International Journal of Technology (2015) 5: 838-846
ISSN 2086-9614

POTENTIAL REDUCTION OF SOLID WASTE GENERATED FROM TRADITIONAL AND MODERN MARKETS

Djoko M. Hartono[1*], Gabriel Andari Kristanto[1], Syaiful Amin[1]

[1] *Environmental Engineering Study Program, Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI Depok, Depok 16424, Indonesia*

(Received: June 2015 / Revised: September 2015 / Accepted: October 2015)

ABSTRACT

Trading activities, whether in traditional or modern markets, generate both solid waste and wastewater. This study aims to analyze the characteristics and composition of solid waste generated from traditional and modern markets and their potential reductions in *Pasar Pondok Bambu* and *Pasar Cinere*, based on waste generation, composition, and solid waste's characteristics that are generated from both markets. The method used in this study is based on SNI 19-3964-1994 about Measurement and Collection Method for Waste Generation and Composition of Municipal Solid Waste Sample. Results showed that the average volume of solid waste generation from *Pasar Pondok Bambu* and *Pasar Segar Cinere* is 2.74 m^3/day and 0.76 m^3/day, respectively. The main components of *Pasar Pondok Bambu* solid waste are 65.56% garden and vegetable waste, 13.04% slaughterhouse waste, 7.34% plastic waste, and 7.28% food waste. Meanwhile, the main components of *Pasar Segar Cinere* are 58.77% garden and vegetable waste, 20.58% food waste, 9.60% plastic waste, and 3.76% paper waste. There is a chance to reduce the amount of waste in both traditional markets in order to reduce the waste load in landfills. Alternatives to reducing the amount of solid waste are through reducing, reusing, recycling, and composting. These alternatives are expected to reduce solid waste generation in both *Pasar Pondok Bambu* and *Pasar Segar Cinere*. In order to be able to be used as compost material, both sources of solid waste should add materials such as leaves from garden waste to increase the levels of carbon content. Based on solid waste composition, potential reduction waste in both *Pasar Pondok Bambu* and *Pasar Segar Cinere* is around 40%.

Keywords: Market waste; Solid waste; Waste characteristics; Waste generation

1. INTRODUCTION

1.1. Overview

Sources of solid wastes in a community are, in general, related to land use and zoning. One of the categories is commercial source solid waste from markets (Tchobanoglous et al., 1993; Tchobanoglous & Keith, 2002). Markets are places where people trade goods and services. Inside each, there is an interaction between institutions, manufacturers, consumers, and distributors of goods and services (Ehrenberg & Smith, 2003). Money and goods circulate within markets, which ultimately drives a region's economy. Markets can be classified into two types: traditional and modern. The differences are, modern market are more well-organized than traditional markets and have a greater variety of goods to be sold. Both market types generate solid and liquid waste as a result of trading activities. Solid waste from markets is the second-

* Corresponding author's email: djokomh@eng.ui.ac.id, Tel. +62-21-7270029, Fax. +62-21-7270028
Permalink/DOI: http://dx.doi.org/10.14716/ijtech.v6i5.2016

largest domestic type of waste source after households' solid waste (Nitami, 2013). If those wastes are not managed, it will cause various environmental problems, which can lead to the degradation of the market's public health, hygiene, and aesthetics as well as water and air pollution and fire. Water pollution and air pollution in the market are a result largely of the fact that a market's solid waste composition is mostly from organic waste and more simply handled than domestic solid waste (Aye & Wijaya, 2006). Besides, based on data from the Department of Cleansing DKI in 2010, market solid waste was as high as 1671 m^3/day in 2007. This amount of generated waste is predicted to rise along with the population growth of Jakarta and its surroundings. With the increase of population, the need for handling solid waste from the market will also increase in terms of quantity as well as quality management. This study aims to analyze the characteristics and composition of solid waste generated from traditional and modern markets and their potential reductions in *Pasar Pondok Bambu* and *Pasar Segar Cinere* based on the waste generation, composition, and characteristics of the solid wastes that are generated from both markets

