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An Application of Value Stream Mapping to Reduce Waste in Livestock Vitamin Raw Material Warehouse

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Abstract: ***The emergence of waste in the raw material warehouse of livestock vitamins is one of the causes of delay in the product distribution process. The company apply the Lean approach with VSM (Value Stream Mapping) technique, to reduce or eliminate the waste. The VSM method visualizes various data and flows (material and information) related to the process, which facilitate the identification of value-added and non-value-added activities to the product. Current state map and process mapping activity found 3 types of waste that occurred, namely excessive transportation, inappropriate process, and waiting time. The Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) methods utilize to reduce those three kinds of wastes. These methods improve based on the degree of relationship between the ongoing activity. This study also uses the Process Flow Map method to eliminate unnecessary activities, distance traveled, and work cycle times. After these improvement steps, the value of work efficiency increased from 81.58% to 82.09%.***

Keywords: Waste, Value Stream Mapping, Efficiency, Raw Material Warehouse

1. Introduction

Delay in the distribution of raw materials is one of the obstacles in warehouse.This delay will affect the cycle time needed to meet consumer demand. The non-value-added activities on the warehouse handling process cause this delay. Indirectly, this will also affect the lead time of production division as warehouse's customer.

Figure 1: Arrangement of livestock vitamin raw material in the warehouse
Source: company data 2019

The potential for waste generation in the raw material warehouse can affect the product distribution process. Figure 1 visualizes the improper placement of goods and obstructs the distribution path of goods. These conditions affect the operator in carrying out their work. The operator's time to handle the material is longer than the standard time. That results in delays in the planned production process. In the end the product distribution process lead time will take longer than promised. This study aims to identify waste in the process at the warehouse of vitamin raw materials for livestock. Furthermore, researchers make appropriate improvements to reduce the waste that occurs. Finally, this research can increase the value of process efficiency in the company's raw material warehouse.

Lean is an approach in identifying and eliminating waste or non-value-added activities through continuous improvement [1] [5]. There are 8 things that cause waste [2][6], which includes Overproduction (excessive production), Unnecessary Inventory (inventory that is not needed), Defect (defective product), Unnecessary Motion (movements that do not add value) , Excessive Transportation (excessive material or product movement), Inappropriate Processing (inappropriate process), Waiting (waiting time), and Unutilized Talent (ability that is not utilized).

In the Lean concept, waste can be removed through 12 techniques, and one of them is Value Stream Mapping [3]. Value Stream Mapping (VSM) is a method used to visualize waste in a complete process. VSM maps the process flow, information flow and material flow [8][9]. VSM helps decision makers identify activities that do not add value by mapping current conditions. This study uses Process Activity Mapping (PAM) to determine the proportion of value-added, non-value-added, or necessary non-value-added activities [4][7].That identification will lead to the target process improvement strategy and put it in the future state map.

2. Research Method

Figure 2 illustrates the steps of this research. Based on Figure 2, this study begins with problem identification and literature review. Furthermore, researchers conducted field observations in collecting data related to job elements, working time and types of existing layouts. This study uses VSM tools as initial process exploration, including current state mapping and Process Activity Mapping. Next step is to improve the value of the efficiency of the work process. Researchers used ARC and ARD tools and described the results of improvements in future state mapping.

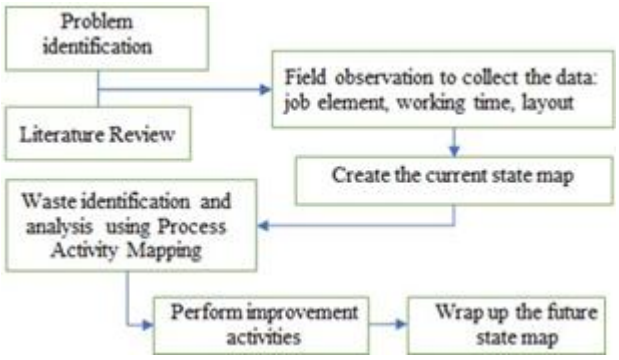

Figure 2: The Steps of VSM Application

3. Result and Analysis

3.1 Step 1: Data Collection and Clarification

Figure 3 shows the warehouse layout of livestock vitamins raw materials. It located in the front area of the factory to facilitate material handling from suppliers.

