Developing Sustainable Solid Medical Waste Management Based on Enterprise Resource Planning in General Hospital

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***Abstract*— The general hospital is one of the health services needed by the community. Apart from positively impacting health, general hospitals also harm medical waste generated from operating activities as health service providers. Medical waste contains various viruses and bacteria that can endanger the health and pollute the environment if not managed properly. One of the hazardous medical wastes is general hospital solid medical waste. Solid medical waste in Indonesia is recorded to increase every year. Many general hospitals do not yet have a sustainable solid medical waste management system in medical waste management. The management process starts from the preparation stage, such as sorting, storing, processing, and reporting, which are still done separated. Separated process can make it difficult to monitor solid medical waste that follows sustainable standards that do not harm the environment. This study will develop a solid medical waste management module based on the Odoo Enterprise Resource Planning (ERP) system with the QuickStart method. This system can integrate data and information from each division responsible for the waste management process. The system will simplify the preparation process for management, monitoring processing following Key Performance Indicators (KPI) for sustainable waste management, such as whether the waste can be reused, recycled, energy consumed, and indicators for waste processing machines according to sustainable standards and government regulations. In the last stage, waste management can be reported automatically by the system, making it easier to analyze the results of solid medical waste management results and assist in decision-making.**

Keywords*— *Enterprise Resource Planning (ERP), Sustainable waste management, Quickstart, Odoo, Key Performance Indicator (KPI)

I. INTRODUCTION

Health services are one of the services needed by the community, one of which is a general hospital. According to the Regulation of the Minister of Health of the Republic of Indonesia Number 30 of 2019, defines a hospital is a health service institution that provides complete individual health services by providing inpatient, outpatient, and emergency services [1]. General hospital operational activities have a positive impact, but they also harm the form of solid medical waste that can pollute the environment and endanger health. It is estimated that solid medical waste originating from health facilities and general hospital operational activities will continue to increase. In 2018 the data of medical waste in Indonesia per day reached 294.66 tons [2]. Meanwhile, in 2020 medical waste has increased by 30% from previous years due to the outbreak of the Covid-19 pandemic [3]. To reduce environmental pollution resulting from general hospital operational activities, the government issued Law No. 44 of 2009 concerning hospitals, namely that waste management in hospitals is carried out including the management of solid, liquid, gaseous materials that are infectious, toxic chemicals and some are poisonous [4].

As producers of medical waste, general hospitals must manage the waste produced so that the waste does not become a source of disease and pollute the environment [5]. One type of hazardous medical waste is solid medical waste that contains various kinds of diseases, such as bacteria, viruses, toxins, and radioactive materials, if not appropriately managed. The negative impact of solid medical waste is caused by poor management, and if left unchecked, it will cause pathogens that hurt the health and the environment [6].

Managing solid medical waste in public hospitals is carried out from the sorting stage to reporting the solid medical waste generated. The solid medical waste management process is carried out using a conventional system without an information system. There is no integration between the departments responsible for solid medical waste management. This resulted in the initial sorting process until the reporting of solid medical waste was not interconnected and integrated. Monitoring solid medical waste management will be complicated because there is no integrated information system for sustainable solid medical waste management that does not endanger the health and the environment.

Sustainable waste management is a waste management process that is carried out sustainably by reducing, reusing, recycling, and recovering, thereby minimizing the production of by-products from waste management, which reduces waste environment pollution in general hospitals [7]. Focused on environmental aspects to minimize the danger of waste generated so as not to pollute the environment [8]. Solid medical waste management needs to be monitored with sustainable indicators so that the results of the processed waste management follow standards that do not endanger the environment and health [9].

One of the integrated information systems to implement sustainable solid waste management is Enterprise Resource Planning (ERP). ERP is a system designed to distribute and integrate data and information into a single system that

supports the requirements so that it can integrate and automate information systems into a centralized database [10]. ERP system is used in this study because it can integrate every existing unit and facilitate classifying the waste generated and how it is processed and reported. Make it easier to analyze the results for decision making than using ordinary information systems [11].

