Composting of grass clippings using different commercial microbial activators

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Abstract: A study was conducted on the utilization of biomass organic waste in the form of grass-clippings waste to make compost. The study proposed to determine the effect of different types of activators used on the temperature, duration of composting and the characteristics of the compost produced. The material used for making compost is grass-clipping, mixed with goat manure and rice bran, then inoculated using three types of commercial activators, EM4, Green Phoskko (GP-1) and Agrisimba. Observation of temperature changes during composting was carried out every day. Compost products were then tested for quality including pH, water content, C-Organic, total nitrogen, C/N ratio, and P₂O₅ levels. The test results showed that the temperature changes of the sample with Green Phoskko and Agrisimba activators were almost the same, but both were different from the sample using EM4 activators. The composting process of all sample treatments lasted for 14 days. The quality of compost produced from the three treatments has met the quality requirements according to the Indonesian National Standard SNI 19-7-30-2004 regarding compost from domestic organic waste.

1. Introduction
Office environment with all its activities has the potential to produce organic and inorganic waste. Organic waste produced can be in the type of remnants of daily activities or the form of scrap from plants or parks. Organic waste is any waste that can undergo biological decomposition. This type of waste can be agricultural waste, market waste, kitchen waste, municipal solid food waste, and municipal solid waste [1].

One of the potential organic wastes generated from office environments, especially those that have a garden, is waste in the form of a piece of grass (grass clipping). Grass clipping is organic waste and seems to be more appropriately categorized as municipal solid waste. Municipal solid waste can be in the form of yard waste, food waste, wood, metals, and other forms [2]. Organic waste can be recycled in several methods depending on its characteristics one of which is by agricultural reuses [3]. Organic waste such as grass clippings can be applied directly to the soil, but direct use may have a negative impact on plants because plants will usually absorb inorganic compounds in the form of nitrates and phosphates [3].
Compost is decomposed organic material so that the original form is no longer recognized, blackish in colour and odourless. Composting is one of the efforts to process organic waste into compost through the decomposition process. Composting can be interpreted as the process of breaking down organic substances into nutritional components in a simpler form [4]. Composting is the best and the most effective methods to handle waste [5]. One of the fastest and acceptable composting methods that produce high-quality compost is aerobic composting [4].

In simple terms, the composting process can be done by just stacking garbage, then leaving it for 3-6 months [6]. At present, the composting period can be shortened to around 1-2 weeks by utilizing microorganisms. Microorganisms will conduct weathering processes that can be driven by providing ideal conditions for their growth through regulation of raw materials, temperature, acidity, and the number of decomposing microorganisms (activators). Activator serves to accelerate the decomposition of organic matter, eliminate odors that arise during the decomposition process, suppress the growth of pathogenic microbes, and increase the activity of beneficial microorganisms [7]. EM4 activator is a mixture of microorganisms containing photosynthetic bacteria, yeast, actinomycetes, and fermented fungi that are expected can accelerate the composting process and enrich microbial diversity[8]. The microorganisms contained in Agrisimba solution are Lactobacillus, Bacillus, Yeast, Azobacter, and Acetobacter [9]. According to product description, Green Phosko (GP-1) is commercial compost activator contains Actinomyces naeslundii, Lactobacillus delbrueckii, Bacillus brevis, Saccharomyces cerevisiae, yeast, and mushrooms and cellulolytic Bacillus sp. The study aimed to utilize organic waste, i.e. grass clipping into compost products and find out the effect of using different types of activators namely EM4, Green Phosko and Agrisimba on changes in temperature during composting, composting time and quality of compost produced.

2. Materials and methods

The material used in this study was clipping grass from the P2TTG LIPI office environment located in Subang Regency, West Java, goat manure (45%), and rice bran (10%), commercial compost activators namely EM4, Agrisimba, and Green Phoskko (GP-1). The equipment used was a composter made of HDPE plastic barrels (High Density Poly Ethylene) with a diameter of 370 mm, height 600 mm, in the middle and top of the Composter equipped with PVC pipes holes Ø ½ inch to regulate air circulation or supply oxygen, maintain humidity and temperature so that bacteria and microorganisms work to break down organic matter optimally. At the bottom, there was a perforated PVC pipe sheet for leachate disposal and separated from the solid material. Figure 1 showed the Sketch of the Composter. Other equipment used was chemical laboratory equipment in the form of glass tools, Kjeldahl units and spectrophotometers.

