Characterization of $PM_{2.5}$ and $PM_{10-2.5}$ air pollution of Ulaanbaatar city

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Abstract

Results of 2006-2007 $PM_{2.5}$ and $PM_{10-2.5}$ aerosol pollution study of Ulaanbaatar city, Mongolia is been presented. PM $_{2.5}$ and $PM_{10-2.5}$ aerosol fractions have been measured twice a week at the Bayanzurkh district of Ulaanbaatar city. Weight of the samples and Black Carbon were determined at the Nuclear Research Centre (NRC), National University of Mongolia. Elemental analysis has been performed at the New Zealand Institute of Geological and Nuclear Sciences using PIXE and PIGE analysis. It includes F, Na, Mg, Al, Si, P, S, Cl, K, Ca,Ti, V, Cr, Co, Ni, Cu, Zn, As, Br, Sr, Ba, I, Hg, Pb. Pollution source identification and its apportionment is been done at NRC. Main pollution sources for $PM_{2.5}$ in Ulaanbaatar city is combustion (40%), soil and construction dust (38%) and auto vehicles (18-22%). Average concentration of $PM_{10-2.5}$ is 147μg/m^3 in winter and 72-80μg/m^3 in summer, $PM_{2.5}$ is 41-52μg/m^3 in winter and 12-18μg/m^3 in summer time.

Keywords: $PM_{2.5}$, $PM_{10-2.5}$, aerosols, particles characterization, Mongolia, Ulaanbaatar city

I. INTRODUCTION

A study of airborne particulate matter pollution and source apportionment of air pollutants is important issue for Ulaanbaatar, the capital sity of Mongolia. Air pollution is not only issue for Mongolia, air pollution level exceeds the of WHO recommendation in many countries, especially Asian countries[1]. Air pollution of Ulaanbaatar city is increasing last years especially in winter study is identification and apportionment of air pollution sources. Filters with air samples were sent to the National Isotope Centre of Institute of Geological and Nuclear Sciences of New Zealand for the accelerator based Ion Beam Analysis (IBA). Around 30 chemical elements were determined in each fine and coarse filter season. By the Ministry of Health information resperatory desease rapidly increasing and in the first place among fisrt 5 reasons of deseases in Ulaanbaatar city[2].

Since the end of 2004 we have been regularly monitoring both fine ($PM_{2.5-0}$) and coarse ($PM_{10-2.5}$) size fractions in the NRC[3]. Purpose of this samples[4]. It includes F, Na, Mg, Al, Si, P, S, Cl, K, Ca,Ti, V, Cr, Co, Ni, Cu, Zn, As, Br, Sr, Ba, I, Hg, Pb. Data evaluation and interpretation of the results of analysis to identify and apportionment were done at the NRC using software EPA PMF1.1.

Samples were generally collected up-to 24 hour period from morning to the morning of next day. But during heavily polluted periods (end of autumn, winter, beginning of spring) samplers were operated on one hour off, one hour on basis over the 24 hour collection period to avoid reduced flow rate.

II. SAMPLING AND SITE

We were using GENT sampler unit for this study, the GENT stacked filter unit with a coarse and fine 47mm nuclepore filters. Coarse filters have a pore size 8μm and coated Apiezon Type L grease to provide a tacky surface that prevents particle rebound and consequent sample loss[5]. The second filter collecting fine particles has a pore size 0.4μm. Average flow rate of 16 l/min (18-14 l/min.) was used for the GENT sampler.

Sampling site: Ulaanbaatar city (E106^{o}58.311, N47^{o}54.811)

We were continuously sampling the air twice a week, routinely Monday and Thursday. Sampler was setup at a height 1.6m above ground level. The population density in the sampling site is medium and near to road and dwelling houses (Ger) area in the East part of city. Wind direction (mainly) for UB city this site is N and NW in the whole seasons.

RESULT AND DISCUSSION

In this paper we have included data of coarse and fine particle samples collected during 2006-2007. Nuclepore filters were measured for determination of mass concentrations using microbalance before and after collection of samples. Then the Smoke Stain Reflectometer was used for the determination of Black Carbon (BC) in the samples. Samples were analyzed for elemental concentrations by PIXE and PIGE analysis. The monthly mass concentrations for fine, coarse fractions and PM10 at sampling site are shown in Fig. 1.

