The air quality index based on measurements of mobile air quality monitoring station at the waste-to-energy incineration plant PLTSa Bantargebang

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Abstract. Ambient air quality monitoring at waste-to-energy incineration pilot plant PLTSa Bantargebang is performed using a mobile monitoring station. The mobile monitoring station is equipped with meteorological and emission (CO, O₃, NO₂, PM₁₀, PM₂.₅, and SO₂) measurement. The monitoring was performed for 24 hour with 1 minute intervals. The emission measurement data was analyzed using Indonesian Air pollution standard index regulation (PermenLHK P.14/2020). The CO, O₃, NO₂, PM₁₀, and SO₂ index were in good category (1-50), while the PM₂.₅ index was classified as moderate (65.992). The results show that the air quality at PLTSa Bantargebang is still acceptable for human health.

1. Introduction
Waste-to-energy incineration pilot plant, PLTSa Bantargebang, located in Bantergebang, Bekasi, Indonesia. The pilot plant was built from 2018 to 2019. It start operated 24 hours a day in 2020. It was built, as an alternative technology to reduce the amount of waste, in a short period of time and also be less harmful for the environment. The capacity of this pilot plant is 100 tpd with maximum power generation of 700 kW [1]. The electricity produced by this plant was used to meet internal plant consumption needs.

Burning waste generates ash and flue gas. They should be treated before being released to the surrounding. The ash is considered as a non-dangerous material, according to the regulation [2], therefore it can be used as a useful material. In PLTSa Bantargebang, it is used as a material for making paving block. The generated flue gas was treated by an air pollution control system, which consists of a quencher, chemical injections (slaked lime and carbon), and a bag filter, to reduce acid gases, dioxin, furan, particulate, and other toxic emissions. Research on environmental disease and health as direct impact of waste to energy incineration shows that monitoring of the pollutant source is more important and real to do so it will ensure safety. Those understandings come since there is no known evidence of the direct impact [3–5].

The stack emission of PLTSa Bantargebang was monitored periodically once a month according to the regulation [6]. Besides stack emissions, the ambient air quality around PLTSa Bantargebang is also monitored since it is also considered as a source of air pollutants. It is all to ensure that the emission is not harmful to humans and the surrounding environment. Measurement of ambient air quality in 2020
showed that all of the measurement locations give a lower value than the limit. However, the monitoring does not indicate whether it is harmful or not especially for the human health, therefore it is necessary to identify the air pollution index.

Regulation of the Minister of Environment and Forestry of The Republic of Indonesia Number P.14/2020 (PermenLHK No. P.14/2020) [7] states that the definition of air pollution index is a value that represents the ambient air quality which considers its impact on human health and estetic value for other creatures. The identification can be done by measuring gas pollution using static or mobile station. The method for determining the air pollution index is described and regulated in PermenLHK No. P.14/2020. There is no static station in the area around PLTSa Bantargebang so measurement was done using a mobile monitoring station. The use of mobile monitoring station is known and it gives more specific measurements results for a source of pollutants, for example, an area near a high way [8,9]. The purpose of this study is to monitor ambient air quality at the waste-to-energy incineration plant PLTSa Bantargebang, using mobile monitoring. In addition, indexes are calculated to evaluate air quality according to the Ministry of Environment and Forestry Regulation PermenLHK No. P.14/2020 to know how much impact the emission has on the ambient air quality.

2. Methods
Ambient air quality monitoring at waste-to-energy incineration pilot plant PLTSa Bantargebang is performed using a mobile monitoring station. The mobile monitoring station is equipped with pollutant analyzer to monitor CO, O₃, NO₂, PM₁₀, PM₂.₅, and SO₂. It also have an instruments that can measure meteorological parameters such as wind speed, wind direction, ambient temperature, and atmospheric pressure. The meteorological data it used to corrected the gas species concentration measurement in the analysis. The ambient air quality monitoring data was then used to calculate the air pollution index according to the regulation of PermenLHK P.14/2020 regarding air pollution standard index. The measurement should be perfomed continously for 24 hours.

2.1. Mobile monitoring specification
Mobile monitoring is basically a modified truck which installed with an air quality monitoring system (AQMS). This study used AP-370 series from Horiba which consists of APMA-370 (Ambient CO Monitor), APSA-370 (Ambient SO₂ Monitor), APNA-370 (Ambient NOₓ Monitor), APOA-370 (Ambient O₃ Monitor). The measurement range of CO, SO₂, NOₓ and O₃ was 0-10/20/50/100 ppm, 0-0.05/0.1/0.2/0.5 ppm, and 0 - 0.1/0.2/0.5/1.0 ppm. PM₁₀ and PM₂.₅, were monitored using Air Pollution Monitor 2 (APM-2) from Comde-Derenda,which has measurement range of 0-1000 μg/m³. This mobile monitoring also equipped with Air Pollution Multigas Calibrator (APMC)-370 to calibrate the gas analyzer for its quality assurance.

2.2. Measurements and Data Processing
Measurements were conducted inside Waste to Energy PLTSa Bantargebang area. The measurement point was -6.351°N/106.997°E and was done for 2 days from 12 to 13 April 2021. The data then downloaded from instrument data logger within 1 minute intervals form each others. The data measured during preparation were removed to minimize the effect of travel and preparation of measurements on the data. From this process, the used data starts from 11 am, 12 April until 11 am, 13 April 2021. The total number of data is 1441 sets which consist of time, atmosphere pressure, temperature, humidity, wind direction, wind speed, and species concentration. Data processing starts from data correction for the each data using standard temperature and pressure condition. The corrected data need to be converted to the μg/m³ to calculate the index. The index is then calculated according to the guideline of PermenLHK P.14/2020.

