

Airborne Particulate Matter at Phuket Bus Terminal 2, Ratsada Subdistrict, Mueang District, Phuket Province

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ABSTRACT

The research of airborne particulate matter at Phuket Bus Terminal 2, Ratsada Subdistrict, Mueang District, Phuket Province aimed to study the amount of airborne particulate matter in the air at Phuket Bus Terminal 2. Airborne particulate matter samples were collected using the High Volume Air Sampler for 24 hours, totaling 9 days. Total suspended particulate (TSP) was collected from March 19 - 21, 2021, PM2.5 was collected from March 26 - 28, 2021 and PM10 was collected from April 9 - 11, 2021. The results showed that TSP had an average value of 0.0542 mg/m³. The highest TSP was 0.0678 mg/m³ on Friday, followed by 0.0525 mg/m³ on Saturday and 0.0424 mg/m³ on Sunday. These were not greater than the air quality standard (0.33 mg/m³) in the atmosphere within 24 hours set by the Pollution Control Department. PM2.5 had an average of 0.0107 mg/m³. The highest PM2.5 was 0.0165 mg/m³ on Friday, followed by 0.0090 mg/m³ on Saturday and 0.0067 mg/m³ on Sunday. These were not greater than the air quality standard (0.05 mg/m³) within 24 hours. PM10 had an average value of 0.0294 mg/m³. The highest PM10 was 0.0321 mg/m³ on Friday, followed by 0.0283 mg/m³ on Sunday and 0.0280 mg/m³ on Saturday. These were not greater than the air quality standard (0.12 mg/m³) in the atmosphere within 24 hours.

Keywords : TSP; PM2.5; PM10; Phuket Bus Terminal 2

INTRODUCTION

At present, particulate matter in Thailand is an increasingly serious air pollution and affects the livelihoods, economy, society, public health and environmental quality. A very high risk of air pollution is the main problem of human beings in daily life. The reasons are caused by transportation, open burning, and construction [1]. Due to the economic and social expansion along with growing population, there are more traffic congestion problems, resulting in increased fuel consumption which releases various toxins and airborne particulate matter into the atmosphere. This is a major air pollution problem in large communities and Bangkok. The particulate matter that exists in the atmosphere around us has a size from 0.002 microns, which is invisible to the naked eye to larger than 500 microns, which is a large sand airborne particulate matter visible to the naked eye. (Particulate matter visible to the naked eye has a size of 50 microns or more). Particulate matter is a substance that has a variety of physical and composition and it may be solid or liquid. Small particulate matter which has a diameter of less than 10 microns usually suspends in the air for a long time due to various falling velocities. If an external force is involved, such as airflow, air current, etc., it will stay suspended in the air for a longer time. Large particulate matter (diameter larger than 100 microns) may be suspended in the atmosphere for only 2-3 minutes, but particulate matter smaller than 0.5 microns may hang in the air for years [2].

Phuket is a province in the south of Thailand and located in the Andaman Sea. It is the only province that is an island and is considered a province that is a major tourist attraction in Thailand which has both Thai and foreign tourists. Therefore, Phuket's main income comes from tourism and results in a huge economic expansion. There are transportation routes by water, air and land especially on the main roads that face the problem of traffic jam due to the travelling of the local people and tourists.

Phuket Bus Terminal 2 is another place that is prone to airborne particulate matter problems. Because it is a station that provides bus services to the public. In order to travel to different places, there are buses and vans traveling in and out of the passenger terminal all the time and starting the engine while waiting for the passengers. From such information, traffic is one of the particulate matter problems caused by the combustion of the vehicle engine which may affect the health of the people who come to use the service, including officers and personnel in Phuket Bus Terminal 2. If they received large quantities of pollution, it will cause accumulation in the respiratory system. Therefore, the researcher is interested in studying the

amount of particulate matter in the air around Phuket Bus Terminal 2 to compare with the standard set by the Pollution Control Department.

