Sustinere
Journal of Environment and Sustainability
Volume 6 Number 1 (2022) 1-13

Print ISSN: 2549-1245 Online ISSN: 2549-1253
Website: https://sustinerejes.com E-mail: sustinere.jes@iain-surakarta.ac.id

RESEARCH PAPER

The optimization of waste transportation systems in Genuk District, Semarang City

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Article history:
Received 16 March 2021 | Accepted 21 March 2022 | Available online 30 April 2022

Abstract. Genuk District is a residential development area which has a role as a Semarang City's transportation hubs. It is directly adjacent to Demak Regency and the Java Sea. As of the time of writing, Genuk District has a population of 117,174 people with the total of 130.88 m^3 waste transported to the landfill each day and the percentage of waste transportation services in the area is 38.53%. The waste transportation average operational time is 0.2 hours exceeding the amount of working time with the number of 17 trips/day. This planning aims to arrange the waste transportation system in Genuk District by taking into account the traffic congestion in order to get the optimal operational time and costs. Arm roll truck vehicle operating costs in the existing conditions in 2020 was IDR 1,347,411,591.00, while in the optimized condition would be IDR 1,341,405,786.37. Meanwhile, dump truck vehicle operating cost in the existing conditions in 2020 was IDR 302,002,441.00, while in the optimized condition would be IDR 278,453,956.22. The operational time for waste transportation should be started at 06.00-15.00. After optimization, the average remaining working hours becomes 2.68 hours per day with a vehicle's speed of 57.11 km/hour. The planning for waste transportation system optimization will reduce the retribution costs by IDR 900.00 and increase the percentage of waste transportation services to 53%.

Keywords: waste transportation; optimization; operational time; vehicle operating costs; traffic congestion

1. Introduction

Dense populations in urban areas produce waste from their entire activities (Purkayastha et al., 2019). This includes Semarang City, the capital city of Central Java whose population continues to grow over the years. The population growth rate of Semarang City from 2015-2018 is 1.64% per year (BPS, 2019). The rapid and constant urban population growth comes with the significant rise of municipal waste generation (Das & Bhattacharyya, 2015). This condition causes an increase in the amount of waste to be managed. Waste management consists of several components, including storage, collection, transfer, transportation, processing, and landfills (Sahil et al., 2016). Waste transportation takes up the most significant percentage of costs that range from 50-70% of the management cost (Tchobanoglous et al., 1993). Meanwhile, the cost of waste transportation in Indonesia is 50 – 60 % of the total cost of waste management (Damanhuri, 2010).

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DOI: https://doi.org/10.22515/sustinere.jes.v6i1.179

Genuk District is a residential development area that has a population growth rate of 10.55% per year. The total area of Genuk District is 27.39 km2, and it is divided into 13 sub-districts that consist of 687 RT (neighborhoods) and 98 RW (hamlets). Genuk District's population is 117,174 people, and it rises steadily every year (BPS, 2019). This condition causes the municipal waste generation of Genuk District increases. It impacts on the increas of the cost of waste transportation in Genuk District.

Genuk District's geographic location, including its waste dumps, is directly adjacent to Demak Regency and the Java Sea, which is far away from the Jatibarang landfill. Additionally, Genuk District is Semarang City's transport hub, and it is also close to the port. This condition causes the community activities and instability of road conditions to increase. According to Siswanto et al (2012), there are three congested spots in Genuk District. These three spots are located on Kaligawe Main Street (in which there is Terboyo Bus Station), Terboyo Industrial Zone, and in front of Genuk Market.

High vehicle mobility will also result in congestion which will lead to the delays in travel time and the increase of burn material consumption (Dharmawan and Setiawan, 2017). Therefore, high vehicle mobility will impact negatively to time and operational costs of waste transportation from Genuk District Waste Dumps to the Jatibarang landfill. The absence of a system that manages the time and route of waste transportation is the reason why the optimization of the waste transportation system in Genuk District is crucially needed to create the most efficient route, time, and cost. Optimization of waste transportation is also one of the main concerns in planning municipal waste management systems (Das & Bhattacharyya, 2015).

2. Methodology

The planning for the optimization of the waste transportation system was designed using clear and systematic steps. Therefore, in conducting the planning, we used three methods, which included:

2.1. Sampling technique

Samples were obtained by doing direct observation of the field in order to understand the existing conditions. The sampling was conducted by routing the waste transportation vehicle using My Track application. It aimed to discover the speed and route of the waste transportation vehicle, either when the container was empty or when the container was filled. Samples obtained in this plan were waste transportation vehicles in Genuk District that consisted of arm roll trucks as well as dump trucks.

