

Bus Commuters' exposure to fine particulate matter and ozone in Bangkok

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Abstract:

Personal air pollution exposures were conducted along traffic routes in Bangkok in comparison to the ambient monitoring data. This study aimed to get a better understanding of the health risks posed by fine particulate matter, PM_{2.5}, PM₁₀ and ozone in the urban transport micro-environment. The exposure pollutants were measured on the non-air condition buses during evening rush hours from 4.00pm to 8.00pm in November 2007 – January 2008. The studied bus routes were selected from traffic volume, 25,000-60,000 car/day urban streets with averaged vehicle speed 14 km/hour. Air pollution exposures were varied among traffic conditions. PM_{2.5} and PM₁₀ were collected using personal air sampler attached size-selected cascade impactor. Ozone was absorbed through the passive gas sampler followed by the ion chromatography analysis. Hourly PM_{2.5} and PM₁₀ commuters' exposures were found 43.0 ± 7.4 and $58.2 \pm 8.4 \mu\text{g m}^{-3}$, (n = 18) respectively. Ozone exposures were found relatively within the National Ambient Air Quality Standard (100 ppb). Hourly O₃ individual exposures in traffic routes averaged were 39.5 ± 17.7 ppb, (n = 16). Fixed monitoring stations were found to be relatively low predictors of PM_{2.5}, PM₁₀ and O₃ exposure concentration levels experienced by individuals.

Keywords: fine particulate matter, PM_{2.5}, PM₁₀, ozone, Bangkok

1. Introduction

It is known that the automobile emissions are the major source of air pollution in a congested city. Investigations in many cities around the world have shown that the traffic induced air pollutions are considerably higher than in the general ambient air concentrations, (Gulliver & Briggs, 2007; Gomez-Perales et al, 2007; Brandon et al, 2007). Exposures to pollutants in the transport microenvironment are often highly elevated compared to elsewhere. Consequently individuals may gain a significant contribution to their daily total exposure in a short period of time (Schweizer et al., 2005). In an urban transport microenvironment the individual exposures are not only restricted to those in motor vehicles. It also includes some people waiting for public transport around the traffic routes, roadside workers, residents, whose homes, flats, shops and other public places overlook onto heavy traffic roads, walking and cycling people. Motor vehicles emit a variety of air pollutants that are known to be associated with adverse health effects (Alan et al, 2002). Common air pollutants emitted by motor vehicles include fine particles, nitrogen dioxide, carbon monoxide, PAHS and ozone. Exposure to air pollutant associated with short and long-term adverse health effects on the lungs and heart, including premature death (Langkulsen, 2006; Barnett, 2006; Weschler 2006). Exposure to ozone is associated with adverse effects on the lungs, particularly irritation to airways and exacerbation of asthma (Alan et al, 2002). PAHs, combustion product from vehicle emissions are associated with a range of human health effects, from headaches and eye irritation to cancer (Thongsanit, 2003).

In this study, we aimed to measure the personal exposure of PM₁₀, PM_{2.5} and O₃ inside the running bus. We also compared the association between the traffic conditions and the exposure concentrations.

2. Methodology

2.1. Sampling Method

The air pollutants, **PM_{2.5}** , **PM₁₀** and **O₃** were collected in the non-air condition buses.

- **PM_{2.5}** and **PM₁₀** were sampling by personal pump attached size selected impactor, flow rate at 1.5 l/min. The sampling flow was measured before and after each sampling period using calibrated rota meters. Moisture on the filters are absorbed in desiccators for at least 24 hours before initial or final weighting to reduce the humidity effects on the filter weights. Filters were weighted before and after sampling use 7 decimal point, electrical balance.
- **O₃** were collected using membrane Passive Gas Samplers. Diffusion filters were made from polytetrafluorethylene (PTFE). The absorbed filters were glass fiber filters coated with NaNO₂, Na₂CO₃ and ethylene glycol. The principle component of coating is nitrite ion, which in the presence of ozone is oxidized to nitrate ion on the filter medium. After exposing the passive sampler, the absorbent filter was put in a polypropylene stopper box, 5 ml of ultra-pure water added and shaken gently for a while. Complete extraction for 30 min at room temperature was then form nitrate ion and finally the nitrate concentration was analyzed by ion chromatography.

2.2 Study duration and study routes

Air samplings were conducted on weekday and weekend during the rush hours evening from 4.00pm to 8.00pm in November 2007 – January 2008. Air samplings were conducted along 3 routes of different transportations, bus route number 4, 13 and 136, Figure 1. Those three routes were selected from three congested roads with traffic volume about 20,000-60,000 car/day, Table 1. The measurement data were compared to the monitoring data from PCD stations along the same routes.

