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Abepura District Garbage Transport Route Analysis Jayapura City Papua

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Abstract

The increase in the population in Jayapura, followed by an increase in the amount of waste produced, needs to be supported by efficient transportation facilities and infrastructure. The cause of the condition of the accumulation of waste in several areas after the daily transportation schedule is carried out is the limited fuel cost and transportation routes that are less effective and efficient. The purpose of this research is to know efficient waste transportation. From the results of the analysis, the route generated by using the savings matrix calculation for each dump truck managed to save the distance of 0.5 km-3.5 Km, saving fuel costs of Rp. 125,469 - 351,313 /truck-year, and save on fuel costs of Rp. 878,281/Year. The results obtained for the needs of waste transport vehicles and the frequency of rites needed by the Abepura District are 14 units of dump trucks with 2 repetitions, and 5 units of arm roll trucks with 3 repetitions.

Keywords
transportation; efficiency, route; saving matrix; waste

I. Introduction

Until now, waste is still a serious problem in many big cities in Indonesia. Waste handling in existing cities still rely on The Disposal Final (TPA) as a place. Waste at household (consumer) levels have not been undertaken to establish the magnitude of the waste and its associated social, economic and environmental impacts (Huho, 2020). Places for disposal of waste from human activities such as industrial waste, household waste, even human waste or feces that are discharged directly into water (Shinta, 2020).

Waste management must be increasingly considered because it is related to time and cost-efficiency. Waste transportation is a solid waste sub-system that aims to carry waste from the transfer location or the waste source directly to the Final Disposal Site (TPA).

By optimizing this subsystem, it is hoped that waste transportation will be easy, fast, and relatively inexpensive with the ultimate goal of minimizing waste accumulation which will have a direct impact on public health and beauty, especially in the City of Jayapura-Papua. Minimization of mileage and cost is the main solution for planning waste transportation routes. The waste transportation route made must be effective and efficient so that the optimum transportation route is obtained. The government designated the Livable City as part of Indonesia's Future City target by Prioriizing slum handling, providing access to drinking water and sanitation as well as waste management and transportation (Tobing, 2021).

The condition of Jayapura City is not supported by an effective and efficient transportation system, especially in the sub-section of determining the route of waste transportation services, resulting in the accumulation of waste in several areas. With limited

fuel costs for each transport vehicle, the waste transportation process can only be carried out in one round, namely from the base to each specific service area, and then taken to the TPA and ends at the base.

1.1 Formulation of the Problem

The problems that will be solved in this Final Project are as follows; What are the effective and efficient waste transportation routes in the 4 sub-districts in Abepura District, namely VIM, Wai Mhorock, Awiyo, and Asano?

1.2 Research Purposes

The objectives of this research are: To analyze effective and efficient waste transportation routes in 4 sub-districts of Abepura District, namely VIM, Wai Mhorock, Awiyo, and Asano.

II. Review of Literature

2.1 Definition of Garbage

According to the definition of the World Health Organization (WHO) waste is something that is not used, not used, not liked, or something that is thrown away that comes from human activities and does not happen by itself. Minister of Home Affairs Regulation No. 33 of 2010 concerning Waste Management Guidelines states that waste is the residue of human daily activities and/or natural processes in a solid form consisting of household waste or household waste.

Based on (SNI 19-2454-2002) Waste is solid waste consisting of organic and inorganic substances which are considered useless and must be managed so as not to harm the environment and protect development investment. Urban waste is waste that arises in the city.

2.2 Sources and Heaps of Garbage

Garbage can be found in many places and almost all activities. According to Chandra (2007), scum on the surface of the earth can come from Settlement, public places and places of trade, Means of government-owned public services, heavy and light industry, Agriculture, and so on. Waste generation according to SNI 19-2454 of 2002 is the amount of waste that arises from the community in units of volume and weight per capita per day or expands buildings or extend roads.

2.3 The Amount of Waste Generation

Practically the sources of waste are divided into 2 groups, namely:

a. The garbage from residential or household waste,
b. The garbage from non-residential areas such as household waste, such as markets, and commercial areas.

The two types of waste sources above are known as domestic waste, while waste or waste that is not a type of household waste as an example of industrial process waste is referred to as non-domestic waste.

