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1.26 Study of Urban Air Pollution in Thailand

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Abstract

The Office of Atoms for Peace has conducted a monitoring study of urban air pollution in Thailand for years. The primary objective of the project was to support the use of nuclear-related techniques for research and monitoring studies on air pollution. The databases obtained have been analyzed and interpreted by statistical methods including source identification using receptor model. This paper reports the work of 2002 at a heavy traffic area in Bangkok. A Gent sampler was set at the curbside of a major road in Bangkok to collect fine and coarse particles routinely on a weekday for 24 hours, once a week. The filter samples were analyzed for elemental concentrations by use of instrumental neutron activation analysis. Black carbon was separately determined by means of the reflectance measurement of the filter sample. In the report, the methodologies and the results of analyses of fine and coarse particles on filters collected in 2002 are presented. The study of the applicability of certified reference material was done by analyses of two standard reference materials provided by JAERI, i.e., NIST 1632c and NIES No.8. The comparisons of the measured and certified values are also given in the paper.

Key words : Air pollution in Thailand; INAA; Particulate matter

1. Introduction

It is generally known that air pollution problem commonly occur in the big cities by one way or another. In Thailand, the situation is most severe in Bangkok metropolis where there are huge population, very dense traffic and continuity of the city development. Concerning to the pollutants in the atmosphere, Thailand regulate and monitor for the major pollutants, i.e., SO_2, NO_2 and CO, O_3, Pb and suspended particulate matter. It has been reported that the lead content in the atmosphere decreases satisfactory due to the regulation of using unleaded gasoline since 1991. The levels of those pollutant gases, on the other hand, still need to be monitored carefully. O_3, in particular, has the increasing tendency. At present, however, the most important pollutant that causes the most serious problem in Thailand, especially in Bangkok, is the atmospheric particulate matter. In recent years, greater attention has been to characterize the nature of particulate matter (PM) since it has the adverse impact on human health and also on the environment. Particles with aerodynamic diameter less than 10 μm, termed PM_{10}, can be transported over large distances and can enter human respiratory system. Particles with aerodynamic diameter less than 2.5 μm, termed as $PM_{2.5}$, are most effective in scattering light and are the major cause of visibility impairment. Regarding the fact that PM_{10} and $PM_{2.5}$ or coarse- and fine-mode PM, in addition to falling into different size ranges, differ in formation mechanisms, chemical compositions, sources, and exposure relationships, the studies on particular modes will have result on the effectiveness of pollution control and air quality management.

Beginning in 1994, the Environmental Research Group, Office of Atoms for Peace (OAP) has conducted the study on air pollution. The Gent stacked filter unit (Gent SFU), provided by International Atomic Energy Agency (IAEA), has been used for the project. Gent SFU is the standard air sampler[1] that collects simultaneously the coarse- and fine-mode PM, i.e., $PM_{2.2\text{-}10}$ and $PM_{2.2}$. The study areas were mainly at urban sites and sometimes at the suburb of Bangkok. The samples were then measured for mass and were analyzed for elemental composition. A receptor model has been applied to some set of data to investigate for airborne particulate sources. In this paper, the work of 2002 at a business area in Bangkok is reported.

2. Methodologies

2.1. Aerosol sampling

Started from January through December 2002, the sampling site was at a business area in Bangkok where is located at latitude 13° 45′ N and longitude 100° 29′ E. A Gent sampler was set at the curbside of a major road in the city center. Figure 1 shows location of the selected area for the study. The map in Figure 2 gives a closer view of the sampling site. Coarse and fine particles, i.e., $PM_{2.2\text{-}10}$ and $PM_{2.2}$, were collected on two sequential 47 mm diameter Nuclepore polycarbonate filters (8 μm and 0.4 μm pore size). The sampling was operated at flow rate about 16 lpm for 24 hours basis on a weekday, normally once a week.

2.2. Analytical technique

The air 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. Up to 27 elemental concentrations, their uncertainties and detection limits were obtained.

