JTAM (Jurnal Teori dan Aplikasi Matematika)
http://journal.ummat.ac.id/index.php/jtam
p-ISSN 2597-7512 | e-ISSN 2614-1175
Vol. 7, No. 4, October 2023, pp. 1143-1154

Optimizing the Implementation of the Greedy Algorithm to Achieve Efficiency in Garbage Transportation Routes

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Article History:
Received : 17-07-2023
Revised : 23-09-2023
Accepted : 28-09-2023
Online : 11-10-2023

Keywords:
Greedy algorithm;
Shortest route;
Pathmapping;
Waste disposal.

ABSTRACT

Until now, the waste problem is still a crucial problem, including in the Banyumas Regency area. The uncontrolled accumulation of garbage at the TPS will of course greatly disturb the comfort of the community around the TPS. As is the case with the accumulation of garbage at TPS (Garbage Disposal Sites) in North Purwokerto District. When searching for this garbage transportation route, the Greedy Algorithm works by finding the smallest weight point by calculating the route passed and calculating the weight depending on the weight of the stages that have been passed and the weight at the stage itself. Based on the results of the system testing that has been made, the shortest route for transporting waste from the starting point of the Banyumas Environment Office is to go to the final disposal site in Tipar, and return to the starting point of the Banyumas Environmental Office. So that the total distance traveled to return to the starting point is 53 km long. Based on the findings and discussions of this research, the results obtained are the determination of the shortest route from node A back to node A. Specifically, the route involves traveling from the DLH Banyumas Regency to TPS Grendeng, TPS Karangwangkal, TPS Pabuwaran, TPS Sumampir, TPS Purwanegara, TPS Bobosan, to TPA Tipar, and then returning to DLH Banyumas Regency. These results have implementable implications in the context of waste management in this area, with a total distance traveled of 53 kilometers.

https://doi.org/10.31764/jtam.v7i4.16612

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A. INTRODUCTION

Environmental issues, including waste management, transcend geographical boundaries and have evolved into a global concern. The intricate web of challenges associated with waste management knows no borders and resonates across nations and continents. The responsible management of waste has become a pivotal concern for our planet as it grapples with the consequences of unsustainable practices (Hussain et al., 2023). Waste, often referred to simply as 'garbage,' encapsulates the broader problem of solid waste management (Calla et al., 2023). The waste problem is a multifaceted issue, particularly pronounced in urban settings, where it perpetually looms as an ever-present challenge, demanding constant attention and innovation (Li et al., 2015).

The gravity of waste-related challenges is not confined to any single nation but extends globally. Indonesia, a nation with its own unique environmental dynamics, is no exception to these pressing concerns. On any given day, Indonesia generates a staggering 175,000 tons of national waste, reflecting the magnitude of the issue within its borders (Ruslinda et al., 2020). This compounding problem is further exacerbated by the scarcity of available land for the management of Final Disposal Sites (TPA). TPA plays a pivotal role in the waste management lifecycle, serving as the ultimate destination for waste, where it undergoes the final stages of processing, transfer, transportation, and disposal.This challenge is compounded by the limited availability of land for Final Disposal Site (TPA) management. TPA is a place where waste is disposed of to reach the final stage of its management, starting from source, collection, transfer/transportation, and processing to disposal. This also happened in one of the North Purwokerto areas, the Banyumas Regency itself. In the North Purwokerto area of Banyumas Regency, these waste management challenges are particularly acute. The suboptimal waste transportation system has resulted in the accumulation of garbage at various points, making disposal and handling difficult. This has also led to extended transit times in the waste transportation process. The total distance covered in North Purwokerto, Banyumas Regency, reaches 32.3 km, with 6 TPS locations and an average transportation time of 15 minutes. One of the vehicles used for transporting waste is the armroll which has 1 unit. To deal with waste problems in North Purwokerto City, Banyumas Regency. The slow process of transporting waste means that some waste must continue to accumulate in the TPS. The imbalance between the quantity of waste transported and the income of waste at the TPS also causes the TPS to accommodate too much waste. Meanwhile, officers are also required to provide maximum service to the community, therefore a number of unserved waste needs to be addressed so that the level of service is much better. Because if some of the waste is not served, it will harm the community. However, to improve service, accuracy is needed in choosing the route for waste transportation (Quercia et al., 2014). The Greedy Algorithm provides local optimum alternatives with the hope that each local alternative will produce the optimal global optimum alternative as a whole (Wilt & Ruml, 2014). The model used with the objective function of cost minimization is due to distance being proportional to the cost, so that when the distance increases it will cause costs to increase as well.Given these problems, it is necessary to create a system that functions to optimize waste transportation routes in a more optimal route or by finding the shortest route. The shortest path is the minimum path required to reach a location from a certain location (Duchon et al., 2014). The benefit of choosing this optimal distance is to minimize the time and costs that will be incurred in traveling (Abu-Aisheh et al., 2015).

