Waste transportation route garbage using network analysis method, a research method design

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Abstract. Semarang city is one of the cities in Indonesia and is the centre of the economy, the centre of education and it is also not free from the garbage problem. Garbage production in Semarang City is 1,200 tons per day and not fully transported. The increasing accumulation of garbage can cause pollution of soil, ground water and air. The volume of garbage that has been produced for the Banyumanik district area is 27% of all the total Semarang waste production. It is important to optimizing garbage transportation routes that can minimize transport distances and maximize transportation routes with constrain all transportable points being passed. The method used in this research is network analysis with ArcGIS10.3 application. The results of this study will display the route map of the garbage transportation which minimizes the distance of transportation from the origin to the final disposal site and a description of the trip of the shortest, fastest and cheapest route.

1. Introduction
Semarang is the capital of the Central Java Province and, the fifth largest metropolitan city in Indonesia. Central Java Province is also the centre of the economy and education centre [1]. The problems faced by big cities is garbage handling and processing. Sometimes, the community does not realize the danger effects of garbage which is not handles properly. Indonesia is the second largest producer of plastic waste after China [2]. Every day, the production of plastic waste in Indonesia reaches 175,000 tons. Every year plastic waste in Indonesia reaches 63.9 million tons. Indonesia have about 500 Final Disposal Sites [3]. Waste production in the city of Semarang reaches 1,200 tons per day and the volume of waste produced, in the process of transportation is not fully transported. The last five years it was recorded that Semarang City experienced an increase in waste production of 1.67% every year and caused various kinds of problems, one of which was a problem in the social environmental aspect [4].

The Semarang City Environment Agency has been releasing a program on improving city cleanliness responsibility of the government and, the community. Just imagine if the city is inhabited by 5,000 people, and every day one person throws away at least one garbage. So every day there is 5,000 rubbishes produced and more and more garbage will accumulate [1]. Banyumanik is one of the large sub-districts in Semarang City which located south at south and one of the densely populated area. Resident in the area only moves waste to landfill without any processing at the source. Based on the 2010 sampling result on waste production, the per capita waste heap in the Banyumanik 325.55 m3/day. The waste managed by the Semarang City Sanitation and Landscaping Service by preparing Temporary Disposal Sites and Final Disposal Sites [5].

Jatibarang is one of the Final Disposal Sites in Semarang, the existence of the Jatibarang has begun to be full capacity. It means that the Jatibarang disposal capacity has been declining because the area not increased while the quantity of waste production has increased every year [6]. Kadafa, A.A, explained that open disposal and management of solid waste had a detrimental impact on the financing aspect because of the relatively high use of public funds [7].
Research conducted by Setiawan et al, 2018 uses LINGO 11 software where the purpose of the study is to look at alternative points of household waste transfer, and the results obtained in research in Surakarta are alternative points of disposal of household waste including Sodakan Grave, Norowangsa, SPSA, Rail Length, Bonoloyo, and Kedung Tungkul [8]. Another study was also conducted by Setiawan et al, 2019 in Boyolali using LINGO 11 software to see the transfer point activity to serve all waste generators, and the results obtained were from 37 selected 13 alternative transfer points, this is because the volume of waste capacity increased to 50% [9].

The urgency of this research is that in Banyumanik District has problems in the collection and transportation of waste. The residents of Banyumanik increases every year and, automatically the number of piles or volume of waste production also increase linear to the increasing of population. In 2012 waste which transported from Banyumanik reached 76.40% of the total waste produced, which amounted to 394.34 cubic meters per day [10]. The purpose of this study is to design the shortest route in the process of transporting waste from Banyumanik to Jatibarangus analysis network application ArcGIS 10.3.

Geographic Information Systems (GIS) is a tool that consist of hardware, software, human resources and data that working together effectively to enter, store, improve, update, manage, manipulate, integrate, analyse and display data in a geographically based information [11]. ArcGIS is one of the tools used in this study as a network analysis that has been provided in a GIS application to analyse transportation networks [12]. Based on the background of the problem, the research is “Routes of transporting waste using the network analysis method in the Banyumanik District of Semarang”.

2. Methodology

This research uses descriptive analysis to describe the circumstances that occur based on facts. The stage of the research is the preparation phase, the data collection phase, system analysis and model development phase, data processing phase, and continued by conclusions and formulate recommendation. Data collection uses primary data and secondary data. The variable in this study is determining the shortest route of transportation of waste from the origin to the point of final disposal. In this study data processing using a computerized system using the application ArcGIS 10.3.

