Research Paper

Sustainability Life Cycle Assessment of Household Food Waste Management in Urban Areas

Devi Angeliana Kusumaningtiar[1*], Gisely Vionalita[1], Prita Dhyani Swamilaksita[2]

1. Department of Public Health, Faculty of Health Sciences, Universitas Esa Unggul, Jakarta, Indonesia.
2. Department of Nutrition Science, Faculty of Health Sciences, Universitas Esa Unggul, Jakarta, Indonesia.

Use your device to scan and read the article online

Citation Kusumaningtiar DA, Vionalita G, Swamilaksita PD. Sustainability Life Cycle Assessment of Household Food Waste Management in Urban Areas. Journal of Research & Health. 2023; 13(6):467-472. http://dx.doi.org/10.32598/JRH.13.6.2255.1

doi: http://dx.doi.org/10.32598/JRH.13.6.2255.1

ABSTRACT

Background: Food waste is a severe problem, and Indonesia is the world's second-largest producer of food waste. A limited waste management system will decrease environmental quality, such as air, water, and soil pollution. So far, the waste management system is limited to reducing waste generation. The life cycle assessment is a method to analyze environmental aspects or environmental impacts at all stages in a resource's life cycle, from the initial process of raw materials to disposal. This study aims to analyze the environmental impact and provide waste management policies to obtain sustainable household waste management and environmental sustainability.

Methods: The study design used in this research is cross-sectional by conducting direct observations and interviews at the Waste Bank. Interviews were conducted to identify more in-depth findings about waste management problems and the characteristics of respondents and waste characteristics. Observations were made to calculate waste generation that refers to Indonesian national standard methods of sample collection and measurement of urban waste generation and composition (SNI 19-3694-1994.) The sampling technique was carried out by the total sampling method, resulting in 100 households.

Results: The research results with organic waste processing with the black soldier fly method. This method impacts global warming, acidification, eutrophication, and ozone depletion. Of the four elements that produce the most negligible impact is the impact of global warming of 0.281 kg CO_2 eq compared to the other effects.

Conclusion: BSF processing can reduce environmental impacts, especially global warming. Meanwhile, education affects people's behavior in generating food waste; therefore, there are policy recommendations for Waste Bank stakeholders in processing food waste.

Keywords: LCA, Food waste, Household waste management, Economic status

Article info:
Received: 27 Feb 2023
Accepted: 30 Jul 2023
Publish: 01 Nov 2023

*** Corresponding Author:**
Devi Angeliana Kusumaningtiar
Address: *Department of Public Health, Faculty of Health Sciences, Universitas Esa Unggul, Jakarta, Indonesia.*
Phone: *+6285775955871*
E-mail: *deviangeliana@esaunggul.ac.id*

[DOI: 10.32598/JRH.13.6.2255.1]

1. Introduction

Food waste can be edible that has not been consumed and is discarded for various reasons or left to rot [1-3]. According to Papargyropoulou et al., in the United States, food waste such as milk, vegetables, and fruit can increase 22% of greenhouse gases social and economic impacts [4]. Drawing on interviews with food waste specialists, this study construes the boundaries between food surplus and food waste, avoidable and unavoidable food waste, and between waste prevention and waste management. This study suggests that the first step towards a more sustainable resolution of the food waste issue is to adopt a sustainable production and consumption approach and tackle food surplus and waste throughout the global food supply chain. The authors examine the factors that give rise to food waste throughout the food supply chain, and propose a framework to identify and prioritize the most appropriate options for prevention and management of food waste. The proposed framework interprets and applies the waste hierarchy in the context of food waste. It considers the three dimensions of sustainability (environmental, economic, and social. Some studies show that reducing food waste can have a beneficial impact on climate change [5].

The limitations of waste management make the system uncontrollable. Public awareness and knowledge of sorting and processing waste is still significantly low. This is also due to the government's inadequate attention to environmental conditions and community sanitation, causing vast amounts of waste to accumulate in landfills in the village. Accordingly, there needs to be an approach from various aspects to determine a sustainable waste management system. Waste banks are one of the solutions to the waste management system in the community. The waste bank is waste management in public space to store community waste through deposits [6, 7].

