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Identification of Waste Supply Chain Flow to Improve Performance

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A B S T R A C T

Semarang city has the amount of waste that piled up in the Landfill as much as 850 tons/day with the amount of unmanaged waste as is 100 tons/day. This phenomenon needs to be identified and evaluated for the flow of waste disposal from upstream to downstream. Therefore, the purpose of this study is to identify the flow of the waste supply chain and simulate it to determine the performance of waste handling in an area. The research method begins with a supply chain questionnaire which will then be statistically tested to be used as input for supply chain flow generation and simulation using Arena software. Based on the identification of the supply chain, the flow of the waste supply chain in the Wonosari area of Semarang is from households to the garbage dump to be taken to the landfill as far as 10 km. From the landfill, it is further processed into a selling value product. In this study, waste from the landfill is also the input material for the paving block production workshop (WPBP FT) at the Faculty of Engineering, Dian Nuswantoro University. Plastic waste will be used as a mixed material for making paving blocks. The supply chain simulation results using Arena show that the performance is good.

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1. INTRODUCTION

Waste management is Indonesia's big homework, especially plastic waste. As much as 24% of waste in Indonesia is left alone. This shows that from about 65 million tons of waste produced in Indonesia every day, around 15 million tons of waste still pollutes the environment and ecosystem, because it is not handled and processed. Meanwhile, 7% of waste is recycled and 69% of waste is in Final Disposal Sites (Sustainable Waste Indonesia, 2018).

Even Semarang City has the amount of waste that is piled up in the landfill as much as 850 tons / day with unmanaged waste is 100 tons / day (National Waste Management Information System, 2019). The highest percentage of waste generation in Semarang City is household waste, which is 70% (DLH, 2019). This is because households produce waste plastic, food waste, paper waste and so on. The amount of heap of waste generated by households certainly needs attention from the government so that waste in the city of Semarang in particular can be managed optimally. The following is a table containing waste production and the volume of waste transported from 2011 to 2018. Table 1 show waste production at Semarang city. Based on the table above, it can be seen that the volume of waste in Semarang City tends to increase every year. The problem of handling complex waste requires cooperation from various parties so that the waste can be handled optimally. Previous research about supply chain management (Setyaningrum, et al, 2021; Ha et al, 2021; Orenstein and Tang, 2021; Herath and Cong, 2021; Setyaningrum, et al, 2020; Okanminiwei & Oke, 2020, Abida and Oke, 2022, Khentaout et al, 2019). This research will identify the waste supply chain flow and perform simulations to improve performance.

2. LITERATURE REVIEW

Supply chain network design is a systematic approach to determine the best location and the most optimal facility size, and ensure the most optimal product flow using a mathematical model (AIMS, 2019). Previous research on organic waste has been carried out by Setyaningrum (2020) on the Supply Chain Flow Model and Simulation of Organic Waste into Catfish Feed. And continued to make PDCA Analysis on Management Administration Information System based on Android at Resik Becik Semarang (Setyaningrum, et al, 2021). Several studies on supply chains also underlie this research, namely green supply chain behavior (Ha et al, 2021), Identifying the Relation Between a Supply ChainNetwork's Structure and Its Overall Financial Performance (Orenstein and Tang, 2021), critical success factors for project management (Herath and Cong, 2021) and A Mathematical Model of Factors Driving Product Success in an Indonesian Market using Design of Experiment (Setyaningrum, et al, 2020). This research using matematichal and statistical process, it is in line with Okanminiwei & Oke (2020), Abida and Oke (2022), Khentaout et al (2019).

3. RESEARCH METHOD

The research subjects were people of Wonosari, Ngaliyan, Semarang, Central Java. Respondents to the questionnaire were community members in Wonosari RW 3 consisting of RT 1, RT 12 and RT 13 who will fill out the waste supply chain questionnaire. This research using random sampling technique. The questionnaire design consist of several statements which include waste capacity, amount of waste, supply chain flow, and waste processing processes. The research phase begins with distributing questionnaires, statistical processing, and designing supply chain simulations with arena software. The design of the waste supply chain flow in Wonosari was identified using a questionnaire, then statistically analyzed the results of the questionnaire and then simulated using the Arena software to identify the waste supply chain flow and its performance.

