

Study on Pollution Characteristics in Winter in Linfen City

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Abstract

PM_{2.5} is the main component affecting the atmospheric environmental quality of many cities in China, while SO₂, NO₂, NO and O₃ play an important role in the formation of PM_{2.5}. This paper focuses on the distribution and pollution of PM_{2.5}, SO₂, NO₂, NO and O₃ during winter heating in Linfen. The results show that there are still many heavily polluted weather conditions in Linfen City during the heating period, with secondary fine particles generated by the action of NO₂ and CO as the main pollutants. Humidity, SO₂, NO₂ and CO have a significant impact on the formation of PM_{2.5}. In addition, SO₂ concentration pollution is still serious, and O₃ concentration may become the next main environmental factor affecting air pollution in Linfen City.

Keywords

PM_{2.5}; Atmospheric Pollutant; Correlation Analysis.

1. Introduction

PM_{2.5} is a kind of fine particulate matter, which has a long residence time in the atmosphere and is easy to carry toxic substances such as organic pollutants and heavy metals, can damage human respiratory tract [1] and cause cancer risk [2]. In China, about 1.6 million people die from air pollution every year. Li, 2018 and Xu, 2019 studies show that nitrate is the main cause of haze events in recent years.

At present, PM_{2.5} focus on large urban areas suffering from urban expansion and rapid population growth [3], such as Beijing Tianjin Hebei, Yangtze River Delta and Pearl River Delta. In recent years, with the implementation of a series of pollution control measures and policies (such as the action plan for air pollution prevention and control), the atmospheric environment of major cities in China has been greatly improved, but there is still insufficient attention to some cities. Shanxi Province is an energy base dominated by coal industry in China, and Linfen city is its main heavily polluted city. From 2016 to 2017, the number of heavily polluted days in Linfen city was the highest in the province, and the atmospheric SO₂ concentration in some parts of winter was as high as 420 μg/m³ [4]. Among 169 key cities in 2018, Linfen ranked last in air quality. This paper focuses on comparing the distribution and variation characteristics of the six atmospheric components (PM₁₀, PM_{2.5}, NO₂, SO₂, O₃, CO) in winter of Linfen City on Fenwei plain. It is found that the factors affecting the environmental quality of northern cities in winter and summer are aimed to highlight the main air pollution problems still existing in some prefecture level cities, put forward relevant suggestions for the main pollutants, and contribute to China's blue sky defense strategy.

2. Overview of the Study Area

Linfen city is located in Fenwei plain, belonging to the type of warm temperate monsoon climate, with less precipitation in winter. Linfen is mainly engaged in coal mining and mining. It is located in the north. In winter, it mainly depends on the combustion of loose coal for heating, and the phenomenon of haze pollution is very serious. The air pollution data comes from the national air quality real-time release platform released by the Ministry of ecology and environment of the people's Republic of China. From December 2020 to February 2021, each station collected the hourly mass concentrations of $PM_{2.5}$, PM_{10} , SO_2 , CO , NO_2 and O_3 . Sampling and synchronous recording of meteorological conditions (air temperature, humidity, wind speed) and online data of ambient air quality ($PM_{2.5}$, SO_2 , NO_2 , CO , O_3).



