Air Pollutant of PM10 and PM2.5 on Air Quality Index in Business Center Kota Baru Parahyangan, West Bandung District

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ABSTRACT
Kota Baru Parahyangan is located between Cimahi City and Padalarang. As an area designed as a satellite city, Kota Baru Parahyangan has various facilities including a business centre. In the present study, PM10 and PM2.5 will be measured at three business centres and one residential location located at the southernmost point for comparison. Data collection was carried out on 2 weekdays, namely Monday and Tuesday, and 2 weekends, namely Saturday and Sunday. The data collection time is from 08:00 to 15:30, where data collection is carried out every 30 minutes. Based on these measurements, PM10 and PM2.5 concentrations in three business centre locations and 1 residential location are still under the PPRI No. 22 of 2021 standards. Meanwhile, when evaluated using Kepmen LHK No. 14 of 2020, the API level for PM10 in three business centre locations and 1 residential location is in the "Good" category. However, the API level for PM2.5 in three business centre locations and 1 residential has reached the "Moderate" category. This means that the concentration of PM2.5 in business centre and residential in Kota Baru Parahyangan should be seriously considered by developer and local government. Because it is confirmed that PM2.5 concentrations will continue to increase over time with increasing activity and an increase in the number of vehicles passing through a region.

KEYWORDS
Air quality
Air pollution index
Kota Baru Parahyangan
PM10
PM2.5

INTRODUCTION
The development of Kota Baru Parahyangan was started in 2000 by PT Lyman Property. The location of Kota Baru Parahyangan is in the west of Cimahi City, located between Cimahi City and Padalarang. As an area designed as a satellite city, almost all facilities that are appropriate in a big city are also available in Kota Baru Parahyangan. Rapid development in an area will be followed by an increase in the number of vehicles passing through the area. The consequence of the increase in the number of vehicles will be followed by an increase in PM10 and PM2.5...
concentrations, because one of the main sources of PM10 and PM2.5 pollutants is from motor vehicle emissions [1], [2], [3].

The concentration of PM10 and PM2.5 in the air is one of the pollutant parameters that can be used to evaluate whether the area is polluted or un-polluted. For this reason, several countries have issued standards for PM10 and PM2.5. For Indonesia, it currently uses the PPRI No. 22 of 2021 standard [4]. Meanwhile, to evaluate the air pollution index in an area, the Minister of Environment and Forestry Regulation (Permen) No. 14 of 2020 is utilized [5]. Furthermore, the World Health Organization (WHO) also issued standards in 2021 [6]. The existence of PM10 and PM2.5 standards from various countries and from WHO is to protect the public from air pollution in one area. This is because based on research on experts found a link between specific diseases [7], [8], [9], [10] and increased mortality due to air pollution in an area [11], [12].

Based on research by experts, the percentage of PM2.5 particulate deposition in the lungs is more than that of PM10 [13], [14], which causes the PM2.5 standard to be smaller than that of PM10. For instance, according to PPRI No. 22 Year 2021 [4], the standard for PM10 is 75 µg/m³, while for PM2.5 is 55 µg/m³. On the other hand, PM2.5 is part of PM10, so in measurements, the concentration of PM10 is always higher than that of PM2.5. For the same concentration, PM2.5 is more harmful than PM10 when inhaled. Increased cases of acute respiratory infections (ARI) are early indicators of PM10 and PM2.5 pollution in affected areas [15], [16], [17].

The impact of PM10 and PM2.5 on human health depends on the content of the constituent particles or what is contained in these particulates [18], [19], [20]. As a relatively new satellite city, air quality monitoring throughout the Kota Baru Parahyangan area should be carried out regularly. Air quality monitoring is to prevent air quality in the Kota Baru Parahyangan area from experiencing a severe decline in air quality as has been experienced by several major cities in Indonesia [21], China and India [22], [23], [24], [25]. Efforts to reduce pollution from PM10 and PM2.5 have been made by several experts including Yang et al. [24] and Belias & Licina [25].

