Characterization of PM10 and Air-borne Metallic Elements Produced in Asan and Seoul

Bu Soon Son[1], Kyung Ho Choi[2], Won Ho Yang*[3]

[1]Department of Environmental Health Science, Soonchunhyang University, Asan, 336-745 Korea
[2]School of Public Health, Seoul National University, Seoul, 110-799 Korea
[3]Department of occupational Health, Catholic University of Daegu, Kyongbuk, 712-702 Korea

Abstract

The purpose of this study was to characterize background mass concentration of fine particle PM10 and metallic composition from September 2001 to August 2002 in comparison with a medium-sized city, Asan and a metropolitan city, Seoul. Annual mean PM10 concentrations in Asan and Seoul were 47.98 and 75.33 $\mu g / m^3$, respectively. The concentrations of PM10 were highest in spring season in both cities. The concentrations of measured metals except As and Pb in Asan were higher than those in Seoul. Yellow dust could affect the mass and metals concentrations of measured PM10 in Asan and Seoul. Relationship between measured metals concentrations showed that Si and Fe were associated with natural sources such as soil. Pb, Cu and Zn were closely related to urban anthropogenic sources such as fuel combustion. Especially, relationship between metals showed different association during yellow dust. Proper management for fine particles is warranted in Asan, considering the concentrations of metallic elements in fine particles in Asan were relatively higher than those in Seoul.

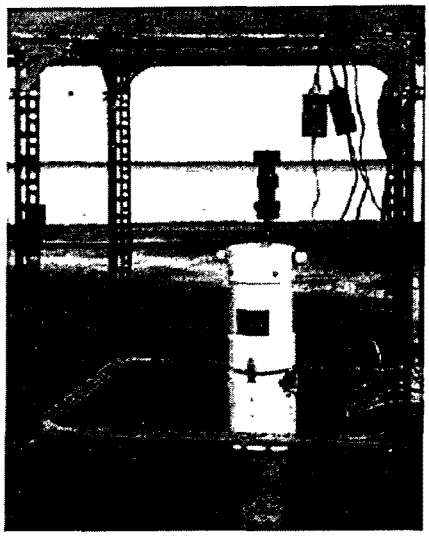
Introduction

The fine particulate problem has raised concern during the last decade. Particulate matter (PM) with aerodynamic diameter ≤ 10um (PM10) was found to associate with urban health problems such increase in daily mortality. Particulate matter pollution is nowadays one of the problems of most concern in great cities not only because of the adverse health effects but also for the reduced visibility, on a global scale effects on the radiative balance are also of great importance. Therefore, the emissions from common urban sources have to be characterized on a molecular level, and their source emission strengths have to be determined to evaluate the origin and fate of airborne fine particulate and metal elements.

The purpose of this study was to characterize background PM10 exposure of the population by comparing a medium city, Asan, with metropolitan city, Seoul, in Korea. With respect to ambient pollution, the levels of air pollutants in Seoul are much higher than in Asan. Therefore, the difference in ambient PM10 concentrations between Asan and Seoul may affect personal exposures. The results of this study will be helpful in determining the relationship between exposure to PM10 and health effects.

Materials and Method

PM10 sampling was conducted in two cities, Asan and Seoul both, in Korea. Asan is a medium city with a population of about two hundred thousand, while Seoul is the capital of Korea with about ten million people. Traffic volume is thought to be the major source of ambient air pollution because only a few major industrial sources of ambient air pollution are located in Asan and Seoul.



The experimental part of the particulate matter study was performed from September 2001 to August 2002. PM10 measurements was carried out by means of Mini-Volume portable air sampler(MiniVol, AIRmetrics) with the flow rate of 5 L/min and pallfex membrane filter (Fig. 1). Sampling was performed consecutive 6 days per week. PM10 ambient air concentrations were determined by gravimetry form filters collected throughout the sampling period. Collected filters were used for subsequent chemical analysis of trace elements such as As, Mn, Ni, Fe, Cr, Cu, Cd, Pb, Zn and Si by means of ICP-OES.

Results and Discussion

Measured PM10 concentrations in Asan and Seoul are summarized in Table 1. Annual mean PM10 concentrations in Asan and Seoul were 47.98 and 75.33 $\mu g/m^3$, respectively. Especially, mean PM10 concentrations in yellow dust condition both Asan and Seoul was significantly higher than those in non-yellow dust condition.