2.3. The study of the applicability of certified reference material

Following the plan set in WURR 2001, the analyses of certified reference materials (CRMs) provided by JAERI, i.e., NIES No. 8 and NIST 1632c were implemented. Sets of different amounts of such CRMs, each of which three samples were weighted and analyzed for elemental compositions by INAA. Four sets consisted of 1, 5, 10, and 15 mg were used for determination of short-lived radionuclides while three sets of 5, 20, and 50 mg were used for determination of those medium- and long-lived radionuclides. For this work, comparative method using three standard reference materials, i.e., ECH (coal fly ash), PACS (marine sediment), and SD-M-2/TM (marine sediment) were performed.

3. Results and discussion

3.1. Particulate composition data

Totally 50 pairs of fine and coarse particulate matter were collected and analyzed. The results of mass concentrations for both fine and coarse particles are shown in Figure 3. 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 1. The black carbon content of the fine and coarse fraction filters is given in Figure 4. Figures 5 and 6 display the box and whisker plots to indicate the median, the 10^{th}, 25^{th}, 75^{th}, and 90^{th} percentile of the elemental concentrations for the fine and coarse fractions, respectively.

The results indicate the rather high level of particulate mass at the sampling site in the business area of Bangkok City. Particularly, both the annual average and the maximum value of PM_{10} derived, as summarized in Table 1, are higher than the ambient air quality standard of Thailand limited by Pollution Control Department. Nevertheless, it can be observed from Figures 3 and 4 that the fine particulate mass and black carbon have the declining trends in rainy season. A few high peaks of both fine particulate mass and black carbon content occur correspondingly. This information can indicate the vehicle combustion source. Elemental data as shown in Figures 5 and 6 are also important for an investigation of pollution sources of fine and coarse particulate matter in atmosphere. In our preliminary study on elemental concentrations of airborne particulate matter, it indicates that the main sources are most likely city dust, emissions from vehicle combustion and refuse incineration.

3.2. Data of select elements in CRMs

The results of the elemental analyses of NIES No. 8 and NIST 1632c are summarized in Tables 2 and 3. Over 20 elements in both materials which have certified or reference values are listed for comparison. In an overview for all elements analyzed, there is not much significant difference in data found for different sets of weight of the samples. However, the set of 1-mg samples analyzed for those short-lived nuclides result in rather high values with higher standard deviations than the other sets. This may imply that too small amount of the material should not be used nor give the reliable result. On the other hand, it may depend, more or less, on the facility and method used and need individual lab's consideration on how to use those CRMs effectively.

4. Conclusion

During 2002, sampling and analysis of both fine and coarse particles in Bangkok metropolitan area at the selected site were conducted and yield a database of chemical information. It shows the trend of atmospheric particulate as a major problem of urban air pollution. After complete the data analysis and validation, this database can be used to provide an estimate of major source types contributing to airborne particulate matter. Therefore, the next step to accomplish this project is to utilize the database with an advance receptor model for source identification and apportionment which is necessary for the development of effective and efficient urban air quality management.

References

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2. Ambient air standards of Thailand (1995). Pollution Control Department, Ministry of Natural Resource and Environment.

Table 1 Mass concentrations of fine and coarse particles and air quality standard of Thailand[2] for PM_{10}

	Mass concentration in $\mu g/m^3$			
	Fine : $PM_{2.2}$	Coarse : $PM_{2.2\text{-}10}$	PM_{10} (this work)	PM_{10} (standard)
Annual average	20.8	35.8	56.6	50
24 hour (max)	60.7	96.2	156.9	120

Table 2 Comparative data of measured values and certified/reference values for selected elements in NIST 1632c

