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Model for Determining Temporary Landfil Facility Locations with Maximal Covering by Considering Capacity, Region and Hotels (Case Study at the Sector of TPS Malioboro-Kranggan Yogyakarta)

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Abstract- Malioboro – Kranggan sector is an area where the problems of waste from the community around 276.99 m^3/day, while the dump stations/ landfills (TPS) capacity is only 221 m^3/day, so the garbage cannot be well accommodated. The other hand, the volumes of garbage can increase up to 60 m^3/day especially at holiday. Maximal Covering Location Problem model is used to evaluate the garbage sources and the availability of waste dump served by the government. Locating the TPS capacity solutions needs to be performed using a screening location for existing and new TPS based on number of point location that meet adequacy of TPS capacity in each region. The result of TPS based on the screening location is used as an inside limit. Based on the results of the calculation model which has been developed, there are 8 dumps (TPS) opened for a total capacity of 350 m^3/day which can accommodate the volume of waste from the community and hotels.
Keywords: Maximal Covering Location Problem, Screening Location

INTRODUCTION

Waste management in Indonesia is managed by the Ministry of Environment and Forestry, under the General Director of Waste and B3 Management. While for the provincial level in Yogyakarta, it is managed by the Yogyakarta Special Region Environment Agency, then for the Yogyakarta city level it is managed by the Department of Environment (DLH).

The policy of DLH in managing waste divides into 5 regions. Those five regions are Malioboro-Kranggan, Krasak, Gunung Ketur, Ngasem Gading, and Kota Gede. The division of regions is intended in order that community disposes the garbage in the region where they belong to. The garbage collected in dump stations has different volumes. To accommodate garbage in Yogyakarta, DLH uses three types of landfill, namely (1) type of tub made of cement with a shape like a large and permanent tub, (2) type of container made of steel that has non-permanent properties , (3) the type of depot which has the largest size of all dump stations [1]. According to the DLH Profile Book in 2017 [1], it provides a garbage transport vehicle consisting of 28 units of dump truck and 28 units of garbage container. It is as a mean to transport trash that has been temporarily accommodated in dump stations.

The increase of population in line with the increase in the number of human necessities causes the increasing amount of waste disposal, it happens in TPS of Malioboro - Kranggan region in several regions [2]. The garbage collected at dump stations has different volume depending on the capacity of the dump stations placed, it can be seen in Table 1.

Table 1. Total and Capacity of TPS in Malioboro – Kranggan

Sub District	TPS			Total of Capasity (m^3/day)
	TPSS	Depo	Container	
A	4	-	-	92
B	-	-	-	0
C	3	1	-	84
D	1	-	1	12
E	1	1	1	33
Total	9	2	2	221

(Source : Department of Environment of Yogyakarta , 2017)

The data from Table 1. relate to the population used to calculate the volume of waste coming from community in the amount of 276.99 m /day. Based on Table 2, the volume of waste is not optimally accommodated at TPS

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with a capacity of 221 m3/day. It is because the volume of waste produced exceeds the capacity of dump stations (TPS), such as B, D and E regions. This condition is getting worse, especially during the Eid season, the garbage accumulation is up to 15 tons/day or 60 m3/day [3] and during the holiday the garbage increases by 15% [4].

TPS of Malioboro - Kranggan sector in several regions has problems such as the sources of garbage that cannot be optimally accommodated in E region as much as 61.89%, D region as much as 65.97%, while B region does not have dump stations so people have to dispose the waste to the nearest dump station (TPS). Garbage problem also occurs in A. The garbage spilled along the highway because the volume of garbage exceeds the capacity. The location of TPS is incidentally right on the edge of the highway. Is so disturbs the flow of passing vehicles [5]. This can be seen in Fig. 1.