From these problems, this research aims to develop a sustainable solid medical waste management system based on open-source ERP in general hospital health services to facilitate managing solid medical waste using the Quickstart method. The system will help start from the preparation stage for sorting, storing, and processing ordinary solid medical waste or reusable waste and assist in reporting the management of solid medical waste generated. The system developed follows the key performance indicator (KPI) of sustainable waste management not to damage the environment and is integrated with the inventory module for storage and purchase module.

II. Literature Review

A. Enterprise Resource Planning (ERP)

Enterprise Resource Planning (ERP) is a system that can optimally integrate various functions in an organization [12]. Using an ERP system, you can incorporate all existing functional areas so that the dissemination of information between each unit can run well and in real-time [13]. Fig.1 describes an overview of the ERP model that is generally applied. This research will focus on developing a module for sustainable solid medical waste management.

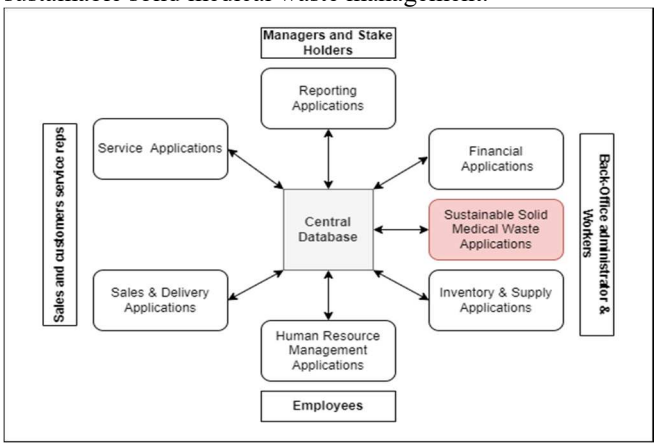

Fig. 1. General ERP model

B. Sustainable Waste Management

Sustainable waste management is a waste management activity to reduce, reuse, recycle, and recover by minimizing the production of by-products from waste management. Sustainable waste management can reduce environmental pollution because the results of waste processing are carried out by taking into account several aspects, namely environmental health, decision making, and stakeholders [7].

C. Solid Medical Waste

Solid medical waste consists of infectious waste, pathological waste, sharp object waste, pharmaceutical waste, cytotoxic waste, chemical waste, pressurized container waste, and waste with high heavy metal content [14]. Based on the potential hazards contained in solid medical waste, the types of solid medical waste can be classified as follows:

1. Infectious waste and sharps
2. Pharmaceutical Waste
3. High Heavy Metal Content
4. Cytotoxic Waste

Fig.2 describes the flow of solid medical waste management according to the regulation of the minister of health no 7 of 2019 regarding general hospital environmental health [1].

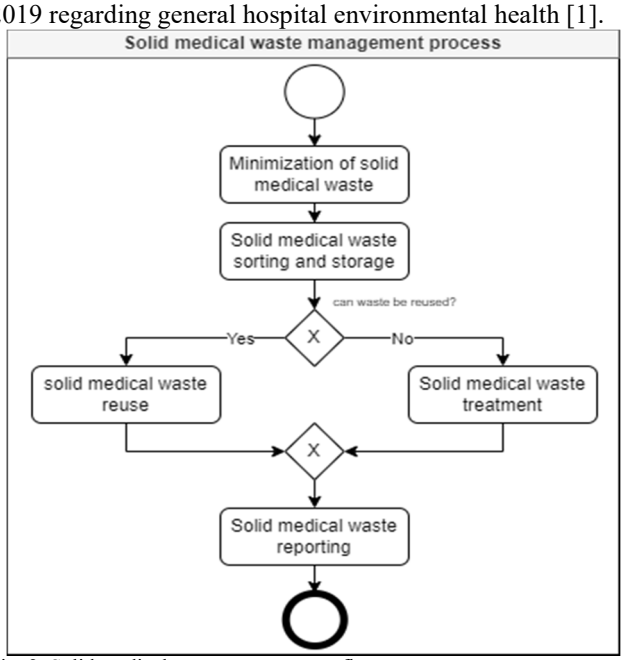

Fig. 2. Solid medical waste management flow process

D. Odoo

Odoo is an open-source ERP software developed by a large community using Python. Odoo provides a variety of business applications that are easy to use by users according to business needs that can be customized and configured as needed [10].

