Life cycle assessment of bricks made from waste of building material and plastics (LDPE and PET)

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Abstract. Plastic waste is the one of the common problem in many countries. The main reason is because the non-biodegradable materials. There are two types of plastic that we discussed in this research, the first one is PET (Polyethylene Terephthalate) which is a type of plastic that often used as a bottle of soft drink packaging and the other one is LDPE (Low Density Polyethylene) which is also widely used as a food or beverage packaging material. The utilization of these two types of plastic continuously without good recycling will have a negative impact on the environment. Waste of building materials is also be a serious problem for the environment. This research aims to provide a solution to the problem of plastic waste above and also building material waste by making it as a mixture to be used as brick. There are various methods for evaluating energy and raw material consumption, emissions released into the environment, and other wastes related to the life cycle of a product or system. Therefore, the method can be used thoroughly from various aspects, the Life Cycle Assessment (LCA) method is the most appropriate method, because it is a holistic approach system that aims to quantify potential environmental impacts (climate change, non-renewable energy use, etc.) generated from the product life cycle, starting from the acquisition of raw materials, use, recycling, and final disposal.

1. Introduction
Increasing of housing and new settlement developments, many large cities in Indonesia have dense residential areas. This condition affects the increase in the volume of household waste annually. According to the data (the third major city in Indonesia) on the volume of waste in 2006, the amount of waste produced is 259,832 m³ / day. Three years later in 2009 the volume of waste produced was 343,266 m³ / day [1].

![Figure 1. Piles of plastic waste](image-url)
Based on data from the 2013 City Sanitation and Landscaping Service, the composition of waste consisted of 61.5% organic waste, and 38.5% inorganic waste with the largest composition being plastic waste which was 17.50% as illustrated in Figure 1 [1]. This percentage is quite high, if the mass is calculated from the total mass of garbage available every day around 106 tons / day, with large amounts of plastic waste amounting to 18,555 kg / day. In this analysis, the purpose was to use plastic for bricks with a mixture of powdered building waste materials. The results of this research is compare the types of PET (Polyethylene Terephthalate) and LDPE (Low Polyethylene Density) plastic by determining the type of plastic that has a high compressive strength product, and small density, porosity, water absorption ([2]–p. 715).

There are many kinds of method for evaluating energy and raw material consumption, emissions released into the environment, and other wastes related to the life cycle of a product or system. Therefore, the method that can be used thoroughly from various aspects, the Life Cycle Assessment (LCA) method is the most appropriate method. A holistic approach system that aims to quantify potential environmental impacts (climate change, non-renewable energy use, etc.) arising from the product life cycle, starting from acquisition of raw materials, use, recycling, and final disposal [3].

2. LCA (Life Cycle Assessment)

LCA is technique that can be used to assess environmental impacts related to a product [3]. In general, LCA is structured in four steps as illustrated in Figure 2. below:

![Figure 2. Main Phase of Life Cycle Assessment (LCA) [3]](image)

LCA Stages:
1. Purpose and Scope
   The first phase defines the scope of the study including defining the function of each part of the study boundary.
2. Inventory Analysis
   The second stage is an inventory of input and output activities related to the scope of the study. The stages of data collection start from the production process, raw materials, and material energy requirements. Inventory analysis more focuses on data on industrial production processes.
3. Environmental Impact Analysis
   The third stage is to conduct a gradual evaluation of the potential impact on the environment by using the results of the Life Cycle Inventory and providing information to interpret in the last phase.
The environmental impact analysis examines waste from material processing, noise levels, exhaust emissions, and production cost efficiency.

4. Interpretation of Results

The Final Stage of the LCA analyzes the life cycle and gives conclusions, recommendations, and decision making based on the study boundaries that have been determined in the first stage [4].

As a measurement method, LCA has a defined scope with the aim of limiting testing. These restrictions are intended to facilitate the grouping of testing an object. There are four scope that have been defined, illustrated in Figure 3 [4].

