# Estimation of Waste Generation in Bandar Lampung Municipality

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## 1. Introduction

Population growth and also changes in consumption patterns and people's lifestyles have increased the amount of waste generation, type, and diversity characteristics of the waste. This condition requires proper management to avoid negative impacts on human health and the environment. Bandar Lampung Municipality in Indonesia only has 1 final disposal site (Bakung Final Disposal) which serves for more than 800,000 inhabitants. Based on previous study [1], Bakung Final Disposal will be closed in 2012 because it will reach the capacity. The purpose of this study is to estimate how much land needed as final disposal to 20 years of service and to evaluate the parameters that affect the waste generation in Bandar Lampung Municipality.

## 2. Current Condition in Bandar Lampung Municipality

Bandar Lampung as the capital of Lampung province and located in southern tip of Sumatra Island is one of the big cities in Indonesia. With total area 192.96 km$^2$, the population of Bandar Lampung in 2008 reached 823,334 inhabitants[2]. Like other cities in developing countries, final disposal in the city of Bandar Lampung uses open dumping systems. Actually, initial design of Bakung Final Disposal is using sanitary landfill system, but owing to lack of equipment, limited funding, and lack of awareness among officials who manage the final disposal, this system changes to open dumping.

Based on data from Hygiene and Gardening Agency of Bandar Lampung Municipality, not all areas get the waste retrieval services and daily average of waste which dumped into Bakung Final Disposal is 436.86 m$^3$/day with density of waste 259 kg/m$^3$ [3]. This waste came from markets, offices and household with composition and characteristics as shown in Table 1.

**Table 1. Waste Composition and Characteristics**

| No | Component | % (Weight) | Water Content (%) | Calories Value (kcal/kg) |
|---|---|---|---|---|
| 1 | Organic | 73.98 | 47.08 | 674.57 |
| 2 | Paper | 10.18 | 4.97 | 235.55 |
| 3 | Glass | 1.75 | | |
| 4 | Plastic | 7.86 | 2.28 | 555.46 |
| 5 | Metal | 2.04 | | |
| 6 | Wood | 0.98 | 0.32 | 38.28 |
| 7 | Cloth | 1.57 | 0.63 | 42.64 |
| 8 | Rubber | 0.55 | 0.02 | 7.46 |
| 9 | Battery | 0.29 | | |
| 10 | Miscellaneous | 0.86 | | |
| Total | | 100 | 55.3 | 1553.96 |

*Source: Kajian Teknis Pengelolaan TPA Bakung Kota Bandar Lampung, 2005*

Waste from the source did not separated based on type. Actually the government has issued rules to separate waste into 2 types, organic and non-organic waste, before go to final disposal location. But in practice, caused by lack of public awareness the waste was mixed.

## 3. Analysis

The data needed to estimate waste generation and area for disposal are population, the amount of waste which transported to final disposal, waste production per capita, and the amount of waste due to leakage of scavenger activity.

The population projection was conducted by using the exponential growth model. This model is suitable for a condition in Bandar Lampung municipality which still growing and according to Oppenheim[4]. This model is more relevant when the growth per year is not fixed but proportional to the existing level of population. Equation for exponential growth model at the time $n$ is expressed as follows:

$$P_n = (1 + r)^n P_0 \quad \text{.....(1)}$$

Where:

$P_n$ = population in the year $n$
$P_0$ = population in the base year
$r$ = rate of change (0.0138)

**Table 2. Service level of waste which transported**

| Year | Population | Generation | Dumped | |
|---|---|---|---|---|
| | | m$^3$/day | m$^3$/day | % |
| **2006** | **803,922** | **2,009.81** | **430.19** | **21.40** |
| **2007** | **812,133** | **2,030.33** | **489.97** | **24.13** |
| **2008** | **823,334** | **2,058.34** | **590.51** | **28.69** |

*Source: Data and Analysis*

Meanwhile, waste production per capita in Bandar Lampung is 2.5 liter/day[5] and the leakage of waste by 20% of the volume of waste plastic and paper, as the impact of scavengers in an effort to benefit from the waste[6]. Based on the data from 2006 to 2008, the ratio of waste transported to final disposal to the waste generated (as seen in table 2) continues to increase. This indicates that the government continually strives to improve their services in the field of waste.

Based on the condition above, waste generation can be calculated using formula as follows:

$$G_n = P_n \text{ x } P_c \quad \text{.....(2)}$$

Composting is one of method to overcome waste problem which can be done in waste source or in final disposal landfill. According to Pratama[7], composting organic waste communally in Cimahi Municipality brings impact decreasing 2.67% to the volume of city waste generation per day. So, waste generation after reduced by composting can be calculated by equation:

$$G_{nc} = G_n\,(1 - C) \quad \text{.....(3)}$$

Where $G_n$ = waste generation (m$^3$/day/capita),
$G_n$ = waste generation after composting (m$^3$/day/capita),
$P_n$ = population in year $n$
$P_c$ = waste production per capita (2.5 liter/day)
$C$ = composting (2.67%)

For volume of waste which dumped into landfill can be calculated using equation (4) and volume of waste after leakage using equation (5).

$$D_w = G_n \text{ x } SL \quad \text{.....(4)}$$

$$V_l = D_w - (D_w \text{ x } PP \text{ x } L) \quad \text{.....(5)}$$

Where $D_w$ = volume of waste which dumped ($m^3$/day),
$SL$ = % of service level (24.13%,
$V_l$ = final volume
$PP$ = % of plastic and paper composition (18.04%)
$L$ = % of leakage by scavenger (20%)

Several scenarios are used to calculate the volume of waste dumped into the disposal site. It is used to anticipate the possibility that might happen even in table 2 since the level of service looks continued to increase.