Table 1. Concentrations ($\mu g/m^3$) of fine particles (PM10) in yellow dust and non-yellow dust conditions of Asan and Seoul

	Asan		Seoul		
	n	Mean±S D. (Range)	n	Mean±S.D. (Range)	p^a
Yellow dust condition	7	99.47±84 86 (27.08 ~ 278 01)	5	103.98±14.66 (85 88 ~ 120.14)	0.223
Non-yellow dust condition	32	36.71±20 53 (15.05 ~ 127.08)	35	71.24±41.47 (20 83 ~ 190.05)	0.001**
Total	39	47 98±45.57	40	75 33±40.52	0.006**
p^b		0 012*		0.023*	

p^a(p-value) . Mann-Whitney U test between concentrations of particles of Asan and Seoul
p^b(p-value) : Mann-Whitney U test between concentrations of particles of yellow sand condition and normal weather condition

Depending on seasons, measured average mass concentrations of fine particles in Asan and Seoul in spring were 67.55(±70.65) $\mu g/m^3$ and 96.30(±22.70) $\mu g/m^3$, respectively. In summer, the average mass concentrations of fine particles in Asan and Seoul were

27.40(±10.50) ㎍/㎥ and 45.96(±16.10) ㎍/㎥, respectively. Especially, the concentration was the highest in spring and the lowest in summer among four seasons.

Table 2. Seasonal concentrations (㎍/㎥) of fine particles (PM10) in Asan and Seoul

	Asan		Seoul		p^a
	n	Mean±S.D. (Range)	n	Mean±S.D. (Range)	
Spring	12	67.55±70.65 (23.84 ~ 278.01)	12	96.30±22.70 (63 66 ~ 132.41)	0.005**
Summer	11	27.40±10.50 (18.06 ~ 55.56)	4	45.96±16.10 (29.64 ~ 67.36)	0.019*
Autumn	9	45.09±32.84 (15 05 ~ 127.08)	12	61.32±49 56 (20.83 ~ 187.73)	0.355
Winter	7	50 46±28 55 (21.76 ~ 104 63)	12	78.17±41.99 (37.73 ~ 190.05)	0.052
p^b		0.029*		0.004**	

p^a(p-value) : Mann-Whitney U test between concentrations of particles of Asan and Seoul
p^b(p-value) : Kruskal-Wallis H test between concentrations of particles with regard to season

Table 3. Concentrations (ng/㎥) of metallic elements in PM10 of Asan and Seoul

	Yellow sand condition			Normal weather condition		
	Asan	Seoul		Asan	Seoul	
	Mean ±S D. (Range)		p	Mean ±S D. (Range)		p
As	N.D	7.72±8.43 (0.001 ~ 18 61)	0.007**	1.87±4.10 (0 001 ~ 14.74)	10 47±11.67 (0 001 ~ 45.24)	0.000**
Mn	99.01±77 26 (45.52 ~ 215.63)	45.36±17.05 (28.80 ~ 65.04)	0.123	30.41±17.62 (5.47 ~ 68.74)	17.97±10 67 (1.84 ~ 46.69)	0.001**
Ni	3.79±6 67 (0.007 ~ 16.05)	N D.	0.212	21 48±18.70 (0 007 ~ 60.00)	N.D.	0.000**
Fe	3037.51±2786.72 (787.25 ~ 7463.59)	1575.14±691.51 (943.39 ~ 2426.44)	0 570	530 14±320.04 (26.52 ~ 1258.72)	600.26±302 62 (23.81 ~ 1352.73)	0.360
Cr	6.05±3.77 (0.44 ~ 11.66)	3.19±2.38 (0 97 ~ 7.27)	0.123	18.01±20.38 (0.55 ~ 104.95)	2.98±2.19 (0.003 ~ 9 36)	0.000**
Cu	127.99±45.80 (83 94 ~ 225.21)	95 47±90.47 (6.49 ~ 246.21)	0.123	172 95±100.90 (33.73 ~ 501.42)	120.35±62 10 (0.01 ~ 275 00)	0 012*
Cd	4 92±2.89 (1 83 ~ 10.85)	2.94±0.76 (1 90 ~ 3.87)	0 088	2.73±3.41 (0.001 ~ 11.87)	1 98±1.40 (0.001 ~ 4 54)	0 260
Pb	51.08±30.10 (29.25 ~ 117.62)	31.58±34.63 (0.001 ~ 90.17)	0.062	36 03±18.61 (1.54 ~ 97.04)	46.70±40.17 (0.001 ~ 167.94)	0.163
Zn	161.42±47 33 (109.27 ~ 242 67)	117 64±103.63 (16.81 ~ 290.92)	0.123	155.86±71.18 (0.011 ~ 309.86)	140.80±71 00 (0.011 ~ 314.77)	0.389
Si	6122.01±6395.02 (1174.50 ~ 15451.39)	2388 49±1845.81 (453.43 ~ 4790.84)	0 291	478.38±485.17 (66.25 ~ 2185.55)	459.63±381.36 (0.15 ~ 1687 99)	0.860

