Ambient TSP and PM_{10} concentrations in Public Parks of Bangkok, Thailand

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Abstract

The objective of this research is to study the concentration of ambient TSP and PM_{10} at aerobic exercise sites in public parks of the Bangkok Metropolitan Administration, Thailand. TSP and PM_{10} samples were collected during the rainy season, from September 2009 to October 2009 and during the winter season, from January 2010 to February 2010 using high volume air samplers. The samples were collected from five sites in four public parks: Lumphini (two sampling sites), Suan Luang Rama 9, Benchasiri, and Saranrom.

The results showed that all 162 samples of 24-hour average TSP and PM_{10} concentrations were lower than Thailand's ambient air quality standards. Concentration levels of TSP at Lumphini 1, Lumphini 2, Suan Luang Rama 9, Benchasiri, and Saranrom in the rainy season varied from 34.1–55.6, 26.6–42.9, 33.7–78.2, 42.0–83.6, and 43.9–73.7 $\mu g/m^3$ respectively, and in the winter season from81.8–124.2, 75.2–118.9, 36.9–113.0, 47.6–125.0, and 56.4–139.9 $\mu g/m^3$ respectively. Levels of PM_{10} in the rainy season varied from 17.5–28.1, 10.4–20.5, 23.4–55.2, 22.2–49.0, and 31.0–60.0 $\mu g/m^3$ respectively, and in the winter season from 51.1–82.7, 42.0–71.2, 20.8–74.9, 27.3–90.6, and 37.0–110.2 $\mu g/m^3$ respectively. Furthermore, there was a statistical significant correlation between TSP and PM_{10} concentrations at four of the five sampling sites during both the rainy and winter seasons ($p < 0.05$), except for at Saranrom which showed no statistical significant correlation during the rainy season. In addition, levels of particulate matter at the two Lumphini sites in the winter season were significantly higher than in the rainy season; whereas at the other three parks, levels of particulate matter were not statistically significantly different between

Key words: Particulate matter/ PM_{10}/ TSP/ Public Park

1. Introduction

Air pollution problem experience in urban area is mainly due to emissions from a large number of motor vehicles. One of the major air pollutants that cause harm to human health is particulate matter (Schwela and Zali, 1999). Large size particles (larger than 10 microns) can be easily removed by defense mechanisms of human respiratory system. It causes a nuisance, reduce visibility and damage to materials (Godish, 1997). Whereas small particles such as particulate matter less than 10 microns (PM_{10}) can enter and deposit deeper in the respiratory system, thereby causing a chronic bronchitis, emphysema and other lung diseases (Herman and Bisesi, 2003). Therefore, human health effect is associated mainly with small particles. The Pollution Control Department (PCD) has been monitoring air quality in Bangkok since 1995. The results showed that annual average of PM_{10} at roadsides during 1995-2008 were all exceeded the annual average of PM_{10} ambient air standard whereas about half of the results in

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general areas exceeded the ambient air standard (Air Quality and Noise Management Bureau, 2009).

Bangkok Metropolitan Region has provided Public Park to improve the quality of urban life, e.g. supporting and promoting healthy lifestyles, increasing greenery, reducing air and noise pollution, etc. The public park also provides open and green spaces for recreation and visual assets to communities. Public Park should have good air quality, e.g. particulate matter should not exceed the ambient air quality standards. However, there is a possibility that people exercising in urban area may be at risk because of exposure to automotive pollution (Sharman, 2005). High concentration levels of TSP and PM_{10} can cause health effect on people especially during exercises. Most of the previous studies have measured particulate matter mainly on the roadside or general area. There is no data available on air quality in any of Public Parks in Thailand. Therefore, this study intends to study TSP and PM_{10} concentration levels from 4 Public Parks in Bangkok, i.e. Suan Luang Rama 9 Park, Lumphini Park, Benchasiri Park and Saranrom Park.

2. Materials and Methods

2.1 Study site

Public Park in Bangkok can be classified to seven categories (Public Park Office, 2009). This research chose only four categories according to their popularity as follows: City Park, District Park, Community Park and Neighborhood Park. It is decided to choose one representative Public Park that is most often used in each category. These are Suan Luang Rama 9, Lumphini, Benchasiri and Saranrom, respectively. One sampling sites is selected for each representative Public Park except Lumphini Park which two sampling sites are selected (one at the park edge and another one at the center of the park). Moreover, all sampling sites are selected to be nearby aerobic exercise site of each representative Public Park.

