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Final Report
INAA of Airborne Particulate Matter Collected in Bangkok and Pathumthani 2002-2004

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Abstract

This paper presents the summary report of the monitoring study on ambient air quality in Bangkok metropolis and its boundary covering the period from 2002 to 2004. The work performed included sampling of fine and coarse fractions of particulate matter at the sites representing urban and suburban areas; measurement of particle mass concentration and elemental concentration; and data interpretation. Instrumental neutron activation by use of research reactor facilities at Office of Atoms for Peace was carried out for multielemental analysis of all filter samples collected. Twenty elements were determined. The database of the three consecutive years are summarized and reviewed in this paper.

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

1. Introduction

The Environmental Research Group, Chemistry and Material Science Research Program, Office of Atoms for Peace (OAP) has conducted the monitoring study on ambient air quality in Bangkok since 1994. The primarily objective was toward application of instrumental neutron activation analysis (INAA) on elemental determination of airborne particulate matter (APM or PM).

As of interest in FNCA-NAA group, a collaborative project for air pollution study was designed for the three-year plan covering the period from 2002 to 2004. The scheme was to collect fine and coarse particulate matter (FPM and CPM) at the specific sites once a month and to analyze those collected samples for multielements by use of neutron activation technique. The results were examined concerned to air pollution as of local and also regional areas.

Since the current-phase project on air pollution study using INAA is completed this year, the results obtained from the three years are concluded and presented in this final report.

2. Methodologies

2.1. Aerosol sampling

The study areas covered in this project are shown in Figure 1. Site [1] and [2] are in the inner areas of Bangkok Metropolitan. Both sites thus represent urban areas. While site [3] representing a suburban residential area is in Pathumthani Province, a Bangkok's boundary in the north approximately 40 km from Bangkok City center. The Gent air samplers were set up at these sites to collect fine and coarse particles (FPM: $PM_{2.2}$ and CPM: $PM_{2.2\text{-}10}$) on two sequential 47 mm diameter Nuclepore polycarbonate filters (0.4 μm and 8 μm pore size). The sampling was generally operated at flow rate about 16 lpm for 24 hours basis once a month from January 2002 to December 2004. The numbers of samples collected are given in Table 1.

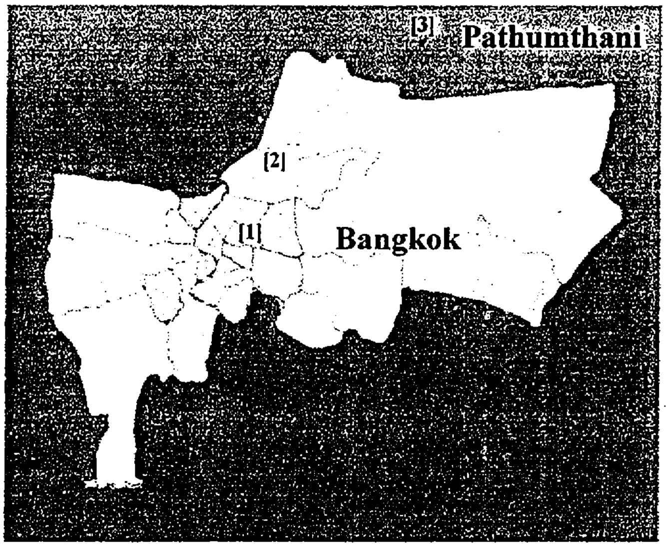


Figure 1 Map of Bangkok and sampling sites at [1] Pathumwan, Bangkok; [2] Chatuchak, Bangkok; and [3] Klongha, Pathumthani.

Table 1 Samples collected during 2002 and 2004

Sampling sites / Year	Bangkok Site* (Urban)		Pathumthani Site (Suburban)	
	No. of Sample		No. of Sample	
	Fine fraction	Coarse fraction	Fine fraction	Coarse fraction
2002	12	12	-	-
2003	12	12	12	12
2004	12	12	12	12
Total	36	36	24	24

* Site [1] in 2002
Site [2] in 2003 and 2004

2.2. Analytical technique

Although the objective of the project is to utilize INAA for elemental analysis, it is important to measure the air filter samples for mass concentration. Therefore, the measurements of PM mass using a Microbalance were first performed. Then, the filter samples were analyzed for elemental concentrations by INAA. All compositions determined were compiled for data report.

