Study of Microbial Air Quality at Surrounding Food and Leaves Waste Composting Facility (Case Study: Composting Facility – Faculty of Engineering, Universitas Indonesia)

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Abstract. Composting process can increase bioaerosol concentrations that can cause health effect on human. The objectives of this research are to study bioaerosol concentration and temperature and humidity factors bioaerosol concentration regarding food and leaves waste composting in Composting Facility – Faculty of Engineering. This study found that bioaerosol concentration of gram-positive bacteria, gram-negative bacteria, and fungi on 1st sampling location about 123.7 to 4699.6 CFU/m³, 0 to 17.67 CFU/m³, and 212.0 to 1484.1 CFU/m³, on 2nd sampling location about 141.3 to 2402.8 CFU/m³, 0 CFU/m³, and 300.4 to 1042.4 CFU/m³, and on 3rd sampling location about 17.7 to 2102.5 CFU/m³, 0 CFU/m³, and 53.0 to 1802.1 CFU/m³. This concentration was higher than related standard. Therefore, we need to do some handing technique to reduce bioaerosol exposure to human.

1. Introduction
Solid waste is a problem found in almost all aspects of the activities of humans and other creatures. Based on research conducted by Banaget, waste generation in the Faculty of Engineering on average per day is 121.65 kg [1]. From the research, it is also known that there is potential for recycling waste from building waste, yard and canteen of the Faculty of Engineering, University of Indonesia. However, inadequate handling steps by related parties at the Faculty of Engineering, University of Indonesia to accommodate the potential for recycled waste. Based on the above matters, composting is expected to be an alternative in dealing with the large amount of waste generation formed in the Faculty of Engineering. Composting is biological decomposition and stabilization of organic substrate under conditions that allow thermophilic temperatures to occur as a result of heat production to produce a final product that is stable, free of pathogens, plant seeds, and can be used for land [2].

The composting process is one of the causes of the increased concentration of bioaerosol in the air [3]. Bioaerosol is a term used to indicate microorganisms that are suspended in the air. Bioaerosol can also be defined as particles in the air consisting of living organisms such as microorganisms or those derived from living things such as toxins and fragments of microorganisms that can have an impact on health [4]. This bioaerosol can be in the form of bacteria, actinomyces, fungi, protozoa, and rotifers [5]. The composting activity increases the number of fungi during the shredding process so that the concentration can be 10 times higher [6].

From the description above, the research on the effect of making compost from food waste and yard waste in composting facilities in the Faculty of Engineering needs to be done. Through this
research it is expected to be able to see the levels of bioaerosol in the form of bacteria and fungi produced from this process. So that it can know the impact and how the next steps that must be taken and play a role in creating better environmental conditions.

2. Methodology

2.1. Research Variables
The independent variables in this study were the age of compost, the distance of sampling from the composting vessel, air humidity, wind speed, air temperature, and compost temperature. While the dependent variable is the concentration of bioaerosol in the composting facility and the surrounding area.

2.2. Research Instruments
The core instrument of this research is the EMS E6 Bioaerosol sample and vacuum pump. In addition to the EMS E6 Bioaerosol sample, another important instrument is the composter at the composting facility under review. Therefore, different composter models will produce effects on different air pollution. In this research, composter is in type of vessel composting method.

2.3. Measurement Procedure for Bioaerosol Concentration and Physical Parameters
Measurements were made using the EMS E6 Bioaerosol Sampler. The principle of research is to use certain agar media as a medium for bacterial and fungal propagation. Sampling was carried out with an air flow of 28.3 L/min. Samples for each point are duplo samples with Malt Extract Agar (MEA) media for fungi and Triptic Soy Agar (TSA) for bacteria. For the measurement of the physical parameters of the air consists of measurement of air humidity and air temperature using an anemometer. Bioaerosol concentration treated to the total concentration of bacteria and fungi per m$^3$ by using the formula from AIHA and adjusting to the capacity of the vacuum pump [7].

2.4. Determination of Gram-Positive and Gram-Negative Bacteria
The determination of positive and negative gram bacteria is done by gram staining. This gram painting starts with preparing a sterilized preparation in alcohol. After that, the application of incubation bacteria is applied to the preparations and fixed. Furthermore, giving crystal violet solution and leave it for 1 minute and rinsed. Followed by giving iodine lugol then leave it for 1 minute and rinsed. After that, the acetone alcohol is dropped for 30 seconds and rinsed. Then drop with safranin then leave it for 30 seconds and rinse. After drying, the preparation is dripped with immersion oil and covered with a glass cover with drops of immersion oil. After that, observation is carried out under a microscope.

