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Assessment of Atmospheric Environmental Quality in Baoji City

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***Abstract*—Using comprehensive pollution index and Daniel trend test rank coefficient methods and monitoring data from 2007 to 2013, the characters of the main air pollutants were analyzed and trend of atmospheric environmental quality was evaluated. Influence factors on air quality were discussed. Results show that air quality is poor in Baoji , the order of the index of main atmospheric pollutants is PM10 > $S0_2$ > $N0_2$ and $N0_2$ and SO_2 are on the rise, while the rank correlation coefficient of PM10 is the highest and decline significantly. The climate elements have great influences on diffusion of atmospheric pollutants and coal combustion and vehicle exhaust emissions are still the main pollution sources. This study provides a basis for environmental management.**

Keywords-Atmospheric Quality; Rank Correlation Coefficient; Trend Analysis.

I. INTRODUCTION

With the speeding up of urbanization in China and the development of industrialization as well as the rapid increase of a motor vehicle, the great emissions of pollutants lead to the city air quality is worse, and air pollution has become one of the serious environmental problems facing our China today. In urban atmospheric environmental quality is a city environmental indicators and important health indicators for direct response people's quality of life. Just because the air pollution has the important effect to the humanity living environment, many efforts have been done to reveal the regional distribution of air pollutants and their variations at different time scales [1-7]. In this paper, monitoring data of the different station constructed in Baoji of China are used to analyze the trends of atmospheric quality and to discuss its influence factors. These studies not only can promote the understanding of the atmospheric environmental quality in regions , but also can help to guide the environmental quality management.

II. DATA AND METHODS

A. Data

Air samplings were collected from four monitoring stations in different areas from 2007 to 2013 and the climate elements including temperature, humidity, wind speed and precipitation were obtained from weather station of Baoji. The four monitoring stations were selected based on characteristics of spatial pattern of Baoji and current pollution situation. The monitored stations scattered in Zhuyuangou, school district, city center and town hospital. The three parameters, including SO_2, NO_2 and PM10 were use in atmospheric quality evaluation indexes.

B. Assessment Methods

According to the actual situation, comprehensive index and the Daniel trend test of spearman rank correlation coefficient method are used in air quality evaluation [8-9].Comprehensive air pollution index can reflect degree of air contaminated and pollutant load coefficients are used to evaluate trend of air pollutants. The evaluation method is as follows.

Various pollutants is calculated as Eq.(1).

$$p_i = \frac{a_i}{b_i} \tag{1}$$

The comprehensive pollution index is calculated as Eq.(2).

$$P = \sum_{i=1}^{n} p_i \tag{2}$$

Pollution load is calculated as Eq.(3).

$$c_i = \frac{p_i}{P} \tag{3}$$

Among them, the a_i is the i^{th} average of the air pollutant concentration, b_i is the i^{th} value of environmental quality standard of air pollutant and P_i is i^{th} index of air pollutants. P is environmental air pollution index and c_i is the i^{th} environment pollution load coefficient.

Daniel trend test of spearman rank correlation coefficient is a commonly method used to analyze the tendency of air environmental pollution [6]. The rank correlation coefficient can be used in a small sample and the single factor correlation test, moreover the method is simple and high accuracy. Equation is as follows.

$$R_S = 1 - \frac{6\sum_{i=i}^{n} d_i^2}{Y^3 - Y} \tag{4}$$

$$d_i = x_i - y_i \tag{5}$$

The Among them, Y is the total cycle time size. The Rs is rank correlation coefficient. x_i is the ordinal number of air pollutants. y_i is ordinal number. When R_s>0, it show concentration of air pollutants is increased, and when R_s <0, concentration of air pollutants is decreasing trend. The absolute value indicates the strength changes of concentration of air pollutants [8-11]. When $/ Rs / \geq Wp$ (Significant level test), it shows that the trend of air pollution is significant change. Otherwise, it is no significant change. According to the national environmental air quality standard [10-11] and actual conditions of Baoji city, Atmospheric environmental quality is divided into three standards and the three levels are listed as the following: not pollution, smaller pollution, and high risk (Tab. 1).

