Results of Source Apportionment by Receptor Modeling of Ulaanbaatar City

S. Lodoysamba[1], D. Shagjjamba[2], C. A. Hasenkopf[3], G. Gerelmaa[2], B. Bulgansaikhan[4]

[1],School of Information Technology of the NUM, P.O.Box 46A/ Ulaanbaatar,Mongolia.
Email: lodoysamba@gmail.com

[2]Nuclear Research Centre of the NUM P.O.Box 46/789 Ulaanbaatar, Mongolia
Email: shagjjambad@gmail.com

[2]Nuclear Research Centre,of the NUM, P.O. Box46A/307, Ulaanbaatar, Mongolia
Email: gerelmaa-g@num.edu.mn

[3] University of Colorada, Boulder, USA
Email: cherista.hasenkopf@gmail.com

[4]Doctor Student, National University of Mongolia, Ulaanbaatar, Mongolia
Email: baldorjb@yahoo.com

Abstract

Results of an air pollution source apportionment study using the Positive Matrix Factorization method (PMF) based on sampling of air pollution from a site of Nuclear Research Center, National University of Mongolia 2004-2009 and Zuun ail site 2008-2009 presented. From the statistical analysis of the data, it was possible to allocate factors to sources associated with coal combustion, motor vehicles, road dust, and soil.

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Keywords: Air pollution,$PM_{2.5}$, aerosols, source apportionment, Mongolia, Ulaanbaatar city

I. INTRODUCTION

Air pollution of the Ulaanbaatar city is extremely increasing last year's connection with extensive growth of populations lived in the Ger districts, soil erosion surrounded by city, increased motor vehicles and city planning including not enough green (surface), engineering system for evacuation of rain water. The air pollution in the city increased especially in winter from use coal and wood for heating and cooking and windblown dust of ground surface in dry seasons.

In the present time most pollutant in the air of Ulaanbaatar capital of Mongolia is Air Particulate Matter(PM). PM is one of the four most common air pollutants – particulate matter, ozone, nitrogen dioxide and sulfur dioxide as mention in WHO air quality guidelines

At the Nuclear Research Centre National University of Mongolia (NUM), PM10-2.5 and PM2.5 monitoring study beging from 2004. On the base large of collected data of this study we were determined main sources of air pollution of the Ulaanbaatar city by the *receptor modeling* [Hopke, 1985; 1991]. Output from a statistical analysis, specifically using the Positive Matrix Factorization method (PMF), identifies a number of "factors" which are defined by their specific and separate element composition, or profile. From this elemental profile, it is often possible to allocate the "factor" to a certain pollution source, based upon knowledge of tracer elements or the elemental composition of the emissions from the source type. From the statistical analysis of the data, it was possible to allocate factors to sources associated with coal combustion, motor vehicles, road dust, and soil.

II. SAMPLING AND ANALYZE OF ELEMENTS

For the collection sample of PM in the air used GENT sampler , where particles are collected on two filters in series, the top filter (Nuclepore filter, pore size 8 μm) collects the coarse particle fraction

($PM_{10-2.5}$) and the bottom filter (Nuclepore filter, pore size 0.4 μm) collects the smaller (fine) particle fraction ($PM_{2.5}$). Samples were analyzed by the ion beam analysis (IBA) facility operated by the Institute of Geological and Nuclear Sciences (GNS) in Gracefield, Lower Hutt, New Zealand. Ion Beam Analysis (IBA) was used to measure the concentrations of elements with atomic number above neon in particulate matter on the filter samples [Trompetter, Markwitz et al. 2005]

III. RESULTS AND DISCUSSION

The study based on sampling data of air pollution from a site of Nuclear Research Center 2004-2009 and Zuun ail site 2008-2009. Results of the source apportionment analysis of PM air pollution study of Ulaanbaatar show much difference of pollution source between two sampling site: Nuclear Research Centre and Zuun ail which is located in 5 km around the east from center city and a few kilometers northeast of central UB, near small valleys to the north, respectively. A fine and coarse particulate matter samples were included in the receptor modeling analyses. More than 30 elemental constituents were detected and for PMF modeling were selected major elements as Na , Mg, Al, Si, S, Cl, K, Ca, Ti, V, Mn, Fe, Zn, Pb and PM_{mass} and BC. The source apportionment results of two sites are summarized in Figure1. The following sources could be identified through the factors derived from the PMF analysis[World Bank 2011]:

