Characteristics of PM_{10} and $PM_{2.5}$ in the Ambient Air of Ulaanbaatar, Mongolia

Chonokhuu Sonomdagva, Byambaa Batdelger, and Byambatseren Chuluunpurev

***Abstract*—The purpose of this study is to analyses mass concentration varied by its measurement of PM $_{2.5}$ and PM $_{10}$ according to the months and seasons. The study explored mass concentration in Ulaanbaatar, Mongolia with above schedule. It lasted from January, 2014 to April, 2015. The selected sites were Zaisan, Sansar tunnel, Kyokushu and Denj myanga within Ulaanbaatar.**

The study also analyses average mass concentration of PM 2.5 and PM 10 for the duration between October, 2009 and January, 2015.

The study concluded that mass concentration of PM 2.5 and PM 10 increases during winter and decreases during summer. This variation depends on climate and pollution sources.

***Index Terms*—Air pollution, Ulaanbaatar, Mongolia, Sansar tunnel, Denj, Zaisan, Kyokushu, PM_{10}, $PM_{2.5}$.**

I. Introduction

In Ulaanbaatar city of Mongolia, most pressing issues of air pollution. By 2014 statistics, population of the city was counted at about 1,314,500 inhabitants [1].

Urbanization has resulted in increasing air pollution due to rapidly expanding vehicular population, growing industrial sector, higher electricity demand, and bludgeoning demand for domestic heating and cooking in the densely packed city of Ulaanbaatar. Fossil fuel, mostly coal is the primary source of energy and consequently air pollution. In addition, the burning of biomass such as firewood, agricultural and animal waste contributes in the household sector [2].

Ulaanbaatar is definitely one of the most polluted cities, and it might be the most polluted city in the world in terms of annual particulate matter concentrations. Arguably, its severity is driven by extreme wintertime PM concentrations. The population of UB is exposed to high concentrations of PM from different sources and with different chemistry and size fractions. The findings of the health effects study conducted as part of AMHIB support conclusions that can be drawn from the health effects literature-that there is a significant public health burden related to exposure to air pollution in UB [3].

Atmospheric particulates, with diameters ranging from 1 nm to 100μm, play a crucial role in regional and global climate change, and public health, including respiratory problems and reduced lung function [4]-[7].

The total emissions are segregated by season. For example, due to heavy snow cover and higher humidity in the winter months, road dust resuspension is suppressed. Hence, we do not include limited road dust resuspension emissions in these months. This is allocated in conjunction with the meteorological data. For the domestic emissions, most of the stoves are operational 24/7 during the colder months and less during the summer months. This is taken into account by allocating 60 % of the emissions between October and March. The vehicle exhaust emissions are kept constant for all months. The power plant emissions are distributed over months based on monthly coal consumption rates, obtained from the power plant annual reports [8].

In this study, the daily concentrations of $PM_{2.5}$ and PM_{10} were measured in Ulaanbaatar in 2014. Based on the average monthly monitored data for PM, this study analyzes the characteristics of temporal distribution and correlations between $PM_{2.5}$ and PM_{10}. The local aspect analysis of the correlation between PM and four seasons indicates that it is stronger in summer and autumn than in winter and spring.

II. Study Area

As a study site, Sansar tunnel, Zaisan, Kyokushu tower and Denj Myanga is Ulaanbaatar, the capital city of Mongolia has been selected. Ulaanbaatar is situated in the central part of Mongolia.

Research conducted within one of the key work of the major air pollutants such as PM_{10} and $PM_{2.5}$ particles, the following point measurement research pollution is giving levels (Fig. 1).

