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Environmental Impact Evaluation of Improved Market Waste Processing as Part of Municipal Solid Waste Management System Using Life Cycle Assessment Method

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ABSTRACT

Payakumbuh City Government has built an Integrated Waste Treatment Plant (TPST) in Ibuh Market as an effort to reduce waste through waste processing by composting. This study aimed to evaluate the environmental impact of the Ibuh Market waste management system with some solid waste management alternatives using the Life Cycle Assessment (LCA) Method. The stages of the research consisted of the measurement and analysis of waste generation, composition, and recycling potential, followed by the application of LCA for composting waste management scenario (scenario 1), with no composting (scenario 2), as well as with composting and recycling (scenario 3). The waste generated by Ibuh Market is 8.99 tons/day, food waste has the highest share in waste composition, amounting to 80.60%, and the waste with the greatest potential to recycle is an inorganic waste by 72.37%. LCA was carried out using the CML-IA impact assessment method. On the basis of the weighting results of the Global Warming Potential, Acidification Potential, and Eutrophication Potential impact categories show that scenario 2 has the highest weight, which is 4.34×10^{-7}, scenario 3 has the smallest weight that is 3.73×10^{-7}. Hence, scenario 3 was chosen as the best option, because it has the lowest impact weight. The study recommended using biofuels as an alternative to the fuels in the transportation process, applying a modified open windrow aeration system in the composting process at TPST, as well as practicing the sanitary landfill, for becoming a more environmentally friendly solid waste management system.

Keywords: environmental impact evaluation, Ibuh Market Payakumbuh, life cycle assessment, solid waste management system, environmentally friendly.

INTRODUCTION

Waste management continues to be a significant challenge in urban areas throughout the world, especially in developing countries. The existence of population growth, industries, urban areas, and economic growth resulted in a significant increase in the amount of municipal waste generation (Kaushal et al., 2012). Waste has excellent potential for environmental pollution because it causes a decrease in the quality of the environment, such as the emergence of threats or negative impacts on health, damage to natural resources, decreased aesthetic value, economic losses, and disruption of natural systems (Permadi and Retno, 2013).

Payakumbuh City is one of the main accesses of the West Sumatra Province to the Riau Province. Payakumbuh City is a strategic area with potential trade routes. This situation has an impact on increasing waste production. The waste that enters the Payakumbuh Regional Landfill averages 200–300 tons per day. One of the efforts that have been made by the Payakumbuh City Government to reduce waste generation is by building an Integrated Waste Management Plant (TPST) in the Ibuh Market Payakumbuh City. A total of 700 kg of organic waste is processed in this waste treatment plant.

In general, the waste management system that implemented in the Ibuh Market Payakumbuh

City is composting. The waste that was brought to the TPST only constituted the compostable organic waste. Currently the processing available at Pasar Ibuh TPST is composting, no other processing has been applied yet. An evaluation of the Ibuh Market Payakumbuh waste management system needs to be carried out to assess the environmental impact of solid waste management, which should be an environmentally friendly one, as mandated by Indonesia Constitution No. 18 Year 2008.

Life Cycle Assessment (LCA) is a technique that aims to address the environmental aspect of a product and their potential environmental impacts throughout that product's life cycle. A product's life cycle includes all stages of a product system, from raw material acquisition or natural resource production to the disposal of the product at the end of its life, including extracting and processing of raw materials, manufacturing, distribution, use, re-use, maintenance, recycling, and final disposal (i.e., cradle-to-grave) (UNEP/SETAC, 2009). The LCA method has been applied in various studies on solid waste management and technology. Some studies used LCA to make a comparison of the environmental impacts of each waste management system by Finnveden et al. (2005), Banar et al. (2009), Gunamantha et al. (2010), and Aziz et al. (2015), while Kalinci et al. (2012) and Aulia (2017) study about technology options for solid waste/ biomass treatment. The LCA method has also been used to assess alternative waste management systems of several institutions by Aziz and Febriady (2016) and a comparative analysis of Padang and Kitakyushu City's domestic waste management by Wulandari and Raharjo (2018). In many studies, LCA is used as a tool to determine effective waste management and can identify each treatment process that requires potential improvements (Suna, 2015).