Vehicle accumulation usually occurs at peak hours in each morning, noon, and afternoon (Pramanasari et al,. 2014). The sampling was also applied to measure the traffic density using the traffic counting method at three-time segments every day (weekday and weekend): in the morning, noon, and afternoon. The time segment division was analyzed based on the calculation of road volume, road capacity, and the degree of traffic saturation (DPU, 1997).

2.2. Data collection technique

The data collected in this plan consisted of primary and secondary data. Primary and secondary data were gathered from the Environmental Services of Semarang City, Technical Implementation Unit of Cleanliness in Region II of Semarang City, Transportation Service of Semarang City, and Public Works Service of Semarang City. The primary data collection was conducted by doing direct observation and interviews. The primary data includes vehicle speed, time, and route. The data was measured by My Track application and stopwatch. Meanwhile, the secondary data was collected by undertaking a literature study on existing inventory documents in each agency. The secondary data includes CCTV data of road sections, side barriers, types of road, and widths of road passed by the waste transportation.

2.3. Data processing and analysis technique

The data processing and analysis techniques applied in the optimization planning of waste transportation in Genuk District were divided into three. These three data processing and analysis techniques included the analysis of the effect of traffic density, existing conditions, and optimization of the waste transportation system in Genuk District by focusing on the traffic density.

The analysis of the effect of traffic density on the waste transportation route in Genuk District was obtained based on the calculation of vehicle volume through CCTV data using the Traffic Counting method (DPU, 1997). In addition, other factors applied in the analysis of traffic density included side barriers, types of road, and the widths of road used to transport the waste. Based on the traffic density analysis result, the road capacity, degree of traffic saturation, and level of service (LOS) were known. The results of this calculation would be used to determine the right time and operational routes along with the vehicle speed. The road capacity and degree of saturation were calculated using Equation 1 and 2 as follows.

$$C = CO \times FCW \times FCSP \times FCSF \times FCCS \quad (1)$$

$$DS = Q/C \quad (2)$$

Where:

C	=	Capacity (pcu/hour)
Co	=	basic capacity (pcu/hour)
FCw	=	Capacity adjustment factor related to lane/path width
FCSP	=	Adjustment factor with respect to direction separator (at undivided distances)
FCSF	=	Capacity adjustment factor related to side resistance
FCCS	=	Capacity adjustment factor with respect to city size
DS	=	Degree of Saturation
Q	=	Traffic Volume (vehicle/hour)

The analysis of the existing conditions was done to understand the operational time, the level of waste transportation service in the next five years projection, the number of trips, and the number of waste transportation vehicles. Operational time was calculated based on the Minister of Public Works Regulation Number 3 of 2013 (PERMEN, 2013). Meanwhile, the population projection used the geometric/arithmetic/exponential method. Equations 3 and 2 were used to calculate waste transportation time ($T_{HCS/SCS}$) and equation 5 and 6 were used to calculate waste collection time ($P_{HCS/SCS}$).

$$T_{HCS} = (P_{HCS} + s + h) \quad (3)$$

$$T_{SCS} = (P_{SCS} + s + a + bx) \quad (4)$$

$$P_{HCS} = (pc + uc + dbc) \quad (5)$$

$$P_{SCS} = CT\,(Uc) + (np-1)(dbc) \quad (6)$$

Where:

$T_{HCS/SCS}$	=	Transportation time (hours/rit)
$P_{HCS/SCS}$	=	Waste collection time (hours/rit)
s	=	Time in landfill for loading and unloading (hours/rit)
h	=	transportation time from TPS to landfill (hours)
a	=	empiric constant charge continuously (hour/rit)

b	=	empiric constant charge (hour/km)
x	=	mileage (km/rit)
pc	=	time to transport the filled container (hours/rit)
uc	=	time to empty the container (hours)
dbc	=	time to travel the distance from container to another container location (hour/rit)
CT	=	number of containers emptied/rit (containers/rit)
Uc	=	average time to empty containers (hours/rit)
np	=	number of container locations retrieved per rit (location/rit)

The optimization of the waste transportation system was conducted by analyzing the routes taken by waste transportation vehicles by using the network analyst feature on ArcGis and Google Maps. The results of this route analysis would obtain the most optimal vehicle route. Besides, the analysis was also done on the data regarding gasoline prices per liter, tire prices per piece, mechanical costs per hour, and recapitulation of vehicle operating costs in existing conditions using the Pacific Consultant International (PCI) Method. The analysis using this method would produce vehicle operating costs and labour wages.

3. Results

3.1. Traffic conditions that were passed by waste transportation vehicles in Genuk District

Genuk District is one of the urban areas in Semarang City with a population that continues to grow every year. The level of traffic density goes hand in hand with population growth. The components used to determine the traffic density in this plan were the types of road, the vehicle's volume, and the degree of saturation on the road passed by the waste transportation vehicle in Genuk District.