Element	Certified/Reference Values (μg/g)	Measured values (μg/g) of samples			
		1 mg	5 mg	10mg	15 mg
Al	9150 ± 137	10433 ± 1071	9139 ± 205	9196 ± 96	8901 ± 235
Ca	1450 ± 300	1657 ± 650	1541 ± 135	1547 ± 296	1571 ± 221
Cl	1139 ± 41	1148 ± 31	1053 ± 41	1143 ± 167	925 ± 30
Mg	384 ± 32	490 ± 128	380 ± 42	376 ± 85	334 ± 25
Mn	13.0 ± 0.5	17.1 ± 3.1	13.7 ± 0.5	12.2 ± 0.1	12.7 ± 0.8
Na	299 ± 5	269 ± 23	283 ± 9	278 ± 14	279 ± 12
Ti	517 ± 32	636 ± 102	630 ± 68	540 ± 47	490 ± 9
V	23.7 ± 0.5	22.1 ± 3.8	22.3 ± 1.0	21.8 ± 1.1	20.9 ± 1.1
			5 mg	20 mg	50 mg
As	6.18 ± 0.27		6.18 ± 0.22	6.68 ± 0.33	7.17 ± 0.07
Br	18.7 ± 0.4		17.6 ± 1.41	18.9 ± 0.46	19.4 ± 0.25
Ce	11.9 ± 0.2		11.5 ± 0.61	11.8 ± 0.64	12.3 ± 0.18
Co	3.48 ± 0.20		3.35 ± 0.10	3.41 ± 0.07	3.50 ± 0.09
Cr	13.7 ± 0.2		13.4 ± 1.14	13.7 ± 0.72	13.3 ± 0.46
Cs	0.59 ± 0.01		0.57 ± 0.06	0.70 ± 0.06	0.67 ± 0.06
Eu	0.124 ± 0.003		0.122 ± 0.027	0.084 ± 0.007	0.083 ± 0.003
Fe	7350 ± 110		7327 ± 78	7310 ± 125	7536 ± 134
Hf	0.58 ± 0.01		0.57 ± 0.19	0.65 ± 0.12	0.60 ± 0.05
K	1100 ± 33		1050 ± 33.7	1154 ± 12.6	1159 ± 12.4
Na	299 ± 5		263 ± 12	295 ± 3	316 ± 2
Rb	7.52 ± 0.33		7.68 ± 1.18	6.98 ± 1.67	7.56 ± 0.70
Sb	0.46 ± 0.03		0.43 ± 0.03	0.47 ± 0.01	0.46 ± 0.01
Sc	2.90 ± 0.04		2.63 ± 0.11	2.74 ± 0.01	2.82 ± 0.05
Sm	1.08 ± 0.03		0.94 ± 0.01	1.04 ± 0.01	1.12 ± 0.01
Th	1.40 ± 0.03		1.38 ± 0.09	1.34 ± 0.04	1.41 ± 0.04
Zn	12.1 ± 1.3		11.8 ± 0.9	13.8 ± 4.96	12.7 ± 2.33

Table 3 Comparative data of measured values and certified/reference values for selected elements in NIES No.8

Element	Certified/Reference Values (μg/g)	Measured values (μg/g) of samples			
		1 mg	5 mg	10mg	15 mg
Al	3300 ± 200	3759 ± 325	3721 ± 28	3798 ± 84	3822 ± 101
Ca	5300 ± 200	5880 ± 711	5522 ± 209	5554 ± 335	5800 ± 212
Mg	1010 ± 50	970 ± 210	878 ± 51	946 ± 137	937 ± 31
Na	1920 ± 80	2020 ± 417	1925 ± 7	2076 ± 305	1992 ± 94
V	17 ± 2	15.9 ± 1.6	15.6 ± 1.1	16.3 ± 1.9	15.9 ± 0.8
			5 mg	20 mg	50 mg
As	2.6 ± 0.2		2.76 ± 0.28	2.86 ± 0.11	2.81 ± 0.10
Br	56		56.1 ± 2.1	60.9 ± 3.0	61.7 ± 0.8
Ce	3.1		3.38 ± 0.17	3.62 ± 0.35	3.75 ± 0.21
Co	3.3 ± 0.3		3.62 ± 0.60	3.31 ± 0.38	3.28 ± 0.09
Cr	25.5 ± 1.5		30.5 ± 6.1	27.6 ± 1.7	26.5 ± 0.7
Cs	0.24		0.49 ± 0.05	0.32 ± 0.15	0.31 ± 0.07
Eu	0.05		0.11 ± 0.01	0.08 ± 0.01	0.06 ± 0.003
K	1150 ± 80		1351 ± 171	1187 ± 57	1245 ± 88
La	1.2		1.16 ± 0.09	1.28 ± 0.01	1.29 ± 0.11
Mo	6.4		7.55 ± 1.04	7.29 ± 0.39	6.57 ± 0.67
Na	1920 ± 80		2018 ± 45	2032 ± 153	2100 ± 89
Rb	4.6		4.66 ± 0.38	5.06 ± 0.49	4.96 ± 0.08
Sb	6.0 ± 0.4		6.38 ± 0.22	6.51 ± 0.30	6.58 ± 0.09
Sc	0.55		0.58 ± 0.03	0.58 ± 0.03	0.58 ± 0.01
Sm	0.2		0.21 ± 0.03	0.22 ± 0.004	0.21 ± 0.01
Th	0.35		0.42 ± 0.06	0.40 ± 0.02	0.36 ± 0.01
Zn	1040 ± 50		881 ± 163	890 ± 183	936 ± 79

