

Analysis of the Influence of Meteorological Factors on Air Pollutants in Nanning from 2018 to 2020

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Abstract. Through the analysis of meteorological factors in Nanning from 2018 to 2020, including temperature, humidity, wind speed, sunshine, air pressure and other indicators, this study summarizes the change characteristics of meteorological factors. The descriptive statistics of the air quality in Nanning in the past three years show that PM₁₀ and O₃ are the main reasons affecting the air quality in Nanning. By means of correlation analysis and stepwise regression, the correlation degree between meteorological factors and PM₁₀ and O₃ was explored, and the relationship between independent variables and dependent variables was established. The conclusions are as follows: (1) There is a significant correlation between PM₁₀, O₃ concentrations and meteorological factors. (2) Average relative humidity, average wind speed and average air temperature can explain 42% PM₁₀, and average relative humidity, average wind speed, average air temperature and sunshine hours can explain 66.3% O₃.

Keywords: Meteorological factors, air quality, correlation, regression analysis.

1. Introduction

Air quality is an important factor affecting urban ecology and living environment, and the concentration of air pollutants can measure urban air quality. Generally speaking, there is a mutual influence between air quality and meteorological factors. Subject to different climate and geographical location, meteorological factors have a great influence on air quality. Studies have shown that meteorological factors have a significant impact on PM_{2.5} concentration, and each meteorological factor has a good correlation with PM_{2.5} concentration[1]. Air temperature mainly affects the concentration of gaseous pollution, humidity mainly affects the concentration of PM_{2.5}, and rainfall mainly affects the concentration of particulate pollutants[2]. There is a significant positive correlation between air pressure and PM_{2.5} and PM₁₀[3]. According to the different geographical location, climatic conditions and other factors, the impact on air quality is different[4-8]. This study analyzes the air quality in Nanning from 2018 to 2020, and finds out the meteorological factors that can explain the air pollution, providing the basis for regional air pollution control.

2. Data source and processing

2.1 Data sources

The meteorological data of this study comes from the daily data of China's surface climate data (<https://data.cma.cn/>), and the meteorological data indicators include air temperature, air pressure, average humidity, sunshine hours and wind speed. The air quality data comes from the Ecological Environment Department of Guangxi Zhuang Autonomous Region (<http://sthjt.gxzf.gov.cn/>). Air quality monitoring indicators include PM_{2.5}, PM₁₀, SO₂, NO₂, CO and O₃. AQI is a dimensionless index to quantitatively describe the air quality status. Air quality sub-index is the air quality index of single pollutant, and the primary pollutant refers to the air pollutant with the largest IAQI when AQI > 50.

2.2 Data processing

According to the Technical Regulations of Ambient Air Quality Index (AQI) (Trial) (HJ633-2012) [9] (Table 1), the air quality grade and its primary pollutants are counted, and the relationship between

meteorological factors and air pollutant concentration is explored by correlation analysis and stepwise regression method.

Table 1 Air Quality Sub-index and Concentration Grade Division of Corresponding Pollutant Items

Air quality index level	Air quality (AQI)	Air quality sub-index (IAQI)	24-h average of sulfur dioxide (SO ₂) (μg/m ₃)	24-h average of nitrogen dioxide (NO ₂) (μg/m ₃)	24-h average/of particulate matter PM10 (particle size less than or equal to 10) (μg/m ₃)	24-h average of carbon monoxide (CO) (mg/m ₃)	8-h moving average of ozone (O ₃) (μg/m ₃)	24-h average of particulate matter PM2.5 (particle size less than or equal to 2.5) (μg/m ₃)
Level 1	0~50	0~50	0~50	0~40	0~50	0~2	0~100	0~35
Level 2	51~100	51~100	50~150	40~80	51~150	3~4	101~160	36~75
Level 3	101~150	101~150	151~475	81~180	151~250	5~14	161~215	76~115
Level 4	151~200	151~200	476~800	181~280	251~350	15~24	216~265	116~150
Level 5	201~300	201~300	801~1600	281~565	351~420	25~36	266~800	151~250
Level 6	>300	>300	1601~2620	566~940	421~600	37~60	>800	251~500

3. Temporal variation characteristics of meteorological factors in Nanning

The meteorological factors in Nanning from 2018 to 2020 are statistically analyzed day by day, and the following figure is obtained.

