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Effectiveness of Waste Transportation in Temporary Waste Dump (TPS)/Container in Maumere, Sikka Regency

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Abstract**—** *Waste is the residual of human activity, its increasing number in a region was due to population growth. One problem in waste management system was related with waste transportation. City of Maumere, which is the capital city of Sikka Regency was the center of various human activities. Therefore, it increase waste volume to be transported to temporary waste dump (TPS) and final waste dump (TPA). Condition of TPSs in Maumere showed several issues in its waste transportation system. In several TPS there was some waste heaps when it was supposed to be clear of any waste. This indicated that system effectiveness regarding transportation in TPS did not reach 100%. Waste transportation can be said effective if there were no longer waste in TPS after the last transport was due.*

This study measured system effectiveness of waste transportation in Maumere based on Indonesia National Standard regarding waste management in residential area. By comparing the current existing condition with the standard, showed that transportation system was not yet effective. Therefore, improvement in transportation system proposed would include service range in TPS location and transport pattern. Transport routes was determined using Network Analyst thus fastest transport route could be obtain.

Keywords**—** *Effectiveness, temporary waste dump, waste truck, transport route*.

I. INTRODUCTION

Waste is the residue of any consumption and considered to be least useful therefore additional processing was necessary to limit its impact so that it did not harm the surrounding environment and waste was mostly solid and consist of organic and inorganic (SNI 19-2454-2002). Population growth such as the existence of urbanization, in its high level would affect degradation in environmental quality such as those involved waste issues (Gong et al., 2012).

With higher population growth and urbanization also with attention toward the existed environmental issues would create a critical situation for waste management (Poser and Awad, 2006; Zhang and Huang, 2014; Cioca et al., 2015; Perez-Lopez et al., 2016; Hua et al., 2017). Most dominant factor among the people was less individual awareness concerning sanitation also people's behavior toward environment is very low thus it can be said that they do not care about environmental cleanliness and tend to show self-interest rationale (Nazaruddin, 2014).

Volume of waste to be transported was predicted to be about 60% to final waste dump (TPA), using *landfilling* system (Damanhuri, 2010). Environmental issue related with waste has become one of the main focuses of each waste manager in regional areas (Rhida, 2016).

Waste problem is a complicated problem to solve since some people view waste as a problem since managing it would exert lots of cost and energy. Unhandled waste was closely related with community's culture that still unaware about healthy environment and supported with weak government regulation regarding waste management (Purwendro and Nurhidayat, 2006).

Waste management is all activities process related with control of waste heap, collection, transportation and final processing. Waste transportation was a waste collection process from TPS to TPA with various collection patterns such as direct individual pattern or collection from transfer location, temporary dump, communals dump toward final waste dump (Statute No 18 of 2008 regarding Waste Management).

From all the existed managing process such as from household to TPA, waste transportation system has become one of the important element (Kanchanabhan et al., 2010). If there was waste heap, it would disturb the comfort of residential areas (Hua et al., 2017). To gain efficient waste transportation system, there should be optimization in waste transport route that could directly reduce the operational cost of waste transport system. This waste transport route optimization has been studied for the last several years (Swapan and Bidyut, 2015; Khanh et al., 2017; Mahmuda et al., 2017). Every region would need optimization in waste transport route as part of its waste management, since it is an effort to reduce operational cost in waste transport. One of the analysis used to optimize waste transport route was network analyst GIS (Amirhossein Malakahmad, 2014).

Effectiveness is a relationship between final results with objectives or aims to be achieved. An activity can be said effective if there was appropriateness from the process to achieve the end and the final objectives of a policy, thus in this study effectiveness was viewed from output or objectives of waste transportation which is by not having waste heap in TPS. Effectiveness assessment by the author was done by implementing concepts from the related management and organizational theories with effectiveness theories (Sumaryadi, 2005).

