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Evaluation of the Commercial Bio-Activator and a Traditional Bio-Activator on Compost Using Takakura Method

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ABSTRACT

Developing countries have a serious problem of limited land for handling organic waste. New, simple, and economical methods that can be applied maximally by people in developing countries are needed. This study aimed to evaluate commercial bio-activator (EM_4) and traditional bio-activator in compost using the takakura method. Seven treatments were carried out to determine the most effective mixture to be applied to composting using the takakura method. The graph of fluctuations in temperature, humidity and pH in the composting process with seven different treatments shows that the activity of decomposing microorganisms is going well. A mixture of 2 kg organic waste and 500 ml EM_4 has the values of potassium oxide (K_2O), phosphorus pentoxide (P_2O_5), and nitrogen which meet the compost content requirements based on the Indonesian National Standard (SNI-19-7030-2004).

Keywords: compost, commercial bio-activator, traditional bio-activator, Takakura method

INTRODUCTION

In 2019, the waste production per day was relatively high on the island of Java; among others, Surabaya City produced 2223.9 m^3 of waste per day, Semarang City produced 5080.51 m^3 of waste per day, and Jakarta City had 8291.81 m^3 of waste. In turn, outside Java, among others, Denpasar produced 3925.37 m^3 per day, followed by Makassar, and Pontianak, respectively, producing 839.34 m^3 of waste; and 1834.4 m^3 per day (Central Bureau of Statistics 2020). On the basis of the Republic of Indonesia Law Number 18 of 2008, the increase in the amount of waste is caused by several things, one of which is that waste management so far has not been in accordance with environmentally sound waste management methods and techniques, causing negative impacts on public health and the environment. One of the causes of the increase in the amount of waste generation is the growing population. In 2025, the estimated population of Indonesia will be 284,829,000 people, which translates into an increase of 23,713,544 relative to 2016 (Central Bureau of Statistics 2020).

There are 4 principles in dealing with the amount of waste, namely reduce, reuse, recycle and replace (Kabirifar et al. 2020). Composting is an effort to reduce waste generation. Composting is a process of decomposition of organic matter with the help of microorganisms. One method of composting that is simple, practical, and can be applied to a household scale is the takakura composting method (Dewilda et al. 2021). The takakura method is a technique of composting organic waste for household scale using a basket. The general time of making compost using the takakura method is about 2–3 months. The takakura basket-style composting process is an aerobic composting process, where air is needed as an important intake in the growth process of microorganisms that break down waste into compost (Vairagade and Vairagade 2019). To reduce the waiting time, an activator can be added. Activator is a mixture of decomposing microorganisms and organic matter (Sutrisno et al. 2020). Some of the activators commonly used for composting are commercial bio-activators and traditional bio-activators. Commercial bio-activators constitute a type of bio-activators that are sold freely and are easy to use for the composting process, one type of commercial bio-activator is Effective Microorganism-4 (EM_4). EM_4 is a mixed inoculant of microorganisms (*Lactobacillus*, yeast, photosynthetic bacteria, actinomycetes, and cellulose-decomposing fungi) that is able to accelerate the maturity of organic fertilizers in the composting or decomposition process of organic matter (Aslanzadeh, Kho, and Sitepu 2020). A traditional bio-activator is a self-made bioactivator of local microorganisms, which is a collection of microorganisms that can be bred as a starter in composting. On the basis of the ingredients, there are two local microorganism that can be made, namely local microorganism tapai and local microorganism stale rice as well as various local microorganism made from other ingredients (Indasah et al. 2018). The ingredients in local microorganism are *Rhizobium* sp, *Azosprillium* sp, *Azobacter* sp, *Pseudomonas* sp, and *Bacillus* sp.

The purpose of the conducted study was to evaluate the comparison of compost quality using a commercial bio-activator and a traditional bio-activator with the Takakura composting method.