Soil: Airborne soil originates from crustal matter. It has been possible to identify two different sources of airborne soil in UB: (i) a source identified by soil elements (named Soil 1) and (ii) a Soil 2 source with a significantly higher black carbon (BC) component. The difference between the two crustal matter sources is most likely the location, with the Soil 2 source originating more locally in Ulaanbaatar, where there is likely to be a greater concentration of settled combustion particles and coal dusts mixed into the crustal matter, hence the higher presence of BC in the source profile. Soil 1 is likely to represent the general crustal matter in the area around Ulaanbaatar. The soil sources contribute to PM in the air through the well-known action of wind and turbulence to suspend the particles in the soil surface in the air. The soil sources in UB contribute mostly to the coarse PM fraction ($PM_{10-2.5}$), but it also accounts for a significant portion of the fine PM fraction ($PM_{2.5}$). The very dry and cold climate in Mongolia probably causes a distribution of the top-soil particles consisting of a higher fraction of very fine particles, compared to areas with more humid and mild climates.

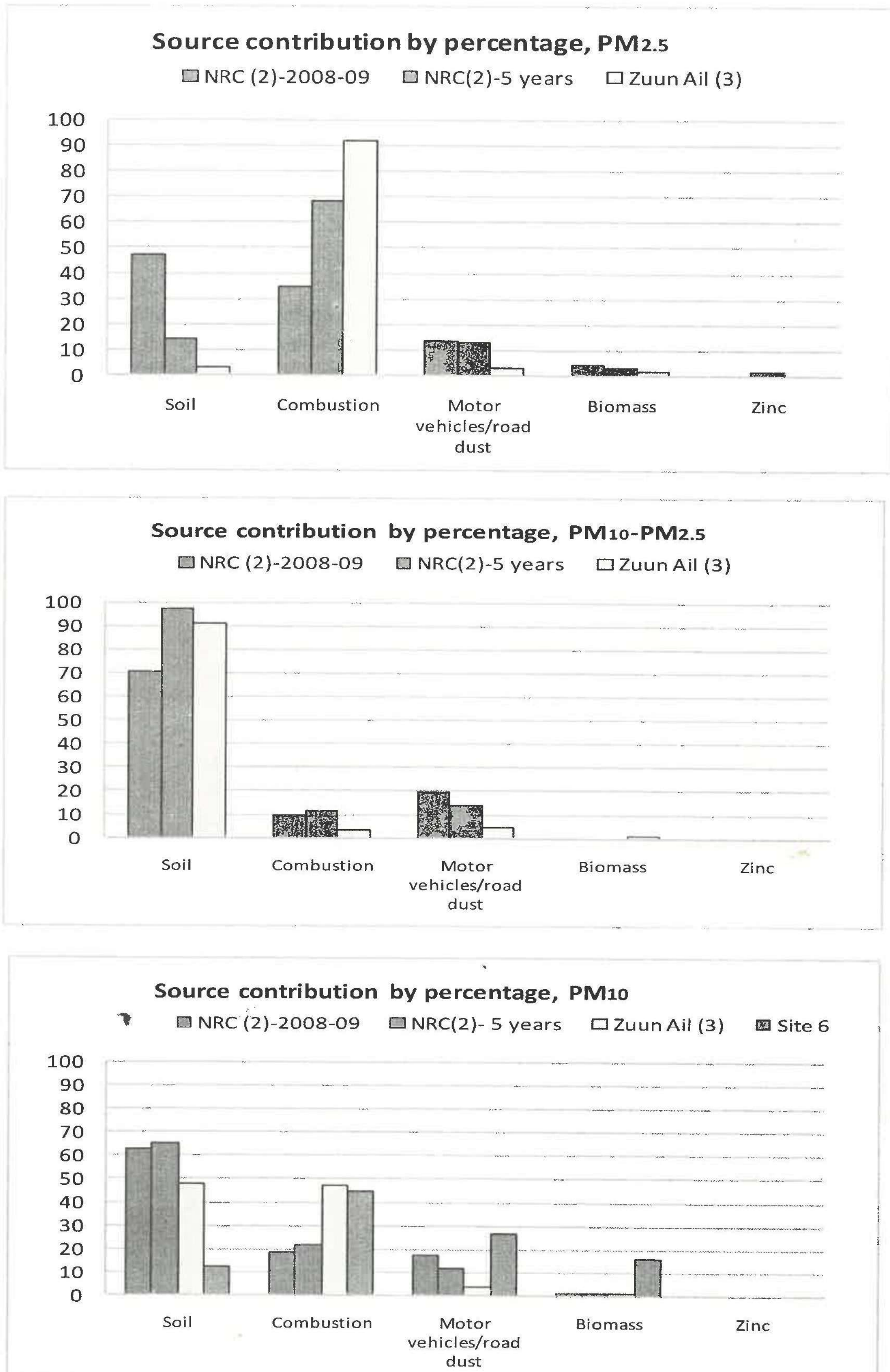
Combustion: In some cases, it has been possible to identify two distinct combustion source types with differing combustion characteristics. One contains black carbon and a significant sulfur component (called Combustion 1); while the other also has black carbon, but with relatively lower sulfur content and higher soil elements (called Combustion 2).The high-sulfur profile is associated with high-temperature coal combustion (such as in power plants and boilers), while the low-sulfur could be associated with low-temperature combustion, such as in small-scale residential stoves. The combustion sources contribute mostly to the fine PM fraction ($PM_{2.5}$), with smaller contributions to the coarse PM fraction.