Based on interview result with Head of Waste and Waste B3 of Environmental Agency in Sikka Regency, Gatot Muryanto SE, he said that regional government has difficulties to maintain the distance between development for growth and infrastructure demand for community service such as waste collection and transport. Waste service still has less attention,

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although government has already gained more knowledge about waste either as problematic source or as recycle material source. Political priority related with waste and status of people involved in waste matter was still low and limited. Other reason why there was less service in the service area was due to limited operational facilities compared to the existed volume of waste, based on data from Waste and Waste Management B3 of Environmental Agency, Sikka Regency in year 2015 for Maumere. Waste volume was reaching 141,37 m^3/day but only 95 m^3/day was able to be transported, thus it leaves 46,37 m^3/day unmanaged. The existed waste transportation would consist of 5 unit of dump truck, 4 unit of amrol, 23 unit of container, 4 unit of three-wheel motorcycle and 5 unit of cartwheel. With this limited facilities, service was not optimum, waste in temporary waste dump cannot be transported, due to limited human labor and operational facilities in Waste and Waste Management B3 and people awareness were still low although socialization concerning when and how to treat their waste was already done but we still can easily find those who dump their waste along with animal waste and building materials also chopped-down trees outside of the existed TPS/container.

II. STUDY METHOD

Stages of this study were identifying location of TPS/container, amount and type of waste transportation vehicles, and initial route of waste transport in study site. Subsequently, effectiveness analysis related with the existed waste transportation system in study site was done according to SNI 3242:2008. Analysis used was meant to found out whether waste transportation system in study site has run effectively based on the valid standard, if it was found effective, subsequent analysis related with waste transport route was done using network analysis with ArcGIS 10.1 to found out the fastest route to final waste dump (TPA), thus distance and fuel comparison between the existed and the fastest routes were obtained.

III. RESULT AND DISSCUSION

Effectiveness of Waste Transport

A. Existed Condition of Waste Transport

Generally according to SNI 3242:2008, waste management system would covers containing, collection, transfer, transportation, processing and final dump. In this study, waste transportation system was discussed. More information can be reviewed from Figure 1. Waste Transportation System.

Location of TPS/containers was spread in residential area of Kec. Alok Timur, Kec. Alok, and Kec. Alok Barat with total TPS/container was 51 units TPS with capacity 2 m^3 each and 22 units container with capacity 6 m^3. It was shown in Table I. Number of TPS/Container in Maumere.

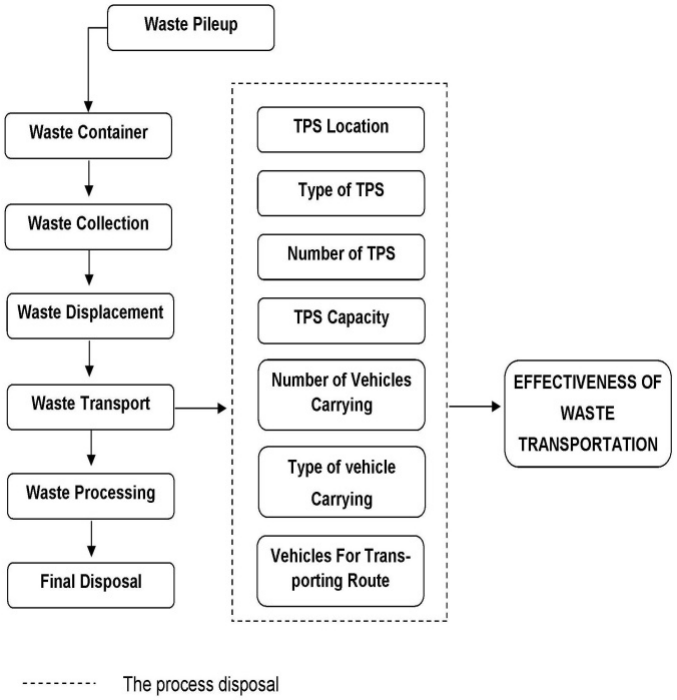

Fig. 1. Waste Transportation System.

TABLE I. Number of TPS/container in Maumere.

Areas	Number of Unit	
	TPS (Waste Dump)	Container
Kecamatan Alok Timur	21	3
Kecamatan Alok	28	12
Kecamatan Alok Barat	2	7
Total	51	22

Source: Survey result, 2016

Waste transport vehicles consist of dump truck with capacity 8m^3 used to transport waste from each TPS and household also amrol truck used to transport container to TPA. The operating vehicles were 5 unit of dump truck and 4 unit of amrol truck. Waste transport route in TPS using dump truck did not have fixed route. Route passed was based on location in which its waste heap has reach (or more of) the capacity of TPS. For route of amrol truck, there was no fix route between garage to container location and to TPA. More information regarding operational area of dump truck can be viewed in Table II. Operational area of dump truck was as follow:

TABLE II. Operational Areas of Dump Truck.

