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Disposal Site Selection Using TOPSIS in Wonogiri District Central Java

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Abstract. *Currently, waste is an important issue faced by almost all countries, including Indonesia, as it can have social and environmental impacts. Waste management needs coordination between local governments and waste-generating communities. The government must provide means of final waste disposal site. At present, Wonogiri District has five disposal sites located in 5 different sub-districts of Pracimantoro, Baturetno, Ngadirojo, Slogohimo and Purwantoro. Determination of alternative final disposal site in Wonogiri District is needed for more effective and optimum waste handling. Using Technique of Order Preference method by Similiary to Ideal Solution (TOPSIS), it is proposed in this article that the Baturetno site is the best alternative for final disposal site compared to the other four sites. This article also proposes a scheme for the further processing of waste into methane gas that can be utilized by the community.*

Keywords: *waste management, disposal site, landfill location, multi attribute decision making, TOPSIS.*

I. INTRODUCTION

Waste is an important issue especially in urban areas, especially due to their considerable population and population density. Human life with all its activities is closely related to waste. Waste is a side effect of human activity, both in the form of household activities and industrial activities. Over time, the number of people grows, the technology turns more sophisticated, and the industry grows quite rapidly, resulting in lots of waste in various kinds.

According to data from Indonesian Central Bureau of Statistics (BPS) in 2014, Indonesia generates about 187.2 million tonnes of waste per year. This makes Indonesia the second largest waste producing countries in the world. In Indonesia, only less than 60% of waste can be disposed to final landfill site. The amount of waste data is only based on the count of the number of conveyance vehicles entering the landfill site, where the main process in the landfill is stockpiling. Currently, waste management in Indonesia uses a collect - transport - landfill paradigm (Aye & Widjaya, 2006). Figure 1 shows the waste management performed at this time. Only few disposal sites have implemented an integrated waste management (Permana, et al., 2015).

Waste management practices vary widely between developed and developing countries. The practices also differ between urban areas and rural areas or between residential and industrial areas. The variation depends on many factors, including types of waste substances, land used for processing, and availability of land. Waste disposal on landfill is the most popular method in the world. This stockpiling is usually carried out on unused land, mined holes, or deep holes (Damanhuri, et al., 2009; Usman, et al., 2013).

Considering the popularity of waste disposal sites, their selection needs to be done well. They need to meet various criteria in order to reduce social problems and environmental problems (Eiselt & Marianov, 2015). Environmental aspects that need to be considered include local climate, hydrological conditions, buffer capacity, and the area used (Idris, et al., 2004; Wibowo, 2008). Related social aspects need to be taken into account are population density and distance of location from human settlements (Al-Khatib, et al., 2015; Rumbruren, et al., 2015).

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Figure 1. Recent waste management system in Indonesia. The waste comes from household or industry (1), sanitary workers pick up the waste (2), The waste is collected on temporary waste shelters (3), The waste is transported to disposal sites by waste trucks, (4) Landfilling to disposal sites (5).

Methods of waste disposal site selection have been widely developed (Coelho, et al., 2017). Taking into account various attributes in the determination of disposal sites, the selection of disposal sites is categorized into multi-attribute decision making issues (Saaty, 1980; Paul, 2012). Various approaches to decision making have been made by some previous researchers. Some use fuzzy method approach, such as the application of fuzzy inference (Ariasih, et al. 2015), modified fuzzy utility (Singh & Dubey, 2012), fuzzy multi objective linear programming (Shaw, et al., 2012), and integrated fuzzy approach (Kharat, et al., 2016). Other approaches used is the analytical hierarchy process (Boskovic & Jovicic, 2015) and VIKOR (Opricovic & Tzeng, 2004; Liu, et al., 2014).

Some researchers also combine multi criteria decision making techniques with geographic information systems (Uyan, 2014, El-Baba, et al., 2015, Bahrani, et al., 2016, Chabuk, et al., 2016, Torabi-Kaveh, et al., 2016). Decision support system for site selection has also been developed based on multi criteria decision making (Alves, et al., 2009).