The search for the shortest route is an application of a branch of graph mathematics (Das et al., 2022). In determining the most optimal route, the author takes steps that describe the routes (trajectories) that are traversed with network diagrams using graph theory and then looks for the most optimal routes (trajectories) using a greedy algorithm. Remembering the Greedy algorithm principle that can solve the problem of finding the shortest travel distance. The greedy algorithm has an approach to build a solution gradually through an ever-growing sequence until a solution to the problem has been reached (Cerrone et al., 2017). This Greedy method is a method that can gradually solve optimization problems through an ever-evolving flow until the solution to the problem can be resolved (Haasdonk, 2013). Previous studies that used the Greedy Algorithm method to find the shortest route, namely the research "Analysis of finding the fastest route to tourist attractions on Kumala Island, Tenggarong City using the Greedy Algorithm". The problem with this research is that due to the increasing number of tourists, the road to the tourist spot is jammed. While being stuck in traffic jams certainly makes someone bored and bored, so they will try to find ways to make their journey unhindered and get to their destination in a short and fast time (Puja Kekal et al., 2021). In a similar vein, another study employed the Greedy Algorithm to recommend tourist destinations based on proximity in the Bali region (Ubaidillah & Gede Dwidasmara, 2020). Furthermore, the Greedy Algorithm has been applied beyond tourism, as seen in a study that focused on determining the shortest route and associated costs from Indarung Village to the Taman University campus in Padang (Santi, 2019). This algorithm's utility extends to various optimization problems, where it gradually builds solutions by iteratively selecting the locally optimal choice, eventually leading to a globally optimal solution (Haasdonk, 2013).

While previous studies have shed light on the efficacy of the Greedy Algorithm in various domains, our research builds upon this foundation to address the specific challenge of optimizing waste transportation routes in the North Purwokerto area. In doing so, we distinguish our work from previous research, including studies like "Finding the optimal route of wood transportation." This earlier study focused on the development of an algorithm to efficiently determine optimal cargo transportation routes while minimizing costs (Mokhirev et al., 2019). It considered factors such as transportation costs, carrying capacities, and different conditions of forest roads, utilizing Dijkstra's approach and dynamic programming. The primary outcome was an algorithm for calculating optimal cargo routes, accounting for cost factors that may vary with cargo volume.

In contrast, our study, titled "Optimization of Garbage Transportation Routes in North Purwokerto Using the Greedy Algorithm," concentrates on enhancing garbage transportation routes in the North Purwokerto region using the Greedy Algorithm. Our aim is to address the challenge of efficient waste transportation and minimize travel distances. The Greedy Algorithm is employed to find the shortest routes, considering weights and travel distances. Our main achievement is determining the shortest route for garbage transportation from the starting point to the final disposal site, covering a distance of approximately 53 kilometers.