Service Areas	Dump Truk
Kecamatan Alok Timur Kelurahan Waioti Kelurahan Nangameting	DH 1010
Kelurahan Wairotang Kelurahan Beru	EB 8002
Kelurahan Kota Baru	EB 939
Kecamatan Alok Kelurahan Madawat Kerurahan Kabor Kelurahan Kota Uneng	B 9011
Kecamatan Alok Barat Kelurahan Wolomarang Kelurahan Wuring	EB 903

Source: Survey result, 2016

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B. *Comparison of Existing Condition with Indonesia National Standard (SNI) 3242:2008*

SNI is the national standard valid in Indonesia. This standard was used as reference regarding waste transport system in Maumere, whether it was effective according to the standard or does it need more development according to the standard. Assessment would cover service capacity of existing condition in study site either from TPS/container type or capacity. More information can be viewed from Table III. Comparison of Existing Condition with SNI 3242:2008.

TABLE III. Comparison of Existing Condition and SNI 3242:2008.

Areas	Type	Service Capacity SNI 3242:2008		Existed	
		Number (Volume)	Person	Number (Volume for 1 unit)	Number of people (BPS, 2016)
Kecamatan Alok Timur	TPS	1 (1m^3)	200	21 (2m^3)	33.319
	Kontainer	1 (6m^3)	3.200	7 (6m^3)	
Kecamatan Alok	TPS	1 (1m^3)	200	28 (2m^3)	34.195
	Kontainer	1 (6m^3)	3.200	12 (6m^3)	
Kecamatan Alok Barat	TPS	1 (1m^3)	200	2 (2m^3)	17.309
	Kontainer	1 (6m^3)	3.200	3 (2m^3)	

Source: Survey result, 2016

Calculation for service capacity in existing condition on TPS/container based on SNI 3242:2008 was existing capacity times existing number and number of people being served can be obtained. After this number was obtained, population based on BPS data minus people served would obtain the difference or number of people not yet served. For TPS/container needed can be obtained from number of people not yet served divided by service capacity and thus the need for TPS/container would be obtained.

Kecamatan Alok Timur with population based on BPS 2016 was 33.319 persons. Existing service capacity of TPS in Kec. Alok Timur was 21 units and volume per unit was 2 m^3, with 8.400 persons were served. Existing service capacity for container was 7 unit with volume per unit 6m^3 and 22.400 person were served, thus total population receiving service from TPS and container were 30.800 person. People not yet served were 2.519 person, obtained from existing population (based on data from BPS 2016) minus number of people receiving service. For the need of TPS or container, it can be obtained from number of people not yet served divided with TPS/container capacity and thus the needs for 6 unit TPS with volume 2m^3 per unit was obtained, and there was no need to increase container for Kec. Alok Timur.

Kecamatan Alok has the population of 34.195 person based on BPS 2016 data, which is the most dense area in Maumere. The existing service capacity of TPS in Kecamatan Alok was 28 units with 2m^3 volumes per unit and 11.200 persons being served. The existing service capacity of container in Kecamatan Alok was 12 units with 6m^3 volumes per unit and 38.400 persons being served, thus total people being served from TPS and container was 49.600 persons. Number of people being served was larger than number of population based on BPS 2016 data thus there was no need to increase TPS/container for Kecamatan Alok.

Kecamatan Alok Barat has the population of 17.309 person based on BPS 2016 data and was the least populated area in Maumere. The existing service capacity of TPS in Kec Alok Barat was 2 units with 2m^3 volumes per unit and 800 persons being served. The existing service capacity of container was 3 unit with 6m3 volume per unit and 9.600 person being served, thus total people being served from TPS and container were 10.400 person. Number of people not yet served was 6.909 persons, obtained from number of population based on BPS 2016 data minus total people being served. For the need for TPS or container can be obtained from people not yet served divided by TPS/container capacity and thus the need for TPS was 7 unit with volume 2m^3 per unit or 2 unit container with volume 6m^3 per unit for Kecamatan Alok Barat. More information can be viewed in Table IV. The Need for TPS/Container and Dump Truck for Maumere.