3. Result and Discussion
Figure 1 shows air quality related to bioaerosol initial concentration at the composting facility site. This aims to find out the effect of composting activities on the distribution of microorganisms at the site after the composting has been carried out.

The results showed that the concentration of gram-positive bacteria was 1024.73 CFU / m$^3$ and the fungi concentration was 636.04 CFU / m$^3$. The concentration of bacteria and fungi is only influenced by human activities at this location because the composting is not yet running. The microorganisms that dominated air quality at this time were gram-positive bacteria with almost twice the concentration of fungi. Meanwhile, gram-negative bacteria were not found in studies that indicated a minimal number of gram-negative bacteria that could cause health effects.
This study was conducted at 3 sampling location. The study begins with field observation and bacteria incubation, then the determination of gram-positive and gram-negative bacteria is done by gram staining. Table 1, 2, and 3 shows the result of bacteria composition at the first, second, and third sampling location respectively.

**Table 1. Bacteria composition at the first sampling location**

| No. | Date       | Day | Gram-Positive Bacteria | Gram-Negative Bacteria |
|-----|------------|-----|------------------------|------------------------|
| 1   | 17-02-2014 | 0   | 115                    | < 1                    |
| 2   | 21-02-2014 | 3   | 133                    | < 1                    |
| 3   | 24-02-2014 | 7   | 3,5                    | < 1                    |
| 4   | 3-03-2014  | 14  | 56,5                   | < 1                    |
| 5   | 24-03-2014 | 30  | 16                     | 1                      |
| 6   | 21-04-2014 | 60  | 11                     | < 1                    |

**Table 2. Bacteria composition at the second sampling location**

| No. | Date       | Day | Gram-Positive Bacteria | Gram-Negative Bacteria |
|-----|------------|-----|------------------------|------------------------|
| 1   | 17-02-2014 | 0   | 52,5                   | < 1                    |
| 2   | 21-02-2014 | 3   | 68                     | < 1                    |
| 3   | 24-02-2014 | 7   | 4                      | < 1                    |
| 4   | 3-03-2014  | 14  | 22,5                   | < 1                    |
| 5   | 24-03-2014 | 30  | 10                     | < 1                    |
| 6   | 21-04-2014 | 60  | 10                     | < 1                    |

**Table 3. Bacteria composition at the third sampling location**

| No. | Date       | Day | Gram-Positive Bacteria | Gram-Negative Bacteria |
|-----|------------|-----|------------------------|------------------------|
| 1   | 17-02-2014 | 0   | 47                     | < 1                    |
| 2   | 21-02-2014 | 3   | 59,5                   | < 1                    |
| 3   | 24-02-2014 | 7   | 11,5                   | < 1                    |
| 4   | 3-03-2014  | 14  | 0,5                    | < 1                    |
| 5   | 24-03-2014 | 30  | 4                      | < 1                    |
| 6   | 21-04-2014 | 60  | 5                      | < 1                    |

![Figure 1. Bioaerosol initial concentration at the composting facility site](image)
Bioaerosol concentration at the first sampling location when the composting processing started increase become 4063.60 CFU/m³ gram-positive bacteria and 1060.07 CFU/m³ fungi. The number of bacteria and fungi has increased sharply. The data shows that bioaerosol concentration increase almost 4 times for gram-positive bacteria and increase about 2 times for fungi compared to the initial concentration. These number was resulted from the number of bacteria and fungi concentration in the compost itself. The others were from bacteria and fungi at the surroundings area. The highest number happened in the 3rd day where gram-positive bacteria reach 4699.64 CFU/m³. This value is quite large when compared to existing standards [8]. However, related to the requirements for temperature and humidity that are set so that the magnitude between 18°C to 28°C and 40% to 60%, conditions in the composting room of the Faculty of Engineering, University of Indonesia still exceeding these standards at certain times.

Second sampling location was 25 meters away from composting chamber. The concentration of bacteria and fungi at second point 2 is influenced by the number of bacteria and fungi in the air and conditions of surroundings area. This is due to the fact that there are waste temporary shelters around the area. So that the concentration of bioaerosol at this point has the potential to partly come from the bioaerosol content of the garbage collection site. In addition, this location is also a parking area. So, when the sampling was done it could be affected by the traffic that occurred at that time. The maximum concentration of bioaerosol at this point is 2402.8 CFU / m³. It is still the same as the condition at first point where the concentration occurs at the 3rd day of composting process. With a maximum number of colonies is 69 colonies. This value is also relatively small to be compared with the provisions of law mention above.