MATERIALS AND METHODS

Commercial bio-activator preparation

Activation of commercial bio-activator (EM_4) is as follows: 500 ml of original EM_4 is mixed with 500 ml of sugar solution, then water is add until mixed to 1500 ml. The finished solution is placed into a container, then tightly closed. It is left for 5–10 days under airtight conditions; the container must be tightly closed and protected from direct sunlight. The lid of the container is opened on the fifth day to let the gas out so it does not explode. After 5–10 days, active EM_4 can be used with an odor indication sweet-sour smell. The pH of active EM_4 ranges from 3.5 to 3.7.

Traditional bio-activator preparation

Making traditional bio-activator (MOL) – rice (new or stale) is shaped into a ball the size of a tennis ball, as many as 4 pieces. It is left to stand for three days to grow mushrooms that are yellow, orange, and gray. The mushroom rice balls are then placed into a plastic bottle/container. One scoop of water that has been mixed with sugar in the amount of four tablespoons is poured into a bottle/container containing mushroom rice. It is left to stand for one week. The mixture of mushroom rice and sugar water will smell sour. Traditional bio-activator can be used as a starter to make compost mixed with water. The ratio of MOL to water is 1:5.

Takakura composting method

The Takakura composting mothod has several stages, starting from making husk pads, making Takakura baskets, the composting process testing the quality of the compost. The first step is to provide 7 baskets with holes measuring 20×40, then the pads containing the husks that have been made are inserted at the bottom of the basket. The wastebasket is lined with used cardboard according to the size of the basket. The chopped organic waste with the prepared activator is mixed into a plastic bucket. The sample of each bucket is stirred until evenly distributed, then placed in the basket. The compost is covered with the second pad of husks. A thermometer and hygrometer are inserted to measure temperature and humidity, respectively; then, the basket is covered with a layer of cloth to prevent small insects from entering.

Sample preparation

This research method uses a semi-quasi-experimental design with a control group and a treatment group. The control group is organic waste without the addition of bioactivator. The treatment group was organic waste with the addition of EM_4 and MOL. The process uses the Takakura composting method with the composition of organic waste and activator in each treatment, namely 3 baskets with the addition of EM_4, 3 baskets with the addition of MOL and 1 control basket. This research was conducted for 16 days of composting period which had seven treatments (Figure 1):

- A1 = 2 kg of chopped organic waste (control),
- A2 = 2 kg of chopped organic waste + 500 ml MOL,
- A3 = 2 kg of chopped organic waste + 400 ml MOL,
- A4 = 2 kg of chopped organic waste + 300 ml MOL,

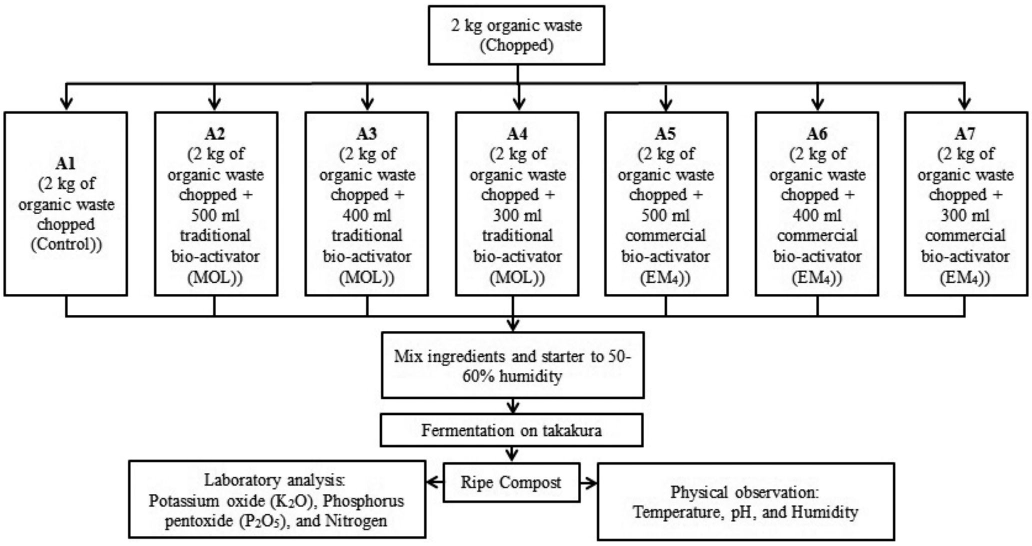

Figure 1. Research flow

- A5 = 2 kg of chopped organic waste + 500 ml EM_4,
- A6 = 2 kg of chopped organic waste + 400 ml EM_4,
- A7 = 2 kg of chopped organic waste + 300 ml EM_4.

