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Determination of Provincial Level of Hazardous Waste Collection Location in East Java Province Using Center of Gravity Method

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Abstract: East Java is the province with the second largest industry in Indonesia. Data from the Ministry of Environment and Forestry of the Republic of Indonesia in 2016 showed that approximately 549,750 ton of hazardous waste produced by industry in East Java and about 58% or about 320,499 ton is treated. While currently treatment hazardous waste is still done outside of East Java Province.Untreated hazardous waste needs to be kept in a suitable place in order not to pollute the environment. Therefore, it is necessary to collect hazardous waste in East Java. The objective of this research is to determinethe site of hazardous waste in East Java. The method used to select the location is Centre of Gravity method based on minimal transportation cost. Following the selection of the best location the warehouse design and risk identification are conducted. Calculation results showedlocation coordinates (-7.34962; 112.68251) with total transportation costs of Rp.170, 370,268,038. Storage area was 4.94784 hectares. Risk Identification, there were 5 risks: Fire, Explosion, Reactivity, Health problems, Environmental pollution.

Keywords: Hazardous Waste, Centre of Gravity, Warehouse, Risk Identification.

I. INTRODUCTION

The development of industry at this time not only impact in economic factors, but also impact in social and environmental factors.The production process not only produce product but also produce waste. The waste, must be well managed to avoid to avoid environmental pollution. The problem of this waste has been a serious concern of the people and the government of Indonesia, because the consequences of this waste will cause harm to many parties. Today's emerging industries should pay attention to three things tooperate their production, there are people planet and profit. Ideally a company should not only consider the maximum profit aspect in carrying out its activities, but must consider the environment and welfare of the community as well.

Improper hazardous waste management will cause damage to the environment. One environmental case that occurs due to poor hazardous waste management is, the case of Minamata in Japan that occurred in the 1950s due to uncontroled mercury waste disposal, which attacks the nerves and brain.

The regulations on the issue of hazardous waste have been issued by the Government, such as Government Regulation No. 101 of 2014 instead of PP 18/99 juncto 85/99. According to Government Regulation No. 101 of 2014 article 1 point 11. Hazardous Waste Management is an activity which includes: reduction, storing, collection, transportation, utilization, processing and / or landfill. All waste management activities should have permit from (Regency / City Government and the Provincial Government also from Central Government (Ministry of Environment and Forestry of the Republic of Indonesia). And it is always reported regarding the management and control of B3 waste materials.

East Java is the province with the second largest industry in Indonesia. With the development of industries in East Java, also result in increasing amount of hazardous waste generated by industries in East Java. Data from the Ministry of Environment and Forestry of the Republic of Indonesia in 2016 shows that approximately 549,750 ton of hazardous waste produced by industry in East Java and about 58% or about 320,499 ton is treated. Due to there are still untreteated hazardous waste, so it need storage for keep this untreated hazardous waste. This becomes an opportunity for the establishment of a Provincial level of hazardous waste collection in East Java.

Facility location selection is one effort in optimizing the transportation of goods.The selection of locations will result in savings on transportation costs. The distance factor to the destinations is calculated to decrease transportation costs as low as possible. In this research will be used Center of Gravity method.The calculation of Center of Gravity method involves the volume of goods to be transported from one point to another, regional coordinates and transportation costs. From this calculation will be known location of provincial level hazardous waste collection in East Java. In addition, a warehouse for this province level collection will be designed also conduct a risk identification for the construction of a provincial level hazardous waste collection in East Java.

II. METHOD

Method in this study use center of gravity method for determining the location of provincial level of hazardous waste collection site and calculate the required warehouse capacity. Also risk identification will be identified. Detail each calculation explain in list below.

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A. *Calculation of Centre of Gravity*.

- The formula

$$X = \frac{\sum_i Vi \times Xi \times Ci}{\sum_i Vi \times Ci} \quad ;$$

$$Y = \frac{\sum_i Vi \times Yi \times Ci}{\sum_i Vi \times Ci} \qquad \ldots\ldots (1)$$

- Input data coordinate of location producer hazardous waste,volume of hazardous waste and transportation rate.
- Calculate the multiplication between the volume of hazardous waste hazardous with the transportation rate

Vi x Ci ..... (2).

- Sum up the value of the multiplication formula …..(3)
- Calculate the multiplication of the volume of hazardous waste with the transportation rate, and also the X coordinates of hazardous waste producer.

