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Comparative Studies on the Concentration of Some Heavy Metal in Urban Particulate Matter, Bangkok, Thailand

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Abstract**—**The main objective of this study was to investigate particulate matter concentration on main and secondary roadsides in urban area and study the concentration of some heavy metals including lead (Pb), zinc (Zn), copper (Cu) and cadmium (Cd) in particulate matter in the Bangkok area.

The averaged particle concentration for main roadsides is higher than secondary roadsides. The particulate matter less than 10 micron concentration contribute the majority of the Total Suspended Particulate matter for main roads and zinc concentrations were higher than copper and lead for both sites.

Keywords**—**Air Pollution, Air Quality, Pollution and monitoring.

I. Introduction

BANGKOK (latitude 13°45′N, longitude 100°29′E) is the capital and the most populous city in Thailand. It has a population of over 7.8 million inhabitants in an area of approximately 1,500 km^2 [1]. The city is congested with a large number of motor vehicles. More than 5.9 million vehicles circulate within the city in 2008 [2]. Traffic has been the main source of air pollution in Bangkok.

Several organizations have studied the amount and composition of urban particulate matter (PM) for a number of years. It is best to say that air pollution is very serious in the areas of heavy traffic flow in the Bangkok metropolis. Exhaust and non – exhaust source (brake wear emissions, tire wear emissions, and road dust) are the main sources of the air pollution.

The main objective of this study was to investigate particulate matter concentrations on main and secondary roadsides in urban areas and study on the concentrations of some heavy metals (Pb, Zn, Cu and Cd) in particulate matter. This work focused on Total Suspended Particle (TSP, particulate matter with aerodynamic diameter less than 100 micron), PM_{-10} (aerodynamic diameter of particulate matter less than 100 micron ; fine particulate matter), and PM_{10-100} (aerodynamic diameter of particulate matter between 10- 100 micron ; coarse particulate matter).

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II. Materials and Methods

A. Sampling Area Description

All samples were collected in the Dusit District (Fig. 1), located in central Bangkok. This district is the main administrative center of the kingdom, as both the National Assembly and royal palace are located in this district.

Two groups of samples were collected on roadsides at

(1) Main road including Samsen Road (traffic flow was 23,705 vehicles per day) and Ratchawithee Road (traffic flow as 16,439 vehicles per day)
(2) Secondary roads; these samples were collected in residential areas including Suan-Oay community and Bangkra Bue community roadsides.

Fig. 1 Map of Dusit District, Bangkok, Thailand

B. Material and Sampling

The TSP (Total Suspended Particle) samples were collected using a high volume air sampler (Tisch, USA), And PM_{10} sample were collected using a high volume air sampler

(Ecotech, Australia). With glass fiber filter (10 x 8 inch: 99.97% retention efficiency of 0.3 microns) and PM_{10-100} were calculated from TSP concentration and PM_{10} concentrations. Approximately 800 m^3 of air were filtered for each sample during 8 hr. in the daytime (8 am – 4 pm.). The sampler was placed at height of 1.5m. above ground level (Fig. 2). 70 samples were collected from March to July 2008.

Fig. 2 The TSP Sampling on Ratchawithi roadside (Main road)

The heavy metal composition in this studied including Lead Zinc Copper and Cadmium was determined by Atomic Absorption Spectrophotometer: AAS (Fig. 3).

Fig. 3 Atomic Absorption Spectrophotometer Instrument (THERMO series)

C. Standard, Reagent and Blank

The primary standards for AAS were obtained from high purity metals or salts dissolved in high purity acids. The blanks of the filters were evaluated by analyzing in the same procedure as the samples.

D. Analysis

After sampling and reweighting, the filters were cut to 200mm x 250mm. Each filter was digested in 20ml of concentrated nitric acid at 150-200°C for 2hrs [2] and then diluted to 25ml. with distilled deionized water. A THERMO series atomic absorption spectrophotometer was used to measure the trace metal concentration. The concentration of heavy metal was calculated by (1) [3]:

$$C = \frac{25 \times A \times B}{D \times V} \quad (1)$$

when
C is heavy metal concentration (μg/m^3)
25 is final volume before analyze by AAS (ml)
A is the total area of filter (m^2)
B is the heavy metal concentration from AAS (mg/l)
D is the area of filter were cut (m^2)
V is the total value of air were collected (m^3)

E. Quality Control

Background contamination was routinely monitored by using operational blanks (unexposed) which processed simultaneously with field samples. In this study, the background contamination is insignificant and can be ignored. At least 10% of the samples were analyzed by spiking with know amount of metal to calculate the recovery efficiencies. The ranges of recovery efficiency tests indicated the ranged of recovery efficiency among every 10 samples varied between 95 % and 102%. The reproducibility test varied between 98 % and 105% for all chemical species.