2.1. Define the Shortest Route

The search of shortest route used Dijkstra algorithm, one of the greedy algorithms. This algorithm is used to solve the shortest path problem with one source on a graph that has no negative side cost and produces the shortest path[13]. Broadly speaking, Dijkstra's algorithm divides the node into two, then it is entered into different table, namely permanent and temporal tables. The permanent table contains the initial node and nodes that have gone through the inspection process and the labels have been changed from temporal to permanent. The data analysis stage begins with a thorough review of the data collection stage, then analyses the data using the Dijkstra algorithm. Can be seen in Figure 1.

![Figure 1. Data analysis stage diagram.](image-url)
3. Result and Discussion

Data which becomes an input to determine the shortest path is the location data of Temporary Disposal Sites and Final Disposal Sites, and the status road of Banyumanik in Semarang City. There are two kinds of input data for the Dijkstra algorithm, which is of the starting point location and location Final Disposal Sites that have been determined based on the Operational System of the Sanitation Office. The output of the Dijkstra algorithm process is the shortest path from the starting point location head Final Disposal Sites location. Details analysis process for determining the shortest path can be seen in Figure 2.

![Diagram](image-url)

**Figure 2.** Shortest path determination flowchart [14].

The results of the study are looking at designed the shortest route that is appropriate and can be applied in the process of transporting waste garbage from the Temporary Disposal Sites to the Final Disposal Sites Jatibarang in Semarang. It's hoping that this research can be a suggestion in the process of changing the construction bee better transportation route waste garbage and expected that with the results that will be obtained later, the waste problem in Semarang city will more be resolved, especially in Banyumanik. The following is an overview of the results of the research to be carried out or the target of this study.
Simple system that can be produced from this research as follow: land transportation as the network system, the location of the Temporary Disposal Sites as the initial node, Final Disposal Sites location and the road/trajectory of the transport as arrows. Types of grooves in the form of vehicles can be see at Table 1.

| System Name | Network System | Node Initial | Node Finish | Arrows | Current Type |
|-------------|----------------|--------------|-------------|--------|--------------|
| Transport line | Land transportation | Temporary Disposal Sites location | Final Disposal Sites location | Road/trajectory | Transportation |

3.1. Transport Route Garbage Search Algorithm
The waste transportation garbage route in this system is divided into four types, that is the closest distance from the garbage transport pool to the Temporary Disposal Sites, the closest distance from the Temporary Disposal Sites to the Temporary Disposal Sites, the closest distance from the Final Disposal Sites to the garbage transport pool. Route selection process on the four types of garbage transportation, the distance from all the nodes will be searched and to be connected, and determine the points of Temporary Disposal Sites and Final Disposal Sites. For the process of finding a route from garbage transport pool to Temporary Disposal Sites, only process just pool node as the initial node, to find a route from Final Disposal Sites to Temporary Disposal Sites and from Final Disposal Sites to Pool, the initial node used is Final Disposal Sites node. While, for route search from Final Disposal Sites, Temporary Disposal Sites to Final Disposal Sites, should be included in all Temporary Disposal Sites like initial nodes and only Final Disposal Sites routes are stored [15].

3.2. Route Garbage Trash Transport Search
The garbage transportation route consists of branching points, pools, Temporary Disposal Sites, and Final Disposal Sites. There are 240 Temporary Disposal Sites Based report on the masterplan activity Semarang City, and 28 Temporary Disposal Sites in Banyumanik. The activity of transporting waste garbage from Temporary Disposal Sites to Final Disposal Sites uses Armroll and Dump truck transportation. The waste garbage transportation route from Banyumanik to the Final Disposal Sites Jatibarang is as depicts in Figure 3 [4].

Figure 4 explains that 28 Temporary Disposal Sites are located in the Banyumanik sub-district and the locations can be seen in Table 2. Meanwhile, Final Disposal Sites is found in the Mijen sub-district in Gedungpane Village.
Figure 3. Trash transport trip routes.
Table 2. Temporary disposal sites.