Fig. 1 Map of the study area

3. Distribution Characteristics of $PM_{2.5}$ and Water-soluble Ions

3.1. Evaluation of Winter Air Quality in Linfen City

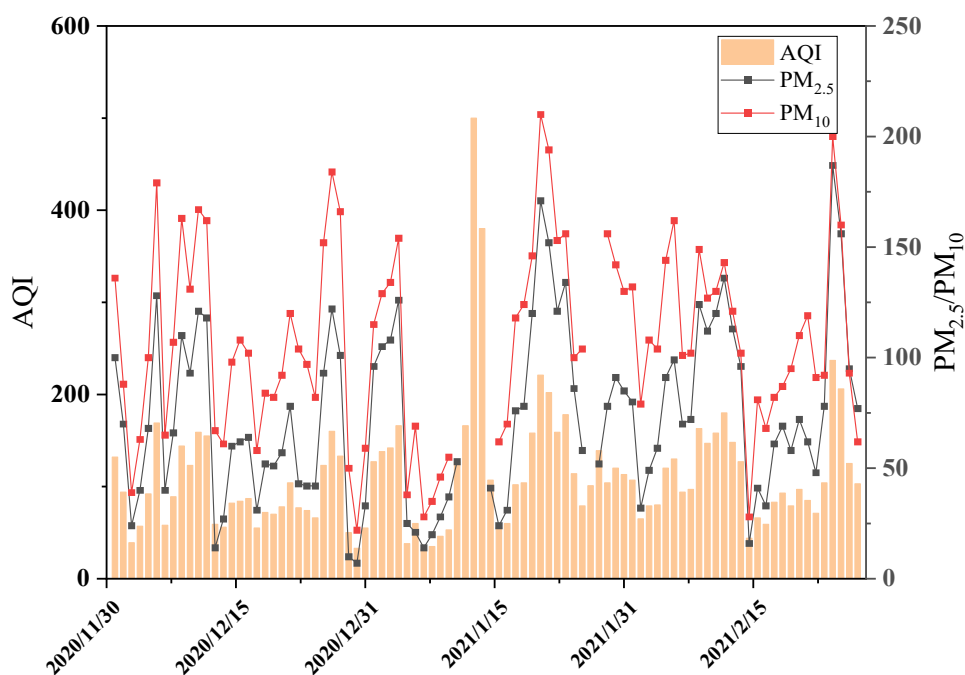


Fig. 2 Time-series plots of the $PM_{2.5}$, PM_{10} and AQI

The average value of winter air quality in Linfen City in 2021 is 112.26 ± 67.91 , which belongs to slightly polluted weather. Among them, the number of days of serious pollution in January 2021 is 9 days, and the highest AQI value is as high as 500 (Fig. 2). The weather in the other two months is dominated by mild pollution weather. In terms of air quality, Linfen city still ranks in the middle and bottom of China's air quality. The haze pollution in Linfen city is in the stage of urban development and aggravation, and there are a large number of civil bulk coal, steel, coking and other enterprises.

$\text{PM}_{2.5}$ concentration during heating is $70.04 \pm 41.72 \mu\text{g}/\text{m}^3$, the pollution level is better than 75% specified in China's national standard for border air quality (GB 3095-2012) $\mu\text{g}/\text{m}^3$, but higher than Tianjin ($52 \mu\text{g}/\text{m}^3$) [5], Shanghai ($53 \mu\text{g}/\text{m}^3$) [6], Chengdu ($67.44 \mu\text{g}/\text{m}^3$) [7] and other national central cities, but lower than $\text{PM}_{2.5}$ ($124 \mu\text{g}/\text{m}^3$) in Linfen heating period in 2019. Concentration[8]. Civil bulk coal, iron and steel, coking and other enterprises in Linfen emit a lot, and the terrain contour is distributed in a "concave" shape, surrounded by mountains. Affected by the terrain, the air mass is easy to stagnate and push in the basin, resulting in the intensification of air pollution in Linfen City[9]. However, since the implementation of coal to electricity measures in 2018, the air pollution environment in Linfen has been greatly improved. The average concentration of PM_{10} during the study period was $99.20 \pm 50.42 \mu\text{g}/\text{m}^3$, the highest value appeared on January 21, and the concentration of $\text{PM}_{2.5}$ also reached the peak on the same date. The discharge of fireworks and firecrackers during the Chinese New Year may be the main reason for its high concentration.