Waste transport vehicles operating in Maumere were amrol truck and dump truck. Both vehicles were used to transport waste from TPS/container to TPA. Numbers of dump truck still operating were 5 unit and 4 unit amrol truck with capacity of dump truck 8m^3. To compare the existing condition with SNI 3242:2008, calculation used was amount of heap per day divided by dump truck capacity, times with tools compactness factor (1,2) and times with ritation, number of heap was calculated based on SNI 3242:2008 with amount of waste per person for small town scale was 2.5 liters. More information can be viewed in Table IV. The Need for TPS/Container and Dump Truck for Maumere.

Calculation for the need of amrol truck was obtained through number of container spread in each area divided with the existing ritation is 3 times ritation in one day transport. For Kec. Alok Timur there was the need for 2 amrol trucks for 7 containers, while for Kec. Alok there was the need for 4 amrol trucks for 12 containers and for Kec. Alok Barat there was the need for 1 amrol truck for 3 containers.

C. *Route Effectiveness for Waste Transportation*

The existing waste transport route at study site was not planned well thus it may become one of the reason there was still waste heap in TPS/container. For the existing waste transport route using dump trucks per Kecamatan was using operational route covers Kelurahans within Kecamatan. Waste transport system using dump truck was collecting waste from TPS such as waste bin on the curb and direct collection from house to house. This means duration of transportation became longer and effectiveness of transportation route can only be measured for waste transportation using container system and amrol trucks.

Determination of shortest route for transportation using amrol truck was done by networking analysis with ArcGIS 10.1 program whereas initial point of vehicles, container point being transported and route to TPA Waturia were analyzed.

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TABLE IV. The Need of TPS/Container and Dump Truck for Maumere.

Areas	Type	Existing Unit (Volume)	Σ Waste Heap (m^3)	Σ Population BPS 2016 (person)	Served (person)	Not Served (person)	Needed Unit (Volume)
Kecamatan Alok Timur	TPS	21 ($2m^3$)	83	33.319	30.800	2.519	6 ($2m^3$)
	Kontainer	7 ($6m^3$)					-
	Dump Truk	3 ($8m^3$)					4 ($8m^3$)
Kecamatan Alok	TPS	28 ($2m^3$)	85	34.195	49.600	-	-
	Kontainer	12 ($6m^3$)					-
	Dump Truk	1 ($8m^3$)					4 ($8m^3$)
Kecamatan Alok Barat	TPS	2 ($2m^3$)	43	17.309	10.400	6.909	17 ($2m^3$)
	Kontainer	3 ($2m^3$)					2 ($2m^3$)
	Dump Truk	1 ($8m^3$)					2 ($8m^3$)

Source: Analysis result

Traffic light is one of the factors that extend transportation duration since traffic lights has 30 seconds duration.

Waste transport mechanism using amrol truck at study site was amrol truck from the initial point carry an empty container to the first container point, and replace its empty container with the full container, done repetitiously until from TPA to garage it will carry an empty container. Average speed for each amrol truck was 40 km/hour with one liters fuel for 7 km. For more information in container spread and its transportation vehicles, Figure 2 showed Container Spread and Its Transport Vehicles in Maumere.

Based on networking analysis by using ArcGIS 10.1, comparison between the existing route and shortest route of each amrol truck were as follows :

- *Amrol truck with plate EB 924*

Amrol truck with plate EB 924 has total existing route length from garage to each container to the TPA and back to the garage was 185,684 km with total duration 5.3 hours and 27 liters of fuel, while for its shortest route from garage to each container to the TPA and back to the garage was 182,901 km with total duration 5 hours and 26 liters of fuel. Comparison of existing route and shortest route obtain 2,783 km difference. More information can be seen in Table V and Figure 3. Comparison between Existed and Shortest Routes of Amrol Truck EB 924.

