PARTICULATE PM$_{2.5}$ AND PM$_{10}$ CHARACTERISTIC IN SUB URBAN AREA (CASE STUDY : PADALARANG)

KARAKTERISTIK PARTIKULAT PM$_{2.5}$ DAN PM$_{10}$ DI WILAYAH SUB URBAN (STUDI KASUS : PADALARANG)

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Abstract: Padalarang constitutes suburban’s region at Bandung Regency where exists a lot of human activity who can get contribution on particulate concentration who is at that region. Particulate sources not only comes from human activities (anthropogenic), but also of natural source as soil. At Padalarang’s region there are many available activity which ascendant on be formed particulate in midair as Kota Baru Parahyangan development project, limestone mining, motor vehicle activity, and people activity at that territorial. That activity gets to result particulate in midair and going to transport to the other place. Particulate concentration that exceed quality standard could some effect to people health especially inhalable particle as PM$_{10}$ and PM$_{2.5}$. Particulate’s sample gathering with Mini Volume Portable Air Sampler and then to be analysed its characteristic in this case concentration and black carbon. From analysis result are gotten average concentration PM$_{10}$ and PM$_{2.5}$ each 85.24 µg/Nm$^3$ dan 68.51 µg/Nm$^3$. Black carbon’s analysis in PM$_{2.5}$ get concentration result as big as 37 – 118 µg/Nm$^3$ with percentage average BC on PM$_{2.5}$ are 10.6%. Source from particulate and black carbon is estimated comes from source sorrounding sampling location among those Kota Baru parahyangan development project, industry at Cipendeuy, limestone mining, and traffic and transportation according to meteorological condition as long as sampling period.

Key words: Padalarang, particulate, concentration, black carbon, meteorological condition

Abstrak: Padalarang merupakan wilayah suburban di Kabupaten Bandung dimana terdapat banyak aktivitas manusia yang dapat berkontribusi pada konsentrasi partikulat yang ada di wilayah tersebut. Sumber-sumber partikulat tidak hanya berasal dari aktivitas manusia (antropogenik), tetapi juga dari sumber alamiah seperti tanah. Di wilayah Padalarang banyak terdapat aktivitas yang berpengaruh pada terbentuknya partikulat di udara seperti proyek pembangunan Kota Baru Parahyangan, penambangan batu kapur, aktivitas kendaraan bermotor, serta dari aktivitas masyarakat di wilayah tersebut. Aktivitas tersebut dapat menghasilkan partikulat di udara dan dapat mengalami transport ke tempat yang lain. Partikulat dalam konsentrasi yang melebihi baku mutu dapat mengganggu kesehatan manusia terutama partikel yang inhalable seperti PM$_{10}$ dan PM$_{2.5}$. Sampel partikulat dikumpulkan menggunakan alat Mini Volume Portable Air Sampler untuk kemudian dianalisa karakteristiknya dalam hal ini konsentrasi dan black carbon. Dari hasil analisa diperoleh konsentrasi rata-rata PM$_{10}$ dan PM$_{2.5}$ masing-masing 85,24 µg/Nm$^3$ dan 68,51 µg/Nm$^3$. Analisa black carbon terhadap PM$_{2.5}$ memperoleh hasil konsentrasi sebesar 37 – 118 µg/Nm$^3$ dengan persentase rata-rata BC pada PM$_{2.5}$ adalah 10,6%. Sumber dari partikulat dan black carbon diperkirakan berasal dari sumber di sekitar lokasi sampling diantaranya proyek pembangunan Kota Baru Parahyangan, industri di Cipendeuy, penambangan batu kapur, serta lalu lintas dan transportasi berdasarkan pula pada kondisi meteorologi selama waktu sampling.

Kata kunci: Padalarang, partikulat, konsentrasi, black carbon, kondisi meteorologi
INTRODUCTION

Particulate matter (PM) refers to the solid and liquid particles that are dispersed into ambient air (Vallius, 2005). These particles can be classified in several ways. Firstly, they can be classified into primary and secondary particles based on the mechanism of their formation. PM is called “primary” if it is in form in which it was emitted into the atmosphere, but it is called “secondary” if it is formed by chemical reaction in the atmosphere (US EPA, 2004). Secondly, particles can be classified by their physical size. Particle size is normally given as the aerodynamic diameter, which refers to the diameter of a unit density sphere of the same settling velocity as the particle in question. The notation PM$_x$ refers to particulate matter comprising particles less than $x$ µm in diameter. In this case, there are PM$_{10}$ refers to particles less then 10 µm in diameter (Sharma, 1994; Chelani, 2005) and PM$_{2.5}$ which refers to particles less then 2.5 µm in diameter (Tsai, 2004; Lei, 2004).