The purpose of this study is to measure the concentration of PM10 and PM2.5 and evaluate the air quality in the central business district of Kota Baru Parahyangan based on the measurement results of these particulate concentrations. Evaluation of air quality in the area is based on Permen No. 14 of 2020 [4], WHO standards [6], and by using the air pollution index (API) [5].

LOCATIONS AND METHOD

There are 4 PM10 and PM2.5 measurement locations, where the three points are considered to represent the business centre, and one point outside the business centre, namely in a residential area located south of the Kota Baru Parahyangan shopping centre. The three business centres are the locations around Mason Pine hotel (location 1), Kawaluyan hospital (location 2), and IKEA shopping centre (location 3), while the residential area is as location 4. The measurement locations of PM10 and PM2.5 concentrations at the four locations are shown in Figure 1. Of the four measurement locations shown in the figure, point 3 is the busiest location, as there is a large shopping centre (IKEA) and culinary centre storehouses. While location 4 represents a residential area where it is considered that the concentration levels of PM10 and PM2.5 are under the business centre.
Data collection was carried out for 4 days, namely 2 days on weekdays, namely Monday and Tuesday, and 2 days on weekends, namely Saturday and Sunday. Data collection time starts from 08.00 to 15.30, where data was taken every 30 minutes. PM10 and PM2.5 concentrations were measured with a particle counter HT-9600. The results of PM10 and PM2.5 measurements at the four locations will be evaluated using two Indonesian standards, namely PP No. 22 of 2021 [4], and Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.14/MENLHK/SETJEN/KUM.1/7/2020 (Kepmen LHK No. 14 of 2020) [5], as well as WHO [6]. To be evaluated using Kepmen No. 14 of 2020 (5), the measurement results at the four locations must be calculated using equation (1). Using equation (1), the air pollution index (API) value for each measurement location will be determined. Based on Kepmen No. 14 of 2020, the API value is divided into 5 categories, namely "Good", "Moderate", "Unhealthy", Very Unhealthy", and "Hazardous".

Table 1. Standards of PM10 and PM2.5 according to Indonesia & WHO standards [4], [6]

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Time</th>
<th>PPRI No. 22, 2021</th>
<th>WHO (2021)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10</td>
<td>24-hour</td>
<td>75</td>
<td>45</td>
</tr>
<tr>
<td>PM2.5</td>
<td>24-hour</td>
<td>55</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 2. API levels and the categories [5]

<table>
<thead>
<tr>
<th>Category</th>
<th>Color</th>
<th>API Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Green</td>
<td>1 – 50</td>
</tr>
<tr>
<td>Moderate</td>
<td>Blue</td>
<td>51 –100</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>Yellow</td>
<td>101 – 200</td>
</tr>
<tr>
<td>Very Unhealthy</td>
<td>Red</td>
<td>201 – 300</td>
</tr>
<tr>
<td>Hazardous</td>
<td>Black</td>
<td>≥ 301</td>
</tr>
</tbody>
</table>

\[
API = \frac{(l_a - l_b)}{(X_a - X_b)}(X_x - X_b) \tag{1}
\]

where,
API = API Level
\(I_a\) = PSI level top limit
\(I_b\) = PSI level bottom limit
\(X_a\) = Ambient concentration top limit (µg/m³)
\(X_b\) = Ambient concentration bottom limit (µg/m³)
\(X_x\) = Measured concentration (µg/m³)
RESULT AND DISCUSSION

Concentrations and API Levels of PM10

The results of PM10 concentration measurements at 3 business centres and 1 residential location are shown in Figure 2. In the figure, the standard of PPRI No. 22 Year 2021 [4] presented in Table 1 for PM10 is 75 µg/m³ indicated by the red dash line. It can also be seen that the concentration in 3 business centre locations and 1 residential location for 4 days of data collection is still below the PPRI No. 22 Year 2021 standard [4]. This means that in terms of PM10 pollutants, air quality in business and residential centres in Kota Baru Parahyangan is still in good condition or not being polluted.

