

The Analysis of Air Quality Characteristics of Shanxi Province

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Abstract: To get the whole picture of the air quality change of Shanxi Province, the data of six pollutants collected from 58 state controlling air sampling sites including SO₂, NO₂, PM₁₀, CO, O₃ and PM_{2.5} during November 2016 to July 2017 were analyzed. The results showed that the air quality of Shanxi Province since November 2016 was worse than that of Beijing, Tianjin and adjacent provinces. The most contaminated air in Shanxi occurred at Taiyuan basin (Taiyuan, Jinzhong), Linfen, Yuncheng and Jincheng. The six pollutants showed evident spatial distribution features. In terms of time series change, air quality during heating period was worst, and contaminants during that time contributed to the majority of pollutants in the whole year. The six contaminants also showed obvious daily and monthly change patterns. This paper examined impacts of heavily contaminated weather and dust storm on air quality. Calculation revealed that every heavily contaminated day would result in increase of PM_{2.5} by 0.38μg/m³, and a dust storm could lead to an increases of PM₁₀ and PM_{2.5} by 0.71μg/m³ and 0.20μg/m³ respectively. Based on the analysis of air pollution status in Shanxi, some suggestions and possible solutions to pollution problems were also given in this paper.

1. Introduction

Shanxi Province is located on the east bank of the middle reaches of the Yellow River and on the Loess Plateau in the west of the North China Plain. The terrain is high in the northeast and low in the southwest. There are a series of basins from north to south, followed by Datong Basin, Xinding Basin, Taiyuan Basin, Linfen Basin, Yuncheng Basin and the Shangdang Basin ^[1]. This province belongs to the temperate continental monsoon climate, with various climate types. The temperature decreases from south to north and from plain to the mountain. The precipitation in the province is low, and the annual precipitation is generally 350-700mm ^[2-3]. Due to the energy structure in Shanxi Province and the large volume of pollutants discharged, combined with the multi-valley basin terrain, the overall situation of ambient air quality is not optimistic.

2. The resource and collecting method of the data

The data of six pollutants collected from 58 state controlling air sampling sites including SO₂, NO₂, PM₁₀, CO, O₃ and PM_{2.5} is already reviewed by China National Environmental Monitoring Centre, while the data of Beijing, Tianjin and adjacent provinces sourced from China National Environmental Monitoring Centre is not reviewed. The calculation of data statistics, evaluation and effectiveness is regulated by the environmental air quality index AQI technical regulations (HJ633-2012), environmental air quality standards (GB3095-2012), environmental air quality assessment technical specifications (trial HJ663-2013) [6-7] and other relevant standards.

3. Results and discussion

3.1 The state of ambient air quality in Shanxi Province from November 2016 to July 2017

From November 2016 to July 2017, the province's comprehensive index of ambient air quality averaged 8.66, the average number of days reached was 120 days, and the number of days of heavy pollution averaged 29 days. In the days exceeding the standard, PM_{2.5} was the primary pollutant.

The number of days is the most, account for 55.1% of the over-the-counter days. The average concentrations of SO₂, NO₂, PM₁₀ and PM_{2.5} in the ambient air of the province were 82μg/m³, 44μg/m³, 133μg/m³ and 76μg/m³, respectively. The average concentrations of CO and O₃ were 3.6mg/m³ and 192μg respectively. /m³.

