Discussion on Related Factors of Air Pollution Based on Automatic Monitoring Data of Air Quality

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Abstract: Air pollution seriously affects people's production and life. In order to explore the main factors affecting the air quality of Zhangye and evaluate the air quality, based on the national air quality automatic monitoring data, first, PM2.5, carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), and sulfur dioxide (SO2) are selected as the component factors of air pollution. Second, based on the fuzzy comprehensive evaluation method, the evaluation standard set and air quality pollution level are established. Finally, the time characteristics of each factor from 2016 to 2019 are analyzed. The results show that: the overall air quality of Zhangye is more serious in spring and winter, while it is more moderate in summer and autumn. PM2.5 and O3 are the two key factors affecting its air quality; the air quality trend of Zhangye in recent years is good, and the overall air pollution level is below V2. The improvement of air quality depends on the effective control of all aspects, including human activities.

1. Introduction

In recent years, the process of urbanization and industrialization has been continuously accelerated. While people's production and living standards have been improved and perfected, environmental pollution problems caused by human factors are also emerging one after another. Air pollution has become the focus of attention from all walks of life, and this type of pollution has potential threats to the ecological environment and people's healthy lives [1]. Given a series of problems caused by air pollution, many efforts have been made so far. However, it is a long-term work with certain complexity to build an appropriate control system and environmental monitoring countermeasures to improve air quality. At present, there are relatively few studies on the same type in northwest inland areas.

Based on this, considering Zhangye's important role in Gansu's commerce and tourism, in order to analyze the time characteristics of air pollution in this city, this paper takes the common air pollution components as the study object, and based on the automatic monitoring data of air quality, discusses the law of time distribution characteristics set of air pollution in Zhangye from 2016 to 2019. Besides, it
evaluates and analyzes air quality based on a fuzzy comprehensive evaluation method to provide some data support for analyzing air quality time characteristics.

2. Methods

2.1 Study Region and Data Source
Zhangye is located in Gansu, an inland province in northwest China. Affected by the climate in this region, there are many sand and dust weather. Zhangye's tourism industry is currently in a prosperous development period. Meanwhile, the city is also a vital commerce circulation transfer station in Gansu Province. Therefore, the improvement and optimization of air quality are of great significance to the city. In this paper, Zhangye is taken as the study city, and the air pollution situation and its influencing factors are analyzed through the automatic surveillance data obtained for air quality.

This paper mainly analyzes the time characteristics of common air pollutants in Zhangye from 2016 to 2019. On this basis, the distribution and change characteristics of air quality in different time dimensions are discussed, thus revealing the main components leading to air pollution. All the data of common air pollutants come from the city's air quality release platform in real-time and are obtained by the national air quality monitoring point automatic surveillance. This paper mainly selects five common air pollutants to discuss, namely PM 2.5, carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), and sulfur dioxide (SO2).

2.2 Air Quality Evaluation Method
To evaluate the air quality based on common air pollutants in the study region, the method adopted in this paper is a fuzzy comprehensive evaluation method [5]. Fundamentally speaking, this method mainly relies on the normalization processing method to obtain evaluation results, of which the construction of the evaluation set and fuzzy relation matrix is the core. Based on the evaluation of conventional air pollutants, the evaluation factor set \( E \) constructed in this paper is as follows:

\[
E = \{e_i\}, i = 1, 2, L, 5
\]

In the above formula, \( e_i \) represents an evaluation factor, which corresponds explicitly to common air pollutants.

Furthermore, the obtained evaluation standard set \( U \) is constructed and expressed as:

\[
U = \{u_1, u_2, L, u_n\}
\]

In the above formula, \( n \) represents the evaluation grade.

In the construction of the relation matrix, the calculation of membership degree \( M \) is the key. In this paper, it is represented explicitly as:

\[
M = m_{ij} = \begin{bmatrix}
m_{i1} & m_{i2} & L & m_{ij} \\
m_{21} & m_{22} & L & m_{2j} \\
L & L & L & L \\
m_{i1} & m_{i2} & L & m_{ij}
\end{bmatrix}
\]

In the above formula, \( i \) represents each evaluation factor, and \( j \) represents the air pollution degree.

