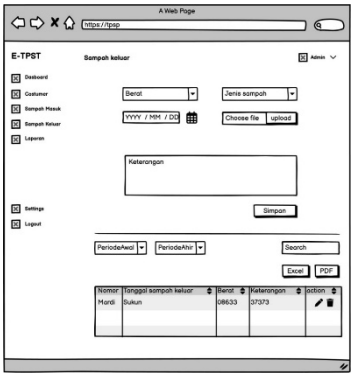

Figure 8. Outgoing Trash Admin Officer Page

D. Verifier
   a. Similar form for verifiers
   b. Includes details such as waste type, entry date, exit date, entry quantity, exit quantity, recycled quantity, and a brief description and correction button.
   c. Data validation to ensure correct input

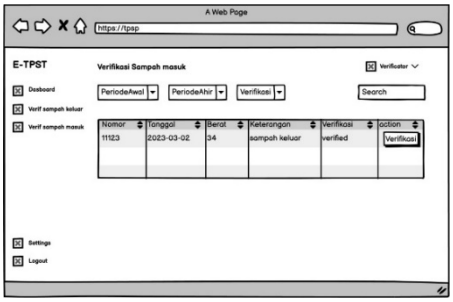

Figure 9. Incoming Waste Verification Page

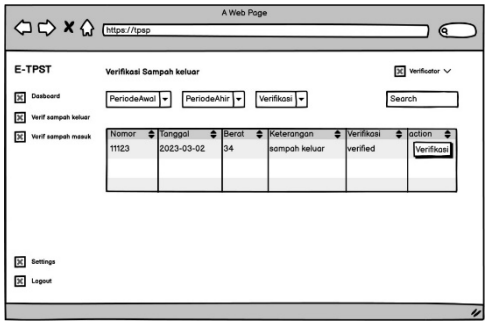

Figure 10. Outgoing Waste Verification Page

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E. Use of Interactive and Dynamic Models

To enrich the user experience, simple motion elements (such as transition animations between pages) are applied to the user interface. This is designed to provide more intuitive interactions, allowing users to easily understand the system's workflow.

F. Design Validation

The design was validated through a trial process with users, including administrators and TPST officers. The feedback provided was used to adjust and refine the interface design before proceeding to the technical development stage.

3.3 Prototype Development (*Construction*)

During the Construction phase, the development of the system and implementation of the planned visual design elements are carried out comprehensively. Based on the images you have attached, here is an explanation of each relevant element:

A. Front-End Development

a. Implementing the user interface (UI/UX) design that was created in the previous phase.
b. Creating the main pages of the web-based system, such as:
c. Login Page: For user authentication.
d. Dashboard: Displaying a summary of data related to waste management.
e. Data Input Form: For entering information about incoming and outgoing waste.
f. Report Page: Presenting data in the form of tables or graphs for analysis.

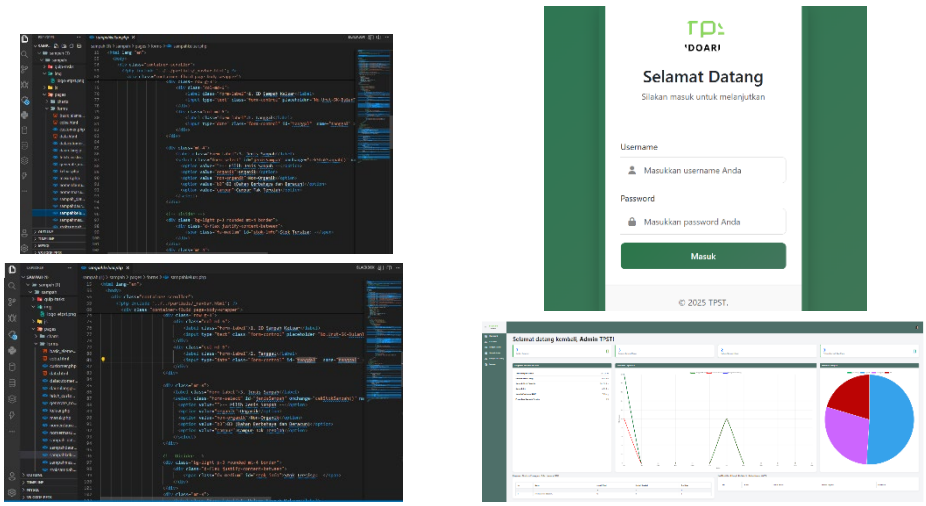

Figure 11. Front-end Development

The login page is used to authenticate users. There are fields for username and password, as well as a login button.

The dashboard displays summary information such as the amount of waste received, recycled, and sent to the landfill. The data is displayed in graphs and tables.

