IOP Conference Series: Earth and Environmental Science

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7th International Conference on Sustainable Future for Human Security in conjunction with 3rd International Conference on Green Development in Tropical Regions "Sustainable Development: Global Challenges on Environmental Protection and Social Justice" 29–30 October 2018, Padang, West Sumatra Province, Indonesia

Accepted papers received: 26 September 2019

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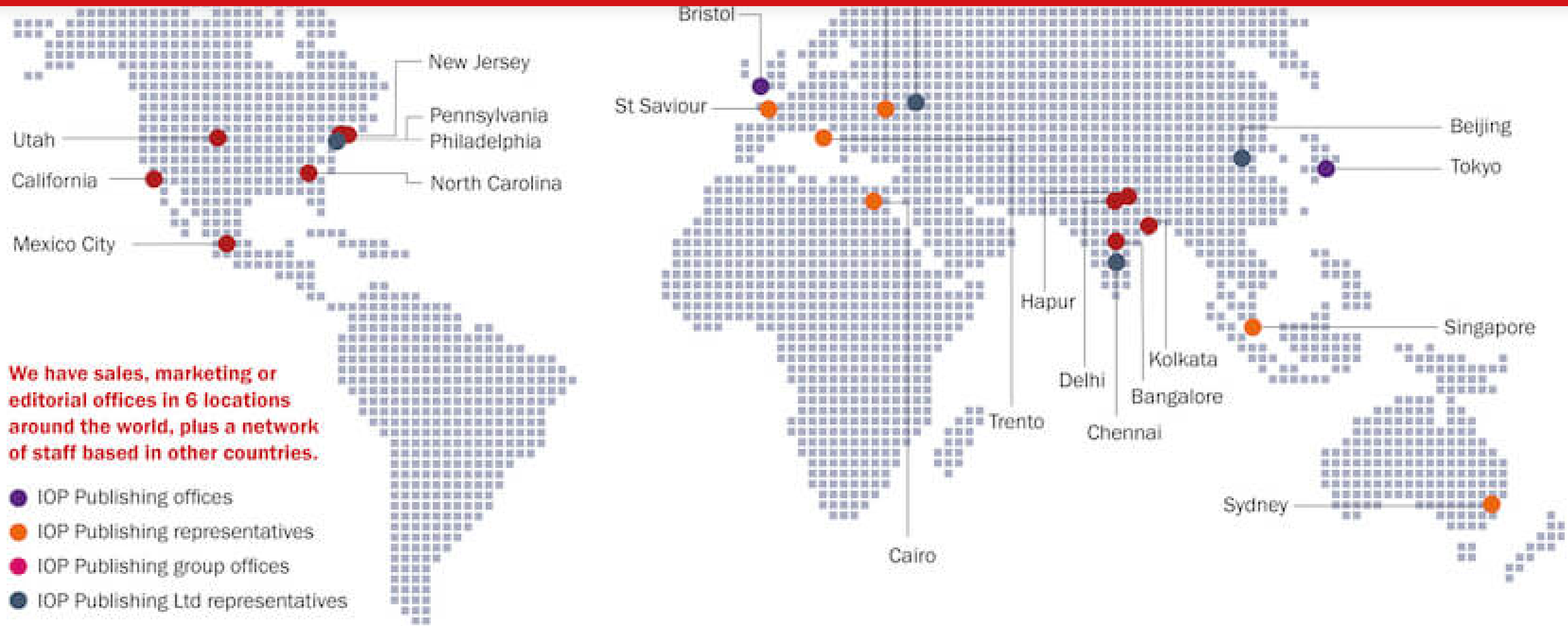

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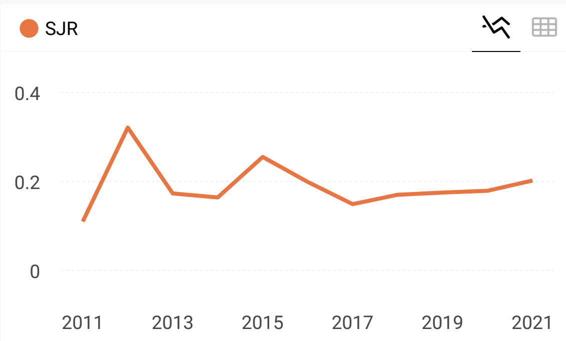