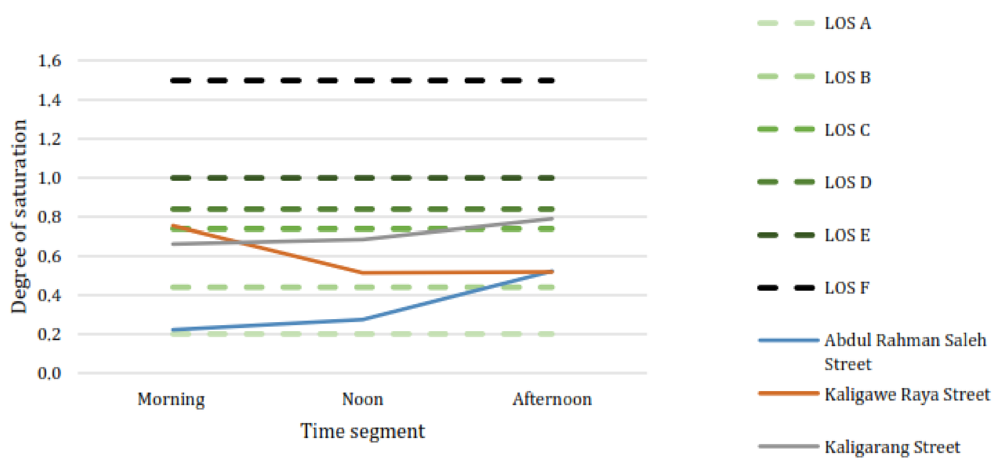

Figure 1. The degree of saturation on the three roads on weekdays

The traffic volume pointed out the number of vehicles that went on the road that the waste transportation vehicles passed in the unit of time (days, hours, and minutes). The degree of traffic saturation was a crucial factor in determining the road traffic conditions that were passed by the waste transportation vehicles from Genuk District. The value of the degree of saturation showed whether or not the road had any problems in accommodating the vehicle volume/road capacity. The traffic volume was calculated based on CCTV footage on roads that were crucial and had high density. These roads included Abdul Rahman Saleh Street, Kaligawe Main Street, and Kaligarang

Street. The traffic volume was determined based on the three-time segments, which were in the morning between 5 a.m – 10 a.m, at noon between 10 a.m – 3 p.m, and in the afternoon between 3 p.m – 5 p.m.

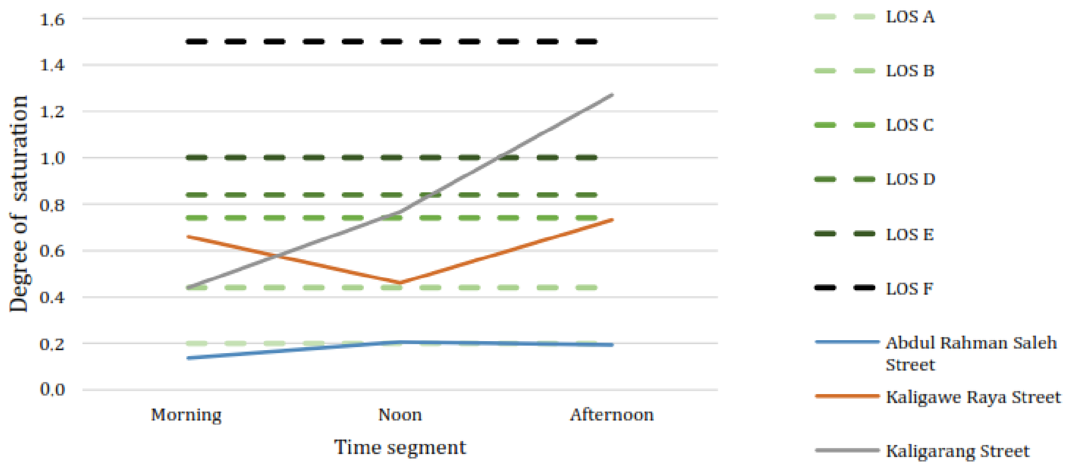

Figure 2. The degree of saturation graphic on the three roads on weekend

The highest degree of saturation occurred on Kaligarang Street in the afternoon (in the time span of 3 p.m -5 p.m) with a degree of saturation value of 1.269. The degree of saturation values that were more than one on Kaligarang Street in the afternoon segment should be avoided in this optimization planning. If the degree of saturation were more than one, it would have a LOS F value, and there would be severe problems in the street during that time frame. This situation was caused by the existing traffic flow plan that exceeds the road capacity's value in accomodating the traffic flow. Based on the degree of saturation values and Level of Service, the waste transportation vehicle from Genuk District when passing the crucial roads was 57.11 km/hour.