E. Quickstart Method

The QuickStart method is designed to implement ERP systems in small to medium-sized companies. The Quickstart method ensures that the results of implementing open-source ERP (Odoo) software are carried out quickly by minimizing module development [15]. Fig.3 describes Quickstart method has four stages of development, including kick-off call, analysis, configuration, and production [16].

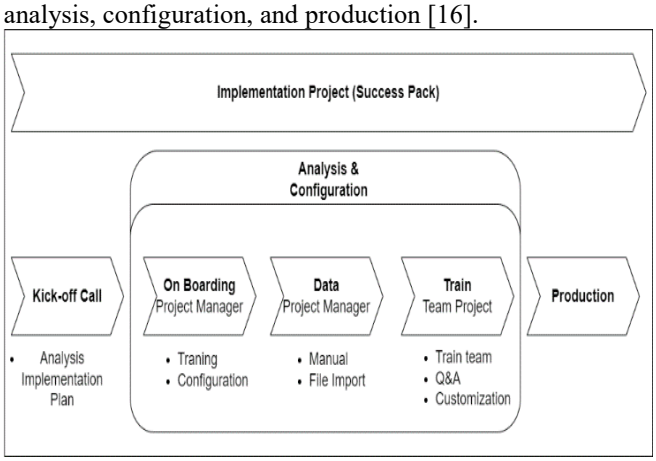

Fig. 3. Quickstart method

F. Key Performance Indikator

Key Performance Indicator (KPI) is an indicator used to measure the performance of an organization following the initial goals that have been set [17]. KPI identification is carried out to develop KPIs based on the objectives of each KPI to produce good results. The implementation of KPIs that are not following the initial goals can impact the performance of an organization being down and inefficient in various aspects [18].

III. Research Methodology

In this study, the development of a sustainable medical solid waste management system uses an ERP system development methodology, namely the Quickstart method. Fig.4 describes Quickstart method systematic. This method was chosen in this study because it is effective for implementing Odoo by minimizing system development and is easier for users to use because it is designed according to the workflow of the existing system in Odoo.

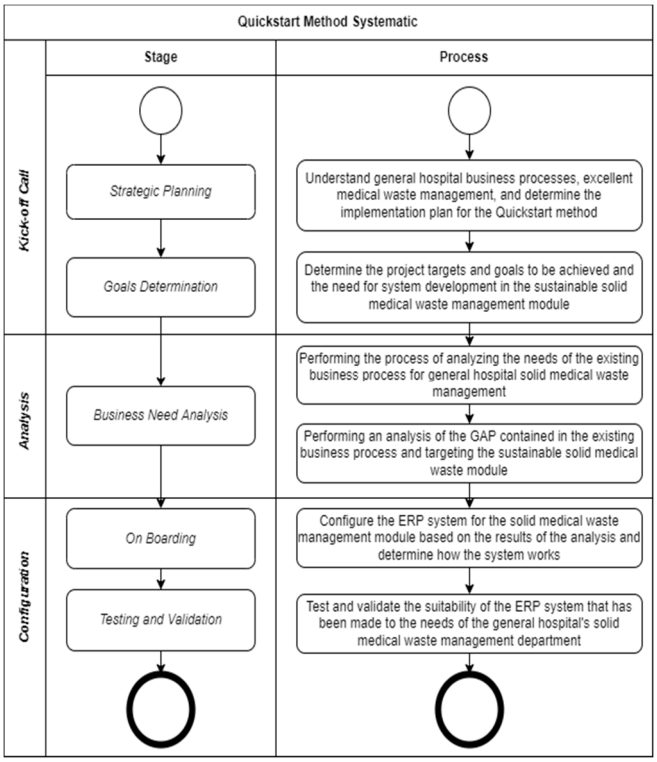

Fig. 4. Quickstart method systematic

The Quickstart method consists of four stages: kick-off call, analysis, configuration, and production. The four stages provide optimal ERP system development results, but in this study, only up to the configuration stage.