- *Amrol truck with plate EB 921*

Amrol truck with plate EB 921 has total existing route length from garage to each container to the TPA and back to the garage was 144,783 km with total duration 4.2 hours and 21 liters of fuel, while for its shortest route from garage to each container to the TPA and back to the garage was 143,962 km with total duration 4 hours and 20.5 liters of fuel. Comparison of existing route and shortest route obtain 0,821 km difference. More information can be seen in Table VI and Figure 4. Comparison between Existed and Shortest Routes of Amrol Truck EB 921.

- *Amrol truck with plate DH 1010*

Amrol truck with plate DH 1010 has total existing route length from garage to each container to the TPA and back to the garage was 161,761 km with total duration 4.2 hours and 23.1 liters of fuel, while for its shortest route from garage to each container to the TPA and back to the garage was 161,043 km with total duration 4 hours and 23 liters of fuel. Comparison of existing route and shortest route obtain 0,718 km difference. More information can be seen in Table VII and Figure 5. Comparison between Existed and Shortest Routes of Amrol Truck DH 1010.

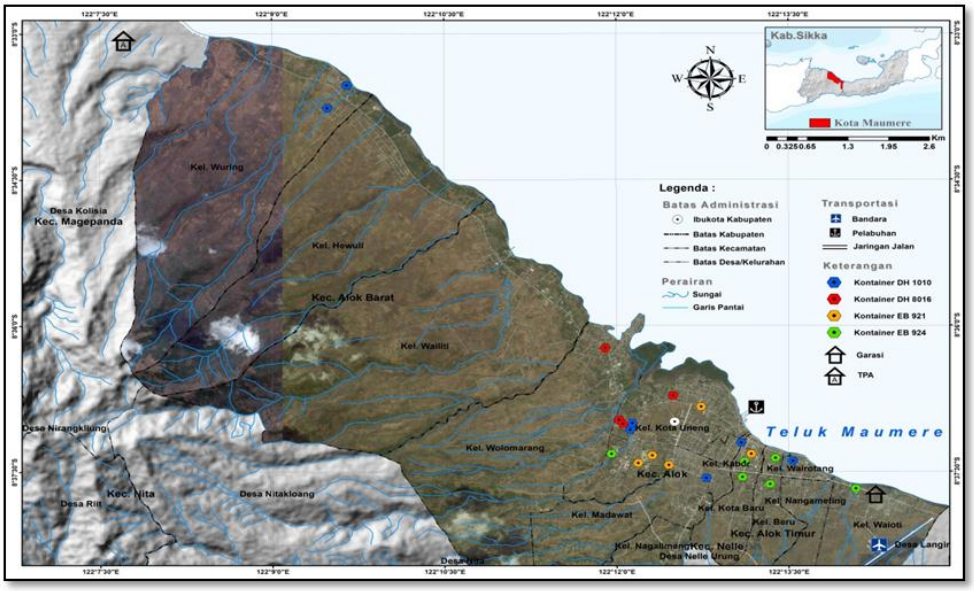

Fig. 2. Container Spread and Its Transport Vehicles in Maumere.

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TABLE V. Comparison between Existed and Shortest Routes for Amrol Truck EB 924.

Route	Distance (km)		Σ Traffic Light		Time (hours)	
	Existing	Optimum	Existing	Optimum	Existing	Optimum
Garasi-K1-TPA	17.224	16.802	4	-	0,52	0,42
TPA-K2	16.048	15.361	3	-	0,49	0,38
K2-TPA	15.292	15.266	-	-	0,38	0,38
TPA-K3	15.898	15.672	2	-	0,46	0,39
K3-TPA	15.680	15.644	2	-	0,45	0,39
TPA-K4	15.392	15.450	2	1	0,44	0,42
K4-TPA	15.166	15.159	2	-	0,44	0,38
TPA-K5	15.505	15.213	2	-	0,45	0,38
K5-TPA	15.260	15.200	2	-	0,44	0,38
TPA-K6	13.632	13.145	-	-	0,34	0,33
K6-TPA	13.145	13.145	-	-	0,33	0,33
TPA-Garasi	17.442	16.844	4	-	0,53	0,42
Total	**185.684**	**182.901**	**23**	**1**	**5,3**	**5**

