Waste Transportation System Optimization on Azzahara Material Recovery Facility (MRF) Bengkulu City

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Abstract - Bengkulu city as the capital city of Bengkulu province, in 2013 had a population of 334.529 inhabitants, with waste generated at 10,003.59 m3 / day. Coverage of waste management services in the city of Bengkulu has recently reached 33.01% or 331.29 m3 / day of the total waste. The effectiveness and efficiency waste transport system will increase the amount of waste transported and more communities are underserved. This research aims to improve the coverage of waste service by waste transportation system optimization. Analysis of optimization solid waste transportation system implemented by creating a network problem model and linear programming problem, generate the decision of how many trip of each conveyance and obtain maximum volume of waste transported.

Index Terms - linier programming problem, network problem, waste processing, waste transportation system.

INTRODUCTION

Bengkulu city located on the west coast of Sumatra island that is connected directly to the Indonesian Ocean and geographically located between 3°45' – 3°59' South Latitude, 102°14' - 102°22' East Longitude. Bengkulu city has a total area 539,3 square kilometer consisted of 151.7 square kilometer land area and 387.6 square kilometer sea area.

Population density of Bengkulu city was about 21 inhabitants/hectare with population growth rate of 2.54% (BPS Bengkulu Province, 2014), which it cause an increase in the rate of waste generation. An increase in the rate of waste generation can not be offset by an increase in facilities and infrastructure waste services. This waste generation needs to be managed properly in order to give no negative impact on the environment.

To increase coverage of waste service can be performed with the addition of a new conveyance vehicles to replace old vehicles transport equipment and supporting facilities. But, it would be ineffective for the long term because it will increase the burden of government in waste management costs. Another way to improve solid waste service coverage is to perform waste transport system optimization.

Financial aspects is an important component in the waste services. Transport phase is a very important phase because it consume the financing of 40-60% of the total waste management cost. By implementing an effective and efficient system of waste transportation, could increase the coverage waste services in Bengkulu city.

METHODS

Research methods used data collection and field observations. Data collection through literature studies conducted to get the theoretical basis supporting research creating the data analysis. Literature study are includes technical aspects, institutional aspects, and financing aspects. Field observations conducted to obtain the data of conveyance's capacity, travel route, long transport time.

Field observation was conducted to all waste conveyance's vehicle that operated in service area of Azzahara Material Recovery Facility. There were 12 waste conveyance's vehicle consisting of 6 Dumptruck and 6 Armroll truck. The service area covers four districts, there are Muara Bangka Hulu, Teluk Segara, Sungai Serut, and Ratu Samban. Observation and Measurement of each set waste conveyances vehicle done 3 times in different time. It is intended to obtain objective data, representative, relevant and small variations.

Travel route of waste conveyance's vehicle is effecting to mileage, cost and time of waste transport. Evaluation of travel route carried by comparing between existing route and optimum route. The optimum route could be obtained by creating a transportation model. Using minimum cost method, obtained minimum travel time route of waste conveyance's vehicle.

A. Transportation Model

The problem is that there are sources of waste generation that need to be transport to landfills using waste conveyance's vehicle. Each vehicle had different garage site. The constrains are can not transport more than waste generation and can not transport more than conveyance's capacity. The purpose is to minimize travel time route of waste conveyance's vehicle.

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B. II. Linier Programming Model

To increase coverage of waste management services, should be increased amount of waste volume transported. The volume of waste transported is the total volume of waste that can be transported from each vehicle conveyance in a day. The volume of waste transported calculated by multiply between conveyance's capacity and amount of trip.

RESULTS AND DISCUSSION

To create a transportation model, travel time from each garage site to every waste source need to calculated. Using equation :

$$travel\ time = \frac{Lenght\ route}{avarage\ speed}$$

Average speed of each waste conveyance's vehicle and Lenght route are obtained from field observations. The transportation model shown as following tabel.

TABLE 1. TRANSPORTATION MODEL.

	AR.1	AR.2	AR.3	AR.4	AR.5	AR.6	AR.7	S
K.1	80,78	134,09	92,39	99,75	137,94	90,21	92,11	
	1			1				2
K.2	117,63	154,82	129,65	151,13	183,66	95,09	144,55	
						1		1
K.3	80,78	147,26	97,52	116,30	152,60	91,21	109,22	
	2							2
K.4	96,97	158,88	113,53	133,60	174,53	97,93	128,02	
						1		1
K.5	88,01	168,75	89,36	105,55	136,89	96,36	90,71	
							2	2
K.6	143,20	252,81	160,61	142,63	201,81	149,32	165,78	
				1				1
K.7	96,05	157,68	89,12	126,94	157,54	103,13	109,36	
			2					2
K.8	91,49	152,23	85,89	121,55	151,71	98,19	106,22	
			1			1		2
K.9	102,02	166,12	94,99	119,54	155,50	109,12	103,92	
			1				1	2
K.10	82,41	133,26	90,42	105,05	137,08	91,16	92,79	
		1						1
K.11	81,73	132,78	89,15	103,25	135,47	90,63	92,29	
		2						2
K.12	96,86	154,07	99,42	94,86	123,71	105,36	84,03	
					1			1
K.13	82,73	128,66	95,16	66,63	91,76	92,22	72,88	
					1			1
K.14	82,06	140,72	94,28	116,09	150,36	88,65	111,47	
						1		1
K.15	92,26	146,74	88,14	117,78	147,74	98,99	99,34	
							1	1
K.16	86,94	139,86	93,36	111,05	144,19	97,16	96,76	
	1	1						2
K.17	87,91	141,78	93,27	90,89	127,93	95,71	78,30	
				1				1
K.18	81,65	132,87	88,55	83,10	115,69	90,11	76,35	
				1	2			3
D	4	4	4	4	4	4	4	

Using northwest corner method, transportation model had solved. Compiled linear equation to obtain optimum volume of each vehicle conveyances. Operational cost and operational time are determined as constrain variable to perform linier programming model. The objective function to be maximized of the following form :

$$Z = C_1.X_1 + C_2.X_2 + C_3.X_3 + C_4.X_4$$

Problem constraints of the following form:

- Operational cost constraint
  $A_{11}.X_1 + A_{12}.X_2 + A_{13}.X_3 + A_{14}.X_4 \leq B_1$
- Operational time constraint
  $A_{21}.X_1 + A_{22}.X_2 + A_{23}.X_3 + A_{24}.X_4 \leq B_2$
- Positive and integer variable constraint
  $X_n \leq 1\ and\ Integer$

Applying optimum route, all conveyance's vehicle could deliver 28 trip of container per day. The total volume of waste that could transport to landfill amount 216,535 m^3 per day. Comparing with eksisting route, all conveyance's vehicle could deliver 20 trip of container per day. Total volume of waste that transported to Landfill amount 154,668 m^3 per day.

CONCLUSION

Optimum route calculated with transportation model using northwest corner method, amount of total volume of waste that could transported to landfill increase 40 % from 154,668 m^3 per day become 216,535 m^3 per day. Increasing the amount of waste transported could improve the coverage of waste service.

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