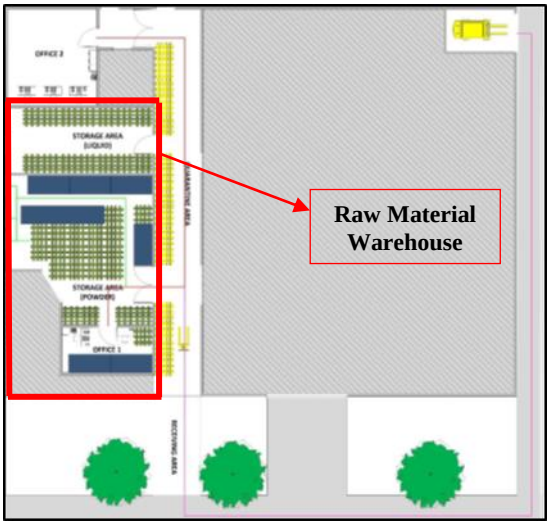

Figure 3. Raw Material Warehouse Layout

This research will use powder type raw material as the object of research. This type of raw material is most needed in the last 10 months of 2019, with an average monthly demand of 14,202 kg.The researchers identify the activities carried out in the warehouse of raw materials from the initial receipt of the document to storage. The next step is to measure the standard time as depicted in table 1. The available work time outside the break time (available time) is 27,300 seconds or 7 hours 35 minutes, and the number of shifts takes place is one shift.

Table 1: Actual Time Activities in the Raw Material Warehouse

Job Type	Activity Description	Activity Code	Actual Time (s)
Document Receiving	Receive the information documents and the receipt of materials from the supplier	A1	2.23
	Submit the information documents and receipt of goods to the Leader	A2	9.55
	Accompany the Leader to meet the Supplier in the Receiving Area	A3	10.42
	Waiting forthe inspection of information documents	X1	58.63
Unloading	Taking containers (pallets) for material loading and unloading	B1	293.15
	Issue a loan letter forklift	B2	48.24
	Submit a loan letter to the owner of a forklift	B3	12.19
	Take the forklift	B4	36.60
	Carrying out the process of loading and unloading of materials	B5	5,587.46
	Move materials into Quarantine Area	B6	815.79
	Return the forklift back to their original place	B7	36.60
	Report the completion of loading and unloading activities to the Leader	B8	12.16
Material Receiving	Awaiting proof of delivery of materials	X2	19.57
	Submit the document of receipt of goods to the Supplier	C1	10.42
	Provide information to the Quality Control related to goods received	C2	24.32
	Write information about the arrival of goods in the logbook	C3	36.60
	Make the quarantine labels for received items	C4	202.56
	Put the quarantine label on materials	C5	286.81
	Waiting for the results of the analysis of materials received	X3	4,859.76
Stock Update	Update inventory information on the stock card	D1	53.97
	Make the QC passed labels for qualified materials	D2	211.24
	Waiting for Leader to checking inventory information on stock cards and information systems	X4	9.55
Storage	Take the hand-lift	E1	17.81
	Move items into the Storage Area	E2	1,633.78
	Put the QC passed label on the goods	E3	285.94
	Returns the hand-lift tool to its original place	E4	15.20
Total			14,590.55

3.2 Step 2. Current State Mapping

Referring to the data in table 1, the researcher mapped the current state ofthe process in warehouse in Figure 4.Based on the results of CVSM made the cycle time required by the operator in carrying out warehousing activities is 14590.55 seconds. There are two of job types that take a lot of time in their activities, which are document receiving and unloading of goods. The researchers conduct brainstorming with supervisors or workers to reduce the cycle time in thosejob types, like eliminate or merge the activities, and eliminate waiting time.