A. Kick-off Call

At this stage, explain to clients and stakeholders how the methodology will be applied and the work steps to be carried out and determine the timeline for project work from the initial stage to the final stage.

B. Analysis

At the analysis stage, an analysis of the existing business processes (as-is) is carried out with the target of the business process to be developed (to-be), which will then produce a fit/gap analysis.

C. Configuration

At the configuration stage, after analyzing the business processes owned by the organization, configurations are carried out according to the data they have. The data will be configured to suit the general hospital's to-be business process.

IV. Experiment and Result

A. Process Business Existing

The business process of solid medical waste management in general hospitals is still carried out using conventional systems without any information system. Fig.5 describe the solid medical waste management process starts from the preparation stage. Each general hospital division, such as the operating room, emergency room, and others, produces solid medical waste, sorted before being given to the warehouse. The warehouse section receives solid medical waste and records the data generated on the solid medical waste data document. The document is submitted to the environmental health department to make a schedule for solid medical waste treatment. The Environmental Health Division prepares a plan for solid medical waste treatment. The next stage is processing solid medical waste through several processes such as heating through an autoclave machine, combustion through an incinerator, and compaction through a solidification machine. The Reporting on solid medical waste management is carried out using a conventional system, which is vulnerable to reporting errors and data manipulation.

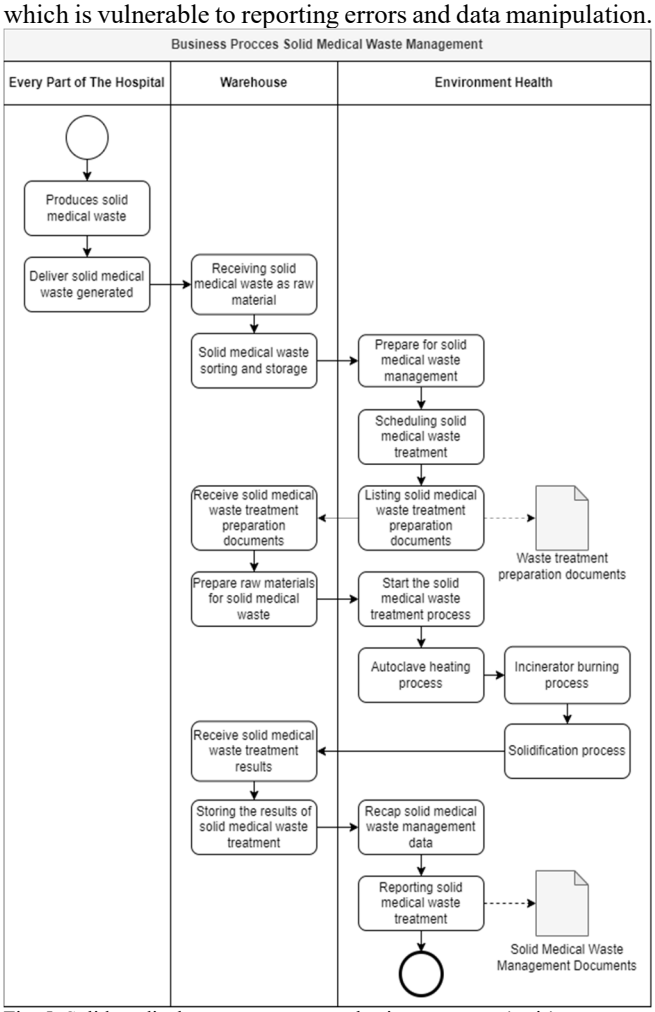

Fig. 5. Solid medical waste management business process (as-is)

B. Analysis of General Hospital

Based on the results of the analysis, general hospitals have several problems, especially in the management of solid medical waste generated by public hospitals, including:

1. The solid medical waste management system is still done conventionally. Have not implemented a sustainable solid medical waste management system to monitor and control the solid medical waste produced not to harm the environment.
2. The distribution of existing data and information has not been integrated between each division in public hospitals that manages waste, which is still carried out separately.
3. Reporting on solid medical waste management is carried out using a conventional system, which is vulnerable to reporting errors and data manipulation.