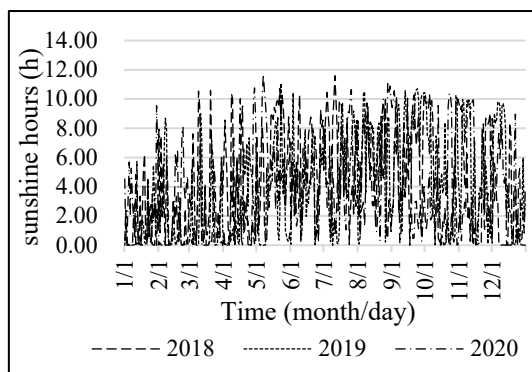


Fig.1 Daily statistics according to hours

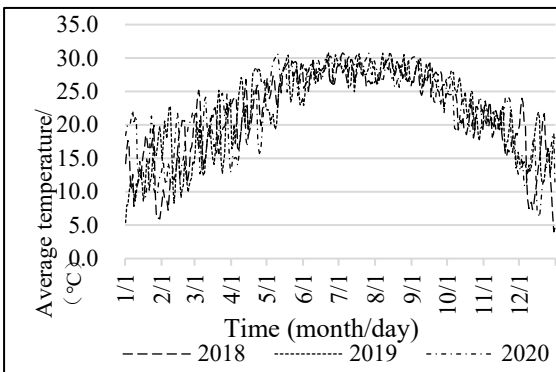


Fig. 2 Daily statistics of average temperature

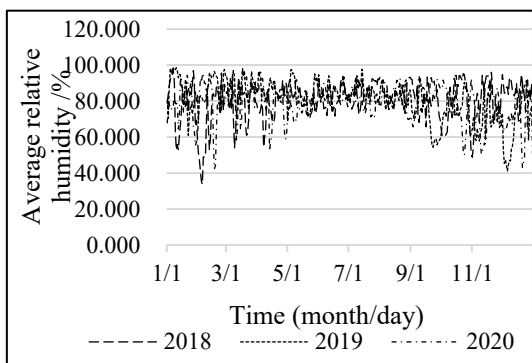


Fig. 3 Daily statistics of average relative humidity

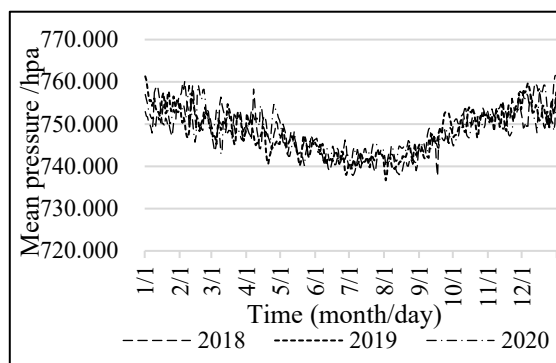


Fig. 4 Daily statistics of average air pressure

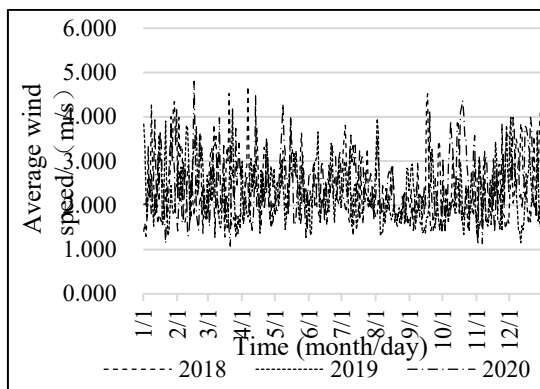


Fig. 5 Daily statistical chart of average wind speed

As can be seen from the above chart, the change trend of meteorological factors is basically the same every year. Among them, the average relative humidity changes little from June to September, but greatly from January to May and September to December, and the annual average relative humidity is close to 80%. This is because Nanning is located in the south of Tropic of Cancer, belonging to humid and hot subtropical monsoon climate with abundant rain. The mean air pressure changes seasonally, and the air pressure gradually decreases from January to July, and increases after August. The accumulated sunshine time is shorter in winter and longer in summer. The average temperature is generally high, reaching the highest point from July to August every year, and the annual temperature is basically maintained between 10 °C and 32 °C.