| No | Disposal site                      |
|----|------------------------------------|
| 1  | TPS Murbei                         |
| 2  | TPS Hotel Serata                   |
| 3  | TPS Meranti                         |
| 4  | TPS PerumahanSetiabudi             |
| 5  | TPS PasarRasamala                  |
| 6  | TPS Brimob                         |
| 7  | TPS S rondolAsri                   |
| 8  | TPS RW 1                            |
| 9  | TPS Hotel Plasa                    |
| 10 | TPS PerumBrigrif                   |
| 11 | TPS PasarS rondol                  |
| 12 | TPS DiklatS rondol                 |
| 13 | TPS Ada Swalayan                   |
| 14 | TPS Bukit Regensi                  |
| 15 | TPS PudakPanyung                   |
| 16 | TPS Kantor BPK                     |
| 17 | TPS Trangkil                       |
| 18 | TPS PasarBanyumanik                |
| 19 | TPS Bukit Sari                     |
| 20 | TPS Resto Panorama                 |
| 21 | TPS Alam Indah                     |
| 22 | TPS RW 2                           |
| 23 | TPS Swiss Roti                     |
| 24 | TPS PasarDamar                      |
| 25 | TPS Ulin                           |
| 26 | TPS PasarJatingaleh                |
| 27 | TPS GrahaEstetika                  |
| 28 | TPS Gedawang                       |

Figure 4. Point map temporary disposal sites and Jatibarang final disposal sites.
3.3. Route Determination with ArcGIS (Network Analysis)

The network is a point called nodes, which are connected by arcs, several terms are often used to describe a particular object in network analysis such as events and activities. Activities are a work assignment, where the completion requires a certain time, costs, and facilities. Usually given the arrow symbol. Events are the beginning or end of an activity. Usually given the circle symbol, seen in Figure 3. ArcGIS is one of the tools used in this study to analyse network that has been provided in a GIS application to analyse transportation network, wherein conducting network analysis will find the path of least impedance. Geographic Information Systems can be divided into two classifications, that is manual and automatic. The difference between the two lies in the processing method. In the manual processing method by combining data in the form of maps transparent sheet media for overlapping. Data can be processed and analysed manually without using a computer. Different case with automated systems that can process data through the digitization process. Data sources can be in the form of satellite imagery or aerial photographs that have been digitized and thematic maps that have been digitized.

![Diagram](image_url)

**Figure 5.** Block analysis model diagram [12].

Figure 5 above explains that to analyse the Geographic Information System begins with image data as basic data. From the image data in the form of physical data, scanning is performed to obtain digital data. The layering process is the process of separating the layer categories that exist in digital data. The result of this layering is vector data that has been divided into several data layers according to their respective covers. For example, the Semarang city map data has been divided into sub-district boundary layers, road layers, river layers, and others. Each layer will get information from tabular data on the related process. The output of this process is a shapefile, where this file is ready to be used to display geographically based information. The parameters in this study were seen based on Aziz 2005 as written in Table 3 [12].

| Effective Path     | Parameters |
|--------------------|------------|
| Shortest Path      | Distance   |
| Cheapest Path      | Cost       |
Based on Table 3 above, the modelling analysis is as follows:

3.3.1. Shortest Route Determination
The external parameter used to find the shortest path is the distance parameter. Segments are determined from each intersection, to determine the total cost field can be modelled as follows:

\[ \text{Total Cost Field} = (D_1 + D_2 + D_3 + \ldots + D_N) = \sum_{k=1}^{n} D \]  

(1)

Where: 
D = Selected Path
N = Number of Alternatives

3.3.2. Low Cost Determination
This study analyses the determination of the cheapest route using the transport route approach. The analysis of the cost path of the cheapest route is determined by considering the tariff of the transport. Segments are determined from each intersection. To determine the total cost field can be modelled as follows:

\[ \text{Fastest Cost Field (CF) for } D = \frac{\text{Distance x Rates}}{100} \]  

(2)

The unit used is meter.

\[ \text{Total Cost Field} = (D_1 + D_2 + D_3 + \ldots + D_N) + \text{Tariff/First start} = \sum_{k=1}^{n} D + T_{sp} \]  

(3)

Where: 
D = Chosen Path in Fastest Analysis
N = Number of Alternatives
Tsp = First Star Rates

By using these equations, the route that provides the shortest distance can be determined after the input data obtained the distance between the point of disposal site and available routes.

4. Conclusion
The route development uses the Dijkstra algorithm to determine the route shortest waste garbage transporting from Temporary Disposal Sites to Final Disposal Sites with manual calculations following existing formulas so that the results of both calculations can be used to determine the shortest route in waste garbage transportation. Hope, whit result from research in determining the shortest route of garbage transportation can help the Semarang City government, especially in Banyumanik can be apply the shortest route waste garbage transporting, so that can get more effective and efficient of waste garbage transporting results in the process that is from Temporary Disposal Sites to Final Disposal Sites.

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