1.2. Solid Waste Paradigm

Almost all solid waste from markets is collected and dispersed to disposal sites. "The Old Paradigm of Solid Waste" so-called *Collect-Transport-Dispose*, is used. A market's solid wastes are usually collected in temporary storage or temporary stations that are located near the market and then transported to the disposal site by using arm roll trucks. With the increasing volume of solid waste generation from markets and the lack of space in landfills, there is concern that landfills will not be able to accommodate solid waste generation in the future, not only from markets but also from other sources of solid waste. However, solid wastes that are generated from these markets have a great potential to be reduced. This reduction may be achieved through sustainable solid waste management, such as composting and trash banks. According to Law Number 18 (2008), reduction, reusing, and recycling (3R) should be done first through solid waste source management by reducing solid waste prior to final disposal. The goal is the processing of solid waste at the source first before Transport and Disposal (*3R: Residue-Transport-Dispose*), the so-called New Paradigm of Solid Waste. This study aims to design an alternative of solid waste management for *Pasar Pondok Bambu* and *Pasar Segar Cinere* based on the solid wastes' generation, composition, and characteristics that are generated in both markets, along with an alternative design for its processing. The purpose of this study is to implement shifting from "the old paradigm of solid waste" to "the new paradigm of solid waste," in handling solid waste from the source with the 3Rs (reuse, reduce, and recycle) concept.

Based on Indonesia International Water Weeks 2014, the Ministry of Public Works and Housing declared what it termed a goal of "100–0–100" to be achieved in 2019. The meaning of 100–0–100, or 100%–0%–100% projects is that 100% of the population will be served drinking water, 0% will live in slum housing areas, and 100% will be receiving 100% sanitation and solid waste services, with the goal being especially solid for solid waste, with 50% of solid waste being processed at the source. One idea among others is based on that the idea that no inorganic material should be brought to the disposal site.

2. METHODOLOGY

2.1. Population and Samples

This study was done in two locations: *Pasar Pondok Bambu* and *Pasar Segar Cinere*. *Pasar Pondok Bambu* represents a typical traditional market, whereas *Pasar Segar Cinere* represents a modern market. Based on an analysis of population data, all the generated solid waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere* every day was measured. The area of *Pasar Pondok Bambu* is 3,023 m^2 with 378 vendors, whereas *Pasar Segar Cinere* has 575 vendors in

the area of 10,400 m^2. The samples were a part of the population that were considered representative for descriptive purposes. The use of samples is intended to infer the characteristics of the population without having to analyze the entire population. In this study, samples were taken from the markets' temporary stations, where almost all of the solid wastes from each market were temporarily placed at a temporary station until it was transported. Field observation was done during December 2013 and January 2014 and the samples were taken from 24 December 2013 until 2 January 2014.

Sampling method was done through Standard National Indonesia about Measurement and Collection Method for Waste Generation and Composition of Municipal Solid Waste Sample. In a homogenous population, sampling can be done with a simple random sampling (Freedman, 2004).

2.2. Research Variables and Measures

The research variables consist of generation rate in terms of volume and weight, specific weight, solid waste composition, and ratio of carbon and nitrogen.

Solid waste generation was measured through load account analysis. In this method, the number of individual loads and the corresponding waste characteristics (types of waste, estimated volume) are noted over a specified time period. By measuring all the amount of waste that came from the temporary stations, the entire amount of solid waste that was generated from both markets can be known. Carbon (C) and Nitrogen (N) were measured to determine the quality of compost product from hand rotary composter or in vessel composting.

2.3. Measurements Method

Solid waste generation measure with SNI 19-3964-1994. Solid waste composition measure with SNI 19-3964-1994. To analyze carbon, the spectrophotometer method was used and to analyze nitrogen, the JIS K 0102 method was used.

3. RESULTS AND DISCUSSIONS

3.1. Volume of Generated Solid Waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*

Figure 1 below is the volume measurement result of generated waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*.

