



# Organic waste management based on supply chain management using arena simulation and macro ergonomics approach

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## ABSTRACT

In this modern era, simulation software such as Arena has become a valuable tool for designing, optimizing, and analyzing the flow of supply chains efficiently. The aim of this research is to describe and analyze the flow of waste supply chains using Arena software. The second objective is to analyze the behavior of the people of Semarang city regarding organic waste processing using a macroergonomics approach. This study employs a simulation approach by utilizing Arena software to model the flow of waste supply chains from collection, sorting, processing, to final disposal stages. Using Arena software, simulation results can be measured and objectively analyzed, serving as a basis for identifying improvements and enhancements in the waste supply chain. To manage organic waste in an area it is necessary to involve cognitive, psychological, organizational and environmental aspects. The strategy for managing organic waste in urban areas such as the Semarang area is to manage and ensure that organic waste has added value and sales value.

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## 1. INTRODUCTION

Semarang City has the largest source of waste from households, this is because the population in the city is dense. Based on the population and civil registration service, in 2022 the population Semarang city will reach 1,688,133 people. Consisting of a male population of 835,849 people and a female population of 852,284 people. It has 16 sub-districts and one of the sub-districts in this is the East Semarang sub-district. East Semarang has 10 sub-districts including the sub-districts of Mlagiarjo, Mlatibaru, Kemijen, Kebonagung, Karangturi, Karangtempel, Bugangan, Rejomulyo, Rejosari, and Sarirejonang. These 10 sub-districts have a population of 70,726 people consisting of a male population of 34,364 people and women numbered 36,362 people. This large population does not rule out the possibility that the amount of waste production will increase. The sum of waste in East Semarang is mostly from household and HORE (Hotel Restaurant). In East Semarang by distributing questionnaires to 32 respondents on HORE. Waste from households and HORE is each collected in the rubbish bin and every day there will be a cleaning crew who will pick up it. The waste is taken using transportation by a truck which will later be taken to the final disposal site (TPA) in Jatibarang. The waste from the TPS comes from household waste which is thrown away in the respective rubbish bins and it will be picked up by cleaning staff using rubbish tricycles and then thrown into the TPS.

After the waste is at the TPS, it will be taken using a waste truck which will be taken to the final disposal site for processing. This research was conducted to determine the supply chain flow of the waste processing process in HORE (Hotel Restaurant) East Semarang so that it can model the supply chain flow to simulate community behavior in waste management in East Semarang using arena software.

The supply chain flow from upstream to downstream in managing organic waste shows the behavior of the people of Semarang city in managing organic waste. Community behavior in managing organic waste will be simulated using Arena software and behavioral suggestions will be provided that will increase the efficiency of organic waste management in the city of Semarang. Previous research about supply chain management have been do to many activities example about customer strategy [1] combine supply chain and macroergonomic [2] about supply chain and logistic [3]–[5]. Previous research about economic analysis have been do tologistic[6]–[9] supply chain in potatoes product [10]. Previous research about culture analysis have been do to many activities [11]–[13]. Previous reaserch explain culture product [14]–[16]. Analysis of the behavior of the people of Semarang city regarding organic waste processing was carried out using a macroergonomics approach. The scope of the macroergonomics approach is presented in Figure 1.

The macroergonomics approach presented in Figure 1 shows that macroergonomics examines it from a cognitive, physical and organizational and environmental perspective. The macroergonomic approach to the behavior of the people of Semarang city will be studied in more detail from an organizational and environmental perspective.

## 2. MATERIALS AND METHODS

The location of this research was carried out at the Jatibarang Final Disposal Site and East Semarang HORE (Restaurant and Hotel) which has joined the Indonesian Hotel Restaurant Association PHRI). Primary data is obtain from observation and interviews conducted at Hotel, Restaurant (HORE) East Semarang. Data from HORE respondents in the Semarang area was collected from 32 respondents, consist of respondent at restaurant and hotels. This primary data consists of name, address, amount of waste collected, type of waste collected, officer who picks up the waste, distance from the location to the landfill, and costs incurred to pay for the waste. During the interview with HORE East Semarang, to find out more about the Purwodadi waste bank and HORE East Semarang, the author used questions referring to 5W + 1H, namely What, Why, Who, When, Where Where), and How.

