Temporal and spatial distribution characteristics and influencing factors of air quality index in Xuchang

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Abstract. In recent years, the problem of air pollution becomes more and more serious. Based on the geographic and seasonal climatic characteristics of Xuchang City, this paper studies the temporal and spatial distribution characteristics of air quality index. The results show that: from the time point of view, air quality index shows seasonal difference. Air quality index is highest in winter and is lowest in summer. From the space point of view, there are differences between the north and the south to a certain extent. Changge City, Yuzhou city and central Xuchang county is higher than the southeast of Xiangcheng county and Yanling county. The spatial and temporal variation characteristics of air quality index in Xuchang are influenced by natural factors and human activities, and the economic development and population are the important factors affecting the urban air quality.

1. Introduction
Air quality is closely related to the whole ecosystem and human health, and has been paid more and more attention [1]. Regional air quality is determined by the interaction of natural environment and human activities. It is the results of the comprehensive effect of various factors [2], such as the city's own geographical features, climate characteristics and layout of city economic development process [3]. When the amount of pollutant emission is constant, air quality index has obvious differences in different seasons. Therefore, we should combine with regional geographical environment, seasonal climate characteristics and the influence of human activity to analysis the disciplinarian of air pollution [4].

At present, some scholars have done many studies in the aspects of regional air quality distribution characteristics [2, 5-8]. Xu Haichao analysed the temporal and spatial distribution of air pollution in nine key cities of Shandong Province in different season’s studies [2]. Tao Shuangcheng studied the Characteristics of major pollutants in Beijing city [5]. Other scholars [6-8] also studied the distribution characteristics of air quality in different regions.

In recent years, the amount of pollutant emissions is increasing with the number of motor vehicles is increasing rapidly and urban population is increasing [9]. Liu Mengjie [9] and Duan Yuhuan [10] have studied on temporal change of air pollutants in Xuchang city, but without the geographical location and economic development factors. This paper studied the spatial and temporal distribution characteristics of the air quality index that based on AQI daily monitoring data and combined with the various counties of Xuchang city's location, seasonal climate characteristics and effects of human
activities. This paper provides the basis and reference for the comprehensive management of city environment and planning.

2. Research area overview

2.1. Research Area Overview
Xuchang city is located in the middle of Henan Province which is 80 kilometers away from Zhengzhou city. It is between 113 degrees 3 minutes east longitude and 114 degrees 190 minutes east longitude, 33 degrees 16 minutes and 34 degrees 24 minutes north latitude. It belongs to the warm temperate monsoon region. It covers a total area of 4996 square kilometers with a population of 480 thousand people. Xuchang includes Changge City, Yuzhou City, Xuchang City, Xiangcheng City and Yanling City.

3. Data and methods

3.1. Data sources
The historical data of air quality index is derived from the Xuchang Environmental Protection Bureau which includes the daily monitoring data of air quality index in five counties of Xuchang from January 2016 to December 2016. GDP, total social electricity consumption, industrial electricity consumption and population data of 5 counties are derived from the main official Medias.

3.2. Air quality classification standard
In 2012, the air quality index (AQI) was used to replace the original air pollution index (API). AQI was divided into six grades, including grade one, grade two, grade three, mild pollution, moderate pollution of grade four, severe pollution of grade five, serious pollution of grade six [11]. See Table 1 for details.

| AQI  | level | category        |
|------|-------|-----------------|
| 0~50 | Class one | excellent    |
| 51~100 | Class two | good          |
| 101~150 | Class three | Mild pollution |
| 151~200 | Class four | moderate pollution |
| 201~300 | Class five | serious pollution |
| >300  | Class six  | serious pollution |

4. results and analysis

4.1. Analysis of monthly variation characteristics of AQI
According to the data of AQI days in five counties of Xuchang in 2016, the standard days of each county is calculated. The details are shown in figures 1 and 2.
Figure 1. AQI monthly variation curve of 25 counties

Figure 2. the standard days of each county

Figure 1 shows that the AQI change trend is "U" type distribution. Monthly air quality index changes can be roughly divided into 3 stages, namely the slow decline stage, rising stage and relatively stable stage. Five counties have the standard number of days more than 25 days in May. From May to October, the standard number of days is relatively stable and have relatively good air quality standards. From November to December, it is the rising stage. The overall air quality in Xuchang city becomes worse. AQI quality index is higher in December and January. The number of days is less in July and October.