The formula is:

Vi x Ci x Xi …… (4).

- Sum up the value of the multiplication formula.
- Calculate the multiplication of the volume of hazardous waste with the transportation rate, and also the Y coordinates of hazardous waste producer.

The formula is:

Vi x Ci x Yi …… (5).

- Sum up the value of the multiplication formula.
- Calculate X coordinates for selected location,

Formula is:

$$X = \frac{\sum_i Vi \times Xi \times Ci}{\sum_i Vi \times Ci} \qquad \ldots\ldots (6)$$

- Calculate Y for selected location,

Formula is:

$$Y = \frac{\sum_i Vi \times Yi \times C\,i}{\sum_i Vi \times Ci} \qquad \ldots\ldots\ldots (7)$$

- Calculate the distance between selected locations and each producer location. With the,

Formula is:

$$Dn = K\sqrt{(X - Xi)^2 + (Y - Yi)^2} \qquad \ldots\ldots (8)$$

- Calculate total Cost, formula is

$$TC = \sum_{n=1}^{k} Cn \times Vn \times D_n \qquad \ldots\ldots (9)$$

- After that conduct iterateion, like steps 2, 3, and 4 by adding Dn (distance) as divider, the formula is as follows:
- Calculate the multiplication between the volume of hazardous waste and the transportation rate divided by distance from previous iteration,

Formula is: (Vi x Ci) / Dn …….. (10).

- Sum up the value of the multiplication formula.
- Calculate the multiplication between the volume of hazardous waste, transportation rate and X coordinates of hazardous waste producer, divided by distance from previous iteration,

Formula is:

(Vi x Ci x Xi)/Dn …… (11).

- Sum up the value of the multiplication formula.
- Calculate the multiplication between the volume of hazardous waste, transportation rate and Y coordinates of hazardous waste producer, divided by distance from previous iteration,

Formula is:

(Vi x C x Ri x Yi)/Dn …….. (12)

- Sum up the value of the multiplication formula.
- Calculate X coordinates for selected location,

Formula is:

$$X = \frac{\sum_i (Vi \times Xi \times Ci)/Dn}{\sum_i (Vi \times Ci)/Dn} \qquad \ldots\ldots (13)$$

- Calculate Y coordinates for selected location,

Formula is:

$$Y = \frac{\sum_i (Vi \times Xi \times Ci)/Dn}{\sum_i (Vi \times Ci)/Dn} \qquad \ldots\ldots (14)$$

- Calculate the distance between selected locations and each producer location. With the formula like formula (8).
- Calculate total Cost, formula like formula (9)
- Select on which iterations shows the smallest total cost. And that location is the location to be selected.

where:

Xi = Coordinates location (i) on the axisX
Yi = Coordinates location (i) on the ordinatY
Vi= Volume of hazardous waste from location (i)
Ci= Transportation Rate from location (i)
X = Coordinates selected locationon the axis (X).
Y = Coordinates selected locationon the ordinat (Y).
Dn = Distance from location (i) to selceted location in iteration n.
K = Distance scale.
TC = Total cost

B. *Warehouse and Other Facilities Design*

- Calculate of warehouse capacity based on the amount of untreated hazardous waste divided by 4, it mean every 3 months is conduct hazardous waste collection activity

from the producer to the provincial level hazardous waste collection.

- Determine the capacity of the warehouse.
- Design the place of packaging and placement in the warehouse by using pallet.
- Determined the area of the warehouse based on the calculation of the number of pallets and material handling facilities.
- Made the building design in accordance with applicable regulations.

C. Risk Identification.

- Risk identification
- Risk control

III. RESULT AND DISCUSSION

A. Data Collection.

From the data of the Ministry of Environment and Forestry of the Republic of Indonesia. Hazardous waste producers are divided into 5 industry groups, there area: Manufacturing, Agroindustry, Services, Infrastructure and Energy & Oil Mining. The volume of hazardous waste can be seen in Figure 1.