Therefore it is necessary to look at reducing the impact that occurs on the waste management system with composting, which is being implemented in the Ibuh Market so that recommendation for the best waste management system can apply in all markets.

MATERIALS AND METHODS

Data collection

The data consists of secondary and primary data. Secondary data in the form of the existing condition of Payakumbuh waste management is related to legal aspects, institutional aspects, technical operation aspects, financial aspects, and community participation aspects. The technical operation aspects consist of generation, storage, collection, processing (composting), transportation, and final processing of waste. Specifically, the existing conditions for the management of the Ibuh Market Payakumbuh waste, both technically and non-technically, as well as materials and equipment needed during the processing that takes place at Ibuh Market Payakumbuh.

Primary data were obtained by conducting a survey in the field, measuring the volume of waste generation, calculating the weight of each waste composition, and the potential for waste recycling at the study site, Ibuh Market Payakumbuh. Moreover, by conducting informal interviews with related parties as assistance were conducted to obtain the appropriate data.

Measurement of solid waste generation, composition, and recycling potential

The samples were taken from seven points from seven bin containers found in Ibuh Market Payakumbuh. On the basis of the Indonesia National Standard No. 19-3964-1994 concerning Method of Sampling Collection and Measurement of Urban Waste Generation and Composition (Badan Standardisasi Nasional, 1994), non-housing samples such as markets calculated with the formula at least 10 % of total number of non-domestic facilities. Moreover, the distribution of types of sources is grouped according to the type of activity.

Data processing and analysis

Sampling in the field was carried out for eight consecutive days to obtain a calculation of the average amount of generation, composition, and potential of waste recycling. The generation calculation consists in calculating the weight and volume of waste. The volume of waste was calculated after compaction by jerking the compactor as high as 30 cm. The waste composition was calculated based on the waste components weight that was separated and divided by the total waste generated. In turn, the recycling potential of waste means the percentage of recyclable wastes from the total amount of waste produced.

Scenarios of Ibuh Market solid waste management system proposed

Alternative scenarios proposed to improve the Payakumbuh City Ibuh Market waste management system are as follows:

1. Scenario 1 (waste management by composting)

Scenario 1 is the existing condition that is being applied by Ibuh Payakumbuh Market. Waste processing implements the composting method. Every day, compostable garbage is sorted and transported by TPST workers using motorized pedicabs. The recyclable waste is collected by the informal sector (scavengers) into the station. Moreover, compostable waste is transported directly to the landfill without processing at the source.

2. Scenario 2 (waste management by no composting)

In scenario 2, there is no waste processing done at the source. The waste that has the potential to be recycled is sorted and utilized by the informal sector. Furthermore, the rest transported to the landfill site. This scenario proposed to compare waste management in scenario 1.

3. Scenario 3 (waste management by composting and recycling)

In scenario 3, an improvement is made in the waste treatment process. The amount of composted waste increased. Then, the processing activities at TPST are supplemented by the process of recycling plastic waste to improve the processing of waste in TPST. This scenario causes a reduction in waste generation transported into the landfill. Thus, the impact on the environment could be minimized.

LCA analysis

This LCA analysis uses the SimaPro 8.4 software, which is easy to operate and accessible software used by many researchers and industries in the world. The LCA research procedure has four main stages to carry out, namely (UNEP/SETAC, 2009):

1. Goal and scope definition

At this stage, the unit determined as the input and output the parameters of the data inventory that allow comparisons between systems to be analysed (ISO, 2006). Limitations on the use of LCA in this study are the generation, composition, and recycling potential. The limit created in each scenario uses the same function unit, which is 1 ton of waste produced by the Ibuh Payakumbuh Market. This functional unit uses as a standard for all processes that occur in this analysis.

2. Life cycle inventory analysis

This stage carried out collecting data that can support LCA analysis, which is then called inventory data. The inventory analysis begins with the determination of functional units, namely 1 ton of waste generation. This stage also modelled a process diagram consisting of several scenarios, and each scenario has its process diagram. Afterwards, the inventory data needed in the subsequent impact analysis can be applied.