4. Analysis of Air Quality in Nanning from 2018 to 2020

4.1 Air Quality Status in Nanning

According to the data of Nanning Ecological Environment Monitoring Center, the number of days with good air quality in Nanning from 2018 to 2020 is relatively large, and the air quality is good. Table 2 below shows the statistical results of air quality in three years.

Table 2 Statistics of Air Quality in Nanning from 2018 to 2020

Year	Excellent		Good		Mild pollution		Moderate pollution		Heavy pollution		Serious pollution	
	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion
2018	169	46.30%	171	46.85%	23	6.30%	1	0.27%	0.00%	0	0	0.00%
2019	160	43.84%	173	47.40%	30	8.22%	2	0.55%	0.00%	0	0	0.00%
2020	222	60.82%	135	36.99%	8	2.19%	1	0.27%	0.00%	0	0	0.00%

It can be seen from the table that the air quality in Nanning is better. From 2018 to 2020, the number of days with good air quality accounted for 93.15%, 91.24% and 97.8% respectively. The number of days of moderate pollution shall not exceed 2 days per year, and the number of days of severe pollution and severe pollution shall be 0.

4.2 AQI Index and Monthly Variation Characteristics of Primary Pollutants

By comparing the change trend of AQI index in 2018-2020, we can get the change law of air quality. As shown in Figure 6 ~ 8.

