Analysis of Factors Affecting Air Quality in ChongQing City Based on Grey Relational Theory

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Abstract: With the development of China’s economy, people's demands on air quality are getting higher and higher. Air quality is an important part of environmental quality. Improving air quality is of great significance for improving the overall environmental quality. In this paper, the influence factors of air quality in Chongqing city are analyzed, and the countermeasures to improve air quality in Chongqing city are put forward.

1. INTRODUCTION
In the process of sustainable economic development, people's demands on air quality are getting higher and higher. Air pollution has become an important factor affecting environmental quality. It is of great significance to study the influencing factors of air pollution to improve air environmental quality.

Many scholars have conducted research on the influencing factors of air quality and made a series of remarkable achievements. Ding lei and other scholars studied the characteristics of Wuhan air environmental response in the process of urbanization. In their opinion, it is necessary to adjust industrial structure, save energy and reduce emissions, and actively prevent construction, roads, bare ground and other dust pollution in the process of urbanization expansion[1]. In another paper, DING Lei and FANG Xue-juan studied factors affecting air quality in Hubei province. The results indicated that built-up area and car ownership made a significant contribution to the air environment[2]. Lilina and PAN Ben Feng analyzed the main factors that affected China’s air quality based on the environmental Kuznets curves. Results indicated that the emission from the energy consumption is the main factor that affect the air quality in China[3]. Bingye, YU Jie drew the conclusion that environmental protection policies such as the upgrading of industrial structure, the improvement of energy efficiency, the total amount control of pollution discharged and the control of pollution source played an important role in improving the air quality. Meantime, natural factors such as topography, meteorology and dust storm were external causes of temporal and spatial variations of air pollutions[4]. ZHOU Guo zhi’s study have shown that human activities have a significant impact on the air quality environment[5].

This paper uses grey relational theory to analyze the factors that affect the air quality in Chongqing City. Then, some countermeasures are put forward.

2. Modeling Steps with Grey Relational Analysis
A. The establishment of the original series and dependent variables refer to the number of columns and compare the number of independent variables listed.

Refer to the number of columns known as the dependent variable sequences recorded as the mother;
Comparing the number of independent variables is also called the sub-sequence of the column, \( \mathbf{X}_0^{(1)}, \mathbf{X}_0^{(2)}, \mathbf{X}_0^{(3)}, ..., \mathbf{X}_0^{(k)} \).

B. The original sequence is to be treated as non-dimensional.

The purpose is to eliminate the impact of different sizes and to facilitate calculation and comparison. Initialize method and the average method can be used.

Calculate formulas are:

\[
\mathbf{X}_i^{(k')}) = \mathbf{X}_i^{(k)} \div \mathbf{X}_i^{(k)}; \quad \mathbf{X}_i^{(k')} = \mathbf{X}_i^{(k)} / \mathbf{X}_i^{(k)}
\]

C. Calculate the absolute value between the parent sequence and each sub-sequence at each time point to identify the biggest difference and minimum difference:

\[
\Delta(k) = |\mathbf{X}_0^{(k')} - \mathbf{X}_i^{(k')}| (i = 1, 2, 3, ..., n)
\]

The biggest difference:

\[
\Delta_{\text{max}} = \max_{k'} \max_i |\mathbf{X}_0^{(k')} - \mathbf{X}_i^{(k')}|
\]

The minimum difference:

\[
\Delta_{\text{min}} = \min_{k'} \min_i |\mathbf{X}_0^{(k')} - \mathbf{X}_i^{(k')}|
\]

D. Calculate the Gray correlation coefficient:

\[
\mathbf{L}_{0i}^{(k)} = \frac{\Delta_{\text{min}} + \lambda \Delta_{\text{max}}}{\Delta(k) + \lambda \Delta_{\text{max}}}
\]

Among these, \( \mathbf{L}_{0i}^{(k)} \) is Gray correlation coefficient between the number of sub-sequences and the parent sequence, \( \lambda \) is distinguish factors, usually between 0 and 1.

E. Calculation of gray correlation degree

The overall correlation need to take the different observation points in the overall level of the importance of observation into account, therefore need to determine the weight of each point. Under normal circumstances, using the arithmetic mean method to calculate the gray correlation degree.

\[
r_{0i} = \frac{1}{n} \sum_{k=1}^{n} r_{0i}(k)
\]

F. Sort the correlation degree

Correlation is sorted based on size of order. The bigger a correlation is, the bigger the relation degree between the mother sequence and sub-sequence. According to experience, when the correlation is greater than 0.6, it will be considered a significant association [6-8].

