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Particulate Matters Pollution Characteristic and the Correlation between PM ($PM_{2.5}$, PM_{10}) and Meteorological Factors during the Summer in Shijiazhuang

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Abstract

In recent years, the haze occurs frequently and air pollution is getting worse in Beijing-Tianjin-Hebei Region, China. The particulate matter pollution characteristic researches are playing a significant role especially in the districts where have higher concentration PM and air pollution. In this study, we collected daily particulate matter (PM_{10}, $PM_{2.5}$) mass concentration data from 7 air pollution monitoring stations in Shijiazhuang City, Hebei, China over a 3-month period from June to August to investigate particulate matter pollution characteristic and the relationship with meteorological conditions. Statistical results show that PM_{10} is the major pollutant in Shijiazhuang City; the average daily concentrations of $PM_{2.5}$ and PM_{10} are 94.45 μg/m³ and 219.15 μg/m³, respectively. The daily average of PM_{10} and $PM_{2.5}$ level over the period exceeded the first grade of the daily average limit of the ambient air quality standards (GB3095-2012). And there is a significantly positive correlation between atmospheric pressure and particulate matter pollution, but there is a significantly negative correlation between atmospheric temperature and PM concentrations. Precipitation has a clear role mainly in the coarse particles; however, there has little effect on fine particulate matter. Relative humidity and wind speed have a poor correlation with atmospheric pollutant concentrations (not remarkably high).

Keywords

Particulate Matter, Air Pollution, Meteorological Factors, Shijiazhuang

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1. Introduction

In recent years, China's dramatic economic rise, rapid industrial development, population growth, construction and demolition projects, and the increase in traffic flow critically affected the atmospheric environment, especially with regard to contamination of atmospheric particulate matter [1]. However, in particular, airborne PM_{10} (atmospheric dynamics equivalent diameter ≤ 10 μm) and $PM_{2.5}$ (atmospheric dynamics equivalent diameter ≤ 2.5 μm) particles are very harmful to the environment, climate, and human health. With China's rapid economic development, environmental air pollution has changed from coal burning to more complex sources, and regional pollution due to atmospheric fine particulate matter has been increasing. Currently, Beijing, Tianjin and Hebei Province often experience long periods of hazy days. The top ten most polluted cities contain 7 cities of Hebei, including Shijiazhuang [2]. Environmental pollution caused by PM_{10} and $PM_{2.5}$ in Shijiazhuang has been aggravated. From January 2013, large-scale fog and haze occurred frequently in urban area. As a typical northern city, there are many reasons to cause particulate pollution in Shijiazhuang.

This paper is based on SPSS software and uses the data which are provided by Shijiazhuang Environmental Monitoring Center and Shijiazhuang Bureau of Meteorology to study the characteristics of particulate pollution in summer and the relationship with air temperature, precipitation, wind speed and other meteorological factors by using correlation analysis method. It provides analysis basis for further study of the origin and composition of atmospheric particles [3] and the causes of atmospheric particulate pollution in areas which are throughout fog and haze. The results from this study will be useful for the Shijiazhuang municipal government in terms of the scientific and rational measures that should be used to effectively alleviate environmental pollution from inhalable particulates.

2. PM_{10} and $PM_{2.5}$ Levels in Shijiangzhuang

During the period of June 2013 through August 2013, the data of pollution concentration of PM_{10} and $PM_{2.5}$ were collected at the 7 monitoring sites of Environmental Monitoring Center and meteorological data were taken from Meteorological Bureau. In summer, the daily average concentrations (in $\mu g \cdot m^{-3}$) of $PM_{2.5}$ and PM_{10} in ambient air were 94.45 and 219.15, respectively. Of these, the $PM_{2.5}$ level exceeded the recently released ambient air quality standard II (daily average limit 75 $\mu g/m^3$), while the PM_{10} level was nearly two-fold higher than the new standard II (daily average limit 150 $\mu g/m^3$). Based on Daily Air Quality Index (AQI), the number of days of Shijiazhuang air quality levels for secondary and less to the secondary were 22 days, only 23% of the total sample. However, the number of days of air quality levels higher than secondary are 70 days, which as high as 76% of the total sample. It can be seen the air pollution is very serious. **Figure 1** shows that changing trend of daily average concentration of pollutions in summer. **Figure 2** shows the number of days in each air quality level.