Based on the problems above, this research will develop an ERP system module for sustainable solid medical waste management using Odoo ERP open-source software that supports general hospital solid medical waste management using the Quickstart method. The ERP system used in sustainable medical waste management will make it easier for general hospitals to manage solid medical waste generated based on sustainable waste management indicators, integrate all sections related to solid medical waste management, and report solid medical waste generated automatically at general hospitals.

C. Gap Analysis

In the fit & gap analysis stage, the researcher analyzes the business processes that are already running with the business processes developed using the ERP system.

1. Solid Medical Waste Management Preparation
   a. As-is process
      Preparation for solid medical waste management is carried out by collecting data on waste raw materials that will be processed separately and have not been recorded centrally in a system.
   b. To- be process
      Enter the solid medical waste material needed in the master data bill of material to find out the material required in the waste management process. The data will be entered into the master data and can be used as a reference in preparing solid medical waste management.
2. Solid Medical Waste Treatment Production Process
   a. As-is process
      The solid medical waste treatment process must be monitored and controlled directly, which takes a long time. The treatment is not recorded in a system that can record the history of solid medical waste treatment.
   b. To- be process
      The solid medical waste treatment process is carried out using the Odoo ERP system. The monitoring and control process can be carried out using procedures with indicators for sustainable solid medical waste management so that the results of waste treatment do not harm the environment.
3. Solid Medical Waste Management Reporting Process
   a. As-is process
      The solid medical waste treatment process must be monitored and controlled directly, which takes a long time. The treatment is not recorded in a system that can record the history of solid medical waste treatment.
   b. To- be process
      The solid medical waste treatment process is carried out using the Odoo ERP system. The monitoring and control process can be carried out using procedures with indicators for sustainable solid medical waste management so that the results of waste treatment do not harm the environment.

D. Business Process To-Be

ERP system implementation in the solid medical waste management process can integrate the waste management process with each part responsible for the waste management process. In addition, it can update waste in real-time, control and monitor easy operations, and report automatically starting from the preparation stage, processing to reporting integrated with one system according to the standards of sustainable medical waste management.

1. Solid Medical Waste Management (To Be)
   Fig.7 describe the business process for preparing solid medical waste after implementing the Odoo ERP system is as follows:
   a. Solid medical waste generated will be recorded in the master data produced by the warehouse so that the waste material data generated is centered on the master data system.
   b. Preparation of solid medical waste management starts from creating work centers, routing, bill of materials, and manufacturing orders can be prepared centrally through the system.
   c. The material availability can be checked in real-time on the system because it has been recorded in a centralized database.

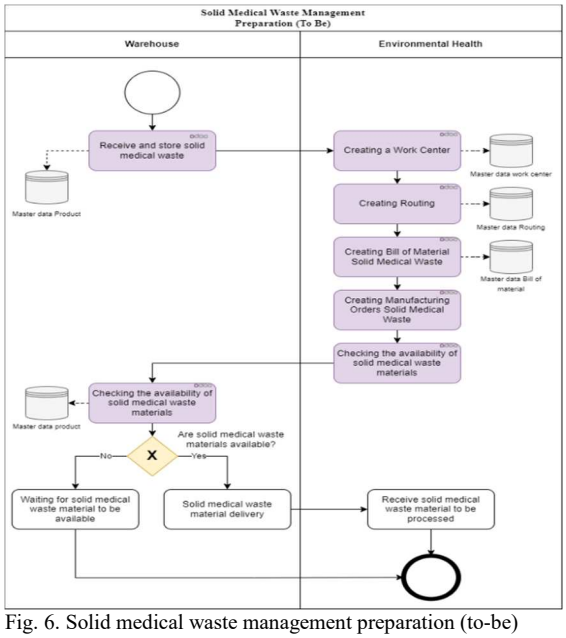

Fig. 6. Solid medical waste management preparation (to-be)