The data that is recorded once a day is the pH, humidity, and temperature of the compost. The indicator of finished compost is when the temperature of the pile of composted material is cold or close to room temperature, does not emit a foul odor, with the physical form like soil (blackish color), if placed in water, the compost will not dissolve (settle), and the pH ranges from 6–8.5. Then, the compost will be subjected to laboratory analysis to determine the content of potassium oxide (K_2O), phosphorus pentoxide (P_2O_5), and nitrogen.

RESULTS AND DISCUSSION

The composting process parameters

Figures 2, 3 and 4 depict the fluctuations in temperature, humidity and pH of the compost during the ripening process. In order for the composting process to take place properly, an ideal composition of organic matter and an appropriate environmental temperature for decomposing microorganisms are required. Indications of the work of decomposing microorganisms can be seen through the increase and decrease in temperature during the fermentation process, as well as the stability of humidity and pH of the material during the composting process. The ideal conditions for the composting process are when the C/N ratio of the material is in the range of 30–35, the temperature is in the range of 40–70°C, the

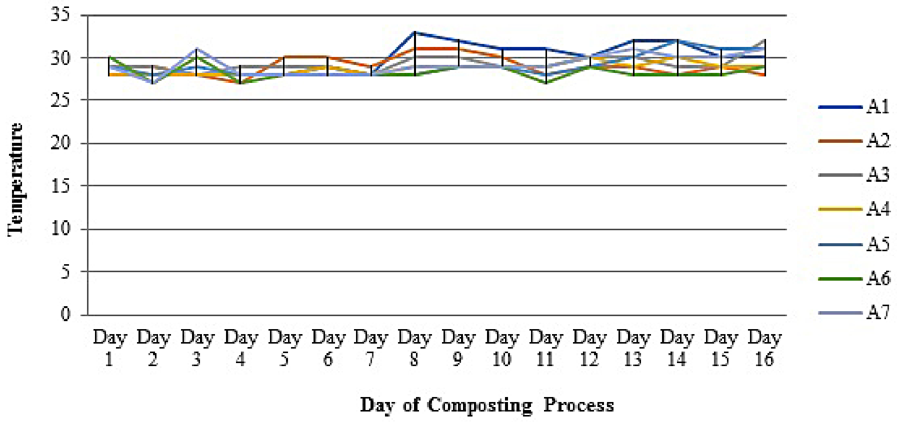

Figure 2. Temperature fluctuations during the composting process

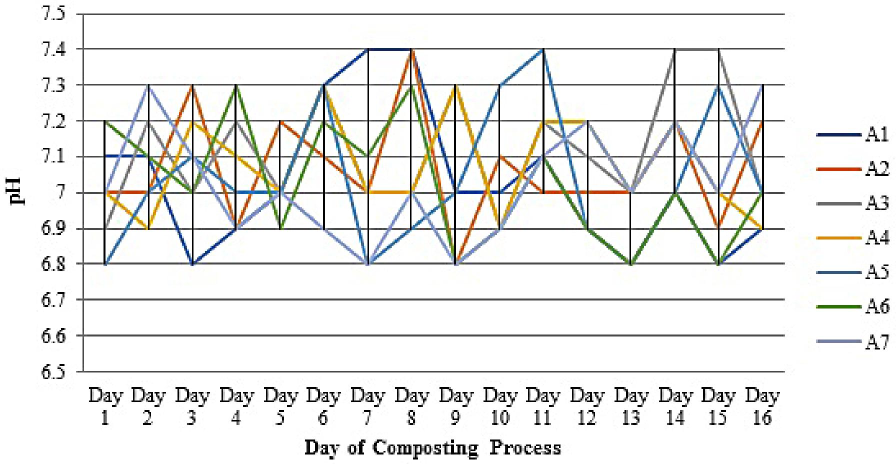

Figure 3. pH fluctuations during the composting process

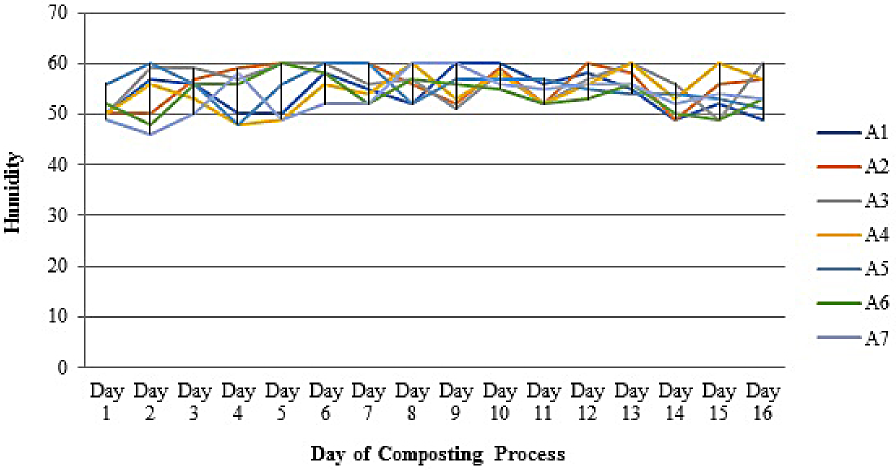

Figure 4. Humidity fluctuations during the composting process

humidity/ water content of the material is 50–60% and the pH is 5–8 (Sharma and Garg 2018). In Figure 2, the daily temperature fluctuations in the seven treatment composts are in line, but there is a slight increase in temperature in the A1 treatment, which is almost parallel to the temperature spike in the A5 treatment compost. In turn, the graph of temperature increase in compost with other treatments tends to be flatter. This is thought to be related to the presence of decomposing bacteria that work well. Each decomposing microorganism has an optimum temperature range for its reproduction. The bacteria present in A5 treatment using EM_4 are known to have the optimal growth temperatures in the range of 40°C (Iriti