Spatiotemporal Analysis of Air Pollutant Concentrations in Major Transportation Hubs of Kunming: A Case Study of Dongfeng East Road Station

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Abstract. The rapid development of industrialization and the continuous acceleration of the urbanization process have continuously improved the quality of life of the people, but at the same time brought important environmental problems such as air pollution and climate change that humans have to face today. In this paper, the meteorological data of Dongfeng East Road Station in Kunming is taken as the research object, and the Spark platform is used to quickly and effectively analyze the air pollution data of Dongfeng East Road Station. Through analysis and research on the air pollution-related conditions of major transportation hubs in Kunming in recent years, the results show that the concentration of air pollutants at Dongfeng East Road Station in Kunming has a relatively obvious downward trend, especially the significant decline in SO\(_2\) and CO. As far as air quality is concerned, the air quality in some areas of Kunming continues to improve.

1. Introduction
With the rapid development of economic society and the rapid advance of urbanization, urban air pollution has gradually become the core issue of the construction of ecological civilization today\(^{[1-2]}\). Since the reform and opening up, China's economy has continued to develop rapidly and its population has grown rapidly. The transportation and industrial consumption of coal as its main source of energy have been increasing, SO\(_2\) emissions have been increasing year by year, and the problem of atmospheric pollution in China has become increasingly prominent \(^{[3-5]}\). The industrialization process has accelerated the discharge of various pollutants such as NO\(_2\), CO, and O\(_3\), and the adverse effects on the urban ecological environment have become increasingly serious. In recent years, urban air pollution has become a prominent problem of air environmental quality pollution in eastern coastal cities of China and other major urban agglomerations \(^{[6-7]}\). Air pollution seriously harms human health and adversely affects residents' daily travel. \(^{[8-9]}\). At present, air pollution control focused on the reduction of sulfur dioxide and nitrogen oxides across the country has been fully launched.
2. Research Area and Data Sources

2.1. Research Area
Kunming, the capital of Yunnan Province, is located in the middle of the Yunnan-Guizhou Plateau, with an average annual temperature of 16.5°C, an annual average rainfall of 1,450 mm, a frost-free period of 278 days, and a pleasant climate. Because it is located on a low-latitude plateau, it has a climate of "four seasons as spring," especially the plateau lake Dianchi is adjusting the temperature and humidity, which makes the air here fresh, the sky high, the clouds clear, the sun shining, and the flowers always open.

2.2. Data Sources
All data are from SO2, NO2, O3, PM10, PM2.5 data monitored daily by more than 10 conventional weather stations in Yunnan Province from 2013 to 2018. This long-term meteorological observations have provided great help for our research.

3. Analysis and Discussion

3.1. Analysis of Characteristics of Pollutant Changes
The primary pollutant in Kunming is PM10, followed by PM2.5. However, Dongfeng East Road, as a traffic pollution control monitoring point, is greatly affected by motor vehicle exhaust emissions, and its primary pollutants are CO and SO2. Therefore, this article mainly analyzes the daily maximum values of CO and SO2.

From the conclusion analysis in Figure 1, it can be clearly observed that the CO concentration in Dongfeng East Road Station has changed in recent years. The highest value was 10.73 mg / m³ around October 2013, and it showed a downward trend year by year in the following years. It did not show a higher value of 6.6 mg / m³ until 2017, compared with the highest concentration of CO in recent years in 2013 year by year.

![Figure 1](image.png)

**Figure 1.** Statistics of daily maximum CO of Dongfeng East Road Station.

From the analysis in Figure 2, the trend of SO2 concentration decline in Dongfeng East Road Station in recent years is very obvious, and it is not difficult to see that the 632μg/m³ peak occurred in August 2013, the highest SO2 concentration time in recent years. Compared to the previous years, the SO2 concentration has been significantly reduced in 2018, and the SO2 concentration in 2018 is relatively stable and less volatile.
From the continuous data in Figure 3 and Figure 4, it can be seen that the concentration of CO and SO2 shows an upward trend from September to January of the following year, and it has dropped significantly since February. This is because February is the traditional Chinese New Year. During this period, various production, processing, and trading activities plummeted, the urban migrant population decreased significantly, the source of motor vehicle emissions weakened, and Kunming did not concentrate on coal for heating in winter. Therefore, CO and SO2 emissions have been reduced since February. Comparing changes in CO and SO2 concentrations between working days and non-working days shows that vehicle emissions are the main source of atmospheric pollutants in Kunming’s main urban area. In general, the inter-annual variation of the Dongfeng East Road Station has shown that the daily maximum concentrations of CO and SO2 have been slowly decreasing from 2013 to 2018. This is due to the gradual opening of various lines since the first phase of the Kunming Metro opened in June 2012. It has significantly improved the carbon emissions of Dongfeng East Road and Kunming.
Figure 4. Daily average of SO2 of Dongfeng East Road Station.

Figure 5. Daily average statistics of CO and SO2 of Dongfeng East Road Station.
3.2. Correlation Analysis of Pollutants

The concentration of pollutants in the atmosphere is related to the emission source, and will be affected by other pollutants and meteorological conditions. Therefore, it is necessary to study the correlation between various atmospheric pollutants. This paper uses Pearson correlation coefficient to measure the correlation between various pollutants in 2013, 2014, and 2015. In theory, PM10 is particles with an aerodynamic diameter less than 10μm, and PM2.5 is particles with a diameter less than 2μm. The concentration of PM10 should include PM2.5. The measured results show that the Pearson correlation coefficient of PM10 and PM2.5 is 0.8573 (P < 0.01), the correlation between the two is excellent.

|         | SO2    | NO2    | CO     | O3     | PM10   |
|---------|--------|--------|--------|--------|--------|
| 2013    | 0.2795 | 0.3929 | 0.1560 | 0.2407 | 0.8345 |
| 2014    | 0.3078 | 0.3974 | 0.3376 | 0.2827 | 0.8573 |
| 2015    | 0.3765 | 0.5511 | 0.3772 | 0.1334 | 0.8460 |

As shown in Table 1, PM2.5 and SO2 have a good positive correlation, \( r = 0.367 \) and \( P < 0.01 \). As a secondary pollutant, PM2.5 is the main source of traffic pollution. PM2.5 has a significant positive correlation with NO2, CO, and O3, and the correlation coefficients are 0.551, 0.377, and 0.282 respectively, under the condition of \( P < 0.01 \).

4. Conclusion

Based on the monitoring data from Dongfeng East Road Ground Meteorological Station in Kunming, this paper uses Spark technology to process the data, and analyzes the changes and correlations of atmospheric pollution by Pearson correlation coefficient method, and analyzes the main pollutant concentrations in Dongfeng East Road Station feature from 2013 to 2018. Through analysis, we can see the relative situation of air pollution in Kunming in recent years. And it is obvious that the concentration of most pollutants in Kunming has a downward trend, especially the decline in SO2 and CO is significant. As far as air quality is concerned, the air quality in some areas of Kunming is constantly improvement.
5. Acknowledgment
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