2.2 Collection of air samples for determination of TSP and PM_{10}

TSP and PM_{10} samplings were collected during two seasons, i.e. rainy season (September-October 2009) and winter season (January-February 2010). The samplings duration is 24 hours and sampling every other day for 2 weeks period at each sampling site. Each sampling site was equipped with 2 high volume air samplers, i.e. one for TSP and another one for PM_{10}. To assure the quality of TSP and PM_{10} measurement, the methodology for sampling and analysis were based on Reference method of 40 CFR 50, Appendix B and J (U.S. Environmental Protection Agency, 2009). Both TSP and PM_{10} samples were collected on 20.3 x 25.4 cm Whatman glass fiber filters. The flow rate of air sampler was re-calibrated whenever sampling site was change and flow rate was set at 1.13 ± 0.11 m^3/min. Each filter was equilibrated in desiccator for at least 24 hours before weigh a filter and determined gravimetrically using an analytical balance with a sensitivity of 0.1 mg. Powder-free vinyl gloves were used for filter handling. Re-spray the shim plate in PM_{10} sampler with a Dow Corning Silicone #316. Blank samples were also used to determine the actual weight of field samples.

2.3 Interlaboratory Comparison

In order to demonstrate that the results from this study are compatible with those from Pollution Control Department (PCD), which is a government agency that responsible for monitoring the ambient air quality in Thailand. Two PM_{10} high-volume air

samplers (one from this study and another one from PCD) were compared at the same sampling site simultaneously. Sampling location was selected from temporary air quality monitoring station of PCD at Land Development Department site which is located on Phahonyothin road with a relatively heavy traffic. The comparing sampling duration was 24-hour average for one week.

3. Results and Discussion

3.1 Concentrations of TSP and PM_{10} at 5 sampling sites

The overall 24-hour average concentrations of TSP varied from 26.6 to 139.9 µg/m^3 (n=81). Whereas those of PM_{10} varied from 10.4 to 110.2 µg/m^3 (n=81) (Table 1). The results showed that all measured TSP and PM_{10} concentration levels from 5 sampling sites in 4 public parks did not exceed the TSP and PM_{10} (24-hour average) ambient air quality standards. Therefore, the results indicated that air quality of Public Parks in Bangkok area are still good and safe for those who come to visit or exercise. In addition, the comparison among the 5 sampling sites of 4 public parks in term of air quality, it appeared that at sampling site Lumphini1, which located near heavy traffic road, had highest means of 24-hour average TSP and PM_{10} concentration levels. This is in agreement with the studied of Chan and Kwok (2001) which also found high concentration levels of particulate matter in the heavy traffic area during winter season. Moreover, there are 2 monitoring sites at Lumphini Park, i.e. Lumphini1 and Lumphini2 which are far away from Rama 4 and Rajadamri roads at approximately 150 and 300 m, respectively. All of the overall mean 24-hour average TSP and PM_{10} concentrations for both rainy and winter seasons at Lumphini1 were higher than those of Lumphini2. It appears that automobile is a major source of particulate matter in Bangkok. Because the particulate matter can be removed by trees (Jim and Chen, 2008), therefore, levels of TSP and PM_{10} at Lumphini2 site that is at the center of the park were lower than those at Lumphini1 site that locates near the road. This result coincides with other studies, e.g. Lam et al. (2005) founded that PM_{10} levels on the park edge were higher than those in the park center.

Table 1 Range and mean ± SD of 24-hour average TSP and PM_{10} concentrations on each sampling site

Sampling site	PM	Rainy		Winter	
		Range (µg/m^3)	**Mean ± SD (µg/m^3)**	**Range (µg/m^3)**	**Mean ± SD (µg/m^3)**
Lumphini1	TSP	34.1-55.6	44.1±7.8	81.8-124.2	102.6±16.6
	PM_{10}	17.5-28.1	23.0±4.5	51.1-82.7	67.8±13.0
Lumphini2	TSP	26.6-42.9	35.2±6.4	75.2-118.9	97.6±17.1
	PM_{10}	10.4-20.5	14.8±4.2	42.0-71.2	57.4±11.4
Suan Luang Rama 9	TSP	33.7-78.2	60.5±16.1	36.9-113.0	64.0±24.4
	PM_{10}	23.4-55.2	41.9±11.6	20.8-74.9	39.9±16.0
Benchasiri	TSP	42.0-83.6	62.0±14.2	47.6-125.0	76.1±27.0
	PM_{10}	22.2-49.0	35.9±10.0	27.3-90.6	50.4±19.7
Saranrom	TSP	43.9-73.7	61.3±10.7	56.4-139.9	76.1±27.4
	PM_{10}	31.0-60.0	41.4±9.5	37.0-110.2	54.2±25.4