For INAA, the air filter samples including standards and filter blanks were packed in polyethylene vials and were 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(1). 20 elemental concentrations, their uncertainties and detection limits were obtained.

3. Results and discussion

The three-year database of mass and elemental compositions of fine and course particles collected from both urban and suburban sites are summarized and interpreted as shown in Tables 2 to 4 and Figures 2 to 5.

Statistics of mass concentrations of fine and coarse particles collected at Bangkok and Pathumthani during 2002 and 2004 are summarized in Table 2 and Figure 2. Apparently, there is not significant difference between PM masses at different years. However, PM masses at urban were much higher than at suburban site especially for coarse fractions. Time variations of fine and coarse particle masses at both sites are presented graphically in Figure 3. It can be observed the similar patterns of which PM were higher during dry season. PM in urban Bangkok was obviously higher than PM in suburban Pathumthani corresponding to the higher pollution in the city. To compare with national ambient air quality standard of PM_{10}[(2)], fine and coarse fractions were added together to obtain derived PM_{10}. Consequently, derived PM_{10} was plotted versus PM_{10} standards as shown in Figure 4. Data of only two years, i.e., 2003 and 2004 were used so that derived PM_{10} of both sites can be collated. The two-year averages of derived PM_{10} were 58.8 $\mu g/m^3$ and 37.0 $\mu g/m^3$ for Bangkok and Pathumthani respectively while PM_{10} standard is 50 $\mu g/m^3$ for annual average. Besides, there were very high values of derived PM_{10} in Bangkok during dry seasons which once exceeded the 24-hour PM_{10} standard, i.e., 120 $\mu g/m^3$. Derived PM_{10} in Pathumthani was corresponding but in lower level and no value exceeded the standard.

Statistical data of elemental concentrations are summarized in Tables 3 and 4 for Bangkok and Pathumthani database accordingly. It can be concluded that, in general, CPM contained most elements in higher concentrations than FPM. Furthermore, elemental contents of both CPM and FPM at urban area were found to be higher than at suburb. Greater information can be obtained from their correlations and time variations. As examples, time series plots of those selected key elements for sea, soil, and pollutants are given in Figures 5 (a) to (d).

From the results above, it can be inferred that air pollution in urban area like Bangkok metropolitan are more serious than at its boundaries as Pathumthani, particularly with concern to PM. The monitoring study on air pollution and trends in urban and suburban areas are still needed to be carried on.

4. Conclusion

A collaborative project for INAA application on air pollution study set up among FNCA members has accomplished in 2004 as planned. The results of the study can be made use for monitoring of air pollution and its trend both in country and regional scales.

In Thailand, the data/information generated from this work will be a part of long-term database that OAP contribute to national authorized agent who has direct responsibility in air quality assessment/management. It will be an advantage from this FNCA collaboration if APM database/information outputs from each member state can be compiled and provided to their end-users. Nevertheless, this issue may need further discussion and agreement in specific.

References

1. Chueinta, S. Bunprapob, and S. Tedthong (2004). INAA of Airborne Particulate Matter Collected in Bangkok and Pathumthani, Thailand. Proceeding in The 2003 Workshop on the Utilization of Research Reactors, Dalat, Vietnam, January 12-16, 2004.

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

Table2 Statistical summary of mass concentrations of FPM and CPM collected at Bangkok (2002-2004) and Pathumthani (2003-2004)

Sampling sites: Size fractions	Particle mass (µg/m³)					
	2002		2003		2004	
	Range	Mean	Range	Mean	Range	Mean
Bangkok: urban area						
FPM	5.50 – 38.6	28.4	2.17 – 26.19	18.3	8.32 – 45.0	20.0
CPM	21.7 – 75.8	36.8	16.7 – 86.3	32.9	19.2 – 85.4	46.4
Pathumthani: suburb						
FPM	-	-	1.71 – 25.0	15.0	7.00 – 42.1	18.2
CPM	-	-	3.39 – 36.7	15.5	7.15 – 57.5	25.3