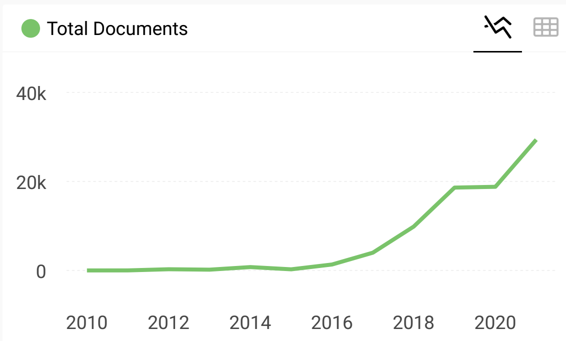

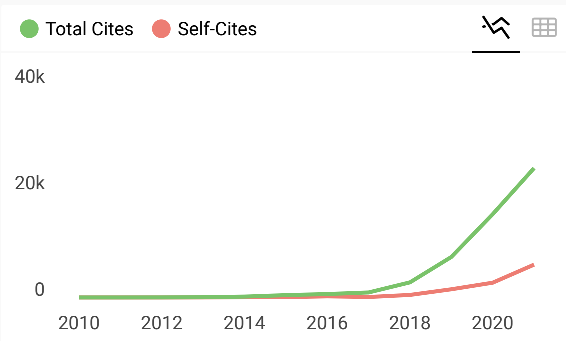

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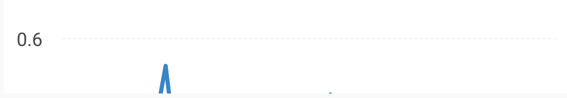

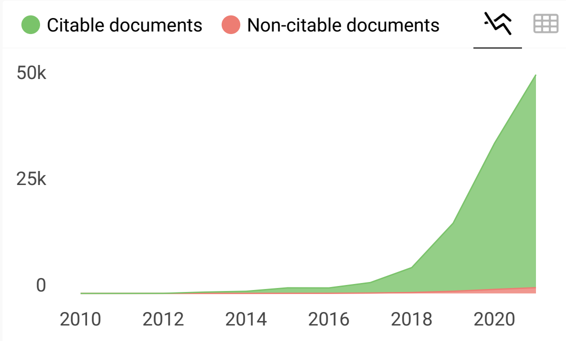

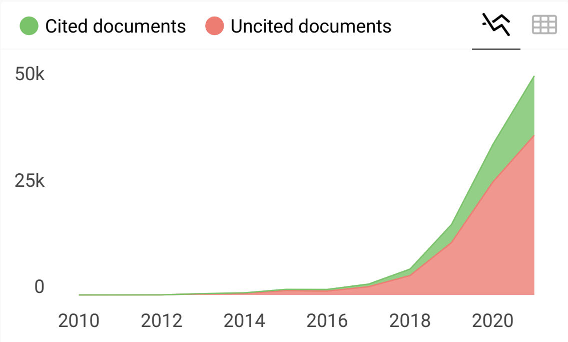

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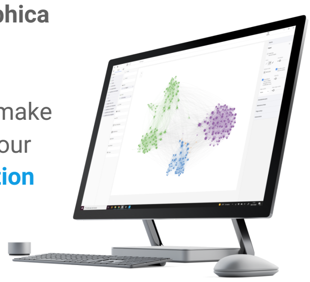

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Comparative study of community-based composters, a case study in West Bandung Regency, West Java – Indonesia

IOP Conf. Series: Earth and Environmental Science **361** (2019) 012013 doi:10.1088/1755-1315/361/1/012013

Comparative study of community-based composters, a case study in West Bandung Regency, West Java – Indonesia

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Abstract. Organic waste is the most dominant waste produced; the reduction of this type of waste has the potential to significantly reduce waste entering a landfill. Composter can reduce organic wastes at the source. This research aims to compare the performances of 3 types of aerobic composters available in Waste Bank Sahdu which are brick overlay, drum, and takakura. The types of wastes are used food and yard waste. The performance of each composter is determined by its capacity, performance, and the quality of composts produced. The capacity of a composter is obtained from the quantity of waste reduced. The performance a composter is assessed based on the composter's ability to process organic waste into compost. The quality of compost is the result of laboratory test for the following parameters temperature, ratio C/N, water content, pH, zinc, copper. The results showed that the capacity of brick overlay, drum and Takakura are able to treat waste per day from 456, 210 and 20 households respectively. Their performances are able to treat 53.45%, 48.27% and 56.01% of organic waste into compost, respectively. The compost quality that produced by all composter has met the standard quality, except for pH of the drum. Based quality of compost produced from all composters is suitable for use. The Takakura included of individual composter, while brick overlay and drum included of communal composters.