The research processing stage begins with statistical testing and continues with a simulation of organic waste management behavior related to organic waste flow using Arena software. This stage is processing data that has been collected using SPSS. The data to be tested is primary data with normality test, Anova test and regression test. In the normality test, it is used to find out whether the variables used are normally distributed or not. The ANOVA test (Analysis of variance) is used to test whether there is a difference in means between groups because the results of this test are the F test value. In the regression test to provide evidence of a functional relationship between the independent variable (X) and a dependent variable (Y). At the Arena simulation stage, a simulation of the organic waste supply chain flow in hotels and restaurants in the East Semarang area will be designed.

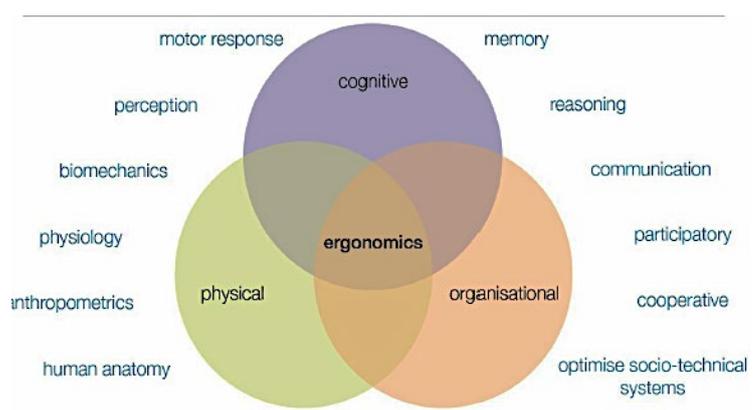


Figure 1. Macroergonomics concept [17]

### 3. RESULTS AND DISCUSSION

#### 3.1. Statistical Test

The statistical test carried were statistical descriptive, data adequacy tes, normality test, anova test, linier regression test. The result of the ANOVA test and regression test are presented in Table 1 and Table 2.

**Table 1.** Output ANOVA

Sum of Squares	ANOVA					
			df	Mean Square	F	Sig.
Organic Capacity	Between Groups	5092.875	28	181.888	6.654	.071
	Within Groups	82.000	3	27.333		
	Total	5174.875	31			
Anorganic Capacity	Between Groups	4615.219	28	164.829	1.435	.438
	Within Groups	344.500	3	114.833		
	Total	4959.719	31			

Based on the ANOVA test output above, it is known that the significance values for organic and inorganic capacity are 0.071 and 0.438 respectively. This value is greater than 0.05 so the averages are different.

**Table 2.** Output Regresi Coefficients<sup>a</sup>

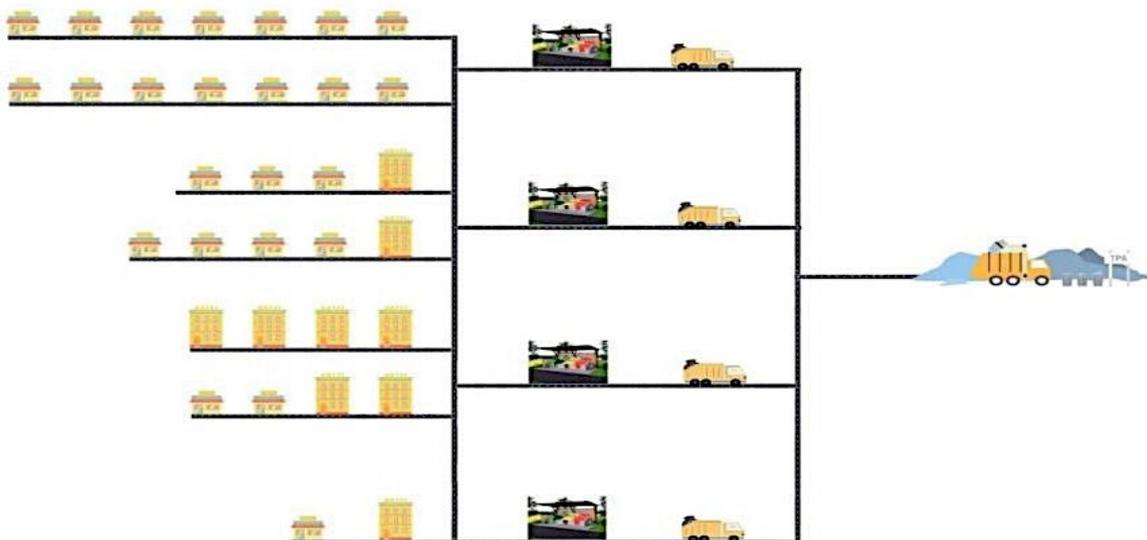
Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-8.145	17.306		-.471	.641
	Distance to TPA	1.525	.890	.253	1.713	.097
	Waste Costs	.046	.012	.560	3.787	.001