2.1 Inoculum propagation

About 15 ml or 15 g of activator EM4, Agrisimba or Green Phoskko (GP-1) were dissolved in 2 litres of water, then added 15 g of sugar, stirred until homogeneous then incubated for 2 hours. Mixing was carried out three times for 2 hours.

2.2 Composting process

Pieces of grass were crushed using a chopper with a capacity of 80 kg per hour. The chopped grass clippings were mixed with goat manure and rice bran with a composition ratio of 45%: 45%: 10%. The mixture was combined homogeneously as possible, then added with a commercial microbial activator of 13% (v/b), mix until evenly distributed, then put into the Composter. Changes in temperature were measured every day and afterwards stirring was done until mature compost was formed. The formed compost then was dried at room temperature.
2.3 Compost characterization

The compost samples were then investigated for quality including pH value, water content, total nitrogen, C-organic, and P₂O₅ level. The pH value was measured by a pH meter, the water content was analyzed by the gravimetric method by drying using an oven at 105°C, the kjeldahl analysis investigated the total nitrogen content, phosphate content was explained by the spectrophotometer method [10] and C-organic content was analyzed using the Walkley and Black methods. Testing the physical quality of compost includes temperature, colour and odour. The compost quality resulted from the test then was compared with that of Indonesian National Standards, SNI 19-7-30-2004 [11]. Another observation was the shrinkage of compost carried out at the end of the composting process.

3. Results and discussions

3.1 Effect of types of activator in temperature changes

During the composting process, temperature changes have occurred. Temperature observations showed that the highest temperature achieved was 60°C in samples with EM4 and Agrisimba activators and 57°C in Green Phoskko activator samples. Figure 2 showed the graphs of temperature changes during composting.

According to Van der Wurff et al. (2016) [12], the composting process generally occurs in three phases and is characterized by changes in temperature. (1) The first phase is the mesophilic phase with a temperature range of up to 40°C, this is a fast growth phase for mesophilic microbes and fungi that utilise nutrients in the form of sugar and dissolved starch; (2) the second phase is the thermophilic phase, this phase takes place with a temperature range of around 40 - 65°C. In this phase, the diversity of thermophilic bacteria, actinomycetes, and tolerant fungi towards heat begin to decrease. They will decompose compounds in the form of fat, protein, cellulose, and hemicellulose; and (3) the third phase is the maturation phase, the temperature begins to decline, so it is below 40°C. The microbial population is in the form of bacteria, actinomycetes and mesophilic fungi. At this stage, the slow degradation process is still ongoing to decompose lignin and other resistant compounds [12].
Temperature changing can be seen in figure 2. The figure showed that on the second day to the fourth day there was an increase in composting temperature in the use of three types of activators, which showed that there had been the decomposition of organic waste. The decomposition process will produce heat which begins the thermophilic phase in the compost material. In this phase, the microorganisms that play a role are thermophilic microorganisms that can live at a temperature of 40-60°C [13]. On the fifth day in the sample with Green Phoskko and Agrisimba activators and on the sixth day with EM4 activators, the temperature decreases, which indicates a reduction in the activity of thermophilic microorganisms. The degradation in the operation of thermophilic organisms is due to the beginning of reduced nutritional sources. According to Sutanto (2002), organic waste is easily decomposed if the C/N ratio is around 20-35 [14].

![Figure 2. Temperature changes during composting](image)

After reducing the activity of thermophilic microorganisms, the mesophilic organisms that previously hid in a rather cold pile begin their operation again and will break down the remaining cellulose and hemicellulose. However, its capabilities are not as good as thermophilic microorganisms. Effective microorganisms is e liquid culture contains selected species of microorganisms that were dominated by lactic acid bacteria, yeast, photosynthetic bacteria, actinomycetes and other types of microorganisms [15]. Lactic acid bacteria (*Lactobacillus sp*) functions to ferment organic matter into lactic acid, accelerate the breakdown of organic matter, lignin and cellulose, and suppress pathogens with the resulting lactic acid. Lactic acid bacteria are also known to have the ability to produce antimicrobial compounds such as organic acid, Hydrogen peroxide and di-acetyl [16]. Yeast can produce or synthesize some important compounds such as antimicrobials, chemical compounds such as sugars and amino acids, and bioactive compounds such as hormones and enzymes [17]. Some lactobacillus species as lactic acid bacteria are known to have interactions with yeast [18]. The secretion of yeast can be used as a useful substrate for effective microorganisms, lactic acid bacteria, and actinomycetes [17].