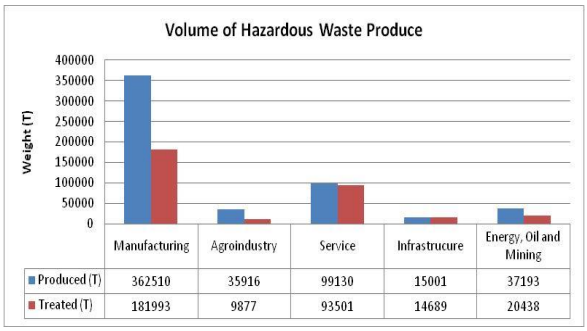

Fig 1. Volume of hazardous Waste produce

There are 171 companies that register their hazardous waste at the Ministry of Environment and Forestry of the Republic of Indonesia. The proportion of 171 companies for each industrial group can be seen in Figure 2.

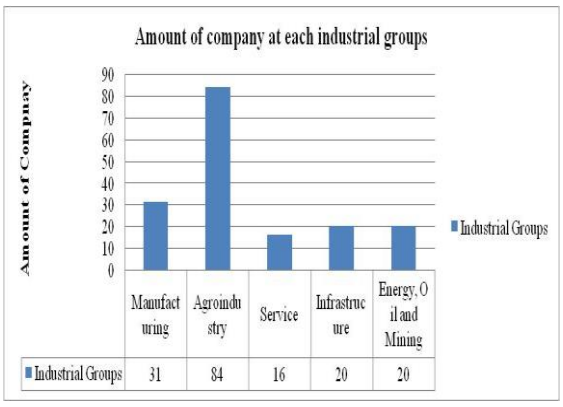

Fig 2. Number of Companies In Each Industry

B. Calculation of Centre of Gravity

Location	Coordinate		Volume (Ton)	Transportation Rate (Rp/km/ton)	Calculation			Distance (Km)	Total Transportation Cost (Rp)
	X	Y	V	C	V*C	V*C*X	V*C*Y	D	TC
1	-7.2281590	112.73007	227.63	43,156	9,823,690.00	-71,007,193	1,107,435,212.24	44.486	437,019,968.7
2	-7.5088339	112.70132	1,324.60	42,795	56,686,890.00	-425,653,192	6,388,690,577.15	37.808	2,143,239,275.5
3	-7.1870241	112.64509	33.30	52,548	1,754,120.00	-12,608,306	197,592,990.43	46.784	82,063,941.3
4	-8.1932149	112.55721	25.84	75,697	1,904,577.50	-15,602,974	214,351,423.71	91.058	173,408,398.0
5	-7.1204567	111.74636	275.86	43,423	11,978,840.00	-85,390,642	1,338,594,174.77	63.656	762,519,666.6
6	-7.6574548	113.02801	250.05	47,200	12,179,087.50	-93,260,089	1,376,579,086.78	59.579	723,184,940.1
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170	-6.9253999	113.90606	273.49	43,800	11,978,840.00	-82,958,257	1,364,462,496.52	73.494	880,369,446.1
171	-7.2627457	112.73819	192.12	44,612	8,570,600.00	-62,246,071	966,233,967.21	44.889	384,728,664.6
Total					3,491,264,456.25	-25,717,815,511	393,447,510,204		173,687,971,591.7

Table 1. Calculation of Center of Gravity

The example calculation of the selected coordinate location is as follows:

$$X = \frac{\sum_i Vi \times Xi \times Ci}{\sum_i Vi \times Ci} = \frac{3,491,264,456.25}{-25,717,815,511} = -7.36633$$

$$Y = \frac{\sum_i Vi \times Yi \times Ci}{\sum_i Vi \times Ci} = \frac{3,491,264,456.25}{393,447,510,204} = 112.69485$$

So the result of selected coordinate location is (-7.36633 ; 112.69485). After that calculate distance from each producer location to selected location.

$$Dn = K\sqrt{(X - Xi)^2 + (Y - Yi)^2}$$
$$= 60.55\sqrt{(-7.36633 - 7.228159)^2 + (112.69485 - 112.73007)^2}$$
$$= 44.486 \text{ km}.$$

Calculate total cost transportation

$$TC = Vi \times CiXD_i$$
$$= 227{,}63\ ton\ x\ Rp\ 43,156\ per\ ton\ per\ km\ x\ 44.486\ km$$
$$Rp\ 437{,}019{,}969\ .$$

Total cost of all hazardous waste producer location the selected location is Rp. 173,687,971,592. The next calculation stage is iteration to the formula. An example of an iteration calculation can be seen in Table 2.