While there are contextual and focal differences between our research and previous studies, they collectively contribute to the field of route optimization. Our work offers a novel contribution within the context of garbage transportation optimization. Leveraging the Greedy Algorithm to identify the shortest routes for waste transportation enhances waste management efficiency, reduces travel distances, and minimizes environmental impact. As a result, our research presents a relevant solution and contributes to the more efficient management of waste in the North Purwokerto area, with potential applications in similar contexts elsewhere.

The problem of our research is optimizing the garbage transportation route in the North Purwokerto area using the Greedy Algorithm taking into account the distance traveled. The results obtained from this study are an alternative shortest route for waste transportation in the North Purwokerto area from several other route options. This study aims to observe the problems faced and to show or find the fastest alternative solutions from the Banyumas Regency Environmental Service to all TPS in the North Purwokerto area and transport the existing waste to the Final Disposal Site (TPA) in Tipar, then back to the Banyumas Regency Environmental Service using the Greedy algorithm method (DeVore et al., 2013).

B. METHODS

1. Data Collection

From the research that will be carried out, researchers can show an algorithm that functions to produce the fastest alternative route using the Greedy Algorithm. Data collection techniques carried out are as follows:

a. Literature Study: In this process the previous researcher had to learn and understand the Greedy Algorithm. Where the Greedy Algorithm can analyze and find solutions quickly in determining alternative routes that are shorter.
b. Interview: In this process the researcher conducted interviews with the community to find out the destinations of the garbage trucks to determine which route was the fastest for each garbage collector to pass.
c. Observation: Observation is an activity as the application of data that aims to ensure the data from interviews is true and accurate.

2. Data Analysis With Greedy Algorithm

To determine the fastest alternative route for waste transportation, we employed the Greedy Algorithm. The core mathematical formula used in this process is the Greedy Score (GS), which quantifies the desirability of a route based on distance. The Greedy Score for a given edge between two locations (u and v) is calculated as:

$$GS(u, v) = \left(\frac{1}{d(u,v>}\right)$$

Where: $d(u, v)$ represents the distance between locations u and v, a crucial factor in route selection. This formula guides the Greedy Algorithm to favor shorter distances, facilitating the selection of the fastest route. To conclude our study, we conducted data analysis using the Greedy Algorithm. Here are the key stages:

a. Data Grouping: In this stage the data that has been collected will be grouped to carry out the steps for calculating the Greedy Algorithm to produce the fastest alternative route (Porta et al., 2013).
b. Data Application: Prepared data, including distances between locations, is applied and processed by the Greedy Algorithm. The algorithm generates the fastest alternative route, optimizing the distance and travel time from the origin to the destination. This expedites waste transportation (Giryes et al., 2014).

In this study, the fastest alternative route for transporting waste in the North Purwokerto area. The results of this study aim to observe the problems faced and to show or find the fastest alternative route solutions from the Environmental Service to TPS-TPS to transport waste and dispose of it in TPA (Final Disposal Sites) using the Greedy Algorithm method. In order to obtain research results that can provide benefits.

3. System Planning

In building a system using the Greedy Algorithm, this stage aims to assist the user's needs in its use (Sakharov et al., 2021). In this application the researcher first builds a Flowchart Diagram which in building this program consists of several commands, namely input data, processing results, and processing history. For data design there are stages of an input or input command and output or output. Here are the stages:

a. Origin of location: The origin of this location is intended as input where in this study the initial location was the location of a parked garbage truck, namely the Banyumas Regency Environmental Service.
b. Selection of fastest route: Selection of the fastest alternative route is a calculation in the Greedy algorithm, which will show an alternative fastest route that will be taken by garbage collectors to go to the intended TPS. The following is a flowchart of the research methodology carried out:

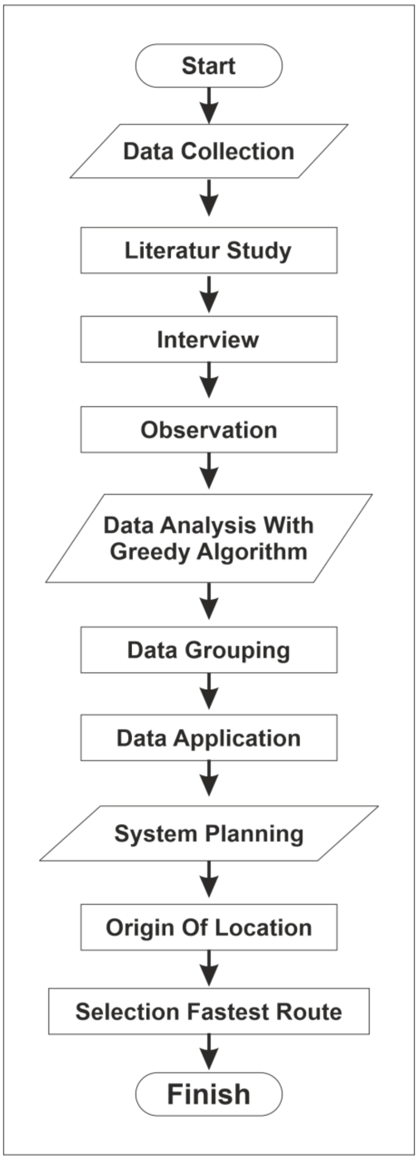

Figure 1. Shortest Route Search Flowchart

C. RESULT AND DISCUSSION

The name of the TPS in the North Purwokerto area and the address obtained from the Banyumas Regency Environmental Service are in Table 1.

Table 1. TPS Locations in North Purwokerto

No	Name TPS	Address
1	Pabuwaran TPS	Jl. Raya Baturaden, Pabuwaran, Pabuaran.
2	Grendeng TPS	Jl. PDU, Karang Bawang, Grendeng.
3	TPS Karangwangkal	Jl. A Jaelani No.12, Dusun II, Tambaksari Kidul.
4	Sumampir TPS	Purwokerto, Sumampir.
5	Polling Purwanegara	Karanganjing, Purwanegara.
6	Bored TPS	Jl. Kamandaka No. 20, Karangpucung, Bobosan.

The following is an illustration of the implementation of the greedy algorithm in finding transport routes from the location of the garbage truck parking lot to several Garbage Disposal Sites (TPS) in the North Purwokerto area. A picture of the TPS location for which the route search will be carried out can be seen in Figure 2.

Figure 2. TPS Locations in North Purwokerto

The picture above shows the position from point A to point H. Point A is the starting point of the journey, while point H is the final destination before returning to point A. From the picture it can be seen clearly if each point with other points has a different distance the distance between each TPS can be represented in the form of a distance table which can be seen in Table 2.

Table 2. Distance between TPS

	A	B	C	D	E	F	G	H
A	0	7.0	5,4	6,9	8,2	9,1	8,7	17,6
B	7.0	0	3,6	4,6	1,2	2,4	2,6	20,6
C	5,4	3,6	0	2,2	4,2	1,9	4.0	18.5
D	6,9	4,6	2,2	0	5,4	3,4	5.0	16,1
E	8,2	1,2	4,2	5,4	0	2,6	2,8	21,2
F	9,1	2,4	1,9	3,4	2,6	0	1,8	19,4
G	8,7	2,6	4.0	5.0	2,8	1,8	0	21,6
H	17,6	20,6	18.5	16,1	21,2	19,4	21,6	0

The table provides information pertaining to various entities. "A" represents the Department of the Environment of Banyumas Regency, which plays a significant role in environmental matters within the region. Additionally, there are several waste collection points denoted by letters "B," "C," "D," "E," "F," and "G." These collection points include Grendeng, Purwanegara, Bored, Karangwangkal, Sumampir, and Pabuwaran, respectively. Finally, "H" represents the Tipar Final Disposal Site, which serves as the designated location for the final disposal of waste materials in the area. This information is crucial for understanding the waste management and environmental infrastructure in Banyumas Regency.