1. Introduction

Increasing public consumption in every activity has an impact on increasing generation of waste. Waste reduction is still a problem in almost all regions in Indonesia, as mandated by Law of the Republic of Indonesia Number 18 Year 2008. Based on data from the Ministry of Environment and Forestry in 2016, the national average of transported waste is 67%. Out of the total waste, only 16% are being reduced at source [1].

In addition, according to data and information released by the Ministry of Environment and Forestry in the National Action Plan on Marine Plastic Debris 2017, the average generation of waste in Indonesia is 64 million tons per year. The composition is 60% organic, and 40% inorganic wastes [2].

IOP Conf. Series: Earth and Environmental Science **361** (2019) 012013 doi:10.1088/1755-1315/361/1/012013

The percentage of waste handling in West Bandung Regency in the period of 2017-2018 has only reached 42%, the rest is garbage that is not transported to TPAS. One of the efforts to reduce waste in West Bandung Regency is by having a garbage bank. Sahdu waste bank is a research place in West Bandung Regency that accepts the processing of organic and organic waste. Processing of available organic waste is using a composter. The organic part of the waste can easily be reduced by composting at the source.

The composters used in this research are brick overlay, drums, and the Takakura. The purpose of this research is to identify the effectiveness of the composter based on their capacity, performance and compost quality. The research location is in Sahdu waste bank, because in this waste bank the 3 types of aerob composters are available.

2. Research Method

2.1. Secondary data collection

Secondary data were available from the previous researches or observations [3]. Secondary data needed were related literature studies from journals, final reports, guidelines, legislation etc. In addition, data on research area and population were also needed. Which all those data can be obtained from the Central Bureau of Statistics in West Bandung or *Badan Pusat Statistik (BPS)* and from the head of the neighborhood association or *Rukun Tetangga (RT)*.

2.2. Primary data collectiom

Primary data were collected directly in the object area [3], which consisted of the composting process, and compost quality. These data will be used to calculate composter capacity, and their performances.

2.2.1. Composting

Composting is a decomposing process of organic material by microorganisms that can occur naturally or be accelerated by human treatment [4]. The composting process consists of several stages, which were as follows: (i) preparation, (ii) monitoring, and (iii) harvesting.

2.2.1.1. Composting preparation

The first step was asking for location to do research to the head of *RT* 2, where organic wastes will be collected for 7 days continuously and composted for 44 days. RT 2 is one of the areas registered as a member of legitimate Sahdu waste bank.

The second step was to acquire the necessary equipment, such as garbage containers, measuring instruments (weights and thermometers), sprinklers, tools, and others. The third step was to clean up existing composters, and ensuring their workability.

There were 3 types of composters; the Takakura, the brick overlay, and the drum. **Figure 1** shows the Takakura which has a lot of holes on its sides and oxygen can be enter passively. The principle of composting on the Takakura is aerobic. The Takakura composter had a volume of 35 L.

Figure 1. Layout of the Takakura

The brick overlay also has holes on its pipes where oxygen can enter passively, but not as much as takakura, which is shown in **Figure 2**. The principle of composting on the brick overlay is semi aerobic. The brick overlay composter had a volume of 1.000 L [5].

Figure 2. Layout The Brick Overlay

The drum composter has also on its pipes like the brick overlay but it is made from plastic, which makes the composting process semi aerobic. The layout of drum can be seen in **Figure 3.** The drum composter had a volume of 120 L.

Figure 3. Layout The Brick Drum

The next preparation was an activator liquid that was a mixture of water, EM4 liquid and sugar liquid with a ratio 50: 1: 1 or 100 L: 2 L: 2 L. After being mixed and stirred, then it was the closed and left for a day.

The trash containers were distributed to residents of *RT* 2, the provided container was a 16 L bucket for food waste and trash bags for yard waste, the following day, the garbage was collected and the container was returned for other trash collection in the next day, then the waste was transported to the waste bank.

The collected trash was weighed according to the types, chopped, and mixed. According to [6], the chopping of waste is done to minimize the surface area of trash that must be decomposed by microorganisms and will shorten the composting process, while the mixing is done to spread aeration evenly and the types of nutrients obtained increase. The chopped and mixed trash was divided into 3 parts, weighed and put into each composter. The garbage collection activities up to weighing trash that entered the composter were done for 7 days.

