The Situation and Prediction of Air PM2.5 Pollution in Shanghai

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Abstract. In the field of environmental science, fine particulate matter (PM2.5) has attracted much attention due to its significant impact on public health. These particles with a diameter of less than or equal to 2.5 microns can carry various harmful substances, penetrate the defense line of the respiratory tract into the deep lungs, and even enter the circulatory system, thereby increasing the risk of cardiovascular and cerebrovascular diseases, respiratory diseases, and cancer. With the acceleration of industrialization and the increase of urban activities, the pollution problem of PM2.5 is becoming increasingly severe, bringing huge challenges to public health management and environmental protection. Therefore, in-depth research on the sources, components, distribution characteristics, and human health impacts of PM2.5 not only has important value in environmental science research, but also has urgent practical significance for formulating effective prevention and control strategies and improving people's quality of life. The article will mainly discuss about these things that mentioned above.

Keywords: PM2.5; data; regional.

1. Introduction

With the development of the times and the progress of technology, people's requirements for the quality of their living environment are gradually increasing, and they are paying more and more attention to pollution [1]. In terms of environmental pollution, air pollution is an unavoidable topic that cannot be avoided. This paper choses to study the city of Shanghai, which has a similar climate and distance to Suzhou. Therefore, it can be used as a reference model for data research and investigation in Suzhou. This article will mainly focus on the air pollution situation in various regions of Shanghai in recent years, including days, pollution components, concentration, duration, main seasons, and analyze why pollution is concentrated in these seasons. At the same time, an investigation will be conducted based on the situation throughout the day to analyze why pollution is concentrated in certain periods and attempt to find a feasible solution to such problems [2]. Lei studied the air quality in Shanghai from 2019 to 2020, it is found that the overall air quality in Shanghai was better than that in 2019 [3]. Although the main pollutants had shifted from PM2.5 to O3, overall PM2.5 pollution was more severe. The AQI in Shanghai showed the worst in winter and the best in autumn, while PM2.5 showed seasonal characteristics of low in summer and autumn and high in winter and spring [4]. Meanwhile, factors such as wind speed, direction, and temperature are also directly related to it. From 2019 to 2020, air quality has significantly improved, and the main air pollutant has also shifted from PM2.5 to ozone [5]. After understanding the general situation, this paper divided it into smaller points. The article focused on the Baoshan area in Shanghai, which is easy to collect data. After research, He Ping and the team concluded that the air pollution level in Baoshan area in Shanghai is relatively serious, and it shows obvious seasonal characteristics. It can be found that winter pollution is greater than summer pollution, summer pollution is greater than spring pollution, and spring pollution is greater than autumn pollution [6]. Zhou et al. found that daily pollution in the southwestern suburbs of Shanghai exhibits two peaks and one valley, namely at 8 am and 7 pm, as well as a valley in the early morning and late night. The main reasons for this are the speed of air flow and the level of traffic and human flow [7, 8]. In summary, this article will conduct research and analysis on PM2.5 in Shanghai, its causes, and possible future development trends.

2. Methods

1.1 Data Source

The data on the air conditions in Shanghai used in this article are all from papers published on CNKI and official data from the Shanghai Meteorological Bureau. The original data is saved in Excel format. The dataset provides crucial insights into the weather conditions and future predictions of Shanghai in recent years. It includes the climate conditions of different regions in Shanghai for over a decade, including temperature, pollution, wind direction and speed, humidity, and rainfall [9, 10]. It is discussed according to different seasons and situations, and can be considered a more authoritative method of discussion.

1.2 Indicator Selection

At present, there is no specific indicator for selecting environmental pollution indicators, which can be discussed from aspects such as per capita emissions, total emissions, and concentration per unit of emissions. This article will mainly focus on the air pollution and climate situation in several locations such as Baoshan, Pudong, and Chongming Island in Shanghai over the past decade, focusing on industrial waste gas emissions, industrial wastewater emissions, dust emissions, smoke emissions, sulfur dioxide emissions, etc. The final data will be the total air pollution situation in Shanghai. Integrate the above indicators and compare them with climate conditions. The indicators of climate conditions are selected from the climate observation stations in Shanghai over the past decade, and compared with the average annual temperature, average annual precipitation, and average annual wind speed to draw the final conclusion. The data on environmental pollution comes from the papers of other predecessors and the China Statistical Yearbook, while the data on climate conditions comes from the meteorological observation station in Shanghai (Table 1).