3.2 Analysis of Spatial Distribution Characteristics of Environmental Air Quality Pollution in Shanxi Province

3.2.1 Comparison with ambient air quality in Beijing, Tianjin and Hebei and surrounding provinces

Compared with Beijing-Tianjin-Hebei and neighboring provinces, Shanxi Province's ambient air quality is generally poor, and the contribution weight of pollution factors is relatively concentrated. From November 2016 to July 2017, Shanxi Province's comprehensive index of ambient air quality ranked first, higher than The average level of Beijing-Tianjin-Hebei and surrounding provinces is 17.0%; the number of days of compliance is less than the average level of Beijing-Tianjin-Hebei and neighboring provinces, ranking second in the bottom; the number of days of heavy pollution is the same as that of Beijing-Tianjin-Hebei and neighboring provinces, ranking third from small to large. The average concentration of SO₂ is the highest in Beijing, Tianjin and Hebei and surrounding provinces, which is about 2.48 times of the average level of Beijing-Tianjin-Hebei and neighboring provinces. It is the main factor affecting the ranking of Shanxi comprehensive index, and the contribution rate to the comprehensive index is 16.7%. The average contribution level of SO₂ to the comprehensive index in Beijing, Tianjin and Hebei and surrounding provinces (cities) (7.4%).

3.2.2 Pollution characteristics of cities in Shanxi Province

From November 2016 to July 2017, the average SO₂ concentration of 11 prefect-level cities in the province is between 61-141μg/m³, which exceeds the national second-level concentration standard. High-value regions are mainly concentrated in Linfen and Jinzhong, which are 1.72 times and 1.59 times respectively of the average level of the province. The contribution rate of the two cities to the province is 29.9%. The average concentration of NO₂ is between 33 - 55 μg/m³, and the overall regional distribution is relatively average. Taiyuan, the provincial capital city, has the highest concentration (related to the high vehicle ownership in Taiyuan), which is 1.25 times of the provincial average. The average concentration of PM₁₀ is between 92-166μg/m³, which exceeds the national second-level concentration standard. The high-value regions are mainly concentrated in Linfen, Taiyuan and Yuncheng. The average concentration of PM_{2.5} is between 45 - 112 μg/m³, which exceeds the national second-level concentration standard. The average concentration of Linfen, Yuncheng and Taiyuan exceeds the provincial average, contributing 34.1% to the province. The average percentile concentration of CO is between 2.2-5.1mg/m³, and the high-value regions are mainly concentrated in Linfen and Jincheng. The average concentration of O₃ percentile is between 152-223μg/m³, except Luliang, the other 10 cities exceed the standard, and the overall regional distribution is relatively average. The concentration of Jincheng and Linfen is the highest, which is 1.16 times and 1.15 times of the provincial average respectively.

3.3 Analysis of time variation characteristics of environmental air quality in Shanxi Province

3.3.1 Variation characteristics of heating period and non-heating period

During the heating period from November 1, 2016 to March 31, 2017 (151 days in total) , the provincial comprehensive index of environmental air quality is 10.26 on average. The number of standard days is 59, the average number of days with heavy pollution is 26. Among the primary pollutants, fine particulate matter PM_{2.5} accounts for the highest proportion, with an average concentration of 101μg/m³.

During the non-heating period (122 days in total) on July 31, 2017, the comprehensive index of provincial environmental air quality is 5.8 on average. The average number of days reaching the standard is 62 days, and the average number of days with heavy pollution is 3 days. The primary

pollutant with the highest proportion is O_3 , and the average percentile concentration in the whole province is $214\mu\text{g}/\text{m}^3$.

Overall, the ambient air quality during the heating period is significantly worse than the non-heating period (except O_3). On the one hand, the pollutant discharge volume during the heating period is generally larger. On the other hand, the temperature in spring and winter is relatively low, the atmospheric junction is relatively stable, and there are many temperature inversion weather, which is not conducive to the dilution and diffusion of pollutants, while the diffusion conditions in summer are relatively good, coupled with the removal of precipitation, the pollution is relatively light [8-11].

3.3.2 Analysis of monthly variation characteristics

The average concentration of six pollutants in the province has obvious monthly variation characteristics, and the monthly variation of SO_2 , NO_2 , PM_{10} , $PM_{2.5}$ and CO is basically the same. From November 2016, the pollutant concentration gradually increases, in December 2016 (the peak concentration of CO appeared in January 2017) peaked, and from January to April 2017, the concentration of pollutants continued to decrease, and the trend from May to July 2017 was relatively flat.