### 3.2 Effect of activator on composting time

The composting process of grass pieces with Agrisimba, EM4 and Green Phoskko activators occurred at almost the same time and were stopped on the 14th day. In the previous study, composting using organic waste in the form of vegetables with EM4 activators occurred faster than that of Green Phoskko and Agrisimba activators, which happened on the 7th day. The more quickly composting is
possible because of the difference in composition of the constituent compounds especially the C/N ratio, where vegetable waste generally has a relatively low C/N ratio. Composting with a mixture of grass and cow manure using Biosmic activator reached maturity on day 46 [19]. Compost maturity is characterised by the destruction of the base material, a temperature close to room temperature, blackish colour, crumbs, easily broken, and in these circumstances usually have a ratio of C/N 10-20 [20].

However, according to Van der Wuff et al. (2016) [12], at the end of the thermophilic compost phase, it is referred to as young compost and becomes mature compost after the drying phase [12]. The maturity of fertilizer depends on the input of the material used and cannot be indicated by a matter of weeks or months. The composting process carried out by Kalamdhad et. al. (2009), from a mixture of organic wastes in various variations of the initial C/N ratio lasting for 20 days [21].

3.3 Compost shrinkage
In the composting process, there was a shrinkage which showed the compost maturity. There was not found a significant difference in the compost depreciation that occurred in this study. The highest reduction of 60.9% occurred in the sample with EM4, followed by a decrease of 60.5% and 60.4% occurred in the sample with Green Phoskko and Agrisimba activators, respectively. Loss of mass and volume will be occurred during composting process. The average mass reduction is around 19.4% of the initial mass and ranges from 11.5-31.4% while the average volume reduction is around 40.7% of the initial volume [22]. The occurrence of contraction is due to the digestive process, where organic matter is decomposed into elements that can be absorbed by microorganisms, so the size of organic matter turns into small particles, which causes the compost volume to shrink. Besides, the digestive process produces heat which evaporates the water content and CO₂ in the compost material and causes shrinkage of compost. According to Nur et.al (2008), shrinkage is caused by the decomposition of lignin, hemicellulose, fat, and cellulose. The decomposition process will produce new materials such as carbon dioxide, water, and heat energy released into the environment. Those resulting material reduction of around 40-60% depend on the basic raw material for compost [23].

3.4 Physical characteristics of compost
Table 1 showed the results of the observations of the physical characteristics, i.e. temperature, colour and odour of compost.

| Parameters     | Green Phoskko | EM4 | Agrisimba | Indonesian Standard |
|----------------|---------------|-----|-----------|---------------------|
| Temperature (°C) | 28            | 28  | 27        | Groundwater temperature |
| Colours        | Blackish brown| Blackish brown | Blackish brown | Blackish |
| Odour          | Odorous soil  | Odorous soil | Odorous soil | Odorous soil |

Table 1 showed that the different types of three type of activators did not affect the temperature, colour or smell of the compost produced. The colour of compost from the three types of activator was blackish brown resembling the colour of the soil which meant that the microorganisms of the three types of activators worked well to decompose organic matter. The smell of compost from the three types of activators was the same as odorous soil. The smell or aroma produced in the composting process indicated that there was a decomposition of material by microbes. The temperature of the compost was almost the same as the temperature of the ground, 27 - 28°C. The physical quality of fertiliser in the three types of activators used met requirement according to the Indonesian National Standard SNI 19-7-30-2004 [11].
3.5 Chemical characteristics of compost

Table 2 showed the testing results of the chemical characteristics of compost with three different types of activators. Content of organic matter is one of the compost quality parameters; the higher the content of organic matter means the more compost quality [24].