On this basis, the weights \( w_i \) of different evaluation factors are represented as:

\[
w_i = \frac{e_i / \left( \frac{1}{n} \sum_{j=1}^{n} u_{ij} \right)}{\sum_{i=1}^{5} \left[ e_i / \left( \frac{1}{n} \sum_{j=1}^{n} u_{ij} \right) \right]}
\]
In the above formula, $A$ represents a weighted vector.

Based on the above, the comprehensive evaluation matrix $C$ finally constructed is represented as:

$$C = A(\oplus)M = \left( w_1, w_2, w_3, w_4, w_5 \right) \begin{bmatrix} m_{11} & m_{12} & L & m_{1j} \\ m_{21} & m_{22} & L & m_{2j} \\ L & L & L & L \\ m_{i1} & m_{i2} & L & m_{ij} \end{bmatrix} = \left[ c_1, c_2, L, c_j \right]$$

The maximum value corresponding to the above formula is the comprehensive evaluation result of air quality in the study region. The corresponding evaluation level can be obtained so that the air quality in the study region can be grasped as a whole based on the data of conventional air pollutants. Using this method, the composition of the evaluation standard set established in this paper and the upper limit values of concentration corresponding to different air pollutants are shown in Table 1 below.

### Table 1 Distribution of Air Quality Pollution Degree

| Level    | V1 | V2       | V3       | V4       | V5       |
|----------|----|----------|----------|----------|----------|
| Pollution degrees | Excellent | Good   | Mild     | Moderate | Severe   |
| PM 2.5 (µg/m³) | <35 | 35-75   | 76-115   | 116-150  | 151-250  |
| SO₂ (µg/m³) | <50 | 50-150   | 151-475  | 476-800  | 801-1600 |
| NO₂ (µg/m³) | <40 | 40-80    | 81-180   | 181-280  | 281-565  |
| O₃ (µg/m³) | <100 | 100-160  | 161-215  | 216-265  | 266-800  |
| CO (mg/m³) | <2  | 2-4      | 5-14     | 15-24    | 25-36    |

### 3. Results and Analysis

#### 3.1 Distribution of Air Pollutants Based on Time Variation

From 2016 to 2019, the changes in the average annual concentration distribution of common air pollutants in Zhangye are shown in Figure 1 below.
From the analysis of the average annual concentration distribution changes corresponding to various common air pollutants in the figure, it can be found that the average annual concentration corresponding to atmospheric particles in Zhangye had obvious distribution and changes from 2016 to 2019. The concentration of PM$_{2.5}$, CO, NO$_2$, O$_3$, and SO$_2$ ranged from 40.6 to 28.9 µg/m$^3$, 1.6 to 1.2 mg/m$^3$, 26.8 to 17.7 µg/m$^3$, 110.4 to 98.7 µg/m$^3$, and 40.9 to 20.7 µg/m$^3$, respectively. Overall, the average annual concentration distribution of different air pollutants has different variation laws in different years.

From 2016 to 2019, the seasonal variation characteristics corresponding to the concentration of common air pollutants in Zhangye are shown in Figure 2 below.

![Figure 2 Seasonal Variation Characteristics of Common Air Pollutant Concentrations](image)

It can be seen from the data distribution and change in the figure, from 2016 to 2019, except for the seasons in some years, the concentration of PM$_{2.5}$, the atmospheric particulate matter, shows a change rule of higher in spring and winter and lower in summer and autumn. It also can be found that the monthly average concentration of PM$_{2.5}$ shows a "U" distribution as a whole. Taking spring as an example, the concentration change of PM$_{2.5}$ shows a significant decrease from 2016 to 2019, which reveals that the pollution situation caused by PM$_{2.5}$ has improved in recent years. In contrast, the concentration change of PM$_{2.5}$ in other seasons is not large, which also shows that spring is the critical season to evaluate the pollution situation of PM$_{2.5}$ in Zhangye.