Location	Calculation							Distance (Km)	Total Transportation Cost (Rp)
	V*C	V*C*X	V*C*Y	D_0	V*C /D_0	V*C*X/D_0	V*C*Y/D_0	D_1	TC
1	9,823,690	-71,007,193	1,107,425,212	44.486	220,825	-1596157.394	24,893,603.87	45.23557867	444,380,302
2	56,686,990	-425,653,192	6,388,698,577	37.808	1,499,326	-11258191.53	168,976,043.18	41.1418095	2,332,205,344
3	1,754,120	-12,608,306	197,592,998	46.784	37,494	-269503.041	4,223,558.18	45.747587	80,246,757
4	1,904,378	-15,602,974	214,351,424	91.058	20,914	-171352.4441	2,354,015.34	91.84618728	174,909,813
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
170	11,978,840	-82,958,257	1,364,462,497	73.494	162,991	-1128780.304	18,565,703.30	72.96265137	874,007,927
171	8,570,600	-62,246,071	966,233,967	44.889	190,927	-1386655.652	21,524,792.93	45.53967221	390,302,315
Total					73,337,149	-53942917	8,264,112,009		170,812,049,727

Table 2. Calculation of Center Of Gravity 1st Iteration

The result of calculating the coordinates of the selected locations in the first iteration is as follows: X = -7.35547; Y = 112.68657. With total transportation cost from each location of hazardous waste producer is Rp. 170,812,049,727. The calculation results for several iterations can be seen in Table 3.

Iteration	Coordinate		Total Transportation Cost (Rp)	Iteration	Coordinate		Total Transportation Cost (Rp)
	X	Y			X	Y	
Iteration 0	-7.36633	112.69485	173,687,971,592	Iteration 23	-7.34962	112.68521	170,370,270,166
Iteration 1	-7.35547	112.68657	170,812,049,727	Iteration 24	-7.34962	112.68521	170,370,269,256
Iteration 2	-7.35178	112.68553	170,734,489,001	Iteration 25	-7.34962	112.68521	170,370,268,736
Iteration 3	-7.35071	112.68531	170,546,379,995	Iteration 26	-7.34962	112.68521	170,370,268,438
Iteration 4	-7.35016	112.68525	170,465,440,680	Iteration 27	-7.34962	112.68521	170,370,268,267
Iteration 5	-7.34992	112.68523	170,421,683,803	Iteration 28	-7.34962	112.68521	170,370,268,169
Iteration 6	-7.34978	112.68522	170,399,139,472	Iteration 29	-7.34962	112.68521	170,370,268,113
Iteration 7	-7.34971	112.68522	170,386,480,733	Iteration 30	-7.34962	112.68521	170,370,268,081
Iteration 8	-7.34967	112.68521	170,379,498,041	Iteration 31	-7.34962	112.68521	170,370,268,063
Iteration 9	-7.34965	112.68521	170,375,517,582	Iteration 32	-7.34962	112.68521	170,370,268,052
Iteration 10	-7.34964	112.68521	170,373,269,314	Iteration 33	-7.34962	112.68521	170,370,268,046
Iteration 11	-7.34963	112.68521	170,371,982,486	Iteration 34	-7.34962	112.68521	170,370,268,043
Iteration 12	-7.34962	112.68521	170,371,249,422	Iteration 35	-7.34962	112.68521	170,370,268,041
Iteration 13	-7.34962	112.68521	170,370,829,510	Iteration 36	-7.34962	112.68521	170,370,268,040
Iteration 14	-7.34962	112.68521	170,370,589,539	Iteration 37	-7.34962	112.68521	170,370,268,039
Iteration 15	-7.34962	112.68521	170,370,452,079	Iteration 38	-7.34962	112.68521	170,370,268,039
Iteration 16	-7.34962	112.68521	170,370,373,428	Iteration 39	-7.34962	112.68521	170,370,268,038
Iteration 17	-7.34962	112.68521	170,370,328,381	Iteration 40	-7.34962	112.68521	170,370,268,038
Iteration 18	-7.34962	112.68521	170,370,302,593	Iteration 41	-7.34962	112.68521	170,370,268,038
Iteration 19	-7.34962	112.68521	170,370,287,824	Iteration 42	-7.34962	112.68521	170,370,268,038
Iteration 20	-7.34962	112.68521	170,370,279,369	Iteration 43	-7.34962	112.68521	170,370,268,038
Iteration 21	-7.34962	112.68521	170,370,274,527	Iteration 44	-7.34962	112.68521	170,370,268,038
Iteration 22	-7.34962	112.68521	170,370,271,753	Iteration 45	-7.34962	112.68521	170,370,268,038

Table 3. Calculation Results For Several Iterations

The coordinates (-7.34962; 112.68251). This location is in Sidoarjo Regency. This coordinate location has passed through several iterations of center of gravity calculations. Iteration is done to determine the value of the smallest total cost. If only one time iteration the resulting cost is still quite high. This can be seen in the Figure 3.