### Table 2. Chemical characteristics of compost with different types of activators

| Parameter          | Activator       | SNI          |
|--------------------|-----------------|--------------|
|                    | Green Phoskko   | EM4          | Agrisimba    | Minimum | Maximum |
| pH                 | 6.95            | 7.46         | 7.47         | 6.80    | 7.49    |
| Water content (%)  | 17.96           | 21.38        | 18.43        | -       | 50      |
| C-organic (%)      | 38.30           | 34.82        | 35.95        | 27      | 58      |
| N-total (%)        | 2.37            | 2.12         | 2.32         | 0.40    | -       |
| C/N ratio          | 16.6            | 16.42        | 15.49        | 10      | 20      |
| P<sub>2</sub>O<sub>5</sub> (%) | 0.59         | 0.59         | 1.91         | 0.10    | -       |

3.6 Degree of acidity (pH)

The pH value is very influential on composting because pH is one of the critical factors for the growth of microorganisms involved in the composting process [25]. A pH value that is too high will cause an increase in oxygen consumption, give bad results for the environment, and can cause changes in the element of nitrogen to ammonia (NH3). Conversely, a pH value that is too low can cause the death of some microorganisms [13].

At first of the composting process, it was found that the pH for each sample with Green Phoskko activators was around 7.85, EM4 was around 8.67 and Agrisimba was about 7.64. Results of the analysis showed that the pH value of the compost decreased compared to the initial pH; this occurred due to several organic components of the material have been converted into organic acids by several microorganisms. In the next process, other types of microbes would consume organic acids which caused the pH value returned to near neutral and tended to be alkaline.

Based on the results of the analysis, the pH values of all samples with different types of activators had met compost quality standards according to SNI, where the minimum pH was 6.80 and maximum was 7.49 [11]. The results of the Hapsoh et al. (2015), revealed that compost from various organic wastes has a pH in the range of 7.42 - 8.89 and only one groups of samples met SNI standards, i.e. compost with rice straw material and market waste [26]. Compost from urban waste has a pH in the range of 8.3 - 8.5 [27]. Compost from household waste has a pH value of around 7.3 [28].

3.7 Water content

Water content plays an essential role in the acceleration of changes and utilisation of organic materials in composting [29]. According to Tom et al., (2002), water content or moisture is one of important key of environmental factors that influence the composting process. Through changes in oxygen diffusion, water potential and water activity, and the rate of microbial growth, moisture will affect the kinetics of biodegradation [30]. During the composting process, water content will affect the physiological characteristics of microbes and the physical structure of the solid matrix. At the right level of water content, aerobic microorganisms will become more active to consume oxygen, so microbial activity will increase [31]. Water content is the percentage of the water content of a material that can be expressed based on wet weight (wet base) or based on dry mass (dry base). Testing results of the compost water content produced from variations of activators of Green Phoskko, EM4 and Agrisimba were 17.96%, 21.38% and 18.43 % respectively. Analysis results of the water content value were by the requirements of SNI 19-7-30-2004 [11]. A compost from various combinations of organic waste has a water content of around 25-47% [26]. Compost with raw materials of urban organic solid waste has a moisture content of approximately 31.05 - 32.52% [27]. Compost with basic household waste
has a moisture content of around 40.06% [28]. Water content also affects the shelf life of compost, where the higher the water content produced, the faster the possibility of compost damage.

3.8 C-organic content
C-organic content has an essential role in increasing the efficiency of fertiliser use because it can supply various macro and micronutrients. Plants can absorb almost all nutrients in organic matter after going through the decomposition process. Organic material is also used as an energy source for microorganisms, and after these microorganisms die, the nutrients will be released so that they can be utilised by plants [32]. C-organic content with a different type of activator as a whole has met compost quality standards according to SNI 19-7-30-2004. The C-organic content for Green Phoskko activators is 38.30%, EM4 34.82% and Agrisimba 35.95%. The C-organic content required by SNI is a minimum of 27% and a maximum of 58%. Compost of organic waste from household waste with activator EM4 has C-organic content of 20% [28]. The results show that C-organic content of various compost made from variation composition of organic waste range from 6.27-34.60% [26].