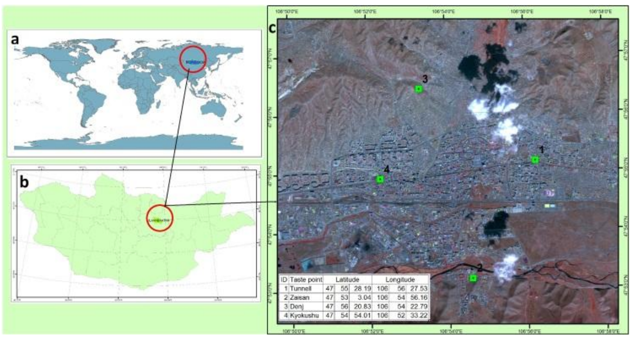

Fig. 1. Geographical location of the research area: (a) location of Mongolia in World; (b) location of Ulaanbaatar in Mongolia; and (c) research site in Ulaanbaatar.

III. Measurements and Instrumentation

Particle mass concentrations of $PM_{2.5}$ and PM_{10} were measured and recorded every 30 min using a Dusttrak^{tm}II

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8532 deployed in the laboratory.

Which define a weighting curve of $PM_{2.5}$ and PM_{10}, with a measuring range of 0.001–400 mg/m^3. In the period from January 2014 to April 2015, 288 groups of valid PM data have been recorded, excluding missing data, abnormal data, and instrument calibration times.

Moreover, the data collected during October, 2009 and January, 2015 were obtained from the Administration of Air Quality in Ulaanbaatar.

Daily meteorological data, including precipitation, wind velocity, and temperature, was gleaned from a weather station in Buyant-Ukhaa and Takhilt, which is attached to the Research institute of Meteorology, Hydrology and Environment.

IV. Results and Analysis

A. Seasonal and Annual Average Mass Concentrations of the PM_{10} and $PM_{2.5}$

In Fig. 2, in the morning, afternoon and evening average concentrations of PM_{10} measured at the site of Sansar tunnel, Zaisan, Kyokushu and Denj myanga.

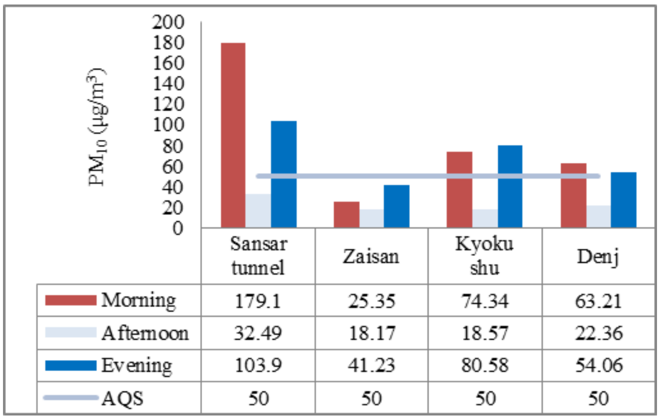

Fig. 2. Hourly average concentrations of PM_{10}.

As shown in Fig. 3, in the morning, afternoon and evening average concentrations of $PM_{2.5}$ measured at the site of Sansar tunnel, Zaisan, Kyokushu and Denj myanga.

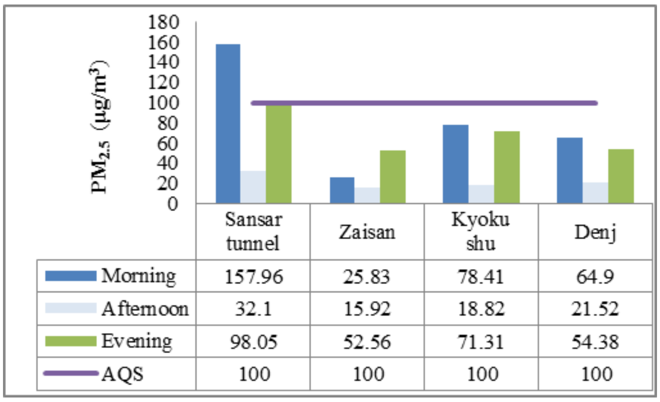

Fig. 3. Hourly average concentrations of $PM_{2.5}$.

In Fig. 4, in the morning, afternoon and evening average concentrations of $PM_{2.5}$ and PM_{10} measured at the site of Sansar tunnel, Zaisan, Kyokushu and Denj myanga.