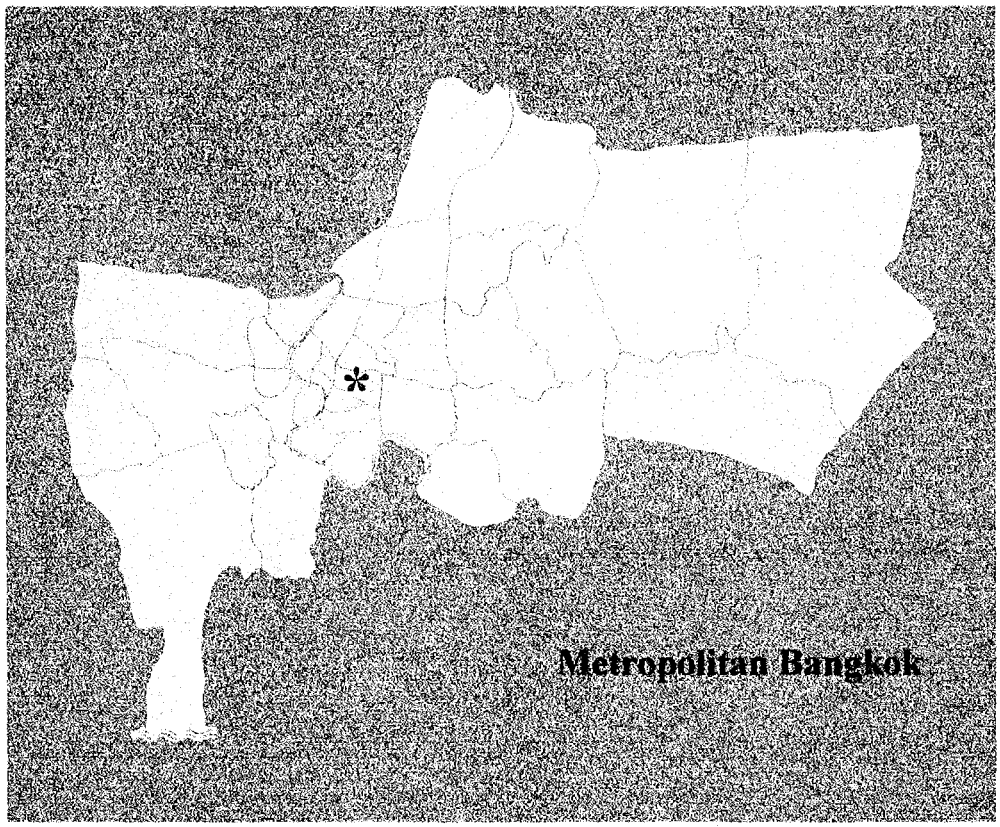

Figure 1 Location of sampling site at Pathumwan district, Bangkok, Thailand.