As PM_{10}/TSP ratio indicates the proportion of particulate matter in two size range, the result shows means of 24-hour average concentrations of PM_{10}/TSP ratios at all sampling site in both seasons were higher than 0.5, indicating that proportion of PM_{10} was quite high, except at Lumphini2 which shows the ratio in rainy season was lower than 0.5 (Table 2). While other studies show similar result e.g. Chan and Kwok (2001) have reported a PM_{10}/TSP ratio of 0.64 in urban site of Hong Kong, Karar et al. (2006) observed mean PM_{10}/TSP ratios of 0.52 in residential area and 0.54 in industrial area in Kolkata, India.

Table 2 Range and mean ± SD of 24-hour average concentrations of PM_{10}/TSP ratio at each sampling site

Sampling site	PM_{10}/TSP ratio **(Rainy)**		PM_{10}/TSP ratio **(Winter)**	
	Range	**Mean ± SD**	**Range**	**Mean ± SD**
Lumphini1	0.48-0.56	0.52±0.03	0.62-0.70	0.66±0.03
Lumphini2	0.36-0.48	0.42±0.05	0.52-0.64	0.59±0.04
Suan Luang Rama 9	0.63-0.77	0.69±0.05	0.56-0.66	0.62±0.03
Benchasiri	0.52-0.67	0.57±0.05	0.57-0.77	0.66±0.07
Saranrom	0.49-0.82	0.68±0.13	0.63-0.83	0.69±0.07

The results from this study suggest that levels of particulate matter in Public Parks are relatively low. In Table 3, it shows the results obtained from this study and the data from air quality monitoring stations of the PCD in 2009 (Air Quality and Noise Management Bureau, 2010). It indicates that the maximum concentrations of both TSP and PM_{10} concentrations in Public Parks are lower than the maximum concentrations obtained from the PCD's roadside and ambient stations.

Table 3 Range of 24-hour average TSP and PM_{10} concentrations of this study and the PCD's monitoring stations

	TSP		**PM_{10}**	
	Range (µg/m^3)	**n[a] / N[b]**	**Range (µg/m^3)**	**n / N**
This study	26.6-139.9	0 / 81	10.4-110.2	0 / 81
Roadside station[c]	20-350	1 / 379	15.5-183.0	109 / 2043
Ambient station[d]	20-320	0 / 533	5.9-193.4	31 / 3171

Note : [a] Number of samples (exceed the ambient air quality standards)
[b] Total number of samples
[c] Data of TSP and PM_{10} (24-hour average concentrations) in 2009 from 7 roadside air quality monitoring stations of the PCD
[d] Data of TSP and PM_{10} (24-hour average concentrations) in 2009 from 10 ambient air quality monitoring stations of the PCD

Furthermore, results of the 24-hour average PM_{10} concentrations from Lumphini1 site are compared with those from Chulalongkorn Hospital station which is the PCD's roadside air quality monitoring station (Air Quality and Noise Management Bureau, 2010) as shown in Table 4. The Chulalongkorn Hospital station is located approximately 240 m from the Lumphini1 site. It indicates that PM_{10} concentrations from Lumphini1 site are relatively lower than those obtained from the Chulalongkorn Hospital station.

Table 4 Comparison of 24-hour average PM_{10} concentrations between Lumphini1 site and Chulalongkorn Hospital air quality monitoring station

	September 2009		**January 2010**	
	Range (μg/m^3)	**Number of samples**	**Range (μg/m^3)**	**Number of samples**
Lumphini1	17.5-28.1	7	51.1-82.7	7
Chulalongkorn Hospital	36.7-77.1	26	56.5-137.5	31

3.2 Relationship between TSP and PM_{10}

Relationships between TSP and PM_{10} at each sampling site in both rainy and winter seasons were analyzed by using linear regression (Table 5). The results revealed that the TSP and PM_{10} are all significant correlated at $\alpha = 0.05$ and the coefficient of determination (r^2) were relatively high, ranging from 0.897 to 0.985. Similarly, Chan and Kwok (2001) showed a good correlation between TSP and PM_{10} in Hong Kong, i.e. value of r^2 between TSP and PM_{10} in winter, summer and whole year were 0.64, 0.79 and 0.71, respectively. Except Saranrom site in rainy season (n = 8) displayed r^2 quite lower than other sites (r^2 = 0.225), it indicates that the relationship between TSP and PM_{10} has a weak correlation.