In Fig. 5 presents an estimated of average concentration of PM_{10} for year of 2009 to 2015. The increasing average concentration winter and spring, there is rapidly declining specifics. The pollution increase in winter when temperature is low, with decrease of temperature and contrariwise.

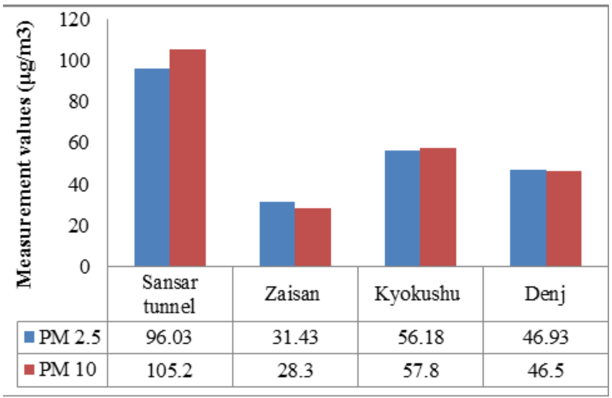

Fig. 4. Hourly average concentration of particulates $PM_{2.5}$ and PM_{10}.

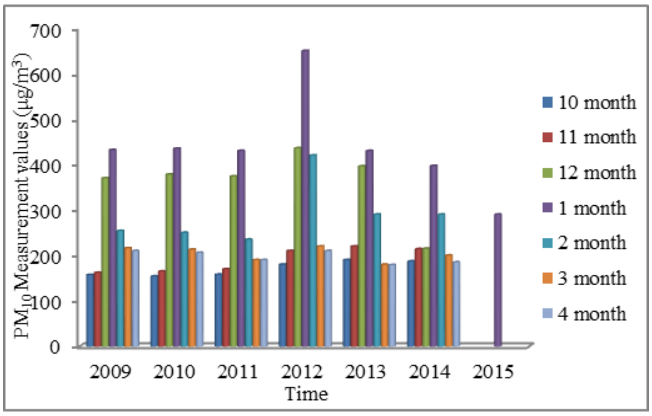

Fig. 5. Research of the 4 locations PM_{10} particles in the time difference.

As shown in Fig. 6, $PM_{2.5}$ particles in increasing average concentration winter and spring, there is rapidly declining specifics. This winter, an increase in the average temperature has decreased, weak ignition machine and getting a sharp decline in the 3 months of spring and is related to the average temperature increasing.

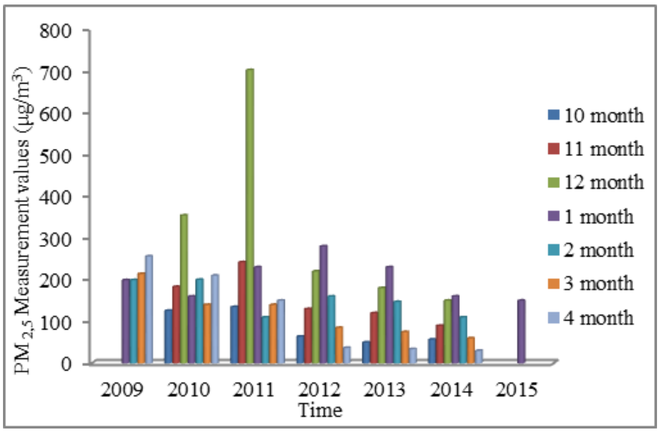

Fig. 6. Research of the 4 locations $PM_{2.5}$ particles in the time differences.

