

Optimization of Garbage Hauling Route in Medan Kota District using Saving Matrix Method to Minimize Cost

Khalida Syahputri¹, Rahmi M. Sari¹, Mangara M. Tambunan¹, Indah Rizkya¹, Ikhsan Siregar¹ and Josua P. Simanjuntak¹

¹Industrial Engineering, Faculty of Engineering, Universitas Sumatea Utara, Jl. Almamater, Padang Bulan, Medan, Indonesia

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Abstract: Medan Kota district is one of the district with the highest population density in the city. This has resulted in the high rate of garbage heap in the Medan Kota that must be managed. Limitations of the means of transporting garbage resulted in the accumulation of garbage in various TPS in Medan district. The purpose of this research, applying Saving Matrix method to optimize the route of transporting garbage in the city field. This method enables route optimization with respect to vehicle capacity and garbage volume for each TPS. The data used is the distance between Pool with the point of point of TPS and the distance between the points of TPS, the amount of garbage volume of each TPS point, and the capacity of the vehicle. The route optimization using Saving Algorithm will result in a route that minimizes the cost of fuel by the amount of garbage transported more. The route generated by using the Savings Algorithm to successfully save the distance as far as 95 Km and save the cost of Rp. 59.525.416 / year.

1 INTRODUCTION

Rate of garbage heap in developing countries will always be high. This was influenced by high levels of population, industrialization, urbanization, and economic growth. Economic garbage management consists of garbage reduction and garbage handling efforts. garbage reduction efforts consist of limiting garbage heap, recycling waste, and reuse of waste. garbage management efforts include sorting, collection, transporting, processing, and final processing (Bozkurt, 2015). Medan Kota district is one of the biggest sub-district in Medan with the population of 118.405 people and is categorized as solid city based on SNI 19. In Medan Kota sub-district, there are shopping area, trade, market that is Sambu Market Center, sports facility that is Teladan Stadium (C. Bozkurt, 2015).

The Increasing number of residents in Medan Kota district, will also increase the amount of garbage volume in Medan city. Based on the results of recap at department of public works and housing (DPUP) municipalities, the volume of garbage in Medan Kota district from year to year also increased. So it is necessary to do proper garbage management. The process of transporting garbage is done by way of

garbage transportation from garbage bins that were spread in every public road. Because of the limited number of transport vehicles, then the process of transporting garbage can only be executed as much as one time round in one day from the base to every particular service area and then taken to the landfill and ended up in the base and not optimal journey truck transport truck that resulted in garbage accumulation in some regions (Kinobe, 2016).

There were many factors that could influence in the process of transporting garbage from the starting point, in this case DPUP to the end point of the landfill, including the capacity of transport means, the volume of garbage in each TPS and the distance travelled in the transport process. The garbage transport process should each pay attention to the capacity of each vehicle and the demand capacity (waste) on each route the issue of garbage distribution involves several major considerations including vehicle routes, vehicles to minimize distribution costs, so as to expand the service area from garbage collection with limited fleets).

The problem of distribution routes was a very much discussed problem in terms of optimization such as about traveling salesman problems and vehicle routing problems and for that has been done a lot of research to discuss the problem VRP in order to

obtain the optimal technique to solve the problem (Hannan, 2018). Traveling salesman problems and routing issues vehicles are a very complex problem in the field of logistics distribution because they should involve a minimum cost design, determining the delivery route from start to finish and determining the start of the depot and the end of the depot (Armenzani, 2017). The solutions generated on the VRP problem are increased exponentially and to find the optimal solution in VRP problems can be solved by using heuristic methods that the proposed heuristic approach allows us to deal with problems in a short time using the heuristic method (Heechul, 2016).

Clarke and Wright create a heuristic algorithm to complete the VRP based on the concept of austerity which provide optimal solution and easy way to calculate and easier to comprehend. The concept of this savings was with the concept of cost that can be obtained by combining the two routes to the top and making it one. This was shown in the figure below where 0 represents the depot and i, j as the customer (Fathoni, 2017) of modified saving algorithms to create feasible solutions for VRPP. The idea was to first serve each customer with a special route, and then combine the route pairs as long as the positive savings can be realized and the vehicle's capacity was not violated. In each iteration, we combine pairs with the highest savings. To combine the two routes r1 and r2, we only consider the edge incidence to the depot and remove one side of r1 and one side r2. Then, we replace it with an edge directly connecting the appropriate customer i from r1 and j r2 (Babae, 2018). The Saving Matrix method was the method used to determine the route of product distribution to the marketing area by determining the distribution route to be traveled and the number of vehicles routing based on the capacity in order to obtain the shortest route and minimal transportation cost. The Saving Matrix method was also one of the techniques used to schedule a limited number of vehicles from facilities with a different maximum capacity. The austerity matrix shows the savings that occur when combining two possible TPS into one truck so that it can save the distance, time, and transportation costs (Babae, 2018).