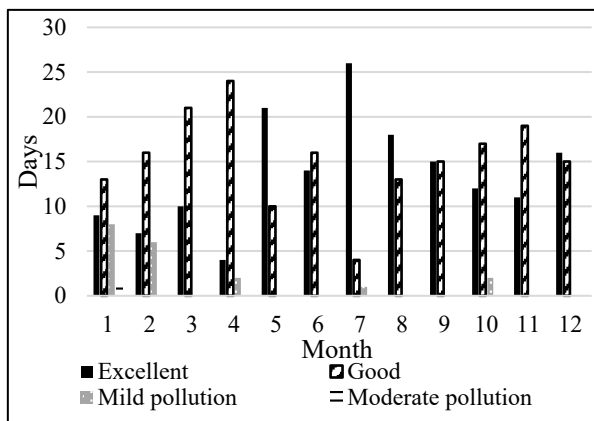


Fig.6 Monthly variation of air quality in 2018

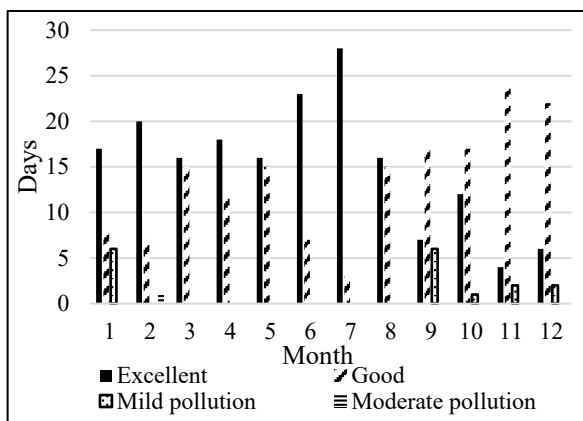


Fig.7 Monthly change of air quality in 2019

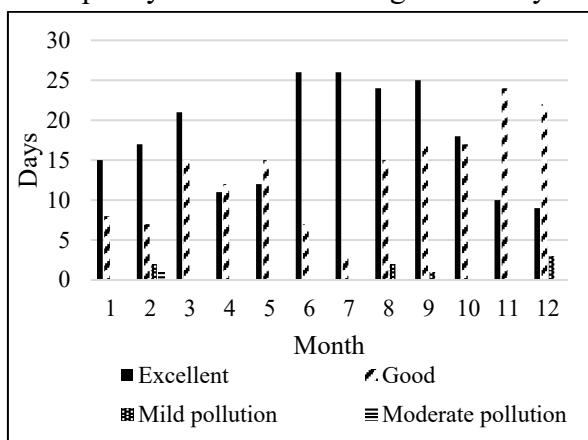


Fig. 8 Monthly variation of air quality in 2020

The monthly change trend of air quality from 2018 to 2020 is basically the same. In summer, the number of days with excellent air quality level is the most, and the number of days with good air quality level is more from January to March 2018, but the air quality will get better from January to March in 2019 and 2020. The air quality decreases from November to December every year. The time of mild pollution and moderate pollution is relatively concentrated from January to March every year. From the monthly variation of AQI index, it can be seen that the air quality in summer is better than that in winter. Nanning is located in the subtropical monsoon climate zone, and there is a certain relationship between the change of air quality and meteorological factors.

In order to explore the changing trend of air pollutants, the daily distribution of air pollutants PM_{2.5}, PM₁₀, SO₂, NO₂, CO and O₃ in 2019 is counted, and the results are shown in Figure 9~14 below.