2.4 Garbage Collection

a. Collection Pattern

Waste collection pattern diagrams as shown in Figure 1.

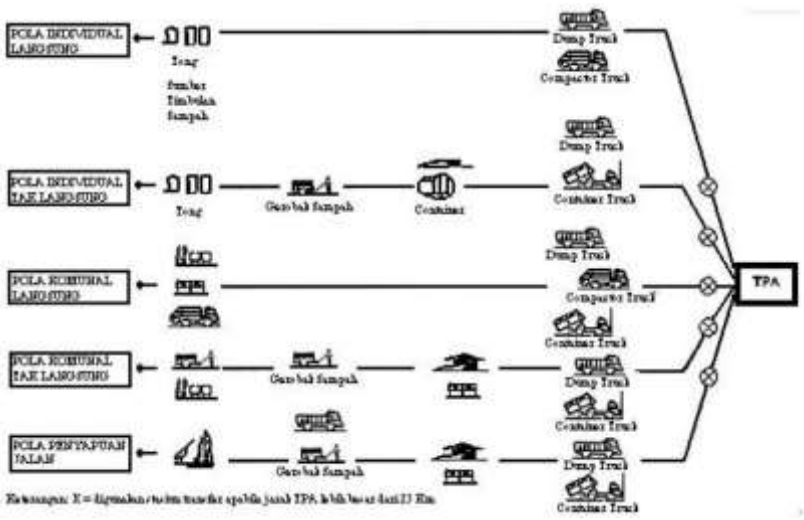

Figure 1. *Service Diagram of each City Waste Operational Pattern*
Source: SNI 19-2454-2002

b. Garbage Transport

Waste transportation is a sub-system that aims to carry waste from the transfer location or the waste source directly to the final processing site or TPA. Garbage transportation is one of the important components and requires quite careful calculations, intending to optimize the transportation time required in the system, especially when:

a. There is a means of transferring waste on a large enough scale that must handle the waste
b. The location of the garbage destination is relatively far
c. The means of transfer is a meeting point for the entry of waste from various areas
d. Rotation needs to be carefully considered. Traffic problems on the way to the target point of waste destination

To increase the effectiveness and efficiency of the operation of waste transportation facilities, the possibility of using stations or container depots is feasible. From this container center, large capacity trucks can transport containers to the processing site or the TPA, while not all of the municipal (small capacity) garbage trucks need to get to that location, they only need to reach the container depot. Thus the number of municipal garbage trucks can be increased.

The minimum lifetime is 5-7 years. The volume of garbage loading is 6-8 m3 or 3-5 tons. Transport truck rites per day can reach 4-5 times for mileage under 20 km, and 2-4 rites for mileage 20-30 km, which basically will depend on the time per rite according to the smoothness of traffic, loading and unloading time the trash.

c. Garbage Transport Method

When referring to systems in developed countries, waste transportation can be carried out in two methods, namely:

1. *Hauled container system (HCS)*

A hauled container system is a waste collection system whose collection containers can be moved around and taken to the final disposal site. This HCS is a transport container system for commercial areas. To calculate the rotation time from the source to the TPS or to the TPA, the following formula is used:

$$T_{HCS} = (P_{HCS} + S + a + bx) \quad (2.1)$$

Information:
T HCS = Time per rite (hours/rit).
P HCS = Pick-up time (hours/rit).
S = Time required for loading and unloading (hours/rit).
A = Empirical constant charge continuously (hours/rit)
B = Empirical charge constant (hour/km).
X = Distance traveled (km/rit).

The number of rites per vehicle per day for the HCS system can be calculated by:

$$Nd = \frac{[H(1-w)-(t_1+t_2)}{T_{HCS}} \quad (2.3)$$

Information:
Nd = Number of rites in one day (rit/day).
H = Working time (hours/day).
W = off route factor
t1 = Time from vehicle pool to 1st container (hours).
t2 = Time from last container to pool (hours).
T HCS = Time per rite (hours/rit).