Margajaya Village is part of the Bekasi City area, West Java, directly adjacent to DKI Jakarta. Margajaya Village is a sub-district of South Bekasi, which has an area of 14.96 km^2 with a population of 210 497 people. Waste handling in Margajaya Village already has a waste bank that manages organic/food and inorganic waste. Inorganic waste is managed at the village level, which is carried out once every two weeks, and people who donate their waste will get a savings book based on the volume in kg. In contrast, the mangosteen black soldier fly (BSF) technique manages organic waste. The scope is still in the house blocks and is collected daily by the janitor; however, some people come directly to the waste bank. The waste bank is a forum for processing waste for the community with the method of buying and selling waste and is managed by local stakeholders. Sustainable waste management is essential. In this study, waste management with the sustainability life cycle assessment (LCA) approach is one of the tools that can be used to calculate and analyze the potential environmental impacts of waste management, primarily to determine the possible effects of global warming if waste bank management is implemented within the village; accordingly, it can choose the most environmentally friendly waste management that can be used sustainably. LCA is a method to analyze environmental aspects or environmental impacts at all stages in a resource's life cycle, from the initial process of raw materials to disposal. With the sustainability LCA approach to waste management, it is hoped that it can provide an overview and solution for sustainable waste management by considering aspects of environmental impact and increasing products from waste management.

2. Methods

This was a cross-sectional study with hypothesis testing. The modeling and simulation were conducted to identify household food waste processing problems. The sampling technique was carried out by total sampling, resulting in 100 households willing to participate. The sustainability LCA model of household food waste processing was used to understand the concept of improving environmental quality in the future. To achieve the research outcome, it was necessary to process and analyze the data as follows: 1) Testing the hypothesis; 2) Sampling the generation and characteristics of household waste; 3) LCA based on ISO 14040:2006; and 4) Determination of waste management scenarios. The calculation of household waste generation refers to SNI 19-3694-1994, which was carried out for 8 consecutive days per sample, while the identification of household waste characteristics was based on SNI 19-2454-2002.

Scenario setting

The scenario setting of this research was to assess and compare the potential environmental impacts of waste processing before and after implementing the waste bank.

Life cycle assessment based on ISO 14040:2006

LCA calculations were carried out via the GaBi software, version 10.6.1 using inventory data from observations and analyses. The LCA calculation should have

[DOI: 10.32598/JRH.13.6.2255.1]

data on the estimated amount of waste generation kg/day/householder and total waste generation tons/day in the Waste Bank. Waste composition consists of two types: Unsaleable waste and saleable waste. Commercial waste includes plastic bags, cups and bottles, buckets, paper, cardboard, books, slippers, cans, iron, rubber, and used fabrics. Non-saleable waste includes food waste, kitchen waste, and yard waste.

Data interpretation

The collected univariate and bivariate data were interpreted according to the study results. The data presentation can be in tables, garfish, bar charts, etc.

Conclusions and policy recommendations

The study results are expected to provide practical policy recommendations for managing sustainable household waste. Data analysis was conducted bivariately while bivariate analysis was used to analyze the relationship between household waste generation and community economic strata using the chi-square test with a P=0.05 considered the significance level.

3. Results

Table 1 shows that the high economic strata with the highest proportion of food waste generation is small at 83.8% (37 people). However, the middle economic strata with the highest proportion of food waste generation was 77.8% (63 people). Based on the results of statistical tests, the P of 0.641 with α=0.05 was obtained. The P is >α; therefore, no significant relationship exists between economic strata and household food waste management. The analysis received the value of PR=0.730 or 1.366. This shows that people with a middle economic strata are 1.366 times more likely to generate a lot of food waste than those with a high economic strata.

In this study, the potential environmental impact uses units of kg and eq. Based on the analysis of potential environmental impacts in processing organic waste with the BSF method, it produces the possible effects of global warming, eutrophication, acidification, and ozone depletion (Table 1).

