Development of Time Correction Factors for Measurement of TSP and PM10 Ambient Concentration in Complying Indonesian Air Quality Standard

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Abstract

Short term ambient air quality standard for TSP and PM 10 either in Indonesia or in other countries has been assigned to have 24 hour averaging time. This means that the measurement should also be conducted within 24 hours. In Indonesia, according to Ministry of Environment Regulation Number 41 in 1999, method for TSP and PM10 should use a high -low volume sampler. In practical situation, many laboratories face some difficulties in fulfilling the 24 hour measurement time using this sampler. Often some laboratories neglect this condition and only measure TSP or PM10 samples for few hours, which certainly may lead to measurement inaccuracy. This research developed a practical way using time correction factor to predict the 24 hour ambient concentration by only measuring at least 2 hours to represent the 24 hours concentration. A series of 24 hours measurement for TSP and PM10 using high and low volume sampler during weekdays and weekends have been conducted in roadside sampling location in Juanda Street Bandung. Other series of two hour measurement, 12 times within 24 hours during weekdays and weekends have also been conducted, and a relation between 24 hour and 2 hour measurement were developed. This may give an easy way for field technician to measure TSP-PM10 ambient concentration in a shorter time, but able to represent a 24 hour ambient concentration.

1. Introduction

Ambient air quality sampling to measure particulate concentration are often practiced by the government, industries, or other related institution to know the status of ambient air quality in certain places, or to fulfill the regulations in air quality management. Standard method for measuring particulate (e.g., total suspended particulate - TSP, PM10), uses the active method applying the high volume sampler for TSP and low volume sampler for PM10, where ambient air is taken using suction pump through a filter at a certain flowrate for 24 hours. The collected particulates on the filter are then weighed and divided by suctioned total volume to represent the ambient concentration. However, due to difficulties in the field (limited human and equipment resources, as well as limited budget), the samplings are often done only for very short period of time (2 hours or less), and still considered to represent the 24 hour concentration. In order to be able to solve this problem, there should be a practical way to estimate the concentration of TSP based on a short measurement time to represent the 24 hour concentrations. This will be useful to save the operational cost, but still able to have accurate results.
2. Materials and Methods

The PM$_{10}$ and PM$_{2.5}$ were measured using Japan International Standard (JIS) no. Z 8814 1994. This Japanese Industrial Standard specifies volume air sampler of the suction capacity at a certain flowrate and has grading capacities out of the air samplers which is used for measurement of mass concentration of airborne dust. The sampler consists of a grading device, filter, holder, flow meter and an suction pump, as shown in Figure 1. This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 100 micro meters (TSP) and less than or equal to 10 micro meters (PM$_{10}$) in ambient air over a 24-hour period. The measurement process is non-destructive, and sample can be subjected to subsequent physical or chemical analyses. Using this method, an air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into size fractions within size range. Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected TSP and PM$_{10}$. The total volume of air sampled, corrected to reference conditions (25°C, 1 atm), is determined from the measured flow rate and the sampling time. The mass concentration of TSP and PM$_{10}$ in the ambient air is computed as the total mass of collected particles in the TSP and PM$_{10}$ size range divided by the volume of air sampled, and is expressed in micrograms per cubic meter (µg/Nm$^3$) [1, 2, 3, 4].

![High volume sampler for TSP](image)

Figure 1. Arrangement of High and Low Volume Sampler for Measuring Ambient TSP and PM$_{10}$ Concentration [1]

3. Results and Discussion

TSP and PM$_{10}$ sampling were carried out on the road side of Juanda Street in Bandung (as shown in Figure 2 and Figure 3), for series of 2 hour sampling and 24 hour sampling time from
Monday to Sunday. Metrological data (pressure, temperature, wind speed and wind direction) and vehicles data passed through Juanda street during sampling were also taken.

![Sampling Location, Road Side, Juanda Street](image)

**Figure 2.** Sampling Location, Road Side, Juanda Street (Source: Field Documentation)

![High Volume Sampler and Low Volume Sampler Arrangement in Sampling Location](image)

**Figure 3.** High Volume Sampler and Low Volume Sampler Arrangement in Sampling Location (Source: Field Documentation)

Number of vehicles passed the sampling location may influence the particulate ambient concentration. The record of vehicle measurements every 2 hour within 24 hour from Monday to Sunday is depicted in Figure 4. TSP and PM10 may originate from road dust, earthen material or dirt that becomes airborne primarily by the friction of tires moving on dust-covered paved roads. Other sources of PM10 may also come from the results of liquid fuel combustion in vehicle engines.
Figure 4. Vehicle Number Measurement Passed by the Sampling Location

The peak number of vehicles was recorded at 6:00 – 8:00 in the morning and at 16:00 -18:00 in the afternoon, with percentage of vehicle type as follows: motorcycles 59.7%, passenger private car 34.5%, passenger public car 4.0%, light duty truck 1.2%, bus 0.4% and heavy duty truck 0.2%. The 24 hour measurement of TSP and PM10 concentrations are shown in Figure 5, all measured concentration are still below the ambient standard according to regulation from Ministry of Environment No. 41 1999 [3].