2. Solid Medical Waste Treatment Production Process (To Be)
Fig.7 describe the solid medical waste treatment process after implementing the Odoo ERP system is as follows:
   a. After the waste material is received, processing can be carried out by making a manufacturing order to carry out the production recording process, such as a waste management schedule, quantity, and material.
   b. The waste treatment process is checked based on the product category and whether they can reuse the waste or not. The processing process can be controlled and monitored through a work order system with various indicators of sustainable waste management.
   c. The results of solid medical waste processing will be stored by the warehouse and automatically updated on the product master data.

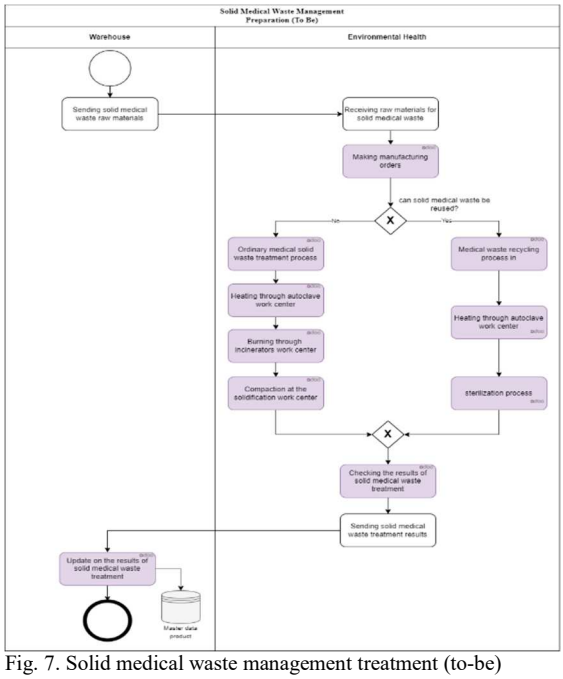

Fig. 7. Solid medical waste management treatment (to-be)

3. Solid Medical Waste Management Reporting Process (To Be)
Fig.8 describe reporting solid medical waste.

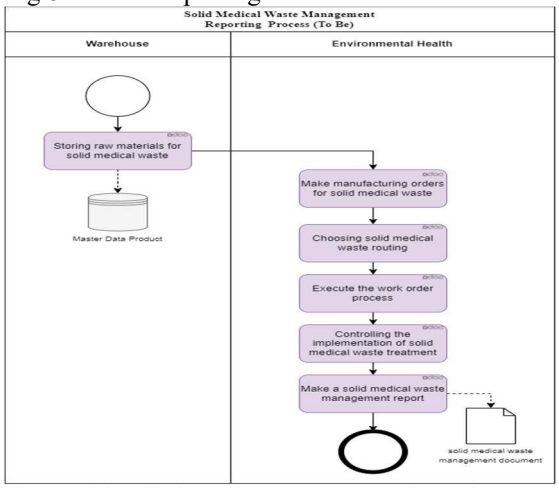

Fig. 8 Solid medical waste management reporting (to-be)

In reporting solid medical waste management after implementing the Odoo ERP system, report generation can be done automatically. The report contains detailed information on implementing waste management to facilitate the analysis and decision-making process.

V. IMPLEMENTATION

A. Configuration

In the configuration, configure the solid medical waste management module to be integrated with the inventory and purchase modules. After the configuration stage, make adjustments to the fields on the work order following sustainable indicators by adding several indicators such as indicators for solid medical waste, energy consumed in the waste treatment process, indicators of whether the waste can be reused or not, and the output of the waste treatment process so that the results of processing waste does not harm the environment. Table I describe Sustainable waste indicator.