Table 2. The Volume of Waste from Community in Malioboro – Kranggan Sector

No.	Urban village	Sub-district	Total of community	Waste volume Per urban village (m^3/hari)
A	A1	12836	24,13	64,01
	A2	10083	18,96	
	A3	11125	20,92	
E	E1	12303	23,13	86,6
	E2	16295	30,63	
	E3	6069	11,41	
	E	11400	21,43	
C	C1	9828	18,48	47,5
	C2	15435	29,02	
D	D1	7368	13,85	35.27
	D2	11395	21,42	
B	B	13025	24,49	43,62
	B1	10176	19,13	
Jumlah		147336	276,99	276,99

(Source : Urban Monograph Data)

The source of waste other than coming from the community is also obtained from hotels. It contributes to the average garbage supply of about 18 m3/day. The number of sources of garbage from the community and the hotel make officers carrying garbage up to twice a day to Piyungan. However, this is not an effective way to reduce the volume of waste produced everyday. Based on the problems of the TPS in Malioboro - Kranggan sector, a solution is needed to determine the location and capacity of the TPS. It is intended to be met by the source of waste by dividing the area based on the sub-district. Determining the location and capacity of TPS must have criteria and standards in accordance with the Regulation of the Minister of Public Works of the Republic of Indonesia Number 03 / PRT / M / 2013 Article 20 Paragraph 4 and SNI 19-2454-2002 [6] concerning on the Procedures for Operational Techniques for Urban Waste Management. This is an efforts that can be made by the government related to waste management facilities and infrastructure.

Fig. 1: Spilled Waste arround TPS
(TPSS Jati, A1, A, 25 November 2017)

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METHODS

The approach model used is the Maximal Covering Location Problem model which aims to determine the adequacy of the location and capacity of TPS by maximizing the amount of waste sources that can be served at a distance that can be reached by the garbage source. The location of dump stations and waste sources is divided into five regions based on the sub-districts, namely A, B, C, D and E Subdistrict and also by considering hotels in the Malioboro - Kranggan sector. The number of dump stations in the Malioboro - Kranggan sector according to The Department of Environment Office is 9 temporary landfills (TPSS), 2 Depots and 2 Container Platforms.
The research begins by determining the location point by determining the discrete solution space in the Yogyakarta map using Google Earth, both the location of the TPS and the location of the source of the waste. Discrete solution space based on abscissa and ordinate point (x.y). The location of the TPS is done by ensuring the real location in the field. While the location of the source of waste is determined from the midpoint of the region (sub-district). The next step is to develop a mathematical model by increasing the boundary of the waste source and type of dump station with the help of LINGO 11.0 software.

Facility Location

Research on location determination has been carried out by several researchers with several models of approaches such as set covering, p-median and maximal covering. Nugrahadi [7] Zuhri [8], Paramitha [9], Sari [10], Alditya [11], Susanty [12], applied the set covering approach to solve problems related to location determination. While several studies conducted by Pirkul and Schilling [13], Wati and Sutha [14], Nurcahyono [15], Rahmawati [16], conducted location determination using the maximal covering location problem model. The p-median model approach is carried out by Novian [17] and Kusuma [18].
Nugrahadi [7] , Nugroho, at al.[19], Zuhri [8], Victorio [18], Paramitha [9], Sari [10], and Susy [12], apply the set covering model approach, p-median and maximal covering for the case of applying location determination to a temporary landfill (TPSS). Nugrahadi [7], Nugroho [19], Zuhri [8], Kusuma [18], Paramitha [9] did not differentiate the types of dump stations, all locations are considered unlimited. While Susy [12] determined the capacity of all temporary landfills (TPSS) as a type of container, but Sari [10] and Alditya [11]considered that each spot of TPS capacity has several different types such as depots and containers.
Current et al [20], Nurcahyono [15], Wati et al [14]who applied the maximal covering model approach is to minimize the number of requests that cannot be fulfilled by the facility. Those all raised proposals that combine or maximize several facilities, thereby reducing the spots of service. This model will also be used to solve the problem of determining the location of dump stations (TPS) in Yogyakarta [21,22].