METHODOLOGY

1. Tools and equipment used in field research studies

- 1) TSP, PM10, PM2.5 HiVol 3000 High Volume Air Sampler - Ecotech
- 2) Motor to let air flow through the filter paper
- 3) Air flow recorder
- 4) Control flow device
- 5) Water Manometer
- 6) Barometer

2. Instruments and equipment used in the laboratory

- 1) Scales (Balance) with a resolution of 0.0000 milligrams.
- 2) Desiccator Cabinet with Thermo Hygrometer
- 3) Silica gel
- 4) Forceps coated with Teflon
- 5) Vinyl non-powdered gloves for holding the filter paper
- 6) Zip plastic bags for packing filter paper
- 7) Glass fiber filter, size 8 x 10 inches
- 8) Quartz filter, size 8 x 10 inches

3. Preparation of filter paper

1) Check the integrity of the filter paper. Glass fiber filter paper was used to collect TSP samples and quartz filter paper was used to collect PM10 and PM2.5 samples. Inspect the filter paper for imperfections such as tears, porous, the color of the filter paper and uneven filter paper.

2) Dry the filter paper before and after sampling.

2.1) Environmental conditions for filter paper prior to sampling: relative humidity less than 50% ($\pm 5\%$)

2.2) Room temperature between 15-30 degrees Celsius (± 3 degrees Celsius)

2.3) Before drying the filter paper, always clean the desiccator cabinet

2.4) Put the silica gel in the desiccator (A very hygroscopic silica gel will change from blue to purple. It can be dried at a temperature of 150 degrees Celsius for about 1-2 hours to be reused).

2.5) Place the filter paper on the shelf of the desiccator cabinet with the sampling side facing up

2.6) Dry the filter paper for at least 24 hours

2.7) After 24 hours, put the filter paper in the zip bag and keep it in a desiccator cabinet for another 2-3 hours to re-absorb the moisture.

*Caution: if filter paper is to be used for further metal analysis. Metal forceps should not be used to hold the filter paper as it may cause contamination.

3) Weigh the filter paper

3.1) Leave the scale on for at least 2 hours

3.2) Adjust the scale to 0.0000 grams (4 decimal places)

3.3) Calibrate the scale by the standard weight. It must differ from the original weight less than 0.5 milligrams.

3.4) Weigh the dried filter paper

3.5) Record the weight of the filter paper

3.6) Put the filter paper in the zip bag and put the zip bag together with the filter paper in a brown paper envelope for collecting samples in the field.

4. Sampling

1) Set sampling points for TSP, PM10 and PM2.5

The air inlet of the sampler is generally required at least 1.50 meters above the ground, but not more than 6 meters, which is enough to not suck airborne particulate matter from the floor. In this regard, the location of the most polluted areas must be taken into account. Here are some general guidelines for installation locations of TSP, PM10 and PM2.5 air samplers.

1) The air sampler should be installed at least 2 meters away from the awning and at least 10 meters away if there are trees as an obstruction.


- 2) The air inlet of the sampler should be away at least 2 times the height of an obstruction, such as a building. Air flow must not be obstructed within a radius of 270 degrees around the air inlet.
- 3) The sampler should not be near the furnace shaft.

2) Sampling point

The sampling point in Phuket Bus Terminal 2 is shown in Figure 1. This sample point was selected because it is closest to the road and all buses entering the bus station must pass this location.



Figure 1 Satellite image showing the sampling point at Phuket Bus Terminal 2

Note:  The symbol represents the sampling point.

3) TSP, PM10 and PM2.5 air sampler calibration

TSP, PM10 and PM2.5 samplers were equipped with a Volumetric Flow Controller (VFC) that has been calibrated to a primary standard and has been approved by the manufacturer, called the Orifice flow rate Transfer standard or Calibration orifice. Orifice Calibration Kit composes of a metal cylinder with 7.6 cm diameter, 15.9 cm length. There is an opening at one end with 5.1 cm diameter.

4) Sampling operation

- 1) Set up the TSP, PM10 and PM2.5 air samplers in a horizontal plane and set the machine stand firmly to prevent the machine from falling.
- 2) Put the filter paper on the filter paper sieve with the side used to collect the sample facing up, balancing the filter paper on the sieve and filter paper holder. Check the connections between the motor and the air flow recorder.
- 3) Turn on the air sampling machine, record the start time, air pressure, temperature and surrounding environment.
- 4) Put the filter paper in a zip-lock bag for further analysis in the laboratory.