2.2.1.2. Composting monitoring

The process of composting, monitoring and giving the same treatment to 3 composters were done every 2 days. The measurement of temperature using a thermometer was performed at 5 points on each side and center to obtain more accurate data.

Aerobicity will be monitored by odor, in which a foul odor indicates anaerobic condition. This condition requires additional activator liquid or more stirring. The addition of activator liquid to all materials evenly spread the entire surfaces. Addition of activator liquid is adjusted to the materials condition; more additional liquid is not needed if it is too moist because it will inhibit the growth of microorganisms, otherwise if it is too dry an additional liquid was needed, because dry conditions can result in reduced number of decomposing microorganisms [6].

Stirring is meant to aerate or supply oxygen, so that the decomposition process can occur and homogenize the nutrients distribution [7]. Stirring the brick composter and drum was done by pushing the garbage out through the bottom door of the composter, and put it back. On the other hand, stirring the Takakura can be easily done using a small shovel.

2.2.1.3. Compost harvesting

Compost harvesting consists of several stages, the first stage was sifting meant to separate the fine from the coarse compost using a sifter (whole 0.5 cm x 0.5 cm). The second stage was weighing the fine and the coarse compost. The third stage was the temperature measurement as the one of the tested compost quality parameters. The final stage was the packaging of fine compost into a waterproof plastic bag (20 cm x 30 cm) that had been given holes.

2.2.2. Composter capacity calculation

The necessary data needed for calculating the composter capacity (in accommodating organic waste) include the total weight of waste entering the composter. To obtain this data, we weighed the amount of waste that entered each composter for 7 days in a row.

The next data was the average weight of waste received per day, which is the total organic waste produced was weighed and the number of people producing the waste. Weighing and collecting data for 7 days (until the composters are full).Composter capacity can determine the number of waste sources that can be accommodated by each composter, from the calculation formula:

$$\text{Number of Sources (People)} = \frac{\text{Waste Weight Entering Composter (Kg)}}{\text{Waste Weight Production (Kg/People/Day)}}$$

2.2.3. Composter performance calculation

The necessary data for calculating the composter performance in processing organic waste include the total data of waste entering the composter for 7 consecutive days, and the weight of the fine compost produced by each composter.

Composter performance can be calculated using the following formula:

$$\text{Percentage of Fine Compos (\%)} = \frac{\text{Weight of Fine Compos (Kg)}}{\text{Waste Weight Entering Composter (Kg)}} \times 100\%$$

2.2.4. Compost Quality

Compost quality parameter which was tested at the Laboratory of Soil Chemistry at University of Padjajaran (UNPAD), were acidity level (pH), water content, C/N ratio and micro-nutrients (copper and zinc). PH measurement used a pH meter. Water content used a drying method. The measurement of C/N ratio was divided into 2 stages, the measurement of C-organic stage that used Walkley & Black method and the total N measurement stage that used Kjeldahl method. The measurement of plant micronutrients, namely copper (Cu) and zinc (Zn) used spectrophotometric method. The result of compost quality would be compared with the Indonesian National Standard or *Standar Nasional Indonesia (SNI)* 19-7030-2004 concerning compost specifications from domestic organic waste.

3. Results and discussion

3.1. Composting

The starting time of composting was divided into three different composters; the drum was 1 day earlier than the other 2 composters. This was due to the drum composter was totally filled on the 6th day of waste collection. Temperature fluctuations during the composting process can be seen in **Figure 4**.