2. *Stationary container systems (SCS)*

A stationary container system is a waste collection system in which the collection container is not carried around (fixed). SCS is a housing system intended to serve residential areas. To calculate the recitation time from TPS or to TPA, the following formula is used:

$$P_{SCS} = (Ct \cdot Uc) + ((np - 1) \cdot (Dbc)) \quad (2.6)$$

Information:
Ct = Number of containers emptied in one cycle (container/rit).
Uc = Container emptying time (hours/rit).
np = Number of container locations taken per rite (location/rit).
Dbc = Time wasted moving from one location to another container location (hour/location).
Number of containers that can be emptied per collection cycle

III. Research Methods

3.1 Data Primer:

a. Interview Survey
b. Live observation
c. Landfill location
d. Distance to landfill

3.2 Secondary Data:

a. Data on waste generation in Jayapura
b. Data on the number of waste transportation facilities
c. Abepura district population data

3.3 Geographical Location and Area

Abepura District is one of 5 districts in Jayapura City, Abepura District is divided into 3 villages and 8 villages, namely Nafri Village, Engros Village, Koya Koso Village, Asano Village, Awiyo Village, Yobe Village, Abe Pantai Village, Kota Baru Village, VIM Village, Kelurahan Wai Mhorock, and Kelurahan Wahno and has 294 RT and 78 RW.

Based on its geographical position, Abepura District has the boundaries of North-South Jayapura District, South - Keerom Regency, West - Ham District, East - Muara Tami District. According to the distance, the location of each Kelurahan the district capital, namely Kota Baru, ranges from 1 km to a distance of 5-10 km. Overall, Abepura District has an area of 155.7 km2. The area of each Kelurahan is listed in Table 3.1.

IV. Discussion

4.1 Savings Matrix Method

Data processing in this study uses quantitative methods, namely by making a calculation model find out how optimal the existing routes are, where this method is used to obtain effective and efficient waste transportation routes in the Abepura district, Jayapura City.

Analysis of the data at this stage will be carried out an analysis of optimizing the waste transportation route to produce time and cost efficiency by redesigning a new route when compared to the current route. Description research using qualitative and quantitative analysis aims to explain a problem with mathematical calculation techniques. The data processing and analysis technique used in this research is the Savings Matrix technique.

Dump truck transportation fleet with the number (DKP 05) serves the Awiyo village area with a daily schedule on several routes with service hours for 5 hours from 00.00-05.00 WIT for one cycle. Dump truck (DKP 05) serves 6 transportation routes.

The Jayapura city garbage truck does not yet have a truck base, so each driver brings the truck back to their respective homes with the poll dump truck location for (DKP 05) located in Abe beach. The dump truck poll is symbolized by 0. Meanwhile, the location of the TPA is in Koya Koso with the TPA symbolized by an X. The image can be seen in the attachment.

Based on observations in the field, there is a build-up of waste related to the limited number of dump trucks and the available costs for fuel, as well as transportation routes that are less than optimal. Determining the distance in this study using Google Maps while still paying attention to the actual distance obtained manually using a motor speedometer. Table 1 describes the length of the service road (DKP 05) as follows.

Table 1. Length of Service Road for Each Region (DKP 05)

Street	1	2	3	4	5	6
Road Length (km)	0.2	0.3	0.28	0.23	0.55	0.28

Source: Primary Data Results (2019)

Description: 0. Base; 1. Jl. Manokwari; 2. Jl. Aru; 3. Jl. Sarmi; 4. Jl. Exclaim; 5. Jl. Health; 6. Jl. Nafi; X. TPA

The distance results obtained from Google Maps are then totaled based on the route passed from the pool to the TPA by dump truck (DKP 05) with data as shown in Table 2 below. The weight of the waste obtained is based on secondary data from the Jayapura City Environment and Hygiene Office document.

Table 2. Routes Traversed So far by Transport Trucks (DKP 05)

Truck	Service Hours	Route	Distance (Km)	Total Waste transported (liters)
DKP 05	00.00 - 05.00	0-1-2-3-4-2-5-6-X-0	±30.6	± 5960

Source: Calculation Data Results (2019)

Description: 0. Base; 1. Jl. Manokwari; 2. Jl. Aru; 3. Jl. Sarmi; 4. Jl. Exclaim; 5. Jl. Health; 6. Jl. Nafi; X. TPA

4.2 Determine the Distance Matrix

The distance from the poll to the inter-route and from the route to the TPA was obtained using the Google Maps application. The distance matrix is presented in Table 3 below.