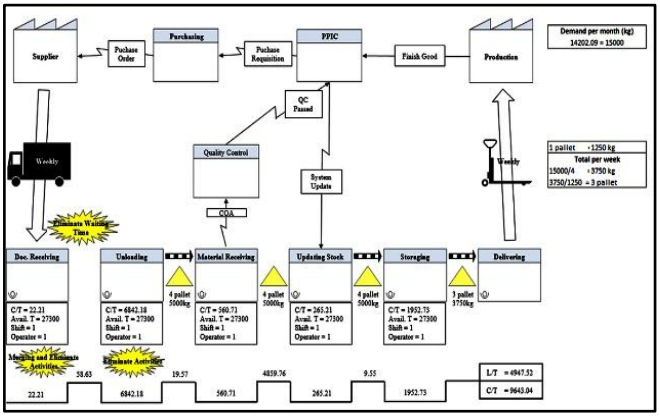

Figure 4: Current State VSM (CVSM)

3.3 Step 3. Waste Identification

Furthermore, researchers investigated non-value-added activities which constitute waste in table 2.This table shows the three types of waste that predominantly occur in livestock vitamin material warehouse, which include excessive transportation, inappropriate processing, and waiting.

Table 2: Process Activity Mapping (PAM)

Activity	Job					Distance (m)	VA/ NVA/ NNVA
	Operation	Transportation	Inspection	Delay	Storage		
	O	T	I	D	S		
A1	O						VA
A2		T				17	NVA
A3		T				17	NVA
X1				D			NNVA
B1	O					28	VA
B2	O					17	NVA
B3		T				30	NVA
B4	O					83	VA
B5	O						VA
B6					S	40	VA
B7	O					26	VA
B8	O					43	VA
X2				D			NNVA
C1		T				17	VA
C2	O					17	VA
C3	O						VA
C4	O						VA
C5	O					14	VA
X3				D			NNVA
D1	O						VA
D2	O						VA
X4				D			NNVA
E1	O					7	VA
E2					S	32	VA
E3	O						VA
E4	O					4	VA

Based on the CVSM and PAM tables, researchers calculate the current process efficiency values using the formulas (1) and (2):

$$Available\ Time - Resistance\ Time = Effective\ Work\ Time \quad (1)$$

$$Available\ Time - (NVA + NNVA) = Effective\ Work\ Time \quad (2)$$

$$27{,}300 - (80.40 + 4{,}947.52) = 22{,}272.08$$

$$\frac{Effective\ Working\ Time}{Available\ Time} x\ 100\% = Work\ Efficiency \quad (3)$$

$$= \frac{22272.08}{27300} x\ 100\% = 81.58\%$$

In this study, researchers brainstormed with supervisors and workers in the raw material warehouse to analyze and determine related causes (or ideas for causes) for a specific problem and grouped them together into categories and are organized into a diagram that resembles the skeleton of a fish, named Fishbone Diagram [12], like shown in Figures 5 to 7.The results of brainstorming state that some of the main causes of waste that arise are the lack of procurement of material handling aids such as forklifts, lack of storage capacity in warehouses, inappropriate arrangement of goods, and the presence of unnecessary activities.