a. Dependent Variable: sum of capacity

The results of multiple linear regression analysis obtained the regression equation:

$$Y = -8.145 + 1.525X_1 + 0.046X_2 \tag{1}$$

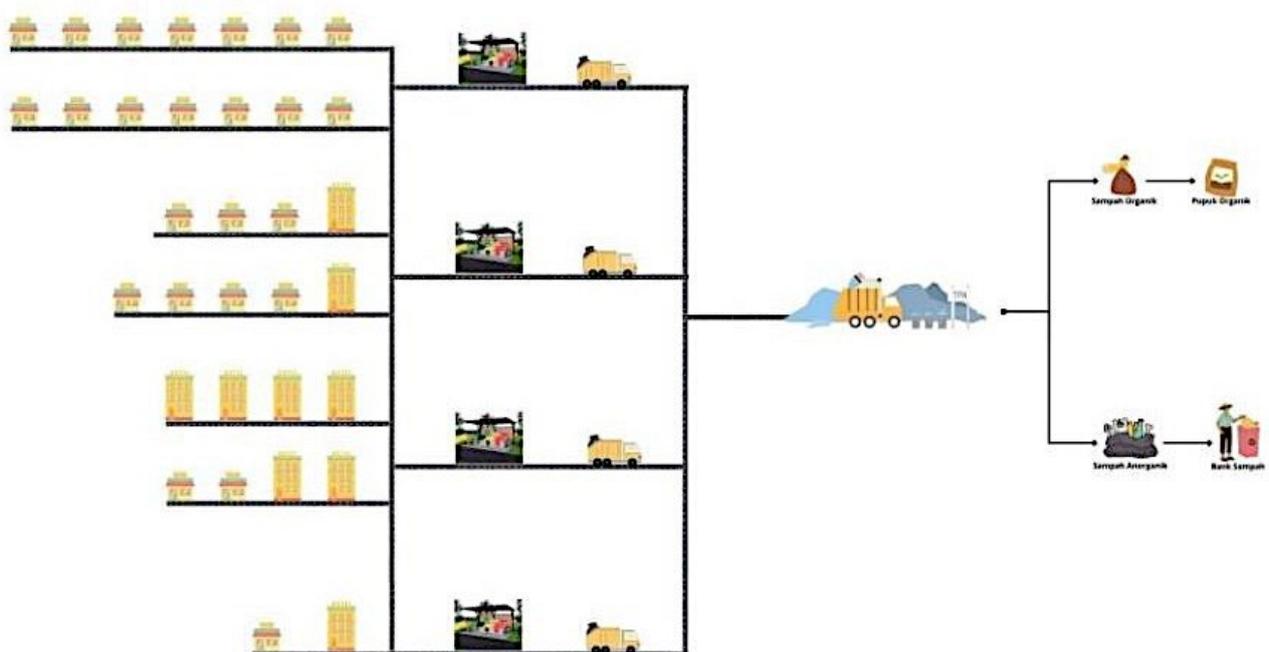
Based on statistical result, independent variable are distance TPA / landfill (X1) and waste cost (X2), as well as dependent is total capacity. The results of the multiple linear regression test are that the constant value (a) has a negative sign, namely -8.145, which means that if the distance to the landfill and the cost of waste is equal to zero (0), the amount of waste will decrease. According to Nurhidayati & Yuliantari[18], negative constants are not a problem and can be ignored as long as the slope value is not zero (0), so there is no need to care about negative constants. According to Ardiani et al [1], the Likert scale used does not include the number 0 (nul), but a range of numbers 1-10, so that variables X1 and X2 cannot possibly be equal to 0 (nul). therefore this negative constant can be ignored[1]. The regression coefficient value for the variable distance to the landfill (X1) is 1.525, which means that the distance to the landfill has a positive effect on the amount of waste capacity; The regression coefficient value for the waste cost variable (X2) is 0.046, which means that waste costs have a positive effect on the total waste capacity. The output of this research shows the regression coefficient value of distance to landfill (1.525) and waste costs (0.046); because 1.525 > 0.046, the distance to the landfill is the variable that has the dominant influence on the amount of waste capacity.