B. Back-End Development

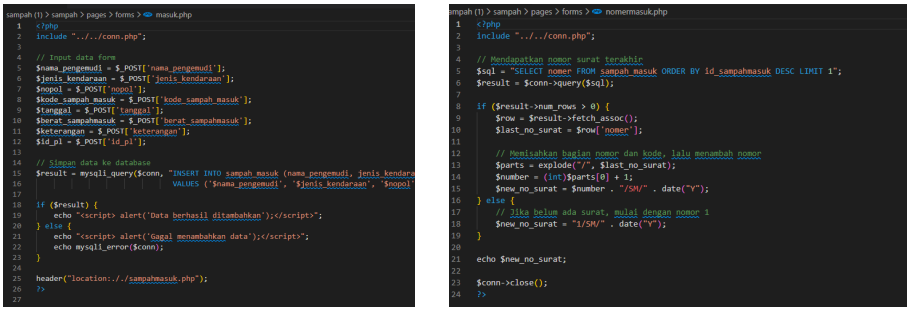

Figure 12. Backend Development

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a. Developing the system's business logic, such as:
b. Storing waste data in the database.
c. Calculating the amount of waste that has been processed.
d. Providing an API to facilitate communication between the user interface and the database.
e. Using technologies such as PHP for server-side scripting and MySQL for database management.

C. System integration

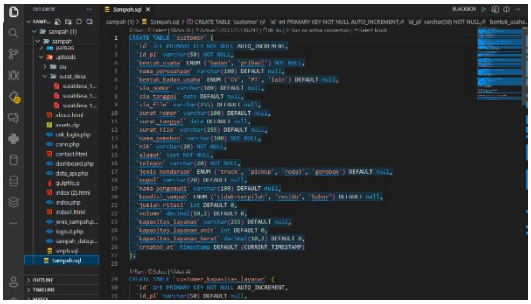

Figure 13. Database Integration

a. Integrating the front-end with the back-end to ensure the system runs smoothly from end to end.
b. Connecting each interface feature to the database, such as garbage data input that is immediately stored and can be viewed in reports.

D. System Testing
a. Conducting tests to ensure all components function as intended.
b. Using black box testing methods to verify:
c. Data input form functions.
d. Page performance such as access speed and data processing.
e. The validity of links and buttons.

E. Final Results of the Construction Phase
a. A functional web system with key features such as data input, process tracking, and reporting.
b. The system is ready for further testing by users before full implementation.
c. Function: To secure user access to the system.
d. Elements: Form with username and password input fields, as well as a login button.

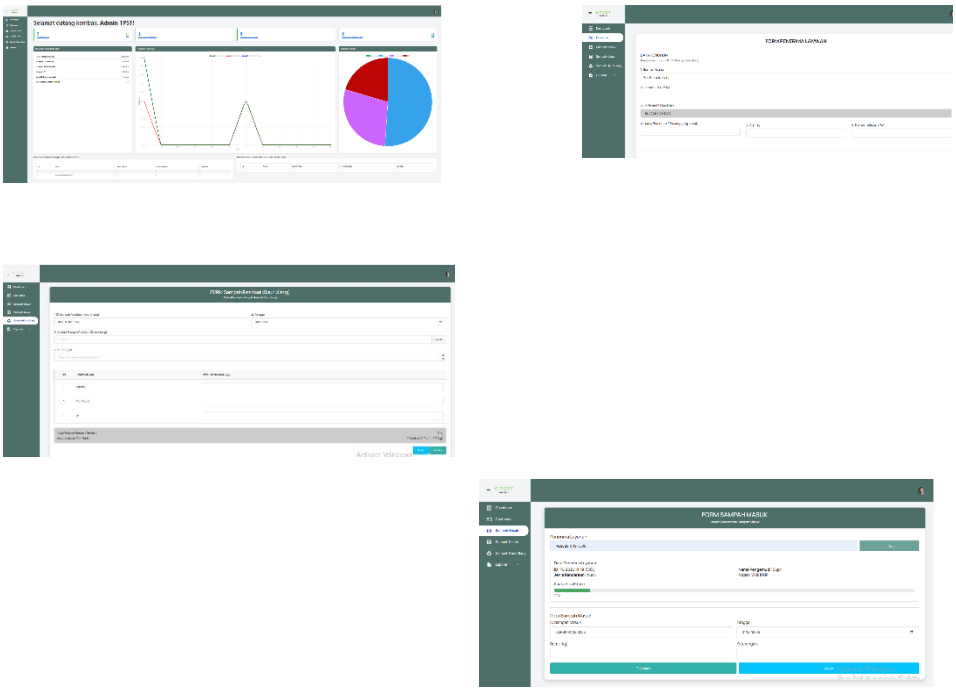

Figure 14. Website Results

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F. Dashboard
   a. Function: To present a summary of waste management data in the form of graphs and tables.
   b. Elements: Data visualization, such as the amount of waste coming in and going out.