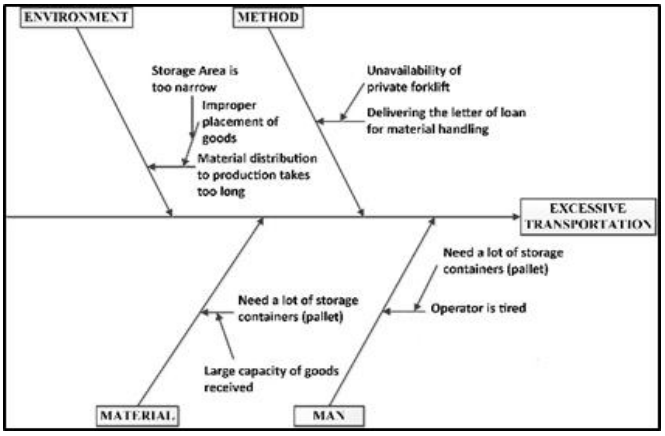

Figure 5: Excessive Transportation Fishbone Diagram

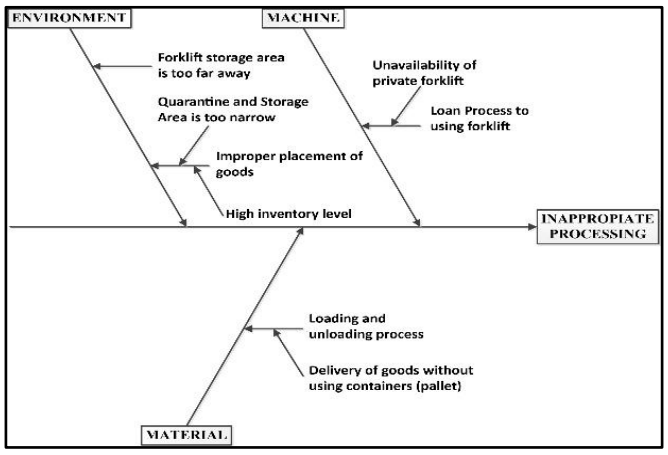

Figure 1: Unsuitable Process Fishbone Diagram

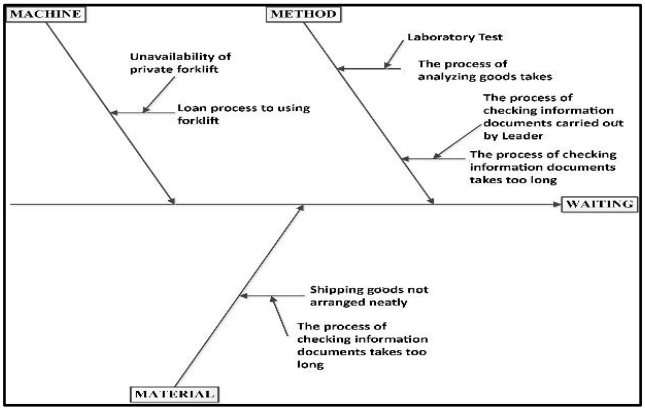

Figure 2: Waste of Waiting Fishbone Diagram

3.4 Step 4. Conduct Improvement Activities

Based on the root cause analysis, researchers compare the size of the storage area with the supplies needed and make improvements to the layout (re-layout). This can eliminate the waste that arises due to mismatches in the layout of raw materials warehouse.

This study uses the Activity Relationship Chart (ARC) in improving warehouse layouts. The ARC technique is quite simple in doing layout design based on the degree of activity relationship [11]. Researchers determined several areas needed in the warehouse of raw materials, which consist of:

1) Receiving Area
2) Forklift Area
3) Office
4) Quarantine Area
5) Storage Area
6) Production Area

The consideration underlying the determination of the degree of relationship is the nature and characteristics of the activity. In the ARC, there are six closeness ratings which may be assigned to each pair of departments or area. Ratings are evaluated by considering a single factor or an overall rating is provided [13].The degree of relationship between areas and the reason for each of them expressed by the letters and numbers symbols as seen in table 3 and table 4.

Table 3: Degree of Relationships Between Area

Symbol	Information
A	*Absolutely necessary*
E	*Especially important*
I	*Important*
O	*Ordinary*
U	*Undesirable*
X	Very undesirable relationship

Source: Zakirah et al., 2018

Table 4: The Reason of Relationship Degree

No.	Reason
1	Material Handling tools Required
2	Documentation Required
3	Flow of goods distribution
4	Causing odor and dirty

Figure 8 shows the Activity Relationship Chart based on subjective assessments to determine the closeness of the relationship between areas. As an example, receiving area and forklift area given the E letter, it means both areas have important relationship and given by 1 symbol. That relationship means the worker needs a material handling tool (forklift) on the receiving area. The result of ARC used as an improvement on the layout design in the raw material warehouse.