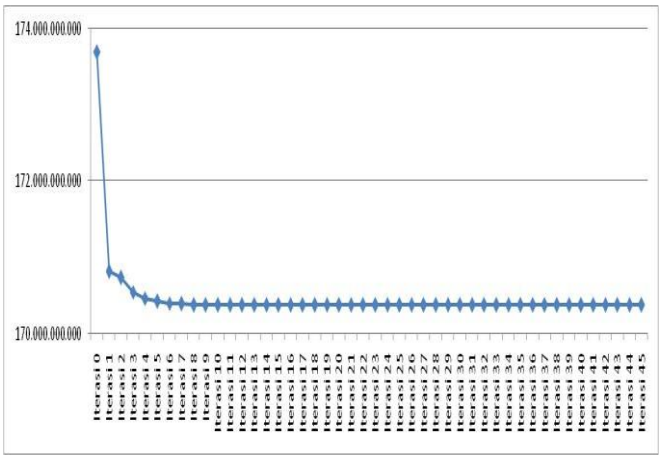

Fig 3. Trend Of Total Transportaion Cost From Each Iteration.

From Figure 3 there was a significant decrease in total transportation cost from the 0th iteration to the 1st iteration. And start moving steadily at the 33rd and at iteration 39th to 45th have not changed again. So the minimum value for the total transportation cost is in the 39th iteration. If the calculation is only done on one iteration then the difference of transportation cost will be equal to Rp. 3,317,703,553, -. A big enough number to do one shipment and it will be done 4 times delivery in 1 year, then in one year will become Rp. 13,270,814,213,- for transportation cost.

The volume amount of transportation costs affect in this calculation. With the increasing volume of B3 waste generated, transportation costs will also rise. Therefore this method looks for locations that provide the smallest transportation cost value. From the calculation total transportation cost is Rp.170,370,268,038.

The center of gravity method assumes that the cost is directly balanced on the distance and amount of carrying material. The ideal location is a location that minimizes the weighted distance between selected locations and hazardous waste producer sites. Where the distance weighting is done according to the number of trucks used to deliver hazardous waste.

C. Warehouse Design

From the data obtained the amount of untreated hazardous waste is 320,499 ton / year. In PP 101 of 2014, described keeping time for hazardous waste is 90 days, because the waste generated more than 50 kg per day. Therefore, the amount of untreated hazarodous waste is divided into 4. This become the number of warehouse capacity designed. So the warehouse capacity is 80,124 ton in 3 months.

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According (Park et al, 2015) wood pallet with size 1219 mm x 1016 mm the capacity is 5kg/mm^2. With a calculation of 1 pallet can accommodate 1 ton of hazardous waste. Pallet required 80,124 pallets, will be placed in rack. Material Handling will use aisle forklift.
The calculation of rack needs is as follows:

- Total volume hazardous waste 80,124 ton
- Each pallet holds 1 ton of hazardous waste, so it needs 80,124 pallet units.
- 1 rack consists of 5 stacks, so for 5 stacks consisting of 5 pallets or 5 tons, see Figure 4 for this arrangement.
- 1 rack consists of 2 rows, so 1 rack consists of 2 rows and 5 stacks, can hold 10 pallets / 10 ton
- Rack length is made to accommodate 100 pallets. So that 1 shelf can accommodate 1000 pallet / 1000 ton
- 1 rack can accommodate 1000 tons, so requiring 81 shelves to accommodate 80.124 ton of hazardous waste.

The rack system used is Single-deep selective pallet racks system. Where this rack system consists of vertical frames connected by a horizontal load beam. One row consists of two vertical frames designed to withstand the total load of a single row unit. Using this rack system, unit load utilization is 85%. Storage methods in this rack system can be either first in, first out (FIFO) or last in, first out (LIFO). Accessibility is excellent. Storage density is low due to the number of aisle required.