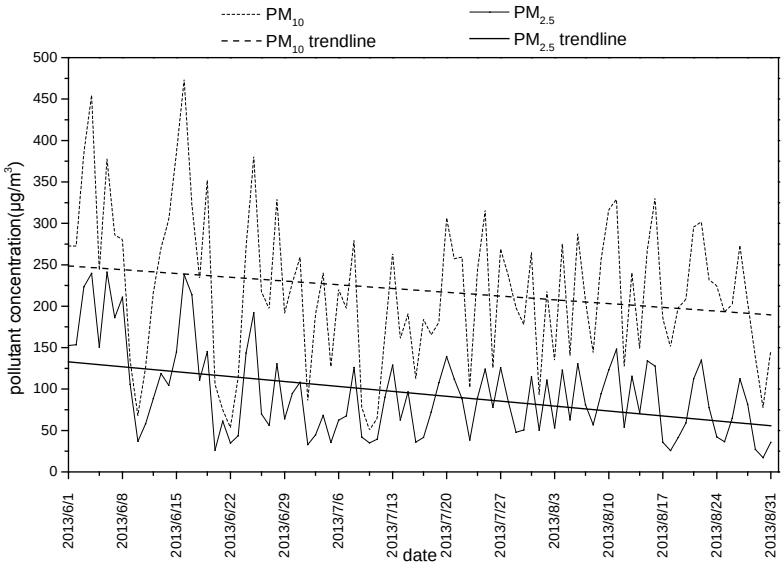

Figure 1. Changing trend of daily average concentration of pollutions in summer.

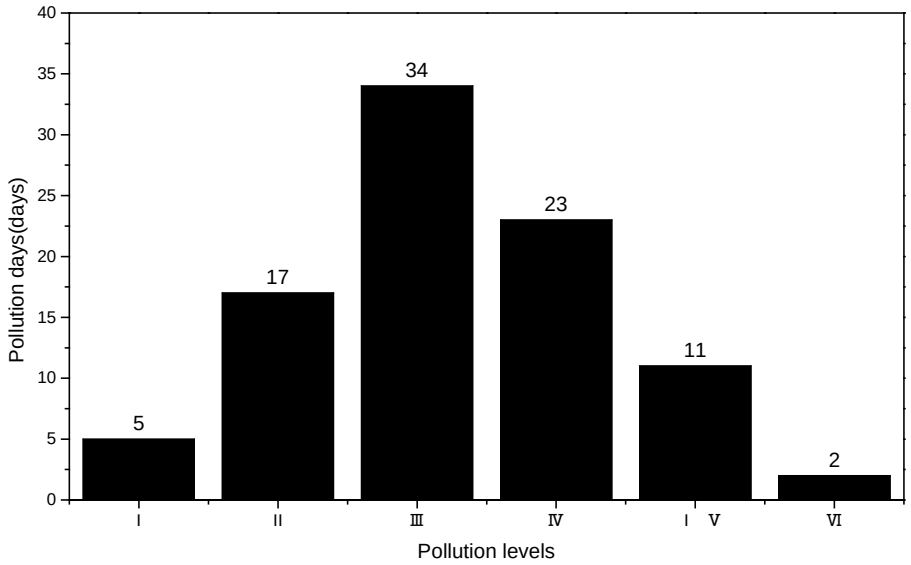

Figure 2. The number of days in each air quality level.

In order to analyze the major pollutants of air pollution of Shijiazhuang in summer, the number of days of PM_{10} and $PM_{2.5}$ as the primary pollutant were counted, where the number of days of PM_{10} as the primary pollutant were 46 days and $PM_{2.5}$ as the primary pollutant were 38 days. Thus, in the summer, the primary pollutant in the atmospheric environment is PM_{10} in Shijiangzhuang.

3. The Relationship between Particulate Matter Pollution and Meteorological Factors

3.1. Correlation Analysis of Meteorological Factors and Particulate Matter Pollution

The studies using SPSS software to explore the correlation between concentrations of air pollutants and meteorological factors [4]. It have shown that air temperature, precipitation and other meteorological factors can preferably explain the relationship between concentrations of particulate matter and meteorological factors [5]. In **Table 1**, atmospheric pressure and concentrations of particulate matter were significantly positively correlated, while other meteorological factors and concentrations of particulate matter have shown a negative correlation but the impact are different. Therein, air temperature was significantly influencing on particulate matter, followed by precipitation and wind speed. From **Table 1** it can be seen that air temperature, atmospheric pressure and wind speed more slightly affected $PM_{2.5}$ [6].