5. Calculation of the concentration of airborne particulate matter

$$\text{airborne particulate matter concentration (mg/m}^3\text{)} = \frac{W_f - W_i}{V_{std}} \times 10^3 \quad (1)$$

where W_f = weight of filter paper after sampling, in grams
 W_i = weight of filter paper before sampling, in grams
 V_{std} = standard air volume in cubic meters
 10^3 = gram to milligram unit conversion

6. Comparison of airborne particulate matter to the standard value

- 1) The average value of total particulate matter or particulate matter less than 100 microns in size (Total Suspended Particulate: TSP) in 24 hours must not exceed 0.33 mg/m^3 .
- 2) The average value of particulate matter less than 10 microns in size (Particulate Matter: PM10) in 24 hours must not exceed 0.12 mg/m^3 .
- 3) The average value of particulate matter less than 2.5 microns in size (Particulate Matter: PM2.5) in 24 hours must not exceed 0.05 mg/m^3 [3].

7. Traffic volume

Traffic volume is one of the factors that causes particulate matter, i.e., incomplete combustion of diesel cars, transportation of materials such as soil, sand, or materials that cause airborne particulate matter and road construction. The number of vehicles passing through the air sampler was counted in order to examine the relationship with the airborne particulate matter.

8. Weather Information

Meteorological parameters affect the airborne particulate matter. The temperature, relative humidity, air pressure, precipitation and wind speed had significant differences in their effects on the concentration of airborne particulate matter.

RESULTS AND DISCUSSIONS

Airborne particulate matter at Phuket Bus Terminal 2 was measured by the High Volume Air Sampler during March-April 2021. Three types of particulate matter: Total Suspended Particulate (TSP), particulate matter less than 10 microns in size (PM10) and particulate matter less than 2.5 microns in size (PM2.5) for 24 hours were examined.

1. TSP

From measuring TSP at Phuket Bus Terminal 2 on 19- 21 March 2021, it was found that on Friday, March 19, 2021, TSP was 0.0678 mg/m^3 , which was the highest airborne particulate matter content in sampling. On Saturday, March 20, 2021, TSP was 0.0525 mg/m^3 . On Sunday, March 21, 2021, TSP was 0.0424 mg/m^3 , which was the least amount of airborne particulate matter in sampling as shown in Figure 1.

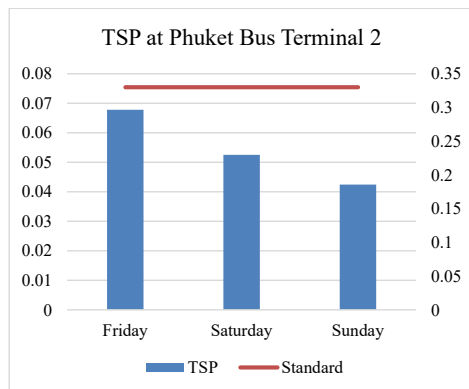


Figure 2 TSP at Phuket Bus Terminal 2

Graph shows the average TSP at Phuket Bus Terminal 2. The field samples of the airborne particulate matter at the Phuket Bus Terminal 2 showed that TSP was 0.0678 , 0.0525 and 0.0424 mg/m^3 on Friday, Saturday and Sunday in March, respectively. This does not exceed the general atmospheric air quality standards (0.33 mg/m^3) in 24 hours set by the Pollution Control Department.

In the study of the number of vehicles, there were 210, 204 and 195 cars passing the airborne particulate matter sampler on 19, 20 and 21 March 2021, respectively as shown in Table 1.

Table 1 The number of vehicles passing the air sampler

D/M/Y	Bus (cars)	Poe-Thong Minibus (cars)	automobile (cars)	Total (cars)
19/03/2021 Friday	142	24	44	210
20/03/2021 Saturday	142	24	38	204
21/03/2021 Sunday	142	24	29	195
				609

The relationship of TSP to the number of countable vehicles showed that on Friday, TSP was equal to 0.0678 mg/m³ with 210 vehicles counted. On Saturday, TSP was equal to 0.0525 mg/m³ with 204 vehicles counted. On Sunday, TSP was equal to 0.0424 mg/m³ with 195 vehicles counted. A number of cars affects the amount of particulate matter. When there is a large number of cars, there is an increase in the amount of particulate matter. This is consistent with the research of TSP and PM10 in Phuket Rajabhat University. It was found that the average TSP was 0.0329 mg/m³. On Sunday, TSP was 0.0329 mg/m³ with 1,774 vehicles. On Monday, TSP was 0.0395 mg/m³ with 2,204 vehicles [4].