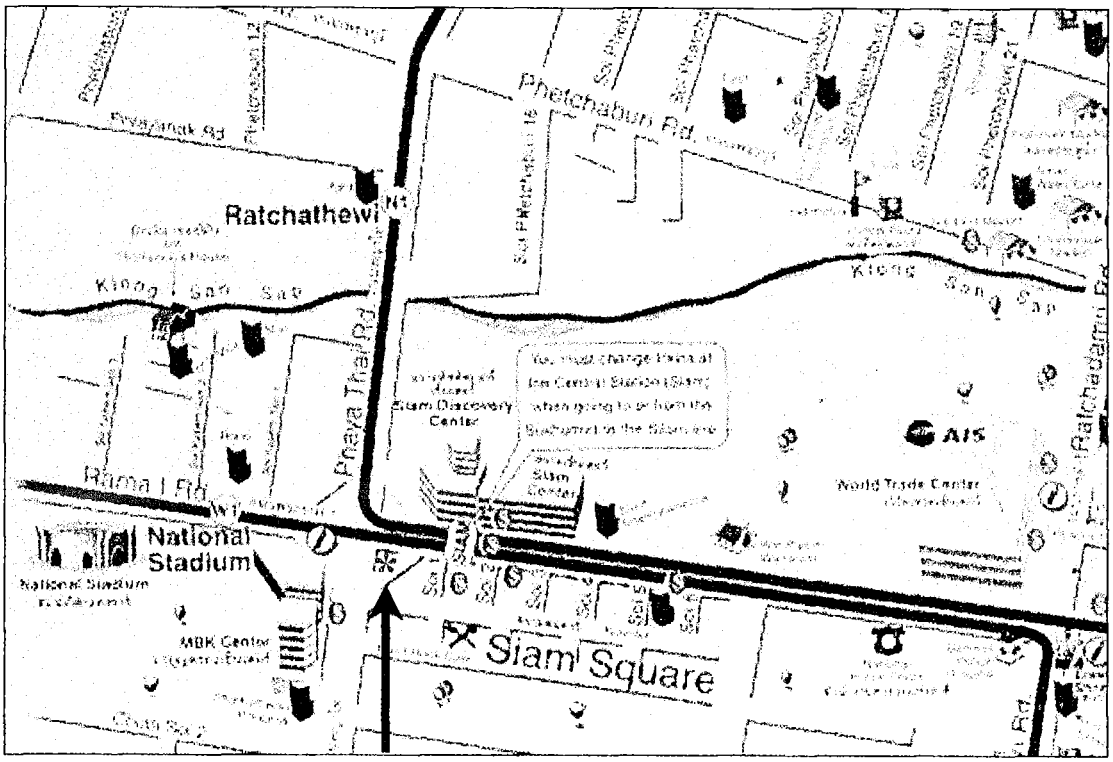

Figure 2 Map of the sampling site at Pathumwan, Bangkok. (* marks for the sampling site)