Maximal Covering Facility Location

The Maximal Covering method according to Pirkul et al [13] is a method of optimizing allocation which aims to maximize the site capacity needed to be able to cover demand. The Selected sites will be able to cover demand, so that it will minimize the number of provided sites so that they can save costs.

$$Max \sum_{i \in I} \sum_{j \in L} c_{ij} a_i x_{ij} \quad (1)$$

$$\sum_{j \in J} y_j \leq p, \quad (2)$$

$$\sum_{j \in J} x_{ij} = 1 \forall i \in I \quad (3)$$

$$x_{ij} \leq y_j \forall i \in I, j \in J, \quad (4)$$

$$\sum_{i \in I} c_{ij} a_i x_{ij} \leq K_j \forall j \in J, \quad (5)$$

$$y_j = [0,1] \forall j \in J, \quad (6)$$

$$x_{ij} = [0,1] \forall i \in I, j \in J, \quad (7)$$

In which:
i = set indexes from all request points
j = a collection of indexex of all potential facility sites
ai = population demand at point i
kj = workload capacity for site facilities j
p = number of facilities to be determined

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s = maximum distance or service time
dij = travel distance or time form j to i
cij = if dij ≤ s the opposite
xij = if the request at point i is rejected by the facility in j, vice versa
yj = if the facility is located in j, vice versa
Problems of TPS in Malioboro – Kranggan sector which has a volume of waste exceeding the available capacity, so it is necessary to determine the adequacy of location points and capacity of TPS in order to meet all sources of waste. The source of considered waste is coming from the community and the hotel. The source of the waste that is considered in the sub-district level. Determination of the location of the facility is discrete in calculating the distance of the source of waste based on the midpoint of the urban to the TPS. The location of the facility is adjusted to the real system which has the type and capacity that is not necessarily the same.

LINGO

LINGO is a tool that is very widely designed to be completed. Operational research problems such as linear and nonlinear, quadratic, quadratic programs restricted, stochastic and integer model optimization faster, easier and more efficiently. LINGO providing a complete integration package which includes the language for the optimization model which is easily discussed.

RESULTS AND DISCUSSION

The availability of initial dump stations in Malioboro - Kranggan sector divided by region as 13 dump stations. It consists of 9 temporary landfills (TPSS), 2 Depos and 2 Container Platforms with a total capacity of 221 m^3/day. It is based on the data from the Department of Environment of Yogyakarta. Based on it, it is necessary to firstly screen the location. The results of screening location of existing TPS are dump locations that have a capacity more than 6 m^3/day including the temporary landfills (TPSS) Jati (80 m^3/day) in A, temporary landfills (TPSS) Wongsodirjan (24 m^3/day) and Depo Pringgokusuman (48 m^3/day) in C region, Depo Utoroloyo's tomb (24 m^3/day) in the E region with a total capacity of 176 m^3/day.
Whereas for new TPS opened based on criteria and standards in accordance with the Regulation of the Minister of Public Works of the Republic of Indonesia Number 03/PRT/M/2013 Market 20 Paragraph 4 and SNI 19-2454-2002 concerning on the Procedures for Operational Techniques for Urban Waste Management. The new selected dump stations (TPS) are namely the Depo Baru B (54 m^3/day), the Kontainer Baru of D (48 m^3/day), the New Depot of E (48 m^3/day) and the Kontainer Baru A (24 m^3/day) with a total capacity of 174 m^3/day.
Based on this explanation, the overall TPS capacity of 350 m^3/day can accommodate the volume of waste in Malioboro - Kranggan sector about 295.13 m^3/day which is derived from the volume of community waste of 276.99 m^3/day and the volume of waste from the hotel of 18 m^3/day. The result of this study needs to carry the sensitivity analysis out by increasing the optimal volume of waste at 3% increase and decreasing the distance of waste disposal as far as 762 meters. Both sensitivity analyzes produced the same TPS in the form of temporary landfills (TPSS) of Jati, temorary landfills (TPSS) of Wongsodirjan, Depot of Pringgokusuman, Depot of Makam Utoroloyo, New Depot of Ngampilan, New Container of Gondomanan, New Depot and Container of Tegalrejo with total capacity of 350 m^3/day.

CONCLUSION

Initially there were 13 dump stations to 8 dump stations with an overall total capacity of 350 m^3/day to temporarily collect garbage from 32 waste sources. It consists of sources of waste which come from 13 villages with a total volume of waste of 276.99 m^3/day and 19 hotels with a volume garbage about 18 m^3/day. Sensitivity analysis was carried out based on a 3% increase in waste volume and a decrease the distance of about 762 meters. The real data processing and sensitivity analysis produced the same existing TPS and new TPS namely TPSS jati, TPSS Wongsodirjan, Pringgokusuman depot, makam Utoroloyo depot, new depot and container.

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