Material handling equipment used is the forklift truck-narrow aisle, which can be used on aisle width of 2.5 m and range of height reaches 6 m. Racks required as many as 81 racks with a width of 2720 mm, while the distance between shelves is 2400 mm for aisle forklift maneuvers.

So the requirement of warehouse width is (81 x 2720 mm) + (80 x 2400 mm) = 412,320 mm or 412.32 m. For rack length, made to accommodate 100 pallets. So the rack length requirement is (100 x (1016 + 100)) = 111,600 mm or 111.6 m. Inside the warehouse will be made tub container with a length of 3.4 m and width of 412.32 m to accommodate hazardous waste spilled, which is placed behind the racks. And a length of 5 m for the forklift ramp on the front of the racks. So the length of the warehouse is (111.6 m + 3.4 m + 5 m) = 120 m. And the warehouse area is 120 m x 412.32 m = 49,478 m2 or 4.9478 hectares.

D. Risk Identification

According to the several references, there are showed general risks from the hazardous waste storage activities. There are five common riskin hazardous storage activities: Fire, Explosion, Reactive, Health problems, Environmental pollution. Fire may occur due to four things: the source of heat, oxygen, fuel and chemical reactions. The heat source in the warehouse can come from electric short, the friction of the object can generate heat. Fuel may come from flammable hazardous waste that stored at warehouse building. Explosion or sudden release of pressure, if there is a tank or storage container accumulating gas inside it suddenly punctured or compressed gas explosion can occur. Reactive may result from contact between certain chemicals, or from certain chemicals that contact with air or water, which may result in a fire, explosion, or release of harmful gases, damage to the equipment by reacting with certain chemicals. Health problems can be caused by excessive exposure to hazardous substances, ranging from minor discomforts such as headaches and skin rashes to more serious impact such as skin burns, organ damage, allergic reactions, cancer and even death. Environmental pollution that can occur in this activities is water pollution and air pollution. Environmental pollution occurs when hazardous substances are spilled or released into water or air. Contaminated water from hazardous waste collection activities can enter to the soil and enter to the community watersource. Air pollution can occur because of the reaction between chemicals resulting in harmful gases, in addition to the loading and unloading activities of the transporter trucks also resulted in air pollution from truck exhaust fumes.

E. Risk Control

- Water pollution can be controled by monitoring wells that made, otherwise if the water source already polluted by activity of hazardous waste, it will supply free water to residents.
- Air pollution comes from the smoke of vehicles that enter to the hazardous waste collection site. Planting trees around a hazardous waste collection site can be an alternative to control this risk impact.
- Provision of fire hydrants, fire extinguishers to overcome the fire. Furthermore the placement of hazardous waste that is flammable and non-flammable is also distinguished by fireproof walls.
- Good ventilation system in the warehouse is one way to control explosion.
- Wear of appropriate personal protective equipment can control the danger of cancer. Also identification/labeling of hazardous waste may reduce the risk of cancer.
- The reactive hazardous material shall be identified in the storage area or in it container of hazardous material to know that the material is highly reactive, so that the handling of the material does not cause reaction to the material and may reduce the hazard.

IV. CONCLUSION AND SUGGESTION

A. conclusion

- From the calculation result of centre of gravity method, the coordinate of selected location for hazardous waste collection site provincial level in East Java is at point (-7.34962; 112.68251). The

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result of the coordinate point is generated from the calculation of the 39th iteration, with total transportation cost of Rp. 170,370,268,038.

- The design of a hazardous waste collection warehouse is made with an area of 120 m x 412.32 m = 49,478 m^2 or 4.94784 hectares.
- Risk Identification, there were 5 risks : Fire, Explosion, Reactivity, Health problems, Environmental pollution.

B. Suggestion

- East Java Province still needs a hazardous waste treatment site, in the future can be done research on the determination of hazardous waste treatment plant in East Java. It can reduce of transportation costs. Determination of hazardous waste treatment sites should also take into account the associated environmental aspects.
- Further research can add risk factors in the calculation of location determination by center of gravity method.

REFERENCES

[1]. Alumur, S and Kara, Bahar Y. 2007. A new model for the hazardous waste location-routing problem. Computers and Operations Research vol 34 , pp : 1406-1423.

[2]. Ballou, Ronald. H. 2004, Business Logistics Managemen Prentice Hall International, Inc., USA.