Figure 2 shows that the highest PM10 concentrations occur at location 1, which is adjacent to the Mason Pine Hotel, both on weekdays and weekends. The figure also shows that PM10 concentrations in business and residential centres on both weekdays are lower than those on both weekends. For example, at location 3, which is the most crowded location on weekdays (IKEA area), the PM10 concentrations on Monday and Tuesday were 25 µg/m³ and 19 µg/m³, respectively. On weekends, i.e. on Saturday and Sunday, the PM10 concentration at point 3 increased to 33 µg/m³ and 31 µg/m³, respectively. The most interesting thing happened at location 4, which is a residential area, where there was a significant increase on Sunday, from 19 µg/m³ (Tuesday) and 25 µg/m³ (Saturday) to 39 µg/m³ on Sunday. The high concentration of PM10 at Site 4 on Sunday compared to other days may be because on Sunday, residents do more activities in their neighbourhoods. Whereas on Monday, Tuesday and Saturday, residents do more activities outside their homes. But even though there was a significant increase at location 4 on Sunday, the PM10 concentration at that location was still far under the PPRI No. 22 of 2021 standard [4].

Furthermore, the PM10 measurement results at the four locations in Figure 2 will be evaluated using the more stringent WHO standard [6]. As seen in Table 1, the WHO standard is 45 µg/m³ [6], which is indicated by the green dashed line. From Figure 2, the PM10 concentrations at the four locations, both on weekdays and weekends, are still under the WHO standard. This means that it proves that the Kota Baru Parahyangan area has not been polluted by PM10.
Figure 2. PM10 concentrations at 4 locations for 4 days

Figure 3. Air Pollution Index (API) of PM10 at 4 locations for 4 days

PPRI No. 22 of 2021 [4] and WHO standards [6] only provide two categories of information about air quality in an area. If the PM10 concentration is still under the standard, the air quality in the area is not yet polluted, and vice versa if the concentration is above the standard, the air in the area is polluted. The regulation of Kepmen No. 14 of 2020 [5] governs more varied air quality in an area, which consists of five categories as seen in Table 2. Figure 3 displays the API level for 4 days of measurement at 4 locations. From the figure, the API level of PM10 for all locations is still categorized as "Good", both on weekdays and weekends. The API level limit for the "Good" category is 50, as shown by the green dashed line. Meanwhile, based on calculations using equation (1) and the PM10 measurement results in Figure 2, the API levels for all measurement locations are in the "Good" category. In other words, locations 1 to 4 still have good or healthy air quality from PM10 pollutants, both during weekdays and weekends.
Concentrations and API Levels of PM2.5

It has been explained above that 4 locations in Kota Baru Parahyangan have not been polluted by PM10. Furthermore, it will be discussed whether the 4 locations are also free from PM2.5 pollution? The results of PM2.5 concentration measurements at 4 locations are shown in Figure 4. From the figure, the PM2.5 concentration is still below the PPRI No. 22 of 2021 standard, where based on this standard, the PM2.5 concentration threshold is 55 µg/m³, as shown by the red dashed line. However, when evaluated using the WHO standard [6], which is 15 µg/m³, shown by the green dash line, PM2.5 concentrations in 4 locations are above the standard. The WHO standard is much lower than PPRI No. 22 of 2021 because based on their research, PM2.5 concentration thresholds below 15 µg/m³ are healthy for people living in affected areas. Meanwhile, PM2.5 thresholds above 15 µg/m³ still have the potential to cause specific diseases in the community [2], [14], [15].