The monthly variation of O_3 concentration is roughly opposite to that of the other five pollutants. High and low values occur in summer and winter respectively. On the one hand, due to the high temperature in summer, the sun radiation is stronger, and photochemical reaction rate is accelerated. On the other hand, high vegetation coverage in summer can generate a large number of volatile organic pollutants, which also promotes the secondary generation of O_3 to a certain extent [12].

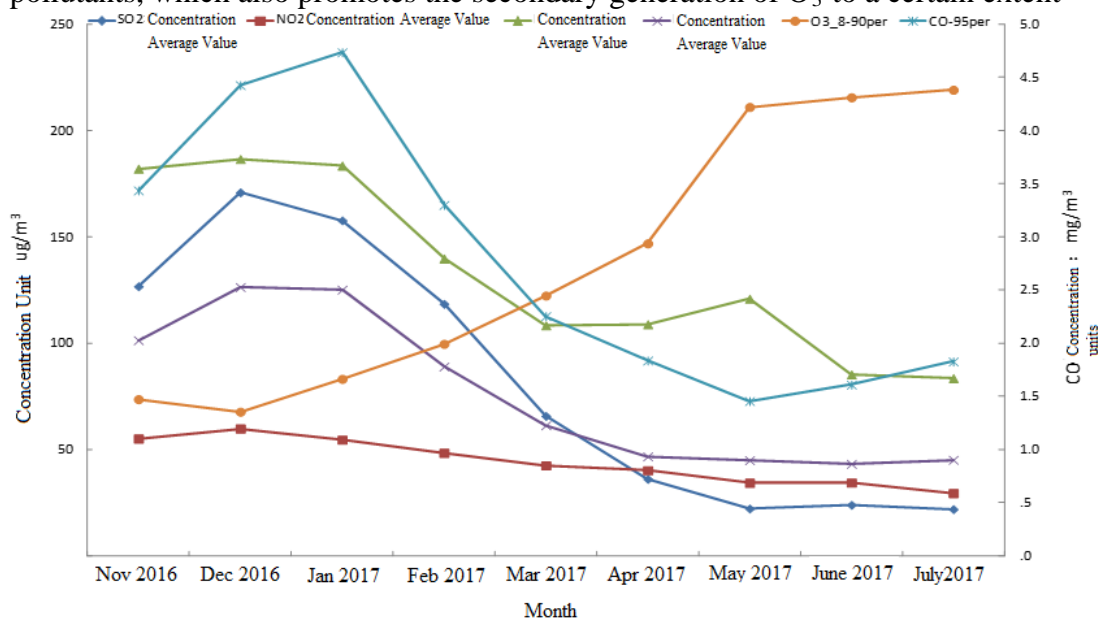


Fig.1 Monthly average concentration changes of six pollutants in Shanxi Province from November 2016 to July 2017

3.3.3 Analysis of daily variation characteristics

From November 2016 to July 2017, except for O_3 , the hourly variation rules of SO_2 , NO_2 , PM_{10} , $PM_{2.5}$ and CO pollutants in the six pollutants are relatively consistent, and they all show the characteristics of "bimodal" change [13]. The concentration is higher at night to morning, and lower from noon to afternoon, the peak appears at 9-11 p.m. and 8-10 a.m.; O_3 shows a significant "unimodal" change pattern, the peak appears at 3-4 p.m.

