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Energy recovery potential and life cycle impact assessment of municipal solid waste management technologies in Asian countries using ELP model

Andante Hadi PandyaSwargo*, Hiroshi Onoda and Katsuya Nagata

Abstract

Natural resource scarcity and the effects of environmental destruction have pushed societies to use and reuse resources more efficiently. Waste should no longer be seen as a burden but rather as another source of material such as energy fuel. This study analyzes the potential of three waste management scenarios that include the combination of four waste management technologies - incineration with energy recovery, composting, anaerobic digestion, and sanitary landfill gas collection - as ways to recover energy and material from municipal solid waste. The study applies the environmental load point (ELP) method and utilizes municipal waste characteristics and composition from India, Indonesia, and China as case studies. The ELP methodology employs integrated weighting in the quantification process to get a one-unit result. This study particularly uses analytic hierarchical process questionnaires to get the weighting value of the nine impact categories: energy depletion, global warming, ozone depletion, resource consumption, ecosystem influence, water pollution, waste disposal, air pollution, and acid rain. The results show that the scenario which includes composting organic waste and sanitary landfill with gas collection for energy recovery has medium environmental impact and the highest practicability. The optimum material and energy potential is from the Chinese case study in which 254 tonnes of compost fertilizer and 60 MWh of electricity is the estimated output for every 1,000 tonnes of waste treated.

Keywords: Life cycle assessment, Environmental load point, Waste management, Analytic hierarchical process, Energy recovery, Asian developing countries

Background

Developing countries in Asia have a number of similarities in terms of their waste composition and characteristics. High moisture content due to the high percentage of organic waste composition results in low calorific value. This makes it is less suitable for thermal treatments and more suitable for biological treatments, such as composting and anaerobic digestion. The organic fraction of municipal waste equates to 62% in Indonesia, 63.4% in China, and 41.8% in India [1]. Waste volume in this region increases with the growth of population, urbanization, industrialization, and economic development. Indonesia, with a population of 232.7 million, generates 38.5 million tonnes of municipal waste annually. China, with a population of 1.3 billion, generates 1.8 billion tonnes. India, with a population of 1.2 billion, generates 66.69 million tonnes

[1]. Another important waste characteristic is the generation rate per capita per day, which is 0.75 kg in Indonesia, 1.54 kg in China, and 0.2 to 0.5 kg in India, depending on the size of the city. Figures 1 and 2 summarize the waste characteristics in the three countries.

The current common practice of municipal waste treatment in these countries is the use of landfill. Almost 68.86% of waste generated in Indonesia is landfilled, and only 10% of the available landfills meet the requirements for a sanitary landfill. China deposits 56.6% of its municipal waste in landfills. India has a very limited number of sanitary landfills, and thus, open dumping is common and widespread. Incineration is not applied on a large scale in Indonesia, whereas 1.9% of China's municipal waste is incinerated. India initiated several projects to incinerate its waste, such as the 300 t/day capacity incineration plant in Timarpur. However, such projects proved to be unsuccessful [2]. Two pilot projects on incineration plants are ongoing in Delhi, with 1,950 and 1,300 t/day capacities [1]. In Indonesia, composting of

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