Characterization of Air Primary Pollutants in Zhejiang Province of Yangtze River Delta

Nina Zheng*, Yaqi Xu, Xueli Liu, Lingyang Pan, Ling Ling, Yalong Jiang

School of Urban Construction, Anhui Xinhua University, Hefei, Anhui, 230088, China

*E-mail: zhengnina2022@163.com

Abstract. Urban air quality is receiving increased attention as a result of the explosive development in demand for energy, industry, and transportation. This study primarily uses Zhejiang province as an example and analyzes air quality monitoring data from 2018 through 2021. The findings indicate that the proportion of days with each primary pollutant in 2021 is O_3 (58%), PM_{10} (18%), NO_2 (18%) and $PM_{2.5}$ (6%), and the proportion of days with O_3 as the primary pollutant is increasing year by year, with O_3 accounting for more than 90% in summer. Ningbo and Huzhou are both afflicted by NO_2. In southern Zhejiang, PM_{10} makes up a greater percentage of the air pollution than in northern Zhejiang. Sea and land breezes have an impact on Jiaxing, Zhoushan, Ningbo, and Taizhou, which are coastal cities. Zhoushan accounts for up to 76% of the days where O_3 is the primary pollutant. The key to attaining persistent improvement in air quality is strengthening ozone prevention and control in significant areas (coastal cities) and doing a good job of joint prevention and control between regions.

Keywords: air; primary pollutants; change.

1 Introduction

Air quality research is critical to ensuring the balance and sustainability of regional development in the Yangtze River Delta[1]. Prior researchers focused their research on the major cities in Jiangsu[2], Shanghai[3], Hangzhou[4] and Taizhou[5-6]. Less studies have been undertaken in the entire Zhejiang. This study conducts a analysis of air quality monitoring data in Zhejiang from 2018 to 2021. In order to determine the types of primary pollutants affecting air quality in Zhejiang and their temporal variation patterns, as well as to investigate the variation of primary pollutant distribution in 11 cities. The study's findings offer crucial data for pollution forecasting and early warning in Zhejiang, and is significant for the efficient prevention and control of air pollution and the Zhejiang's air quality improvement.

A. E. Abomohra et al. (eds.), *Proceedings of the 2023 9th International Conference on Advances in Energy Resources and Environment Engineering (ICAESEE 2023)*, Atlantis Highlights in Engineering 29,
https://doi.org/10.2991/978-94-6463-415-0_90

2 Analysis Methods

The China environmental monitoring stations' urban air quality release platform and the weather post report website provided air quality monitoring data used in this study. The data includes 11 cities daily average concentrations of $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2, and CO from January 2018 to December 2021 in Zhejiang. The daily primary pollutants were assessed using the air quality index method (AQI)[7-8]. Based on the evaluation results, the monthly and seasonal change of primary pollutants and the distribution characteristics of primary pollutants in 11 cities are analyzed respectively[9].

3 Distribution Characteristics of Primary Pollutants

3.1 Annual Variation of Primary Pollutants

The data analysis of 11 cities in Zhejiang from 2018 to 2021 (where O_3 is assessed by its daily maximum 8-hour average concentration) reveals that the percentage of days where PM_{10} becomes the primary pollutant, accounting for around 20%, does not change significantly throughout the four years. The NO_2 percentage shows a small increase, rising to about 18% in 2021. As indicated in Figure 1, the $PM_{2.5}$ percentage falls annually, from 24% in 2018 to 6% in 2021, whereas the O_3 percentage rises annually, rising by 28.9% in four years. This further demonstrates the recent efforts made by Zhejiang to reduce particulate matter, particularly $PM_{2.5}$ pollution. While particulate matter pollution has decreased, the impact of O_3 pollution on air quality has increased noticeably, creating new challenges for its air quality improvement.