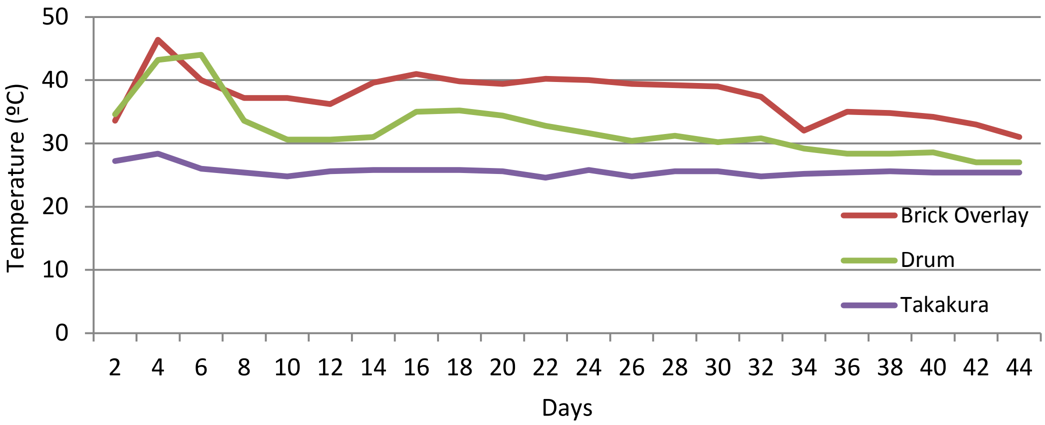

Figure 4. Temperature fluctuation for 3 composters

The composting is done in line with the literature, where the initial composting is mesophilic phase that is seen on the 2nd day that the temperature in the three composters is in the range of 25ºC - 45ºC. After the second day there is an increasing temperature which indicates there is a changing from the mesophilic phase to the thermophilic phase. High temperature in composting process benefits to kill pathogens and weeds. After passing through the thermophilic phase, the temperature of the organic materials relatively decrease meaning that it enters the cooling phase. The cooling phase indicates the decomposition of organic materials into the simpler ones.

The Brick Overlay composter had the highest average temperature, while Takakura had the lowest temperature that was in the range 24 ºC - 27 º C. This was influenced by the volume of the composter, where the greater the volume of the composter the more amounts of organic material to be decomposed, and the release of heat the energy. Recapitulation of problems found during composting process can be seen in **Table 1.**

Table 1. Problem found during composting process

Composter	Finding/Problem	Cause	Solution
Brick overlay	Flies, cockroaches, and rats	• Food waste is too close to the surface of composter • There is a gap at the opening	• Stirring/mixing • Re-designing of the door (change the door material with stainless)
	The waste pile is too moist	Need more oxygen	• Addition of activator liquid • Stirring/mixing
Drum	Flies and cockroaches	• Food waste is too close to the surface of composter • There is a gap in the composter	• Stirring/mixing • Prepare the composter with no gap
	Odor arises because the waste pile is too moist	Need more oxygen	• Addition of activator liquid • Stirring/mixing • Re-design of air fSt pipes
Takakura	The waste pile is too dry	Water is absorbed by chaff pads	Addition of activator liquid

The 42nd day was for Brick Overlay composting and the 43rd day was for drum done drying, this was due to the compost condition of both composters was very moist. The composting for Brick Overlay and takakura composters was conducted for 45 days while the composter drum was 46 days. The characteristics of mature compost from the three composters are, according to SNI 19-7030-2004, include in suitability with soil water temperature (≤ 30 ºC), resemblance of soil texture, blackish brown color and soil-like scent.

3.2. Composter capacity

The total weight of waste entering the composter for 7 consecutive days of can be seen in **Table 2**.

Table 2. Waste weight entering the composter

Composter	Brick Overlay	Drum	Takakura
Waste Weight Entering (Kg)	129,72	59,71	5,57

The average weight of waste per day that was collected from the 7 consecutive day of the measurement can be seen in **Table 3**.

Table 3. Waste production weight

Parameter	Day						
	1	2	3	4	5	6	7
Total of Organic Waste (Kg) (*)	16,23	23,81	29,83	22,82	20,15	17,56	21,33
Numbers of Person Producing The Waste (Person) (*)	38	93	96	75	96	82	82
Waste Weight Production per Day (Kg/Person/Day) (**)	0,43	0,26	0,31	0,30	0,21	0,21	0,26

The average weight of waste weight accommodated at the research object location was0.28 kg/person/day. The capacity of each composter, the following formula was used:

Waste Entering Weight = 129.72 Kg
Waste Production Weight = 0.28 Kg/People/Day

$$\text{Numbers of sources} = \frac{\text{Weight of Waste Entering Composter (Kg)}}{\text{Weight of Waste Production } (Kg/People/Day)} = \frac{129{,}72 \text{ Kg}}{0{,}28\ Kg/People/Day} = 456 \text{ People}$$

Then the capacity of each composter can be seen in **Table 4**.

Table 4. Recapitulation of Composter Capacity

Composter	Brick Overlay	Drum	Takakura
Composter Capacity (Person)	456	210	20

Table 4 shows that the Brick Overlay and the drum can accumulate the largest amount of waste, therefore Brick Overlay and drum can be used as communal. The takakura as the individual composter or is only for household. This data can be used in planning either the number or type of composters suitable in the 3R activities from the source.