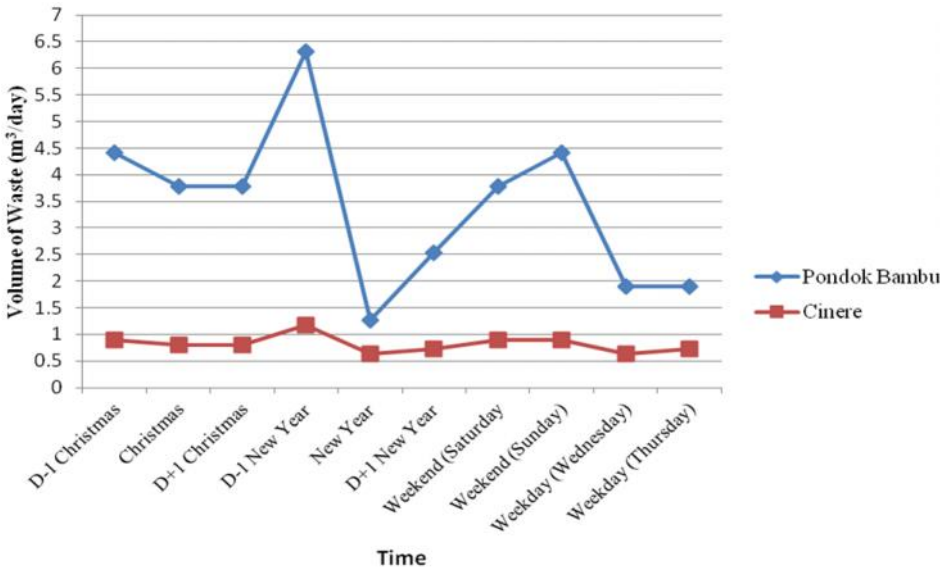

Figure 1 Volume of generated waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*

Results showed that the average volume of generated solid waste from *Pasar Pondok Bambu* on holidays, weekends, and weekdays is 3.65 m^3/day; 4.10 m^3/day; and 1.9 m^3/day, respectively. Meanwhile, there are 44 days of holidays (D - 1, D, D + 1), 104 weekends, and 217 weekdays in a year. Thus, *Pasar Pondok Bambu* may generate solid waste of 1001.36 m^3/year, which is equal to 2.74 m^3/day in a year. Results from *Pasar Segar Cinere* showed that the average volume of generated solid waste on holidays, weekends, and weekdays is 0.84 m^3/day; 0.9 m^3/day; and 0.675 m^3/day, respectively. Annually, *Pasar Segar Cinere* has a solid waste generation of 277.04 m^3/year or 0.76 m^3/day.

From Figure 1, it can be seen that solid waste generation and volume in *Pasar Pondok Bambu* is much larger when compared to *Pasar Segar Cinere*. This may be caused by the conditions that exist in each of the markets. During the study, *Pasar Pondok Bambu* tended to have a larger crowd than *Pasar Segar Cinere*. Moreover, *Pasar Pondok Bambu* also has a much longer operational schedule than *Pasar Segar Cinere*. Trading activities in *Pasar Pondok Bambu* begin before 3:00 AM, while it starts at 6:00 AM in *Pasar Segar Cinere*. The volume of generated solid waste from *Pasar Pondok Bambu* was more fluctuating and was highly influenced by holidays and weekends, whereas it was relatively more stable in *Pasar Segar Cinere* although there was a slight increase on holidays and weekends.

3.2. Weight of Generated Solid Waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*

The result of solid waste weight from *Pasar Pondok Bambu* and *Pasar Segar Cinere* is presented in Figure 2 below.