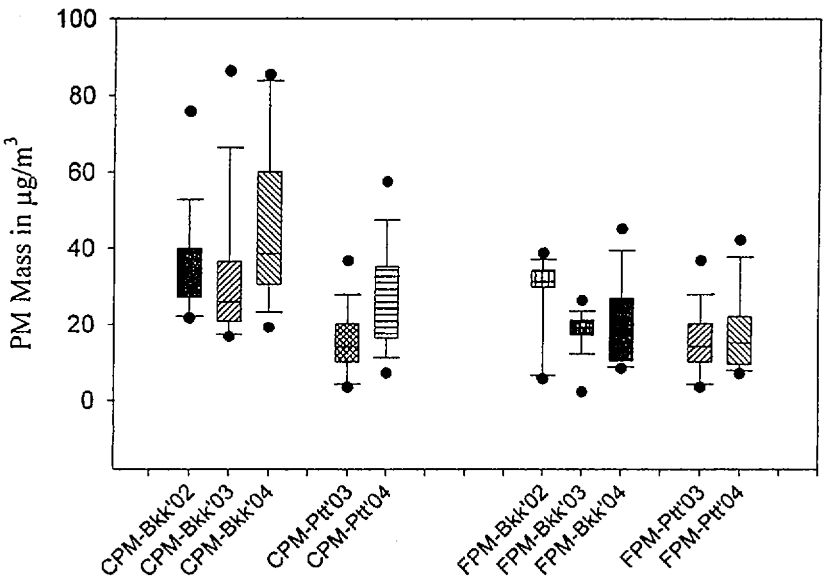
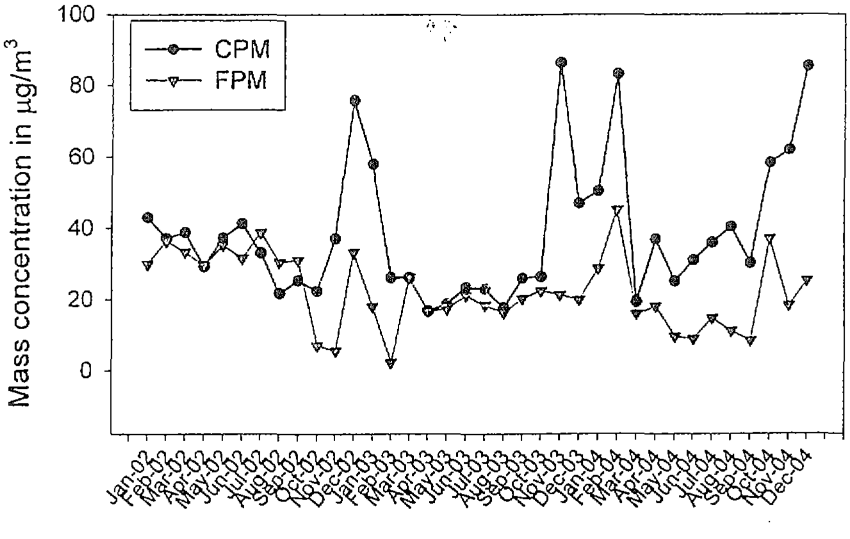
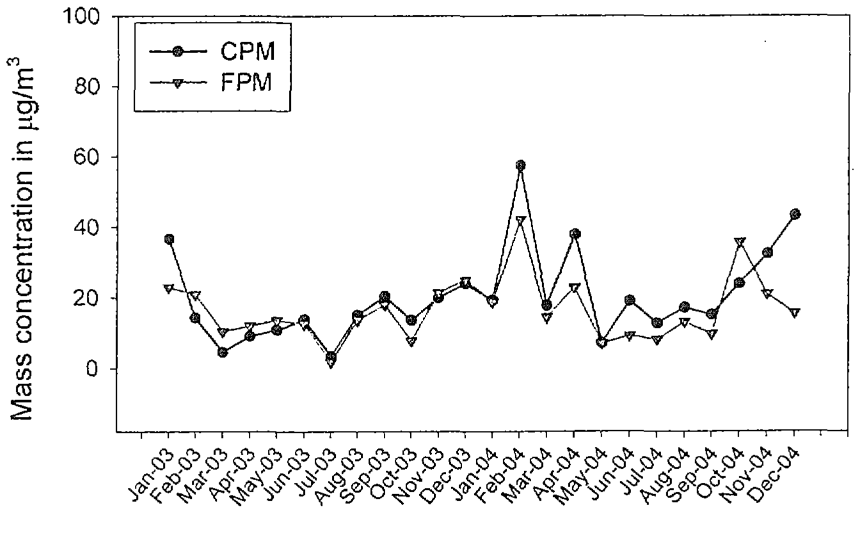


