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Optimization of Garbage Collection Routes Using The Clarke-Wright Saving Heuristic Method in Medan

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ABSTRACT

Garbage is a classic problem that occurs in big cities like Medan. As a city of commerce and industry, the amount of waste generated in the city of Medan is increasing every day. This research was made based on the existing problems in Medan Marelan District. The problem of waste distribution in Medan Marelan does not yet have a fixed route and runs two routes or two rounds every day so that waste transportation is not optimal which results in piles of garbage at several points that are missed and ineffective time. Based on these problems, this research was made using the Clarke and Wright Saving Heuristic method. The purpose of this study is to determine the optimal waste transportation route for waste distribution so as to minimize distribution costs. From the processing, the route that will be obtained can be determined by two methods, namely nearest neighbor and farther insertion. From the observations of the two methods used, the total distance on each route is different. For example, on the first Typer Truck route, the Farthest Insert Method is 34,126 km and the Nearest Neighbor Method is 32,595 km with the required fuel of 6.8 liters and 6.5 liters. The second Typer Truck Farthest Insert Method is 13,275 km and the Nearest Neighbor Method is 13,506 km with 2.65 liters and 2.7 liters of fuel. And the third Typer Truck Farthest Insert Method is 13,075 km and Nearest Neighbor Method is 13,225 km with 2.6 Liters and 2.64 Liters of fuel..

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1. INTRODUCTION

Daily activities of Medan city residents generate waste both from household waste and economic sectors such as markets, shops and restaurants. Waste problems cause various problems in people's lives. Waste that accumulates and is left without proper processing and handling can cause various impacts on life, such as flooding and diseases caused by environmental pollution (Nazar 2022). Waste management problems in the waste transportation process need to be improved due to the high growth rate in Medan- city. To be able to make this-happen it requires the role of the government and local residents to be included by an effective waste transportation distribution system. From the problems that arise, we need a waste

transportation distribution system that can determine the shortest route with maximum capacity using the Clarke and Wright Saving Heuristic method. The Clarke and Wright Saving Heuristic method is a method of finding the next customer location by calculating the distance savings that arise from combining two or more customers into a route. This method is also used to determine the route that must be taken by taking into account the vehicle capacity (K and Sumiati 2020). According to Hafid in Rezki 2016, Clarke and Wright's saving method is an exchange procedure, where a set of routes at each step are exchanged to get a better set of routes.

Based on the background above, the formulation of the problem in this study is how to optimize the transportation of waste in areas that have a high level of waste accumulation using the Clarke Wright savings heuristic method, with the title "Optimization of waste transportation routes in the city of Medan using the Clarke Wright savings heuristic method".

So that this research does not expand, it is necessary to provide limitations, namely:

1. Calculations were made to determine the route with optimal mileage using the Clarke Wright savings heuristic method.
2. Garbage transportation using garbage trucks.
3. The distribution route for the transportation of waste taken in the area of Medan City, Medan Marelan District

The purpose of this study is to identify waste problems and create optimal routes that prioritize waste transportation in areas with high waste piles in Medan Marelan District using the Clarke Wright savings heuristic method.

2. RESEARCH METHOD

This research was conducted from February 2023 until completion in the Medan City area, especially in the Medan Marelan District. This study uses applied research by carrying out field observations and collecting data that will be used to design a waste transportation route plan and then evaluate the route using the Clarke-Wright Saving Heuristic method. There are 2 (two) types of data collected, namely primary data and secondary data. Primary data were obtained from observations and interviews with the West Medan District. Secondary data was also obtained from related institutions and other relevant sources.The steps of the Clarke and Wright saving heuristic method are as follows (Chopra, 2010) :

1. Identifying the distance matrix

$$D_n = \sqrt{(x - x_n)^2 + (y - y_n)^2}$$

Description

Dn : Distance

X : Lattitude or Latitude of the earthly

Y : Longitude or longitude of the earth

2. ide ntifying the saving matrix

$S(x, y) = J(DC, x) + J(DC, y) - J(x, y)$

Where,

S(x,y) : saving matrix value / saving distance

DC : Center point distance

X : First base distance

Y : Second base distance

3. Divide consumers into vehicle travel routes

The procedure used for grouping consumers is based on the largest saving matrix value. So first, sort the largest to smallest saving matrix value. Then group consumers starting from the largestsaving matrix value until the capacity of the vehicle used can accommodate all requests. If the vehicle capacity is maximized, then the procedure will repeat until all consumers are allocated on atravel route.