3.3. Composter performance

The function of a composter is to process organic waste into compost. The results show that organic waste entering the whole composter produced fine and coarse compost, and others like$NH_3{}^+$, CO_2, steam, and heat that will affect its weight [8].

Fine compost weight data produced by each composter which will be used to calculate the percentage of composter performance can be seen in **Table 5**.

Table 5. Fine Compost Weight

Composter	Brick Overlay	Drum	Takakura
Fine Compost Weight (Kg)	69,34	28,82	3,12

Percentage of composter performance is obtained from calculation result. Example percentage calculation of fine composted brick compost:

Waste Entering Weight = 129.72 Kg
Fine Compos Weight = 69.34 Kg

$$\text{Fine Compos (\%)} = \frac{\text{Wight of Fine Compos (Kg)}}{\text{Weight of Waste Entering Composter (Kg)}} x100\% = \frac{69{,}34 \text{ Kg}}{129{,}72 \text{ Kg}} \text{ x } 100\% = 53{,}45\%$$

Table 6. The Percentage of Composter Performance

Composter	Brick Overlay	Drum	Takakura
Composter Performance (%)	53,45	48,27	56,01

In **Table 6** shows that the performance of the three composters in processing organic waste has approached 50%. This data can be used to determine the amount of organic waste that can be processed or reduced by each composter. Performance can be further optimized by chopping the waste to a smaller size.

3.4. Compost quality

The quality of compost produced affects the feasibility of compost for consumer use and prevents environmental pollution. Comparison of SNI 19-7030-2004 [9] with compost quality parameters can be seen in **Table 7**.

Table 7. The Recapitulation of Compost Quality

<table>
<tr><th rowspan="2">Composter</th><th colspan="5">Compost Quality</th></tr>
<tr><th>Temperature</th><th>pH</th><th>Water Content</th><th>Ratio C/N</th><th>Micronutrients</th></tr>
<tr><td>Brick overlay</td><td rowspan="3">Fulfilled with quality standard</td><td>Fulfilled with quality standard</td><td rowspan="3">Fulfilled with quality standard</td><td rowspan="3">Fulfilled with quality standard</td><td rowspan="3">Fulfilled with quality standard</td></tr>
<tr><td>Drum</td><td>Unfulfilled with quality standard</td></tr>
<tr><td>Takakura</td><td>Fulfilled with quality standard</td></tr>
</table>

3.4.1. Temperature

The temperature of compost is one of the many indicators for its maturity. According to SNI 19-7030-2004 the suitable temperature for compost to be used is at the matching with soil water temperature at maximum temperature which can be absorbed by the roots of plants exactly at ≤30 ºC. Temperature measurement is also done directly at the research location using a thermometer.

Temperature measurement results show that compost produced by Brick Overlay composter has the highest value rather than drum and Takakura, the compost temperature value of the three composters meets the existing quality standards. Temperature values can affect the moisture content of a compost. In addition, high compost temperature values indicate that the heat energy produced is high or equal to the amount of organic materials that is decomposed more and more. This is in accordance with the condition at the field that the amount of waste entering the highest composter is Brick Overlay followed by drums and the last is Takakura.

3.4.2. Level of acidity (pH)

The pH value is influenced by nitrogen from the source of compost raw material (organic material). Acidic pH value proves that there is a decomposition process of nitrogen into ammonia, whereas, when it becomes ammonia, the pH value turns to base [10]. The pH values for viable compost are within the range 5.5-9 [11], while the ideal compost is in the range 6.5-8. According to SNI regulation the PH value that the compost produced must be in the range of 6.8-7.4.

Based on laboratory test result, the average pH value of Brick Overlay, drum and takakura compost were 7.13; 7.52; and 7.23. If it is compared with SNI 19-7030-2004 the drum composter does not fulfill the quality standards, although according to other literature it is still in the range of compost that is suitable for use. A low pH value indicates microorganism's activity breaking down the reactive organic material. While a high pH value indicates reducing microorganism's activity of because organic matter has become compost [12].

The high pH value of the compost which was resulted from drum composter showed that the compost was first mature; this was in line with the conditions in the field, where the composting start time by using drums was 1 day earlier compared to other composter.

3.4.3. Water content

Water content is one of the parameters that should be maintained during the composting process because too dry condition will make the microorganism does not work while too wet condition will make the condition anaerobic [13].