Figure 2 Comparison of PM mass at different sites and times.



(a) Bangkok



(b) Pathumthani

Figure 3 Time variations of fine and coarse particle masses at (a) Bangkok and (b) Pathumthani.

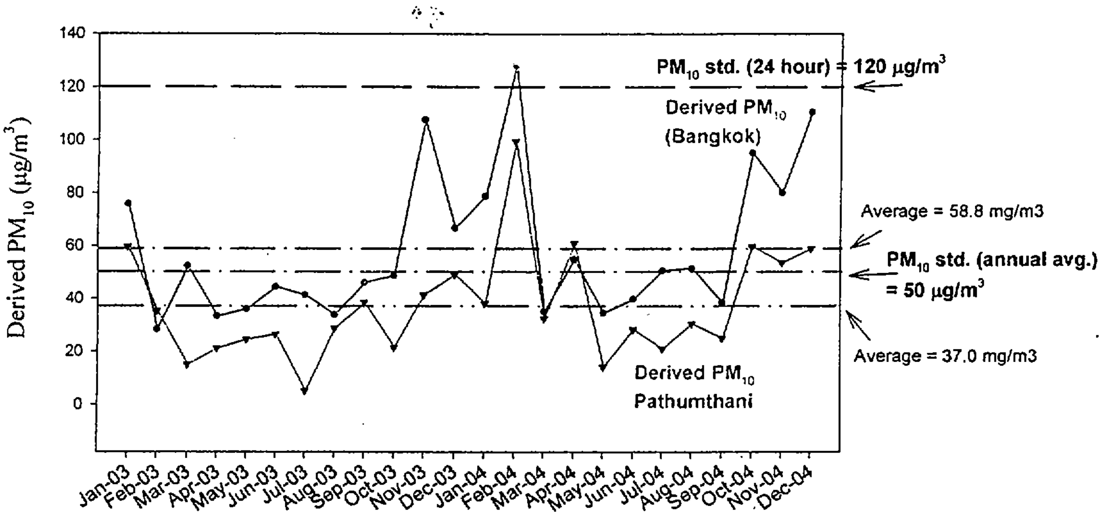


Figure 4 Time series plots of derived PM_{10} vs. PM_{10} standards.

Table 3 Mean and standard deviation (in ng/m^3) of elemental concentrations of FPM and CPM collected at Bangkok in 2002-2004