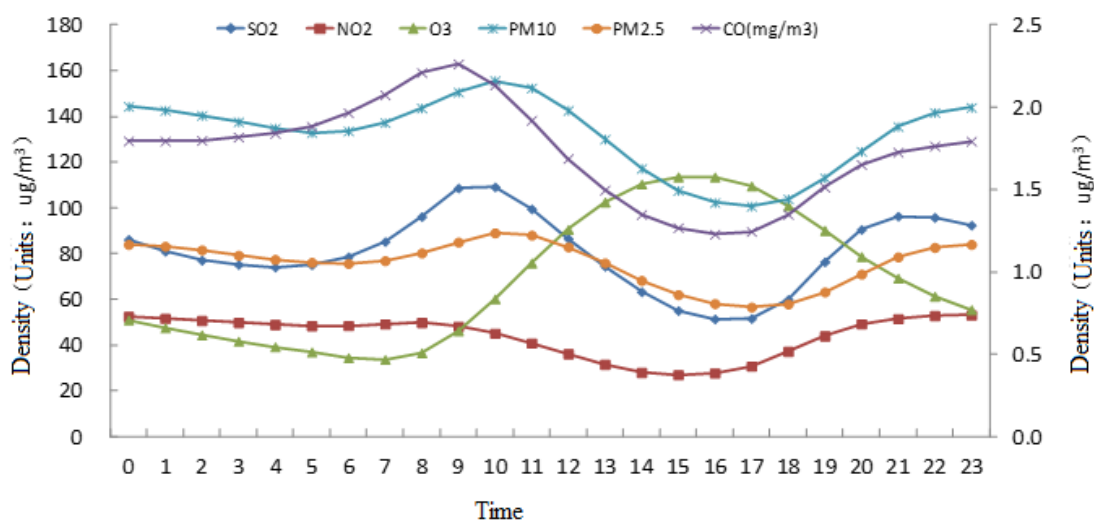


Fig.2 Hourly concentration change of six pollutants in Shanxi Province from November 2016 to July 2017

The reason for this may be that from the night, the ambient temperature is lowered, the atmospheric stratification becomes very stable, and the pollutants gradually accumulate. The first peak occurs at 21-23, starting from 7:00 in the morning, although the meteorological diffusion conditions are gradually improved. At the same time, human activities have also become frequent and concentrated, resulting in increased emissions of pollutants, which are not easily diffused in a short period of time, so pollutants continue to accumulate until a second peak occurs between 8 and 10 hours^[14-15] Then, with the strengthening of solar radiation, the convection is intensified and the diffusion conditions become favorable. At this time, the pollutant concentration begins to decrease, and it drops to the lowest at around 15-16 hours. O₃ shows a significant "unimodal" variation and changes with the intensity of solar radiation. The concentration during the day is higher and the night is lower. O₃ concentration will reach the lowest value at 6-7° due to the consumption of O₃ at night and the deposition on the near surface. After the photochemical action increases, the O₃ concentration begins to rise and peaks at 15-16 pm. Then gradually decreased, and the change tends to be flat after 21:00^[16].

3.4 Analysis of the impact of special weather conditions on the ambient air quality in the province

3.4.1 Heavy pollution weather

From November 2016 to July 2017, there were 10 regional heavy pollution processes in the province, with an average of 26 days (except for heavily polluted weather caused by dust and dust), all concentrated during the heating period from November 2016 to March 2017. Among the heavy pollution days, PM_{2.5} is the most important pollutant, accounting for 96.5%. The average daily concentration of PM_{2.5} during the heavy pollution process is 216 μ g/m³, which is the average concentration during non-heavy pollution during the heating period. 2.8 times. It is calculated that each heavy pollution day will cause the average annual concentration of PM_{2.5} in the province to increase by 0.38 μ g/m³. The heavy pollution of the heating period in 2016-2017 will lead to an increase in the average annual concentration of PM_{2.5} in the province.9.9 μ g/m³.

3.4.2 Dust weather

From May 3 to 8, 2017, 11 cities in Shanxi Province were affected by different levels of dust and sand weather. The average number of days affected was 3 days. During the dusty weather, the daily average concentration of PM₁₀ in the province was 354 μ g/m³; PM_{2.5} The daily average concentration is 110 μ g/m³, and the annual average concentration of PM₁₀ in the province will increase by 0.71 μ g/m³, and the annual average concentration of PM_{2.5} will increase by 0.20 μ g/m³. The dusty weather in May 2017 attributed to the average annual concentration of PM₁₀ and PM_{2.5}

in the province increased by 2.1 $\mu\text{g}/\text{m}^3$ and 0.59 $\mu\text{g}/\text{m}^3$, respectively.