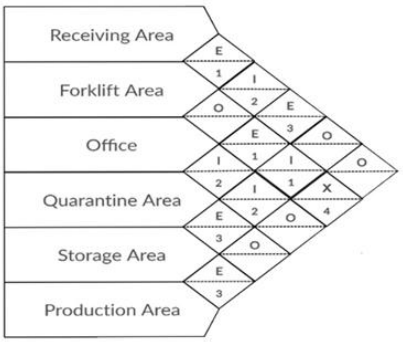

Figure 8: Activity Relationship Chart

The researchers translated results of the ARC into a work sheet as in table 5. This table facilitate the determination of the location of each area, using the Activity Relationship Diagram (ARD) tool. The diagram explains the relationship of material flow patterns and locations of each area. This study describes the Activity Relationship Diagram in the form of an Activity Template Block Diagram (ATBD), as visualized in Figure 9.

Table 5. Activity Relationship ChartWork Sheet

No	Area	Degree of Relationship					
		A	E	I	O	U	X
I	Receiving Area	-	II, IV	III	V, VI	-	-
II	Forklift Area	-	I, IV	V	III	-	VI
III	Office	-	-	I, IV, V	II, VI	-	-
IV	Quarantine Area	-	I, II, V	III	VI	-	-
V	Storage Area	-	IV, VI	II, III	I	-	-
VI	Production Area	-	V	-	I, III, IV	-	II

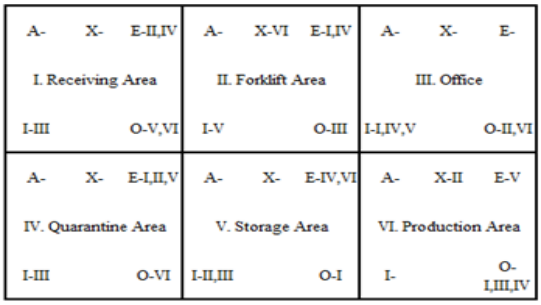

Figure 3. Activity Template Block Diagram

There are no U (Unwanted) symbol on the ATBD because it has no effect on activities that occur between one area and another.Figure 10 is an Activity Relationship Diagram generated based on ARC and ATBD. Based on this ARC, researchers propose a change in the layout of raw materials warehouse.

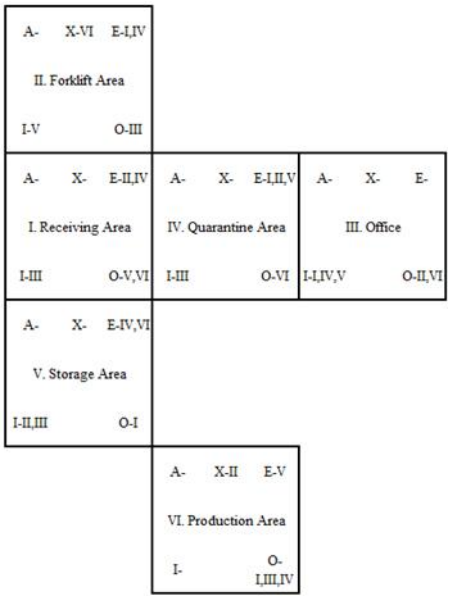

Figure 4: Activity Relationship Diagram

Layout improvements will affect the flow of ongoing processes, by reducing unnecessary activities or cutting the distance and time needed from one activity to the next. Table 6 shows nine unnecessary activities improved in this study. This diagram helps the researcher in determining the appropriate corrective actions to reduce the waste that occurs.

Table 6: Dot and Check Technique for Warehouse Activities

No	Activity	Analysis	Improvement
1	A2	Walk to the office to submit information documents and receipt of goods to the Leader.	Activity eliminated. The leader joins the operator when receiving documents.
2	A3	Walk back to see the Supplier with the Leader.	Activity eliminated. The leader joins the operator when receiving documents.
3	X1	The leader inspects information documents, documents of receipt of goods, and goods carried by the Supplier.	Implementers added. Operators assist the Leader in conducting inspections.
4	B2	Make the forklift loan letter.	Activity eliminated. Improvement is done by submitting forklift tools to be used privately.
5	B3	Delivering the forklift loan letter to the division head who owns the equipment.	Activity eliminated. Improvement is done by submitting forklift tools to be used privately.
6	B4	Take the forklift in its storage.	Re-Layout. Improvements were made to move the forklift storage area.
7	B6	Bring goods to the Quarantine Area.	Re-Layout. Improvement is done by moving the Quarantine Area.
8	B7	Return the forklift to its storage area.	Re-Layout. Improvements were made to move the forklift storage area.
9	E1	Bring goods to the Storage Area.	Re-Layout. Improvement is done that is moving the Storage Area.