Element	Bangkok, urban residential area					
	2002		2003		2004	
	Mean ± SD		Mean ± SD		Mean ± SD	
	FPM	CPM	FPM	CPM	FPM	CPM
Al	73.2 ± 47.4	564 ± 282	94.5 ± 65.5	761 ± 609	139 ± 73	1022 ± 474
As	1.17 ± 1.02	1.98 ± 1.53	1.89 ± 1.74	3.07 ± 2.66	2.29 ± 2.28	3.22 ± 2.39
Br	2.52 ± 1.72	3.35 ± 1.61	8.71 ± 2.44	10.4 ± 3.67	5.16 ± 2.39	6.06 ± 3.08
Ca	370 ± 277	1563 ± 109	133 ± 87.6	1585 ± 1034	163 ± 63	1989 ± 715
Cl	65.3 ± 58.8	683 ± 702	21.3 ± 12.9	309 ± 148	45.0 ± 34.4	706 ± 752
Cr	2.25 ± 1.43	2.46 ± 1.14	2.01 ± 1.69	2.62 ± 0.86	2.08 ± 1.12	4.31 ± 2.29
Cu	5.25 ± 3.08	18.7 ± 12.6	4.33 ± 1.33	10.4 ± 3.91	6.47 ± 2.64	17.7 ± 7.0
Fe	150 ± 82	680 ± 247	131 ± 67	641 ± 450	207 ± 68	899 ± 305
K	245 ± 130	365 ± 128	217 ± 134	508 ± 430	334 ± 201	628 ± 353
La	0.17 ± 0.07	0.52 ± 0.29	0.088 ± 0.050	0.48 ± 0.33	0.13 ± 0.06	0.69 ± 0.30
Mg	46.9 ± 35.9	161 ± 110	27.9 ± 12.9	183 ± 135	51.7 ± 22.6	295 ± 91
Mn	3.59 ± 1.86	59.1 ± 54.3	4.52 ± 2.11	15.8 ± 9.77	12.4 ± 12.4	26.4 ± 14.7
Na	78.1 ± 48.6	652 ± 553	71.7 ± 34.3	481 ± 185	130 ± 86	678 ± 519
Sb	1.01 ± 0.78	3.55 ± 1.85	1.09 ± 0.58	2.29 ± 1.77	1.91 ± 1.59	3.75 ± 3.15
Sc	0.015 ± 0.011	0.096 ± 0.041	0.017 ± 0.013	0.13 ± 0.10	0.033 ± 0.017	0.19 ± 0.09
Se	0.71 ± 0.40	0.50 ± 0.28	0.87 ± 1.37	0.67 ± 0.25	-	-
Sm	0.013 ± 0.007	0.065 ± 0.029	0.010 ± 0.006	0.064 ± 0.052	0.016 ± 0.006	0.089 ± 0.038
Ti	16.6 ± 8.7	61.3 ± 51.6	8.04 ± 3.13	53.4 ± 35.5	13.4 ± 5.5	73.3 ± 29.7
V	0.92 ± 0.40	2.51 ± 1.13	1.55 ± 0.93	3.32 ± 2.10	2.43 ± 1.25	4.76 ± 2.35
Zn	39.6 ± 29.8	69.3 ± 21.0	46.2 ± 27.9	97.7 ± 37.2	71.1 ± 40.0	136 ± 70

Table 4 Mean and standard deviation (in ng/m^3) of elemental concentrations of FPM and CPM collected at Pathumthani in 2003-2004

Element	Pathumthani, suburban residential area			
	2003		2004	
	Mean ± SD		Mean ± SD	
	FPM	CPM	FPM	CPM
Al	55.2 ± 52.9	488 ± 329	151 ± 83	724 ± 421
As	1.29 ± 1.33	0.73 ± 0.63	2.00 ± 2.07	1.40 ± 1.37
Br	8.84 ± 4.54	7.36 ± 3.01	5.41 ± 3.80	4.19 ± 3.84
Ca	83.9 ± 69.9	811 ± 426	149 ± 60	1106 ± 441
Cl	13.1 ± 12.0	178 ± 109	34.2 ± 26.3	371 ± 289
Cr	1.67 ± 1.88	1.41 ± 0.89	1.58 ± 1.59	2.53 ± 1.95
Cu	3.77 ± 4.31	4.18 ± 2.53	5.95 ± 4.36	4.83 ± 1.82
Fe	103 ± 60.4	308 ± 177	144 ± 58	437 ± 221
K	279 ± 220	201 ± 128	395 ± 229	406 ± 223
La	0.081 ± 0.044	0.32 ± 0.15	0.12 ± 0.04	0.48 ± 0.22
Mg	30.4 ± 28.0	102 ± 66.2	53.0 ± 28.8	180 ± 80
Mn	3.09 ± 2.16	8.41 ± 5.93	10.2 ± 16.0	15.0 ± 10.4
Na	81.6 ± 44.0	230 ± 81.4	139 ± 82	417 ± 313
Sb	1.17 ± 1.35	0.49 ± 0.38	1.66 ± 1.56	0.90 ± 0.84
Sc	0.018 ± 0.016	0.081 ± 0.055	0.034 ± 0.018	0.13 ± 0.08
Se	0.47 ± 0.34	0.35 ± 0.32	-	-
Sm	0.011 ± 0.008	0.044 ± 0.023	0.018 ± 0.007	0.070 ± 0.033
Ti	7.61 ± 4.77	31.0 ± 17.5	13.1 ± 6.1	44.9 ± 21.8
V	1.09 ± 0.79	1.40 ± 0.67	1.91 ± 0.61	2.28 ± 0.89
Zn	30.6 ± 24.5	34.3 ± 24.1	55.2 ± 29.4	48.1 ± 21.8