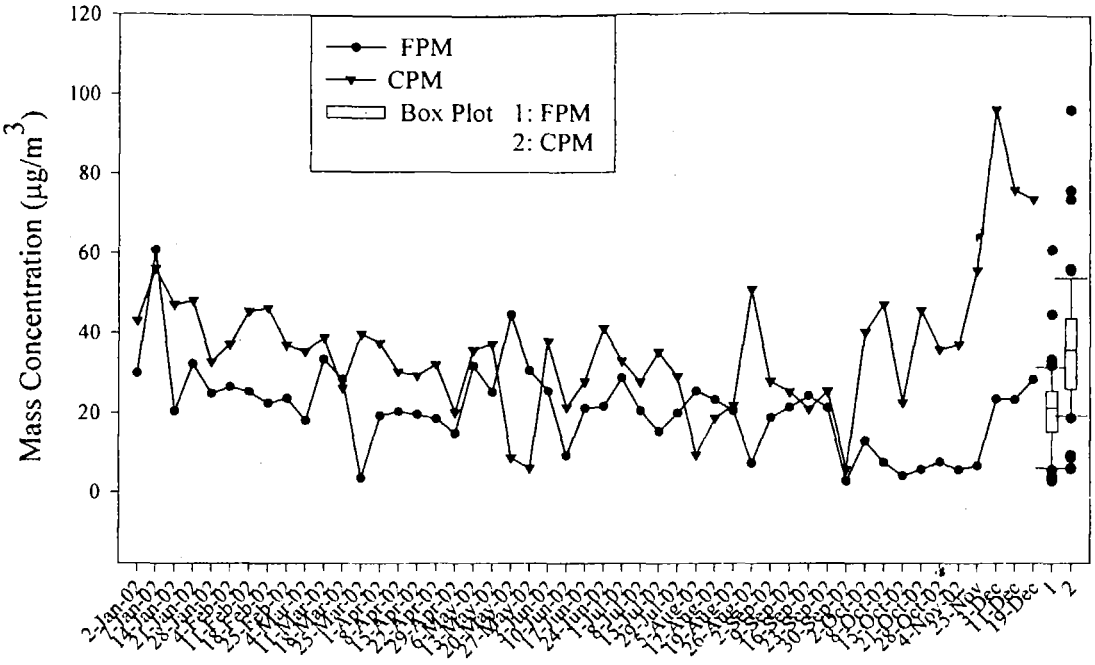

Figure 3 Time series and box-whisker plots of the fine and coarse particle fraction mass concentrations.

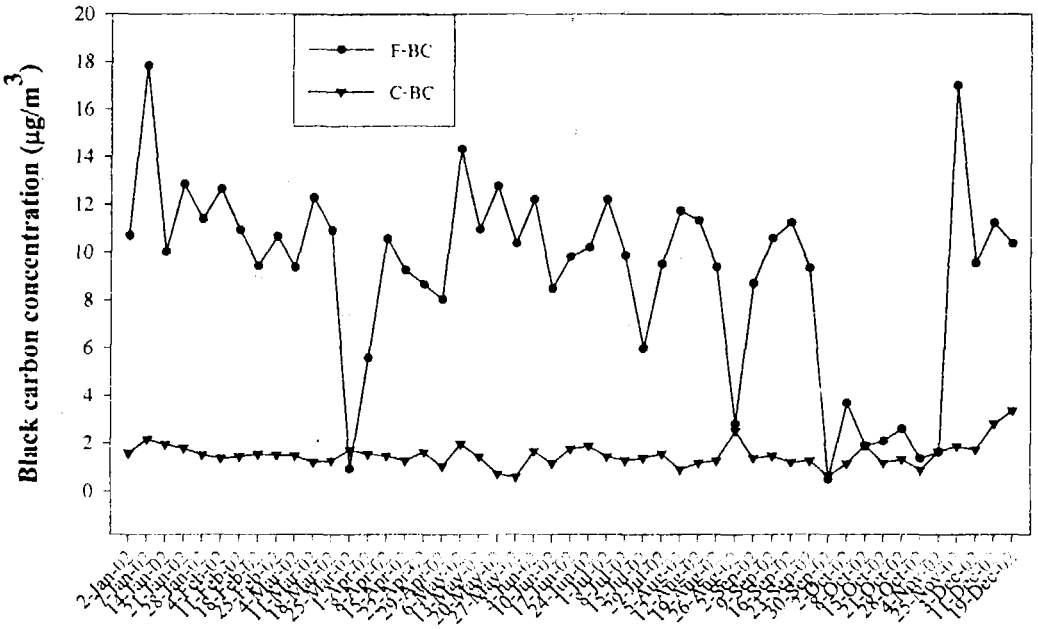

Figure 4 Time series plots of the black carbon concentrations in the fine and coarse particle samples.