Next, we will represent the route in a weighted graph. Graph from node A to node H and the weight of each edge. Each weight represents the distance from each node one to another (Algabli & Serratosa, 2018). If we look at the weighted graph below, there are 3 route options that can be chosen by the garbage transporter to go to the second point, namely point B (TPS Grendeng), point C (TPS Purwanegara) and point D (TPS Purwanegara). The following is the implementation of a route into a weighted graph as shown in Figure 3.

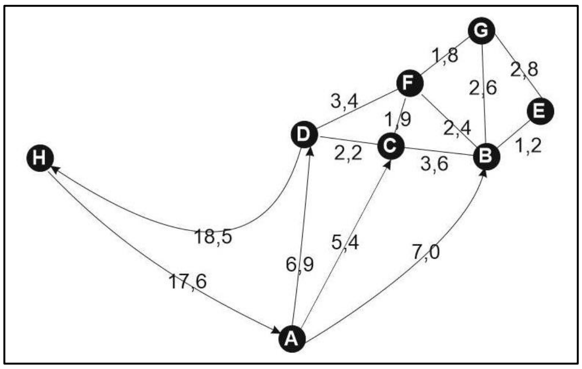

Figure 3. Implementation of Routes Into a Weighted Graph

The figure 3 is the result of the implementation of several available routes on the subject of this study, as shown in Table 3.

Table 3. Route I

No	Route I	Weight (KM)
1	A - C	5,4
2	A – C - F	7,3
3	A – C – F - G	9,1
4	A – C – F - G - B	10,7
5	A – C – F - G - B - E	11,9
6	A – C – F - G - B – E – B – C – D	17,7
7	A – C – F - G - B – E – B – C – D – H	36,2
8	A – C – F - G - B – E – B – C – D – H - A	53,8

Table 3 shows the results of implementing the Greedy algorithm on the first route with a total distance traveled of 53.8 kilometers. An illustration of the route can be seen in Figure 4 below on a directed graph.

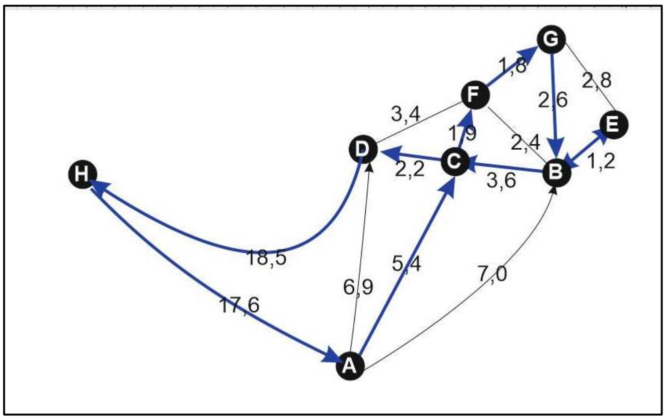

Figure 4. Route I of a Directed Graph

After applying the greedy algorithm method on the first route, to ensure that there is no other faster route, the method must also be applied to other route choices (Chen et al., 2018). The weight table for the second route can be seen in Table 4.

Table 4. Route II

No	Route II	Weight(KM)
1	A–D	5,4
2	A – D - C	7,3
3	A – D – C – F	11.0
4	A – D – C – F – G	12,8
5	A – D – C – F – G – B	15,4
6	A – D – C – F – G – B – E	16,6
7	A – D – C – F – G – B – E – B – C – D - H	42,1
8	A – D – C – F – G – B – E – B – C – D – H - A	59,7

Table 4 shows the results of implementing the Greedy algorithm on the second route with a total distance traveled of 59.7 kilometers. An illustration of the route can be seen in Figure 5 below on a directed graph.