Table 1. Waste production at Semarang City

Year	Waste production		Volume of waste transported		Percentage of transported (%)
	M^3	Ton	M^3	Ton	
2014	4916,82	1736,36	4179,30	1475,91	85
2015	4998,65	1765,25	4348,83	1535,77	87
2016	5080,00	1793,98	3897,04	1376,23	77
2017	5130,76	1811,91	4236,08	1495,22	82
2018	5156,94	1821,16	4516,76	1595,08	87

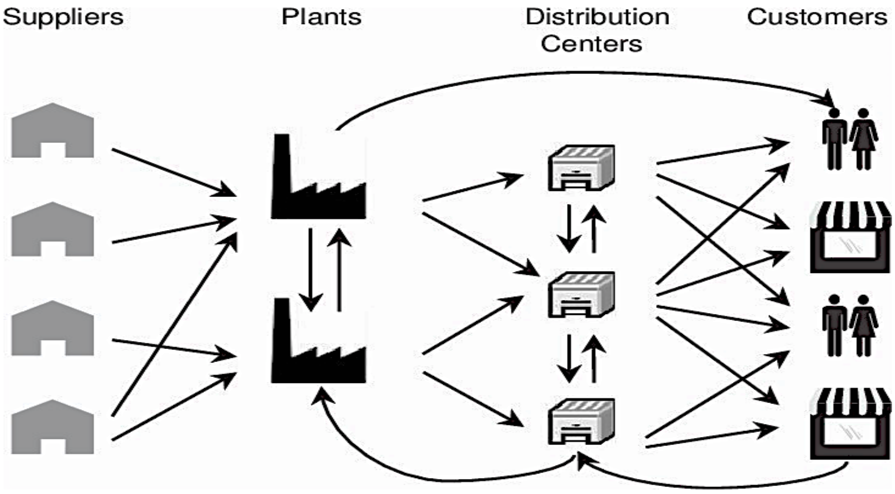

Fig. 1. Supply chain flow (Melo et al, 2006)

The supply chain model that will be made in general is presented in Fig 1. The research data are size of plastic waste from society, waste collection period and capacity of eash final garbage dump. The data will be processed statistically (Mongomery, 2001, Hair et al, 2010 and Box and Hunter, 2005).

The data sources determined for this research can be divided into two, namely primary data and secondary data. The data needed in this study include: (1) Primary Data, is data taken through the source or object of research directly by observing the object directly. This data was obtained from supply chain questionnaires and related parties, many suppliers (customers) including people in RW 3 Wonosari Ngalian, Semarang. Capacity of each final garbage dump per month, waste collection period, (2) Secondary data, is a statistical data collection of Wonosari Semarang.

4. RESULT AND DISCUSSION

Supply chain questionnaire statistical tests include descriptive statistical test, anova test, and regression test that presented in Table 2 until Table 6. Regressin used to determind correlation between dependent and independent variabel. The questionnare that statistically processed is 45 with the variables are organic waste, capacity, waste price, Landfills distance, that shows the mean, deviation standart that presented in Table 1.

Table 2. Descriptive statistics

Descriptive Statistics

	Mean	Std. Deviation	N
Organic waste size	3,38	1,173	45
capacity	1,00	,000	45
Waste price	5,04	2,099	45
Landfills distance	4,76	3,556	45

Table 3. Variable enetered in regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Landfills distance, waste price [b]	.	Enter

a. Dependent Variable: size of anorganic waste
b. All requested variables entered.

Table 3 gives us information about what variables were entered and excluded. The variables included are waste price, Landfills distance. The model column provides information that there is only 1 (one) regression model generated.

Table 4. Model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,202[a]	,041	-,005	1,176

a. Predictors: (Constant), Landfills distance, waste price

Model Summary, here we can obtain information about the magnitude of the influence of all independent variables on the dependent variable. It can be seen that the Adjusted R Square value is -0.05 or 5% of the influence of the independent variable on the dependent variable. The next column in the Model Summary table shows the level of accuracy of the regression model, which can be seen in the Standard Error of The Estimate column, where the number 1.176 is listed. This value is closer to 0 (zero) the more accurate it is, with a figure of that size it can be said that the model formed is accurate at 98.824% (1.176 x 100%).