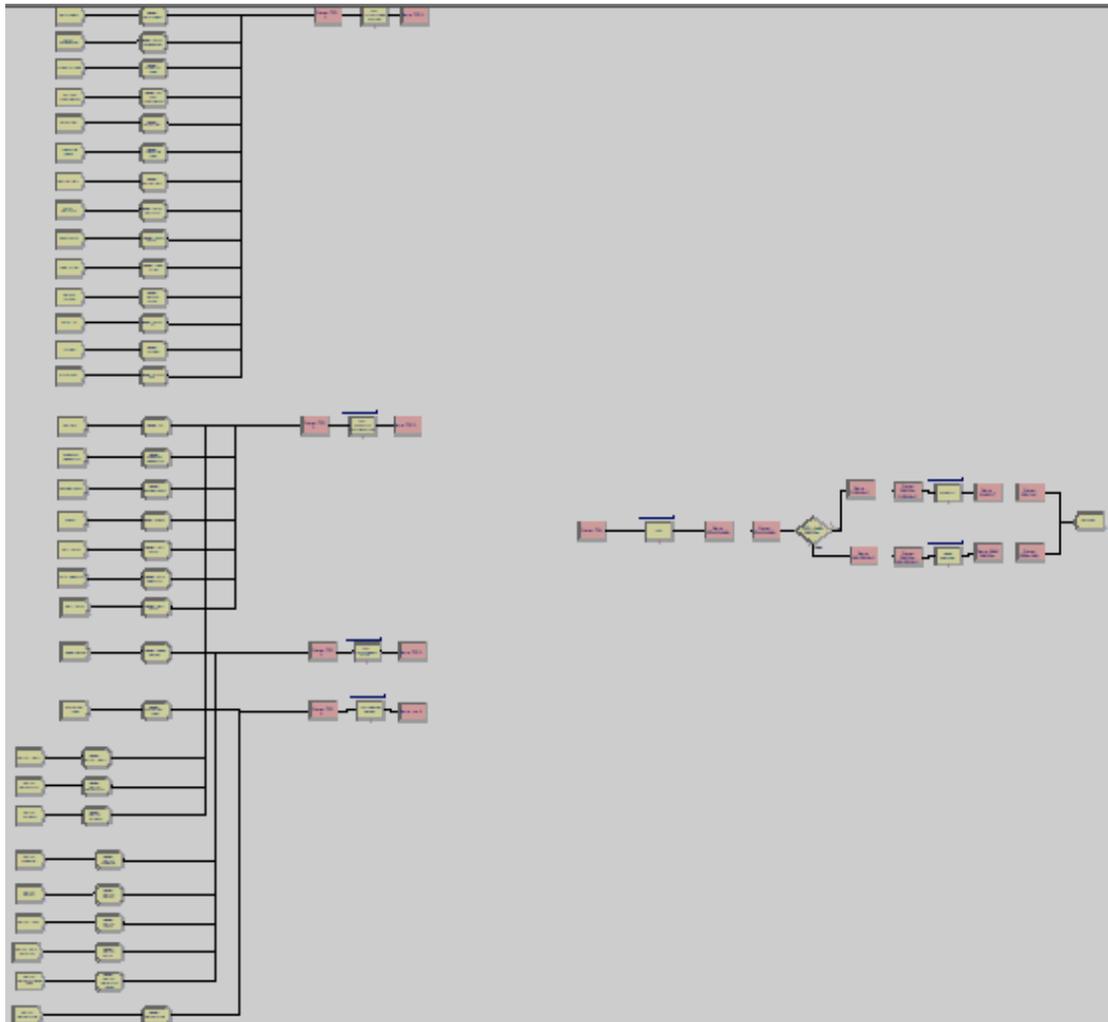
**Figure 2.** Flow of the organic waste supply chain for hotels and restaurants in the East Semarang area (current conditions).