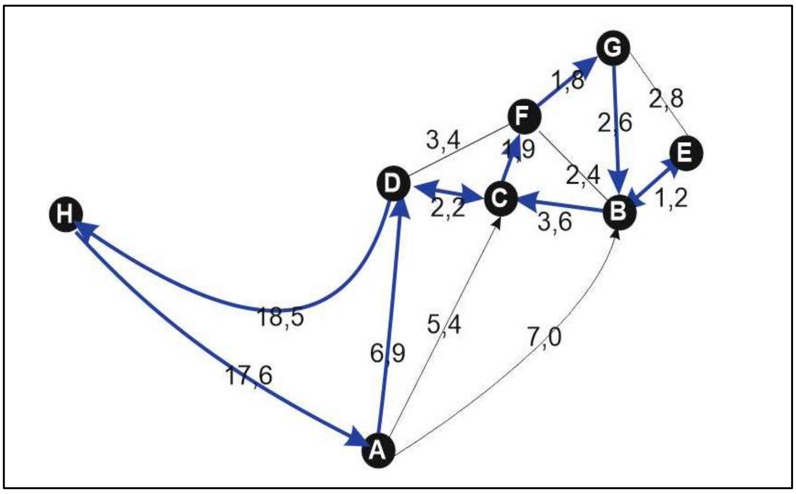

Figure 5. Route II Directed Graph

Based on the implementation of the Greedy Algorithm method on the second route experiment above, it can be concluded that the second route is much longer than the first route. However, because there is still a third route option that can be passed by garbage collectors, we will apply the same method to that route. The following is a table of weights from the third route.

Table 5. Route III

No	Route II	Weight(KM)
1	A – B	7.0
2	A – B - E	8,2
3	A – B – E - G	11.0
4	A – B – E - G - F	12,8
5	A – B – E - G - F – C	14,7
6	A – B – E - G - F – C – D	16,9
7	A – B – E - G - F – C – D – H	35,4
8	A – B – E - G - F – C – D – H - A	53.0

Table 5 shows the results of implementing the Greedy algorithm on the third route with a total distance traveled of 53 kilometers. Illustration of the route can be seen in Figure 6 below on a directed graph.

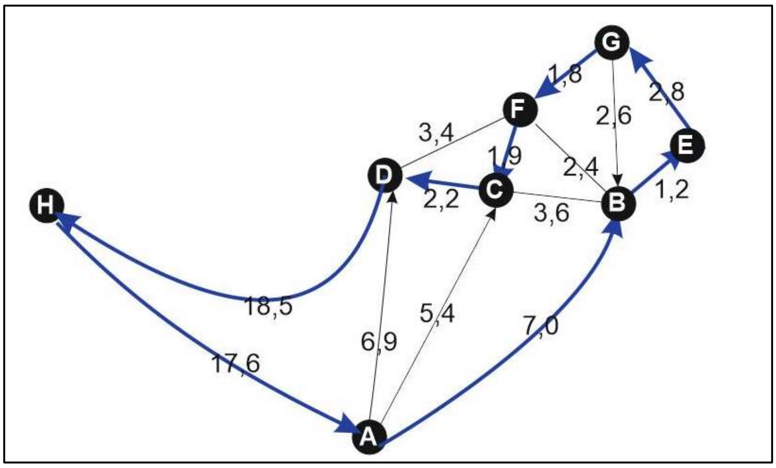

Figure 6. Route III of a Directed Graph

Based on the implementation of the Greedy algorithm on existing routes, it can be seen that the third route is the shortest route compared to the first and second routes. The third route has a weight of 53 Kilometers, while the first route has a weight of 53.8 Kilometers and the second route has a weight of 59.7 Kilometers. The following is the implementation of the third route (the shortest route) into Google Maps which can be seen in Figure 7 below.