3. Index Choose and Calculation

A. Index Choose

In this paper, proportion of high air quality days in downtown(%) is used as a general index to measure the degree of air quality, which was denoted as A (unit: %). Factors that affect the air quality degree in Chongqing city are as follows: GDP quantity (unit: hundred million yuan, denoted as B1); the population quantity (unit: ten thousand, denoted as B2); energy consumption quantity (unit: ten thousand tons of standard coal, denoted as B3); expenditure quantity for education (unit: hundred million yuan, denoted as B4); expenditure quantity for environment protection (unit: hundred million yuan, denoted as B5); vehicle ownership quantity (unit: ten thousand, denoted as B6). Specific data are as follows:

| Year | A   | B1 (unit: hundred million yuan) | B2 (unit: ten thousand) | B3 (unit: ten thousand tons of standard coal) | B4 (unit: hundred million yuan) | B5 (unit: hundred million yuan) | B6 (unit: ten thousand) |
|------|-----|---------------------------------|-------------------------|--------------------------------------------|---------------------------------|---------------------------------|------------------------|
| 2013 | 56.4| 12783.3                         |                         |                                            |                                 |                                 |                         |
| 2014 | 67.4| 14262.6                         |                         |                                            |                                 |                                 |                         |
| 2015 | 80  | 15717.3                         |                         |                                            |                                 |                                 |                         |
| 2016 | 82.4| 17559.3                         |                         |                                            |                                 |                                 |                         |
| 2017 | 83.0| 19500.3                         |                         |                                            |                                 |                                 |                         |
According the importance, the grey relation coefficient are as follows:
B1 > B6 > B4 > B3 > B5 > B2

4. Conclusion
According to the above calculation results, it can be seen that, according to the influencing factors, the factors affecting the air quality of Chongqing are as follows: GDP quantity, vehicle ownership quantity civil, expenditure quantity for education, total energy consumption quantity, expenditure quantity for environment protection, population quantity.

The total GDP quantity is the most important factor affecting the quality of the air environment in Chongqing city. In recent years, the total quantity of GDP has grown quickly in Chongqing city. At the same time, the extensive growth mode plays a very important role in Chongqing’s GDP growth. The extensive growth process has a greater impact on environmental quality, including the impact of air quality. Therefore, in the process of economic and social development in the future, Chongqing city should adopt a more scientific and environmentally friendly economic growth mode while maintaining rapid GDP growth. This can ensure the improvement of the quality of the air environment while maintain the increase of GDP growth, which is conducive to the improvement of the level of ecological civilization construction.

The vehicle ownership quantity is the second important factor affecting the quality of the air environment in Chongqing city. The number of car owners in Chongqing city has increased from 4.076 million in 2013 to 5.675 million in 2017, with a growth rate of 39%. The existing results show that the exhaust gas discharged during the use of civil vehicles contains more than 100 kinds of toxic and harmful gases. These toxic and harmful gas has a serious impact on the quality of the air environment and can significantly reduce the quality of the air environment. Therefore, while maintaining economic and social sustainable development, Chongqing city should take effective measures to control the further increase in the number of civilian vehicles. At the same time, the existing civilian vehicles are scientifically modified, and more advanced fuels and technologies are adopted to promote the effective reduction of exhaust emissions in order to effectively improve the quality of the air environment.

The expenditure quantity for education also has a significant impact on the quality of the air environment in Chongqing city. The improvement of the level of financial education expenditure can promote the improvement of the education level in Chongqing city, which can help to stabilize and improve the overall quality of citizens in Chongqing city. The citizens with high quality can proactively form living habits to protect the air environment in daily life, such as reducing littering, reducing the use of plastic bags, and reducing the number of driving. In this way, air quality in Chongqian city can be improved effectively.

The total energy consumption quantity is another important factor affecting the quality of the air environment in Chongqing city. The total energy consumption quantity in Chongqing city increased from 72.539 million tons of standard coal in 2013 to 85.788 million tons of standard coal in 2017, with an increase rate of 18%. A large amount of toxic and harmful gases are released during the energy consumption process, which has a great impact on the quality of the air environment. Therefore, Chongqing city should adopt more scientific measures to control the increase in total energy consumption.
consumption while maintaining sustained economic development and steady improvement of people's lives. This will have a positive effect on promoting the improvement of air quality in Chongqing city.

Expenditure quantity for environment protection also have a significant impact on the quality of the air environment in Chongqing city. With the increase in environmental protection expenditure, more advanced environmental protection equipments can be used to improve air quality. Meanwhile, the use of more advanced environmental protection technology has a positive effect on improving the quality of the air environment in Chongqing city. Chongqing city should further increase investment in environmental protection in order to promote the further improvement of the quality of the air environment.

The population quantity also has impact on the quality of the air environment in Chongqing city. As the population increases, the variety of consumer goods will increase accordingly. At the same time, more domestic waste will be generated and more exhaust gas will be emitted, which can affects the quality of the air environment. In recent years, the total population quantity of Chongqing city has gradually decreased. In the future, the total population of Chongqing city should be stabilized, which has a positive effect on promoting the quality of the air environment in Chongqing city.

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