Analysis of air quality characteristics in Dezhou

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Abstract. Based on the national air quality network monitoring and management platform, the data from July 1, 2018 to June 30, 2019 were obtained, and major pollutants were analyzed. The study found that air quality grade in spring and summer in Dezhou region was better than that in autumn and winter; The air quality in Decheng district was better, and Xiajin county was relatively poor in the five monitoring points. According to the results, the corresponding control measures are proposed in order to provide reference for the joint prevention and control of air pollution in Dezhou.

1. Introduction
In the 40 years of reform and opening up, the Dezhou economy have flourished. With the acceleration of urbanization and the continuous increase in energy consumption, the air quality has deteriorated, such as acid rain and smog. In May 2019, Shandong Dezhou issued the "Key Points of Air Pollution Prevention and Control Work in Dezhou City in 2019", pointing out that Dezhou City will carry out the three-year action plan for the Blue Sky Defence War and achieve the overall improvement of air quality in 2020. Consequently, based on the monitoring data of Dezhou City Air Quality Network Monitoring Platform from July 2018 to June 2019, this paper quantitatively analyzes the air quality changes in Dezhou City, and studies the monitoring points contaminant concentration levels, air quality levels, and primary pollutants.

2. Data source
Dezhou City has 2 districts, 7 counties, 2 county-level cities. Relying on the national air quality network monitoring and management platform, there are 45 air quality monitoring points. In order to prevent the contingency and repeatability of data[1], five monitoring points distributed in different locations are selected for data analysis. Decheng District (Shandong Huayu Institute of Technology), Laoling County (City Government), Qihe County (Martyrs Memorial Hall), Xiajin County (Citizen Center), and Lingcheng District (Ling County Yizhong) are shown in Figure 1. Evaluation indicators of SO2, NO2, CO, O3-8h, PM10 and PM2.5 were selected to evaluate the air quality.
3. Evaluation standard

According to the regulations[2-3], the concentration limits for basic air pollutants are shown in Table 1.

| Contaminant | Time                      | Concentration limit | Unit    |
|-------------|---------------------------|---------------------|---------|
|             |                           | Level 1  | Level 2 |         |
| SO2         | annual average            | 20       | 60      | μg/m³   |
| NO2         | annual average            | 40       | 40      |         |
| CO          | 24-hour average           | 4        | 4       | mg/m³   |
| O₃-8h       | Average maximum 8h per day| 100      | 160     | μg/m³   |
| PM10        | annual average            | 40       | 70      |         |
| PM2.5       | annual average            | 15       | 35      |         |

4. Results analysis

By calculating and analyzing the data of the five monitoring points, the average days of different air quality levels from July 2018 to June 2019 is obtained which are shown in Table 2. It can be seen that there is a 140-day air quality rating is good in a year, accounting for 38.5%; the second air quality level is mild pollution, accounting for 34.9%; the air quality is excellent for only 17 day. It can be seen that the overall air quality situation during the year is dominated by good and light pollution.

| Air quality grade | Day | The proportion (%) |
|-------------------|-----|--------------------|
| excellent         | 17  | 4.7                |
| good              | 140.4 | 38.5              |
| Mild pollution    | 127.4 | 34.9              |
| Moderately polluted | 45.2   | 12.4              |
| Severe pollution  | 30.6 | 8.4                |
| The more severe pollution | 4.4 | 1.2               |

By calculating and analyzing the data of five monitoring points, the number of days and the proportion of primary pollutants from July 2018 to June 2019 were obtained. The statistics on primary pollutants are shown in Table 3. According to the calculation results, it can be seen that the most pollutants area O₃-8h. The number of days as the primary pollutant is as high as 150 days, followed by PM2.5 and PM10, and the proportion of days in which NO₂ is small.
Table 3. Statistics on primary pollutants

| primary pollutants | day | The proportion (%) |
|--------------------|-----|--------------------|
| NO₂               | 10.9| 3                  |
| PM2.5             | 118.3| 32.4              |
| PM10              | 89.1| 24.4              |
| O₃-8h             | 146.7| 40.2              |

By calculating and analyzing the data of five monitoring points, the annual average concentration and over-standard rate of major pollutants at each monitoring point in Dezhou from July 2018 to June 2019 were obtained which are shown in Table 4. Compared with the concentration limit of basic air pollutants (Table 1), it is found that the average annual concentration of SO₂ is <20, only 18.23 of Decheng District (Shandong Huayu University of Technology) meets the requirements, and the average annual concentration of NO₂ is <40 (Level 2), most areas of Dezhou meet the requirements, the annual average concentration of PM10 is <40 for the first level, <70 for the second level, all is exceeding the standard, and the over-standard rate is extremely high; the annual average concentration of CO is <4, the areas of Dezhou meets the requirements. The average annual concentration of O₃-8h is <100 for the first grade, <160 for the second grade, and the region is at the secondary level for most of the year; the average annual concentration of PM2.5 is <15 for the first grade, <35 is the second grade, Xiajin County is the most serious. Through comprehensive comparative analysis, it can be seen that the air quality in Decheng District is better than other areas.