In Figure 4, the highest concentration of PM2.5 during the 4 days of measurement occurred at location 1, which is near the Mason Pine Hotel. The reason for this is unknown, even though the area at location 1 is not as busy as location 3 (shopping centre). This of course still requires further research to investigate this phenomenon. The figure also shows that weekdays are relatively lower than weekends at all four locations. The lowest concentration occurs at location 4 or the residential location for Monday, Tuesday, and Saturday. However, the highest increase in PM2.5 concentration occurred at location 4 on Sunday, where on Saturday the concentration was only 22 µg/m³ to 36 µg/m³ on Sunday. The concentration at location 4 (residential) on Sunday was higher than location 3 (shopping centre). The increase on Sunday at location 4 may be due to the activities of residential residents who are busier than usual. These data show that PM2.5 concentrations in crowded centres are not always higher than in residential areas. In fact, sometimes PM2.5 concentrations in residential locations are higher than in shopping centres.

In contrast to the evaluation using the PPRI No. 22 Year 2021 standard [4], where PM2.5 concentrations at all locations are still below the standard, as seen in Figure 4. However, when evaluated with the Kepmen No. 14 Year 2020 standard [5], the API level for all locations is above the "Good" category and is in the "Moderate" category, as seen in Figure 5. Based on this figure,
locations 1, 2 and 3, are in the "Moderate" category, this is understandable because the three locations are business centres. However, the "Moderate" category for residential locations (location 4), this should receive attention from the related stakeholders, because generally most of the time people live in residences rather than in business centres. This means that if someone breathes air with the "Moderate" category for a long duration, then in the long run the residents will be at risk of being affected by pollutants. This is the basis why the WHO standard [6] uses a low concentration of PM2.5, namely 15 µg/m³, so that residents in an area or housing are safe from potential diseases due to polluted air from PM2.5. As explained above, PM2.5 is more harmful to human respiration than PM10, because the percentage of PM2.5 deposition in the lungs is higher than that of PM10 [13], [14], [25].

Based on the API level for PM2.5 as shown in Figure 5, where the "Moderate" category also occurs in residential areas, both on weekdays and weekends. This should receive attention from both the developer and the residents in the area, so that PM2.5 concentrations can be reduced. Otherwise, it will be disadvantageous to the residents in the long run.

Based on pollutant size, PM2.5 is part of PM10. This means that when PM10 concentrations are obtained from measurements, most of the PM10 is less than 2.5 µm in diameter. The percentage of PM2.5 to PM10 is shown in Figure 6. From the figure, the percentage of PM2.5/PM10 is quite high, more than 80%. This means that most of the pollutants in the 4 locations are less than 2.5 µm in diameter. In terms of impact on human health, a high percentage of PM2.5/PM10 is riskier, as PM2.5 is more easily absorbed into the lungs compared to PM10 [13], [25].
Figure 6 illustrates that the percentage of PM2.5 to PM10 on weekdays and weekends is relatively the same, which is above 80%. The highest percentage was 92%, which occurred on Monday at location 3 (shopping center) and on Sunday at location 4 (residential). The high percentage of PM2.5 to PM10 certainly needs to be a concern, hence the need for efforts to reduce it. Reduction efforts include reducing the volume of fossil fuel vehicles passing by and reforesting the affected areas, because the leaves of plants could absorb PM2.5 and PM10 particulates [24], [25].

CONCLUSION

Based on the evaluation using PPRI No. 22 of 2021 and WHO (2021), the results of PM10 measurements at three locations of business centres and one residential location in Kota Baru Parahyangan show that in general the air quality in the area is relatively unpolluted. While the results of PM2.5 measurements in four locations show results still under the PPRI No. 22 of 2021 standard, but above the WHO standard. This means that developers, residents, and local governments must work together to reduce PM2.5 concentrations in the Kota Baru Parahyangan region.

Evaluation using the API (Air Pollution Index) for PM10, at 4 locations showed air quality in the "Good" category. However, the API level for PM2.5 shows that the 4 locations in Kota Baru Parahyangan are in the "Moderate" category. The lowest and highest average API levels for PM2.5 occurred on Tuesday and Sunday, respectively. One of strategies to reduce PM10 and PM2.5 concentrations in the Kota Baru Parahyangan area is to plant trees and to limit the volume of fossil fuel vehicles passing through the business centre and replace with electric vehicles.

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