The concentration of bacteria and fungi at the third sampling location, namely in the area around the front of the Manufacturing Research Center which is about 60 meters from the composting chamber is influenced by the number of bacteria and fungi in the air and the surrounding conditions. Around this area there are parking areas. Thus, the concentration of bioaerosol at this point is potentially derived in part from the content of bioaerosol from traffic occurred or from the surrounding area. The maximum concentration of bioaerosol at this point is 2102.4 CFU / m³. This maximum concentration occurs during the composting period of the 3rd day. With a maximum number of colonies of 75 colonies. This value is quite small when compared with the provisions of law mention above.

In general, factors for the spread of microorganisms in the air are aerodynamics, air humidity, electrostatic effect, motion scale, temperature and pressure [9]. In this study will focus on air humidity and temperature. Figure 2 and 3 show relationship of air humidity with gram-positive bacteria and fungi respectively. Bioaerosol distribution is related to air humidity, especially for fungi. Because of their small physical size and large surface area, this causes microorganisms to increase in number when exposed to changes in relative humidity. A sample will have more bioaerosol content if the sample has higher relative humidity. When there is relatively higher air conditions, the concentration of bioaerosol tends to rise as well. When there is an increase in humidity, the concentration of bioaerosol will tend to decrease and vice versa. On days 0 through 14, the corresponding relationship between higher air humidity results in decreased fungi concentration. However, on days 30 to 60 the humidity does not affect the concentration of bioaerosol concentrations in accordance with the relationship stated earlier (fungi concentrations continue to decrease). This is caused by a situation where on the 30th day the number of bacterial and fungal colonies at this point is getting smaller. Similar to what happened at the second and third test points, where ideally air humidity will affect the concentration of microorganisms, especially fungi. However, decreased bioaerosol concentrations do not have to follow the pattern of the relationship due to various other factors that can affect the distribution of microorganisms in the air. For example, from human activities and other objects that are sources of increasing or decreasing the concentration of bioaerosol.

Based on the linear regression test the relationship of air humidity to the concentration of bioaerosol, resulting R² of 0.021 for gram-positive bacteria and 0.165 for fungi. This R² value does not show the correlation between the influence of air humidity on the concentration of bacteria and fungi.
in the air. However, it is separately known that the higher the humidity of the air, the higher the water vapor in the air which affects the distribution of microorganisms in the air.

Figure 2. Relationship of air humidity with (a) gram-positive bacteria and (b) fungi

Another important factor in the distribution of microorganisms in the air is temperature. Where microorganisms have the optimum temperature for growth [10]. At this optimum temperature, the microorganism can reach its peak growth conditions. Figure 3 show relationship of temperature with gram-positive bacteria and fungi respectively.

Bioaerosol concentration at the first sampling point is not expected to be too affected by the surrounding conditions, due to its location (indoor). When there is an increase in temperature, the concentration of gram-positive bacteria tends to increase. While the concentration of fungi does not follow this pattern. However, bacterial concentrations in this study do not follow this pattern. This is thought to be influenced by bioaerosol around second sampling point where the location is located not far from a waste temporary shelters. So the influence of air temperature does not have a significant impact due to other factors which also affect the spread of microorganisms here. The relationship between temperature is less visible in relation to the distribution of air microorganisms at the third sampling point. It is difficult to conclude its effect on the presence of microorganisms due to the location of this point is quite far from the composting facility so that the age of compost is not a binding factor. At this point, the existence of humans and other objects and their activities can be a big influence.

Based on the linear regression test the relationship of air temperature to the concentration of bioaerosol, resulting in an R2 of -0.163 for fungi and -0.001 for gram-positive bacteria. The results of this regression show wrong results because the value of R2 is negative, while the value of R2 should always be positive. Thus, the relationship between air temperature and the concentration of bacteria and fungi in the air cannot be drawn. This is estimated due to various external factors that also influence it. For example from human activities and so on. In fact, bacteria are more likely to live at higher temperatures than fungi.

Figure 3. Relationship of temperature with (a) gram-positive bacteria and (b) fungi
4. Conclusion
The presented study shows that the presence of composting activities has an influence on increasing the concentration of bioaerosol in the form of gram-positive bacteria and fungi around the composting site. The distance from the composting facility also influences the concentration of bioaerosol at the sampling point. The farther from the location of the composting facility will be the smaller number of air microorganisms that exist there apart from other factors that can affect the concentration of bioaerosol.

The influence of air physical parameters namely temperature and humidity is less visible in influencing the concentration of bioaerosol at the test point. However, the theory is that air humidity helps increase the concentration of bioaerosol, especially fungi. When there is a decrease in air humidity there will be a decrease in the concentration of bioaerosol and vice versa.

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