Source: Analysis result

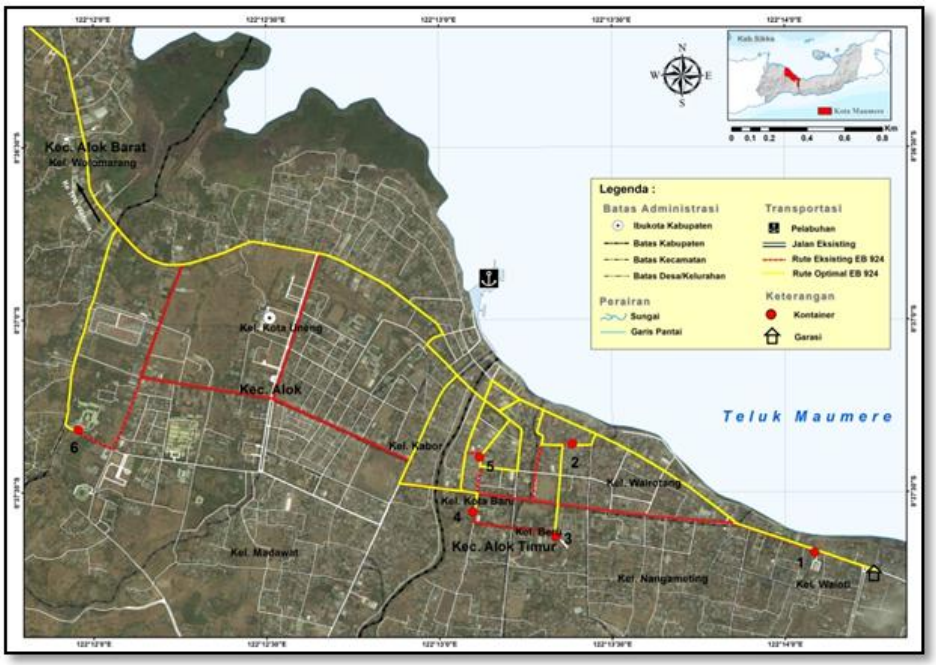

Fig. 3. Existed and Shortest Routes of Amrol Truck EB 924.

TABLE VI. Comparison between Existed and Shortest Routes for Amrol Truck EB 921.

Route	Distance (km)		Σ Traffic Light		Time (hours)	
	Existing	Optimum	Existing	Optimum	Existing	Optimum
Garasi-K7-TPA	17.201	17.170	2	1	0,49	0,46
TPA-K8	13.297	13.301	-	-	0,33	0,33
K8-TPA	13.297	13.301	-	-	0,33	0,33
TPA-K9	14.402	14.090	1	-	0,39	0,35
K9-TPA	14.174	14.090	-	-	0,35	0,35
TPA-K10	13.952	13.953	-	-	0,35	0,35
K10-TPA	14.036	13.953	-	-	0,35	0,35
TPA-K11	13.633	13.630	-	-	0,34	0,34
K11-TPA	13.635	13.630	-	-	0,34	0,34
TPA-Garasi	17.156	16.844	4	-	0,55	0,42
Total	**144.783**	**143.962**	**7**	**1**	**3,83**	**4,04**

Source: Analysis result

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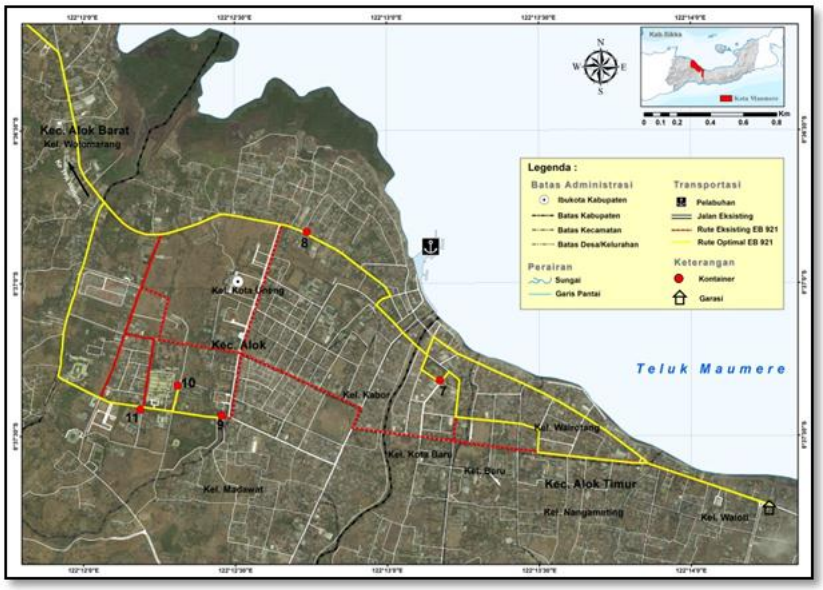