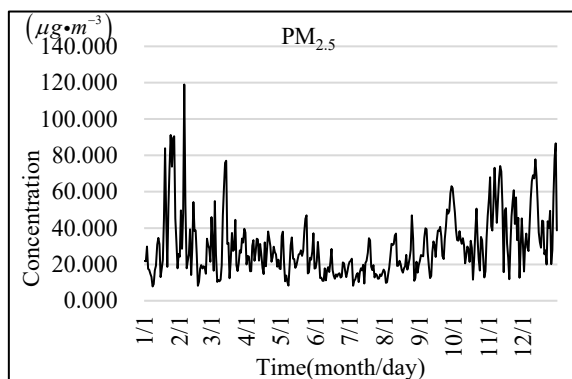


Fig.9 Daily change of PM_{2.5} in 2019

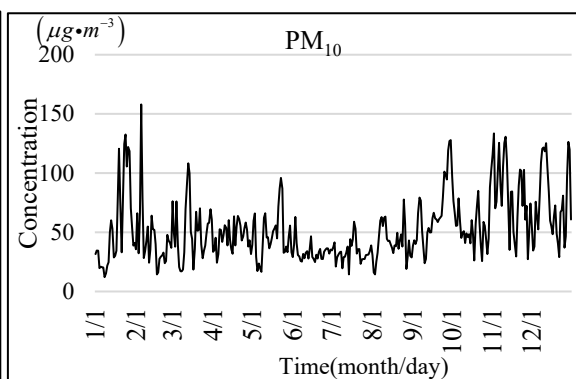


Fig.10 Daily change of PM₁₀ in 2019

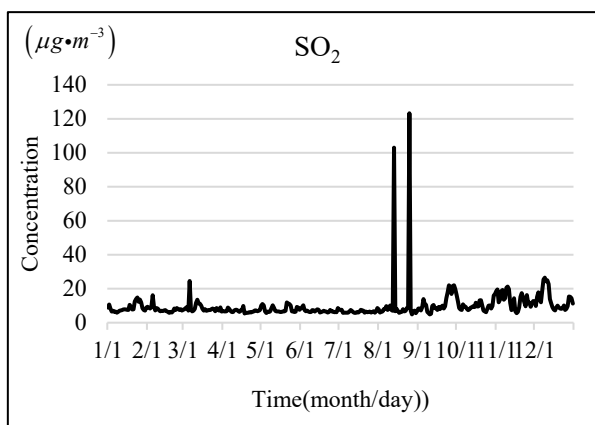


Fig. 11 Daily change of SO₂ in 2019

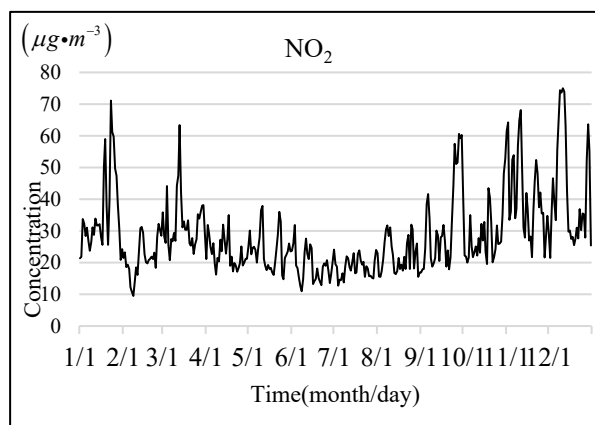


Fig. 12 Daily change of NO₂ in 2019

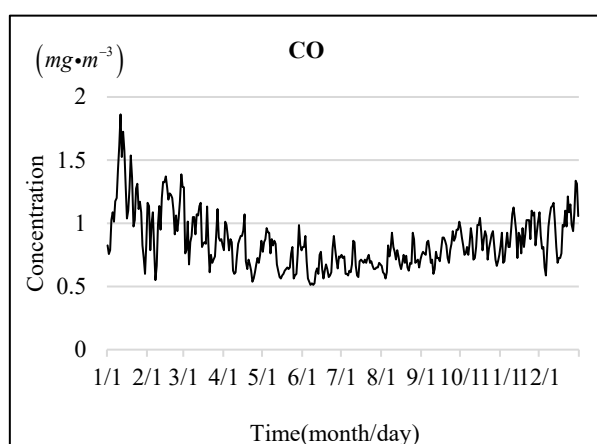


Fig. 13 Daily change of CO in 2019

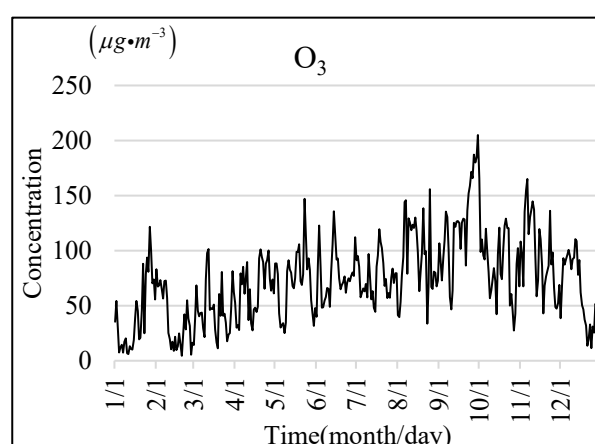


Fig.14 Daily change of O₃ in 2019

According to the change characteristics of air pollutant concentration in 2019, the concentration of PM_{2.5} remained basically within good, with the lowest from April to August, and the concentration in January and February was higher than the annual average level, reaching mild pollution. The concentration of O₃ has an upward trend from September to November, and the concentration in October is the highest, which is a mild pollution level. The concentration of PM₁₀ was lower in summer, that is, from May to August, but the annual average concentration was not high. However, the concentrations of SO₂ and CO are kept within the first-class standard for most of the year, so these two pollutants have little influence on the air quality index.

According to the statistics of the primary pollutant items and the number of days in 2019, the number of days when PM_{2.5} is the primary pollutant is 35 days, NO₂ is 1 day, and the number of days when PM₁₀ and O₃ are the primary pollutants reaches 75 days and 47 days. It shows that PM₁₀ and O₃ are the main factors of air pollution in 2019, and also the important reasons affecting air quality. Descriptive statistics are made on the concentrations of PM₁₀ and O₃ from 2018 to 2020, as shown in the table. It can be seen that the concentration grade of O₃ has not changed much in the past three years, and the proportion of Level 1 and Level 2 is high, and it has a good development trend year by year, but it still reaches the standard of mild pollution. The concentration of PM₁₀ also decreased year by year. Combined with the statistical results of air quality index AQI in Table 1, PM₁₀ and O₃ are determined as the main pollutants affecting air quality.