General environment while measuring TSP on 19 March, 2021, the temperature was 30.59 degrees Celsius, daily average pressure was 1008.06 millibar, daily average relative humidity was 67.25 % and daily average wind speed was 1.88 knots. On 20 March, 2021, temperature was 30.6 degrees Celsius, daily average air pressure was 1007.12 mbar, daily average relative humidity was 70.63 % and daily average wind speed was 2 knots. On 21 March, 2021, temperature was 31 degrees Celsius, daily average air pressure was 1007.22 mbar, daily average relative humidity was 70.88 % and daily average wind speed was 0.63 knots.

2. PM10

The amount of PM10 was measured in April. PM10 was 0.0321, 0.0280 and 0.0283 mg/m³ on Friday, Saturday and Sunday, respectively as shown in Figure 2. This does not exceed the general atmospheric air quality standards (0.12 mg/m³) in 24 hours set by the Pollution Control Department. The highest PM10 was 0.0321 mg/m³ on Friday and the minimum PM10 was 0.0280 mg/m³ on Sunday. The average value of PM10 was 0.0294 mg/m³.

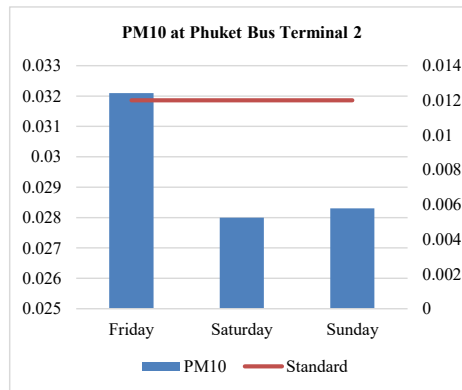


Figure 3 PM10 at Phuket Bus Terminal 2

The relationship of PM10 to the number of countable vehicles showed that on Friday, PM10 was equal to 0.0321 mg/m³ with 273 vehicles counted. On Saturday, PM10 was equal to 0.0090 mg/m³ with 253 vehicles counted. On Sunday, PM10 was equal to 0.0067 mg/m³ with 260 vehicles counted as shown in

Table 2. According to the research of PM10 at the passenger terminal in Phitsanulok, PM10 was in the range of 73.62-299.84 mg/m³ [5].

General environment while measuring PM 10 airborne particulate matter was as follows: on April 9, 2021, temperature was 29.72 degrees Celsius, daily average air pressure was 1009.27 mbar, daily average relative humidity was 73.88 % and daily average wind speed was 1 knot. On April 10, 2021, temperature was 30.59 degrees Celsius, daily average air pressure was 1009.77 mbar, daily average relative humidity was 70.38% and daily average wind speed was 1.63 knots. On April 11, 2021, temperature was 29.96 degrees Celsius, daily average pressure was 1010.66 millibar, daily average relative humidity was 72.5 % and daily average wind speed was 0 knots [6].

Table 2 The number of vehicles passing the air sampler

D/M/Y	Bus (cars)	Poe-Thong Minibus (cars)	Automobile (cars)	Total (cars)
9/04/2564 Friday	200	24	49	273
10/04/2564 Saturday	208	24	21	253
11/04/2564 Sunday	198	24	38	260
				786

3. PM2.5

The field samples of the airborne particulate matter at the Phuket Bus Terminal 2 showed that PM2.5 was 0.0165, 0.0090 and 0.0067 mg/m³ on Friday, Saturday and Sunday, respectively as shown in Figure 3. This does not exceed the general atmospheric air quality standards (0.05 mg/m³) in 24 hours set by the Pollution Control Department. The highest PM2.5 was 0.0165 mg/m³ on Friday and the minimum PM2.5 was 0.0067 mg/m³ on Sunday. The average PM2.5 was 0.0107 mg/m³.

The relationship of PM2.5 to the number of countable vehicles showed that on Friday, PM2.5 was equal to 0.0165 mg/m³ with 227 vehicles counted. On Saturday, PM2.5 was equal to 0.0090 mg/m³ with 213 vehicles counted. On Sunday, PM2.5 was equal to 0.0067 mg/m³ with 206 vehicles counted as shown in Table 3. The study was consistent with the research of the particulate matter caused by vehicles at the market. It was found that PM2.5 was less than PM10 and TSP and the increased vehicle amount effectively caused particulate matter [7].