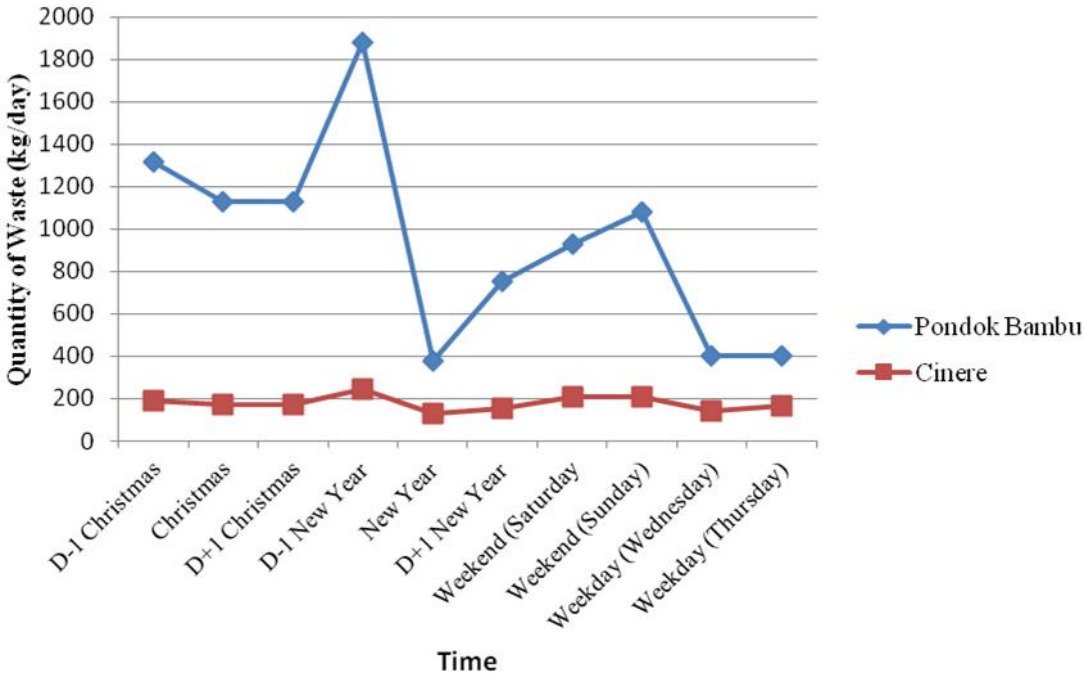

Figure 2 Weight of generated solid waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*

Figure 2 indicates that the solid waste weight from *Pasar Segar Cinere* is relatively stable. The average weight of solid waste from *Pasar Segar Cinere* on holidays, weekends, and weekdays is 210.14 kg/m^3, 228.5 kg/m^3, and 228.39 kg/m^3, respectively. This is because the location of *Pasar Segar Cinere's* temporary station is in a closed condition and therefore it is less affected by rainy seasons. Moreover, solid waste from *Pasar Segar Cinere* derived from an enclosed space and its floor is always dry so the waste that goes into the temporary station is always dry. In general, solid waste density from *Pasar Segar Cinere* is not overly affected by holidays or

weekends. Solid waste density increased only slightly during the holidays. This increase was due to a slight addition of food waste component in the holidays. Food waste tends to have a higher density and wetness. The average weight of solid waste generated from *Pasar Segar Cinere* is 171.53 kg/day while the average weight of solid waste generated from *Pasar Pondok Bambu* is 658.81 kg/day.

In *Pasar Pondok Bambu*, based on 378 vendors in the area of 3023 m^2, the weight generation rate of solid waste is 1.74 kg/vendor/day or 0.218 kg/m^2/day.

In *Pasar Segar Cinere*, based on 575 vendors in the area of 10400 m^2, the weight generation rate of solid waste is 1.32 liter/vendor/day or 0.07 $liter/m^2$/day.

Solid waste density from *Pasar Pondok Bambu* and *Pasar Segar Cinere* is presented in Figure 3.