Table 3 Statistical table of O₃ concentration in Nanning from 2018 to 2020

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
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Year	Level 1		Level 2		Level 3		Level 4		Level 5		Level 6	
	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion
2018	281	77%	80	22%	4	1%	0	0%	0	0%	0	0%
2019	293	80%	64	18%	8	2%	0	0%	0	0%	0	0%
2020	296	81%	67	18%	2	1%	0	0%	0	0%	0	0%

Table 4 Statistical table of PM10 concentration in Nanning from 2018 to 2020

Year	Level 1		Level 2		Level 3		Level 4		Level 5		Level 6	
	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion	Days	Proportion
2018	192	53%	171	47%	2	1%	0	0%	0	0%	0	0%
2019	210	58%	155	42%	1	0%	0	0%	0	0%	0	0%
2020	245	67%	119	33%	1	0%	0	0%	0	0%	0	0%

5. Analysis of the influence of meteorological factors on air pollutants

5.1 Correlation analysis between main pollutants and meteorological factors

The correlation analysis between the main air pollutants PM₁₀ and O₃ and meteorological factors is carried out. As shown in Table 5, there is a significant correlation between PM₁₀ concentration and meteorological factors, in which the average air pressure and sunshine time have a significant positive correlation with PM₁₀ concentration at 0.01 level, and the average air temperature, average relative humidity and average wind speed have a significant negative correlation with PM₁₀ concentration. In addition, there is a strong positive correlation between O₃ and sunshine hours, with a correlation coefficient of 0.695, and a negative correlation between O₃ and average relative humidity, average wind speed and average air pressure, among which there is a strong negative correlation between O₃ and average relative humidity. It shows that in order to prevent and control air pollution and improve air quality, the concentration of air pollutants can be reduced by adopting appropriate measures such as increasing air humidity.

Table 5 Correlation analysis results between PM10, O3 and meteorological factors

	Average temperature	Mean pressure	Average relative humidity	Sunshine hours	Average wind speed
PM10	-0.171**	0.314**	-0.46**	0.215**	-0.361**
O3	0.403**	-0.169**	-0.607**	0.695**	-0.243**

5.2 Stepwise regression analysis of main pollutants and meteorological factors

Correlation analysis can only know the covariant relationship between variables, but regression analysis is needed to determine the relationship between dependent variables and multiple independent variables and their mathematical expressions, so as to better predict and control. The stepwise regression method of two main pollutants is used to find the independent variables with high influence on the dependent variables, and the irrelevant and low-correlation variables are eliminated by stepwise input to find the optimal regression equation. Stepwise regression analysis was carried

out by SPSS.20, and the following table 6 was obtained. The variables that can be explained by PM₁₀ and O₃ can be obtained by analysis.

Table 6 Stepwise regression results of PM₁₀, O₃ and meteorological factors

Dependent variable	Adjusted R2	Independent variable				Constant
		Average relative humidity	Average wind speed	Average temperature	Sunshine hours	
PM ₁₀	0.422	-1.239	-18.642	-0.875	—	213.739
O ₃	0.663	-1.810	-11.177	1.871	1.84	197.795

Among them, average relative humidity, average wind speed and average air temperature are meteorological factors that can explain PM₁₀ well. Average relative humidity, average wind speed, average air temperature and sunshine hours can explain O₃ well. The influence of these meteorological factors on dependent variables is consistent with the results of correlation analysis, which proves the scientific conclusion.

6. Conclusion

1. The air quality in Nanning is improving year by year, and the number of days when the air quality standard reaches the excellent level is gradually increasing. PM₁₀ and O₃ are the main pollutants in the atmosphere, and their concentrations decrease year by year.

2. There is a strong negative correlation between average relative humidity and PM₁₀ and O₃ concentrations, which shows that increasing air humidity by appropriate methods can effectively promote the improvement of air quality. Average air temperature, average relative humidity and average wind speed have negative correlation with PM₁₀ concentration. There is a significant positive correlation between average temperature, sunshine hours and O₃ concentration.

3. Average relative humidity, average wind speed and average air temperature can explain 42% of PM₁₀, and average relative humidity, average wind speed, average air temperature and sunshine hours can explain 66.3% of O₃.

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