![Figure 3. LCA Scope](image)

1. **Gate to gate**, is the scope of the shortest life cycle analysis because this process only reviews the closest activities.
2. **Cradle to gate**, starting from (raw material) to raw material before the product operation. Cradle to gate only reviews the production process until the material is ready for sale or use by consumers.
3. **Cradle to grave**, starting from (raw material) to the operation of the product.
4. **Cradle to cradle**, part of life cycle analysis that shows the scope of (raw material) to material recycling.

The basic concept of LCA is based on the idea that an industrial system cannot be separated from the environment in which the industry is located. In an industrial system there are inputs and outputs. Inputs in the system are materials taken from the environment and the output will be discharged into the environment again. The input and output of this industrial system will certainly have an impact on the environment.

Excessive retrieval of material (input) will cause a reduction in the supply of material, while the output from industrial systems that can be waste (solid, liquid, air) will have a negative effect on the environment. Therefore, LCA seeks to evaluate to minimize material extraction from the environment and also minimize industrial waste. The purpose of the LCA is to compare all possible environmental damage that can be caused by a product or process. Then that products and processes can be selected which have the minimum impact.

3. Implementation of LCA on bricks (mixture of plastic and building materials)

Research with the title "Implementation of LCA (Life Cycle Assessment) on Bricks has a process scope defined in this research, including analysis of raw material requirements, energy consumption and analysis of potential waste generated at each stage of production. The production process under research starts from collecting raw materials, stirring or mixing materials until the bricks are ready to be marketed. The product of brick made from LDPE, PET and building material waste can be seen in Figure 4.

*Life cycle assessment (LCA)* has been recognized as an analytical tool for evaluating various waste management strategies [5]. According to [5] LCA as an analytical tool that allows to compare
environmental performance of various waste management options, both for the flow of certain products and mixed waste.

Figure 4. Bricks mixed with LDPE, PET and chunks

This research purpose is to apply the LCA methodology approach to analyze the potential environmental impacts of various scenarios of urban waste management choices. LCA in waste management has been implemented both in developing countries [6], as well as being developed. Nevertheless the results of the study cannot be generalized because the characteristics of waste depend on local conditions. The trash characteristics determine the amount of pollutants emitted and the energy that can be produced [7].

A). Determination of goals and scope.
The purpose of the LCA application in this research was to evaluate the effect of the mass ratio between plastic and a mixture of building material waste, the effect of types of PET and LDPE on the quality of plastic bricks.

B). Analysis of inventory
To find out the impact of brick production in the environment in all phases of the acquisition of raw materials, industrial production, packaging and transport. Energy use and emissions are quantified and potential environmental impacts are assessed. In this research, the main energy inputs to the production system are electricity, diesel and solid fuels (Pet-Coke). Environmental loads arising from brick making are mainly due to air emissions originating from the use of fuel such as: wood or gas [8].

C). Life Cycle Impact Assessment (LCIA)
Environmental load data (emissions) generated from the LCI (Life Cycle Impact) stage are classified into the category of air pollution impacts resulting from the burning of the bricks themselves. Furthermore, the impact category indicator is calculated according to the equivalent factor expressed in reference emission mass per unit of function (UF). Indicator of the categories of impacts of water and soil pollution.

4. Emissions from the burning bricks
In general, brick making (from soil) is burned at a temperature of 800°C (illustrated in Figure 5), while its combustion uses uncontrolled rice husks or uses firewood, consequently that it will cause air pollution through its CO2 emissions and make it difficult and prolong the brick making process. Besides that, brick making is influenced by weather conditions, because drying of red bricks that have been printed relies on sunlight, however during the rainy season it will be difficult to make hence that the productivity of bricks will be reduced and difficult to obtain.
5. Conclusion
From this research bricks can be produced from a mixture of plastic waste and building material chunks showed good results as well. This type of brick has a mass that is lighter than ordinary bricks, has pores smaller than ordinary bricks, and the strength at the time of building is not less competitive than ordinary bricks. However, the negative impact of this brick processing is emissions from burning bricks because of dioxin gas especially. Therefore, that is a need for other innovations to reduce the emissions they produce.

6. References
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