3. Life cycle impact assessment

An evaluation of the potential impact on the environment was carried out using the results of inventory analysis and providing the information to be interpreted at the last stage. The impact assessment for each scenario modeled on the SimaPro software calculated automatically after the CML-IA Method is selected (Pre Consultants, 2013). The environmental impacts assessed in this study include Global Warming Potential (GWP), Acidification Potential (AP), and Eutrophication Potential (EP).

GWP states the value of the potential for global warming caused by emissions within 100 years. GWP is expressed in units of kg CO_2 equivalent, which is the main greenhouse gas that causes global warming. The equivalent value is issued periodically by the International Panel on Climate Change (IPCC). The compounds that contribute most to this global warming potential are CO_2 and CH_4. Meanwhile, AP is a decrease in pH in soil and water due to the formation of H^+ ions. AP analyses the impact that can cause potential acidification on the environment. The compounds that contribute most to this acidification potential are acidic compounds such as SO_X, NO_X, HF, and HCl. The potential for acidification expresses in kg SO_2 units, while other compounds that contribute to the acidification express as equivalent to the mass unit SO_2. Moreover, EP analyses the impact that can lead to potential eutrophication. The compounds that contribute the most to this eutrophication potential are nitrogen and phosphorus. This EP is expressed in units of kg PO_4^{3-}, so that other compounds that are not PO_4^{3-} but which contribute to the occurrence of eutrophication are equivalent to PO_4^{3-} units.

This phase consists of several steps, firstly impact classification, this process requires all incoming resource data and environmental emissions generated for various impact categories, grouping inventory data based on the similarity of estimated ecological impacts. Secondly, it involves impact characterization, which provides a way to directly compare the results of inventory analysis in each impact category. Characterization factors translate different inventory inputs into impact indicators so they can be directly compared. Thirdly, normalization, it shows the extent to which the results of the impact category indicator have relatively high or relatively low values compared to the existing references. Normalization also solves the unit mismatch. The last is weighting, which inconsists in assessing and weighting the predetermined environmental impacts. The weighting carried out using an impact analysis matrix to produce important significant implications for further study.

4. Life cycle interpretation

An interpretation should be drawn based on the inventory analysis of data, comparative analysis for impact characterization of life cycle steps of systems, contribution analysis of data input related to the higher impact caused, and also by improvement analysis for future system operation.

RESULTS AND DISCUSSIONS

Ibuh Market solid waste generation, composition and recycling potential

Solid waste generation of the Ibuh Market Payakumbuh in units of weight and volume is shown in Table 1, meanwhile the composition is presented in Table 2. On the basis of the calculation results, it was shown that the composition of the Ibuh Market Payakumbuh is dominated by food waste, which is 80.61%. In turn, other waste contributing to the component of plastic, paper, non-ferrous metals, textiles, other wastes, rubber/leather, glass, wood, and ferrous metals.

Table 1. Solid waste generation of Ibuh Market Payakumbuh

Sample	Solid waste generation	
	(kg/day)	(lit/day)
Bin 1	166.06	232.40
Bin 2	169.81	231.74
Bin 3	172.14	232.48
Bin 4	171.42	232.34
Bin 5	165.26	231.00
Bin 6	169.98	231.80
Bin 7	172.64	233.76
Average	169.62	232.22

Table 2. Solid waste composition of Ibuh Market Payakumbuh

Waste Component	Composition (%)
Food waste	80.61
Paper	3.80
Plastic	5.57
Textile	2.55
Rubber	0.78
Wood	0.64
Glass	0.73
Ferrous metal	0.34
Non ferrous metal	3.39
Other	1.60
Total	100.00

Moreover, the recycling potential of Ibuh Market Payakumbuh waste for wet waste is 72.37%, paper waste is 84.62%, plastic waste is 68.51%, glass waste is 74.33%, non-ferrous metal waste is 85.19% and ferrous metal waste 76.82%.

Development scenarios of solid waste management system of Ibuh Market Payakumbuh

The proposed alternatives to improve the Ibuh Payakumbuh Market waste management system are as follows:

Scenario 1 is the existing scenario that is being run by Ibuh Payakumbuh Market, where sorting has been done for compostable waste. The percentage of compostable solid waste processed at TPST is 7.79%, recycled waste by the scavengers is 2%, and the waste that is not processed is very high at 90.21% of the total generation of Ibuh Payakumbuh market.