Table 1. Climate of Shanghai in recent years (Partly)

longitude	dimension	year	Average temp (℃)	maximum temp (℃)	minimum temp (℃)
121.467	31.4	2008	17.29	20.88	13.53
121.467	31.4	2009	17.46	20.98	13.74
121.467	31.4	2010	17.27	20.79	13.66
121.467	31.4	2011	16.99	20.5	13.24
121.467	31.4	2012	16.91	20.23	13.36
121.467	31.4	2013	17.61	21.19	13.59
121.467	31.4	2014	17.03	20.5	13.36
121.467	31.4	2015	17.03	20.13	13.25
121.467	31.4	2016	17.66	20.69	13.87
121.467	31.4	2017	17.79	20.97	13.73
121.467	31.4	2018	17.73	20.88	13.68
121.467	31.4	2019	17.41	20.87	13.18
121.467	31.4	2020	17.83	22.75	13.56
121.467	31.4	2021	18.16	23.37	13.71
121.467	31.4	2022	18.03	23.1	13.7
121.467	31.4	2023	18.76	24.16	14.25

1.3 Method Introduction

For the method, adopting a comparison and model construction approach. First, the article focuses on founding all the data which is needed in journals, papers, and various materials, screened and analyzed them to find reliable and usable data for this article. Then, the article is collected and integrated all the searched and filtered data, and put all the completed statistics into an Excel spreadsheet. After being placed in the spreadsheet, the data is divided it into several columns to clearly see the relationship between air pollution and climate. After completing the above steps, a data model

can be constructed. Based on the previous data, predictions can be made using Excel spreadsheets to make a more accurate and reliable prediction of future development. This can better contribute to future development and social progress, thereby improving the production level of society. After the successful construction of the data model, people will attempt to analyze and study it, and finally summarize a formula composed of the above data that can be used to represent the overall direction and trend if the current situation continues to develop. The main way to do the research is investigative research. This article uses monitoring data from multiple time periods in Shanghai from 2019 to 2020, including hourly, daily, monthly, and annual, to analyze the characteristics of air quality changes in Shanghai in recent years and months, and compares them with previous years to explore the meteorological causes of air quality changes in Shanghai, in order to provide a certain reference basis for air quality forecasting and air pollution prevention and control.

3. Results and Discussion

1.4 Annual PM2.5 Pollution

In table 2, it can be found that from 2003 to 2022, the concentration of PM2.5 has been continuously decreasing, from 114.06 μ g/m3 to 86.39 μ g/m3. Overall, although the concentration of PM2.5 has rebounded in the middle of a few years, the overall trend is still declining at a uniform rate. Therefore, a relatively vague prediction formula can be calculated Y=-1.5918x+128.9172, where y is the concentration of PM2.5 and x is the number of years after 2000. For example, in 2003, x was equal to 3. Based on this formula, more accurate predictions can be made for the pollution concentration of PM2.5 in the coming years.

Table 2. Annual average PM2.5 pollution rate in Shanghai

Name	longitude (lon)	dimension (lat)	PM2.5(μg/m3)	Year
SHANGHAI	121.5	31.5	114.06	2003
SHANGHAI	121.5	31.5	116.86	2004
SHANGHAI	121.5	31.5	122.2	2005
SHANGHAI	121.5	31.5	118.92	2006
SHANGHAI	121.5	31.5	119.24	2007
SHANGHAI	121.5	31.5	124.9	2008
SHANGHAI	121.5	31.5	123.27	2009
SHANGHAI	121.5	31.5	115.37	2010
SHANGHAI	121.5	31.5	111.31	2011
SHANGHAI	121.5	31.5	103.74	2012
SHANGHAI	121.5	31.5	109.04	2013
SHANGHAI	121.5	31.5	104.66	2014
SHANGHAI	121.5	31.5	113.21	2015
SHANGHAI	121.5	31.5	105.17	2016
SHANGHAI	121.5	31.5	105.66	2017
SHANGHAI	121.5	31.5	96.2	2018
SHANGHAI	121.5	31.5	96.37	2019
SHANGHAI	121.5	31.5	97.46	2020
SHANGHAI	121.5	31.5	96.37	2021
SHANGHAI	121.5	31.5	86.39	2022