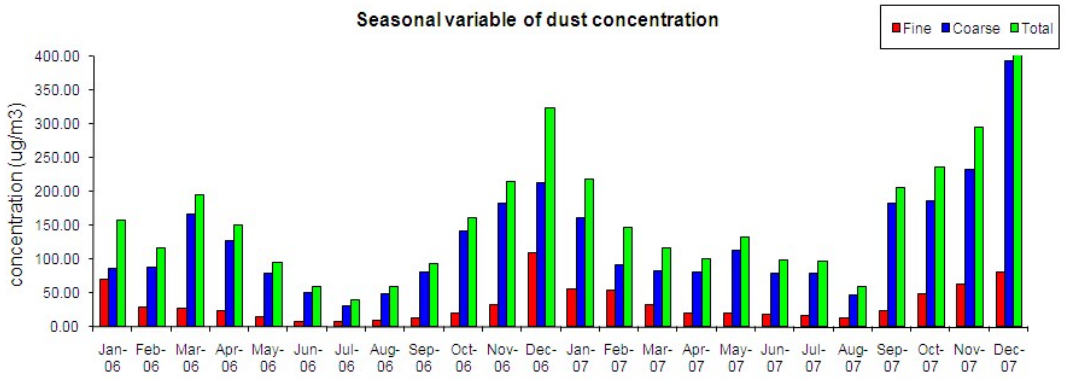

Fig. 1. The monthly mass concentrations for fine, coarse fractions and PM_{10} (Total) at the sampling site

The monthly average total concentrations of fine and coarse particles in the cold seasons at sampling site is much higher than ambient air quality standard of Mongolia (year average PM_{10} 50μg/m^3). Results show that particle mass concentration is decreasing in the green period, due to more humidity and not heating and increasing in the cold period, due to heating and dust rise-up from ground into the air[3]. Average Black Carbon and elemental concentration is shown in the table 1.

Elements	Average	Minimum	Maximum	Elements	Average	Minimum	Maximum
	$PM_{2.5-0}$				$PM_{10-2.5}$		
BC	6949.26	680.06	81035.47	BC	4401.20	483.24	25617.20
F	129.14	1.92	2320.94	F	189.15	4.86	3300.27
Na	379.46	4.01	3142.17	Na	895.29	12.15	4433.89
Mg	308.5	30.67	1355.23	Mg	909.40	70.10	4780.86
Al	884.33	31.91	4393.45	Al	5524.27	191.18	23436.18
Si	2292.98	129.08	10553.63	Si	13579.30	507.46	61059.97
P	86.04	0.26	615.8	P	221.16	7.43	2086.68
S	1817.84	125.17	32086.06	S	1458.10	128.58	13830.68
Cl	137.18	11.94	666.59	Cl	330.80	33.76	1284.11
K	319.19	35.48	1249.79	K	1760.20	72.14	7813.39
Ca	789.66	49.87	3194	Ca	4603.88	256.79	20023.50
Sc	21.33	0.26	106.53	Sc	73.53	0.64	785.13
Ti	38.81	0.6	156.03	Ti	297.51	6.78	2980.92
V	7.83	0.13	60.01	V	13.91	0.18	115.36
Cr	17.17	0.54	212.76	Cr	39.78	0.11	334.00
Mn	16.42	0.34	65.18	Mn	80.01	2.64	363.60
Fe	520.77	26.22	2150.32	Fe	3338.38	115.58	14213.58
Co	10.77	0.12	54.35	Co	30.03	0.20	153.76
Ni	6.73	0.17	75.57	Ni	11.25	0.15	79.14
Cu	12.87	0.3	372.59	Cu	23.03	0.47	371.91
Zn	44.22	4.9	400.06	Zn	99.49	4.77	2414.80
Ga	10.36	0.26	121	Ga	12.07	0.42	99.59
Ge	14.12	0.35	163.89	Ge	17.60	0.59	134.59
As	22.78	0.66	184.73	As	21.02	0.54	241.47
Se	22.55	0.65	185.5	Se	20.47	0.60	232.24
Br	34.65	0.93	319.35	Br	29.26	1.41	307.39
Rb	57.26	1.33	713.29	Rb	50.32	1.34	556.20

Sr	71.55	1.76	793.96	Sr	91.16	3.12	876.91
Mo	63.43	4.88	1866.43	Mo	49.09	4.88	803.82
I	132.32	0.76	2152.56	I	225.73	0.48	4439.81
Ba	121.95	0.3	3109.64	Ba	334.46	0.68	5579.17
Hg	39.82	1	383.11	Hg	53.33	1.31	538.19
Pb	60.41	1.09	560.44	Pb	60.51	2.27	488.91

Table.1 Black Carbon and elemental concentration (ng/m^3) $PM_{2.5}$ and $PM_{10\text{-}2.5}$ air particles.

Results of chemical analysis are used for pollution source identification and apportionment, but presence of some heavy toxic elements can be determined. See table 1.

Results of factor analysis show that, there are 4 of main air pollutant source (includes 90-98% of total) in Ulaanbaatar city. This is a combustion, soil, construction dust and motor vehicles. In the Fig. 2a and Fig. 2b the results of factor analysis of fine ($PM_{2.5}$) and coarse ($PM_{10\text{-}2.5}$) particles are shown.

