*i*Journals: International Journal of Software & Hardware Research in Engineering
ISSN-2347-4890
Volume 7 Issue 10 October 2019

The Life Cycle Assessment (LCA) Study of Existing Utilization of Empty Fruit Bunch at The Oil Palm Factory

Author: Khumaidah Darojat[1], Wahyono Hadi[2]

Affiliation: Institut Teknologi Sepuluh Nopember Surabaya, Indonesia

E-mail: ieda.darojat@gmail.com[1]; wahyonohadi@.its.ac.id[2];

ABSTRACT

Indonesia is the largest palm oil producer in the world. Biomass is mainly derivated from the agriculture sector. The large area and productivity of oil palm plantations have the potential of biomass, especially oil palm empty fruit bunches (EFB). EFB is produced from the palm oil factory. The utilization of this waste is less than optimal so that accumulates in the dumping site. The use of EFB is a natural fertilizer that applied around oil palm trees. Oil palm empty fruit bunches are biomass that has great potential to produce a higher value of new products, namely renewable energy. The impact of emissions from the use of EFB is identified by using the Life Cycle Assessment (LCA). The LCA method is used to assess the environmental impact related to the process of the existing utilization of EFB using Simapro 8.5.

LCA is carried out in four phases: goal and scope, life cycle inventory, life cycle impact assessment, and interpretation data. The results showed that the utilization of EFB the existing conditions of 974 kg SO2eq as the cause of acidification; 181 kg PO4eq causes of Eutrophication; and 20,400 kg CO2eq global warming (GWP100a).

Keywords: Empty Fruit Bunches and Life Cycle Assessment

1. INTRODUCTION

Indonesia is the largest producer of palm oil in the world, and together with Malaysia is the world's largest exporter. World demand for palm oil is increasing every year with the largest supply coming from Indonesia. The total area of oil palm plantations reached 11.26 million hectares in 2015 and is estimated to be 12.31 million hectares in 2017. The total production of palm oil produced is 31.07 million tons and palm kernel is 6.21 million tons [1].

PT. X is a private company of oil palm factory, in East Kalimantan Province, Indonesia. The company was founded in 2006 and has 9,511 hectares of plantation areas. The process of planting oil palm trees began in 2006 so it has entered a productive age for harvesting. the oil palm industry besides producing the main products also produce solid waste. These various types of solid waste are generated from oil palm plant activities and also plantation activities. Seed shells, fruit fibers, and empty fruit bunches are the main solid wastes produced during the grinding process while the leaves and stems are obtained from the process of harvesting, pruning, and felling [2].

This company focuses on processing oil palm fruit into CPO (Crude Palm Oil), so that biomass waste is abundant, especially empty fruit bunches. Empty fruit bunches are high water content materials, in existing conditions they are just stacked in the factory area due to the transportation costs. The abundance of biomass waste needs to be utilized because it can contribute to providing a large potential for the supply of renewable and sustainable energy sources [3].

The utilization of existing oil palm waste, empty fruit bunch, and/or implementation of new ones, including natural fertilizers, involve appropriate tools for evaluating how they relate with their environment. One of these tools is a life cycle assessment (LCA), which can be used to identify, quantify and, evaluate the total potential environmental impact of the processes, from the procurement of raw materials (the ‘cradle’), to production and utilization (the ‘gates’) and their final storage (the ‘grave’), as well as to determine ways to repair damage to the environment [4].

Life Cycle Assesment (LCA) is a useful apparatus to evaluate the performance of a system or a process based on its impact on the environment.

LCA is used to assess the energy balance and Global Warming Potential (GWP) of biochar production from oil palm empty fruit bunches [5]. The LCA of several technologies, such as gasification, pyrolysis, oxidation and their combinations, was reported [6]. An in-depth study of LCA that starts from the beginning of the process until its utilization can be used as one of the basic guidelines for decision making of biomass conversion technology. This paper is assessed LCA studies in the context of the existing utilization of empty fruit bunch at oil palm factory.

2. METHODOLOGY

LCA is a comprehensive method for assessing the environmental impact of a product or an activity over its entire life cycle [7]. In this study, the LCA technique is conducted based on the standard ISO 14040 series, there are four major phases in a complete and comprehensive LCA. The LCA reported in this study is coherent with the mentioned standards: goal and scope definition, life cycle inventory (LCI), life cycle impact assessment (LCIA), and interpretation. The Simapro 8.5.2 with EPD 2013 methods used for data processing and assess the environmental impacts.

