การวิเคราะห์หาปริมาณธาตุและแหล่งที่มาของฝุ่นละอองอากาศในเขตปทุมวัน

Elemental Quantification and Source Identification of Airborne Particulate Matter in Pathumwan District

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บทคัดย่อ: ปัญหามลภาวะในอากาศที่พบมากที่สุดในเขตเมืองใหญ่และเมืองหลวง คือ ฝุ่นละอองอากาศ ซึ่งเป็นสาเหตุให้เกิดปัญหาความเสื่อมโทรมต่อสิ่งแวดล้อมและต่อสุขภาพของประชาชน โดยเฉพาะฝุ่นละอองขนาดเล็กกว่า 10 ไมครอน (PM_{10}) ซึ่งสามารถเข้าสู่ระบบหายใจอันเป็นผลให้เกิดโรคในระบบทางเดินหายใจได้ ฝุ่นละอองละเอียดขนาดตั้งแต่ 2.5 ไมครอน ($PM_{2.5}$) ยังเป็นสาเหตุสำคัญของปัญหาทัศนวิสัย งานวิจัยนี้เป็นการศึกษาคุณภาพอากาศในเขตปทุมวันซึ่งเป็นย่านธุรกิจใจกลางเมืองกรุงเทพฯ โดยดำเนินการเก็บตัวอย่างฝุ่นอากาศที่มีขนาดเล็กทั้งชนิดหยาบ ($PM_{2.2-10}$) และชนิดละเอียด ($PM_{2.2}$) ด้วยเครื่องเก็บอากาศ Gent stacked filter unit ในช่วงเดือนมกราคม ถึงธันวาคม 2545 มาทำการตรวจวัดมวลและปริมาณ black carbon และวิเคราะห์ปริมาณธาตุต่างๆด้วยเทคนิคการอาบนิวตรอน ผลการศึกษาพบว่าฝุ่นอากาศ ณ บริเวณจุดเก็บ มีปริมาณค่อนข้างสูงโดยมีค่าเฉลี่ยรวมทั้งปีของPM_{10} 56.6 $\mu g/m^3$ และสูงกว่าค่าระดับมาตรฐานที่กำหนดคือ 50 $\mu g/m^3$ สำหรับข้อมูลปริมาณของ black carbon และธาตุอื่นๆ นำมาใช้ในการวิเคราะห์ด้วยโมเดลทางคณิตศาสตร์ เพื่อการบ่งชี้ถึงแหล่งของมลพิษในบรรยากาศที่เป็นไปได้ ซึ่งพบว่าแหล่งสำคัญได้แก่ ฝุ่นดินทรายในเมือง การเผาไหม้ของเชื้อเพลิงรถยนต์ และการเผาขยะและอื่นๆ

Abstract: Airborne particulate matter (APM) is apparently the biggest air pollution problem found in capital and other big cities. APM has the adverse impact on human health and also on the environment. PM_{10} (particle with aerodynamic diameter less than 10 μm), in particularly, can cause the respiratory diseases since it can penetrate the respiratory system. Furthermore, $PM_{2.5}$ (particle with aerodynamic diameter less than 2.5 μm) is the major cause of visibility impairment. This paper reports the study of urban air pollution at Pathumwan District, a business area in Bangkok City center. Coarse and fine fractions of PM_{10} ($PM_{2.2-10}$ and $PM_{2.2}$, respectively) were collected by a Gent stacked filter unit air sampler during January – December 2002. The filter samples were measured for mass and black carbon. Elemental concentrations were analyzed by instrumental neutron activation analysis. The results indicate the rather high level of PM_{10} at the sampling site. The annual average of PM_{10} is 56.6 $\mu g/m^3$ compared to the ambient air quality standard of 50 $\mu g/m^3$. The obtained data of black carbon and elemental concentrations were used for investigation of pollution sources by applying a receptor model called Positive Matrix Factorization. It could identify that the main sources were most likely city dust, emissions from vehicle combustion, incineration and sea-salt.

Methodology: A Gent stacked filter unit air sampler was set at the curbside of Phayathai Road in the city center. The sampling was operated at flow rate about 16 lpm for 24 hours once a week from January to December 2002. Coarse and fine particles, i.e., $PM_{2.2-10}$ and $PM_{2.2}$, were collected on two sequential 47 mm diameter Nuclepore polycarbonate filters (8 μm and 0.4 μm pore size, respectively). The total of 50 pairs of coarse and fine particles were collected. The filter samples were first measured for mass concentrations using a Microbalance. The Smoke Stain Reflectometer (Model 43D of EEL) was used for the determination of elemental carbon in the samples. The filter

samples were then analyzed for elemental concentrations by Instrumental Neutron Activation Analysis (INAA). For INAA, the air filter samples including standards and filter blanks were packed in polyethylene vials and irradiated in 1.2 MW TRIGA MARK III Research Reactor at the thermal neutron flux in the order of 10^{12} n/cm^2.sec. All irradiated samples were then transferred to new vials and counted for gamma ray activities. Two different irradiations and four gamma ray counts after appropriate decay times were conducted in order to determine short-, medium, and long-lived radionuclides. The conditions and elements determined are summarized in Table 1. Up to 27 elemental concentrations and their uncertainties were obtained. A receptor model was then applied for source identification using these elemental and black carbon concentrations as a database. Positive Matrix Factorization (PMF) (1) was selected for this work.