Fig. 4. Existed and Shortest Routes of Amrol Truck EB 921.

TABLE VII. Comparison between Existed and Shortest Routes for Amrol Truck DH 1010.

Route	Distance (km)		Σ Traffic Light		Time (hours)	
	Existing	Optimum	Existing	Optimum	Existing	Optimum
Garasi-K12-TPA	17.122	16.866	-	-	0,43	0,42
TPA-K13	14.307	14.373	-	-	0,36	0,36
K13-TPA	14.369	14.373	-	-	0,36	0,36
TPA-K14	14.939	14.725	1	1	0,40	0,40
K14-TPA	14.732	14.725	1	1	0,40	0,40
TPA-K15	12.959	12.959	-	-	0, 32	0,32
K15-TPA	12.814	12.814	-	-	0,32	0,32
TPA-K16	12.829	12.829	-	-	0,32	0,32
K16-TPA	12.705	12.705	-	-	0,32	0,32
TPA-K17	4.559	4.559	-	-	0,11	0,11
K17-TPA	4.559	4.559	-	-	0,11	0,11
TPA-K18	4.356	4.356	-	-	0,11	0,11
K18-TPA	4.356	4.356	-	-	0,11	0,11
TPA-Garasi	17.155	16.844	4	-	0,55	0,42
Total	**161.761**	**161.043**	**6**	**2**	**4,23**	**4,08**

Source: Analysis result

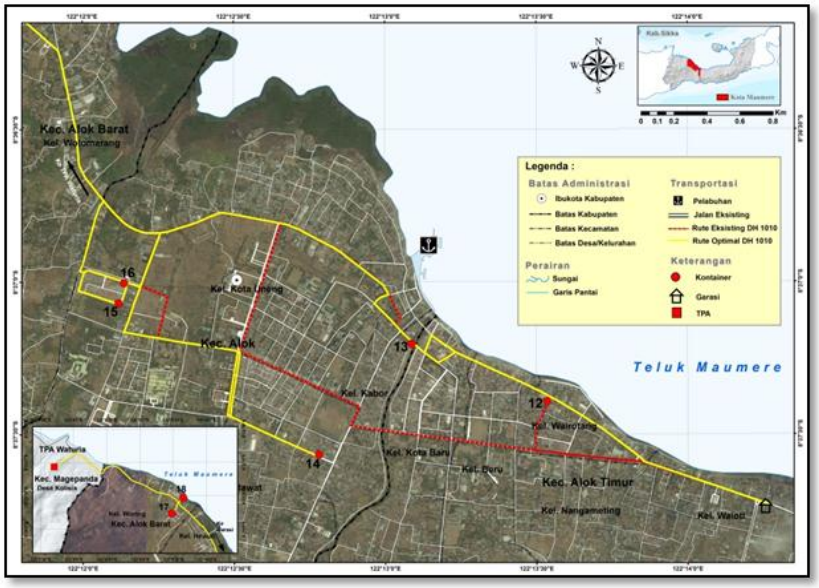

Fig. 5. Existed and Shortest Routes of Amrol Truck DH 1010.

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TABLE VIII. Comparison between Existed and Shortest Routes for Amrol Truck DH 8016.