1. Scenario 1 and scenario 2 was made with the assumption that the city government does not give priority and serious attention to the waste and have a variety of constraints such as limited equipment and finances which causing the same level of service as previous years i.e. 24.13% and 28.69%.
2. Scenario 3 uses the assumption that the city government seeks to increase the level of service while not a priority, but sustained by an increase of 1% per year.

Wide area for final disposal will be calculated by using assumption that pile of waste is the square-shaped. According to the recommendation of JICA[6], by using heavy equipment to achieve the highest compression at 850 kg/$m^3$, so the thickness pile of waste decreased to 45%.

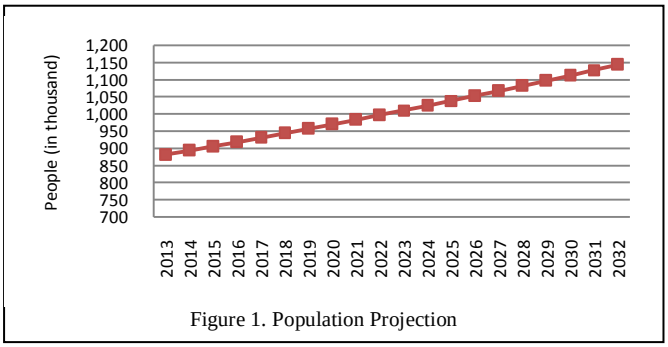


Figure 1. Population Projection

## 4. Result and Discussion

Population projections show a significant increase with 1.38% of the rate of change. This makes the waste generation in the Bandar Lampung municipality in year 2032 reached 2,859.46 $m^3$ per day which is generated by 1,143,783 people (see Fig. 1 and 2). If community in Bandar Lampung Municipality can be empowered like in Cimahi Municipality to do composting communally, composting activity can reduced waste generation as big as 490,862 $m^3$ from 2013 to 2032.

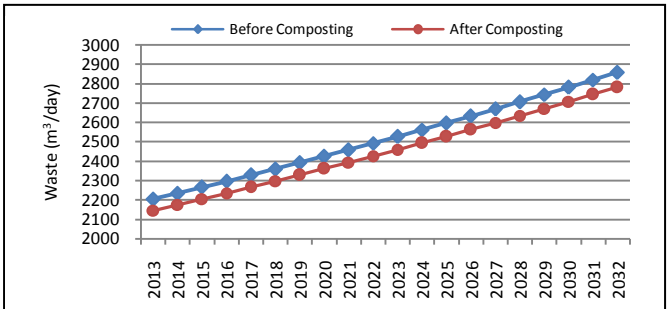


Figure 2. Waste Generation

Calculation volume of waste which is dumped into the disposal site shows that volume of waste which transported to final disposal based on scenario 3 has very big difference compared to scenarios 1 and 2 (see Fig. 3).

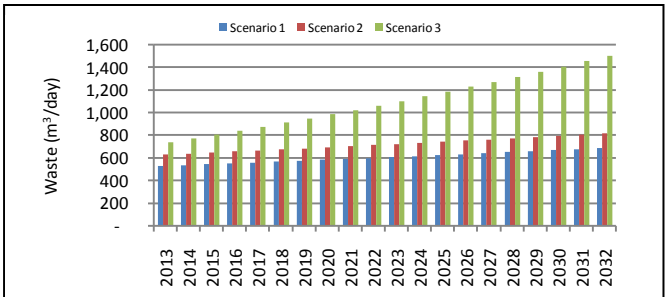


Figure 3. Volume of Waste which Dumped

A consequence of the scavengers' activity is a reduction in waste volume significantly. For example, in scenario 3, scavenger activity can reduce 289,492 $m^3$ volume of waste or almost 0.7 Ha in width.

By combining composting, highest service level, and scavenger activity amount of waste which is stored in landfill is about 7.528 x $10^6$ $m^3$ and this volume will be need area about 18.8 Ha with height of waste pile is 18 m after compression.

## 5. Conclusions

(1) Population rate of change and waste production per capita bring a significantly affect in waste generation.
(2) The need for land used as a disposal service for a period of 20 years is very extensive. With the potential of organic waste that can be used as natural fertilizer by composting, it can reduce the need for land.
(3) Although increased service levels can make the city cleaner, but its impact by increasing demands for land disposal.

**Table 3. Scenario of Land Needed**

| | Before Scavenger Activity | | After Scavenger Activity | |
|---|---|---|---|---|
| | Volume ($m^3$) | Wide (ha) | Volume ($m^3$) | Wide (ha) |
| Scenario 1 | 4.436 x $10^6$ | 11.09 | 4.276 x $10^6$ | 10.69 |
| Scenario 2 | 5.275 x $10^6$ | 13.19 | 5.084 x $10^6$ | 12.71 |
| Scenario 3 | 8.024 x $10^6$ | 20.06 | 7.734 x $10^6$ | 19.34 |

## Reference

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