Motor vehicles/road traffic: The profile associated with a local motor vehicle and road dust component contains BC, zinc, and lead, along with elements typical of crustal matter. This is a mixed profile consisting of exhaust particles in the fine fraction ($PM_{2.5}$) and suspended road dust in the coarse PM fraction ($PM_{10-2.5}$). These two parts of the profile are highly correlated in time since they both originate from road traffic with its specific time variation, and thus they appear in the analysis as one source.

Biomass burning: The profile associated with biomass burning contains black carbon and potassium in the samples. In UB, biomass burning contributes mostly to the fine PM fraction ($PM_{2.5}$).These profiles/sources contribute differently to the coarse and fine fractions of PM at the various sites as in Figure1.

The PM concentrations in Ulaanbaatar are extremely high. There is a very strong seasonal variation with very high winter concentrations and much lower summer concentrations. The highest PM concentrations are measured in the ger areas, $PM_{2.5}$ concentrations in the ger areas are much higher than in the center, with an annual average concentration in the range of 200 to 350 $\mu g/m^3$.

Figure 1. Relative contributions (percent) to PM in air from main sources in UB. Top: $PM_{2.5}$; Mid: $PM_{10-2.5}$; Bottom: PM_{10}.



The worst recorded annual average concentration was more than 10 times higher than the Mongolian AQS for PM_{10} and 25 times higher than the Mongolian AQS for $PM_{2.5}$ (Table1). The main sources of the particles in the ger areas are coal burning for heating and cooking during the winter, and the suspension of dust by wind action throughout the year.

Table1. Indicated ranges for annual average PM concentrations in Ulaanbaatar[WB 2011]

Area	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	Exceedance: Ratio to AQSs	
			Mongolian:	WHO
Central city areas	150–250	75–150	3–6	7–15
Ger areas	350–700	200–350	7–14	17–35

Compared to the data from other cities in global data bases, Ulaanbaatar could be the most PM polluted capital in the world, with higher concentrations than in Chinese cities. Figure3 shows examples of PM concentrations in other highly polluted cities[World Bank 2011].