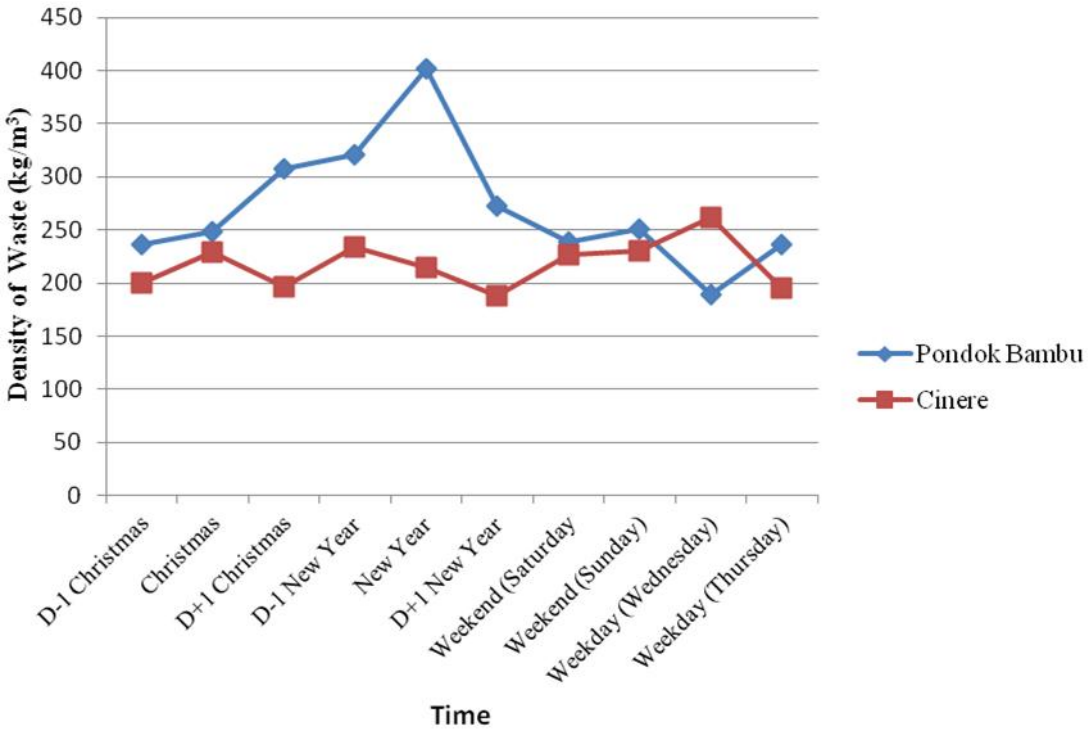

Figure 3 Density of solid waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*

Figure 3 shows that the range variety of density of solid waste from *Pasar Segar Cinere* is between 175 and 250 kg/m^3, whereas the density of solid waste from *Pasar Pondok Bambu* is between 180 and 400 kg/m^3. According to Tchobanoglous et al., 1993, municipal solid wastes as delivered in compaction vehicles have been found to vary from 175 kg/m^3 to 415 kg/m^3.

3.3. Composition of Solid Waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere*

The composition of generated solid waste from *Pasar Pondok Bambu* and *Pasar Segar Cinere* can be seen in Table 1 below. Solid waste calculation for composition was done based on the percentage of each solid waste component's weight in accordance with SNI, 1994 and Tchobanoglous et al., 1993. Weight of the solid waste sample was taken as 91–136 kg.

In general, there is a significant difference between the waste composition from *Pasar Pondok Bambu* and *Pasar Segar Cinere*. However, both markets have a dominant composition of garden/vegetables' waste and food waste (organic waste). Solid waste from *Pasar Segar Cinere* was more varied than from *Pasar Pondok Bambu*. This condition may be caused by the high

variety of stalls and stands that *Pasar Segar Cinere* has compared to *Pasar Pondok Bambu*. Based on field observations that were done in this study, *Pasar Pondok Bambu* has an organic composition of 85.88% and 79.35% for *Pasar Segar Cinere*.

In *Pasar Segar Cinere*, inorganic solid waste composition was higher than in *Pasar Pondok Bambu*. This is because grocery stalls and textile stalls are generally more active than other activities from similar stalls in *Pasar Pondok Bambu*. Solid waste composition from both markets is presented in Table 1.

Based on the table above, solid waste composition in *Pasar Pondok Bambu* was dominated by garden and vegetable waste. Garden and vegetable waste composition were around 65% from the total waste. This is because the trading stalls in *Pasar Pondok Bambu* that are most active and always crowded with shoppers are those that provide vegetables and people's daily needs. These stalls also have a longer operational time compared to the others.