One of multi-attribute decision-making methods used is the Technique of Order Preference Similarity to the Ideal Solution (TOPSIS) (Asadzadeh, et al., 2014). The TOPSIS method is often compared to analytical hierarchy process (AHP) to get optimal solution of problems solved (Önüt & Soner, 2008, Ertug˘rul & Karakasog˘lu, 2008, Beskese, et al., 2015, Zakerian, et al. 2015).

II. RESEARCH METHODS

The data collection process is done by searching the data directly from the field as well as looking for additional data through relevant agencies. The agencies include the Sanitation Office (Dinas Kebersihan) and the Environment Agency (Dinas Lingkungan Hidup) of Wonogiri District. The data are also searched by using google maps. The data collected include those associated with landfill areas, climatic conditions, population demography, biological environmental utilities, soil conditions, buffer zones, and distance of the landfills from the human settlements.

The next stage is a two-steps data processing. The first step is the determination of criteria that will be used for the selection of alternatives for the final waste disposal and their weight. The second step is the determination of alternative locations for the final waste disposal, and is based

on the highest value of alternative locations. These two steps are carried out by applying TOPSIS.

TOPSIS is widely used to solve practical decision making. This is because the concept is simple and easy to understand, computation needed is efficient, and it has the ability to measure the relative performance of decision alternatives. TOPSIS method is commonly used in multi-criteria decision-making process with many criteria and alternatives. The solution produced by TOPSIS method is quite different from other methods. The TOPSIS method considers the distance to the ideally positive solution and the distance to the ideally negative solution simultaneously (Hwang & Yoon, 1981).

First, we create a normalized decision matrix. Decision matrix *D* refers to *m* alternatives that will be evaluated based on *n* criteria.

The elements are resulted from the normalization of the decision matrix by Euclidean length of a vector method. Second, we create a normalized weighted decision matrix. Third, we determine the matrix of positive ideal solutions and negative ideal solutions. Fourth, we count separation measure. Fifth, we determine the distance between the value of each alternative with the positive and negative ideal solution matrix. And sixth, we specifies the preference value for each alternative.

III. Result And Discussion

This article discusses waste management in Wonogiri District. The location of the final disposal site needs to be established and optimized. It is important to implement and urgent to be realized, given the increasing volume of waste in the region and the increasing environmental awareness. Currently, the Wonogiri District government has five disposal sites located in Ngadirojo, Purwantoro, Slogohimo, Baturetno and Pracimantoro. It is also found that the waste management at the five final disposal sites is not good.

The objectives of the research are to folds: (1) to determine the best location of the final disposal site in Wonogiri District, and (2) to provide a proposal for further processing that can be applied at the chosen location. The results of this study are expected to be considered by the Government of Wonogiri District in managing waste with minimum social impacts.

Pracimantoro disposal site is located in Gebang Harjo village, with the coordinate point -8.049819, 110.78047. Pracimantoro landfill has an area of about 512 m2 with a rocky road access. The landfill distance to the nearest settlement is approximately 600 m. The settlement around the landfill has a not-too-dense population. The landfill is surrounded by more than 15-ha buffer zone area. The area of agriculture around the

Figure 2. Maps of Wonogiri District.

Figure 3. Map of Pracimantoro disposal site.

Figure 4. Map of Baturetno disposal site.

landfill is more than 10 ha. Figure 3 shows Pracimantoro landfill area.

Baturetno disposal site is located in Temon village, with the coordinate point -7.9780, 110.9749. The landfill has an area of about 3944 m2 with an asphalt road access. The distance of the landfill to the settlement is less than 500 m and has a not-too- dense population around it. The buffer zone and the agriculture around the landfill are more than 20 ha and more than 10 ha, respectively. Figure 4 shows the Baturetno landfill area.

Ngadirojo disposal area is located in Temon village, with the coordinate point -7.8337, 111.0153. The landfill counts for about 89,000 m2 with an asphalt road access. The settlement is less than 500 m from the landfill and has a moderate population density. The landfill is supported by less than 10-ha buffer zone. The area of agriculture is more than 10 ha. Figure 5 shows the landfill.