et al. 2019), so that the increase in temperature in the compost using commercial bio-activator indicates the decomposing bacteria are working well. At temperatures close to 40°C, the work of microorganisms in traditional bio-activator and commercial bio-activator improves. In the compost, the temperature in the control treatment (A1) increased almost the same and in line with EM_4. Because the control treatment (A1) has the potential to contain more varied decomposing bacteria, as is the case with EM_4, compared to MOL. The commercial bio-activator is known to contain photosynthetic bacteria, *Lactobacillus* sp., *Saccharomyces* sp., and *Actinomycetes* sp.

It can be seen that the temperature dynamics of each compost variation undergoes three stages of the composting process (Fig. 2). In the ideal composting process, the first stage is the mesophyll stage, microorganisms are present in the compost material quickly and the temperature increases (Palaniveloo et al. 2020). Mesophilic microorganisms live at a temperature of 10–45°C and are tasked with reducing the particle size of organic matter so that the surface area of the material increases and accelerates the composting process (Rastogi, Nandal, and Khosla 2020). The second stage is the thermophilic stage, where the thermophilic microorganisms are present in the compost heap. Thermophilic microorganisms live at a temperature of 45–60°C and are responsible for consuming carbohydrates and proteins so that the compost material can be degraded quickly (Papale et al. 2021). Some of the actinomycetes are able to break down cellulose and hemicellulose, then the decomposition process begins to slow down and the peak temperature is reached. After the peak temperature is exceeded, the pile reaches stability, where the material is more easily decomposed. The third stage is the cooling and ripening stage. At this stage, the number of thermophilic microorganisms is reduced because the food for these microorganisms is also reduced; this causes mesophilic organisms to start their activities again. Mesophilic organisms will break down cellulose and hemicellulose left over from the previous process into simpler sugars, but their ability is not as good as that of thermophilic organisms. The decomposed material decreases in quantity and the heat released is relatively small.