Scenario 2 is the solid waste management without any treatment before landfilling. This scenario means that the generation of waste generated by Ibuh Payakumbuh Market is directly transported to the landfill. In this scenario, the garbage collected is mixed, even though the market manager has provided a communal container, the garbage collected at the waste collection spot (TPS) is still mixed. Recycling by the informal sector, such as scavengers, remains at a percentage of 2%, the same as the existing scenario. This condition means that 98% of the waste generated from the Ibuh Payakumbuh Market is taken to the landfill without processing at the source.

Lastly, in scenario 3, there is an increase in composting processing and the existence of plastic recycling processing. The garbage collected is divided into three types, namely compostable waste, recycled waste, and others. This collection process is structured to facilitate further processing. In this scenario, an increase in the composting process increased by 5%, to 12.79%. The enumeration process will treat plastic waste, which can reduce the size of the waste particles. The enumeration process was assumed to be able to process 50% of the total recyclable plastic waste, which is 1.91%. Whereas recycled waste is handled by the scavengers, amounting to 2%.

LCA application on assessing the solid waste management scenarios

In this study, the LCA method compares each of the waste management scenarios. The LCA analyzes for its feasibility in environmental aspects, and the potential impact of each system contained in waste management, starting from the garbage collection system to the waste arriving at the landfill. LCA identifies the energy and material requirements used as well as the emissions released to the environment.

a) Goal and scope definition

This study limited the analysis from the collection system, processing at source (composting and recycle), transportation from source to TPST, transportation from TPS to shanties, transportation from TPS to landfill for a final processing. The processing system carried out by the informal sector was not analyzed in this study. In this scenario, the use of primary materials from supporting tools and facilities is also assessed. The functional unit used is 1 ton of waste generation. Limits were applied to each scenario using the same functional unit. The assessment compares the emissions produced in each system. The process of reducing waste generation by applying composting and recycling processing analyzed so that the total waste treated at the landfill was minimized.

b) Inventory analysis

The functional unit used in this study is 1 ton of waste treated. This waste generation is an input in each of the scenarios prepared. The related data used was refers to Niltrit and Pantawat (2012) for vehicle emission, TGO (2013) for emission of power plant, Colon et al. (2010) for composting process emission, and Adbuli et al. (2010) for emission of landfill operation. The following is the inventory data used in the SimaPro 8.4 software based on the proposed scenarios:

Table 3. Data inventory of scenario 1

Items	Data	Unit
Transportation from sources to TPST	0.0389	tkm
Transportation from TPS to landfill	4.9616	tkm
Transportation from TPS to collector	0.0764	tkm
Energy for compost grinder	0.6437	MJ
Energy for compost siever	0.2555	MJ
Energy for plastic crusher	0.0779	MJ
Compost product	0.004	ton
Plastic recycling product	0.001	ton
Water consumption	0.9021	ton
EM4 used	0.001	ton
Waste treated in landfill	0.9021	ton
Energy for bulldozer in landfill	17.474	MJ
Energy for excavator in landfill	17.474	MJ

Scenario 1 is an existing condition that is applied in the Payakumbuh City Ibuh Market. In this scenario, there is composting with waste processing done at TPST. All processes carried out starting from the collection of waste at the source will be assessed in terms of environmental impacts. The energy demand for inventory data needed for scenario 1 is shown in Table 3.

Meanwhile, Scenario 2 assumes no waste processing has been carried out at the Ibuh Payakumbuh Market. This situation compares the treatment processes that applied in scenario 1 (existing) so that it can assess the strengths of the treatment processes that have applied in scenario 1. The inventory data required for the energy needs for scenario 2 is shown in Table 4.