4. Sort consumers into travel routes.

This is the final stage of the Clark and Wright Saving Heuristic method. Some of the methods that can be used to sort visits are Farthest Insert and Nearest Neighbor.

3. RESULT AND ANALYSIS

This research will discuss the application of the Clarke-Wright Saving Heuristic method. Medan Marelan District has a garbage collection site such as TPS, this location has implemented a garbage transportation route for each village with details of 3 Typer trucks, 1 Amrol truck and 3 convector trucks. This study discusses Typer trucks that run in 4 sub-districts consisting of Paya Pasir, Labuhan Deli, Jump, and Tanah 600.

Typer Truck	Path	Road Passed	Distance (Km)	BBM	Capacity	Total of the waste/Day
BK 9220 J	Route 1	1. Jl Titipahlawan	20,570	22 Liter	6 Ton	5 Ton
		2. Jl Paluh nibung				
		3. Jl kapten rahmad Buddin				
	Route 2	1. gang kambing	19,499			
		2. Jl Jala				
		3. gang pringan				
		4. Jl take naka				
		5. Jl pasar Nippon				
		6. Jl young panah hijau				
BK 9655 J	Route 1	1. Jl kapten rahmad Buddin	2,516	22 Liter	6 Ton	5 Ton
	Route 2	1. Jl kapten rahmad Buddin	15,722			
		2. Jl sani muthalib				
		3. ko. Tut Urihandayani				
		4. Ko Citra Anugrah Prima				
		5. Ko Terjun Indah				
		6. Jl. Marelan V				
		7. Jl. Marelan IX				
		8. Ko Griya Pesona Minimalis				
BK 9921 H	Route 1	1. Jl Marelan raya	5,275	22 Liter	6 Ton	5 Ton
	Route 2	1. Jl. Marelan IX	11,839			
		2. Jl. Marelan VII				
		3. Jl. Baut				
		4. Jl. Muslim Pancasila				
		5. Ko Deli Indah				
		6. Ko Maryland				
		7. Ko 88				

Table 1. Typer truck route data

3.1 Application of the Clarke-Wright Saving Heuristic Method

1. Identify the distance matrix
   Typer truck Bk 9220 J

	0	a	b	c	d	e	f	g	h	i	z
0	0										
a	1,836	0									
b	6,181	6,273	0								
c	0,426	2,208	6,002	0							
d	5,868	5,432	11,684	6,221	0						
e	2,335	2,814	8,481	2,621	3,691	0					
f	1,564	0,304	6,348	1,951	5,337	2,559	0				
g	2,199	0,396	6,186	2,553	5,588	3,163	0,699	0			
h	2,504	0,840	5,852	2,817	6,009	3,642	1,130	0,483	0		
i	4,283	2,559	6,132	4,581	6,811	5,198	2,863	2,164	1,782	0	
z	0,951	1,306	5,508	1,139	6,258	3,001	1,153	1,565	1,734	3,465	0

Table 2. Matrix Distance from Typer truck BK 9220J

2. Typer truck Bk 9655 J

	0	c	k	l	m	n	o	p	q	z
0	0									
c	0,426	0								
k	2,393	2,209	0							
l	1,426	1,805	2,768	0						
m	0,307	0,127	2,221	1,678	0					
n	0,334	0,760	2,566	1,145	0,638	0				
o	1,543	1,595	1,294	1,483	1,532	1,570	0			
p	2,632	2,614	1,034	2,433	2,575	2,680	1,111	0		
q	1,126	0,701	2,031	2,449	0,821	1,459	1,866	2,695	0	
z	0,951	1,139	3,320	1,919	1,104	0,936	2,476	3,577	1,674	0

Table 3. Distance Matrix of *Typer truck* BK 9655 J

3. Typer truck Bk 9921 H

	0	j	p	r	s	t	u	v	w	z
0	0									
j	1,822	0								
p	2,632	1,896	0							
r	2,117	1,394	0,563	0						
s	3,444	2,018	1,258	1,460	0					
t	3,301	1,621	1,690	1,648	0,729	0				
u	3,449	1,854	1,566	1,634	0,436	0,325	0			
v	3,872	2,275	1,844	1,999	0,588	0,678	0,428	0		
w	3,897	2,300	1,862	2,021	0,604	0,702	0,453	0,025	0	
z	0,951	2,502	3,577	3,050	4,318	4,088	4,274	4,701	4,727	0