Particulate existance in ambient air caused negative effects to human health. According to Soedomo, air pollution because of dust particles usually cause chronic respiratory disease as bronchitis chronic, lung enphisema, bronchial’s ashtma, and even lung cancer. Besides halth effects, particles also impacted in distortion in visibility (Manahan, 1994). According to Manahan, particle among 0.1 – 1 µm cause interference phenomenon because that particle have same dimension with visible light wavelenght, so gets to cause light dispersion significantly. Besides that, exposure from suspended particulate matter (SPM) and specially PM$_{2.5}$ in ambient air causing 4 – 8% premature death (Ravindra, 2008).

Particulate in midair comes from different sources. To identify source of particulate at a region, we can see through particulate's chemical characteristic and then can be modelled so we can get source proportion on particulate concentrates at that territorial. One of the model we can use is receptor modelling which is a model to identify and quantify source contribution to the receptor.

The purpose of this research is to be know the characteristic from particulate with objective to know the particulate's source. Besides that, seen also meteorological factor that affected to particulate motion from its source to the receptor.

Research is done at Kertajaya's Village, Padalarang's district as shown in Figure 1.
METHODOLOGY

The methodology of this research can be seen in Figure 2 below.

Methodology of this research consisting of five main stages. First step which is initial survey that consisting of research location determining, secondary data collecting (meteorology and topography), parameter determining, sampling tool, and sampling duration. Research location determination is determined bases sampling location requisites at sub urban territorial
terminologicals literature (Noll, 1977). Historical meteorology data which is on year 2007 acquired of Meteorological and Geophysics Institute (BMG) Husein Sastranegara's Airport. Second stage is collecting sample. Particulate's sample is taken by using Mini Volume Portable Air Sampler and filter type Mixed Cellulose is Ester with diameter measure 47 mm and pore measure 0.8 µm, wind speed data took by anemometer tool, humidity and air temperature is taken with sling phycrometer's tool. Hereafter been done laboratory analysis to know particulate's concentration and particulate's characteristic as black carbon concentration.

RESULT AND DISCUSSION

Meteorological Analysis
Following is historical meteorology data Bandung region acquired from Meteorological and Geophysics Institute Husein Sastranegara's Airport on year 2007. This meteorology data for Bandung's region and sorrounding including Padalarang. This meteorology data is utilized to see wind move trend up to year 2007 to estimate before do data collecting, to which aims wind blown so can estimate particulate's source approximately comes from which location. Direction and wind speed data was plotted by using software WRPLOT in windrose form as can be seen on Figure 3.

From this windrose figure upon, largely wind blows from west and west south west with average wind speed is 2.1 m/s.

For meteorology data after sampling can be seen on Figure 4 followings.
During sample collecting, dominant wind blows of East and West with average speed 1.14 m/s. From that windrose apparently wind blows dominant of West and East so we can assumed particulate's source at sampling location (Kertajaya's village, Padalarang) come from East that main source of particulate pollutant which is traffic and transportation (Bandung City and Padalarang), Kota Baru Parahyangan development project, and industry at territorial Cipendeuy, and of westwards where main source possible it is of limestone mining that quite a lot available over there.

Figure 5 below show the daily meteorological data at sampling location.
Particulates Characteristic Data
After sampling, acquired particulate's characteristic as particulate's concentration and black carbon concentration. Particulate concentration measurement used Gravimetry's method (California EPA, 2002), and measurement black carbon concentration utilizes Reflectometer's tool with reflectance principle. Calculation example concentrates particulate and black carbon as follows.