The management of organic waste with the BSF method produces a global warming impact of 0.281 kg CO_2 eq, acidification of 2.37e-3 kg SO_2 eq, eutrophication of 6.43e-4 kg N eq, and ozone layer depletion of 7.65e-12 kg CFC 11 eq. The highest potential impact is the depletion of the ozone layer, resulting from the decay of waste, which will form methane gas (Table 2).

4. Discussion

Most urban areas in Indonesia have not sorted their solid waste according to waste composition. Only a few households in urban areas segregate waste, and even if they do, it is due to a waste bank that can be used to exchange segregated waste, such as bottles, glass, paper, organic, and others. Based on the study results, people with middle economic strata produce more food waste than individuals with high economic strata. According to Pariathamby (2014) [7], household waste management is the responsibility of wives at 54%, husbands at 23%, adult women at 20%, and the rest stated that it is the responsibility of adult men. The containerization pattern in this area is individual and communal containerization, where all communities do individual disposal first as temporary disposal in a particular container and then disposed of in collective disposal. However, some are also transported by waste bank officers to be collected in the waste bank, which later, if there is saleable waste, will be sold, and organic waste is processed as maggot feed.

The local cleanliness department carries out the condition of the temporary landfill in the neighborhood for no more than three days. This is because the landfill is not vastly big; therefore, it cannot accommodate too much waste for a long time. Neighboring communities that have the availability of facilities are good because they already have adequate facilities, and waste storage is no more than three days. This is due to the attitude or awareness of the community to have good facilities and economic factors playing a role in the availability of facilities. Such places require spending both for trash containers and the cost of monthly garbage that is transported by officers daily. With this problem, the policy suggestions that can be given to waste banks are as follows (Figure 1):

Managing organic waste with the BSF method impacts global warming, acidification, eutrophication, and ozone layer depletion. Of the four impacts, the most minor effect is global warming, with 0.281 kg CO_2 eq compared to other factors. With the processing of organic waste with maggot, BSF can reduce the impact on the environment. According to Anasstasia's research (2020) with LCA, the scenario of open landfilling waste processing and open waste burning can produce a more significant impact on global warming than waste processing in waste banks, where open dumping waste processing is 13,057 kg CO_2 eq and open waste burning is 10,850 kg CO_2 eq [8] Other research shows that open dumping is the highest form of waste management that has the potential to cause global warming impacts due to the

[DOI: 10.32598/JRH.13.6.2255.1]

Table 1. Relationship between economic strata and household food waste generation

Economic Level	No. (%)			P	PR (95% CI)
	Food Waste Generation		Total		
	A Lot	A Little			
High	6(16.2)	31(83.8)	37(100)	0.641	0.730 (0.307-1.735)
Middle	14(22.2)	49(77.8)	63(100)		

JRH

Table 2. Potential impacts of organic waste treatment scenarios with the black soldier fly method

Scenario	Global Warming	Acidification	Eutrophication	Ozone Depleting
Processing organic waste using the black soldier fly (BSF) method	0.281 kg CO_2 eq	2.37e-3 kg SO_2 eq	6.43e-4 kg N eq	7.65e-12 kg CFC 11 eq