2.3. Determine the air pollutant index
The air pollution index is determined using equation
$$I_{aq} = \frac{(I_{ul} - I_{ll})(x_{av} - x_{ll})}{(x_{ul} - x_{ll})} + I_{ll}$$

(1)

Which $I_{aq}$ is the calculated air pollution index, $I_{ul}$ for upper limit species index, $I_{ll}$ for the lower limit species index, $x_{ul}$ for the upper limit species concentration, $x_{ll}$ for the lower limit species concentration, and $x_{av}$ for the average corrected species concentration. If the index within 1-50 then it is considered as good air quality, 51-100 is moderate, 101-200 is unhealthy, 201-300 is very unhealthy, and higher 300 is considered as dangerous.

3. Results and Discussions
3.1. Mobile monitoring results
The species concentration measured were CO, O\textsubscript{3}, NO\textsubscript{2}, PM\textsubscript{10}, PM\textsubscript{2.5}, and SO\textsubscript{2}. The concentration data were corrected based on the meteorological condition at the time of measurement. The corrected data are shown in Figure 1 and Figure 2. Figure 1 compares the monitoring results of CO, NO\textsubscript{2}, SO\textsubscript{2} and O\textsubscript{3} concentration.

![Figure 1. CO, NO\textsubscript{2}, SO\textsubscript{2} and O\textsubscript{3} concentration](image)

The concentration of CO in the beginning of monitoring was between 500 – 1000 µg/m\textsuperscript{3}. The concentration was relatively stable from afternoon until the next day morning. Figure 1 shows that after 5 am, the concentration of CO climbs up and reaches the maximum point until 2500 µg/m\textsuperscript{3}. The concentration then goes down again after reaching the maximum point. Other species, SO\textsubscript{2}, O\textsubscript{3}, and NO\textsubscript{2}
have relatively stable trend and the value is below 500 µg/m³. The concentration of CO in the ambient air was relatively higher than others. When compared with [10], the maximum values of CO, SO₂, O₃, and NO₃ in the area around the PLTSa Bantargebang are higher than measurements in urban areas such as Bogor and Cibereum. It can be said that the air condition in the PLTSa Bantargebang area looks more polluted when compared to urban areas.

Figure 2. PM₁₀ and PM₂.₅ concentration

PM₁₀ and PM₂.₅ are shown in Figure 2. Both concentrations fluctuated depending on the time. Figure 2 shows that in the morning, both of them go up until 8 am, then go down from 12 – 13 pm and rise again until 17 pm. For the concentration, both species in the ambient were relatively same below 120 µg/m³. When compared with [10], the maximum PM₁₀ and PM₂.₅ values in the PLTSa Bantargebang are higher than the measurement results in the cities of Bogor and Cibereum. However, when compared to the literature[11–13], the measured PM concentration around the PLTSa Bantargebang area is lower than some measurements in areas related to the transportation routes. This is due to the location of the PLTSa Bantargebang which is far from the highway and only traversed by garbage trucks. It can be said that PM as measured from waste processing activities is lower than transportation but higher than urban areas.

3.2. Air pollution standard index identification

Air pollution standard index was calculated by using the equation (1). The index based on 24 hours measurements. The results are shown in Table 1. Most of the parameters were in the good category results. Those species are CO, NO₂, O₃, SO₂, and PM₁₀. The index value was in the range of 9 – 50. The highest concentration CO has low index value, which mean that the concentration is considerably low compared to the standard. PM₂.₅ has different results which were in moderate category although concentration itself was relatively similar with PM₁₀.

|      | CO   | NO₂  | O₃   | SO₂  | PM₁₀ | PM₂.₅ |
|------|------|------|------|------|------|-------|
| Index| 9.862| 36.239| 45.555| 36.109| 38.843| 65.992|
| Category| good | good | good | good | good | moderate |

3.3. Discussions

The concentration of all parameters was found to be fluctuated for several reason, such as pollution form landfill equipment activity and transportation near the PLTS. Beside that, the graph also show that concentration for all parameters in the morning were much higher compared to the night. It is possible
because of the effect of operational hours in other division in Integrated Waste Management Site (UPST) Bantargebang. Moreover, the value of PM in the monitoring was also affected by the monitoring point. The measurement was conducted near the fly ash silo, it is possible that the fly ash handling caused the PM monitoring value to be higher. It means, the monitoring results also can be used as a warning. So that ash handling area should be labeled as risk area.

Identification of the Index shows that all parameter have a good air pollution index. The good index means that the concentration is low and it is healthy for people to do activity. The moderate index means the condition is still acceptable to do activity. The activity around PLTSa Bantargebang such as operational equipment, waste combustion process monitoring, air pollution control monitoring and ash handling need to be care off. The people who have high potential impact in long term mainly are the workers. Although the index shows that it is still acceptable to do activity, but the impact need to be minimized by providing mask and encouraging workers for always using it.

4. Conclusion
Monitoring ambient air quality at the waste-to-energy incineration plant PLTSa Bantargebang is carried out using mobile monitoring for CO, O₃, NO₂, PM₁₀, PM₂.₅, and SO₂. The emission measurement data were analyzed using the Indonesian Air pollution standard index regulation (PermenLHK P.14/2020). The results show that the CO, O₃, NO₂, PM₁₀, and SO₂ indexes were in the good category (1-50), while the PM₂.₅ index was classified as moderate (65.992). Based on this category, the air quality at PLTSa Bantargebang is still acceptable for human health.

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