Based on the improvement activities in table 6, the researchers conduct the below improvement activities, which are:

- eliminated 4 activities that do not add value. Those activities are; walk to the office to submit information documents and receipt of goods to the Leader; walk back to see the Supplier with the Leader; Make the forklift loan letter; and delivering the forklift loan letter to the division head who owns the equipment.
- reduced the activity by 4 activities.
- reduced the activity mileage by 148 meters.
- shortened the work cycle time carried out by operators as much as 153.34 seconds.

3.5 Step 4. Wrapping up the result

Figure 15 illustrates a map of the process flow, material flow, and data flow that occurred after the improvement activities in the warehouse of vitamin raw materials for livestock. Improvements that have been made, both in the layout and in the ongoing process, are able to reduce waste that arises in the warehouse of raw materials by eliminating non-value-added activities in the ongoing activities.

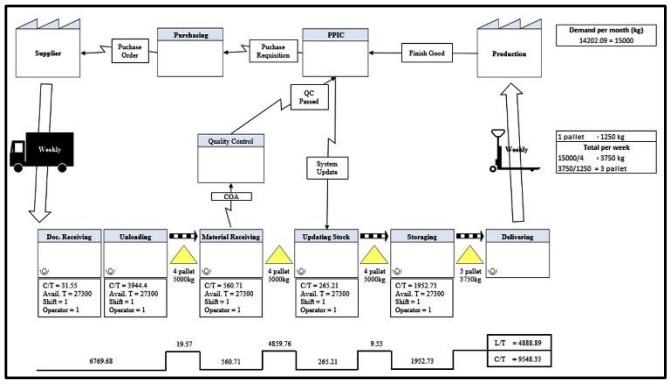

Figure 15. Future State VSM (FVSM)

After eliminated and merged some activities, and eliminate waiting timethat happened between document receiving process and unloading process, it is known that there is a decrease in the amount of activity and the amount of distance. In addition, they impact to a decrease in the work cycle time in the process. The cycle time required by the operator in carrying out warehousing activities after the improvements is 14,437.22 seconds.Calculation of work efficiency after taking corrective actions are as follows:

$$Effective\ Work\ Time = 27{,}300 - (0 + 4{,}888.89) = 22{,}411.11$$

$$Work\ Efficiency = \frac{22{,}411.11}{27{,}300}\ x\ 100\% = 82.09\%$$

4. Conclusion

The VSM method has helped this study in identifying waste and describing improvements to the process in a more structured manner. There are 3 types of waste that occur in the process that takes place in the warehouse of vitamin raw materials for livestock, including excessive transportation (excessive transportation), inappropriate process (inappropriate processing), and waiting time (waiting).

This study also uses ARC and ARD techniques to improve the layout of facilities. This improvement can eliminate 3 types of waste that occurs. With this technique, researchers changed the structure of the location of 6 parts of the warehouse. Researchers also use the dot and check technique to reduce the amount of activity, distance traveled, and unnecessary work cycle times. These improvement activities can reduce waste in the raw material warehouse in three ways. First, this improvement eliminated 4 activities that do not add value. Second, it reduced the activity mileage by 148 meters. Third, it reduced the work cycle time carried out by operators as much as 153.34 seconds. By implementing VSM, ARC / ARD, and Process Improvement, the value of the efficiency of the warehouse process increased by 0.51%.

In the future, other researchers can develop further study to explore delay problem in warehouse from the production system point of view. They can apply other lean manufacturing techniques such as Kanban system, 5S, in the warehouse.

5. Other recommendations

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