G. Testing Process
   a. Function: The testing flowchart illustrates the testing sequence from login to reporting.
   b. Elements: Process boxes such as login, data input, and report generation.

3.4 Testing and Integration (*Custover*)

The Cutover phase is the final phase in the Rapid Application Development (RAD) methodology, which involves implementing the system for use by end users. At this stage, the focus is on integrating the system into the operational environment and ensuring that the system functions properly through thorough testing.

Activities in the Cutover Phase:

A. Data Migration
   a. Transferring data from the old system (if any) to the new system to ensure operational continuity.
   b. Cleaning and aligning data to make it compatible with the new system structure.
   c.

B. User Training
   a. Training system users, such as administrators and TPST officers, to understand the features of the developed system.
   b. Provide guidance on using web-based systems and simple troubleshooting steps.

C. System Functionality Testing
   a. Final testing of the system using the Black Box Testing method to ensure that all key features function according to user requirements.

D. System Integration
   a. Ensuring that all modules in the system are properly connected and function as a single unit.
   b. Testing communication between the front-end and back-end, as well as validating data flow within the system.

E. Implementation and Maintenance
   a. Activating the system for use by end users.
   b. Provide initial technical support to monitor system performance and resolve any bugs or issues that arise.
   c. Prepare a system maintenance plan to maintain its performance and functionality.

Table 1 BlackBox Testing

No	Features Tested	Test Scenario	Input Data	Expected Results	Test Results
1	Login	Enter a valid username and password	Username: admin, Password: 1234	The system redirects to the dashboard	Correct / Incorrect
2	Login	Entering an invalid username or password	Username: admin, Password: incorrect	The system displays an error message	Correct / Incorrect
3	Inputting junk data	Entering new waste data into the system	Waste data entered: 100 kg	Data successfully saved and appears in the history table	Compliant / Non-compliant
4	Data Validation	Ensuring that the entered data is valid	Input: alphanumeric characters	The system accepts input without error	Compliant / Non-compliant
5	Generate Report	Create a waste management report based on a specific period	Period: January 2024	The report appears in the form of a table or graph	Compliant / Non-Compliant
6	Waste Data Deletion	Deleting specific junk data	Junk Data ID: 5	Data successfully deleted from the database	Compliant / Non-Compliant

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7	System Performance Testing	Access the dashboard to check system speed	Click on the dashboard	The system displays data in less than 3 seconds	Compliant / Non-compliant

Previous studies have discussed waste management information systems with different focuses. Ahlis Noor Kholili developed a mobile-based system to address household waste disposal issues. Nurul Rizky Amaliah designed an information system to improve administrative efficiency at the Demang Asri Waste Bank, which previously used manual recording. Meanwhile, Suleman et al. created a web-based system to process waste bank transaction data in a more modern and accurate manner. The similarity between these studies is their contribution to the digitization of waste management. However, the focus of this study is different, namely on the analysis of waste disposal results, including monitoring of recycled waste and waste disposed of at temporary storage sites.

4 Conclusion

This study aims to analyze and design a website-based Integrated Waste Disposal Site (TPST) information system in Siwalanpanji Village, Sidoarjo Regency. The designed system focuses on effective waste data management, with the aim of monitoring and analyzing waste disposal results, including monitoring recycled waste and waste disposed of at the Waste Processing Site (TPS). This information system aims to improve efficiency, transparency, and reporting in more sustainable waste management.

Previous studies have shown that information technology-based waste management systems have been widely implemented in various forms, such as mobile applications and web-based systems for waste banks. However, most previous studies have focused more on waste transaction management and administration, while this study emphasizes the analysis of waste disposal results and the preparation of analytical reports that are useful for evaluation and decision making.

Compared to previous studies, this study offers a more comprehensive approach, utilizing information technology to monitor and evaluate the waste management process in a more structured manner. The developed system is expected to assist TPST in improving operational effectiveness, facilitating waste data recording, and providing more accurate reports for relevant parties in decision making.

Overall, this research makes a significant contribution to information technology-based waste management by utilizing waste disposal analysis as a basis for policy-making and more efficient resource management. The resulting system can serve as a model for the development of similar systems in other regions, as well as supporting efforts for more environmentally friendly and sustainable waste management.

It is hoped that further research can develop an XR-based campus exploration application in the motion sector by adding voice features so that users can not only see visuals but also hear clear instructions and expand the area by adding buildings that are not yet listed in the application.

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