TABLE I. ATMOSPHERIC ENVIRONMENTAL QUALITY ASSESSMENT STANDARDS (UNIT: MG/ M3)

Pollutants	Class standard		
	1	*2*	*3*
SO_2	0.02	0.06	0.10
NO_2	0.04	0.08	0.12
PM10	0.04	0.10	0.15

III. RESULTS ANALYSIS

A. Atmospheric Quality Assessment

The climate elements in Baoji are shown in (Tab.2). It can be seen that the highest temperature is in summer, and the lowest temperature is in water. The largest average precipitation and humidity are in autumn. The biggest wind speed is in spring and least wind speed is in autumn. Except the maximum wind speed is reduced, other climatic factors are increasing trend.

TABLE II. THE VARIATION OF CLIMATE ELEMENTS OF BAOJI IN 2007-2013

Climate elements	Spring	Summer	Autumn	Winter	Annual average	Trend rater/year
Maximum temperature (°C)	14.0	29.0	26.0	8.0	19.0	0.01
Minimum temperature (°C)	4.0	18.0	15.0	-1.0	9.0	0.03
Precipitation (mm)	29.1	83.4	96.1	10.0	218.7	20.2
Maximum humidity (%)	88.3	91.6	93.6	85.3	89.6	1.63
Minimum humidity (%)	36.4	49.2	57.3	38.1	45.2	1.65
Maximum wind Speed (m/s)	29.1	26.4	25	26.1	26.6	-1.04
Minimum wind Speed (m/s)	5.7	5.6	2.7	4.8	4.7	1.16

From (Fig. 1), it can be seen that the annual average concentration of SO_2 is 0.023 Mg/m^3, and the maximum concentration is 0. 024 Mg/m^3, as well minimum value is 0. 023 Mg/m^3. Annual average concentration of NO_2 is 0.026 Mg/m3, and the maximum value is 0.027 Mg/m^3, while the minimum value is 0.025 Mg/m^3. The average concentration

of PM10 is 0.1024 Mg/m^3, the maximum average of 0.110 Mg/m^3, and the minimum value is 0.095 Mg/m^3. Air pollution index is the same change as pollutants density, but the comprehensive index of air environment is decreasing. The pollution density of PM10 is the biggest and is main pollutants in Baoji, while the average density of PM10 exceeds the national second-class index, and pollution is serious. Before 2010 the density of PM10 declined slowly trends then increase, it is related to environmental protection aware of governance. The densities of SO_2 and NO_2 have approximately the same trend change as PM10 and is only slightly change.

It can be seen from (Fig. 2), PM10 pollution index is the higher than SO_2 and NO_2. The SO_2 and NO_2 pollution index exhibit fluctuations. PM10 pollution index in 2007-2009 was a downward trend, then upward. SO_2 and NO_2 pollution index is rising slowly. In 2008, the NO_2 pollution index is higher than that of SO_2 pollution index. In other years NO_2 pollution index is higher than that of SO_2 pollution index. Overall SO_2 pollution index is greater than NO_2 pollution index.

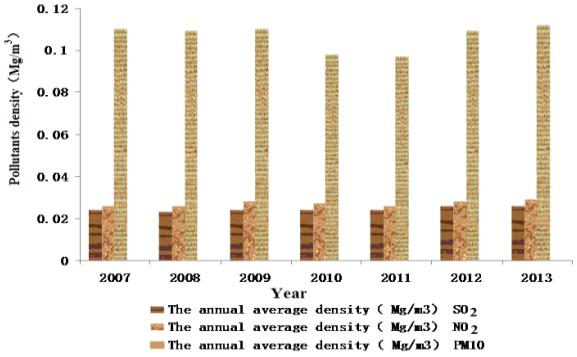

Figure 1. Annual variation trend of air pollutants density in Baoji

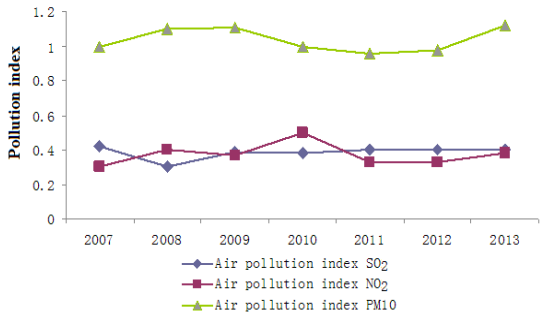

Figure 2. Annual variation trend of pollution index of air environmental quality in Baoji