[3]. Bartholdi, Jhon J, Hackman, Steven J. 2011, *Warehouse and Distribution Science*, The Supply Chain and Logistics InstituteSchool of Industrial and Systems EngineeringGeorgia Institute of TechnologyAtlanta, USA

[4]. Edil, T.B., 2003. A review of aqueous-phase VOC transport in modern landfill liners.Waste Management.

[5]. ElFadel, M., Findikakis, A.N., Leckie, J.O., 1997. Modeling leachate generation and transport in solid waste landfills. Environmental Technology 18 (7),

[6]. Erkut, Eand Verter, V, 1997. Modeling Of Transport Risk For Hazardous Materials. Operations Research vol 46 no 5, pp : 625-642. Informs.

[7]. Ferrier, Norman. Haque, C. Emdad. (2002). Hazards Risk Assessment Methodology forEmergency Managers: A Standardized Frameworkfor Application. Natural Hazards.

[8]. Hanafi, M.M. (2006), Manajemen Risiko, UP STIM YKPN, Jogjakarta.

[9]. Jorion, P. (2001), Value a Risk: The New Benchmark for Managing Financial Risk. McGraw Hill, USA.

[10]. Karnchanawong, S., Koottatep, S., Ikeguchi, T., 1993. Monitoring and evaluation of shallow well water-quality near a waste-disposal site. Environment International.

[11]. Keputusan Kepala Badan Pengendalian Dampak Lingkungan. Nomor : Kep-01/Bapedal/09/1995. Tentang Tata Cara Dan Persyaratan Teknis Penyimpanan DanPengumpulan Limbah Bahan Berbahaya Dan Beracun

[12]. Li, Ying. Li Jinhui. Chen, , Shusheng (2012). Establishing indices for groundwater contamination risk assessment in thevicinity of hazardous waste landfills in China. Environmental Pollution

[13]. Mor, S., Ravindra, K., Dahiya, R.P., Chandra, A., 2006. Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site.Environmental Monitoring and Assessment.

[14]. Park, Jonghun. Horvath, Laszlo. Araman , Philip. White, Marshall S. Bush, Robert J. Phanthanousy , Samantha. 2015. The Influence of Package Size and Flute Type of Corrugated Boxes on Load Bridging in Unit Loads. Packaging Technology And Science.

[15]. Peraturan Menteri Lingkungan Hidup No 30 tahu 2009 TentangTata Laksana Perizinan Dan Pengawasan Pengelolaan Limbah Bahan Berbahaya Dan Beracun Serta Pengawasan Pemulihan Akibat Pencemaran Limbah Bahan Berbahaya Dan Beracun Oleh Pemerintah Daerah.

[16]. Peraturan Pemerintah Nomor 101 Tahun 2014 Tentang Pengelolaan Limbah B3.

[17]. Pradhanangga, R; Taniguchi, E dan Yamada, T, 2007. "Optimization Of Vehicle Routing And Scheduling Problem With Time Window Constraints In Hazardous Material Transportation. Proceedings of the Eastern Asia Society for Transportation Studies, Vol.7.

[18]. Prayitno, Irwan H, 2007. "Pengembangan Model Optimasi Pengangkutan Sampah di Jakarta Pusat. ",Institut Pertanian Bogor.

[19]. Ramli, Soehatman. 2010; Sistem Manajemen Keselamatan & Kesehatan Kerja OHSAS 18001. Dian Rakyat. Jakarta .

[20]. Riyanto. 2013; Limbah Bahan Berbahaya dan Beracun (Limbah B3). Deepublish. Yogyakarta.

[21]. Scott, J., Beydoun, D., Amal, R., Low, G., Cattle, J., 2005. Landfill management, leachate generation, and leach testing of solid wastes in Australia and overseas. Critical Reviews in Environmental Science and Technology.

[22]. Shaw, Gary M. Windham, Gayle C. Leaonard, Alvin. Neutra, Raymond R. (1996). Characteristics of hazardous Material Spills from Reporting System in California. American Journal of Public health.

[23]. Yang, Jie. Li, Fengying. Zhou, Jingbo. Zhang, Ling. Huang, Lei. (2010). A survey on hazardous materials accidents during road transport in China from 2000 to 2008. Journal of Hazardous Materials 184 (2010) 647–653.

[24]. M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.