Table 3. Base Distance to Each Service Area, between Regions Services, and to the TPA (DKP 05) in Km

	0	1	2	3	4	5	6	X
0	0	4.7	4.8	4.5	4.6	4.3	4	19.4
1		0	0.29	0.45	0.3	0.75	1	23.7
2			0	0.2	0.17	0.5	0.8	24.2
3				0	0.35	0.55	0.75	24
4					0	0.7	0.8	24.1
5						0	0.29	23.65
6							0	23.4
X								0

Source: Calculation Data Results (2019)

Description: 0. Base; 1. Jl. Manokwari; 2. Jl. Aru; 3. Jl. Sarmi; 4. Jl. Exclaim; 5. Jl. Health; 6. Jl. Nafi; X. TPA

4.3 Determine the Savings Matrix

The distance of each road is the same as the distance from j to i, and the total volume of waste per TPS is always constant, with the following details:

$$Da = c0i + ci0 + c0j + cj0 \quad \text{(1)}$$

$$Db = c0i + cij + cj0 \quad \text{(2)}$$

$$Sij = Da - Db = ci0 + c0j - cij \quad \text{(3)}$$

By using Equation 3, the value of the distance between roads is entered and the value of the savings is obtained as shown in Table 4. below.

Table 4. *Savings* Calculation Results (DKP 05)

	0	1	2	3	4	5	6	X
0	0	0	0	0	0	0	0	0
1		0	9.21	8.75	9	8.25	7.7	0.4
2			0	0.54	0.42	0.54	0.49	-0.21
3				0	0.02	0.15	0.25	0.4
4					0	0.2	0.3	0.25
5						0	1.21	1.15
6							0	0.54
X								0

Source: Calculation Data Results (2019)

Description: 0. Base; 1. Jl. Manokwari; 2. Jl. Aru; 3. Jl. Sarmi; 4. Jl. Exclaim; 5. Jl. Health; 6. Jl. Nafi; X. TPA

With the results of the savings matrix above, the calculation method is derived as follows the savings matrix that will be calculated, namely S (1,2) can be seen in Table 5 the distance from poll to node 1 is 4.7 then the distance from poll to node 2 is 4.8 and the distance from node 1 to node 2 is 0.29 then:

$$S(1,2) = d(0,1) + d(0,2) – d(1,2)$$
$$= 4.7 + 4.8 - 0.29$$
$$= 9.21$$

After doing the overall calculation, the results of ranking savings are obtained:

Table 5. Ranking List of Truck *Savings* (DKP 05)

No	Coordinate	Saving
1	1 - 2	9.21
2	1 - 4	9
3	1 - 3	8.75
4	1 - 5	8.25
5	1 - 6	7.7
6	5 - 6	1.21
7	5 - x	1.15
8	2 - 3	0.54
9	2 - 5	0.54
10	6 - x	0.54
11	2 - 6	0.49
12	2 - 4	0.42

13	1 - x	0.4
14	3 - x	0.4
15	4 - 6	0.3
16	4 - x	0.25
17	3 - x	0.25
18	4 - 5	0.2
19	3 - 5	0.15
20	3 - 4	0.02
21	2 - x	-0.21

From the results of the savings calculation above and by paying attention to the road settings that must be passed every day, a route is made as shown in Table 6 below

Table 6. Route of Calculation Results for DKP Truck Savings 05

Truck	Service Hours	Route	Distance (Km)	Total Waste transported (liters)
DKP 05	00.00 - 05.00	0-1-2-4-3-5-6-X-0	±30.1	± 5960

Source: Calculation Data Results (2019)

Description: 0. Base; 1. Jl. Manokwari; 2. Jl. Aru; 3. Jl. Sarmi; 4. Jl. Exclaim; 5. Jl. Health; 6. Jl. Nafi; X. TPA

With the same matrix formula, the Dump Truck Transport Fleet with the number (DKP 48) serves the Geriliawan road route from the Kamkey red light crossing to the end of the Asano village road with a daily service schedule and 5 hours of service from 00.00-05.00 WIT for once rhythm. The dump truck (DKP 48) started transporting garbage from the end of the Asano Tanah Hitam sub-district road to Jl. Guerrilla and return to the Tanah Hitam road and head for the TPA. By using the VRP calculation, it is obtained that one round of transportation is divided into 3 roads for 48 DKP services.