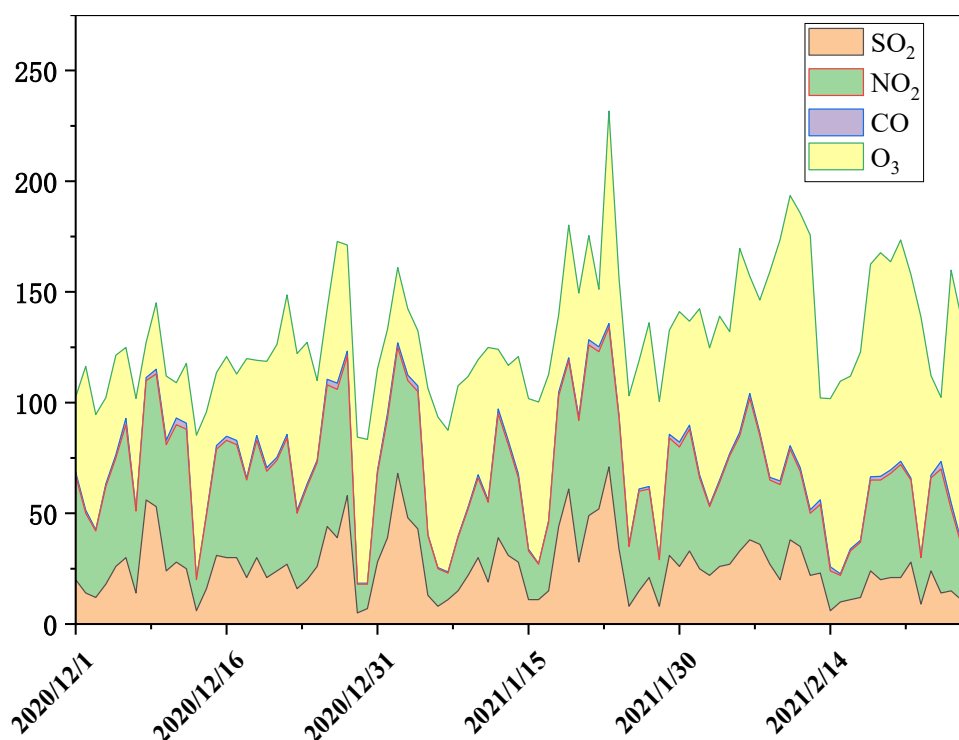


Fig. 3 Time-series plots of the SO_2 , NO_2 , CO and O_3

The average values of SO_2 , NO_2 , CO and O_3 during the study period were $25.96 \pm 14.36 \mu\text{g}/\text{m}^3$, $42.80 \pm 15.60 \mu\text{g}/\text{m}^3$, $1.47 \pm 0.67 \mu\text{g}/\text{m}^3$ and $60.08 \pm 24.81 \mu\text{g}/\text{m}^3$ (Fig 3). The main emission sources of NO_2 are fixed combustion sources, road mobile sources and non road mobile sources, SO_2 is mainly from process sources and fixed combustion sources, CO is from road mobile sources, and O_3 is mainly from road mobile sources and process production[10]. The average concentration of SO_2 and NO_2 in Linfen is lower than the standard of grade I in 2012, but the

average concentration of SO_2 and NO_2 is still lower than the standard of grade I in 2012 ($\mu\text{g}/\text{m}^3$), which is related to Linfen being a coal resource-based city. However, compared with 2019, the concentrations of SO_2 , NO_2 and co environmental factors decreased in varying degrees [11], and only the concentration of O_3 increased. Recent research results show that O_3 has become the main pollution factor of ambient air, which will be related to $\text{PM}_{2.5}$ interaction, on the other hand, it also promotes the conversion of NO_2 and SO_2 to secondary ions [12].

3.2. Correlation Analysis

The correlation between environmental factors can reflect their possible sources and mutual relationship [13]. $\text{PM}_{2.5}$ in Linfen City during the study period and PM_{10} are significantly correlated. The high correlation between them indicates that these particulate pollutants have similar formation mechanism locally, and the external sand dust and wet sedimentation scouring have little impact on them (Fig. 4). In addition, the correlation of humidity and $\text{PM}_{2.5}$ is high, which is 0.62. High humidity is easy to promote the conversion of NO_x , SO_2 and NH_3 to secondary ions, $\text{PM}_{2.5}$. The concentration increases.