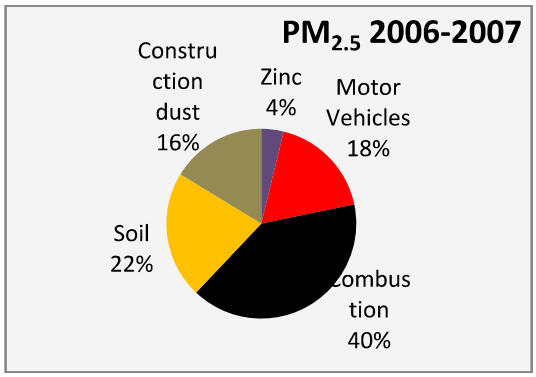

Fig. 2a. Source apportionment of $PM_{2.5}$ air particles

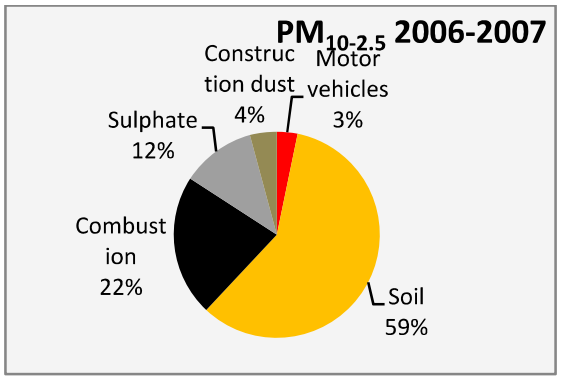

Fig. 2b. Source apportionment of $PM_{10\text{-}2.5}$ air particles

In the Fig.2a. main pollutant sources are coal combustion 40%, soil and construction dust 38%. But the most pollutant source for coarse particles is windblown soil, which contribution is 59% (Fig. 2b). From this can be concluded that the main pollution source in Ulaanbaatar city is dust. Affecting reasons are soil erosion in the city and increasing activity of construction. Also the global climate change that rises the year average temperature 2.1 degree influences to reduce the humidity and increase the fugitive dust.

As soil is one of the most pollutant source of Ulaanbaatar city we are introducing here the Factor 1 (soil) characteristics, as an example. Fig. 3. shows the elemental mass distribution and its percentage in factor and the time series of the contribution of soil into the air pollution.

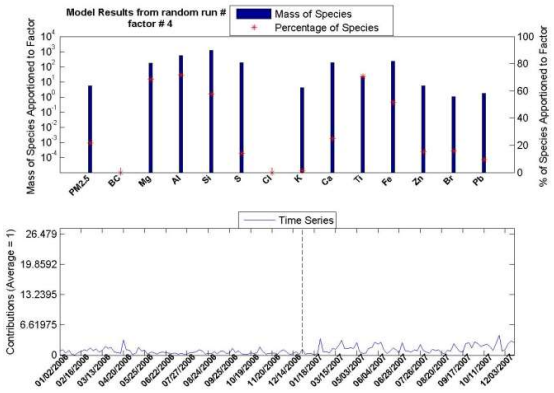

Fig. 3. The elemental mass distribution and the time series of soil, as most pollution source

IV. RATIO of $PM_{2.5}$ AND $PM_{10\text{-}2.5}$

The average ratio of $PM_{2.5}$ or fine particles of anthropogenic origin and PM_{10} coarse particles in the air of the main cities of the world are 0.5 [7]. For Ulaanbaatar city this ratio is different, as average concentration ratio of $PM_{2.5}$ / PM_{10} is 0.33. or this ratio is lower than other Asian cities[6]. This ratio is decreasing with the increasing total PM concentration see Fig.4.

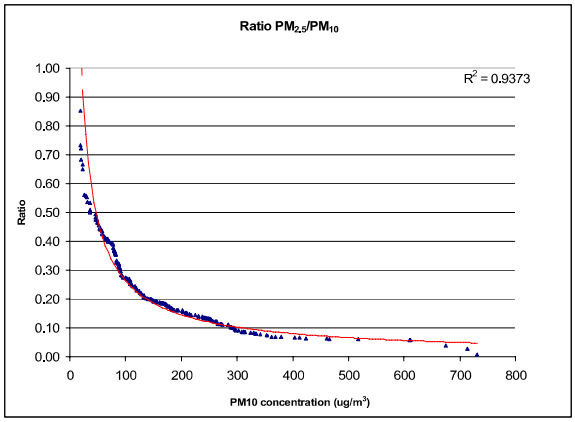

Fig. 4. Ratio of $PM_{2.5}$ / PM_{10}, depending on concentration of PM_{10}

This difference shows the contents of particulate matter pollution in the air of Ulaanbaatar city is different from the industrial cities of the world and consists of mainly coarse fractions of PM.

V. CONCLUSION

- Year average concentration of Ulaanbaatar city is 133.1 for $PM_{10\text{-}2.5}$ and 33.7 for $PM_{2.5}$. This is results of measurement held in one point and the result should be compared with other yearly measurements,
- According to the results, year average concentration exceeds 3.3 times for PM_{10} and 1.3 times for $PM_{2.5}$ against national standard,
- Main pollution sources of Ulaanbaatar city is soil and construction dust (38-59%) combustion (22-40%) and vehicles (3-18%) and others.
- Average $PM_{2.5}$ / PM_{10} ratio is 0.33 and this ratio is decreasing with increasing PM concentration.

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