3.2. Existing condition of waste transportation system in Genuk District

In the present study, we analyzed the existing conditions of the waste transportation system in Genuk District in terms of the level of waste transportation services, waste generation, facilities and infrastructure, waste transportation systems, waste transportation vehicle routes, and transportation time.

3.2.1. Waste generation of Genuk District

Genuk District produced 339.65 m^3 of waste per day. Based on the weigh station results at the Jatibarang landfill for eight days starting from 14^{th} to 21^{st} of November 2020, the average volume of waste in Genuk District that entered the Jatibarang landfill was 130.88 m^3/day. The percentage of waste transportation services that entered the landfill in Genuk District based on the calculation results was 38.53%.

3.2.2. Facilities and infrastructure

Genuk District is equiped with facilities and infrastructure that supported waste transportation with varying conditions based on its type. The condition of facilities and infrastructure in Genuk District could be viewed from the results of the interviews and observations. The waste transportation in Genuk District, which was regulated by Semarang City's Regional Technical Implementation Unit of Cleanliness in Region II from the waste dumps to the landfill, used two types of vehicles: arm roll truck and dump truck. There were four arm roll trucks that served the Genuk District and there was only one unit of dump truck in this district. Waste transportation in Genuk District started from the East Garage Pool, which is located in Kaligawe Subdistrict, Gayamsari District, Semarang City. Waste transportation vehicles would depart from the pool to the waste dumps. Genuk District had 12 waste dumps, each of which had a container in it. Most of the waste dumps in Genuk District are roofless. This condition would cause problems during the rainy seasons because all the waste in the open containers can become quickly decomposed and overloaded.

3.2.3. Waste transportation systems

Genuk District applied two types of waste transportation patterns which complies with Indonesia National Standard (SNI) 19-2454-2002 (BSN, 2002) concerning Municipal Waste Engineering Management procedures. The systems used were the Hauled Container System (HCS) and Stationary Container System (SCS). The system applied to transport the waste containers at each waste dump in the HCS used the third way in (SNI) 19-2454-2002. The third way can be viewed in Figure 3. Shortly, the waste transportation pattern using the third way in Genuk District was Pool-waste dumps-landfills- waste dumps- landfills- waste dumps- landfills-Pool. The waste transportation in Genuk District using the dump truck started from the East Garage Pool then it would go around or flush from one waste dump to another. The waste transportation system used for waste transportation in Genuk District was Pool – waste dump – waste dump – waste dump – landfill -Pool.

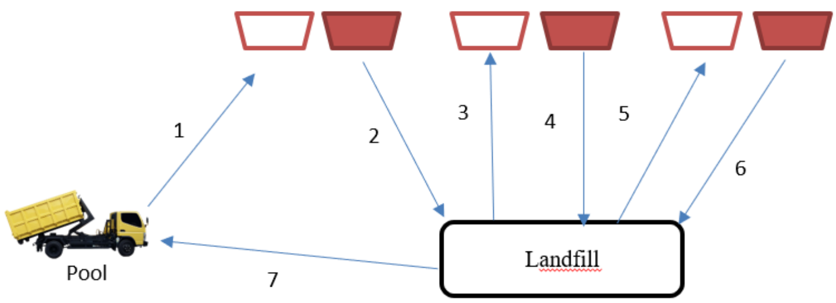

Figure 3. The HCS used the third way in (SNI) 19-2454-2002

3.2.4. Waste transportation routes

The arm roll truck routes in the existing condition could be found with the assistance of 'my tracks' application. The route that the waste transportation vehicle took in the existing condition was uncertain and only relied on the drivers' decision. The drivers took three routes from the waste dumps to the landfill.

The route usually taken by arm roll truck vehicles is Kaligawe Main Street- Yos Sudarso Street - Siliwangi Street - Muradi Street - Abdul Rahman Saleh Street - Untung Suropati Street. On the other hand, the route that is usually chosen by the dump truck is Kaligawe Main Street - Barito Street - RA Kartini Street - Mayor Jend. I.D Panjaitan Street - Mayjend Sutoyo Street - MH Thamrin Street- Pandanaran Street- Kaligarang Street - Taman Gedung Batu Raya Street - Simongan Street - Untung Suropati Street or Kaligawe Main Street - Yos Sudarso Street - Kokrosono Street - Bojong Salaman Street - Pamularsih Street - Simongan Street - Untung Suropati Street. The routes passed by arm roll trucks and dump truck were also used as routes from the landfill to the next waste dumps.