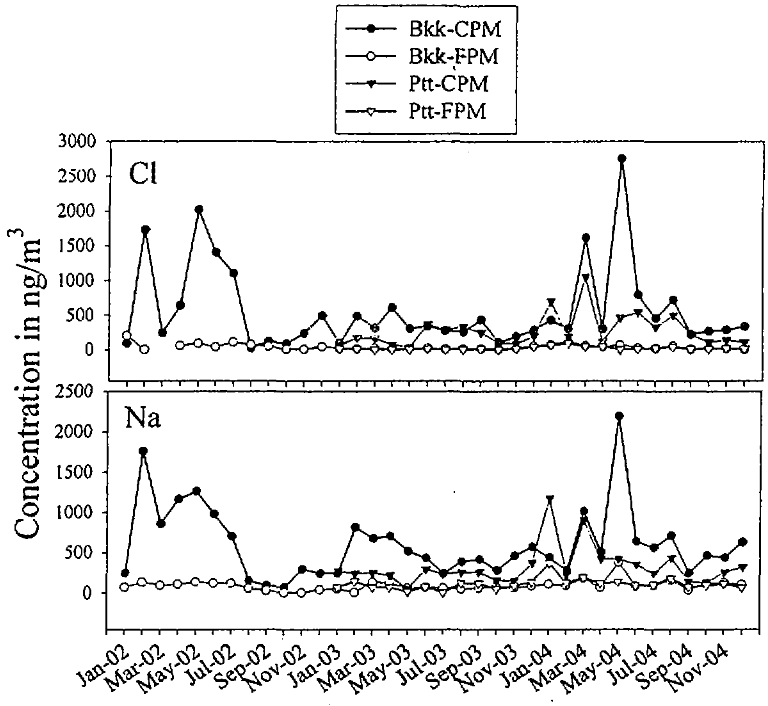


Figure 5 (a)

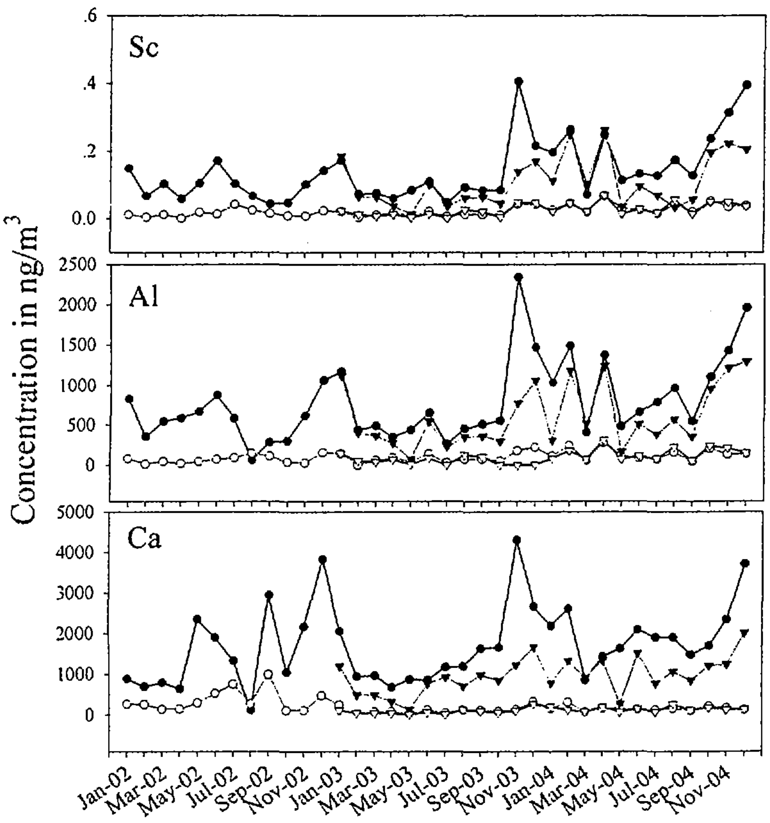


Figure 5(b)