Average concentrations of manganese(Mn), iron(Fe), chromium(Cr), cadmium(Cd), lead(Pb) and silicon(Si) in fine particles in Asan were significantly higher in Seoul ($p<0.05$).

Average concentration of Si in fine particle in Asan was statistically higher than that of Seoul during yellow -sand condition ($p<0.05$). Considering the characterization of four seasons, average Pb concentration of fine particle in Asan is significantly higher than that of Seoul in spring($p<0.01$). In summer, average Mn and Cr concentrations of fine particle in Asan is higher than those of Seoul ($p<0.05$). Average Mn, Fe. Cr and Si concentrations in fall ($p<0.05$), and average Mn, Fe, Cr, Pb, and Si concentrations in winter ($p<0.05$) in Asan were higher than those of Seoul, respectively. Mass concentrations of each Mn, Fe, Cd and Si in fine particles were significantly correlated with both cities. In normal weather condition, Mn, Cu and Si concentrations are statistically significant in Asan, while Mn, Fe, Cu and Si concentrations are statistically significant in Seoul. Mn, Fe and Si concentrations in both cities were statistically significant during yellow-sand weather (Table 3).

Conclusion

Recent epidemiologic studies revealed that the concentration of air pollutants and fine particulated matter have some effects on health status and are associated with increased mortality and morbidity. The purpose of this study was to characterize background mass concentration of fine particle (PM10) and metallic composition from September 2001 to August 2002 in comparison with a medium city, Asan and metropolitan city, Seoul. Conclusively, proper management for fine particles was required in a medium city, Asan, considering the concentrations of metallic elements in fine particles in Asan were relatively higher than those in Seoul.

References

Lee, J.T. and Shy, C.M. : Respiratory function as measured by peak expiratory flow rate and PM10: six communities study. Journal of Exposure Analysis and Environmental Epidemiology, 9(4), 293-299, 1999.

John, W., Wall, S.M., Ondo, J.L. and Winklmay, W. : Modes in the size distribution of atmospheric inorganic aerosol. Atmospheric Environment, 24A(9), 2349-2359, 1990.

Simpson, R.W. : A statistical analysis of particulate data sets in Brisbane, Australia. Atmospheric Environment, 26B(1), 99-105, 1992.

Salvador, P., Artinano, B., Alonso, D.G., Querol, X. and Alstuey, A. : Identification and characetisation of sources of PM10 in Madrid (Spain) by statistical methods. Atmospheric Environment, 38, 435-447, 2004.

Marcazzan, G.M., Ceriani, M., Valli, R. and Vecchi, R. : Source apportionment of PM10 and PM2.5 in Milan (Italy) using receptor modelling. The Science of Total Environment, 2004, In Press.

Watson, J.G., Zhu, T., Chow, J.C., Engelbrecht, J., Fujita, E.M. and Wilson, W.E. : Receptor modeling application framwork for particle source apportionment. Chemosphere, 49, 1093-1136, 2002.

US EPA : Compendium of methods for the determination of inorganic compounds in ambient air. EPA, 625, R-96010a, 1999.

Qin, Y., Chan, C.K., Chan, L.Y.. : Characteristics of chemical compositions of atmospheric aerosols in Hong Kong: spatial and seasonal distributions. The science of the total environment, 206, 25-37, 1997.