3.2. Organic waste supply chain flow (Current Condition and Recommendation)

The flow of the HORE organic waste supply chain in the East Semarang area, there are 4 TPS presented in Figure 2. At the first TPS, namely the Tlogosari Wetan TPS, which receives waste from the Hokben restaurant, Memori Coffee, Virgin Cake, Indonesian iced tea, Domino, Laffeine Coffee & Katsu, Swiss Deli, Kellon Coffee, Kata Kopi, Café Our, Home Café, Kopi 17, Cobek, and Pizaa Hut. At the second TPS, namely TPS 3R Dadi Resik, which consisted of Rodjo, Bangor Burger, Antara Kata, Fancy, Dol Kopi, Mie Ramon, Beli Kopi, Dalu Hotel and Horizon Hotel. In the third TPS, namely Mukthiharjo Kidul TPS which consists of Cloud Direction, MuriA Hotel, Homi Hotel, Triz Hotel, Bliz Hotel, Redor near USM, Sunrise Hotel. Meanwhile at the 4th TPS, namely the Sawah Besar TPS which consists of the Redorz Hotel and Medono Café. The waste from each TPS will be taken later to the final disposal site at the Jatibarang TPA. The following is an implementation in Arena software.



**Figure 3.** Flow of the organic waste supply chain for hotels and restaurants in the East Semarang area (recommendation)



**Figure 4.** Simulation of the behavior of the HORE waste processing flow in the East Semarang region

The proposed East Semarang HORE supply chain flow simulation shows the behavior of East Semarang city residents in managing organic waste. Community behavior in managing organic waste systematically can be shown through the flow of the organic waste supply chain from upstream to downstream, presented in Figure 3. Simulation of organic waste management flow behavior using Arena software is presented in Figure 4.

The next step is to simulate the flow using Arena software. The output produced from the proposed Arena simulation is 49 fertilizers from the total waste produced of 146 waste. Based on the Arena simulation results presented in Figure 5, it shows that these 49 fertilizers are processed into fertilizer within a working time of 8 hours per day. Proposed Initial Simulation Output of East Semarang HORE Supply Chain Entity. The NVA Time entity generated an average of 7.3878 at a transfer time of 4892.32 at another time of 20.1020 with a total entity of 4919.81. Proposed initial simulation of the East Semarang HORE supply chain queue with the output produced in the queue, there is a waiting time at the waste bank with an average of 4500.92 for compost fertilizer, 4263.42 for TPA, 4473.97 for TPS 3R dadi resik, 4428.52 for TPS Tlogosari Wetan 4422.32. Meanwhile, for waiting numbers, there are waste banks, compost fertilizer, TPA, TPS 3R Dadi Resik, TPS Mukthiharjo, TPS Sawah Besar, and TPS Tlogosari.

### 3.3. Macroergonomic Approach in HORE Waste Management in the East Semarang City Area

The concept of macroergonomics combines cognitive, physical and organizational. Besides that, macroergonomics, based on what is presented in Figure 1, also considers the environment. Patterns of organic waste management behavior in th Semarang area can be studied using a macroergonomics approach. To manage organic waste in an area it is necessary to involve cognitive, psychological, organizational and environmental aspects. The cognitive aspect is developed through educational

programs to increase understanding about organic waste management, education about the self-awareness of the people of Semarang city to protect and preserve the environment as in Figure 6.