Table 4. Matrix Distance from Typer truck BK 9921 H

2. Identifying saving matriks
   a. Typer Truck Bk 9220 J

	a	b	c	d	e	f	g	h	i
a	0								
b	1,744	0							
c	0,054	0,605	0						
d	2,272	0,365	0,073	0					
e	1,357	0,035	0,140	4,513	0				
f	3,096	1,397	0,039	2,095	1,340	0			
g	3,639	2,194	0,072	2,478	1,371	3,063	0		
h	3,499	2,832	0,113	2,362	1,197	2,937	4,219	0	
i	3,560	4,332	0,128	3,340	1,420	2,984	4,318	5,005	0

Table 5. Saving Matrix of Typer truck BK 9220 J

   b. Typer Truck Bk 9655 J

	c	k	l	m	n	o	p	q
c	0							
k	0,609	0						
l	0,047	1,051	0					
m	0,605	0,479	0,054	0				
n	0,000	0,161	0,615	0,002	0			
o	0,374	2,643	1,486	0,318	0,307	0		
p	0,444	3,991	1,626	0,364	0,285	3,064	0	
q	0,852	1,488	0,103	0,612	0,001	0,803	1,063	0

Table 6. Saving Matrix of Typer truck BK 9655 J

   c. Typer Truck 9921 H

	j	p	r	s	t	u	v	w
j	0							
p	2,558	0						
r	2,544	4,186	0					
s	3,248	4,818	4,102	0				
t	3,502	4,243	3,769	6,016	0			
u	3,416	4,515	3,932	6,457	6,425	0		
v	3,419	4,660	3,990	6,729	6,495	6,894	0	
w	3,419	4,668	3,993	6,738	6,496	6,893	7,744	0

Table 7. Saving Matrix dari Typer truck BK 9921 H

3. Divide consumers into vechicle travels routes
   a. Typer Truck 9220 J

No	Titik	hasil
1	i,h	5,005
2	e,d	4,513
3	I,b	4,332
4	I,g	4,318
5	h,g	4,219
6	g,a	3,639
7	I,a	3,560

8	h,a	3,499
9	I,d	3,340
10	f,a	3,096
11	g,f	3,063
12	I,f	2,984
13	h,f	2,937
14	h,b	2,832
15	g,d	2,478
16	h,d	2,362
17	d,a	2,272
18	g,b	2,194
19	f,d	2,095
20	b,a	1,744
21	I,e	1,420
22	f,b	1,397
23	g,e	1,371
24	e,a	1,357
25	f,e	1,340
26	h,e	1,197
27	c,b	0,605
28	d,b	0,365
29	e,c	0,140
30	I,c	0,128
31	h,c	0,113
32	d,c	0,073
33	g,c	0,072
34	c,a	0,054
35	f,c	0,039
36	e,b	0,035

Table 8. Sorting matrix of *Typer truck* BK 9220 J

b. Typer Truck Bk 9655 J

No	Titik	Hasil
1	p,k	3,991
2	p,o	3,064
3	o,k	2,643
4	p,l	1,626
5	o,l	1,486
6	q,k	1,488
7	q,p	1,063
8	l,k	1,051
9	q,c	0,852
10	q,o	0,803
11	n,l	0,615
12	q,m	0,612
13	k,c	0,609
14	m,c	0.605
15	m,k	0,479
16	p,c	0,444
17	o,c	0,374
18	p,m	0,364
19	o,m	0,318

20	ro,n	0,307
21	p,n	0,285
22	n,k	0,161
23	q,l	0,103
24	m,l	0,054
25	l,c	0,047
26	n,m	0,002
27	q,n	0,001
28	n,c	0,000

Table 9. Sorting matrix of Typer truck BK 9655 J

c. Typer Truck Bk 9921 H

No	Titik	Hasil
1	w,v	7,744
2	v,u	6,894
3	v,w	6,893
4	w,s	6,738
5	v,s	6,729
6	w,t	6,496
7	v,t	6,495
8	u,s	6,457
9	u,t	6,425
10	t,s	6,016
11	s,p	4,818
12	w,p	4,668
13	v,p	4,660
z14	u,p	4,515
15	t,p	4,243
16	r,p	4,186
17	s,r	4,102
18	w,r	3,993
19	v,r	3,990
20	u,r	3,932
21	t,r	3,769
22	t,j	3,502
23	w,j	3,419
24	v,j	3,419
25	u,j	3,416
26	s,j	3,248
27	p,j	2,558
28	r,j	2,544