4.2. Analysis of spatial variation characteristics of AQI

According to the monthly statistics of the standard number of days, draw the space distribution of AQI based on the standard number of days in Xuchang from January to December in 2016. See the figure 3.
Figure 3. the space distribution of AQI in Xuchang from Jan to Dec

On the whole, the standard number of days is inverted "U" type distribution which corresponds to the above conclusions. The standard number of days is most in October. In December, the number of counties reaches the minimum, and the pollution is the most serious, followed by January and February. From the spatial geographical point of view, the standard days of Northwest County are lower than the southeast county. The number of standard days in Changge, Yuzhou and Xuchang counties is lower than that in Yanling and Xiangcheng counties.

4.3. Analysis of influencing factors of AQI
The increase of surface inversion frequency in winter makes the pollutants accumulate in the near earth layer, leading to the gradual accumulation of pollutants in the atmosphere near the ground and reaching a high concentration level [12]. Secondly, the northern city in the winter is in the heating period. Coal consumption increases significantly, so air quality is poor [13]. At the same time, plants grow slow in winter. Adsorption capacity of plants to air declines, the air quality decline. Therefore, the number of days is relatively small in November, December, January and February. The spring temperature is warmer and windy in spring which is conducive to the diffusion of pollutants, and the number of days reaching the standard is higher than that in winter. However, due to the influence of dust in the north, the number of days reaching the standard in spring is less than that in summer. There are high temperature, high intensity rainfall and sunny weather in summer. It is conducive to the spread of pollutants and clear. So the summer in a year the lowest AQI index.

Xuchang City is adjacent to Zhengzhou and Pingdingshan, and there are more popular northwest wind in the autumn and winter. Seriously affected the northwest input pollution, the pollution in winter is more serious. The pollution in Changge and Yuzhou are relatively more heavy pollution than Xiangcheng and Yanling. The Xiangcheng and Yanling have little influence on the imported pollution, and the pollution degree is relatively low.

Air quality is affected by geographical location, and also is related to various human activities. This paper selects four affecting air quality correlations of the GDP, the whole society electricity
consumption, industrial electricity consumption and population of Xuchang to analysis. See in Table 2 and table 3.

|                | GDP (million yuan) | total social electricity consumption (KWH) | industrial electricity consumption(KWH) | population (10000) | AQI  |
|----------------|-------------------|------------------------------------------|----------------------------------------|--------------------|------|
| Changge        | 543               | 23.68                                    | 15.86                                  | 68                 | 100.3|
| Yuzhou         | 558               | 20.41                                    | 10.64                                  | 113                | 115.6|
| Xiangcheng     | 330.2             | 11.6                                     | 6.73                                   | 67                 | 85.4 |
| Xuchang        | 262.1             | 9.16                                     | 4.72                                   | 76                 | 98.3 |
| Yanling        | 275.9             | 6.42                                     | 2.1                                    | 55                 | 87.9 |

| variable                  | correlation coefficient | variable                  | correlation coefficient |
|---------------------------|-------------------------|---------------------------|-------------------------|
| industrial electricity consumption | 0.540                  | GDP                       | 0.745                   |
| total social electricity consumption | 0.677                  | population                | 0.904                   |

It can be seen from table 2 and 3 that the four indexes are related to air quality, it is highly correlated with population. The GDP and the total electricity consumption of Changge and Yuzhou are higher than that of Xuchang, Xiangcheng and Yanling. The AQI index is also higher than that of the other three counties. Changge and Yuzhou are adjacent to Zhengzhou airport development zone. In recent years, the development is relatively fast. Coal industry and building materials market increase the degree of air pollution. Therefore, the more emissions of pollutants have, the more serious air quality pollution is. At the same time, the total electricity consumption basically is closely related with GDP. The higher GDP is, the more the total electricity consumption has. The whole society electricity consumption relates to air quality. When the temperature rises, it appears more prominent heat island effect. The air pollution index is influenced by the influence of human activities.