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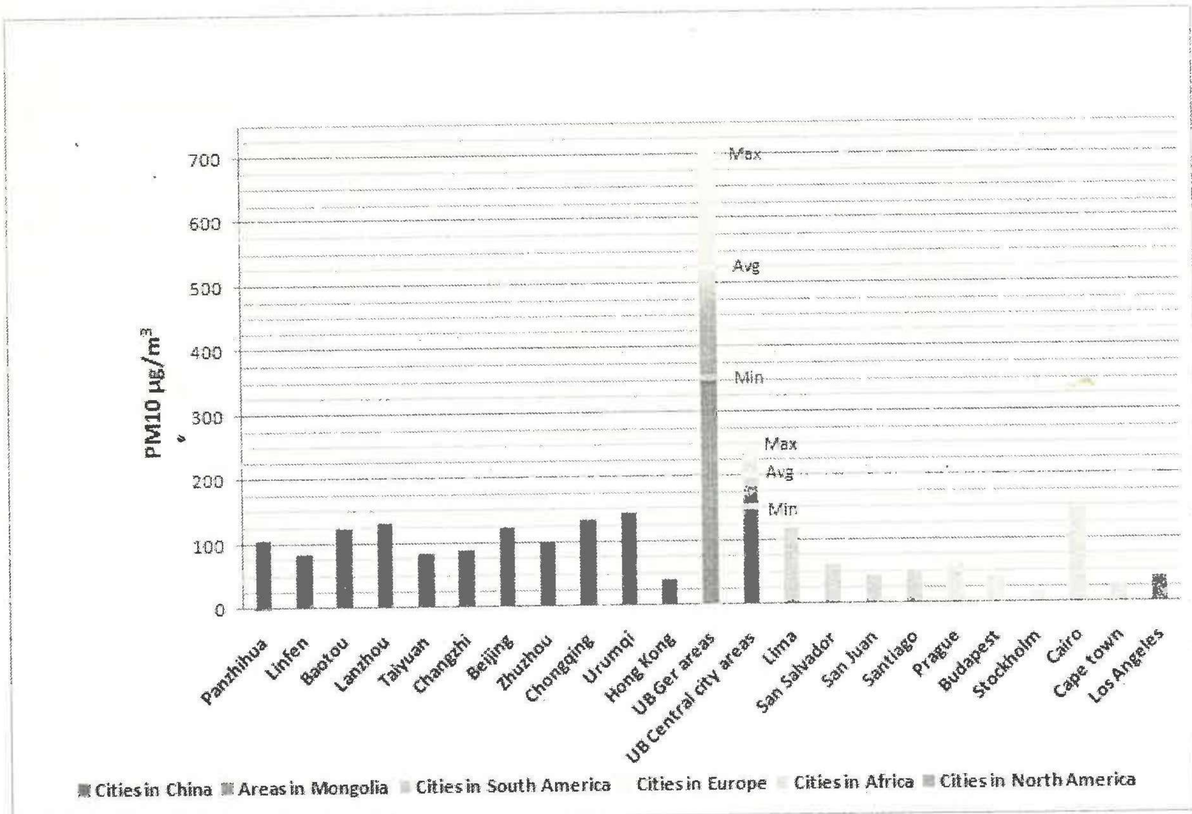
Figure2. Comparison of UB PM_{10} concentrations (2008–09) with Chinese cities (2008) and other world capitals (2004)4)



Source: Authors' illustration based on data from the China Environment Yearbook 2009 for Chinese cities, AMHIB study for UB, and WHO Air Quality Guidelines - Global Update 2005 for other cities

·IY.CONCLUSIONS

1.Main pollution source of PM of Ulaanbaatar, Mongolia is Soil erosion, Coal combustion, Motor vehicle+Road dust and Biomass burning.
2.Main source of PM2.5 is ger, house stoves (87% in the Zuun ail site) for PM 10-2.5 soil erosion.
3. From those measurements it was concluded that Ulaanbaatar city is the most PM polluted capital in the world and worst air quality city,
4. These apportionment results can be used for air pollution mitigation measures for policymakers.

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Товч утга

Энэхүү өгүүлэлд МУИС-ийн Цөмийн судалганы төвд 2004-2009 онд, Зуун айлын байрлалд 2008-2009 онд авсан агаарын бохирдлын дээжний дүнд Эерэг Матрицын Факторын аргаар бохирдлын үүсгүүрийн бохирдолд өгөх хувь хэмжээг тодорхойлсон дүнг авч үзсэн болно.Өгөгдлийн статистик анализын дүнгээс нүүрсний шаталт, тээврийн хэрэгсэл, замын тоос болон хөрс зэрэг үүсгүүрүүд тодорхойлогдож байна.

Резюме

В данной статье представлены результаты факторо-анализа по определению долей источников в загрязнении в образцах, взятых в точках Центра ядерных исследований Монгольского государственного университета в 2004-2009 гг, а также Зуун айл в период 2008-2009 г. Статистическийн анализ данных показывает такие источники загрязнения как сжигание угля, транспортные средства, дорожная пыль, почва.