**Particulate concentration**
Filter weight before sampling = 0.07204 grams
Filter weight after sampling = 0.07212 grams
Filter weight initial blank = 0.07198 grams
Filter weight end blank = 0.07170 grams
Particulate weight = 0.7212 – 0.7204 grams = 0.00008 grams
Blank weight difference = 0.7170 – 0.7198 grams = -0.00028 grams
Corrected particulate weight = 0.00008 grams – (-0.00028) grams = 0.00031 grams

Flowrate = 4.1524 lpm
Sampling time = 1446 minutes
Actual air pressure = 697.085 mmHg
Actual temperature = 298.46 Kelvin
Actual air volume = 4.1524 lpm x 1446 minutes = 6004.3 liter = 6.0043 m³
Calculate standard air volume:
\[
P_1 \times V_1 \times T_1 = P_2 \times V_2 \times T_2
\]
\[
\Rightarrow \frac{P_{std} \times V_{std}}{T_{std}} = \frac{P_{act} \times V_{act}}{T_{act}} \Rightarrow V_{std} = \frac{P_{act} \times V_{act} \times T_{std}}{P_{std} \times T_{act}}
\]
\[
=> V_{std} = \frac{697,085 \times 6,0043 \times (25 + 273)}{(25,46 + 273) \times 760}
\]
\[
=> V_{std} = \frac{697,085 \times 6,0043 \times 298}{298,46 \times 760} = 5.499 \text{ Nm}^3
\]

Particulate concentration = Corrected particulate weight / \( V_{std} \)
\[
= (0.00031 \times 10^6) \mu g / 5.499 \text{ Nm}^3
\]
\[
= 65.105 \mu g/ \text{Nm}^3
\]

Black Carbon Concentration
Standard air volume = 5.492 Nm³
Reflektometer reading result = 35.2 ; 35.3 ; 35.4 (rata-rata = 35.3)
Black carbon's mass count is gotten from AIT'S formula curve:
\[
\Rightarrow y (BC) = 4.37638 \times (-\ln ( R )) + 21.199
\]
\[
\Rightarrow y (BC) = 4.37638 \times (-\ln (35.3)) + 21.199
\]
\[
\Rightarrow y (BC) = 5.6 \mu g
\]
Black carbon concentration = \( BC / V_{std} \) = 5.6 \mu g / 5.492 Nm³ = 9.18 \mu g/ Nm³

Overall calculation result is featured on Table 1 and Table 2 below.

**Table 1.** Concentration of PM₁₀ and PM₂.5

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>PM₁₀ (µg/Nm³)</th>
<th>PM₂.5 (µg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KT 1</td>
<td>48.18</td>
<td>37.61</td>
</tr>
<tr>
<td>KT 2</td>
<td>105.31</td>
<td>79.96</td>
</tr>
<tr>
<td>KT 3</td>
<td>82.48</td>
<td>59.11</td>
</tr>
<tr>
<td>KT 5</td>
<td>101.72</td>
<td>82.17</td>
</tr>
<tr>
<td>KT 6</td>
<td>93.49</td>
<td>61.32</td>
</tr>
<tr>
<td>KT 7</td>
<td>65.11</td>
<td>55.96</td>
</tr>
<tr>
<td>KT 9</td>
<td>84.61</td>
<td>70.12</td>
</tr>
<tr>
<td>KT 10</td>
<td>77.90</td>
<td>68.58</td>
</tr>
<tr>
<td>KT 11</td>
<td>68.73</td>
<td>52.08</td>
</tr>
<tr>
<td>KT 12</td>
<td>124.87</td>
<td>118.15</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>85.24</strong></td>
<td><strong>68.51</strong></td>
</tr>
</tbody>
</table>
Table 2. Black Carbon Concentration in PM$_{2.5}$

<table>
<thead>
<tr>
<th>Code</th>
<th>C PM$_{2.5}$ µg/Nm$^3$</th>
<th>BC µg/Nm$^3$</th>
<th>% BC in PM$_{2.5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>KT 2.5-1</td>
<td>37.61</td>
<td>6.24</td>
<td>16.59</td>
</tr>
<tr>
<td>KT 2.5-2</td>
<td>79.96</td>
<td>5.28</td>
<td>6.60</td>
</tr>
<tr>
<td>KT 2.5-3</td>
<td>59.11</td>
<td>6.51</td>
<td>11.01</td>
</tr>
<tr>
<td>KT 2.5-5</td>
<td>82.17</td>
<td>9.07</td>
<td>11.04</td>
</tr>
<tr>
<td>KT 2.5-6</td>
<td>61.32</td>
<td>7.52</td>
<td>12.26</td>
</tr>
<tr>
<td>KT 2.5-7</td>
<td>55.96</td>
<td>6.58</td>
<td>11.77</td>
</tr>
<tr>
<td>KT 2.5-9</td>
<td>70.12</td>
<td>6.49</td>
<td>9.26</td>
</tr>
<tr>
<td>KT 2.5-10</td>
<td>68.58</td>
<td>6.43</td>
<td>9.38</td>
</tr>
<tr>
<td>KT 2.5-11</td>
<td>52.08</td>
<td>9.18</td>
<td>17.63</td>
</tr>
<tr>
<td>KT 2.5-12</td>
<td>118.15</td>
<td>9.03</td>
<td>7.64</td>
</tr>
</tbody>
</table>