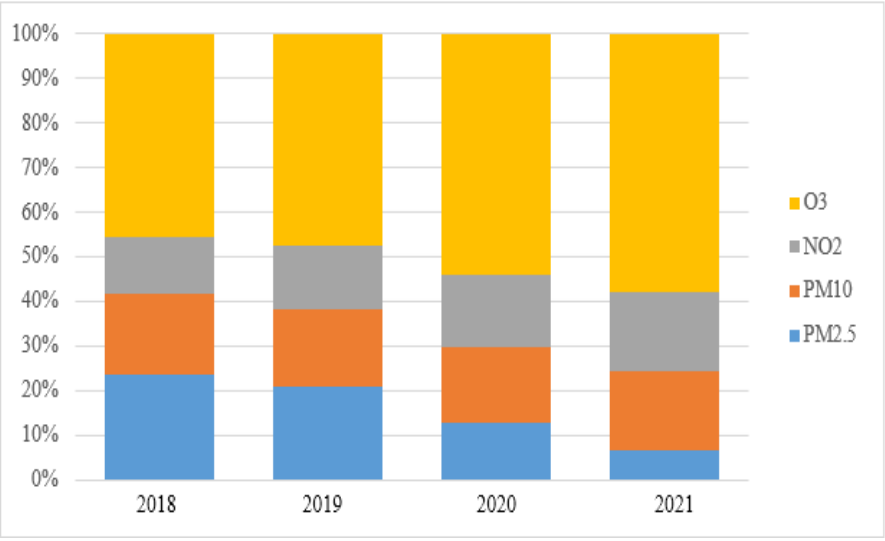

Fig. 1. The various primary pollutants percentage of days from 2018 to 2021

3.2 Seasonal Variation of Primary Pollutants

Fig. 2. The seasonal proportion of primary pollutants from 2018 to 2021

As indicated in Figure 2, the seasonal proportion of primary pollutants changes consistently from 2018-2021:(1) O_3 pollution has obvious seasonal characteristics. O_3 is the main primary pollutant affecting air quality in Zhejiang in spring, summer, and autumn. The proportion of days when O_3 becomes the primary pollutant in summer is the highest, approximately 91%-95%. In spring and autumn, the proportion is about 55%-75%. In winter, O_3 accounts for the smallest proportion, about 0.6%-7%. (2) There is a consistent seasonal distribution of PM_{10} and $PM_{2.5}$. In summer, $PM_{2.5}$ is the primary pollutant on only about 0-2%; in the fall and winter, the proportion gradually rises, reaching a maximum of 25%-57% in the winter. The main cause of the opposite seasonal distribution of $PM_{2.5}$ and O_3 is that summertime advantageous diffusion conditions and increased rainfall improved particulate matter clearance or diffusion. Summertime's consistently high temperatures and intense sunshine are favorable for atmospheric photochemical reactions involving volatile organic chemicals and ammonia-nitrogen complexes, which produce potent oxidants like O_3 near the ground. As a result, O_3 rises in the summer as the temperature rises. While atmospheric conditions are not favorable for the production of O_3 in autumn and winter, atmospheric dispersion conditions deteriorate due to an increase in stationary weather and inverse temperature weather, which causes pollutants (especially $PM_{2.5}$) to accumulate and be difficult to disperse, leading to high $PM_{2.5}$ concentrations. (3) The number of days where NO_2 was the primary pollutant over the past four years was concentrated in the autumn and winter, with the lowest number occurring in the summer.

3.3 Monthly Variation of Primary Pollutants

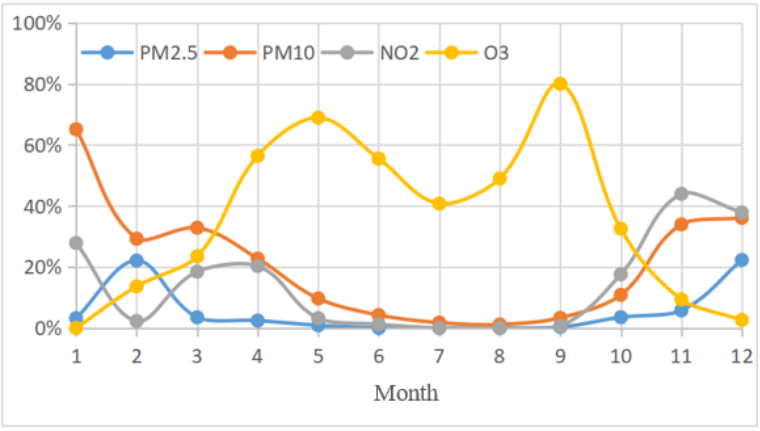

Fig. 3. Monthly variation of the number of days of each primary pollutant in 2021

In 11 cities in Zhejiang, a monthly count of primary pollutant days was done in 2021. From January to March 2021, the proportion of days with PM_{10} as the primary pollutant is at its maximum. The pattern for PM_{10} and NO_2 is similar. The particulate matter have a greater proportion in the winter and spring. The $PM_{2.5}$ percentage rise above 20% only in March and December, otherwise, it was very low. The O_3 percentage varied greatly. The O_3 proportion reversed in April, increasing from 23% to 69%. From April to September, the number of days with particulate matter as the primary pollutant rapidly decreased, the average O_3 proportion was 58%, and the highest proportion occurring in September (80%). In the summer and fall, O_3 had the biggest impact on the air quality in Zhejiang. After October, the temperature drops and light decreases, the impact of O_3 on air quality weakens and the number of days with particulate matter as the primary pollutant rises slightly. Figure 3 depicts an overall adverse correlation between particulate matter and O_3 in the monthly distribution.