2 METHODOLOGY

This research was conducted in the district of Medan Kota. The object studied was the route of transporting garbage from the pool to the TPS and from the TPS to the landfill located in Marelan Raya Street, Market V TPA Plunge, Rengas Island, Medan Marelan. The

data collected to conduct the research is the data of the number of temporary garbage disposal sites, the number of consumer demand or the volume of landfills. From the data obtained will be processed using Clarke and Wright Saving Matrix method, the route of garbage transportation in sub-district of city was divided into 4 polls where each poll has different number of different TPS for each POOL

The first step done in this research was to create a matrix that contains distance between TPS the distance between each pair of locations to visit. Determining the distance was based on the distance of each TPS where the location of each TPS can be symbolized as notation, Juanda street was symbolized by A1, Sisingamangaraja street symbolized by A2, Mahkamah street symbolized by A3, Tengah street symbolized by A4, Samarinda symbolized with Rahmadsyah by A6, Raja street symbolized by B1, Pelangi street symbolized by B2, Turi street symbolized by B3, Gedung Arca street symbolized by B4, Halat street symbolized by B5, Halat street symbolized by B6, Juanda street symbolized by B7, H M Joni street symbolized by B8, Seksama street symbolized by C1, Saudara street symbolized by C2, Bahagia street symbolized by C3, Kemiri 1 street symbolized by C4, Kemiri 2 street symbolized by C5, Pelajar street symbolized by D1, Jati street symbolized by D2, Aman street symbolized by D3, Meranti street symbolized D4. Sakti Lubis street symbolized by D5, Pintu Air street symbolized by D6, Busi street symbolized by D7, Gg Pegawai symbolized by D8, Bali street symbolized by D9, Sempurna symbolized by E1, Santun street symbolized by E2, Laksana street symbolized by E3, Amalium street symbolized by I4, and Rahmadsyah street symbolized by E5. The second stage is to create a distance-saving Matrix that shows the savings that occur when combining two possible TPS into one truck so that it can save the distance, time, and transportation costs.

$$S(x, y) = \text{Dist}(\text{Center}, x) + \text{Dist}(\text{Center}, y) - \text{Dist}(x, y) \quad (1)$$

Third stage. Allocate TPS points to a transport route. The first step of each TPS was allocated to different trucks or routes. The second step was to combine two routes based on the saving distance obtained using the largest Saving Matrix formula and check whether the merger was feasible or not. It was said to be appropriate if the total shipments that should be passed through the route do not exceed the capacity of the conveyance. The integration of the route was focused on saving the greatest distance to

obtain the distance efficiency, so the time spent will be faster.

The fourth stage. This stage aims to minimize the travel distance that must be transported each means of conveyance. To get an optimal transportation route, can be done two stages of determining the initial delivery route for each vehicle and make improvements to the route that is not feasible. The fifth stage. Calculates the fuel cost of each total distance with the fuel consumption for each garbage truck average of 3km / liter and the diesel price is Rp 5,150.

3 RESULTS AND DISCUSSION

3.1 Truck Transportation Garbage Route in Medan Kota District

In this research, the data consists of Primary Data and Secondary Data. Primary data collected were among others: truck route of garbage transport during operational time and location of service area; truck capacity; and the amount of garbage heap in each service area. Secondary data collected were: number and type of garbage truck, truck data (type, police number, and year of output); data speed of truck (speed), time of loading and unloading of waste, garbage transport vehicle in sub district Medan of 7 unit consisting of:

1. In pool A there was 1 unit of truck garbage of capacity 8m³
2. In pool B there were 2 units of 8m³ capacity truck.
3. In pool C there was 1 unit of 8m³ capacity truck.
4. In pool D there were 2 units of 8m³ capacity truck.
5. In pool E there was 1 unit of 8m³ capacity truck.

Research determination of garbage dumping route in sub-district of Medan Kota with the capacity of 8m³ garbage truck which the actual route from garbage collection in sub-district of Medan Kota.

On the actual route the garbage truck that was in each pool only runs every TPS once a day and when the volume of garbage meet the capacity of the truck, not yet lifted will resume on the next day, on Monday the truck in pool E will lift the garbage at A1-A2-A3 point with a volume of 7.5 after lifting the truck truck will depart to TPA, and for the garbage located at A5-A4-A6 will be taken the next day because each truck there was only one rotation per day. After using Clarke method and Wright Saving Matrix could be obtained new route which can be seen in Table 2.