B. Monthly and Seasonal Variations of $PM_{2.5}$ and PM_{10}

Fig. 7, Fig. 8 and Fig. 9 show the local monthly and seasonal average mass concentrations of $PM_{2.5}$ and PM_{10}, respectively, combined with monthly precipitation and wind in 2014. Fig. 7 reveals the trend of monthly average mass concentration of PM from January to December, is consistent and takes a concave parabolic form, which is approximatively opposite to the trend of precipitation. The peak value of monthly average mass concentrations of $PM_{2.5}$ and PM_{10} appear in January, reaching 157 μg/m^3, 160 μg/m^3, respectively, while the trough value are in July, reaching 68 μg/m^3, and 74 μg/m^3. On the contrary, the monthly total precipitation in July 53mm, while those in January are both less than 1.2 mm. It is observed that mass concentrations of $PM_{2.5}$ in January, February, March, April, November, and December exceed the daily average $PM_{2.5}$ upper limit of 100 μg/m^3 as defined by the ambient air quality standard MNS 4585:2007, illustrating the severity of $PM_{2.5}$ pollution in the Ulaanbaatar area during late autumn, early spring, and winter.

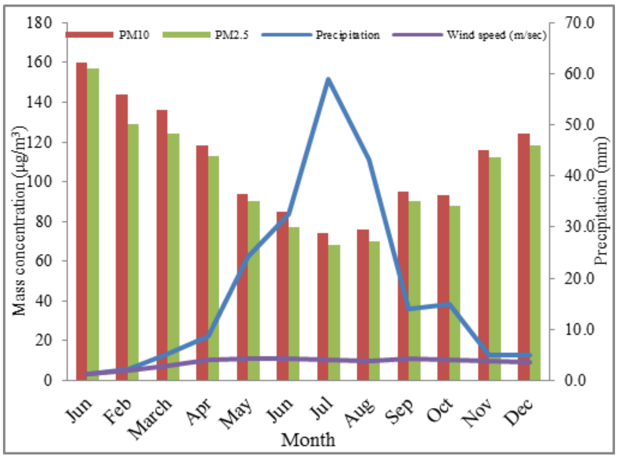

Fig. 7. Monthly variations of $PM_{2.5}$ and PM_{10} mass concentration with monthly total precipitation.

Fig. 8 and Fig. 9 illustrates local seasonal characteristics in the seasonal average mass concentration of $PM_{2.5}$ and PM_{10}, respectively. In this study, spring consists of the months of March, April, and May; summer refers to June, July, and August; autumn includes September, October, and November; winter includes December, January, and February.

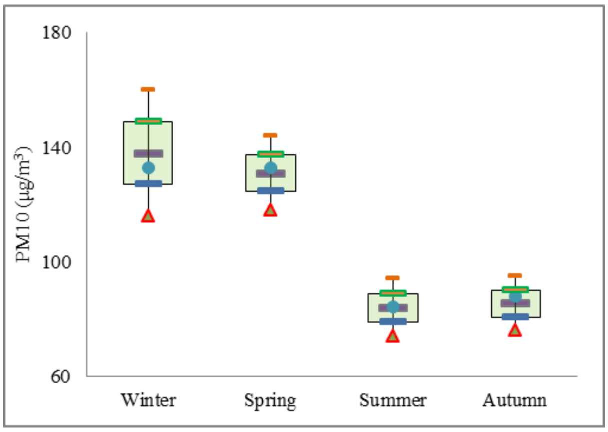

Fig. 8. Seasonal characteristics of PM_10 mass concentration. The blue dot represents the mean value of PM in each season and the box represents the twenty-fifth and seventy-fifth percentiles (upper and lower edges of box); the short red horizontal line represents the maximum; the red triangle represents the minimum, and the horizontal black line shows the median value of PM in each season.

Fig. 8 and Fig. 9 indicates that regardless of particle size, summer has the lowest PM mass concentration. In contrast, winter has a significantly higher level of PM mass concentration, probably caused by the stagnant atmosphere which leads to pollution's cumulative effect in winter. From the figures above, based on the boxplot, which graphically depict numerical data via quartiles, it is demonstrated that there was a tiny minority of large values in summer, since the mean and median values is below the middle position between maximum and minimum, which could result from longstanding high temperature and low pressure with occasional precipitation in summer.