In table 3 and 4, the monthly average PM2.5 concentration data in Shanghai are displayed, which are for 2022 and 2021, respectively. It is not difficult to find that the time of severe PM2.5 pollution is still winter and spring, and the concentration in summer and autumn is much lower, still showing strong seasonality. Therefore, it can be concluded that Shanghai should consider its own situation, that is, weather conditions, Take corresponding measures and solutions for the high concentration of PM2.5 in the spring and winter seasons.

Table 3. Monthly average PM2.5 pollution rate of Shanghai in 2022

Name	longitude (lon)	dimension (lat)	PM2.5(μg/m3)	Time
SHANGHAI	121.5	31.5	125.56	202201
SHANGHAI	121.5	31.5	96.55	202202
SHANGHAI	121.5	31.5	102.98	202203
SHANGHAI	121.5	31.5	91.84	202204
SHANGHAI	121.5	31.5	83.63	202205
SHANGHAI	121.5	31.5	63.5	202206
SHANGHAI	121.5	31.5	75.17	202207
SHANGHAI	121.5	31.5	65.84	202208
SHANGHAI	121.5	31.5	55.71	202209
SHANGHAI	121.5	31.5	56.74	202210
SHANGHAI	121.5	31.5	92.02	202211
SHANGHAI	121.5	31.5	127.1	202212

Table 4. Monthly average PM2.5 pollution rate of Shanghai in 2021

Name	longitude (lon)	dimension (lat)	PM2.5(μg/m3)	Time
SHANGHAI	121.5	31.5	129.17	202101
SHANGHAI	121.5	31.5	110.9	202102
SHANGHAI	121.5	31.5	106.98	202103
SHANGHAI	121.5	31.5	95.6	202104
SHANGHAI	121.5	31.5	91.89	202105
SHANGHAI	121.5	31.5	68.85	202106
SHANGHAI	121.5	31.5	54.14	202107
SHANGHAI	121.5	31.5	64.65	202108
SHANGHAI	121.5	31.5	71.19	202109
SHANGHAI	121.5	31.5	75.44	202110
SHANGHAI	121.5	31.5	131.47	202111
SHANGHAI	121.5	31.5	156.17	202112

The data displayed in table 5 is the daily PM2.5 concentration data in Shanghai in January 2022. After observation, it can be concluded that the degree of PM2.5 pollution is arranged irregularly in each day of the month, without any regularity. Therefore, it can be concluded that the value of daily average data does not play a significant role in long-term prediction.

Table 5. Daily average PM2.5 pollution rate in Shanghai

Name	longitude (lon)	dimension (lat)	PM2.5(μg/m3)	Date(UTC)
SHANGHAI	121.5	31.5	199.8	2022-01-01
SHANGHAI	121.5	31.5	235.41	2022-01-02
SHANGHAI	121.5	31.5	278.69	2022-01-03
SHANGHAI	121.5	31.5	78.85	2022-01-04
SHANGHAI	121.5	31.5	44.43	2022-01-05
SHANGHAI	121.5	31.5	60.59	2022-01-06
SHANGHAI	121.5	31.5	99.79	2022-01-07
SHANGHAI	121.5	31.5	133.07	2022-01-08
SHANGHAI	121.5	31.5	254.67	2022-01-09
SHANGHAI	121.5	31.5	142.45	2022-01-10
SHANGHAI	121.5	31.5	84.2	2022-01-11
SHANGHAI	121.5	31.5	164.88	2022-01-12
SHANGHAI	121.5	31.5	84.72	2022-01-13
SHANGHAI	121.5	31.5	139.19	2022-01-14
SHANGHAI	121.5	31.5	330.95	2022-01-15
SHANGHAI	121.5	31.5	141.21	2022-01-16
SHANGHAI	121.5	31.5	106.81	2022-01-17

The data in table 6 is the PM2.5 emission data recorded every three hours in the Shanghai region from 0:00 on January 1, 2022 to 0:00 on January 3, 2022, according to world time. Due to the holiday on January 1st, PM2.5 pollution was not high in the morning, but it began to increase in the afternoon. In the following days, the data remained high, but it was also evident that the PM2.5 concentration was relatively low from noon to evening, with several peaks occurring during the morning and evening peak periods. In the early morning, due to the lack of air circulation and the high traffic volume in Shanghai, the PM2.5 concentration was also high.

