NANOPARTICLE CONCENTRATIONS IN BANGKOK AMBIENT AIR

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INTRODUCTION

Ambient air particulate matter (PM) is the major health and environmental concern in most urban areas due to the prevalent of PM emission sources and its detrimental health effects with no threshold limit. With better understanding of PM characteristics and its reactions in the human respiratory system as well as the environment, more countries have imposed stricter environmental standards for PM as well as adopted fine particulate matter ($PM_{2.5}$) standards in place of coarse particulate matter (PM_{10}) standards. Various studies have shown that $PM_{2.5}$ can penetrate lower respiratory system resulting in possible damage to the most critical respiratory organ, the alveolar system. Presently, the focus is on the comparative health effects of even finer PM down to the nanometer level (less than 100 nanometers or 0.1 micron). Nanoparticles in Bangkok ambient air, the capital of Thailand, were investigated to determine their potential detrimental health effects in comparison to larger particles. Nanoparticles present possible adverse effects, both on human health and the environment. These are mostly due to their high surface area to volume ratio. Larger surface area increases gaseous pollutant adsorption on its surface resulting in greater toxic air pollutant concentrations in the smaller particles.

EXPERIMENTAL METHOD

The study carried out measurement of sized-selected particulate matter by Nanosampler, developed by a part of the authors [3]. Nanosampler can collect particles down to nano-size range and has the flow rate of 40 $Lmin^{-1}$. Nanosampler consists of three impactor stages, an inertial filter [4] and a backup filter. providing 5 particle size fractions, namely >10 μm, 2.5-10 μm, 1-2.5 μm, 0.07-1 μm and less than 0. 07 μm (~70 nm). Quarts fibrous filters, or, donut filters (⌀ 65 × 30 mm) and backup filters (⌀ 47 mm) were used in the impactor stages and 9 mg of webbed SUS fibers (9.6 μm diameter) was packed in a nozzle of the inertial filter cassette [3]. All filters were kept in a desiccator for 72 hours before and after sampling then weighted on a micro-balance (Sartorius) with the accuracy of 0.01 mg.

Three monitoring stations were carefully chosen in order to compare particulate matter concentration with data of Pollution Control Department (PCD) in Thailand: (1) Dindaeng station, far from main road (Asok-Dindaeng road) less than 10 meters (2) Bansomdet Chaopraya Rajabhat University station, far from main road (Isaraparp road) more than 50 meters, commercial and residential area of Bangkok. and (3) Chulalongkorn University Station far from main road (Phayathai road) more than 50 meters and collecting at roof floor of Environmental Engineering Building which is 20 meters height from ground level. The samplings were carried out 24 hours in every 6 days for 2 months at each station for the period of 6 months in total during November 2008 until May 2009. Chulalongkorn University Station, nanoparticle sampler was co-located with high-volume sampler and 8-stage cascade impactor as well as comparing the data with automatic PM_{10} samplers (Taper Element Oscillating Microbalance (TEOM) and Beta ray type) at Dindaeng and Bansomdet Chaopraya Rajabhat University station.

RESULTS AND DISCUSSION

Particulate matter was collected by nano-particle sampler in 3 sampling sites: Dindaeng station, PM concentrations increase from November to highest in midmonth of December which is the cool season, Bansomdet Chaopraya Rajabhat University Station, PM concentrations trend decrease from midmonth of January to very low concentrations in March, and Chulalongkorn university station, the highest sampling site, PM average concentrations is clearly lower than PM concentrations from ground level sampling station.