Table 5. Anova

ANOVA[a]

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2,470	2	1,235	,893	,41[b]
	Residual	58,108	42	1,384		
	Total	60,578	44			

a. Dependent Variable: size of anorganic waste
b. Predictors: (Constant), Landfills distance, waste price

In Table 5, Anova shows information about the effect of the independent variable on the dependent variable simultaneously (together). In this table there are several things that do not need to be discussed, firstly Sum of Square and secondly Mean Square because we don't need them to conclude whether or not the independent variable influences the dependent simultaneously. This is by following the sig level. 0.05 as the cut off value from the significance value. This means that if the probability value (significance) is below 0.05 then all independent variables affect the dependent variable and vice versa. Results sig. is 0.417 result shown that waste price, Landfills distance has no effect on size of inorganic waste.

Table 6. Coefisients

Coefficients[a]

	Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3,34	,518		6,46	,00
	Price waste	-,05	,084	-,090	-,59	,55
	Landfills distance	,060	,050	,181	1,196	,238

a. Dependent Variable: size of anorganic waste

In Table 6, our coefficients are presented with various important and unimportant information, the important information consists of variable names, constant values, t values and significance values. As I said earlier this table can be used to see the effect per variable. There are two ways, first by looking at the sig value. on each variable, if the value of sig. is smaller than 0.05 then the conclusion is effect the smaller sig. the more influential. Based on the results of sig. shows that process waste and Landfills distance have no effect on the size of inorganic waste.

The flow of the plastic waste supply cjain management in the Wonosari area, Semarang city show in Fig 2.

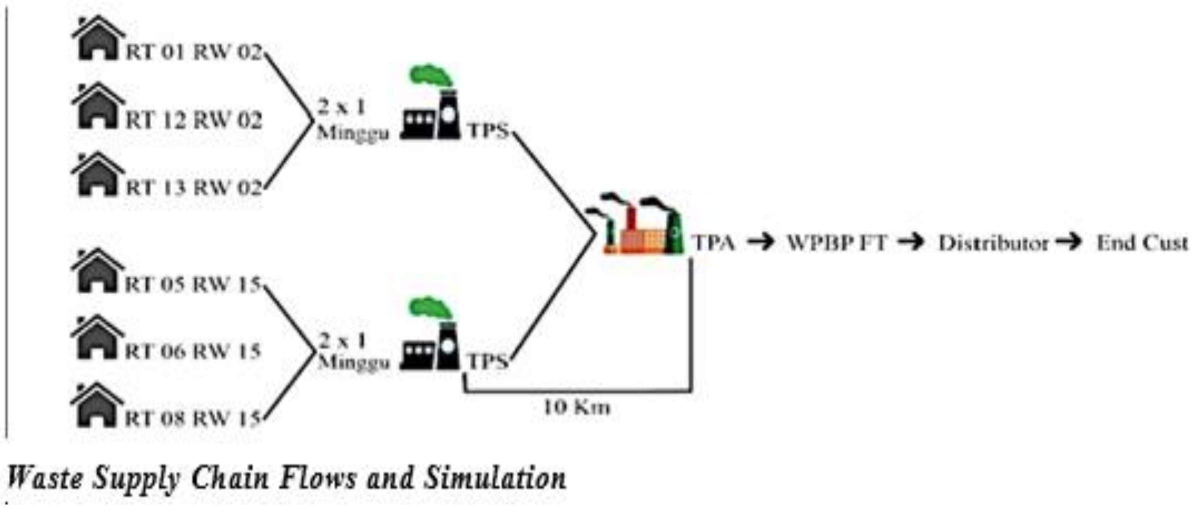

Fig. 2. Waste supply chain flow at Wonosari, Semarang

Fig. 2 shows the flow of the supply chain starting from households in the RW 2 area to 3 RT, namely RT 01, RT 12 and RT 13 in Wonosari Village, Ngalian, Semarang, Central Java, Indonesia. Garbage from the community is taken by garbage officers who travel around the area twice a week. The waste is in the form of vegetable, fruit, plastic and cardboard waste. Garbage officers transport waste from the community to a garbage dump to be taken to a landfill 10 km away.