There is also one shortest route that could only be passed by waste transportation vehicles from the waste dumps to the landfill because it passes through the heart of Semarang City. The route is Untung Suropati Street - Simongan Street - Kaligarang Street - Kapten Piere Tendean

Street - Pemuda Street - Kolonel Sugiono Street - Imam Bonjol Street - Empu Tantular Street-Taman Tawang Street - Pengapon Street - Kaligawe Main Street. The distance traveled by the arm roll truck was 630.5 km with an average speed of 20.35 km/hour. Meanwhile, the total distance for transporting waste using the dump truck was 67.38 km, with an average speed of 13.35 km/hour. The existing waste transportation route can be viewed in Figure 4

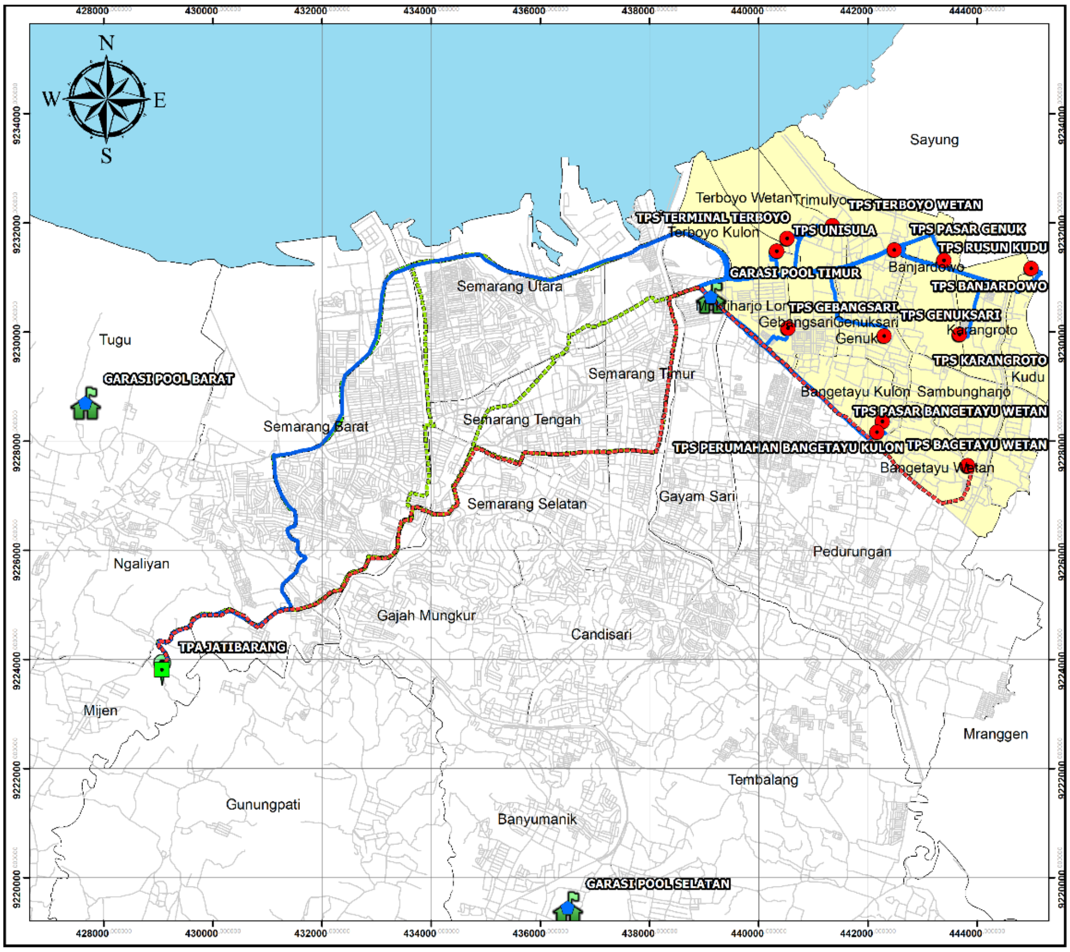

Figure 4. Waste transportation route in existing conditions

3.2.5. Vehicle operating time and costs

The arm roll trucks that serve Genuk District have tasks for transporting waste from each waste dump in 3-5 trips each day. The distribution of the number of trips for each arm roll truck which operate in Genuk District have not been inclusive. Waste transportation using arm roll trucks had excess working time of 1.01 hours. The dump truck serves Genuk District in two trips in its existing condition. The dump truck's first trip will be combing the streets, illegal dumpsites, and waste dumps where the waste is overloaded. Waste transportation using dump truck's had remaining working time of 3.06 hours. The average operational time of the waste transportation vehicles was 8.02 with an excess working time of 0.2 hours/day.