Table 10. Sorting matrix of the Typer truck BK 9921 H

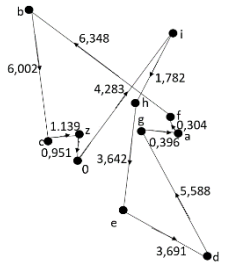
4. Sort consumers in the travel route

Typer truck	Metode	Rute	Jarak
BK 9220 J	Farthest Insert	0 - i - h - e - d - g - a - f - b - c - z - 0	34,126
	Nearest Neighbour	0 - c - b - f - a - g - d - e - h - i - z - 0	32,595
BK 9655 J	Farthest Insert	0 - p - k - o - q - l - n - m - c - z - 0	13,275
	Nearest Neighbour	0 - c - m - n - l - q - o - k - p - z - 0	13,506

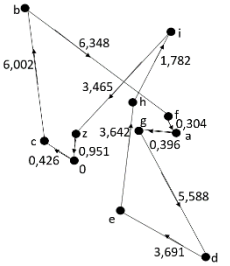
BK 9921 H	Farthest Insert	0 - w - v - u - s - t - r - p - j - z - 0	13,075
	Nearest Neighbour	0 - j - p - r - t - s - u - v - w - z - 0	13,225

Table 11. Comparison of the Route Sequence of the Typer truck

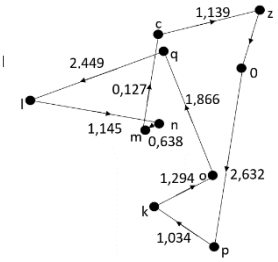
From the results of the new route with the two methods above, this route is obtained by looking at the value of the saving matrix, the amount of garbage collection must be less than or equal to the load capacity of the trucks used to transport garbage and the route results to be obtained can be determined by two methods, namely the nearest neighbor and farther's insertion. So that a graph of the route of the three vehicles can be obtained as follows.



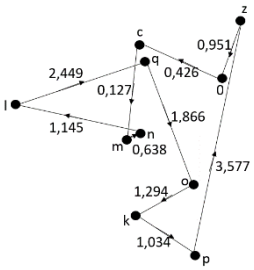
Figuri 1. First BK 9220 J Route Graph



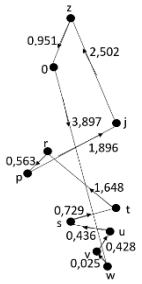
Figuri 2. Second graph of Route BK 9220 J



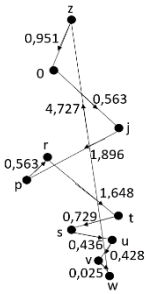
Figuri 3. First BK 9655 J Route Graph



Figuri 4. Second graph of Route BK 9655 J



Figuri 5. First BK 9921 H Route Graph



Figuri 6. Second graph of Route BK 9921 H

The fuel required fro transportation of each truck after route determination as follow:

$$\frac{\text{Total distance}}{5}$$

Therefore, the cost for each transportations are

1. $\frac{Total\ distance}{5} = \frac{34{,}126}{5} = 6{,}8\ Liter$

2. $\frac{Total\ distance}{5} = \frac{32{,}595}{5} = 6{,}5\ Liter$

3. $\frac{Total\ distance}{5} = \frac{13{,}275}{5} = 2{,}65\ Liter$

4. $\frac{Total\ distance}{5} = \frac{13{,}506}{5} = 2{,}7\ Liter$

5. $\frac{Total\ distance}{5} = \frac{13{,}075}{5} = 2{,}6\ Liter$

6. $\frac{Total\ distance}{5} = \frac{13{,}225}{5} = 2{,}64\ Liter$

4. CONCLUSION

From the results of the above research it can be concluded that the Clarke-Wright Saving Heuristic methodcan minimize transportation costs and distance. Where for the total initial distance the first Typer truck was 40.069 km, the second was 18.238 km, and the third was 17.114 km by going through two unfixed routes, while for the new total distance the first Typer truck Farthest Insert Method was 34.126 km and the Nearest Neighbor Method was 32.595 km, the second Farthest Insert Method was 13.275 km and the Nearest Neighbor Method was 13,506 km and the third Farthest Insert Method of 13.075 km and Nearest Neighbor Method of 13.225 km and for fuel, basically using 22 liters per truck, after the researchwas carried out, the first fuel was obtained as much as 6.8 liters and 6.5 liters, the second 2.65 liters and 2.7 liters and the third 2.6liters and 2.64 liters. From the results that have been obtained, this research is inaccordance with its objectives, namely to optimize Waste Collection Routes in Medan City Using the Clarke-Wright Saving Heuristic Method which is precisely in the Medan Marelan sub-district withthe address Jalan KaptenRahmad Buddin No.190, Terjun, Kec. Medan Marelan, Medan City, North Sumatra 20255, so as to minimizedistribution costs.

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