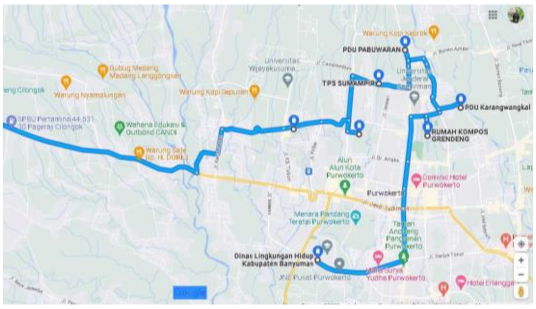

Figure 7. Implementation of Route III on Maps

Our research findings on optimizing waste transportation routes using the Greedy Algorithm can be compared with several previous studies that focused on route optimization in different contexts. One such study is "Analysis of finding the fastest route to tourist attractions," which applied the Greedy Algorithm to find the quickest routes to tourist destinations (Puja Kekal et al., 2021). Although the cases differ, the common thread among these studies is the use of the Greedy Algorithm to find the shortest routes. However, our research extends the understanding of the Greedy Algorithm's application in the context of waste management, which presents unique and significant logistical challenges.

The implications of our research findings have direct relevance for both the community and government in the pursuit of more efficient waste management. By utilizing the Greedy Algorithm to identify the shortest routes for waste transportation, efficiency in waste management can be significantly enhanced. Shorter travel distances reduce operational costs and environmental impact. This, in turn, means that waste management services to the community can be improved by becoming faster and more efficient. Moreover, cost savings in transportation can lead to budgetary savings for the government and more efficient resource allocation. Therefore, our research provides tangible benefits for improving the quality of life for the community and enhancing government policies related to environmental management.

Our research makes a valuable contribution to the field of route optimization, particularly in the context of garbage transportation. We have adapted the Greedy Algorithm to address the unique logistical challenges of waste transportation in North Purwokerto, and the results can serve as a model for similar research in other locations facing similar issues. The use of the Greedy Algorithm in solving route optimization problems is not only relevant in waste transportation but also in various other applications. Thus, our research paves the way for further innovations aimed at improving transportation efficiency and resource management in general.

D. CONCLUSION AND SUGGESTIONS

Based on the implementation of the Greedy Algorithm method on the three available route options, it can be concluded that the third route is the shortest route. The shortest route is taken from the route with the smallest weight of all existing route options (Xiang et al., 2022). In accordance with the agreed objectives of this study and supported by the findings of the Greedy Algorithm implementation, we can theoretically conclude that the third route represents the optimal solution in the context of waste transportation logistics. The primary objective of this study was to identify the most efficient route for garbage collection and disposal in North

Purwokerto. To address this objective, the Greedy Algorithm was applied, which is a well-established approach for solving optimization problems with a focus on minimizing distances between nodes (Malkov et al., 2014). The analysis revealed that the third route, spanning from point A through key waypoints, covers a total distance of 53 kilometers and represents the most optimal choice. This route includes the following sequence of key waypoints, from DLH Banyumas Regency to TPS Grendeng, then to TPS Karangwangka, followed by TPS Pabuwaran, leading to TPS Sumampir, and further to TPS Purwanegara, continuing to TPS Bobosan, and reaching TPA Tipar before returning to DLH Banyumas Regency. The significance of this theoretical conclusion lies in its alignment with the study's primary goal, which is to determine the most efficient route for waste transportation. By identifying and implementing such an optimal route, we can ensure timely and cost-effective waste collection and disposal. It is important to note that this conclusion is grounded in both theoretical principles and empirical data resulting from system testing. Moving forward, it is recommended to further validate and refine this theoretical framework by considering real-time traffic conditions, environmental factors, and cost-efficiency metrics. Additionally, future studies can explore the integration of advanced technologies to enhance route optimization further. This will contribute to the ongoing efforts to improve waste management practices and ensure the timely delivery of services in North Purwokerto.

ACKNOWLEDGEMENT

The author would like to thank Amikom Purwokerto University for providing moral and material support.

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