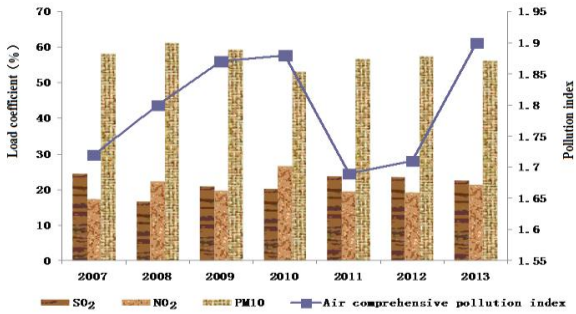

Figure 3. Change of air pollution load coefficient and comprehensive pollution index

From (Fig.3) it can be seen that comprehensive air pollution index exhibit fluctuations. During 2007-2009, it showed a increasing trend, followed by decreased then increased. The minimum comprehensive pollution index is in 2011, and the highest comprehensive pollution index is in 2013. It indicates that atmospheric environmental quality is poor in Baoji. The load coefficients of air pollutants of SO_2, NO_2 and PM10 are concluded (Fig. 3). It can be seen that PM10 pollution load coefficient was the highest, followed by SO_2, then is NO_2. This is because that Baoji is still a heavy industry City, and there are more emissions of particulate pollutants. With the rapid increase of motor vehicles, exhaust of SO_2 and NO_2 is also increasingly serious.

TABLE III. RANK CORRELATION COEFFICIENT AND SIGNIFICANCE LEVEL

Y	WP significant level α= 0.05	WP significant level α= 0.10
5	0.9000	1.0000
6	0.8290	0.9430
7	0.7140	0.8930
8	0.6430	0.8330
9	0.6000	0.7830
10	0.5640	0.7460
12	0.5060	0.7120
14	0.4560	0.6450
16	0.4250	0.6010
18	0.3990	0.5640
20	0.3770	0.5340

TABLE IV. RANK CORRELATION COEFFICIENT TREND OF DIFFERENT POLLUTANTS

Pollutants	Rs	Trend	Significant
SO_2	0.2142	Rising trend	No
NO_2	0.0142	Rising trend	No
PM10	-0.7464	Downward trend	pass

From (Tab.3, Tabl.4), it can be seen that the significance level of 0. 0 5, when Y = 7, or the critical value WP = 0.7140, and compared with the value of Rs calculated, the Rs of NO2 and SO_2 are positive rank correlation coefficient ,but rank correlation coefficient of PM10 is negative, which indicates that changes of SO_2 and NO_2 are slowly rising trend, and PM10 change is on the decline. It indicates we need to find out reasonable control measures to reduce the emissions of

SO_2 and NO_2, to improve the atmospheric environment quality.

B. Affecting Factor Analysis

In Baoji, heating period is long in winter, which leads to higher pollutant concentration, and south, west and north of Baoji surrounded by mountains and influenced by topography, pollutants is not easy to spread. Due to weather systems, temperature is low and precipitation and wind speed are small, while storms can blow Baoji City from North-west, so as to make the serious dust weather, lower visibility and decline of environmental air quality. In addition Baoji is a heavy industry city, energy structure is main the burn coal. Exhaust emission becomes an important source of air pollution in Baoji. Especially, the technology advancements have great role upon the direct sources of air pollution, including cars, machinery, energy infrastructure, combined mobility of transportation modes being applicable. The burn coal and pollutants emissions of motor vehicle and large factories continue to increase PM10, NO2 and SO2 content and also caused serious the atmospheric environment pollution. Therefore, the reasonable measures should be taken to reduce emissions, use patterns of energy, and take advantage of clean energy, thereby reducing air pollution to improve atmospheric environment quality.

IV. CONCLUSION

The above analysis shows, atmospheric environmental quality Baoji city is the lower than national atmospheric environmental quality standards, and it is moderately polluted state. In atmospheric pollutants, index of PM10 pollutant is highest, followed by the $S0_2$, and then the $N0_2$. Load rank correlation coefficients of $N0_2$ and SO_2 show a slow upward trend respectively, but PM10 pollution load coefficient is a significant downward trend. The climate elements have great influences on diffusion of atmospheric pollutants and coal combustion and vehicle exhaust emissions are the main sources of air pollution.

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