Rata-rata 10.62

Figure 6 and Figure 7 show the calculation result of PM$_{10}$ and PM$_{2.5}$ concentration and Black Carbon on graph.

Figure 6. PM$_{10}$ and PM$_{2.5}$ Concentration

Figure 7. Black Carbon Concentration
On Figure 6 shown particulate concentrations PM2.5 and PM10. For PM10, its concentration is ranging among 48 – 125 µg/Nm³, with average 85.24 µg/Nm³. Meanwhile on PM2.5 its concentration is ranging among 37 – 118 µg/Nm³ with average 68.51 µg/Nm³. PM10 is particulate with diameter size less than 10 µm(<10 µm) and PM2.5 is particulate with size diameter less than 2.5 µm(<2.5 µm). Therefore, total particulate concentration PM10 shall ever be greater from PM2.5. Data upon have pointed out good result.

From meteorology data daily seen that wind blows from direction which that will take in particulate goes to sampling location. On day one, wind blows from northwest direction with average speed 1.18 m/s. Day second wind blows dominant from south-east with speed 1.13 m/s. Day third wind blows from south with average speed 1.15 m/s. Day fifth wind blow from northeast with average speed 1.23 m/s. Day sixth wind dominant blows from westwards with average speed 1.07 m/s. Day seventh to twelve each wind blow dominants from east, east, east and west, northeast, and south-west with average speed each 1.37; 1.32; 1.65; 0.85; and 0.91 m/s. From wind blows direction we can estimate particulate's source comes from source on that direction, e.g. from east direction are from vehicle issue at Padalarang's highway and Bandung and Kota Baru Parahyangan development project, from south and west direction from limestone mining, and from north direction from activity at Padalarang's highway. But dominantly the sources seen from meteorological are from west and east direction with average wind speed 1.14 m/s i.e. from Padalarang's highway, Kota Baru Parahyangan development project, and limestone mining.

Black carbon is one of component which exist on particulate. Particulate emission factor are generally stated for black carbon (BC) with an aerodynamic diameter of less than or equal to 2.5 µm (PM2.5) (Chung, 2005). In other words black carbon tends to associate by PM2.5, so black carbon is analysed on PM2.5 only. From analysis result, black carbon's concentration ranging among 5.28 – 9.18 µg/Nm³ with percentage average BC who exists on PM2.5 is 10.6%. That persentage was big enough. If is sighted from its source, black carbon usually stemmed from burning biomassa and fossil fuel as on diesel and gasoline engines. Sampling location nearby arterial road that passed by vehicle that is used on Kota Baru Parahyangan development project and Padalarang's highway that have density until 2000 vehicle units per hour. Besides nearby sampling location exists trail that often been passed through motor vehicle that utilized by village resident. Therefore gets to be concluded that black carbon's concentration that high enough reverential since a lot of vehicle issue around sampling location.

CONCLUSION

Mass concentration of PM10 is ranging among 48 – 125 µg/Nm³, with average 85.24 µg/Nm³. Meanwhile on PM2.5 its concentration is ranging among 37 – 118 µg/Nm³ with average 68.51 µg/Nm³.

Black carbon's concentration ranging among 37 – 118 µg / Nm³ with percentage average BC who exists on PM2.5 are 10.6%. Therefore gets to be concluded that black carbon's concentration that high enough caused by a lot of vehicle activities around sampling location.

Main source of particulate in Padalarang area including Kota Baru Parahyangan development project, limestone mining, and traffic and transportation.
REFERENCES

California Environmental Protection Agency. 2002. *Standard Operating Procedure for the Determination of PM$_{2.5}$ Mass in Ambient Air by Gravimetric Analysis*. Northern Laboratory Branch, Monitoring and Laboratory Division.