Moreover, Scenario 3 increases the percentage of composted waste and the addition of a plastic handling process that was enumerated at TPST. All processes carried out were assessed as

Table 4. Data inventory of scenario 2

Items	Data	Unit
Transportation from TPS to landfill	5.390	tkm
Transportation from TPS to collector	0.0764	tkm
Waste treated in landfill	0.9800	ton
Energy for bulldozer in landfill	18.988	MJ
Energy for excavator in landfill	18.988	MJ

Table 5. Data inventory of scenario 3

Items	Data	Unit
Transportation from source to TPST	0.0734	tkm
Transportation from TPS to landfill	4.5821	tkm
Transportation from TPS to Collector	0.0764	tkm
Energy for Compost grinder	0.5270	MJ
Energy for Compost siever	0.6886	MJ
Energy for Plastic crusher	0.7745	MJ
Compost product	0.1279	ton
Plastic Recycling product	0.0189	ton
Water consumption	0.008	ton
EM4 used	0.002	ton
Waste treated in landfill	0.8331	ton
Energy for Bulldozer in landfill	16.1404	MJ
Energy for Excavator in landfill	16.1404	MJ

having environmental impacts. The data on the energy demand inventory needed for scenario 3 is shown in Table 5.

c) Impact assessment

The impact categories are the Global Warming Potential (GWP), Acidification Potential (AP), and Eutrophication Potential (EP). Furthermore, grouping and evaluation of the impact on the environment carried out through stages of classification, characterization, normalization and weighting of impacts. The results of the impact characterization assessment are shown in Table 6, while the results of normalization are presented in Table 7, and weighting results are indicated in Table 8.

d) Interpretation analysis

Impact comparison

On the based of the characterization results, a comparison of each scenario can be described as follows: in Scenario 1, in all impact categories, landfill operation has the highest impact on several impact categories, as shown in Figure 1.

Impact contribution

On the basis of the results of the impact contribution to the level of GWP, the overall scenario has a significant level of GWP caused by landfilling activities in the landfill. The emissions that have the greatest influence on the high level of GWP are CH_4, CO_2, $NO_{X,}$ and VOC. Because the treatment of leachate and gas does not work in the landfill is the leading cause of the amount of exhaust emissions. Treatment processes such

Table 6. Impact characterization of all scenarios

Process Scenario	Unit/FU	Composting	Informal recycler	Plastic recycling	Landfilling	Total
Scenario 1						
GWP	Kg CO_2-eq.	4.809	1.01×10^{-2}	-	852.69291	857.5121
	%	0.56	0.00	-	99.44	100
AP	Kg SO^2-eq.	3.16×10^{-3}	3.25×10^{-5}	-	4.88×10^{-2}	5.21×10^{-2}
	%	6.07	0.06	-	93.67	100
EP	Kg PO_4^{3-}-eq.	4.89×10^{-3}	7.69×10^{-6}	-	4.29×10^{-2}	4.78×10^{-2}
	%	10.23	0.02	-	89.75	100
Scenario 2						
GWP	Kg CO_2-eq.	-	1.01×10^{-2}	-	926.32715	926.3373
	%	-	0.01	-	99.99	100
AP	Kg SO^2-eq.	-	3.25×10^{-5}	-	5.31×10^{-2}	5.31×10^{-2}
	%	-	0.06	-	99.94	100
EP	Kg PO_4^{3-}-eq.	-	7.69×10^{-6}	-	4.66×10^{-2}	4.66×10^{-2}
	%	-	0.02	-	99.98	100
Scenario 3						
GWP	Kg CO_2-eq.	7.896	1.01×10^{-2}	1.80×10^{-2}	787.47243	795.3916
	%	0.993	0.001	0.002	99.004	100
AP	Kg SO^2-eq.	5.18×10^{-3}	3.25×10^{-5}	2.22×10^{-5}	4.51×10^{-2}	5.03×10^{-2}
	%	10.29	0.03	0.02	89.66	100
EP	Kg PO_4^{3-}-eq.	8.042×10^{-3}	7.69×10^{-6}	5.78×10^{-6}	3.96×10^{-2}	4.77×10^{-2}
	%	16.95	0.02	0.01	83.02	100