JRH

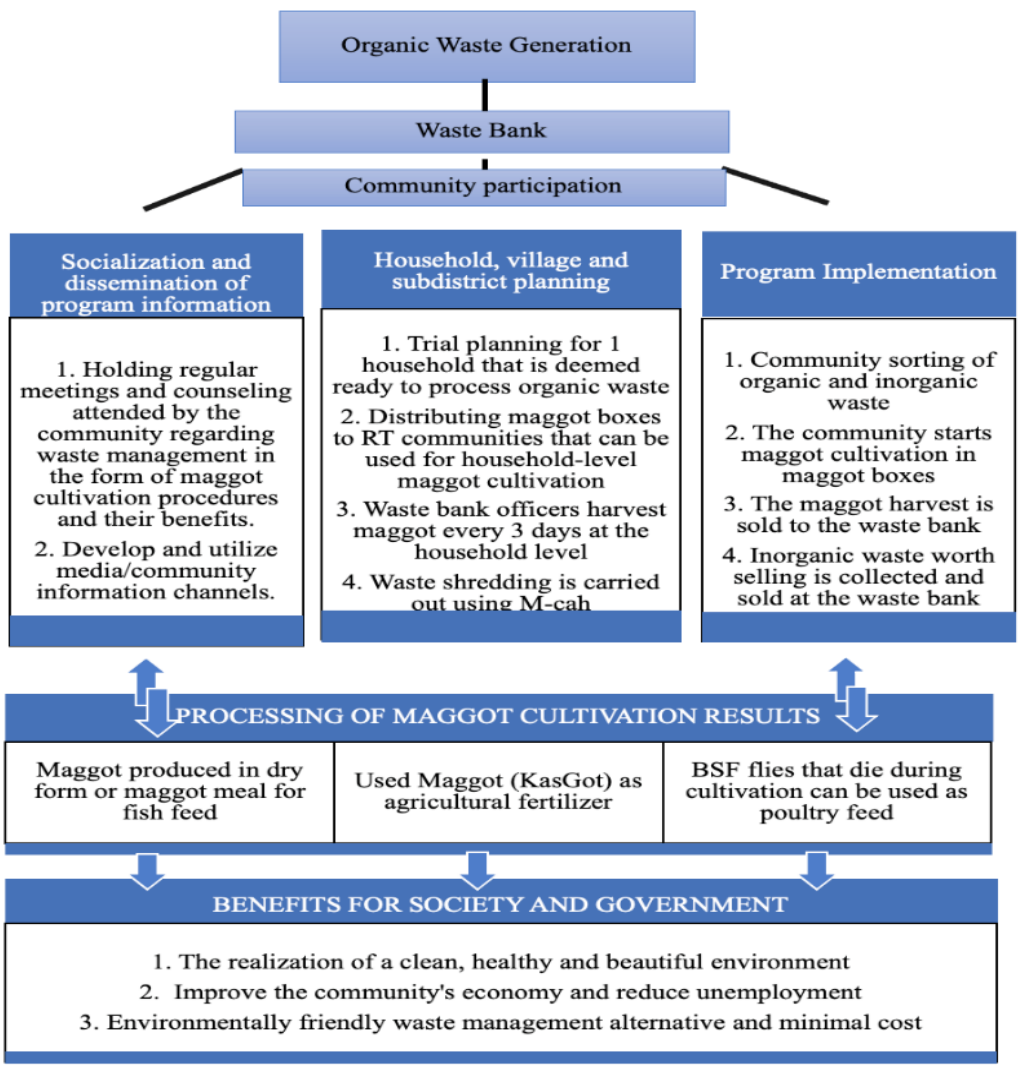

Figure 1. Organic and inorganic waste treatment policy

JRH

[DOI: 10.32598/JRH.13.6.2255.1]

absence of gas handling from the waste decomposition process and leachate processing [9, 10]. The gas produced from the decomposition of waste will pollute the air, while the leachate produced will contaminate the soil and groundwater.

Based on the scenario of processing organic waste with the BSF method, the most significant impact still felt in the environment is the ozone layer depletion by 7.65e-12 kg CFC 11 eq. The lack of the ozone layer can be caused by an increase in CFC and CO_2 gases, which can cause ozone bonds to break loose and thin out and can cause the greenhouse effect and an increase in UV-B radiation, which has an impact on the vulnerability of resistance in humans, animals, and plants. The environmental impact will be even more significant if organic waste is not processed. Food waste is an inevitable part (34%-53%) of total household waste [11]. More than 30% of food produced is estimated to be wasted globally [12] landfilling, incineration, and composting, nearly 1.6 billion tons per year [13]. Accordingly, efforts need to process organic waste, especially food waste, in a sustainable manner. Every 1 kg of waste managed by a waste bank can produce a lower potential environmental impact compared to waste that is not processed.