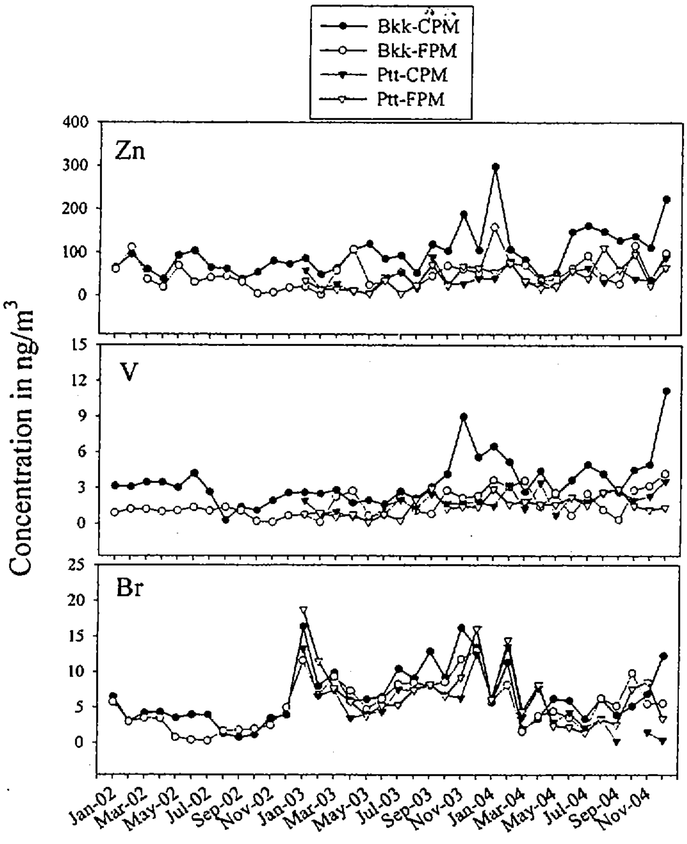


Figure 5 (c)

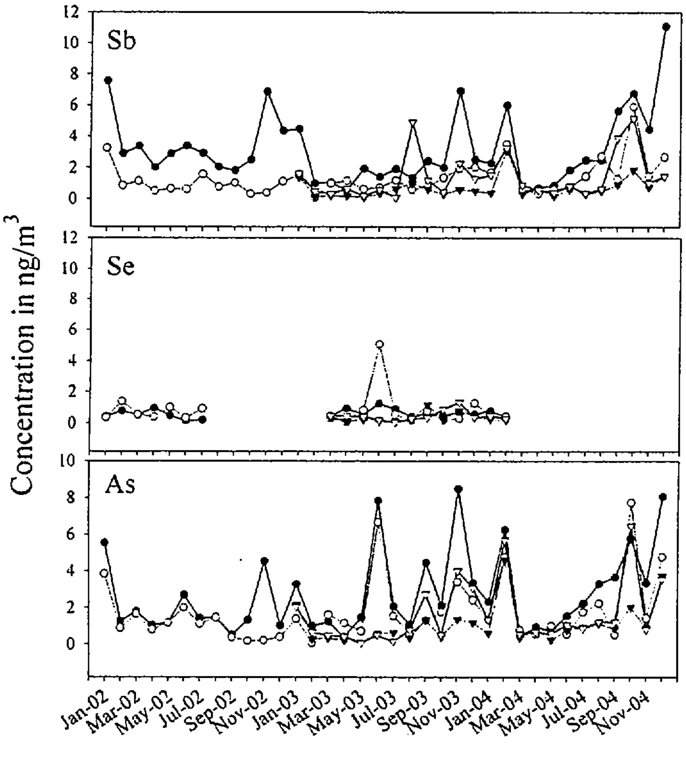


Figure 5 (d)

Figure 5 Time variations of selected key elements for (a) sea; (b) soil; (c) and (d) pollutants.