Assumptions used for this study:

1. At dumping sites, 20% aerobic and 80% anaerobic conditions occur (IPCC 2006a), and the biodegradable carbon is equally converted to carbon dioxide and methane.
2. The transportation distance is assumed to be 20 km using a diesel truck's capacity is 5 tons.
3. The empty fruit bunch is assumed to be collected using a backhoe loader with lift capacity is 745 kg.

a) Goal and scope

1. Goal

The goal of this LCA study is to identify and compare the environmental impact of the existing utilization of oil palm empty fruit bunch at the dumping site and land application.

2. Scope

The scope of the LCA analysis in this study is gate-to-gate, where empty fruit bunches produced from the processing of palm oil factories.

3. Functional unit

When LCA is used in agriculture, the functional unit most often chosen is the weight of the raw material or product (eg 1 kg, 1 t) or surface area (eg 1 ha) [8]. The functional unit of this study was defined as kilogram per year empty fruit bunch, whereas the weight should be used in analyzing production intensity.

b) LCI

The empty fruit bunch is assumed to collect and transport from the dumping site to the land application using a backhoe loader and diesel truck.

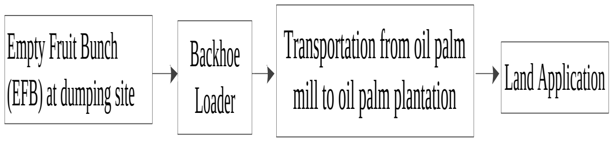

Figure 1 System boundary of utilization EFB

c) LCIA

In this study, the emissions related to the process stages studied in the system boundary (Fig. 1) are used to evaluate 3 environmental impact categories. These impact categories are Acidification, Eutrophication, and Global warming (GWP100a). The impacts are calculated from various emissions based on the conversion factors reported in the Handbook of Life Cycle Assessment [9]. The criteria for evaluating the environmental impacts were selected from environmental problems that significantly in this case study.

d) Interpretation

This phase was carried out to the identification and elaboration of the LCIA to obtain the research conclusions.

3. RESULT AND DISCUSSION

LCI analysis

The life cycle inventory data for utilization of empty fruit bunch are presented in **Tables 1**. These data are based on the primary data and also from relevant literature as mentioned in the methodology section. The emission associated with the processes is also summarized in **Table 1**. These emissions are based on stoichiometric equations. The inventory data are used to predict the potential impact of the utilization of empty fruit bunches.

Table 1 LCI of utilization of EFB

Category	Item	Unit	Amount	
			Dumping	Application
Input	EFB	kg/day	11,632.24	87,105.81
Energy	Loader	TJ/hour	-	1.188 x 10-3
	Truck	TJ/hour	-	6.48 x 10-3
Output	EFB	kg/day	6,218.56	60,860.50
Emission	CO_2	kg	6,644.56	80,306.41
	CH_4	kg	1,455.92	1,455.95
	NH_3	kg	41.14	0.113
	NO_2	kg	-	0.029033

LCIA

This phase assesses the impact of the process on the environment. Three obligatory tasks have been presented: assortment of impact categories, classification, and characterization. The characterization factors are shown in **Table 2**. **Figure 2** shows the plot of environmental impact on the processes.

Table 2 characterization factors

Impact Category	Characterization Factors	Examples
GWP (kg CO_2 eq.)	GWP100	1 kg carbon dioxide = 1 kg CO_2 eq. 1 kg methane = 28 kg CO_2 eq. 1 kg dinitrogen oxide = 265 kg CO_2 eq.
Acidification potential (kg SO_2 eq.)	AP	1 kg ammonia = 1,88 kg SO_2 eq. 1 kg nitrogen dioxide = 0,7 kg SO_2 eq. 1 kg sulfur dioxide = 1 kg SO2 eq.
Eutrophication potential (kg PO_4^{3-} eq.)	EP	1 kg phosphate = 1 kg PO_4^{3} eq. 1 kg ammonia = 0,35 kg PO_4^{3-} 1 kg COD (to freshwater) = 0,022 kg PO_4^{3}