Potassium oxide content

The value of potassium oxide (K_2O) using a commercial bio-activator with 3 different treatments, ranged from 0.14–0.23%. The value of K_2O using a traditional bio-activator with 3 different treatments, ranged from 0.17–0.23%. The value of K_2O without using both bio-activators was 0.24% (Table 1). On the basis of the Indonesian National Standard (SNI-19-7030-2004), the value that meets the minimum requirements is 0.20%. The value of K_2O in some of these composts has met the requirements or is of good quality, whereas some still do not meet the requirements. The compost that has met the requirements can be used as organic fertilizer that can be applied to plants because K_2O is a macro nutrient that is needed in large quantities.

The potassium oxide levels will increase, this is presumably due to the addition of MOL and EM_4, there will be more microorganisms in the degrading process which causes the carbon chain to break into simpler carbon. The carbon chain causes the phosphorus pentoxide and potassium oxide elements to increase. Potassium oxide is a compound that is also produced by bacterial metabolism, where bacteria use free K^+ ions (Etesami, Emami, and Alikhani 2017). The difference in the percentage content of K_2O, P_2O_5, and nitrogen is caused by the differences in the number of microorganisms that play a role in the composting process. With the increasing number of activators added, the microorganisms that decompose amino acids in protein into nitrogen are more and more active. The work of enzymes that convert carbohydrates into phosphate by phosphorus-forming bacteria is improved, the binding of several types of nutrients in the body of microorganisms, especially K_2O, Phosphorus pentoxide and nitrogen will take place better with the number of microorganisms that play a role.

Microorganisms are the most important factor in the composting process, because they break down organic matter into compost (Wang and Liang 2021). Apart from the activator added to the compost, organic waste also naturally contains K_2O. Potassium oxide is very important for plants, especially in the generative phase, which functions to increase plant resistance to pests and diseases. The lack of K_2O in plants can cause the leaves to shrivel or curl, brownish red spots appear and on a weight scale the plant will die (Prajapati and Modi 2012).

Potassium oxide is a macronutrient found in compost to increase plant resistance to pests and diseases. The symptoms of this nutrient deficiency are indeed rather difficult to detect, because

Table 1. Compost quality laboratory test results

Parameters	Indonesian National Standard (SNI-19-7030-2004)	A1 (2 kg organic waste), %	A2 (2 kg organic waste + 500 ml MOL), %	A3 (2 kg organic waste + 400 ml MOL), %	A4 (2 kg organic waste + 300 ml MOL), %	A5 (2 kg organic waste + 500 ml EM_4),%	A6 (2 kg organic waste + 400 ml EM_4), %	A7 (2 kg organic waste + 300 ml EM_4), %
Potassium oxide (K_2O)	Minimum: 0.20%	0.24	0.17	0.19	0.23	0.23	0.16	0.14
Phosphorus pentoxide (P_2O_5)	Minimum: 0.10%	0.15	0.11	0.14	0.15	0.21	0.16	0.15
Nitrogen	Minimum: 0.40%	0.34	0.47	0.41	0.36	0.57	0.57	0.56

they are rarely shown when the plant is young. The symptoms found in the leaves occur locally at first it looks a bit shriveled and sometimes shiny; then, since the tips and edges of the leaves look yellow, in the end, the leaves look dirty, brown in color. Symptoms on the stem are weak and short stems so that the plant looks stunted (Rajendran, Hepziba, and Ramamoorthy 2009).

Phosphorus pentoxide content

The value of phosphorus pentoxide (P_2O_5) using a commercial bio-activator with 3 different treatments, ranging from 0.15–0.21%. The value of P_2O_5 using a traditional bio-activator with 3 different treatments, ranging from 0.11–0.15%. The value of P_2O_5 without using both bio-activators is 0.15% (Table 1). On the basis of on the Indonesian National Standard (SNI-19-7030-2004), the value that meets the minimum requirements is 0.10%. The phosphorus pentoxide value in some composts has met the requirements or is of good quality, whereas some still did not meet the requirements. The compost that meets the requirements can be used as organic fertilizer that which be applied to plants because P_2O_5 is a macronutrient that is needed in large quantities.