The following is shown in Table 7 regarding the length of the waste transportation are carried out by the DKP 48 dump truck fleet as follows.

Table 7. Length of Service Roads for Each Region (DKP 48)

Street	1	2	3
Road Length (km)	0.75	0.75	1

Source: Primary Data Results (2019)

Description: 0. Base; 1. Jl. Black Soil Asano; 2. Jl. Al-Hikmah Mosque T-junction; 3. Jl. Guerrilla No. 117; X. TPA

The data in Table 8 above is then calculated the length of the route between points, point 1 to point 2, point 2 to point 3 to obtain the length of the route carried out by the DKP 48 dump truck. The weight of the resulting waste is obtained from data from the Jayapura City Environment and Hygiene Service which into the scales at the TPA, the following are the results of the sum of the route distances and the resulting waste.

Based on the results of the savings Algorithm, a route that minimizes distance is created so that it can save the available fuel and is able to transport more waste every day. From the results of the comparison between the routes that have been carried out so far and the routes from the calculation of savings, the distance savings are obtained as follows.

Table 8. Comparison of Initial Routes and *Savings* Routes

No	Dump Truck	Initial Route (km)	Savings Route (km)	Distance Savings (km)
1	DKP 05	30.6	30.1	0.5
2	DKP 48	27.8	24.3	3.5
3	DKP 44	31.1	29.7	1.4

Source: Data Processing Results (2019)

4.4 *Dump Truck* Cost Efficiency

From the results of interviews with each driver, the fuel used every day for dump trucks is 30 liters of diesel, so that if converted into rupiah, assuming the price of diesel is Rp. 5,500/liter, it is Rp. 165,000. With this fuel, every day the trucks are only able to cover the distance from the base to the service area and then to the TPA and back to the base.

From the results of the comparison between the routes that have been carried out so far and the routes calculated by savings, the following cost savings are obtained. It is assumed that 1 liter of fuel can cover a distance of ± 8 km without a hitch. (Source: Interview with Driver). With distance and cost savings as in Table 9:

Table 9. Results of Dump Truck Fuel Cost Savings

No	Dump Truck	Initial Route (km)	Savings Route (km)	Distance Savings (km)	Before Savings	After Savings	Difference
1	DKP 05	30.6	30.1	0.5	IDR 7,678,688	Rp7,553,219	Rp 125.469
2	DKP 48	27.8	24.3	3.5	Rp 6,976,063	Rp6,097,781	IDR 878,281
3	DKP 44	31.1	29.7	1.4	Rp7,804,156	Rp7,452,844	Rp 351,313
Total					Rp22,458,906	Rp21,103,844	Rp1,355,063

Source: Data Processing Results (2019)

Then the biggest cost savings can be found in the DKP 48 dump truck by being able to save Rp. 878,281/year and the lowest cost saving is found in the DKP 05 dump truck with a cost savings of Rp. 125,469/Year. From these data, it is found that the total cost of fuel for each dump truck is Rp. 22,458,906/year before using the savings route and Rp. 21,103,844/Year after using savings. With a total fuel cost savings of Rp. 1,355,063/Year after using the saving route.

V. Conclusion

5.1 Conclusion

1. The effective and efficient route generated by using the savings matrix calculation for each dump truck (DKP 05, DKP 44, DKP 48) each managed to save ±500 m distance traveled by saving fuel costs of Rp. 125,469/Year, ±1.4 km with fuel cost savings of Rp. 351,313/Year, and ±3.5 km and save on fuel costs of Rp. 878,281/Year.
2. The frequency of daily rotation of waste transport vehicles (dump trucks and arm roll trucks) needed by Abepura District is for dump trucks with 2 cycles per day, and arm roll trucks with 3 cycles per day.

5.2 Suggestion

It is better to determine the optimal route for each waste transporting fleet from the Jayapura City Environment and Hygiene Service, in an effort to save fuel costs.

Currently, there are 10 units of dump trucks operating in the Abepura District. While the results of the calculation obtained 14 units then it can be said

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