The ecological environment of Xiangcheng county and Yanling county is relatively good. Yanling County is a typical southern climate type and an excessive climate region in North China. The terrain is flat. It has four distinct seasons, and the location and climate conditions are superior. The flower industry develops rapidly. The forest coverage rate of is 38.6%. It has the excellent ecological environment, and air quality is good. Xiangcheng County has the beautiful mountains and rivers. It is the ecological garden city and provincial and provincial health city. In recent years, the development of "village forest" project makes the air quality greatly improved.

In general, the air quality index of Northwest Changge, Yuzhou and central Xuchang is higher than that of Xiangcheng and Yanling counties in the southeast.

5. Conclusion

Based on the analysis, we can draw the following conclusions:

In the time point of view, the air quality index of Xuchang showed a trend of "U" distribution, and the air quality index in December was the highest, followed by January in AQI. In July and October, the air quality index was low, and reached the maximum number of days. The amount of coal increase in autumn and winter, and pollutant emissions increased. The pollution is more serious. In summer, the weather is clear. Rainfall and windy weather are frequent which is conducive to the diffusion of pollutants, so the air quality is better.

The spatial distribution of air quality in Xuchang has a certain degree of difference between North and south, and the air quality index in northwest is higher than that in the southeast. The average air quality index in Xiangcheng County is the lowest, followed by Yanling County. The highest average AQI in Yuzhou was 115.6, and the pollution was the most serious. The temporal and spatial variation
characteristics of air quality index in Xuchang are influenced by natural factors and human activities. In general, the air quality index of Changge, Yuzhou and central Xuchang in the northwest of Xiangcheng, Yanling and the middle part of the county is higher than that of the southeast of China. Economic development, urban industrial development and population size are important factors affecting urban air quality.

This paper discussed some influencing factors about the characteristics of temporal and spatial variation factors of air quality index in Xuchang city. It provides reference for the comprehensive management of city environment and a comprehensive understanding of the distribution of air quality in Xuchang City.

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References
[1] Jiang Xinhua, Xue Heru. Analysis of the influence of air quality of Hohhot principal. 2016.1.
[2] Xu Haichao, Li Zijun. air quality index distribution characteristics of Shandong province. Journal of University of Jinan. 2017.3.
[3] Han Jing. Spatio temporal change characteristics of area air quality analysis in Huaiyiin. Chinese Journal of Environmental Science. 2008.
[4] Jiang Wenhua, Chen Dao Jin. Analysis of air quality and pollution characteristics in the main urban area of Chongqing. 2015.
[5] Tao Shuangcheng. Analysis of air pollution characteristics in Beijing heating period typical regional.2016.25 (11): 1741-1747.
[6] Pan Yuepeng, Ni Changjian. Analysis of summer atmospheric pollutant concentration characteristics of temporal and spatial variation in Chengdu City. 2015.
[7] Lv Xin. Analysis of the temporal and spatial distribution characteristics of air quality in Anhui. 2016.
[8] Yang Huiru, Yue Chang. Relationship between air quality and meteorological elements in the Jiaodong Peninsula [J]. environmental science and technology.2014 June. Vol. thirty-seventh, issue 6N.
[9] Liu Mengjie, Wang Junchao. Analysis of change trend of ambient air quality in Xuchang city. 2016.7.
[10] Yuhuan. Fang Heng. Analysis of variation trend and law of ambient air quality in Xuchang city 2002.
[11] People's Republic of China environmental protection department. Technical specification for ambient air quality index (AQI) (Trial): HJ633 – 2012 [S]. Beijing: China Environmental Science Press, 2012.
[12] Huang Jumei, Zhou Hui. Variation characteristics of air pollution and meteorological factors in Yueyang urban area. 2015, 43 (5): 932-938.