Slogohimo disposal site is located in Sedayu village with the coordinate point -7.8098, 111.1911. Slogohimo landfill area is approximately 310 m2 with a concrete road access. The nearest settlement is less than 100 m and has a high density population. The buffer zone of the landfill is less than 5 ha, while agricultural area around it is more than 15 ha. Slogohimo landfill has a unique characteristic in the sense that it is located on the slope or hillside. Figure 6 shows Slogohimo landfill area.

Purwantoro disposal site is located in Tegalrejo village, with the coordinate point -7.8601, 111.2633. The Purwantoro landfill has an area of about 2483 m2, and has a rocky road as

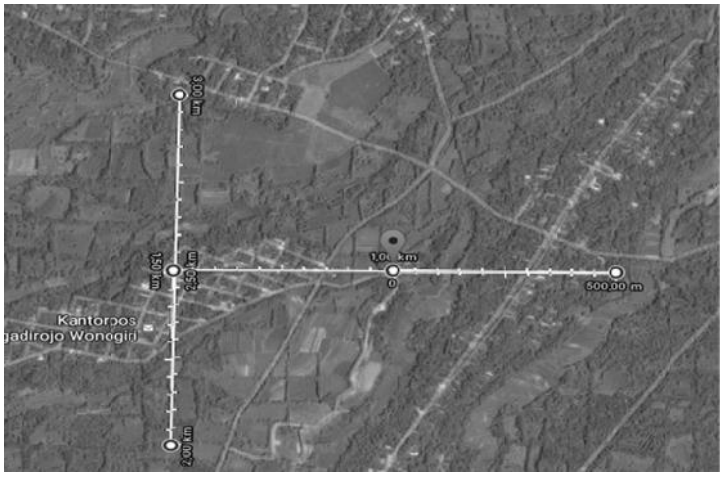

Figure 5. Map of Ngadirojo disposal site.

Figure 6. Map of Slogohimo disposal site.

Figure 7. Map of Purwantoro disposal site.

access to it. The settlement is less than 150 m from the landfill and has a high density population. The landfill has buffer zone of less than 10 ha. The agricultural area around the landfill is more than 15 ha. Figure 7 shows the Purwantoro landfill area.

Table 1. Data collected

No	Alternative	Criteria							
		A	B	C	D	E	F	G	H
1	Pracimantoro	2	4	5	1	3	5	5	5
2	Baturetno	4	4	4	4	3	4	4	4
3	Ngadirojo	5	4	3	5	3	3	3	3
4	Slogohimo	1	4	1	3	3	1	1	1
5	Purwantoro	3	4	2	2	3	2	2	2

Table 2. Normalized matrix

No	Alternative	Criteria							
		A	B	C	D	E	F	G	H
1	Pracimantoro	0.300	0.447	0.670	0.130	0.447	0.674	0.674	0.674
2	Baturetno	0.500	0.447	0.540	0.540	0.447	0.539	0.539	0.539
3	Ngadirojo	0.700	0.447	0.400	0.670	0.447	0.405	0.405	0.405
4	Slogohimo	0.100	0.447	0.130	0.400	0.447	0.135	0.135	0.135
5	Purwantoro	0.400	0.447	0.270	0.270	0.447	0.270	0.270	0.270

Table 3. Weighted normalized matrix

No	Alternative	Criteria							
		A	B	C	D	E	F	G	H
1	Pracimantoro	0.300	3.578	2.020	0.670	2.683	4.719	2.697	1.348
2	Baturetno	0.500	3.578	1.620	2.700	2.683	3.776	2.157	1.079
3	Ngadirojo	0.700	3.578	1.210	3.370	2.683	2.832	1.618	0.809
4	Slogohimo	0.100	3.578	0.400	2.020	2.683	0.944	0.539	0.270
5	Purwantoro	0.400	3.578	0.810	1.350	2.683	1.888	1.079	0.539

Table 4. Ideal and anti-ideal solution matrix

Solution	Criteria							
	A	B	C	D	E	F	G	H
Ideal	0.6742	3.5777	2.0226	3.3710	2.6833	4.7194	2.6968	1.3484
Non Ideal	0.1348	3.5777	0.4045	0.6742	2.6833	0,9439	0.5393	0.2697

Data were the extracted from the above mentioned 5 existing landfills. The attributes or criteria used in this assessment include: (A) area of disposal site, (B) environmental climatic conditions, (C) population demography, (D) utility of surrounding land, (E) biological environment, (F) soil condition, (G) buffer zone, and (H) distance from the settlement. The attributes or criteria used are taken from Regulation of the Indonesia Minister of Public Works No. 03/PRT/M/2013.