For common air pollutants, including CO, NO$_2$, and SO$_2$, the overall distribution changes also show a "U" type. Zhangye is one of the cities suffering from the most serious SO$_2$ pollution. From its seasonal distribution changes, it can be found that the SO$_2$ concentration was relatively high in spring and winter every year from 2016 to 2019, especially in winter, which shows that winter is the primary season to evaluate SO$_2$ pollution. Taking winter as an example, the overall SO$_2$ concentration in Zhangye has decreased significantly, indicating that the pollution caused by SO$_2$ has improved in recent years. Different from SO$_2$, the seasonal variation of NO$_2$ concentration shows a change rule of lower in spring and summer and higher in autumn and winter. However, the concentration of NO$_2$ has decreased in recent years, indicating that the pollution situation caused by NO$_2$ has improved. The change in CO concentration is also the highest in winter and has decreased from 2016 to 2019.

In contrast, the concentration change of O$_3$ is obviously different from other air pollutants. Overall, its concentration shows the most considerable change in summer and the lowest change in winter. The reason is that in the season, when the temperature is relatively high, and the atmospheric ultraviolet rays
are relatively strong, more O₃ is generated due to strong light reaction. In contrast, the light duration in winter is shorter, and the formation conditions of O₃ are relatively weak.

3.2 Air Quality Analysis and Evaluation
Based on the seasonal distribution laws and changes of common air pollutants in the cities studied above, the fuzzy comprehensive evaluation method is applied to get the seasonal weight values and air quality evaluation results corresponding to each air pollution component factor, as shown in Figure 3 below and Table 2 below.

![Figure 3 Seasonal Weight Distribution of Each Air Pollution Component Factor](image)

| Season | Year | Comprehensive Evaluation Score | Pollution Degree |
|--------|------|--------------------------------|------------------|
| Spring | 2016 | 0.5369                         | V2               |
|        | 2017 | 0.7467                         | V1               |
|        | 2018 | 0.7218                         | V1               |
|        | 2019 | 0.7364                         | V1               |
| Summer | 2016 | 0.4608                         | V2               |
|        | 2017 | 0.7017                         | V1               |
|        | 2018 | 0.8525                         | V1               |
|        | 2019 | 0.8609                         | V1               |
| Autumn | 2016 | 0.7458                         | V1               |
|        | 2017 | 0.7528                         | V1               |
|        | 2018 | 0.7697                         | V1               |
|        | 2019 | 0.8212                         | V1               |
| Winter | 2016 | 0.6833                         | V1               |
|        | 2017 | 0.6397                         | V1               |
|        | 2018 | 0.9236                         | V1               |
|        | 2019 | 0.6739                         | V1               |

After analyzing the data distribution and changes in the figure, it can be found that the overall air quality in Zhangye was relatively good from 2016 to 2019, and the corresponding pollution degree was
above mild pollution (excluding mild pollution). In terms of seasonal distribution, the air quality in spring is the worst, followed by that in winter.

It can be found that PM 2.5, CO, NO2, O3, and SO2 are the main pollution components that affect the air quality of the cities studied, combining the time variation characteristics of different pollution components with the comprehensive evaluation results of air quality. During 2016-2019, the air quality in Zhangye was generally low in spring and winter, but better in summer and autumn. From the concentration changes corresponding to various pollution factors, it can be found that the improvement of urban air quality in recent years is evident. In winter, PM 2.5 and SO2 are two main factors to measure air quality. Compared with atmospheric particles, the pollution degree caused by gaseous pollutants is relatively small. Through the evaluation of air quality, it is found that atmospheric particulate matter and O3 are the two most essential factors in the study of urban air quality.

4. Conclusions
This paper takes Zhangye as the study city. By analyzing the time characteristics of common air pollution components in the city from 2016 to 2019, the influence of different pollution factors on the city's air quality is revealed. Overall, the air quality in summer and autumn is relatively good, while the pollution in spring and winter is relatively serious. Meanwhile, it can be found that the improvement of air quality in recent years is relatively apparent. The evaluation results based on the fuzzy comprehensive evaluation method show that the study city's overall air quality is better, which is below light pollution.

About the Author
Li Xia (April 1986), female, a native of Sunan, Gansu Province, bachelor degree, engineer, is engaged in ecological environment monitoring, and in the experimental analysis of automatic air station, water quality automatic station, organic gas chromatograph, and early warning and forecasting of ambient air.

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