Table 7. Impact normalization for all scenarios

Process Scenario	Composting	Informal sector recycler	Plastic recycling	Landfilling	Total
Scenario 1					
GWP	9.57×10^{-13}	2.01×10^{-15}	-	1.70×10^{-10}	1.71×10^{-10}
AP	1.12×10^{-13}	1.15×10^{-13}	-	1.73×10^{-12}	1.85×10^{-12}
EP	3.71×10^{-13}	5.83×10^{-16}	-	3.25×10^{-12}	3.63×10^{-12}
Scenario 2					
GWP	-	2.01×10^{-15}	-	1.84×10^{-10}	1.84×10^{-10}
AP	-	1.15×10^{-15}	-	1.88×10^{-12}	1.89×10^{-12}
EP	-	5.83×10^{-16}	-	3.53×10^{-12}	3.53×10^{-12}
Scenario 3					
GWP	1.57×10^{-12}	2.01×10^{-15}	3.59×10^{-15}	1.57×10^{-10}	1.58×10^{-10}
AP	1.84×10^{-13}	1.15×10^{-15}	7.89×10^{-16}	1.60×10^{-12}	1.79×10^{-12}
EP	6.10×10^{-13}	5.83×10^{-16}	4.38×10^{-16}	3.00×10^{-12}	3.62×10^{-12}

Table 8. Impact weighting of all scenarios

Process Scenario	Unit	Composting	Informal recycler	Plastic recycling	Landfilling	Sub total	Total
Scenario 1							
GWP	Pt	6.75×10^{-9}	1.42×10^{-11}	-	1.2×10^{-6}	1.20×10^{-6}	1.20×10^{-6}
AP	Pt	3.39×10^{-11}	3.48×10^{-13}	-	5.24×10^{-10}	5.58×10^{-10}	
EP	Pt	1.42×10^{-10}	2.23×10^{-13}	-	1.25×10^{-9}	1.39×10^{-9}	
Scenario 2							
GWP	Pt	-	1.42×10^{-11}	-	1.3×10^{-6}	1.30×10^{-6}	1.30×10^{-6}
AP	Pt	-	3.48×10^{-13}	-	5.69×10^{-10}	5.70×10^{-10}	
EP	Pt	-	2.23×10^{-13}	-	1.35×10^{-9}	1.35×10^{-9}	
Scenario 3							
GWP	Pt	1.11×10^{-8}	1.42×10^{-11}	2.53×10^{-11}	1.11×10^{-6}	1.12×10^{-6}	1.12×10^{-6}
AP	Pt	5.56×10^{-11}	3.48×10^{-13}	2.38×10^{-13}	4.84×10^{-10}	5.40×10^{-10}	
EP	Pt	2.33×10^{-10}	2.23×10^{-13}	1.68×10^{-13}	1.15×10^{-9}	1.38×10^{-9}	

as composting and recycling of plastic waste are not very significant in their impact on the environment.

On the basis of the results of the impact contribution that occurs on the AP, the average overall scenario has the most considerable AP level in the landfill process at the landfill. The NO_X and NH_3 emissions generated in the landfill and composting process are the leading causes of the increased AP value. Composting has a far more significant impact on acidification than landfills. However, landfills have shown to have an enormous impact. Besides, the collection and transportation process also contributes to the occurrence of AP.

In turn, based on the contribution of the impact that occurred for the EP, the average overall scenario has an immense AP level in the landfill process at the landfill. In scenarios 1 and 3, there is a composting process that contributes to an increase in EP values caused during the composting process resulting in significant air pollutants. The resulting gas emissions, such as CH_4, N_2O, NH_3, and VOC, cause the increase in EP values. Besides, the collection, transportation, and energy requirements of using tools for waste treatment also contribute to the EP value in a small percentage.

Improvement recommendation of the best scenario

On the basis of the results of weighting in the previous stage, scenario 3 is the best because it has the smallest weight value, which is 3.73×10^{-7}. In this scenario, some processing has carried out at the source, such as composting and recycling. However, after being analysed using the LCA method,