3.3. The optimization of the waste transportation system in Genuk District

The planning for optimization of waste transportation in Genuk District was conducted to obtain the most suitable policy or solution for the waste transportation system in Genuk District. The optimization was conducted based on the existing conditions compared with the results of the transportation routes' analysis using network analyst and Google Maps.

3.3.1. The optimization of waste transportation routes

The determination of the route was based on the analysis performed using the network analyst feature. The analysis results using network analyst feature would be compared with the known road conditions through the calculation of traffic density. The route chosen was the closest route and taking into account the traffic density.

In the optimized condition, almost all waste dumps would use this route: Kaligawe Main Street - Barito Street - RA Kartini Street - Mayor Jend. D.I Panjaitan Street - Mayjend Sutoyo Street - MH Thamrin Street - Pandanaran Street - Kaligarang Street - Taman Gedung Batu Raya Street - Simongan Street - Untung Suropati Street. There were five waste dumps that its waste transportation used the route of Kaligawe Main Street- Yos Sudarso Street - Siliwangi Street - Muradi Street - Abdul Rahman Saleh Street - Untung Suropati Street. The waste dumps included Rumah susun Kudu waste dump, Universitas Islam Sultan Agung waste dump, Genuksari waste dump, Terboyo Bus Station waste dump, and Gebangsari waste dump. This condition occurred because those waste dumps were transported when the traffic density on Kaligarang Street was relatively high, which was at 8 a.m-9 a.m and 10 a.m-12 p.m.

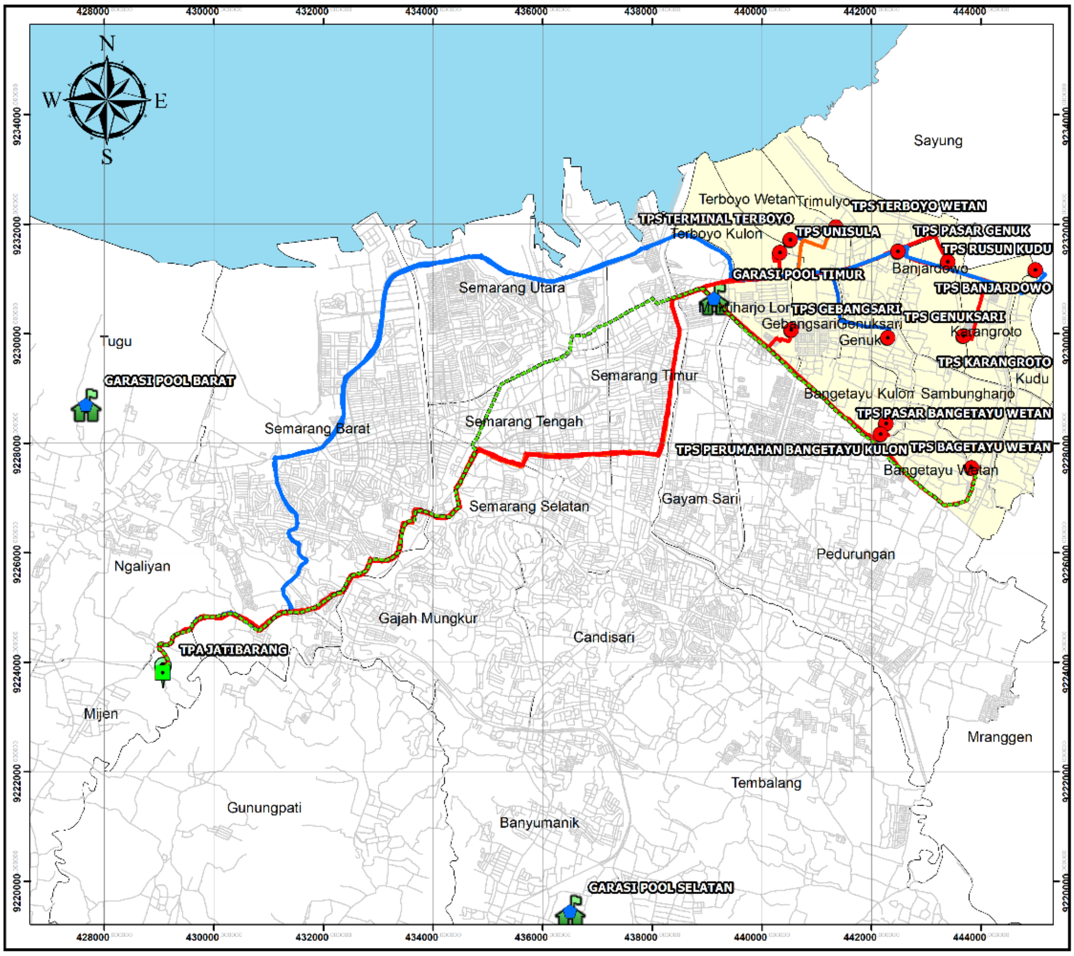

Figure 5. Waste transportation routes in the optimized condition

The route for all waste transportation vehicles from the landfills to waste dumps took the shortest route by passing Untung Suropati Street - Simongan Street - Kaligarang Street - Kapten Piere Tendean Street - Pemuda Street - Kolonel Sugiono Street - Imam Bonjol Street - Empu

Tantular Street- Taman Tawang Street- Pengapon Street- Kaligawe Main Street. This route could only be passed by waste transportation vehicles in empty conditions because it passed through Semarang city center. The route for waste transportation in the optimized condition can be viewed in Figure 5.