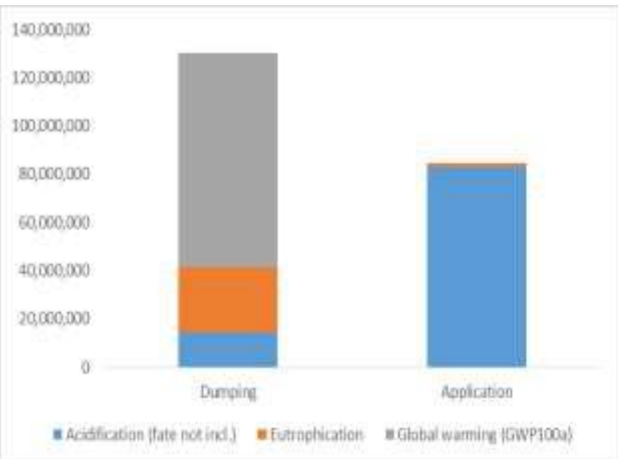

Figure 2 Environmental Impact

Interpretation

Based on Fig. 2, it is estimated that for every kilogram (kg) of biomass that utilized 20,400 kg of CO_2 equivalent is produced through biodegradation processes. In this context, the contribution to global warming potential (GWP) is due to the release of greenhouse gases, particularly CO_2 and CH_4.

Compared to GWP, the emission leading to other environmental impacts such as acidification and eutrophication are less severe. Acidification is occurring as a result of NH_3, NOx, and SO_2 emissions [4]. For all these environmental impacts, the emission from biodegradation at dumping site processes is higher compared to that of the biodegradation process at land application. The remaining acidification effect is contributed by the emission of SO_2, particularly in the biomass degradation stage.

Eutrophication has the least impact on the environment. This impact associated with the process is less severe compared to GWP and acidification. In this context, the eutrophication impact is mostly contributed by the release of NOx as the result of biomass biodegradation processes at the dumping site.

4. CONCLUSION

In the LCA study of utilization of empty fruit bunch existing, a net 20,400 kg CO_2 equivalent is generated per kilogram of empty fruit bunch utilized. Comparatively, the other environmental impacts such as acidification and eutrophication are less severe.

5. REFERENCES

[1] Kementan, (2016). Statistik Perkebunan Indonesia 2015-2017 Kelapa Sawit, Jakarta: Sekretariat Direktorat Jendral Perkebunan, Direktorat Jendral Perkebunan, Kementrian Pertanian.

[2] Abnisa, F. Wan Daud, W.M.A. dan Sahu, J.N. (2013). "Utilization of oil palm tree residues to produce bio-oil and bio-char via pyrolysis", Energy Conversion and Management, 76, 1073–1082.

[3] Hosseini, S.E., Wahid, M.A. & Ganjehkaviri, A., 2015. An overview of renewable hydrogen production from the thermochemical process of oil palm solid waste in Malaysia. Energy Conversion and Management, 94, pp.415–429.

[4] Brentrup F., Küsters J., Lammel J., Barraclough P., and Kuhlmann H., 2004b. Environmental impact assessment of agricultural production systems using the life cycle assessment (LCA) methodology II. The application to N fertilizer use in winter wheat production systems. Europ. J. Agron., 20, 265-279.

[5] Harsono, S.S, Grundman, P., Hansen, A., Azni I., Mam, S., Ghazi, T.I.M., dan Lek H.L. (2011), "Life Cycle Analysis of Biochar from Palm Oil Empty Fruit Bunch", Development on the margin, Tropentag, Bonn.

[6] Khoo HH (2009) Life cycle impact assessment of various waste conversion technologies. Waste Manag 29:1892-1900.

[7] Menoufi, K.A.I. (2011). Life Cycle Analysis and Life Cycle Impact Assessment methodologies: A state of the art. Universitat de Lleida.

[8] Hayashi K., 2013. Practical recommendations for supporting agricultural decisions through life cycle assessment based on two alternative views of crop production: the example of organic conversion. Int. J. Life Cycle Assess., 18, 331-339.

[9] Guinee JB (ed) (2002) Handbook of life cycle assessment: operational guide to the ISO standards. Kluwer Academic Publishers, Dordrecht.