3.9 N-Total content
Nitrogen has important rules for organisms including plants. Nitrogen is an important element or constituent for plants that is involved in all vital processes related to protein [33]. The lack of nitrogen in plants causes plants to turn yellow quickly. The changing colour of plants is because the available N is not enough to form protein and chlorophyll which creates the ability of plants to produce carbohydrates to decrease. Thus, over time, plant growth becomes slow and stunted [34]. Excess N amount is also not right because it causes plant stems from breaking easily, plants are susceptible to disease and infected.

The total N-content of the three types of compost with different activators met compost quality standards according to SNI 19-7-30-2004, where the total N-content was at least 0.40% [11]. The total N-content with Green Phoskko, EM4 and Agrisimba activators were 2.37%, 2.12% and 2.32% respectively. Nitrogen is an essential element for all organisms including plants. Nitrogen is a one of fundamental element for plant photosynthesis so it becomes a key role for plants in chlorophyll production [35]. In addition, nitrogen is an important constituent of proteins such as enzymes. This enzyme has an important role in the process of catalysis and regulation of plant growth [36]. Nitrogen plays an important role in the physiological processes of plants such as giving a dark green color to plants and also in the growth and development of leaves, stems and roots of plants [37].

3.10 C/N ratio
The value of C/N ratio shows the maturity of organic compost. The smaller C/N ratio of about 10-20 indicates that organic fertiliser has reached adulthood. In the decomposition process of organic matter, carbon is used by microorganisms as a source of energy and nitrogen is used as a constituent of its cells. The value of C/N ratio affects the availability of nutrients in compost, the high of C/N ratio is mean the availability of nutrient content for plants is small, whereas the low of C/N ratio indicates the high availability of nutrients and plant needs will be sufficient.

Based on the results of the analysis was known that the C/N ratio of compost samples with different types of activators was 16.6, 16.42 and 15.49 of Green Phoskko, EM4 and Agrisimba respectively. This value met the quality requirements following standard of SNI 19-7-30-2004, which required a C/N ratio of around 10-20 [11]. The amount of C/N ratio from the results of other studies, i.e. compost from household waste is about 13 [28]. Compost samples from organic waste with C/N ratio of the initial mixtures of 16, 22, 30 and 38 at the end of the composting process each have a C/N ratio of 5.3, 10.9, 16.5, and 27.1 [21].

3.11 Phosphate (P₂O₅) content
Phosphorous elements as organic materials have an essential role in soil fertility where nutrient intake from organic matter is beneficial in increasing soil nutrient levels to achieve optimal fertility intensity.
Phosphorous elements are critical to the process of photosynthesis and chemical physiology of plants. Phosphorus is also needed in cell division, tissue development and plant growth points [29]. For plants, phosphate acts as a trigger for root growth and the formation of a better root system, maturation of fruits and seeds, and as a constituent of fat and protein cell nuclei. The essential of the phosphorus element is by the opinion of Hardjowigeno (2007), phosphorus is needed to compile 0.1 - 0.4% of dry matter of plants [34].

Phosphate content (P$_2$O$_5$) of the three types of compost with different types of activators, i.e. Green Phoskko, EM4 and Agrisimba was 1.23%, 0.59 %, and 1.91% respectively. The test results showed that all variations met the quality standards of compost according to SNI 19-7-30-2004 [11]. Organic fertiliser from vegetable waste using local microorganism activators has P$_2$O$_5$ content of 0.38% [38]. Organic fertiliser from a mixture of water hyacinth and cow manure on various compositions has P$_2$O$_5$ values ranging from 0.47 - 0.72% [39].

4. Conclusion
The grass pieces could be used as compost using Green Phoskko, Agrisimba and EM4 activators. Compost produced by using the activator had met the quality requirements by SNI 19-7-30-2004 regarding the specifications of compost from domestic organic waste. The duration of composting is at least for 14 days. The physical characteristics of the three are almost the same namely blackish brown and smell of soil. The chemical characteristics are pH (6.95 - 7.46), water content (17.96 - 21.38%), organic C content (34.82 - 38.30%), total N content (2.12 - 2.32%), C/N ratio (15.49 - 16.6) and P$_2$O$_5$ levels (0.59 - 1.91%).

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