The assessment is conducted in the form of Likert scale for each attribute to make it easier in TOPSIS calculation. The scales are: very bad (1), poor (2), sufficient (3), good (4), and very good (5). Table 1 shows the data obtained from the field. The first step in the TOPSIS method is to determine a normalized decision matrix. The result of the normalized decision matrix is listed in Table 2. After determining the normalized matrix, the next stage is to determine the weight of the normalized matrix. The weighted normalized matrix is shown in Table 3.

After determining the weighted normalized matrix, the next step is the calculation of the ideal solution matrix and the anti-ideal solution matrix. The result of the ideal solution matrix and the anti-ideal solution is provided in Table 4. This is followed by calculating a distance score for each

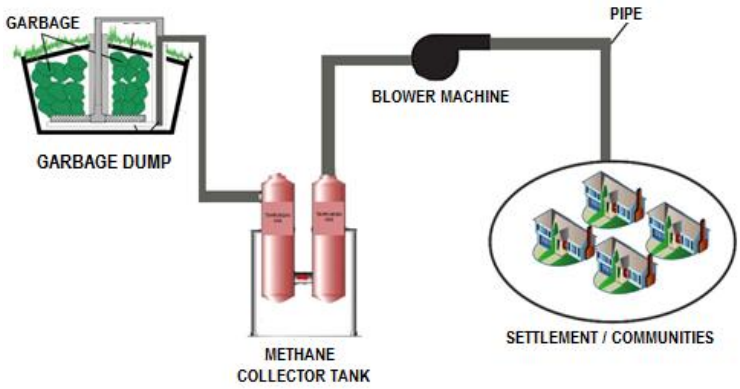

Figure 8. Scheme of waste management as methane generator

of the alternatives from ideal solution and anti-ideal solution, from which score Table 5 is provided.

Alternatives can be ranked based on the ordered distance matrix of the disposal sites. Therefore, the best alternative is the one with the shortest distance from the ideal solution and the furthest away from the anti-ideal solution. The next stage sets the attribute preference score against the alternatives of which result is provided in Table 6. Based on the calculation using the TOPSIS method, it is clear that Baturetno, of which preference score is 0.75, is the best alternative for the waste disposal site.

The development that can be done on the chosen final disposal site in Wonogiri District is making a proposed scheme of waste treatment in the site. According to the Regulation of Minister of Public Works of the Republic of Indonesia Number 03 / PRT / M / 2013, final disposal sites should perform further processing on the waste. Waste that enters the 5 Wonogiri's final disposal sites is more than 500 ton/ day. Until now, the incoming waste has not been utilized properly. There is no further processing on the waste and the landfilling system is the only scheme taking place in the sites. This often creates social problems for the communities around the disposal sites. Therefore a good waste management needs to be carried out in the chosen disposal site. The solution offered in this article is to tranform the high volume of waste into energy which, in turn, will give benefits to the community around the disposal site. More specifically, the article proposes a methane gas generator for the collected waste. Figure 8 shows the scheme of generating methane from the collected waste for the benefits of the surrounding community.

IV. CONCLUSION

This article looks at waste disposal site selection in Wonogiri District, with final disposal sites of Pracimantoro, Baturetno, Ngadirojo, Slogohimo and Purwantoro, as alternatives under concern. The criteria for the selection derived from the Regulation of the Minister of Public Works. Based on the calculation by using TOPSIS method, it is concluded that the chosen final disposal site is Baturetno, with the next highest scores are Ngadirojo, Pracimantoro, Purwantoro, and Slogohimo, respectively.

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