Table 1 Compared composition between *Pasar Pondok Bambu* and *Pasar Segar Cinere*

Composition	**Weight Percentage**	
	Pasar Pondok Bambu	***Pasar Segar Cinere***
Plastic	7.34%	9.60%
Metal	0.01%	0.17%
Rubber	0.05%	0.83%
Glass	0.07%	0.90%
Paper	4.33%	3.76%
Electronics	0.00%	0.00%
Wood	1.97%	2.44%
Textile	0.30%	0.94%
Food Waste	7.28%	20.58%
Garden & Vegetable Waste	65.56%	58.77%
Slaughterhouse Waste	13.04%	1.00%
Hazardous	0.00%	0.20%
Absorbent	0.05%	0.12%
Others	0.00%	1.69%

In *Pasar Pondok Bambu*, there are chicken abattoirs and meat and fish stalls. The solid waste composition created in the stalls in this market contained slaughterhouse waste. Plastic waste from *Pasar Pondok Bambu* was no more than 10% of the total waste. Plastic waste was dominated by plastic bags and plastic for packaging. These plastic wastes mostly came from convection and clothing stalls and from food packaging, while paper waste was dominated by cardboard, duplex stock, and food wrappers. Cardboard and duplex stock were mostly derived from grocery stalls that were located inside the market. Based on field observations, there is a change of composition in *Pasar Pondok Bambu* during the holidays and weekends. This change of composition mostly occurred for slaughterhouse waste. This slaughterhouse waste was dominated by wet chicken feathers, feces, and body parts that are not sellable. On holidays and weekends, slaughterhouse waste tends to increase due to the increasing demand for chicken and meat in *Pasar Pondok Bambu* on those days. There are also changes in composition on other waste components; however, these changes are not quite significant.

Solid waste composition in *Pasar Segar Cinere* was also dominated by organic waste from gardens and vegetables. These wastes mostly came from vegetable and fruit stalls that were

located on the second floor. Vegetable waste was dominated by rotten vegetables, which were not sellable. The second largest solid waste component in *Pasar Segar Cinere* was food waste. These food wastes mostly came from food courts and other places to eat in the market. This market also has hazardous and toxic waste, which mostly derived from auto parts stalls. These hazardous and toxic wastes consist of Pylox paint and paint buckets for cars.

According to field observations, there was a slight change of composition in *Pasar Segar Cinere.* This change of composition was affected by holidays and weekends. On holidays, there was an increase of plastic and food waste. From its composition it can be seen that there are potentials for solid waste reduction in both markets.

The amount of all organic waste in Table 1 (food waste, garden & vegetables' waste and slaughterhouse waste) for *Pasar Pondok Bambu* is around 86%. Based on Kristanto et al. (2015), with a recovery factor for organic of 32.6%, the potential reduction of organic waste is around 27%. In addition, with an inorganic waste amount of around 14%, maximum reduction potential will be around 40%. *Pasar Segar Cinere* has a reduction potential for organic waste of around 25%. In addition, with inorganic waste of around 16%, the maximum potential reduction of *Pasar Segar Cinere* is the same as for *Pasar Pondok Bambu*, that is, around 40%. In comparison with the Ministry of Public Works and Housing target, it can be understood that the calculation based on solid waste from housing sources with inorganic waste is higher than with market waste.

3.4. Compost Quality

Compost qualities that were measured consist of moisture content, volatility, and carbon to nitrogen ratio. Compost qualities from both *Pasar Pondok Bambu* and *Pasar Segar Cinere* are presented in Table 2.

Table 2 Compost quality of *Pasar Pondok Bambu* and *Pasar Segar Cinere*

No.	Parameter	*Pasar Pondok Bambu*	*Pasar Segar Cinere*
1	Moisture Content	76.10%	69.36%
2	Volatility	94.31%	94.23%
3	C/N ratio	23.85%	17.89%

Based on observations, it can be seen that compost moisture content from *Pasar Segar Cinere* was quite high: 69.36%. Moisture content from organic waste could be taken into consideration whether watering before composting is needed or not. With a moisture content of approximately 70%, watering is not needed before composting. If the moisture content is too high, it will inhibit the composting process, in this case *Pasar Pondok Bambu's* moisture content.