From the landfill, you can proceed to the process of making recycled waste products. In this study, waste from the landfill is also the input material for the paving block production workshop (WPBP FT) at the Faculty of Engineering, Dian Nuswantoro University. Plastic will be used as a mixed material for making paving blocks. The flow of the waste supply chain will be simulated using the Arena software to identify the flow and evaluate the performance of the supply chain flow which is presented in Fig. 3.

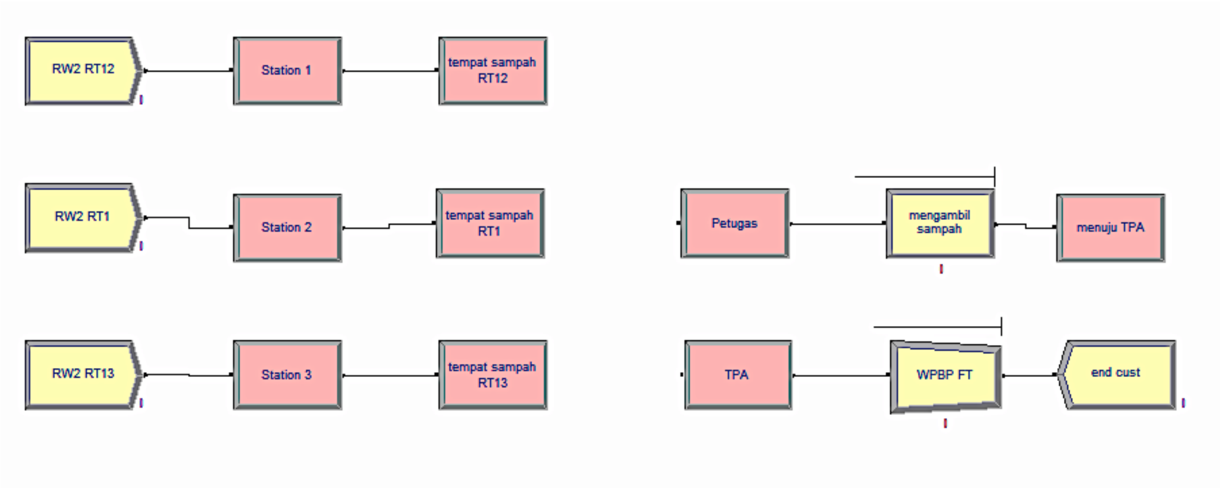

Fig. 3. Simulation waste supply chain flow using arena

In general, the flow of the waste supply chain presented in Fig. 3 is waste in the household (RT/RW) then to the collectors to the landfill in Wonosari. In this study, the area that became the object of research was the Wonosari village in RW 2 which was represented by RT 1, RT 12 and RT 13. The process starts from RW 2 RT 1 where information from the data shows that in 1 day 1 kg of waste is generated and in RT 1 there are 9 residents, each of which has 1 kg of organic waste and 1 kg of inorganic waste. and if the total amount of waste is about 18 kg in RT 1 in a day. Then in RW 2 RT 12 has 10 residents in the data where for about 10 kg of organic waste and 12.8 kg of inorganic for 1 day from the total residents of RT 12.

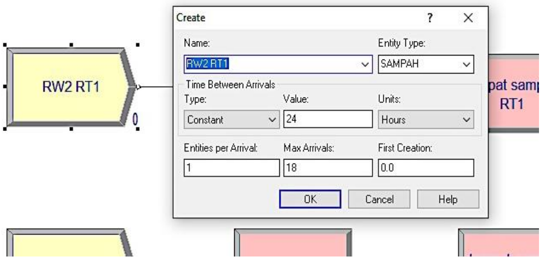

Fig. 4. Interface at arena software

After all the entities have been identified, they will enter the next step, namely the process where the garbage officer picks up trash 2 times a week. From the ARENA simulation, it looks very simple because the path described is very easy to understand if you follow the recap of the questionnaire data. The data looks lacking because in the questionnaire it is stated that waste is sorted and differentiated between organic and inorganic waste. If in the questionnaire there is waste being sorted, then there should be a different process treatment between organic and inorganic waste. Because in the ARENA simulation there is a sorting process. If indeed organic and inorganic waste are processed simultaneously, then the ARENA simulation is more or less like the picture above. If there is a description of the waste or it is classified between bottled waste, vegetables, iron and so on, it must be known how much waste, vegetables, iron and others.