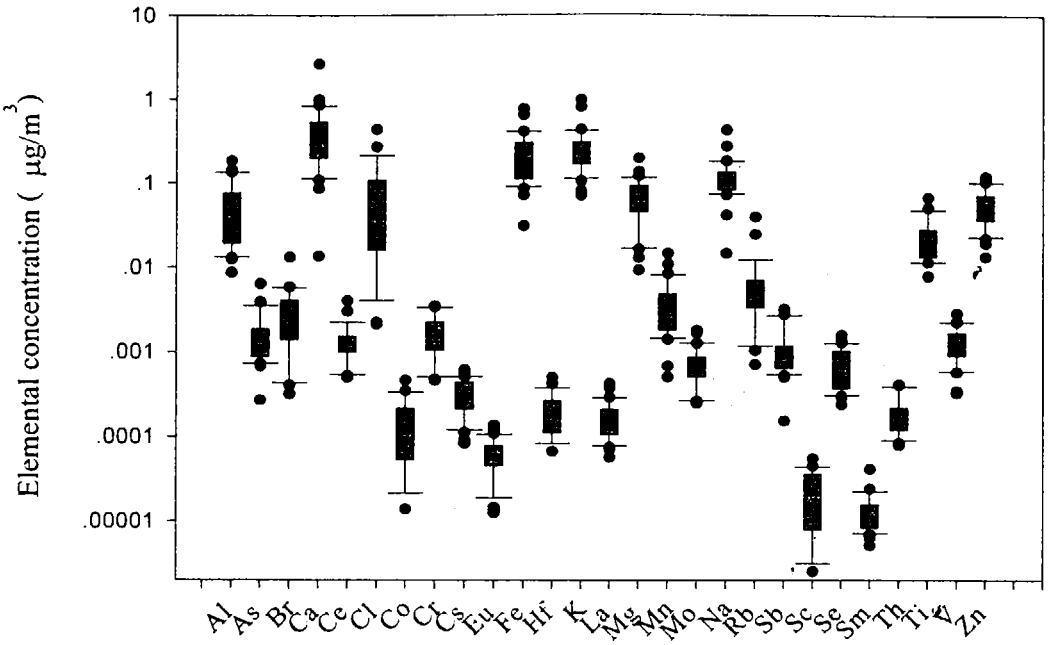

Figure 5 Box-whisker plots of the elemental concentrations in fine particle samples.

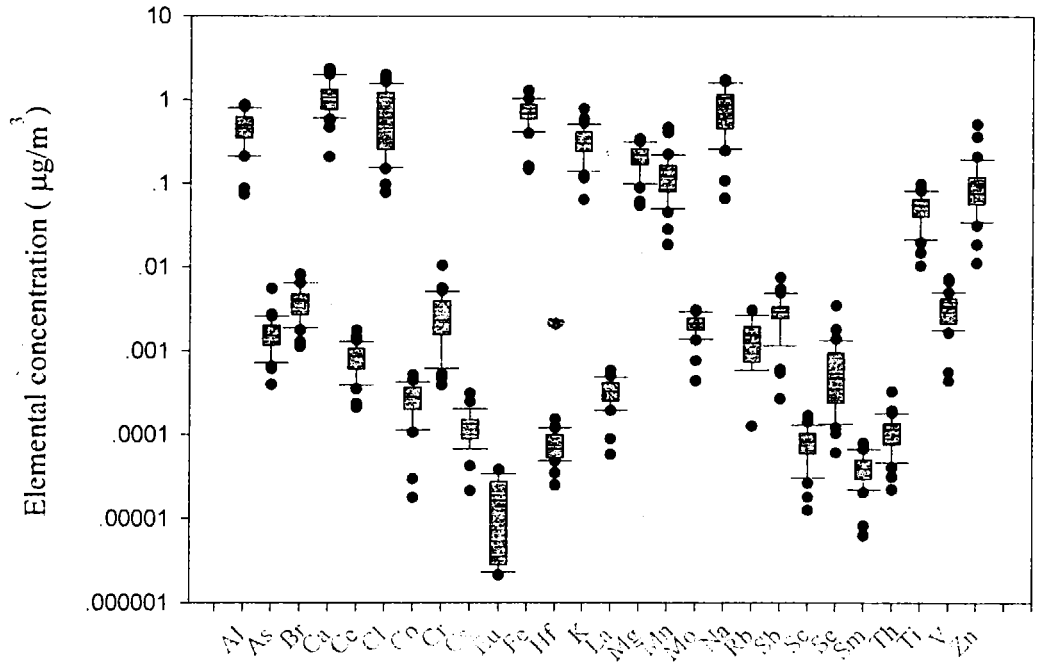

Figure 6 Box-whisker plots of the elemental concentrations in the coarse particle samples.