C. Relationships between $PM_{2.5}$ and PM_{10}

Fig. 10 illustrates the correlations between $PM_{2.5}$ and PM_{10}. After conducting a linear regression of monthly average is 2014 of valid samples, the local aspect correlation coefficients between them were calculated to be 0.98 while the R-squared of the regression model reached 0.98 respectively, which emphasizes the significance of correlations between $PM_{2.5}$ and PM_{10} in Ulaanbaatar. There is a lower correlation between $PM_{2.5}$ and PM_{10} when mass concentration of PM_{10} increases, which indicates that fine particles with diameters less than 2.5 μm might not be the only factor contributing to the increase in PM_{10}.

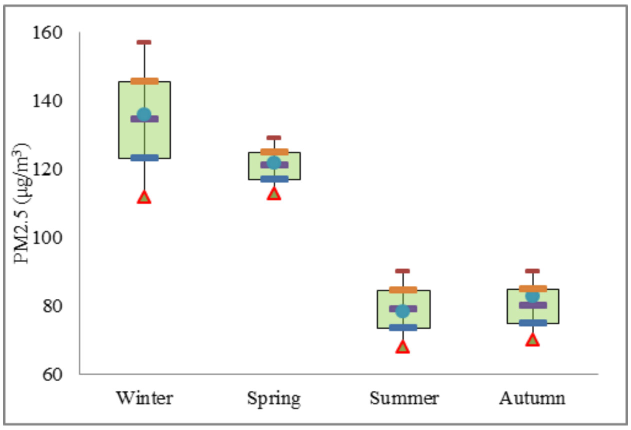

Fig. 9. Seasonal characteristics of PM_{10} mass concentration.

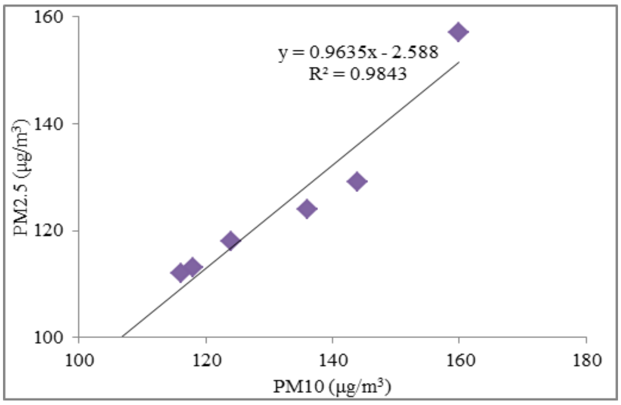

Fig. 10. Correlation between mass concentration of $PM_{2.5}$ and PM_{10}.

V. Conclusions

In this study employed the characteristics of temporal distribution and correlations between $PM_{2.5}$ and PM_{10}. The local aspect analysis of the correlation between PM and four seasons indicates. Through a series of analyses, conclusions have been conducted as follows:

The research comparing the four location Sansar tunnel about PM_{10} and $PM_{2.5}$ particle pollution, while most Zaisan around particles are the least polluted. Clearly the PM_{10} and $PM_{2.5}$ particle pollution have a same source of these are related to each of the others.

Mass concentrations of $PM_{2.5}$ and PM_{10} were higher in winter observed summer. The peak values of monthly average mass concentrations of $PM_{2.5}$, and PM_{10} occurred in January, reaching 157μg/m^3, 160μg/m^3, respectively. The trough values occurred in July, reaching 68μg/m^3, and 74μg/m^3, respectively. The concave parabolic pattern of the distribution can be explained by the abundant precipitation in summer and the cumulative effects of pollution in winter, due to the microclimate in Ulaanbaatar

The local aspect correlation coefficients and R-squared model between $PM_{2.5}$ and PM_{10} are high, reaching 0.98, respectively. There is decreasing coherence between $PM_{2.5}$ and PM_{10} when mass concentration of PM_{10} increases, which implies that fine particles with a diameter less than 2.5μm might not be the only contributor to PM_{10}.

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