Series of TSP measurement every 2 hours within 24 hours which also denote the TSP diurnal concentration from Monday to Friday are shown in Figure 6. It can be seen that TSP concentrations were changing from time to time. The highest TSP concentrations were observed at 6:00-8:00 am along with peak number of vehicles passing by the sampling location at the same time as shown in Figure 4. The lowest TSP concentration occurred in the middle of the night until morning at 4:00 – 6:00 am also along with lowest number of vehicles passing by the sampling location. Several measurements results especially at 6:00 to 8:00 am exceeded the 24 hour standard.
Figure 5. TSP and PM10 Concentration - Results of 24 Hour Measurement.

Series of PM10 measurement every 2 hours within 24 hours which also denote the PM10 diurnal concentration from Monday to Friday are shown in Figure 7. The PM10 concentrations were also changing from time to time, but have a rather different behaviour compared to TSP diurnal concentration. Similar to TSP, the highest PM10 concentrations were also measured when vehicles which passed by the sampling location reach the peak number at 6:00 to 8:00 am.

Different from TSP, the lowest PM10 concentrations were observed after midnight at 2:00 – 4:00 am, in the morning at 4:00-6:00 am and in the afternoon at 14:00-16:00. This means that the influence of vehicle numbers to the PM10 concentration was not as strong as to the TSP concentration. Since TSP contains particulates ≤ 100 μm, it can be concluded that measured particulates around the sampling location dominated by the coarse particulates with diameter higher than 10 μm but lower or the same as 100 μm.

In order to be able to know whether the 2 hour concentration of TSP and PM10 are able to represent the 24 hour concentrations, the comparison between these two kinds of concentrations were calculated and represented in histograms. The principle of this histogram is based on the fact that the area of each rectangle represents the proportion of observations falling in that interval[9].
Figure 6. TSP Diurnal Concentration from Monday to Sunday

Figure 7. PM10 Diurnal Concentration from Monday to Sunday
Figure 8 shows the histogram of frequency distribution of comparison values for TSP which skewed to the left. The 2 hour concentrations are mostly higher than 24 hour concentrations, which means that using the 2 hour concentration for estimating 24 hour concentrations could result in an over estimate concentration. This situation might occur with the condition if measurement is carried out between 6:00 to 20:00, and this is the time which is mostly preferred for field investigation. An opposite behavior was shown by Figure 9, histogram for PM10, which skewed to the right. The 2 hour concentrations are mostly lower than 24 hour concentration, which means that using the 2 hour concentration for estimating 24 hour concentration could result in an underestimate concentration. This situation occurs because it takes longer time for PM10 which is generally lighter than TSP to be collected on the sampling equipment.

Figure 8. Frequency Occurrence of Comparison Values between 2 Hour Concentration of TSP and 24 Hour Concentration of TSP

Figure 9. Frequency Occurrence of Comparison Values between 2 Hour Concentration of PM10 and 24 Hour Concentration of PM10
4. Conclusions

This research has shown that there is a distinct change of TSP and PM10 diurnal concentrations from Monday to Friday, therefore measuring 2 hour concentration to represent a 24 hour concentration might lead to an overestimate or underestimate results. The 2 hour TSP concentrations are strongly influenced by number of vehicles passed by the sampling locations. The 2 hour PM10 concentrations are only slightly influenced by number of vehicles, which denote that vehicles contribute to increase coarser particles (diameter between 10 and 100 micrometer) around the sampling site. From the frequency occurrence of comparison values between 2 hour concentration and 24 hour concentration, it can be concluded that: the 2 hour concentration of TSP can represent the 24 hour concentration by applying correction factor of (1/1.3) if measurements are taken between 6:00am to 8:00 pm, while the 2 hour concentration of PM10 can represent the 24 hour concentration by applying correction (1/0.7) if measurements are taken between 6:00 am to 8:00 pm.

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References