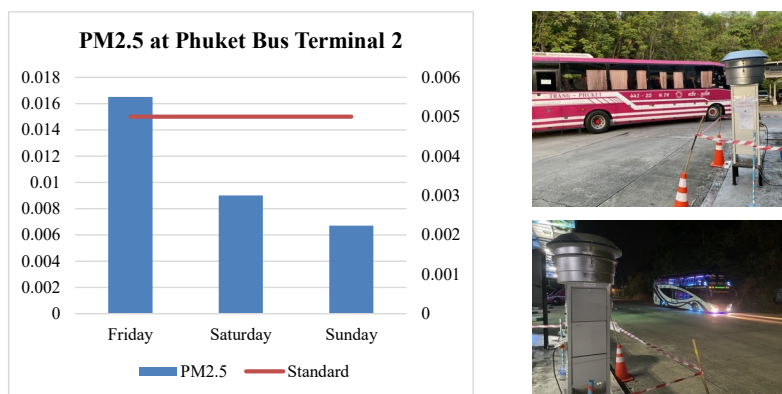


Figure 4 PM2.5 at Phuket Bus Terminal 2

The general environment while measuring PM 2.5 airborne particulate matter was as follows: on March 26, 2021, rainfall duration was 25 minutes from 8:20 to 8:45 p.m., with an average daily rainfall of 16.2 millimeters, mostly cloudy, an average daily temperature was 30.23 degrees Celsius, daily average air pressure was 1008.4 millibars, daily average relative humidity was 70.13% and daily average wind speed was 2.75 knots. On March 27, 2021, no rain but mostly cloudy, temperature was 30.2 degrees Celsius, average daily air pressure was 1007.24 millibars, daily average relative humidity was 75.25% and daily average wind speed was 2.75 knots. On March 28, 2021, rainfall duration was 45 minutes from 6:50 to 7:35 p.m., with an average daily rainfall of 26 millimeters, temperature was 29.79 degrees Celsius, daily average air pressure was 1007.69 millibars, daily average relative humidity was 74.63 % and daily average wind speed was 3.13 knots [6]. Friday, March 26, 2021 and Sunday, March 28, 2021 was rainy. This caused the leaching of dust and particulate matter floating in the air.

Table 3 The number of vehicles passing the air sampler

D/M/Y	Bus (cars)	Poe-Thong Minibus (cars)	Automobile (cars)	Total (cars)
26/03/2021 Friday	162	24	41	227
27/03/2021 Saturday	162	24	29	213
28/03/2021 Sunday	160	24	20	206
				646

Research Obstacles

Due to an uncontrollable weather, there was the storm and heavy rain during the data collection period, it caused the leaching of some dust and particulate matter.

Suggestions

1. There should be a continuous study of particulate matter at Phuket Bus Terminal 2. As a basis for monitoring particulate air quality, it should be repeated every year.
2. There should be a study of the amount of particulate matter both at Phuket Bus Terminal 1 and Phuket Bus Terminal 2, as a basis for monitoring particulate air quality in Phuket.

CONCLUSION

The airborne particulate matter at the Phuket Bus Terminal 2 was found that the average TSP was equal to 0.0542 mg/m³. TSP was 0.0678, 0.0525 and 0.0424 mg/m³ on Friday, Saturday and Sunday, respectively. This does not exceed the general atmospheric air quality standards (0.33 mg/m³) in 24 hours set by the Pollution Control Department.

The average of PM10 was 0.0294 mg/m³. PM10 was 0.0321, 0.0280 and 0.0283 mg/m³ on Friday, Saturday and Sunday, respectively. This does not exceed the general atmospheric air quality standards (0.12 mg/m³) in 24 hours.

The average PM2.5 was 0.0107 mg/m³. PM2.5 was 0.0165, 0.0090 and 0.0067 mg/m³ on Friday, Saturday and Sunday, respectively. This does not exceed the general atmospheric air quality standards (0.05 mg/m³) in 24 hours.

From the study of airborne particulate matter at Phuket Bus Terminal 2, it was found that TSP, PM2.5 and PM10 within 24 hours did not exceed the air quality standards set by the Pollution Control Department. The standard criteria for TSP, was 0.33 mg/m³, PM2.5 was 0.05 mg/m³, and PM10 was 0.12 mg/m³. Moderate to strong winds may cause less accumulation of airborne particulate matter. While the wind is still weak, it will result in an increase in the airborne particulate matter accumulation.

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