Tabel 1: Actual Route

Pool	Route	Volume Transported (m ³)	Distance (km)	Cost
Pool A	A0-A1-A2-A3-X-A0	7,5	46,60	Rp468.135
	A0-A5-A4-A6-X-A0	7,5	44,3	
Pool B	B0-B4-B7-B3-X-B0	7	62,3	Rp829.923
	B0-B6-B1-B8-X-B0	8	50,75	
	B0-B5-B2-X-B0	5,5	48,1	
Pool C	C0-C1-C4-C2-X-C0	7	53,90	Rp545.128
	C0-C3-C5-X-C0	6,	51,95	
Pool D	D0-D6-D2-D7-X-D0	7,5	53,9	Rp841.510
	D0-D3-D5-D1-X-D0	8	56,9	
	D0-D9-D4-D8-X-D0	7	52,6	
Pool E	E0-E4-E2-E1-X-E0	7,5	58,70	Rp628.815
	E0-E4-E3-X-E0	4,5	63,40	

Tabel 2: Actual Route

Pool	Route	Volume Transported (m ³)	Distance (km)	Cost
Pool A	A0-A4-A1-A3-X-A0	7	42,40	Rp418.438
	A0-A2-A6-A5-X-A0	8	38,85	
Pool B	B0-B4-B6-B7-X-B0	8	43,75	Rp695.250
	B0-B2-B3-B8-X-B0	7,5	43,75	
	B0-B1-B5-X-B0	6	47,50	
Pool C	B0-C5-C1-C2-X-C0	6,5	49,00	Rp489.250
	C0-C4-C3-X-C0	6,5	46,00	

Pool D	D0-D8-D7-D6-X-D0	8	53,15	Rp831.210
	D0-D1-D9-D3-X-D0	8	57,70	
	D0-D4-D5-D2-X-D0	6,5	50,55	
Pool E	E0-E3-E5-E4-X-E0	7	51,70	Rp587.100
	E0-E1-E2-X-E0	5,5	62,30	

From the Table 1. Can be seen that there were 5 garbage truck pools that serve garbage collection in each TPS in the Medan Kota district, the results obtained were the garbage in the coverage TPS of pools E, F, G, H and I can be trapped in one day 2 garbage hauling and in pools F and H there were 3 routes that must be trucked by garbage trucks but in pools F and H each have 2 different trucks with other pools that have only one truck, the determination of the route of garbage by using Saving Matrix method was based on the volume and capacity of garbage truckers. On the trucking trip, each truck will do two rotations a day if the truck was only one ritual in one day, the garbage in each TPS is all due to the limited number of trucks and the limited capacity of the conveyance at each pool.

3.2 Comparison of the Total Actual Cost with the Cost of the Proposed Route

Based on the determination of the cost of truck transporting garbage using saving matrix method, then compare between actual route and with the regular route.

Table 3: Comparison Of Total Actual Cost With Cost Of Proposed Route

No	Pool	Total Distance (km)	
		Actual	Proposal
1	E	Rp468.135	Rp418.438
2	F	Rp829.923	Rp695.250
3	G	Rp545.128	Rp489.250
4	H	Rp841,510	Rp831.210
5	I	Rp628.815	Rp587.100

From the table it can be seen that the total fuel cost of the actual route is greater than the total cost of the proposed route with savings of 8.8%. Peter Majercak's research on the determination of the distribution route of goods to each consumer by considering the capacity of the truck using the Clark and Wright's Savings Algorithm method successfully

minimizes the delivery distance of the product to the consumer. Clark and Wright's Savings Algorithm methods have also managed to minimize waste transport distance between TPS in Medan Kota District.

4 CONCLUSIONS

The total traveled distance by all trucks so far in Medan Town sub-district is 643.4 km. After using the saving matrix method the total traveled distance become 586.65 km km. The total fuel cost incurred by the urban district is Rp. 3.313.000,- per month. After using the saving matrix method the total cost of board materials issued to RP. 3.021.000,- per month. The percentage of total cost savings is 8.8%, The results shows that the route and cost of fuel with saving matrix method is minimized.

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REFERENCES

Cuma Bozkurt, 2015. *International Journal Of Energy Economics And Policy* Vol 5, No 2.

Cuma Bozkurt." Industrial-waste management in developing countries: The case of Lebanon Volume 61, Issue 4, April 2015.

Kinobe,j.r dkk, 2016. *Habitat International* Volume 49, October 2015, Pages 126-137

M.A.Hannan, M.A 2018. *Waste Management* Volume 71, January 2018. Pages 31-41

Gendreau Michel." Efficiently Solving Very Large Scale Routing Problems4 Florian Arnold1", diakses dari https://www.researchgate.net/profile/Florian_Arnold/publication/322317599

Armenzoni 2017. *Distribution Journal of Advanced Transportation* Volume 2017.

Heechul Bae 2016, *Mathematical Modelling* 40(13-14)

Fathoni, Ali, 2017. *International Journal of New Technology and Research* Volume-3, Issue-10

Babae dkk 2018, *Sustainability* 2018. 10(5), 1366

Fisher, M.L. 1995. "Vehicle Routing in Operations Research and Management Science"Vol.8. Amsterdam, New York, Elsevier

- Majercak, Peter. 2016. Application of Clark and Wright's Savings Algorithm Model to Solve Routing Problem in Supply Logistics Vol 25 (2), PP.125-145
- Uchoa, E., Pecin, D., Pessoa, A., Poggi, M., Vidal, T., and Subramanian, A. 2017. *European Journal of Operational Research*, 257(3):845-858.