The selection of the optimized route would affect the distance and speed traveled. The total distance traveled of the arm roll truck in the optimized condition would be 598.11 km with an average speed of 57.11 km/hour, and the total distance traveled of the dump truck of 98 km with an average speed of 57.11 km/ hour.

3.3.2. The optimization of waste transportation trips

The average trips for arm roll trucks in the existing condition is four trips, and the number of trips of the dump truck before optimization is two trips. After the calculation of the optimization, the arm roll trucks' trips woulf be five per day and the dump truck would be able to make three trips each day..

3.3.3. The optimization of waste transportation time

The most effective operational time for waste transportation from Genuk District to Jatibarang Landfill started from 6 a.m – 3 p.m. The average total working hours of arm roll trucks after optimization would be 5.39 hours/day, while the total working hours of dump trucks would be 5.04 hours/day. The average remaining working hours of waste transportation vehicles in Genuk District would be 2.68 hours per day. The details of waste transportation time optimization can be seen in Table 1.

Table 1. The comparison of waste transportation operational time in the existing condition and after the optimization

License plate	Type of vehicle	Existing			Optimized		
		Trips	Total working hours	Remaining working hours	Trips	Total working hours	Remaining working hours
H 9589 LA	Arm roll truck	3	6.91	1.09	5	5.14	2.86
H 9541 RS	Arm roll truck	5	12.23	-4.23	5	5.48	2.52
H 9542 TS	Arm roll truck	4	9.78	-1.78	5	5.62	2.38
H 9564 WS	Arm roll truck	3	7.12	0.88	5	5.32	2.68
H 9547 SS	Dump truck	2	4.94	3.06	3	5.04	2.96

3.3.4. The optimization of waste transportation facilities and infrastructure

The changes in facilities and infrastructure should include the increase in the number of containers at some waste dumps in Genuk District. The waste dumps that should get additional containers include Karangroto waste dump, Banjardowo waste dump, Genuksari waste dump, Bangetayu Market waste dump, and Bangetayu Wetan waste dump. Containers should be added to the waste dumps that are still overloaded but still have sufficient space to put in more containers. The details of additional containers for waste transportation of Genuk District can be seen in Table 2.

3.3.5. The optimization of vehicle operating costs

According to Burhamtoro (2012), the method used to calculate vehicle operating costs is the Pacific Consultant International (PCI) method. This method is measured by involving the speed of the waste transportation vehicle. The vehicle speed used to calculate the operating cost of waste transportation is the vehicles' speed after analyzing the traffic density. Vehicle operating costs in the existing condition and after the optimization can be seen in Table 3.

Table 2. Additional containers at the waste dumps in Genuk District

Name of waste dump	Number of existing containers	Number of optimization containers
Gebangsari	3	3
Pasar Genuk	1	1
Perumahan Bagetayu Kulon	1	1
Terboyo Wetan	1	1
Rusun Kudu	1	1
Unissula	1	1
Karangroto	1	2
Banjardowo	2	3
Genuksari	1	3
Pasar Bangetayu	1	2
Bangetayu Wetan	1	2
Terminal Terboyo	1	1
Total	15	21

Table 3. The comparison of existing and optimization waste transportation operating costs in Genuk District

Subject	Unit	Existing	Optimization
Year		2020	2020
Arm roll truck VOC	IDR/Year	IDR 1,347,411,591.00	IDR 1,341,405,786.37
Dump truck VOC	IDR/Year	IDR 302,002,441.00	IDR 278,453,956.22
Overhead costs	IDR/Year	IDR 164,941,403.00	IDR 161,985,974.26
Containers	IDR	-	IDR 151,800,000.00
Total budget	IDR	IDR 1,814,355,435.00	IDR 1,933,645,716.85
APBD (Regional Revenue and Expenditure) budget	IDR/Year	IDR 2,296,330,249.48	IDR 2,296,330,249.48
Retribution fee	IDR/family/year	IDR 35,545.00	IDR 24,749.00
Retribution fee	IDR/family/month	IDR 2,962.00	IDR 2,062.00

3.4. The level of waste transportation service in Genuk District

The level of waste service based on the total waste dumped into landfill in the existing conditions is 38.53%, and the total volume of waste which enters the landfill from Genuk District is 130.88 m^3/day. Meanwhile, in the optimized condition, the level of waste service based on the total waste generated to the landfill would be 53% and the total waste transported to the landfill would be 180 m^3/day.