TABLE I. SUSTAINABLE WASTE INDICATOR

No	Field Name	Explanation
1	Solid Waste Indicator	Solid medical waste management indicators
2	Recyclable Product	Solid medical waste can be recycled
3	Reusable Product	Solid medical waste can be reused
4	Energy Consumption	Energy expended in the waste treatment process
5	Output Process	The result of solid medical waste treatment process

B. Test Execution

After configuring the sustainable solid medical waste management module, the configuration results for the solid medical waste treatment process form are provided. In fig.9 describe customizing the work order form, adding several indicators such as a solid waste indicator, the energy consumed in the waste treatment process, an indicator of whether the waste can be reused or not, and and the output of the waste treatment process.

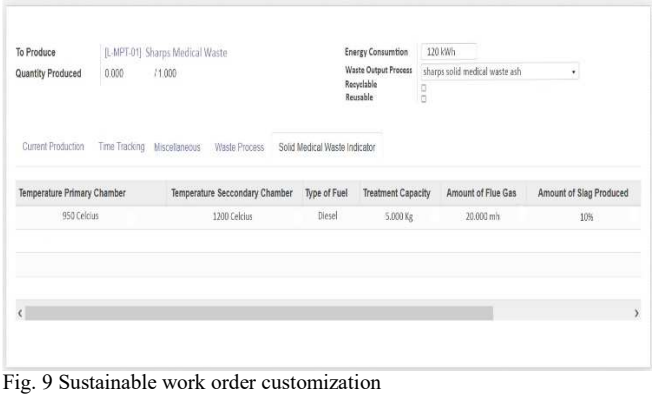

Fig. 9 Sustainable work order customization

The ERP system will generate a manufacturing document after the processing of solid medical waste is complete. Fig.10 describes the document contains detailed information on processed solid medical waste, such as product information, management schedule, planned operations, sustainable indicators, product to consume, and managed solid medical waste. All of that is included in the solid medical waste

management report, which will use in reporting the results of solid medical waste management.

Manifest Dangerous and Toxic Waste

WH/MO/00010

Waste Product:	Sharps solid medical waste	**Printing Date:**	Sunday, 22 Feb2022 17.00
Scheduled Date:	Monday, 16 Feb 2022 00:11 - Friday, 20 Feb 2022 16.00	**Waste Source:**	Public Hospital
Quantity:	4.000 Kg	**Responsible:**	Environmental Health Manager

Operations Planned

Operation	WorkCenter	No. Of Minutes
Autoclave	Autoclave Machine	60.00
Incenerator	Incenerator Machine	60.00
Solidfication	Solidfication Machine	60.00

Sustainable Indicator

Indicator	Information
Energy Consumtion	120 kWh
Dangerious Waste	Dangerious
Recyclable	No
Reusable	No
Solid Medical Waste Indicator	1200 Celcius

Products to Consume

Product	Quantity
[L-MP-01] Syringe Waste	1.000 kg
[L-MP-02] Surgical Knife Waste	1.000 kg
[L-MP-03] Medicine Glass Bottle Waste	1.000 kg
	1.000 kg

Total Solid Medical Waste Treatment: 4.000 Kg

Fig. 10 Reporting sustainable solid medical waste management

VI. CONCLUSION

In research on developing a sustainable solid medical waste management system using the ERP system with the Quickstart method, the system designed with the Quickstart method can accelerate the development process by following general hospital solid medical waste management standards and sustainable solid medical waste management. Implementing a sustainable solid medical waste management system based on an ERP system can integrate each part of the hospital's solid medical waste producer with the division responsible for managing waste, which was initially handled separated. The monitoring process is also practical because it can be monitored through a system related to waste management following sustainable indicators such as solid medical waste indicators, energy consumed, reuse, recycling, and output of waste after processing which does not harm the surrounding environment. An effective reporting process to assist hospitals in analyzing the results of solid medical waste management results and facilitating decision-making. In addition, not too many configurations and customizations have been carried out because they are following system development needs. Implementing a sustainable solid medical waste management system with this ERP system can minimize environmental pollution due to ineffective and unsustainable medical solid waste management.

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