The PM_{10} concentrations in Dindaeng as shown in Table 1, ranged from 50.3 to 127.0 $\mu g/m^3$ and average is 81.5 $\mu g/m^3$.The highest concentrations exceeded the national standard of air quality (120 $\mu g/m^3$). However, PM_{10} concentrations in Dindaeng in 2000 ranged from 37.0 to 137.0 $\mu g/m^3$ with the average value of 72.0 $\mu g/m^3$ (Thongsanit et al., 2003), which indicates the pollution situation is still serious in Bangkok. The sampling at Dindaeng roadside station showed the proportions of $PM_{10\text{-}2.5}$, $PM_{2.5\text{-}1}$, $PM_{1\text{-}0.07}$ and $PM_{0.07}$ to the total PM_{10} mass were 32.7, 20.9, 35.4 and 11.0%, respectively. Bamsomdej Chaopraya station showed the proportions of $PM_{10\text{-}2.5}$, $PM_{2.5\text{-}1.0}$, $PM_{1.0\text{-}0.07}$ and $PM_{0.07}$ to the total PM_{10} mass were 35.9, 24.5, 29.6 and 10.0%, respectively. Chulalongkorn station showed the proportions of $PM_{10\text{-}2.5}$, $PM_{2.5\text{-}1}$, $PM_{1\text{-}0.07}$ and $PM_{0.07}$ to the total PM10 mass were 31.5, 22.4, 34.9 and 11.2%, respectively. Proportions trend of all stations was similarity and indicating bimodal peaks for $PM_{10\text{-}2.5}$ and $PM_{1\text{-}0.07}$ rather than $PM_{2.5\text{-}1}$. The average $PM_{2.5}$: PM_{10} ratio in 3 stations ranged from 0.64 to 0.67. This raises the issue of targeted PM size for prescribing ambient air quality standards which now call for $PM_{2.5}$.

Table 1 Concentrations of PM in studied area during November 2008 – May 2009

Particle size	PM Concentration (μg/m^3)								
	Dindaeng	Bamsomdej	Chulalongkorn	Dindaeng	Bamsomdej	Chulalongkorn	Dindaeng	Bamsomdej	Chulalongkorn
N = 10	Minimum			Average			Maximum		
$PM_{0.07}$	4.3	0.1	1.0	9.0	7.1	3.3	13.5	18.6	6.6
PM_{1}	20.8	5.6	4.3	37.8	28.2	13.7	50.9	53.4	30.0
$PM_{2.5}$	28.9	10.8	8.3	54.9	45.7	20.3	93.9	79.4	43.7
PM_{10}	50.3	24.7	19.6	81.5	71.3	29.7	127.0	119.2	46.7

Table 2 PM concentrations from Nanosampler and other samplers.

PM concentrations (μg/m^3)	Dindaeng Station		Bansomdet Chaopraya Station			Chulalongkorn Station		
	Nano-particle sampler	TEOM	Nano-particle sampler	Beta Ray	High volume sampler	Nano-particle sampler	Cascade impactor	High volume sampler
PM_1	37.84	NA	28.21	NA	NA	11.73	10.32	NA
$PM_{2.5}$	54.88	NA	45.70	NA	NA	17.50	14.92	NA
PM_{10}	81.49	99.35	71.30	101.56	NA	28.40	31.99	NA
TSP	95.65	NA	98.43	NA	133.09	32.09	NA	32.37

The comparing results of PM concentration from nano-particles sampler, high-volume sampler, 8-stage cascade impactor Taper Element Oscillating Microbalance (TEOM) and Beta ray type at the air quality monitoring station as shown in Table 2, PM concentrations comparison from nano-particle sampler were closely to other sampler. TSP of nano-particle sampler is the total concentrations in all stages of sampler and NA is not applicable. Coefficient correlation (R^2) ranged from 0.66 to 0.91 indicates nano-particle sampler is enough accuracy for sampling instead of other samplers.

CONCLUSIONS

The results at Bangkok roadside area, Dindaeng station, showed concentrations of $PM_{0.07}$, PM_1, $PM_{2.5}$ and PM_{10} were 9.0, 37.8, 54.9 and 81.5μg/m^3, respectively. Background concentrations of $PM_{0.1}$, PM_1, $PM_{2.5}$ and PM_{10} at Bansomdet Chaopraya Rajabhat University were 7.1, 28.2, 45.7 and 71.3 μg/m^3, and at Chulalongkorn University were 3.3, 13.7, 20.3 and 29.7 μg/m^3, respectively. The proportions of $PM_{10\text{-}2.5}$, $PM_{2.5\text{-}1}$, $PM_{1\text{-}0.\ 07}$ and $PM_{0.\ 07}$ to the total PM_{10} mass averaged for 3 stations were 33.4, 22.6, 33.3 and 10.7 percent. The average $PM_{2.5}/PM_{10}$ *ratio*s of roadside area to background area were 0.67 and 0.66. The results showed relative large concentration of particles smaller than 1 μm and significant concentration of particles smaller than 100 nm. It can be concluded that fine particles is the important air pollutant and need to be properly control to protect human health and the environment. Nano-particle sampler is enough accuracy for sampling instead of high-volume sampler, 8-stage cascade impactor Taper Element Oscillating Microbalance (TEOM) and Beta ray type.

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