III. Result and Discussion

A. Particulate Matter Concentration

The averaged concentration of the TSP PM_{10-100} and PM_{10} is shown in Table I.

TABLE I
PARTICLE METER CONCENTRATION

	Main roadside (μg/M^3)			Secondary roadside (μg/M^3)		
	TSP	PM_{10-100}	PM_{10}	TSP	PM_{10-100}	PM_{10}
n	35	35	35	35	35	35
Min-max	0.06 – 0.6	nd – 0.37	0.04 – 0.12	0.01 - 0.48	0.01 – 0.48	0.04 – 0.10
Mean	0.20	0.12	0.08	0.19	0.12	0.07
SD	0.10	0.009	0.02	0.10	0.10	0.02
Ratio : PM_{10}/TSP	0.21-5.44 (average 0.57 ± 0.87)			0.20-0.90 (average 0.49 ± 0.22)		

The averaged concentrations of TSP and PM_{10} at main roadsides were higher than secondary roadside. The ratios of PM_{10}/TSP for main roadside averaged 0.57 ± 0.87 μg/m^3 and averaged 0.49 ± 0.22 μg/m^3 for secondary roadside. These results are similar to the value of 0.68 suggested by G-C.Fang et al. [4] as a typical for central Taiwan. The ratios of

PM_{10}/TSP for main roads were greater than 0.5, these results indicated that the PM_{10} concentration contribute the majority of the TSP.

B. Heavy Metal Concentrations

The concentrations of the heavy metal for all collected air samples are presented in Table II. The averaged concentrations of main roads were higher than secondary roads. The heavy metals generally have an anthropogenic origin from vehicles.

The average concentration of Lead in TSP for main road was higher than secondary roads. And the averaged concentration of lead, copper and zinc in TSP were higher than PM $_{10\text{-}100}$ and PM_{10}.

TABLE II
PARTICLE METER CONCENTRATION

road		Heavy metal concentration (µg/m^3)			
		Pb	Cu	Zn	Cd
Main	$PM_{10\text{-}100}$	Nd – 0.23 (0.04 ± 0.07)	Nd – 0.29 (0.05 ±.07)	Nd – 9.13 (1.23 ± 2.59)	nd
	PM $_{10}$	Nd – 0.07 (0.02 ± 0.02)	Nd – 0.18 (0.03 ± 0.04)	3.04 – 13.11 (5.69 ± 1.60)	nd
secondary	$PM_{10\text{-}100}$	Nd – 0.09 (0.02 ± 0.03)	Nd – 8.47 (0.78 ± 1.68)	Nd – 9.22 (2.45 ± 2.63)	nd
	PM $_{10}$	Nd – 0.06 (0.02 ±0.02)	Nd – 1.88 (0.24 ± 0.43)	1.09 – 13.52 (5.58 ± 2.35)	nd

Nd = nondetectable

C. Particulate Composition

The components of heavy metals in TSP are presented in Fig. 4. For main roadsides were 98.22 % zinc, 1.09% copper and 0.68% lead. For secondary roadsides were 88.45% zinc, 11.11% copper and 0.44% lead.

The components of $PM_{10\text{-}100}$ are presented in Fig. 5. For main roads were 93.18% zinc, 3.79% copper and 1.32% lead. For secondary roadsides were 75.37% zinc, 24.00% copper and 0.62% lead.

The components of PM_{10} are presented in Fig. 6. For main roads were 99.13% zinc, 0.52% copper and 0.35% lead, for secondary roadsides were 95.55% of zinc, 4.11% copper and 0.34% lead.

The cadmium concentration could not be detected for all samples.