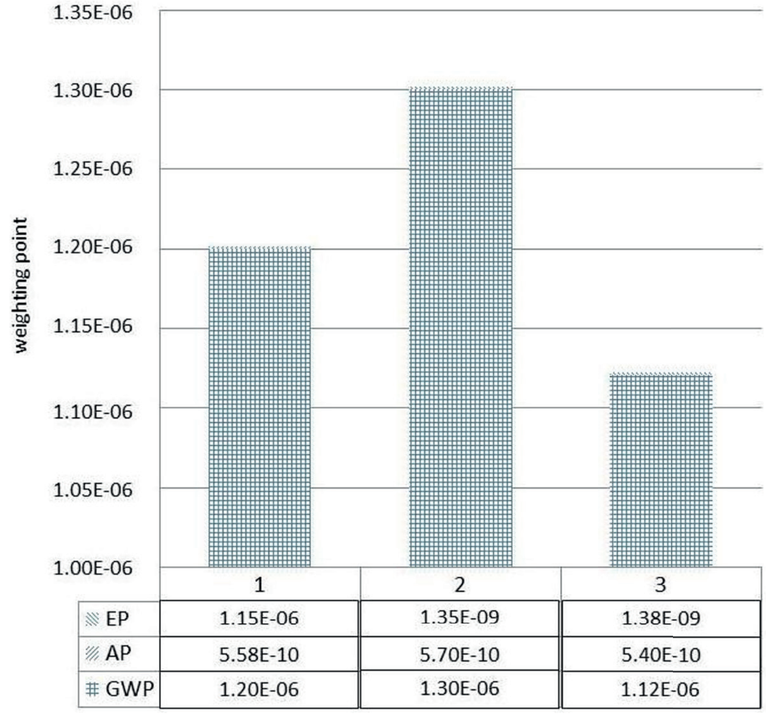

Figure 1. Impact comparison of all scenarios based on weighting method

the treatment that initially expected to reduce the environmental impact was, in fact, still having an impact, especially on any process that uses energy-producing equipment. Therefore, improvement is needed as well as alternative solutions to minimize the impact. Some of the recommendations submitted for the selected scenario are as follows:

1. Collection process and transportation. The emissions released into the air contribute to each impact. Therefore it is recommended to use environmentally friendly fuels that have perfect combustion so that it can help reduce the impact on the environment. Like the use of the *Manihot Esculenta* biofuel because the calorific content contained in *Manihot Esculenta* is very supportive in making environmentally friendly bioethanol (Sarianti et al., 2014). Besides that, in every waste transportation device, an air pollution control device is installed to filter the emission produced.
2. Treatment process in TPST. The composting process also contributes to each impact category. The application of a modified open window aeration system composting process can minimize the gases emission. The modified aeration system by installing triangular bamboo slats placed at the base of the compost material (Purnamayani and Syafri, 2012). This composting system will not pollute the surrounding environment so that compostable processing of waste in Ibuh Market Payakumbuh has a smaller and impact, being more environmentally friendly.
3. Processes in landfill. Reducing waste generation to landfills can be done by optimizing waste collection and generation reduction on the waste treatment at TPST. Some things that are needed to apply are the processing methods where the waste cell is covered by soil every day. The height and width of the waste cell is also taken into account. At the bottom of the disposal site, pipes drain leachate, which are then processed into energy. Among the waste cells, methane gas catching pipes are installed as well, which then process the gas into energy.

CONCLUSIONS

On the basis of the results of the study, the average solid waste generation in the Ibuh Payakumbuh Market is 8.99 tons/day. The composition of the Ibuh Market Payakumbuh consists of organic waste, namely 80.60% food waste, 3.8% paper, 5.5.7% plastic, 2.55% textile, 0.78% rubber/leather, 0.64% wood, and inorganic waste namely glass 0.73%, ferrous metal 0.34%, non-ferrous metal 3.39% and other waste 1.6%.

Potential recycling of Pasar Ibuh Payakumbuh waste consists of 72.37% wet waste, 84.62% paper, 68.51% plastic, 74.33% glass, 76.42% ferrous metal and 85.19% non-ferrous metal.

On the basis of the weighting results from the normalization of the impact assessment using the CML-IA method from SimaPro software, scenario 2 is the least environmentally feasible scenario because it has the highest weighting rating of 4.34×10^{-7}. In contrast, scenario 3 is the best because it has the weight the smallest rating is 3.73×10^{-7}.

Recommendations for a more environmentally friendly system including uses biofuels for transportation system that can produce smaller impacts such as the use of *Manihot Esculenta* biofuel, because the caloric content contained in *Manihot Esculenta* is very supportive in making environmentally friendly bioethanol. The composting process can apply the modified open windrow aeration system. The aeration system modified by installing triangular bamboo slats placed on the base of the compost material so that the composting process will not take a long time, which causes a contribution to the impact on the water and air environment. Lastly, landfill processes need to operate the sanitary landfill method accurately through the treatment of leachate and gas treatment. Therefore, the main cause of the magnitude of the level of impact categories can be minimized.

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