Volatile solids describe organic materials that are contained in the samples. Municipal solid wastes that are made into compost usually contain 80% of organic materials. Both samples from *Pasar Pondok Bambu* and *Pasar Segar Cinere* contained more than 90% of organic materials. These organics will decrease during the composting process. However, a high content of organic material will cause a slower composting process and therefore pretreatment with additions of other materials is needed. Laboratory tests provided a result of carbon to nitrogen ratio of organic solid waste from *Pasar Pondok Bambu* of 23.85 and 17.89 for *Pasar Segar Cinere*. Based on Tchobanoglous and Keith (2002) about composting, an ideal ratio of C/N must be between 120% and -25%. A C/N higher than 20/1 or 30/1 can slow the composting process. A C/N that is too low (less than 15/1 to 20/1) leads to loss of nitrogen in the form of

ammonium N. The addition of nitrogenous waste can lower an unfavorably high C/N, whereas the addition the addition of carbonaceous waste can raise an undesirably low C/N. Example of nitrogenous wastes are grass clipping, green vegetation, food wastes, sewage sludge, and commercial chemical fertilizers. Example of carbonaceous wastes are hay, dry leaves and paper (Tchobanoglous & Keith, 2002).

3.5. Alternative Solid Waste Management

In implementing a solid waste management system for both markets, integrated solid waste management should be applied. The collecting methods should be improved by separating different sources of waste such as organic and inorganic waste. Sorting should be done to separate waste according to the recycled process or compost process. Solid waste transfer/transports should also be managed based not only based on the amount of generated solid waste but also considerations of the environmental impact. Increasing compost quality by increasing carbon content can be achieved by mixing with paper and leaves from garden waste. To improve the efficiency and effectiveness of solid waste management, the implementation of Integrated Solid Waste Management (ISWM) should be applied. The success of ISWM depends not only on the technical aspect, but also the institution aspect, regulation aspect, and financial aspect as well as community participation. Since *PD Pasar Jaya* acts also as the autonomous management company for solid waste, including both *Pasar Pondok Bambu* and *Pasar Segar Cinere*, supporting some spaces in the location and other facilities and equipment for implementing 3R (Reduce, Reuse, and Recycle) would be highly advisable.

4. CONCLUSION

To overcome the limited land available for sanitary landfills, reducing the amount of solid waste at the source is a must. Based on the composition of solid waste generated from both *Pasar Pondok Bambu* and *Pasar Segar Cinere*, there is a potential for solid waste reduction up to 40% in order to reduce the waste load in landfills. The reduction can be implemented as a 3R process as well as to increase the compost quality implementation in each location.

5. REFERENCES

ASTM International, 2003. *Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste*. In: ASTM D 5231–92. American Society for Testing and Materials. US

Aye, L., Widjaya, E.R., 2006. Environmental and Economic Analyses of Waste Disposal Options for Traditional Markets in Indonesia. *Waste Management*, Volume 26(10), pp. 1180–1191

Dinas Kebersihan Provinsi DKI Jakarta, 2010. *Management of Jakarta Solid Waste 2010*. Jakarta (in Bahasa)

Ehrenberg, R., Smith, S., 2003. *Modern Labor Economics.* New York: Addison Wesley

Freedman, D.A., 2004. *Sampling*. California Department of Statistics, University of California

Kristanto, G.A., Gusniani, I, Ratna, A., 2015. The performance of Municipal Solid Waste Recycling Program in Depok, Indonesia. *International Journal of Technology*, Volume 6(2), pp. 264–272

Kuncoro, M., 2008. *Development of Modern Market and Traditional Markets*. Available online at http://www.kadin-indonesia.or.id/enm/images/dokumen/KADIN-107-2998-18072008.pdf, Accessed on 4 July 2014 (in Bahasa)

Law Number 18, 2008. *Solid Waste Management*

Nitami, A., 2013. *Study of Solid Waste Generation and Composition as Basic Alternative for Technical Systems Operations on Gading Nias Recidence Apartment and Condominium Tower Kelapa Gading.* Unpublished Bachelor Thesis. Environmental Engineering Study

Program, Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia (in Bahasa)

Standar Nasional Indonesia (SNI) 19-3694-1994, *Method on Sample and Measurement of Municipal of Solid Waste*

Standar Nasional Indonesia (SNI) 19-7030-2004, *Mature Compost Quality Standards in Indonesia*

Tchobanoglous, G., Keith, F., 2002. *Handbook of Solid Waste Management*. USA: McGraw-Hill

Tchobanoglous, G., Theisen, H., Vigil, S., 1993. *Integrated Solid Waste Management.* Singapore: McGraw-Hill