Table 6. Hourly average PM2.5 pollution rate in Shanghai

Name	PM2.5(μg/m3)	UTC	UTC+8
SHANGHAI	94.79	2022-01-01 00:00:00	2022-01-01 08:00:00
SHANGHAI	34.77	2022-01-01 03:00:00	2022-01-01 11:00:00
SHANGHAI	41.19	2022-01-01 06:00:00	2022-01-01 14:00:00
SHANGHAI	110.3	2022-01-01 09:00:00	2022-01-01 17:00:00
SHANGHAI	187.59	2022-01-01 12:00:00	2022-01-01 20:00:00
SHANGHAI	227.45	2022-01-01 15:00:00	2022-01-01 23:00:00
SHANGHAI	245.72	2022-01-01 18:00:00	2022-01-02 02:00:00
SHANGHAI	250.29	2022-01-01 21:00:00	2022-01-02 05:00:00
SHANGHAI	195.51	2022-01-02 00:00:00	2022-01-02 08:00:00
SHANGHAI	165.44	2022-01-02 03:00:00	2022-01-02 11:00:00
SHANGHAI	133.32	2022-01-02 06:00:00	2022-01-02 14:00:00
SHANGHAI	158.16	2022-01-02 09:00:00	2022-01-02 17:00:00
SHANGHAI	212.14	2022-01-02 12:00:00	2022-01-02 20:00:00
SHANGHAI	220.26	2022-01-02 15:00:00	2022-01-02 23:00:00
SHANGHAI	259.53	2022-01-02 18:00:00	2022-01-03 02:00:00
SHANGHAI	283.5	2022-01-02 21:00:00	2022-01-03 05:00:00
SHANGHAI	305.28	2022-01-03 00:00:00	2022-01-03 08:00:00

4. Conclusion

After the above analysis, this paper can find that although the overall pollution characteristics, namely temporal and seasonal changes, are not significant, the air quality has been steadily improving. The urban air quality management is good, and the future predictions are also optimistic, which can be said to be promising. The daily hourly data changes significantly compared to before, mainly due to the significant increase in nighttime traffic volume in Shanghai. Overall, the air quality in Shanghai is showing an overall upward trend.

The above tables summarize the observation and analysis of the changes in PM2.5 concentration in Shanghai in recent years, as well as the prediction of future trends: From 2003 to 2022, the concentration of PM2.5 continued to decline, although there was a slight rebound in the middle, the overall trend continued to decline at a uniform rate. According to a relatively fuzzy prediction formula, it is possible to predict the concentration of PM2.5 pollution in the coming years. The monthly average concentration data of PM2.5 in Shanghai in 2021 and 2022 show that the time of severe pollution has shifted to the winter and spring seasons, and the concentration in summer and autumn is relatively low, still showing seasonality. Therefore, the weather conditions in Shanghai should be considered and corresponding measures should be taken to address the high concentration of PM2.5 in winter and spring. The daily PM2.5 concentration data in Shanghai in January 2022 showed that the daily PM2.5 pollution levels were arranged irregularly and lacked obvious regularity. Therefore, daily data has lower value in long-term forecasting.

From January 1st to 3rd, 2022, the PM2.5 emission data recorded every three hours in the Shanghai area showed that although the PM2.5 concentration was lower in the morning due to the holiday on January 1st, it began to increase in the afternoon. In the next few days, although there will still be high concentration data, the concentration is relatively low from noon to evening, with several peaks appearing during peak hours in the morning and evening. In the early morning, due to insufficient air

circulation and high traffic volume in Shanghai, the concentration of PM2.5 was also very high. In summary, observing and analyzing changes in PM2.5 concentration can help develop targeted solutions to improve air quality.

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