Table 5 Regression and correlation analysis between TSP and PM_{10} in 5 sampling sites

Site	**Season**	**Regression relationship**	**r^2**
Lumphini1	Rainy	TSP = 6.011 + 1.661PM_{10}	0.919
	Winter	TSP = 17.169 + 1.259PM_{10}	0.969
Lumphini2	Rainy	TSP = 12.933 + 1.496PM_{10}	0.964
	Winter	TSP = 15.856 + 1.422PM_{10}	0.897
Suan Luang Rama 9	Rainy	TSP = 4.875 +1.328PM_{10}	0.916
	Winter	TSP = 3.936 + 1.505PM_{10}	0.979
Benchasiri	Rainy	TSP = 12.674 + 1.374PM_{10}	0.945
	Winter	TSP = 9.017 + 1.330PM_{10}	0.941
Saranrom	Rainy	TSP = 39.123 + 0.535PM_{10}	0.225
	Winter	TSP = 18.148 + 1.068PM_{10}	0.985

3.3 Relationship between rainy and winter season of TSP and PM_{10}

The results of this study indicate that almost all means of 24-hour average TSP and PM_{10} concentrations at all sampling sites in rainy season are lower than those in winter season, except means of 24-hour average PM_{10} concentration at Suan Luang Rama 9 in winter season was slightly lower than in rainy season (Table 1). The results from this study are in agreement with the 24-hour average TSP and PM_{10} concentrations in Kolkata, India which were highest during winter and lowest during monsoon (Karar et al., 2006). The TSP and PM_{10} concentrations at Lumphini1 and Lumphini2 show the p-value lower than the determined statistical significance at $\alpha = 0.05$, it means that the TSP and PM_{10} concentrations at Lumphini1 and Lumphini2 are significant

difference between rainy and winter seasons. Whereas TSP and PM_{10} concentrations at Suan Luang Rama 9, Benchasiri and Saranrom show the p-value higher than the determined statistical significance at $\alpha = 0.05$, it means that TSP and PM_{10} concentrations at Suan Luang Rama 9, Benchasiri and Saranrom are not significant difference between rainy and winter seasons.

3.4 Interlaboratory comparison between the PM_{10} high volume air sampler used by this study and that used by the PCD

A total of seven samples each were collected and determined for 24-hour average PM_{10} concentrations as shown in Table 6.

Table 6 Comparison of 24-hour average PM_{10} concentrations between the instrument used by this study and that used by the PCD

Date	PM_{10} ($\mu g/m^3$), 24-hour average	
	This study	**PCD**
2/12/09	93.3	95.8
4/12/09	104.1	104.9
5/12/09	85.3	89.8
7/12/09	131.4	129.1
8/12/09	143.2	135.3
9/12/09	140.4	133.2
10/12/09	124.0	122.2

The result of a paired t-test, which is determined at $\alpha = 0.05$ show the probability Sig. (2-tailed) of 0.393 that is larger than the determined statistical significant. It means that 24-hour average concentrations of PM_{10} obtained from this study are not significantly difference from those obtained from the PCD. This result showed the compatibility of data between this study and PCD and indicated that the data of TSP and PM_{10} from the 5 sampling sites are compatible with those from the PCD.

4. Conclusion

In this study, it was found that the ambient 24-hour average TSP and PM_{10} concentrations in both rainy and winter seasons at all 5 sampling sites in 4 public parks did not exceed the ambient air quality standards. Therefore, it appears that the ambient air quality in those 4 public parks are good and safe for people to come to visit or exercise. It was also found that most of the relationships between TSP and PM_{10} measured at the same sampling site were quite high with r^2 ranging from 0.897 to 0.985. The statistical analysis showed that TSP and PM_{10} concentrations between rainy and winter seasons at both Lumphini1 and Lumphini2 were significant difference, while TSP and PM_{10} concentrations between rainy and winter seasons at Suan Luang Rama 9, Benchasiri and Saranrom were not significant difference.

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