3.2. The Relationship between Concentrations of Particulate Matter and Air Temperature

From **Figure 3** and **Figure 4**, it can be seen that concentrations of particulate matter had an obviously negative correlation with air temperature. As air temperature rised, concentrations of particulate matter were significantly decreased. Because intense radiation heats city underlying surface. The lower atmosphere is not very stable and turbulent strengthens, which is advantageous to the diffusion of pollutants. Therefore, the probability of atmospheric pollution decreased with the increase of air temperature in summer. While the temperature of surface is low, the situation is contrary [7].

3.3. The Relationship between Concentrations of Particulate Matter and Atmospheric Pressure

Atmospheric pressure and concentrations of particulate matter were significantly positively correlated, and the correlation coefficient is about 0.8. When the ground is controlled by a low pressure, high pressure air mass is counter-clockwise around the center of the flow. Subsequently the updraft is formed in the center and the wind increase, which will help pollutants evacuate upwards. Then concentrations of particulate matter are getting

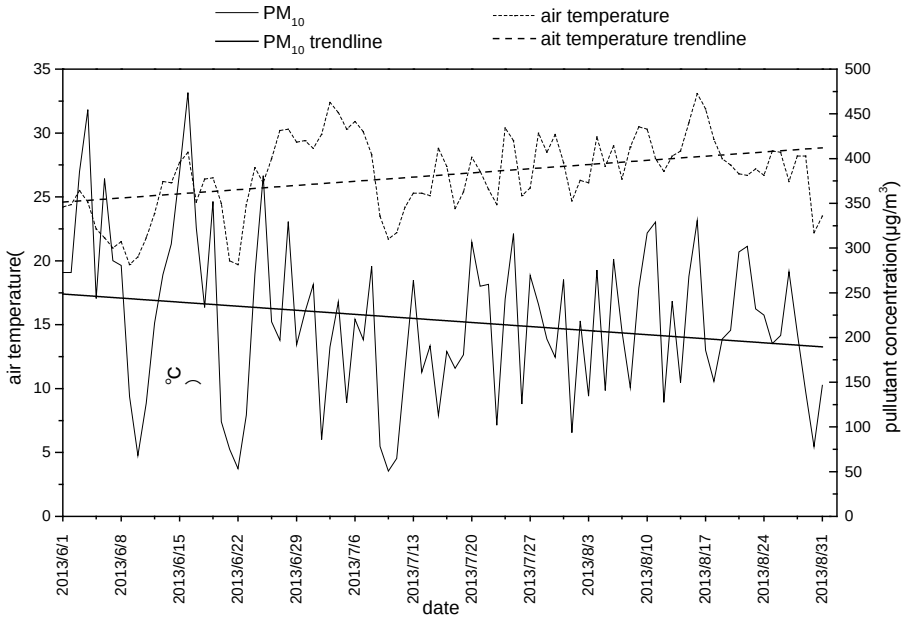

Figure 3. The relationship between concentrations of PM_{10} and air temperature.

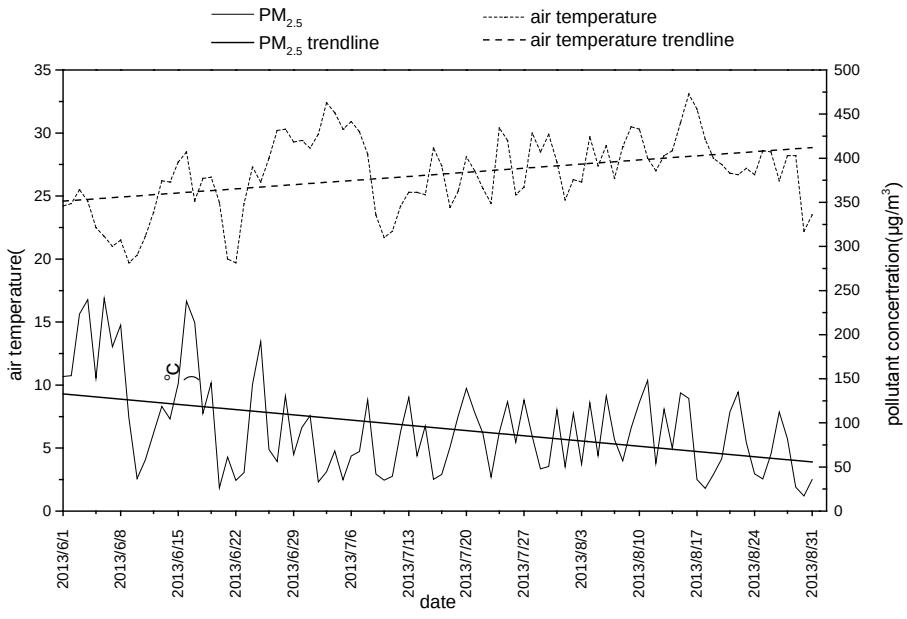

Figure 4. The relationship between concentrations of $PM_{2.5}$ and air temperature.