The quality of compost is largely determined by the level of maturity (Muscolo et al. 2018). In addition, the quality of compost is also identified with the content of nutrients in it, such as K_2O, P_2O_5, and nitrogen (Mokrani, Hamdi, and Tarchoun 2018). The increase in the value of P_2O_5 is thought to be due to the greater volumes of traditional bio-activator and commercial bio-activator added; the greater the number of microbes as organic decomposition agents, so that the amount of P_2O_5 minerals added, produced from the metabolic processes of microorganisms will be increased. This increase in P_2O_5 levels is thought to be the impact of the *Lactobacillus* sp. activity which converts glucose in EM_4 into lactic acid so that the environment becomes acidic which causes phosphate bound in long chains to dissolve in the organic acids derived from microorganisms (Adnan et al. 2021).

Phosphorus pentoxide is a macronutrient that functions for the growth of roots, fruits, and seeds. The deficiency of this nutrients can hinder the growth of the root system, leaves, stems, as in cereal plants, the leaves are dark green/ greyish glossy, often with a red pigment on the lower leaves. This is followed by the death of the plant. The leaf stalks appear to be pointed; moreover, poor fruit formation and reduced seed yields are observed (Morrissey and Guerinot 2009).

Nitrogen content

The nitrogen value using a commercial bio-activator with 3 different treatments, ranged from 0.56–0.57%. The nitrogen value using a traditional bio-activator with 3 different treatments, ranged from 0.36–0.47%. The value of nitrogen without using both bio-activators was 0.54% (Table 1). On the basis of the Indonesian National Standard (SNI-19-7030-2004), the value that meets the minimum requirements is 0.40%. In some cases, the nitrogen content of these composts has met the requirements or is of good quality and in others the requirements have not been met. The compost that meets the requirements can be used as organic fertilizer that can be applied to plants because nitrogen is a macronutrient that is needed in large quantities.

The nitrogen content in the compost using MOL and EM_4 is quite high. This is because the bacteria found in bouth bio-activators are able to bind free nitrogen (Hendriani et al. 2017). The increase in the nitrogen value is thought to be caused by the addition of a commercial bio-activator, so the number of microbes as agents for the decomposing organic matter will also increase. Organic nitrogen sources, namely proteins, will first undergo decomposition by microorganisms into amino acids, which is known as the demonization process. The natural nitrogen content is also contained in vegetable waste so that at the time of decomposition, nitrogen pooling occurs. Microbes use C to obtain energy and utilize N, P, and K for metabolic growth and reproduction (Jacoby et al. 2017). Nitrogen is the main macronutrient that is very important for the growth of shoots, stems, and leaves which are essential for plants in the vegetative stage. The average nitrogen content in plant tissue is 2–4% dry weight. Nitrogen is a source of energy for microorganisms in the soil which plays an important role in the process of weathering or decomposition of organic matter, because it is needed in the process of photosynthesis. The symptoms related to this nutrient deficiency can be seen from the leaves, the green color is slightly yellowish, then turns into yellow completely dead leaf tissue and this is what causes the leaves to become dry and red-brown in color. The low nitrogen content can cause the leaves to be full of fiber; this is due to the thickening of the leaf cell membrane, while the cells themselves are small (Holland et al. 2020).

CONCLUSIONS

The results of composting process with seven different treatments shows that the activity of decomposing microorganisms is going well. The quality of the compost produced showed that the mixture of 2 kg organic waste and 500 ml commercial bio-activator was more effective than other treatments. The obtained yield of potassium oxide was 0.23%, phosphorus pentoxide was 0.21% and nitrogen was 0.57%. These results being above the minimum limit of content, according to the Indonesian National Standard (SNI-19-7030-2004).

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