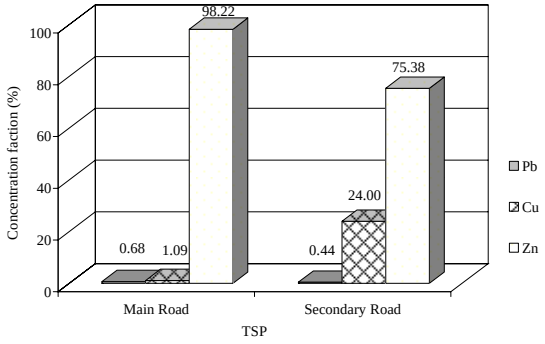

Fig. 4 The heavy metal concentration in TSP

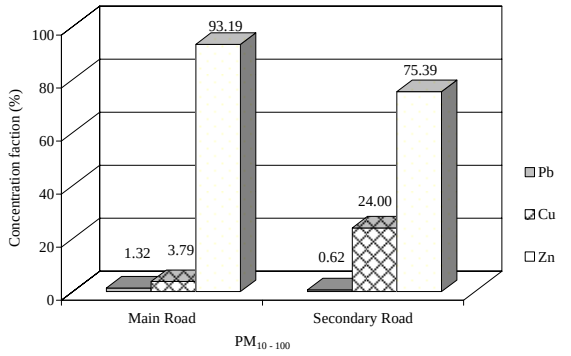

Fig. 5 The heavy metal in PM $_{10\text{-}100}$ concentration

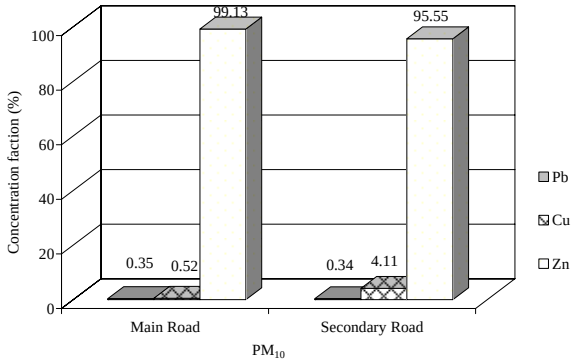

Fig. 6 The heavy metal concentration in PM_{10}

The result showed that the zinc concentration was the highest. A major source of zinc comes from Tire wear [5], [6]. All heavy metal concentration of TSP was higher than PM_{10} and $PM_{10\text{-}100}$ for both sites (Figs. 7-9).

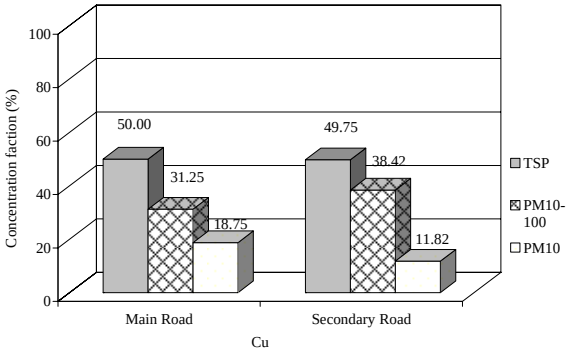

Fig. 7 The copper concentration in particulate mater

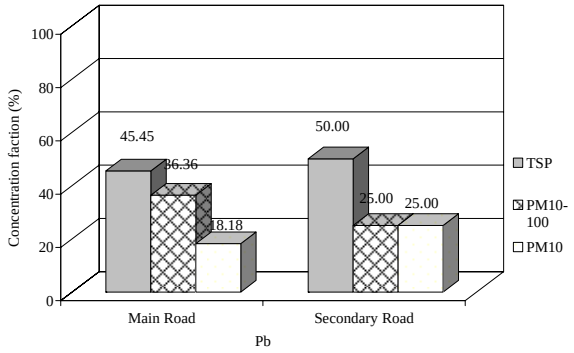

Fig. 8 The lead concentration in particulate mater

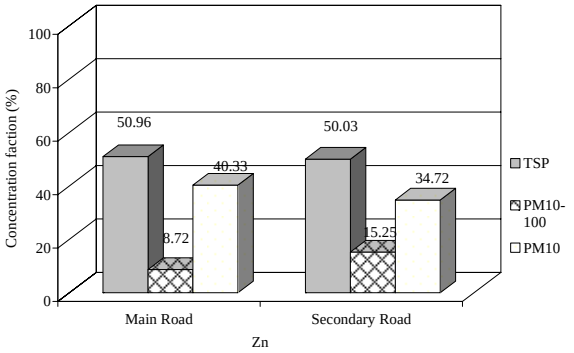

Fig. 9 The zinc concentration in particulate mater

IV. Conclusion

The main conclusions for this study are listed as followed;

(1) The averaged particle concentration for main roads was higher than secondary roads.
(2) The PM_{10} concentration contributed the majority of the TSP for main roads
(3) Zinc concentrations were higher than copper and lead for both sites.

Acknowledgment

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