3.4.1. The projection of Genuk district's waste transportation system

The amount of waste generation in Genuk District based on the projection results in 2021 - 2025 is 360 m^3/day, 381.57 m^3/day, 404.44 m^3/day, 428.69 m^3/ day, 454.40 m^3/day. Meanwhile, the amount of waste after entering Jatibarang landfill if the optimization is executed 194.4 m^3/day, 216 m^3/day, 237.6 m^3/day, 259.2 m^3/day, 280.8 m^3/day. The average percentage growth of waste entering Jatibarang landfill after optimization would be 1.8%.

There would be an increase in the number of containers in 2025 by 35 containers and 1 unit of dumpster. The increase in the number of containers in 2025 would impact the increase in the number of vehicle trips per day. The arm roll trucks would go on 35 trips, and the dump truck would go on three trips. The increase of containers and trips in Genuk District would cause an increase in the waste transportation fleet. The total number of additional fleets from 2021 to 2025 would be three fleets, in the form of arm roll trucks. They are chosen because of several considerations, including time and energy efficiency during operational activities than the dump trucks.

3.4.2. Standard operating procedures for waste transportation in Genuk District

Standard operating procedure (SOP) is a written rule that contains steps or systematics in conducting particular activities. SOPs are designed to facilitate each step in doing activities to reduce the risk of errors (Darmayanti, 2017). Standard Operational Procedure planned for the waste transportation system in Semarang City's Regional Technical Implementation Unit of Cleanliness in Region II is equipped with the mandatory usage of PPE (Personal Protective Equipment) for each driver and crew in charge of transporting the waste. Besides avoiding work accidents, using PPE in waste transportation activities can prevent occupational illness (PAK). The proposed SOPs also have a schedule for transporting waste starting from 6 a.m-1 p.m.

3.4.3. Recommendations for transportation optimization at landfill

The transportation process at Jatibarang landfill takes a lot of time. Time ineffectiveness at the landfill is caused by long queues when weighing, reporting, and unloading. The recommended procedure to minimize queuing time is to replace the reporting system before the weigh stations using a barcode scanning system. Barcode can be attached to each garbage collection vehicle. Attaching the barcode to the left side of the waste transportation vehicle aims to scan the waste transportation vehicle directly by a digital system as a report when the vehicle arrived at the weigh station. An example of a barcode attached to a waste transportation vehicle of Genuk District can be seen in Figure 6.

Figure 6. The barcode on arm roll truck vehicle

4. Conclusion

Traffic density analysis was used in the present study to understand the time and speed of waste transportation vehicles from Genuk District. We found that the best time to transport garbage from Genuk District would be from 6 a.m - 3 p.m.

The street with the highest degree of saturation is Kaligarang Street during weekdays and holidays in the afternoon. Kaligawe and Kaligarang Street also have exceptionally high levels of traffic density at 8 a.m – 9 a.m. The determination of time and route of waste transportation in Genuk District could influence the vehicle speed. The speed of the waste transportation vehicle after analyzing its traffic density is 57.11 km/hour.

The level of service of waste transportation to the waste dumps in Genuk District in the existing condition is 38.53%. The waste transportation vehicle's average operational time is 8.02, with an excess working time of 0.2 hours/day. The operational cost of the arm roll trucks and the dump truck in the existing condition is IDR 1,814,355,435. With the vehicle operating costs in the existing condition, each family needs to pay a retribution fee of IDR 35,545/year.

If the optimization is applied, the level of service of waste transportation to the Genuk District waste dump will increase to 53%. After optimization, the waste transportation vehicle's operational time will have an average of 5.32 per day with an average remaining working time of 2.68 hours/day. The operational cost of arm roll trucks and dump truck after optimization is IDR 1,933,645,716.85. With the vehicle operating costs after optimization, each family needs to pay a retribution fee of only IDR 24,749/year. The results of the planning for the waste transportation system in Genuk District are going to be implemented in the period of 2021-2025. In that period, in order to make waste transportation service becomes more optimal, it is necessary to increase the number of containers and waste transportation fleets in the form of arm roll trucks. The addition of containers from 2021 to 2025 will be 14 containers, and the addition of arm roll trucks will be three units. The level of waste transportation service in 2025 is going to be 61.8%, with an annual service growth rate of 1.8%.

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