5. Conclusion

Calculating potential environmental impacts on waste banks by processing organic waste with the BSF method can reduce the effects of global warming when compared to the findings of the open dumping environmental assessment, which has the highest potential impact in the impact categories of global warming, ozone depletion, and others. It was also found that the middle-income community generated more food waste than the high-income community.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Universitas Esa Unggul (Code: 0923-02.072/DPKE-KEP/FINAL-EA/UEU/II/2023).

Funding

This research was supported by the Ministry of Education, Culture, Research and Technology and the Education Fund Management Agency through the scientific research program funding.

Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors would like to thank institutions Universitas Esa Unggul and waste bank partners.

References

[1] Bernstad A. Household food waste separation behavior and the importance of convenience. Waste Management. 2014; 34(7):1317-23. [DOI:10.1016/j.wasman.2014.03.013] [PMID]

[2] Hanssen OJ, Syversen F, and Stø E. Edible food waste from Norwegian households-Detailed food waste composition analysis among households in two different regions in Norway. Resources, Conservation and Recycling. 2016; 109:146-54. [DOI:10.1016/j.resconrec.2016.03.010]

[3] Stenmarck Å, Hanssen O, Silvennoinen K, Katajajuuri JM, Werge M. Initiatives on prevention of food waste in the retail and wholesale trades. Stockholm: Ivl Svenska Miljöinstitutet; 2011. [Link]

[4] Papargyropoulou E, Lozano R, Steinberger JK, Wright N, Bin Ujang Z. The food waste hierarchy as a framework for the. Journal of Cleaner Production. 2014; 76:106-15. [DOI:10.1016/j.jclepro.2014.04.020]

[5] Priefer C, Jörissen J, Bräutigam KR. Food waste prevention in Europe - a cause-driven approach to identify the most relevant leverage points for action. Resources, Conservation and Recycling. 2016; 109:155-65. [DOI:10.1016/j.resconrec.2016.03.004]

[6] Friedberg E, Hilderbrand ME. Observing policy-making in Indonesia. New York: Springer; 2017. [DOI:10.1007/978-981-10-2242-5]

[7] Pariatamby A, Tanaka M. Municipal solid waste management in asia and the pasific Island: Challenges and strategic solutions. New York: Springer; 2014. [DOI:10.1007/978-981-4451-73-4]

[8] Anasstasia TT, Azis MM. [Life cycle assessment (LCA) kegiatan bank sampah di pedesaan (Bank Sampah Asoka Berseri, Desa Sokosari, Tuban) (Indonesian)]. Journal of Environmental Sustainability Management. 2021; 4(3):537-51. [DOI:10.36813/jplb.4.3.537-551]

[9] Sivakumar Babu GL, Lakshmikanthan P, Santhosh LG. Life cycle analysis of municipal solid waste (MSW) land disposal options in Bangalore City. Paper presented at: International Conference on Sustainable Infrastructure 2014; 18 November 2014; Long Beach, California. [DOI:10.1061/9780784478745.075]

[DOI: 10.32598/JRH.13.6.2255.1]

[10] Saheri S, Mir MA, Basri NE, Mahmood NZ, Begum RA. Life cycle assessment for solid waste disposal options in Malaysia. Polish Journal of Environmental Studies. 2012; 21(5):1377-82. [Link]

[11] Braguglia CM, Gallipoli A, Gianico A, Pagliaccia P. Anaerobic bioconversion of food waste into energy: A critical review. Bioresource Technology. 2018; 248(Pt A):37-56. [DOI:10.1016/j.biortech.2017.06.145] [PMID]

[12] Xu F, Li Y, Ge X, Yang L, Li Y. Anaerobic digestion of food waste - Challenges and opportunities. Bioresource Technology. 2018; 247:1047-58. [DOI:10.1016/j.biortech.2017.09.020] [PMID]

[13] World Biogas Association. Global food waste management: Full Report an implementation guide for cities. London: World Biogas Association; 2018. [Link]

[DOI: 10.32598/JRH.13.6.2255.1]