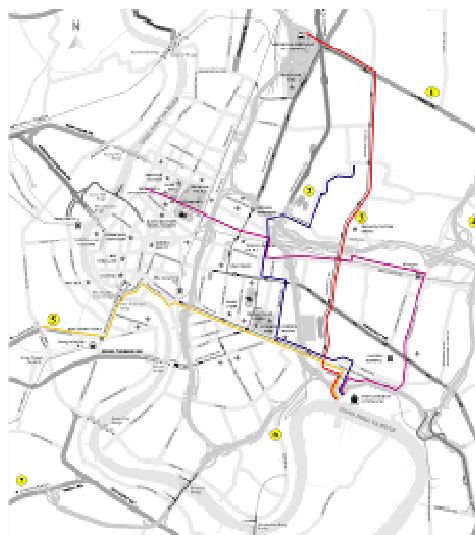


Figure 1 route of bus

Remark : Red line is route 136 from Klong-toei to Morchit
Blue line is route 13 from Klong-toei to Huai Kwhang
Yellow line is route 4 from Klong-toei to Paseechareuan

Table 1. Traffic volume

Bus route	Distance (km)	Traffic volume (car/day)
4	13	26,000
13	16	43,000
136	19	59,000

3. Result and discussion

The average vehicle speed of three study routes are ranged from 13-15 km/hour which is very lower concerning efficient economic driving speed, 80-90 km/hour. Air pollution exposures were varied among traffic conditions, speed and time, Table 2. Hourly PM_{2.5} and PM₁₀ commuters' exposures were found 43.0 ± 7.4 and $58.2 \pm 8.4 \mu\text{g m}^{-3}$, (n = 18) respectively. Hourly O₃ individual exposures in traffic routes averaged were 39.5 ± 17.7 ppb, (n = 16), (n = 16). PM₁₀ and Ozone exposures were found relatively lower than the National Ambient Air Quality Standard (daily PM₁₀ = 120 $\mu\text{g m}^{-3}$; O₃ = 100 ppb).

Table 2. Hourly Average of PM_{2.5}, PM_{2.5-10}, PM₁₀ ($\mu\text{g m}^{-3}$) and ozone (ppb) route 13, 136, 4

Bus route	Speed (km/hr)	Time (hr)	PM _{2.5}	PM _{2.5-10}	PM ₁₀	PM ₁₀ (PCD)	O ₃	O ₃ (PCD)
13	9.41	1.70	30.53	10.34	40.87	53.33	23.70	6.10
	11.43	1.40	34.41	19.28	53.70	62.00	70.04	4.20
	20.78	0.77	49.60	nd	49.60	72.67	nd	11.20
	20.51	0.78	50.63	nd	50.63	47.00	nd	5.20
	15.24	1.05	43.28	17.92	61.20	61.50	46.61	5.70
	11.27	1.42	33.73	16.15	49.89	47.00	34.66	6.10
	14.77±4.9	1.19±0.4	40.36±8.6	15.92±3.9	50.98±6.6	57.25±10.0	43.75±19.8	6.42±2.4
136	6.64	2.86	48.28	4.73	53.02	108.20	24.52	30.30
	15.20	1.25	40.83	18.44	59.27	104.50	58.91	23.90
	15.83	1.20	38.19	19.93	58.12	63.00	35.48	19.30
	15.83	1.20	40.68	22.19	62.88	45.00	31.24	14.70
	14.07	1.35	41.41	19.90	61.31	55.00	38.11	14.40
	10.67	1.78	39.46	15.66	55.13	54.00	22.83	25.70
	13.04±3.7	1.61±0.7	41.48±3.5	16.81±6.3	58.29±3.7	71.62±27.5	35.18±13.1	21.38±6.4
4	13.98	0.93	57.33	11.90	69.24	49.50	48.42	13.80
	14.77	0.88	57.21	17.84	75.05	45.33	50.65	14.00
	9.15	1.42	41.86	11.48	53.35	52.67	43.21	14.50
	14.94	0.87	38.80	29.09	67.89	54.00	28.32	19.00
	14.77	0.88	43.90	14.43	58.32	47.50	39.50	21.80
	14.94	0.87	43.96	23.28	67.24	46.50	35.96	34.00
	13.76±2.3	0.98±0.2	47.18±8.0	18.00±6.9	65.18±7.9	49.25±3.5	41.01±8.3	19.52±7.8

Particulate matter

Generally, roadside PCD monitoring data of PM₁₀ were found to be relatively close to exposure concentration levels among three study routes. The hourly average PM_{2.5}, PM₁₀ were found highest in bus No.4, 47.18 and 65.18 $\mu\text{g m}^{-3}$. The moderate exposure route, bus No. 136, the average PM_{2.5} and PM₁₀ were 41.48 and 58.29 $\mu\text{g m}^{-3}$ and the low exposure route, bus No.13, were 40.36 and 50.98 $\mu\text{g m}^{-3}$. Comparison the average PM₁₀ concentration between our exposure measurements with the PCD monitoring data by Paired Simple T-test, PM₁₀ sampling from bus No.13 and bus No.136 were found no significantly different from PCD data. However exposure from bus No.4 which the highest one was found significantly higher than the monitoring average values in the same interval time (p< 0.05).

Ozone

The hourly average ozone level in bus No.4, 13 and 136 are 41,61 and 35 ppb respectively. Exposure ozone level in bus No.13 is highest.

However the individual O₃ exposures were higher than monitoring data. In this study, we measured inside the running non-air condition bus during the rush hour evening. O₃ is a secondary pollutant from photochemical reactions which could be formed and accumulate for whole day. In addition, the outdoor pollutants along the roadside could have added effect upon the background level.

4. Conclusion

Roadside pollutants are often affected by the climate conditions and other air pollution related factors such as picking up and dropping off the passengers, bus model and the number of passengers inside the bus. The high exposure levels in the current study could be due to the slow moving traffic patterns. In order to get a better understanding of the health risks posed by traffic induced air pollutants, the individual exposures from different routes and other vehicle types need to be further investigated.

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