Table 1. Correlation coefficient between concentration of particulate matter and a variety of meteorological factors.

Meteorological factors	$PM_{2.5}$	PM_{10}
Air temperature	−0.839*	−0.863*
Atmospheric pressure	0.809*	0.839*
Precipitation	−0.507	−0.675
Wind speed	−0.537	−0.353

lowly [8]. Contrary, when the ground is controlled by the high pressure, air of the central portion drop to the surrounding and it shows a clockwise rotation, having the formation of a anticyclone. Then the weather is nice and wind speed decreases. In the circumstances, it is easy to develop thermal inversion layer. Thermal inversion layer would lead to stable atmospheric condition. Therefore pollutants are much harder to dilute diffusion and accumulated around land surface. Thus, under the control of stable atmospheric condition, air pollution will aggravated [9].

3.4. The Relationship between Concentrations of Particulate Matter and Precipitation

In summer, precipitation has a great impact on concentrations of particulate matter. On June 9, June 21, July 2 and July 10, concentrations of PM_{10} decreased significantly with large precipitation in this four days, while, concentrations of $PM_{2.5}$ declined less than PM_{10} (**Table 2**, **Figure 5**, **Figure 6**). It has said that precipitation can reduce dust, and it mainly gets rid of coarse particles while have little effect on fine particles.

3.5. The Relationship between Concentrations of Particulate Matter and Wind Speed, Wind Direction

In summer, wind direction of Shijiazhuang was dominated by southeast wind (**Table 3**). However, the industrial area is located in southeast where power plants, pharmaceutical factors, sewage treatment plants and other

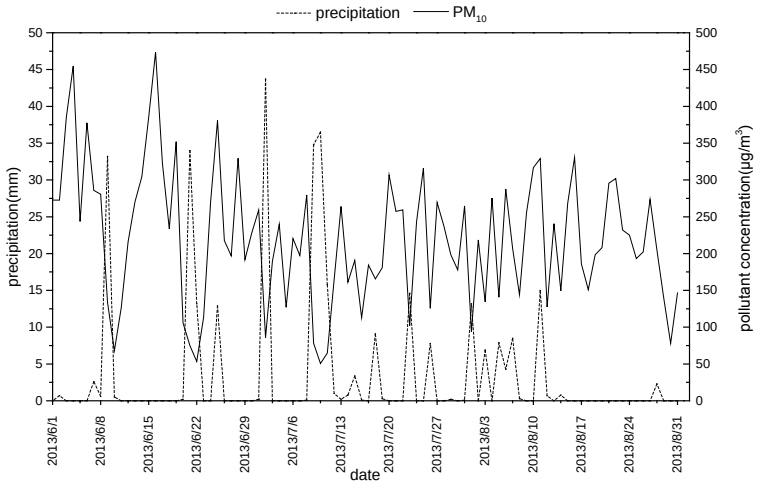

Figure 5. The relationship between concentrations of PM_{10} and precipitation.

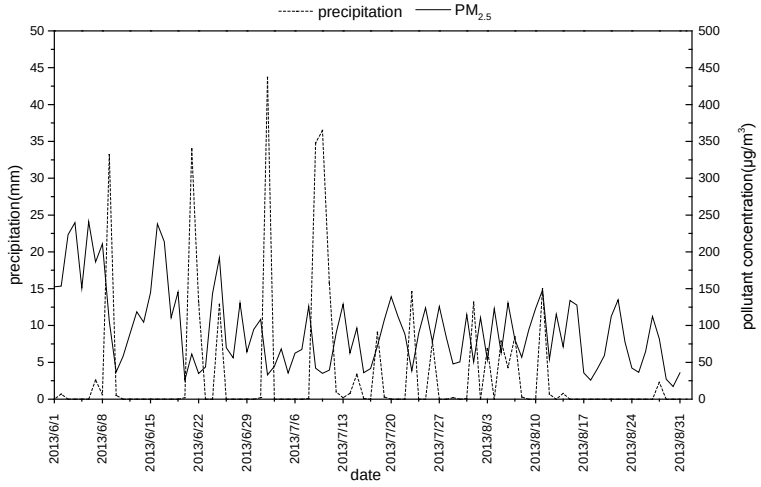

Figure 6. The relationship between concentrations of $PM_{2.5}$ and precipitation.

Table 2. The number of precipitation days of summer in Shijiazhuang.