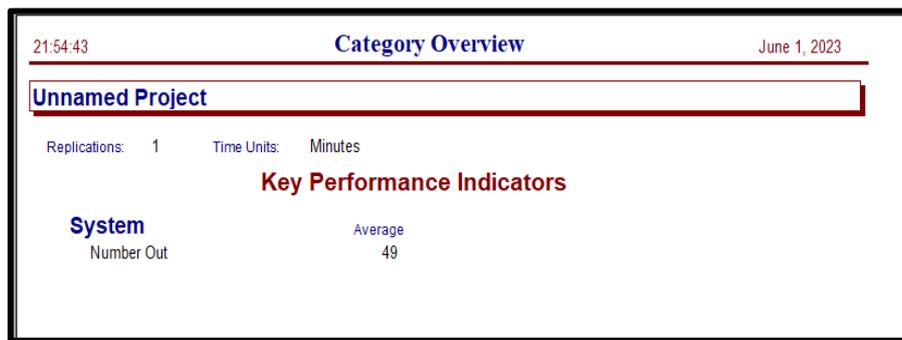


Figure 5. Arena simulation results of HORE supply chain flow in the East Semarang region

Previous research about macroergonomics implemented in company to improve productivity and retention [19], [20]. The organizational aspect is an aspect related to the culture, behavior and habits of the people of Semarang city in managing organic waste. Based on research conducted by Setyaningrum et al [21], it shows that the people of Semarang City have cultural characteristics and habits which are studied based on Hofstede cultural which is processed using principal component analysis [21]–[23]. According to Hofstede, the city of Semarang shows high power distance index (PDI), masculinity (MAS) and collectivism (COLL) dimensions while the uncertainty avoidance (UAI) and long-term orientation (LTO) values are medium. This cluster consists of several large Indonesian cities, some of which are regional capitals of Indonesia. Based on the value of the cultural dimensions of internal characteristics (PDI, MAS, COLL) it has a relatively high internal characteristics value which is a characteristic of urban society. The cultural dimension of masculinity is defined as a preference for success (money, competition and material) and relatively higher awards (achievement). Material success is one measure of life satisfaction and happiness[24]. The environmental and future characteristics dimensions are classified as medium because regional conditions have dynamic uncertainty and risk factors. This is related to the conditions of big cities which are closely related to the nuances of government and a dynamic political system as well. Political and economic conditions influence cultural change and communication in society[25], [26]. Therefore, the strategy for managing organic waste in urban areas such as the Semarang area is to manage and ensure that organic waste has added value and sales value. The final result of this research are supported by previous reference related to supply chain, culture change on product development.



Figure 6. Improving cognitive and environmental aspects through organic waste management workshops

#### 4. CONCLUSION

Based on the Arena simulation results shows that these 49 fertilizers are processed into fertilizer within a working time of 8 hours per day. Proposed initial simulation of the East Semarang HORE supply chain queue with the output produced in the queue, there is a waiting time at the waste bank with an average of 4500.92 for compost fertilizer, 4263.42 for TPA, 4473.97 for TPS 3R Dadi resik, 4428.52 for TPS Tlogosari Wetan 4422.32. Meanwhile, for waiting numbers, there are waste banks, compost fertilizer, TPA, TPS 3R Dadi Resik, TPS Mukthiharjo, TPS Sawah Besar, and TPS Tlogosari. The strategy for managing organic waste in urban areas such as the Semarang area is to manage and ensure that organic waste has added value and sales Patterns of organic waste management behavior in the Semarang area can be studied using a macroergonomics approach. To manage organic waste in an area it is necessary to involve cognitive, psychological, organizational and environmental aspects. The strategy for managing organic waste in urban areas such as the Semarang area is to manage and ensure that organic waste has added value and sales value.

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