Route	Distance (km)		Σ Traffic Light		Time (hours)	
	Existing	Optimum	Existing	Optimum	Existing	Optimum
Garasi-K19-TPA	17.724	17.071	2	-	0,50	0,43
TPA-K20	13.048	13.048	-	-	0,33	0,33
K20-TPA	12.727	12.727	-	-	0,32	0,32
TPA-K21	13.054	13.054	-	-	0,33	0,33
K21-TPA	12.477	12.477	-	-	0,31	0,31
TPA-K22	10.928	10.928	-	-	0,27	0,27
22-TPA	10.928	10.928	-	-	0,27	0,27
TPA-Garasi	17.454	16.844	4	-	0,56	0,42
Total	**108.340**	**107.077**	**6**	-	**2,89**	**2,68**

Source: Analysis result

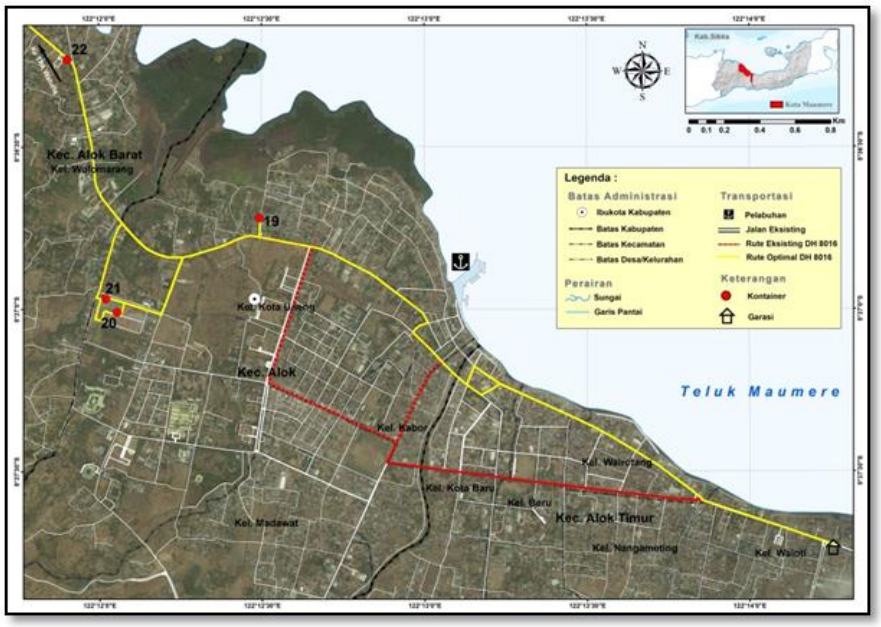

Fig. 6. Existed and Shortest Routes of Amrol Truck DH 8016.

- *Amrol truck with plate DH 8016*

Amrol truck with plate DH 8016 has total existing route length from garage to each container to the TPA and back to the garage was 108,340 km with total duration 3.2 hours and 15.5 liters of fuel, while for its shortest route from garage to each container to the TPA and back to the garage was 107,077 km with total duration 3 hours and 15.2 liters of fuel. Comparison of existing route and shortest route obtain 1,263 km difference. More information can be seen in Table VIII and Figure 6. Comparison between Existed and Shortest Routes of Amrol Truck DH 8016.

For waste transportation route using container system, in the figures this transportation route to TPA was not displayed since the route passing through Kec. Alok Barat was going in straight lines, while all waste transportation route to TPA through Kec. Alok Barat was using the same road. Waste transportation system for container was using amrol truck with empty container from the starting point to replace it with the first full container and took it to TPA, afterward it goes to the second full container and done it repetitiously until the last reit. By using the shortest route, it would maximize waste transport operation for container system in Maumere.

IV. CONCLUSION

From the result of this study, it can be concluded that:

1. Viewed from the existing condition of waste transport at study site, it can be said that waste management was still ineffective. There was some area that still not served.
2. Number of TPS/container and its transport vehicles cannot serve all people in Maumere.
3. There were differences between the existing route and fastest (shortest) route and distribution of container transport at container points was not well-proportioned.

V. SUGGESTION

Input suggestions that can be said for this study were:

1. It was necessary to obtain complete data regarding number of house condition to found out more about garbage heap of each house at study site.
2. It was necessary to conduct more study regarding gas emission pollution from garbage vehicles.
3. It was necessary to conduct study regarding role and contribution of the people in an effort to reduce garbage in TPS.

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