	June	July	August
≥0.1 mm	4	9	3
≥1.0 mm	1	2	2
≥5.0 mm	0	2	3
≥10.0 mm	4	5	2

Table 3. Wind direction frequency of Shijiazhuang in summer (%).

C	E	ENE	ESE	N	NE	NNE	NNW	NW	S	SE	SSE	SSW	SW	W	WNW
13	9	5	13	25	11	24	24	13	11	25	44	3	3	47	15

enterprises are at there. It is quite clear that pollution sourses from southeast in summer. This suggested that wind direction was the important influence factor to atmospheric pollution.

For many years, Shijiazhuang has a low wind speed that average wind speed is 2.1 m/s in summer. Wind speed and concentrations of $PM_{2.5}$, PM_{10} have shown a negative correlation (**Table 1**), and the influences of wind speed to concentrations of $PM_{2.5}$ were more obviously than concentrations of PM_{10}. Under the condition of wind speed less than 1 m/s, high probability of atmospheric pollution were harder to dilute diffusion that lead to atmospheric pollution seriously.

4. Conclusions

In summer, the daily average concentrations (in $\mu g \cdot m^{-3}$) of $PM_{2.5}$ and PM_{10} in ambient air were 94.45 and 219.15, respectively. They all exceeded the ambient air quality standard II ($PM_{2.5}$ daily average 75 $\mu g/m^3$, PM_{10} daily average 150 $\mu g/m^3$) and the primary pollutant in the atmospheric environment is PM_{10} in Shijiazhuang.

The meteorological factors, such as air temperature, atmospheric pressure, precipitation and wind speed, may have an influence on the atmospheric pollutants concentration. Air temperature and concentrations of particulate matter had shown an obviously negative correlation. As temperatures rose, pollutant concentrations were significantly decreased. Atmospheric pressure and concentrations of particulate matter were significantly positively correlated. As the atmospheric pressure increased, the concentration of various pollutants also increased. Precipitation has a great impact on concentrations of particulate matter and it mainly gets rid of coarse particles while have little effect on fine particles. Besides, the wind speed showed a slight impact on atmospheric pollution.

Acknowledgements

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References

[1] Liu, X.S. and Liu, N.H. (2014) The Current Situation of China's Urban Air Pollution, the Consequences and Counter Measures. Beijing, Tianjin and Hebei Province Steel Cleaner Production, Environmental Protection Exchanges, 91-94.

[2] Wang, Y., Pei, J.G. and Wang, B. (2013) Where Is the Way to Improve the Air Quality of the Environment in Hebei. *Environmental Economy*, **117**, 59-61.

[3] Deng, L.Q., Qian, J. and Liao, R.X. (2012) Pollution Characteristics of Atmospheric Particulates in Chengdu from August to September in 2009 and Their Relationship with Meteorological Conditions. *China Environmental Science*, **32**, 1433-1438.

[4] Sun, Y.M. (2007) Using SPSS Software to Analyze the Correlation between Variables. *Journal of Xinjiang Education Institute*, **23**, 120-123.

[5] Tai, A.P.K., Mickley, L.J. and Jacob, D.J. (2010) Correlations between Fine Particulate Matter ($PM_{2.5}$) and Meteorological Variables in the United States: Implications for the Sensitivity of $PM_{2.5}$ to Climate Change. *Atmospheric Environment*, **44**, 3976-3984. http://dx.doi.org/10.1016/j.atmosenv.2010.06.060

[6] Pateraki, S., Asimakopoulos, D.N., Flocas, H.A., *et al*. (2012) The Role of Meteorology on Different Sized Aerosol

Fractions (PM_{10}, $PM_{2.5}$, $PM_{2.5-10}$). *Science of the Total Environment*, **419**, 124-135. http://dx.doi.org/10.1016/j.scitotenv.2011.12.064

[7] Wu, H.M., Wang, W.Z., Ma, B.H., *et al*. (2012) Temporal and Spatial Distributions of Air Pollutions in Lishui and Their Correlation with Meteorological Elements. *Environmental Pollution and Control*, **34**, 51-55.

[8] Zhao, C.X., Wang, Y.Q., Wang, Y.J., *et al*. (2014) Temporal and Spatial Distribution of $PM_{2.5}$ and PM_{10} Pollution Status and the Correlation of Particulate Matters and Meteorological Factors during Winter and Spring in Beijing. *Environmental Science*, **35**, 418-427.

[9] Ben, J.D. (2012) The Correlation Analysis between the Air Pollution Status and Meteorological Conditions in Changchun. Ph.D. Thesis, Jilin University, Changchun.