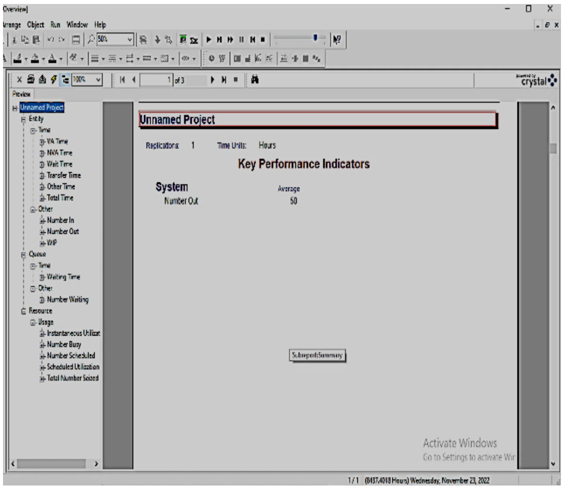

Fig. 5. Output of arena simulation

The output of the simulation using the Arena software shows that the output of 50 kg of waste is presented in Fig. 4. The total waste time is 4079.75 minutes, the number in and number out in the simulation are 100 waste and 24 work in process (WIP) waste, 1765 hour which is presented in Fig. 6. The model has been verify and validate with arena simulation software The results of the Arena software simulation can be used as a reference for the flow of the upstream to downstream plastic waste supply chain

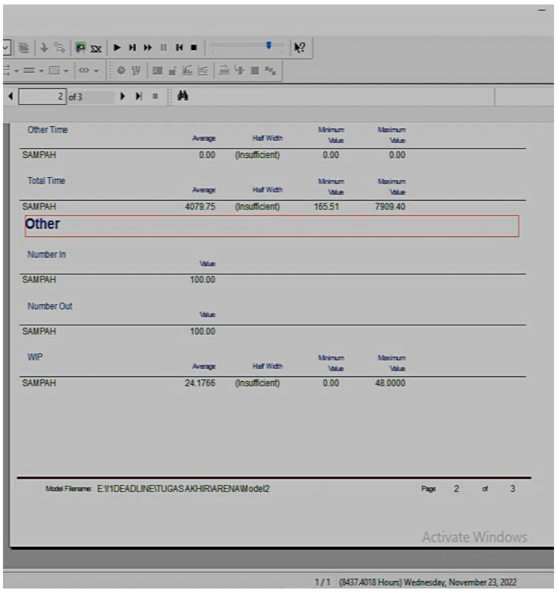

Fig. 6. Waste time analysis using arena simulation

5. CONCLUSION

In this analysis of statistical regression shown that Landfills distance and waste price has no effect on size of inorganic waste. Based on the identification of the supply chain, the flow of the waste supply chain in the Wonosari area of Semarang starts from households in the RW 2 area to 3 RT, namely RT 01, RT 12 and RT 13 in Wonosari Village, Ngalian, Semarang, Central Java, Indonesia. Garbage from the community is taken by garbage officers who travel around the area twice a week. The waste is in the form of vegetable, fruit, plastic and cardboard waste. Garbage officers transport waste from the community to a garbage dump to be taken to a landfill 10 km away. From the landfill, you can proceed to the process of making recycled waste products. In this study, waste from the landfill is also used as material input for the paving block production workshop (WPBP FT) at the Faculty of Engineering, Dian Nuswantoro University. Plastic waste will be used as a mixed material for making paving blocks. The supply chain simulation results using Arena show that the performance is good.

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