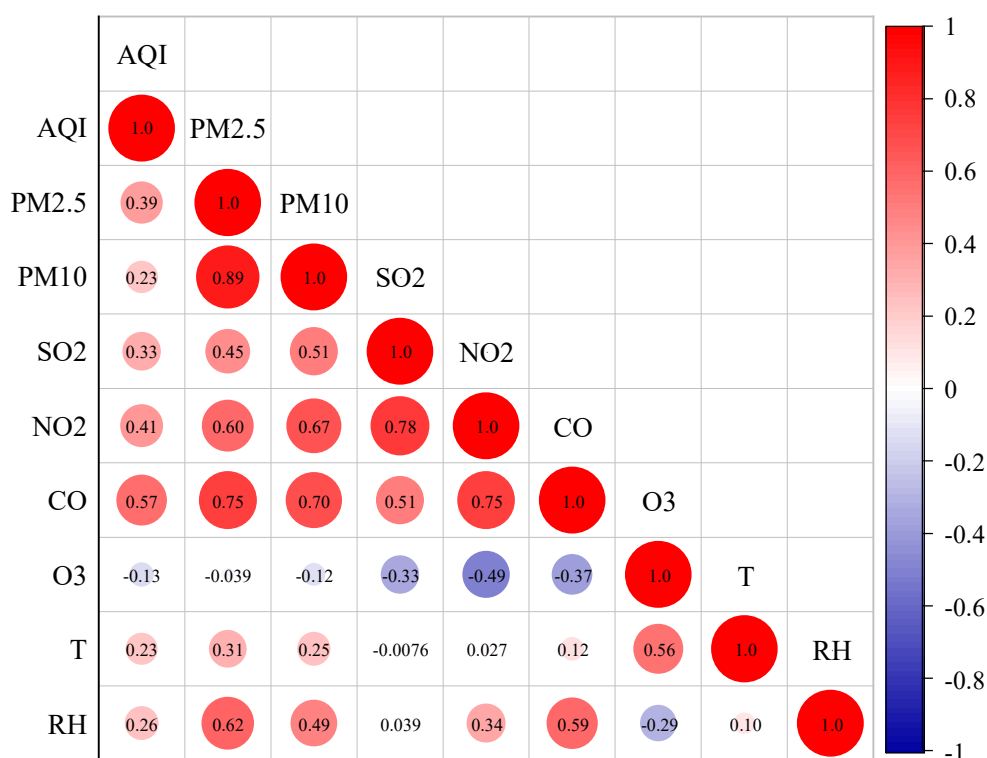


Fig. 4 Correlation between every environmental factors

In addition, CO has high correlation with other elements, and the source components of atmospheric CO are complex, which is similar to $\text{PM}_{2.5}$ and other environmental factors have the same emission sources. The correlation between NO_2 and SO_2 is 0.78. As the precursors of the main secondary pollutants NO_3^- and SO_4^{2-} , NO_2 and SO_2 have a strong impact on the concentration of atmospheric aerosols. In addition, NO_2 can also promote the conversion of SO_2 to sulfate aerosol.

4. Conclusion

$\text{PM}_{2.5}$ during heating in Linfen City in 2021. The concentration is $70.04 \pm 41.72 \mu\text{g}/\text{m}^3$, the average concentration of PM_{10} is $99.20 \pm 50.42 \mu\text{g}/\text{m}^3$, after the implementation of coal to electricity measures, the atmospheric pollution environment in Linfen has been greatly improved, but

there are still many heavily polluted weather conditions. Humidity, SO₂, NO₂ and CO are important for PM_{2.5} the formation of 5 has a significant impact. The average values of SO₂, NO₂, CO and O₃ are 25.96±14.36µg/m³, 42.80±15.60µg/m³, 1.47±0.67µg/m³ and 60.08±24.81µg/m³, SO₂, NO₂ and CO source components, in which SO₂ concentration pollution is still serious, while O₃ concentration may become the next main environmental factor affecting air pollution in Linfen City.

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