The water content of the compost produced by the Brick Overlay composter had the highest value and followed by drum and Takakura which were 44,05%, 39,51%, 14,69%. The value of the compost water content produced by the three composters had fulfilled the criteria compared with SNI. The water level can be affected by the temperature where the heat that was produced from the decomposition process by microorganism would evaporate the water contained in organic material [14]. The result of this research is in line with the literature which states that the compost of Brick Overlay composter had the highest temperature and water content followed by drum and Takakura. In addition, the low compost water content resulted from Takakura can be caused by the presence of paddy pads and the above composter that can absorb water.

3.4.4. C/N Ratio

The C/N ratio is the ratio between organic carbon and nitrogen, where organic carbon acts as an energy source of microorganisms while nitrogen acts as a complementary protein for the metabolism of microorganisms [15].

Based on the results of laboratory test, it showed that compost with the highest C/N ratio came from Takakura composter and followed by drums and Brick Overlay. Besides, the C/N ratio compost value of the three composter results fulfilled the quality standard. According to Mulyono (2014) the C/N ratio which is too high indicates that the microorganism decomposers are not optimally developed due to the lack of nitrogen, while the C/N ratio that is too low indicates the amount of nitrogen lost in the form of ammonia. In addition, the higher C/N ratio, it will slow down the decomposition process due to N deficiency for protein synthesis [16].

The C/N ratio on compost will continue to change to resemble the C/N ratio of the soil or the C/N ratio value that is acceptable to the plant. The use of Takakura compost will slow down the decomposition process rather than using drum and Brick Overlay compost, it is due to high Takakura compos ration c/n value and equal to the allowed maximum value.

3.4.5. Micronutrient

Measurement of micro nutrient level in compost has been done. It aims as an additional compost value in fulfilling the needs for plant growth. The tested micro nutrient parameters were copper (Cu) and zinc (Zn). Plants need copper element, especially for photosynthesis, while the zinc element is needed to help the process of photosynthesis [17].

The result of measurement shows that the highest micro nutrient is produced by drum composter. The source of micro nutrients on compost comes from the waste in the form of plants and foliage, or due to contamination of leachate water [18]. Copper and zinc elements can be absorbed by plants in the form of Cu^{2+} and Zn^{2+} through its root. The compost micro nutrient value data can be used to determine the type of suitable compost for the growth of a plant. In addition, the compost of the three composters also can be used for plant growth, especially the process of photosynthesis.

3.5. Analysis

In the selection of composter factors that need to be considered are the conditions and characteristics of the community. Communities that are easier to work together are suited to using an overlay brick and drum composter, while individuals who are suitable match using Takakura composter.

Things that must be considered during the composting process to optimize the compost produced include (a) waste is recommended to be chopped up to a small surface size of about 0.5-1 cm [13]; (b) it is necessary to ensure oxygen availability due to composting aerobically; (c) stirring is carried out when it is seen that moisture from the waste has begun to increase; (d) monitoring the temperature during the composting process to find out whether the temperature is in the normal range or not, ie 25-45°C [6].

4. Conclusion

The measurement results show that the largest composter capacity was the brick overlay that can accommodate waste from 456 sources, while the drum and Takakura capacity are from 210 sources and 20 sources. The performance of composters in processing organic waste was seen from the percentage of finely produced compost. The biggest composter performance is Takakura followed by roster brick and drum that are 56.01%, 53.45% and 48.27%. Takakura has the best performance because it has the highest aeration among other composters.

The highest temperature compost was brick overlay followed by drum and Takakura composter which are 29ºC, 27ºC and 24ºC. The highest average pH was drum followed by Takakura and brick overlay which are 7.52, 7.23 and 7.13. The highest water content of compost were brick overlay followed by drum and Takakura that are 44.05%, 39.51%, 14.69%. The highest C/N ratio of compost was Takakura followed by drum and brick overlay which are 20, 12.9 and 12.4. Judging from the content of micro nutrients i.e. copper (Cu) and zinc (Zn), compost produced from drum composter has the highest result compared to the other 2 composts. The quality of compost produced by all composters has fulfilled the quality standard, except the compost pH parameter of the composter drum which does not meet the quality standard.

Suggestions that can be given from the results this study are modifying the composter, it is necessary to have socialization activities in the implementation of the waste reduction system with composter, and the construction waste bank of a RW scale or in neighborhood**.**

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