4. Suggestions

4.1 Focus on key areas and systematically promote the air pollution control work in Shanxi Province

The pollution areas in Shanxi Province are mainly concentrated in Taiyuan, Jinzhong, Linyi, Yuncheng and Jincheng. The main factors affecting air quality are particulate matter and SO_2 . The main factor affecting air quality ranking is SO_2 , strengthening supervision and management of key polluted areas. Comprehensive policy is of great significance for improving the environmental air quality of the province. The first is to continuously tap the potential of emission reduction and promote the clean energy structure. Reduce the amount of coal used and accelerate the management of loose coal in urban and rural areas; scientifically and rationally set the city assessment indicators and continue to integrate SO_2 into the province's air quality improvement target system; Second, implement the responsibilities of all parties in accordance with the law and establish a common prevention and control system. They should strengthen supervision, management, and assess ranking of air quality, include environmental and air quality improvement indicators into the evaluation system of county-level governments, and urge county-level governments to take responsibility for environmental protection. Taking the disclosure of enterprise environmental information as the starting point, enterprises are forced to take responsibility for environmental protection. Good atmosphere of public opinion should be created to guide public actively practice a green lifestyle. Third, law enforcement should be enhanced and oversight and accountability should be strengthened further. Relevant provincial, municipal and county law enforcement departments should maintain a high-pressure situation of intensive law enforcement and regular night inspections, and comprehensively apply online penalty, daily penalty and transfer to judiciary to expand the effectiveness of law enforcement.

4.2 According to the pollution pattern, polluting enterprises should be organized orderly to carry out off-peak production

The environmental air quality in Shanxi Province has obvious time variation characteristics. The pollution season is mainly in the heating period, and the pollution period is mainly from 22 p.m. to 11 a.m. every day. The atmospheric diffusion conditions in the above period are poor, and the environmental carrying capacity is relatively weak, which is most likely to lead to regional air pollution. The duration and peak concentration of pollution can be effectively reduced by organizing polluting enterprises in the region to carry out off-peak production to reduce the environmental load in the pollution period. Firstly, enterprises should be supervised to arrange equipment maintenance, overhaul, replacement and other work in the heating period, moderately increasing production load in the season with better diffusion conditions. Secondly, based on the characteristics of the enterprise and the daily variation law of pollutants, the corresponding production plan is formulated to moderately reduce the production load in the daily pollution period and moderately increase the production load in the period with better diffusion conditions.

4.3 strengthen analysis and judgment, and properly deal with heavy pollution weather

To cope with heavy pollution, the key is to respond in advance, and the core is to implement emission reduction through joint prevention and control. The first is to enrich monitoring means, strengthen the research and analysis of heavy pollution weather, improve the accuracy of forecast, and provide technical support for effective response to heavy pollution weather. Second, improve joint law enforcement mechanism, improve regional cooperation, realize joint prevention and control, and constantly reduce the impact of heavy pollution weather. Third, we will continue to strengthen supervision and inspection of heavy pollution weather, check the launch of emergency plans for heavy pollution weather and the implementation of measures, urge local governments to strictly implement their main responsibilities for dealing with heavy pollution weather, and ensure

proper handling of heavy pollution weather.

References

- [1] Hu Hongyan, Zheng yu. Influence of geographical environment on regional culture in Shanxi Province [J]. *Journal of Taiyuan Normal University*, 2014, 13 (3): 88-92.
- [2] Yang ding, Fang Fengman, Ren Jianmei. Analysis of the characteristics of climate change in Shanxi Province in recent 50 years, *Resource Development and Market*, 2008, 24 (1): 60-62.
- [3] Qian Linqing, Zheng Yanmou. *Shanxi Climate* [M]. Beijing: Meteorological Publishing House, 1985:10-15.
- [4] Zhao Ruitong, Liu Hanbin, Li Miao. Research on Shanxi's energy development path in the new era [J]. *Coal Economy Research*, 2008, 38 (2):35-39.
- [5] HJ633-2012, AQI Technical Regulations[S].
- [6] GB3095-2012, Environmental Air Quality Standard[S].