Results, Discussion and Conclusion: The results of mass concentrations for both coarse and fine particles are shown in Figure 1. The annual average and the 24-hour maximum values of those mass concentrations are compared with the ambient air quality standard of Thailand (2) as shown in Table 2. The black carbon content of the fine and coarse fraction filters are given in Figure 2. Figure 3 presents average concentrations of all elements including black carbon in coarse and fine fractions. The identified source types from PMF data analysis are listed in Table 3.

The results as summarized in Table 2 indicate the high level of particulate mass at the sampling site in the business area of Bangkok City. Particularly, the annual average of PM_{10} derived is a little higher than the ambient air quality standard of Thailand limited by Pollution Control Department. The 24-hour maximum of PM_{10} derived is also found to be as high as the standard value. However, it can be observed from Figures 1 that the fine particulate mass has a declining trend in rainy season. This is similarly to the pattern of black carbon in fine fraction. It is also obvious in Figure 2 that black carbon is a major constituent in fine particles and it is, as a matter of fact, a marker species indicating a vehicle source. According to Table 3, the general sources of pollution in the city are found to be soil, motor vehicles, and sea-salt. It has to be noted that some source types may contribute to both size fractions but in different ratio.

References:

1. Paatero, P., Tapper, U. Environmetrics 5, 111-126. (1994).
2. Pollution Control Department, Ministry of Science, Technology and Environment. Ambient air standards of Thailand (1995).

Table 1 INAA conditions and determined elements

Irradiation time	Decay time	Counting time	Elements determined
2 min	5 min	5 min	Al, Ca, Cl, Mg, Ti, V
	3 hr	5 min	Mn, Na
10 hr	3-5 days	30 min	As, Br, K, La, Na, Mo, Sb, Sm
	2-3 weeks	1 hr	Ce, Co, Cr, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Se, Th, Zn

Table 2 Mass concentrations of particulate samples collected at Pathumwan in 2002 compared to the air quality standard of Thailand for PM_{10}

Mass concentration in $\mu g/m^3$				
	Fine : $PM_{2.2}$	Coarse : $PM_{2.2-10}$	PM_{10} (Fine + Coarse)	PM_{10} (standard)
Annual average	20.8	35.8	56.6	50
24 hour (max)	60.7	96.2	120*	120

*24 hour maximum of derived PM_{10} when $PM_{2.2-10}$ and $PM_{2.2}$ reached 96.2 and 23.8 $\mu g/m^3$

Table 3 Possible source types by PMF

Source type	Fine particles : $PM_{2.2}$	Coarse particles: $PM_{2.2-10}$
Soil dust	/	/
Vehicle	/	/
Refuse incinerator	/	
Sea-salt	/	/
Cement		/
Motorcycle	/	/

/ shows the presentation of the factor contribution to the particular data set

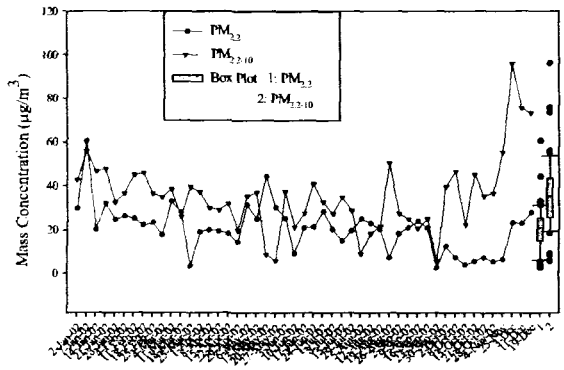

Figure 1 Time series and box-whisker plots of fine and coarse particle mass concentrations.

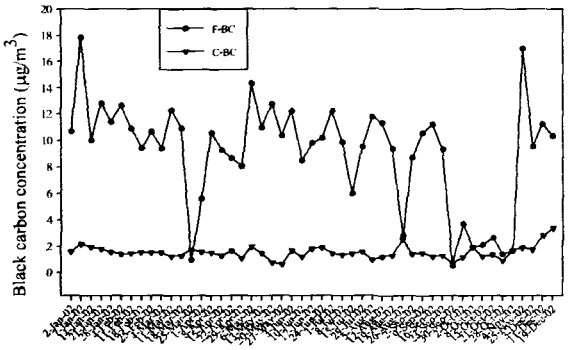

Figure 2 Time series plots of the black carbon concentrations in fine and coarse particle samples.

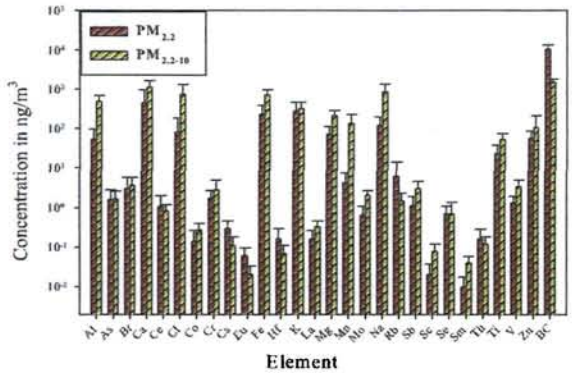

Figure 3 Means and standard deviations of elemental concentrations in fine and course particle samples.

Key words: Air pollution in Thailand, INAA, airborne particulate matter