3.4 Proportion of Primary Pollutants in Different Cities

In 2021, there are differences in the distribution of primary pollutants among the 11 cities in table 1. (1) In southern Zhejiang, the proportion of PM_{10} as the primary pollutant is usually higher than in northern Zhejiang. In southern Zhejiang, the proportion of PM_{10} as the primary pollutant ranges from 32% to 42%, whereas in northern Zhejiang, the PM_{10} proportion ranges from 11% to 22% in Huzhou, Jiaxing, Shaoxing, Ningbo, and Zhoushan. (2) Based on the proportion of days with NO_2 as the primary pollutant, it appears that NO_2 has little impact on air quality in Zhoushan, Taizhou, Quzhou, and Lishui, but its impact on Ningbo and Huzhou cannot be ignored, with 36% and 29% of days, respectively. (3) Coastal cities Jiaxing, Zhoushan, Ningbo, and Taizhou accounted for more than half of the days with O_3 as the primary pollutant. Zhoushan has the highest percentage (76%), owing mostly to sea and land breezes[10]. High concentrations of O_3 precursors in cities follow the land breeze at night to the sea

surface, where photochemical reactions occur to produce O_3, which is then blown back to land by the sea breeze, resulting in higher O_3 concentrations in coastal cities. The proportion of days with O_3 as the primary pollutant ranged from 40% to 51% in northern Zhejiang, demonstrating that O_3 has a significant impact on air quality in Zhejiang.

Table 1. The proportion of days in which air pollutants become the primary pollutants in 11 cities of Zhejiang Province in 2021

City	NO_2	$PM_{2.5}$	PM_{10}	O_3
Lishui	0%	17%	34%	49%
Jinhua	26%	9%	20%	45%
Quzhou	9%	2%	42%	47%
Taizhou	5%	8%	36%	51%
Wenzhou	24%	4%	32%	40%
Huzhou	29%	3%	17%	51%
Jiaxing	28%	7%	12%	53%
Hangzhou	16%	9%	41%	34%
Shaoxing	16%	11%	22%	51%
Ninbo	36%	1%	11%	52%
Zhoushan	3%	1%	20%	76%

4 Conclusion

The primary pollutant percentage of days is as follows in 2021: O_3 (58%), PM_{10} (18%), NO_2 (18%) and $PM_{2.5}$ (6%). From 2018 to 2021, the $PM_{2.5}$ percentage falls year by year, with a 75% decrease in four years. This demonstrates that Zhejiang has made tremendous progress in controlling particle pollution. The influence of NO_2 on Ningbo and Huzhou cannot be overstated. The O_3 percentage has increased year on year, ranging from 46% to 58%. In terms of monthly and seasonal distribution, the percentage of particulate matter and O_3 are inversely. Ozone accounts for over 90% of days in summer, followed by spring. O_3 has become the main factor affecting air quality in the province. Improving ozone pollution prevention and management in the summer will be a key part of Zhejiang's ongoing air quality improvement. Sea and land winds affect the coastal cities of Jiaxing, Zhoushan, Ningbo, and Taizhou, and the proportion of days with O_3 as the primary pollutant is high, with Zhoushan accounting for 76% of the highest proportion. Strengthening ozone pollution prevention and control in coastal cities is important for the improvement of air quality.

Acknowledgements

The work presented was supported by the Natural Science Research Project in HigherEducation Institutions in Anhui Province (Grant No. 2022AH051875), Anhui Xinhua

University Key Discipline Project (Grant No. zdxk202101) and the National College Student Innovation Training Program (Grant No. 202312216026).

References

1. Guang W, Kai W. (2016) A research on urban ecological environment evaluation system: Taking the Yangtze River Delta as an example. Ecological Economy, 2:139-146.
2. Zeng J, Zhang L, Yao C, et al. (2020) Senlin. Relationships between chemical elements of $PM_{2.5}$ and O_3 in Shanghai atmosphere based on the 1 year monitoring observation. Journal of environmental sciences, 95:15-23.
3. Zhang Y, Yu Q, Fu Q Y, et al. (2010) Impact of the transport of atmospheric pollutants from the Yangtze River Delta on the air quality in Shanghai. China Environmental Science, 30:914-923.
4. Chen K, Metcalfe S E, Yu H, et al. (2021) Characteristics and source attribution of $PM_{2.5}$ during 2016 G20 Summit in Hangzhou: Efficacy of radical measures to reduce source emissions. Journal of Environmental Science, 08:47-65.
5. Ying W U, Yu X W, Lei W, et al. (2018) The Characteristics of Air Quality in Taizhou by Coordinated Emission Reduction Measures during the Great International Conferences. Environmental Science and Technology, 01:50-55.
6. Gu P, Qian J, Liu D, et al. (2020) Cold fronts transport features of North China pollutant over Jiangsu Province, China. Atmospheric Pollution Research, 11:32-41.
7. Bishoi B, Prakash A, Jain V K. (2009) A Comparative Study of Air Quality Index Based on Factor Analysis and US-EPA Methods for an Urban Environment. Aerosol & Air Quality Research, 9:1-17.
8. Mayer H, Holst J, Schindler D, et al. (2008) Evolution of the air pollution in SW Germany evaluated by the long-term air quality index LAQx. Atmospheric Environment, 42:5071-5078.
9. Kelessis A G. (2001) Eleven years of primary air-pollutant observations in the city of Thessaloniki, Greece. Fresenius Environmental Bulletin, 10:624-628.
10. Liu H, Chan J C L. (2002) An investigation of air pollutant patterns under sea land breezes during a severe air pollution episode in Hong Kong. Atmospheric Environment, 36: 591-601.