Table 4. Annual average concentration and over-standard rate of major pollutants at each monitoring point

| Site name          | SO₂ Annual average concentration (<μg/m³> | SO₂ Excess rate (%) | NO₂ Annual average concentration (<μg/m³> | NO₂ Excess rate (%) | PM10 Annual average concentration (<μg/m³> | PM10 Excess rate (%) | CO Annual average concentration (<mg/m³> | CO Excess rate (%) | O₃-8h Annual average concentration (<μg/m³> | O₃-8h Excess rate (%) | PM2.5 Annual average concentration (<μg/m³> | PM2.5 Excess rate (%) |
|--------------------|------------------------------------------|---------------------|------------------------------------------|---------------------|------------------------------------------|---------------------|------------------------------------------|---------------------|------------------------------------------|---------------------|------------------------------------------|---------------------|
| Laoling County     | 25.51                                    | 42.5                | 34.57                                    | 31                  | 112.42                                   | 95.3                | 1.34                                     | 0                   | 127.28                                   | 59.7                | 66.66                                    | 96.2                |
| Qihe County        | 20.53                                    | 38.4                | 41.72                                    | 38.4                | 124.55                                   | 98.1                | 1.06                                     | 0                   | 122.37                                   | 58.1                | 64.84                                    | 96.4                |
| Lingcheng District | 28.73                                    | 63                  | 37.07                                    | 35.6                | 119.7                                    | 94.8                | 0.88                                     | 0                   | 139.72                                   | 61.4                | 68.79                                    | 97                  |
| Xiajin County      | 34.51                                    | 64.4                | 44.8                                     | 48.2                | 130.11                                   | 96.7                | 0.92                                     | 0                   | 123.1                                    | 61.4                | 70.38                                    | 97.3                |
| Decheng District   | 18.23                                    | 25.2                | 38.35                                    | 39.7                | 122.2                                    | 96.2                | 1                                        | 0                   | 126.04                                   | 61.4                | 64.82                                    | 96.4                |

Figure 2 shows the excess rate curve change of SO₂. As can be seen from Table 4, the highest rate of Xiajin County in the five monitoring points is 64.4%, followed by 63% in Lingcheng District, and again in Laoling County and Qihe County. It can be seen from Figure 2 that the first and fourth quarter have higher SO₂ exceeded days, with peaks appearing in December and January.

Figure 3 shows the change of NO₂ over-standard rate curve. As can be seen from Table 4, the highest rate of Xiajin County is 48.2%, and the lowest rate of Laoling County is 31%. It can be seen from Figure 3 that the number of days of NO₂ exceeding the standard in December and January is higher. Among them, the number of days in which Qihe County and Xiajin County exceeded the standard in January was 30 days, and the maximum value was 117, which was nearly 300% higher than the first standard.

Figure 4 shows the change of PM10 over-standard rate curve. It can be seen from Table 4 that the PM10 over-standard rate of the five monitoring points is basically flat, both exceeding 94%, and the maximum value is 98.1% in Qihe County. It can be seen from Figure 4 that in the Dezhou area, only the PM10 exceeded the number of days in August was relatively small, and other months exceeded the standard.
Figure 2. Excess rate curve of SO2

Figure 3. Excess rate curve of NO2

Figure 5 shows the change of O3-8h over-standard rate curve. It can be seen from Table 4 that the change trend of O3-8h over-standard rate of five monitoring points is consistent, and the minimum value appears in Qihe County is 58.1%. It can be seen from Figure 5 that the number of O3-8h over standard days in December and January is almost 0. The highest number of days exceeded in May and June. In the summer, the inhalable particulate matter is reduced, and the O3-8h over-standard rate is increased due to the increase in temperature. Ozone pollution has obvious seasonal characteristics, and the concentration is generally high from May to September.

Figure 4. Excess rate curve of PM10

Figure 5. Excess rate curve of O3-8h

Figure 6 shows the change of the PM2.5 over-standard rate curve. As can be seen from Table 4, the PM2.5 over-standard rate of the five monitoring points is basically flat, and varies range between the 96-97%. The monthly PM2.5 value area is almost exceeded. Therefore, it is extremely urgent to control PM2.5 in Dezhou.

In summary, the main pollutants affecting the air quality are O3-8h, PM2.5, PM10, SO2 and NO2. Taking the API values of the typical months of 5 monitoring points (December 2018 and June 2019), the daily average curve of different pollutants in the following figure is obtained. Figure 7 shows the change of NO2 daily mean curve. It can be seen from Fig. 7(a) that the concentration of NO2 in the air is less than 0.08 for most of December, and the concentration of individual days in Qihe and Xiajin County is greater than 0.08, less than 0.12; It can be seen from Fig. 7(b) that the concentration of NO2 in the air is less than 0.08 in June. According to the API classification standard of the China Urban Air Quality Daily, if only the NO2 concentration in the air is considered, it can be judged that
the air quality is superior in December. All are excellent in June. Overall, the NO2 concentration in the air of Qihe and Xiajin County is relatively high.

Figure 7. Daily mean curve of NO2 in typical month

Figure 8 shows the change of the daily mean value of SO2. It can be seen from Fig. 8(a) that the concentration of SO2 in the air in early and late December is mostly less than 0.05, and the maximum concentration of SO2 in the air is less than 0.1 in the mid-season. SO2 in the air of Xiajin County is higher; Figure 8(b) shows that the concentration of SO2 in the air is less than 0.04 in June. According to the API grading standard of China’s urban air quality daily report, if only the SO2 concentration in the air is considered, it can be judged that the air quality in the Dezhou area is superior to the best in December, and the air quality is superior in June. Overall, the concentration of SO2 in the air in Lingxian and Xiajin County is relatively high.

Figure 8. Daily mean curve of SO2 in typical month

Figure 9 shows the change of the daily mean value of PM10. From Fig. 9(a), the concentration of PM10 in the air in December is mostly in the range of 0.05-0.25. Figure 9(b) shows that the concentration of PM10 in the air is less than 0.16 in June. According to China's air quality daily report API grading standards, if only the PM10 concentration in the air is considered, the air quality is mainly good and slight pollution in December, while the air quality in June is good.
5. Conclusion

(1) The air quality in June was significantly better than that in December. By analyzing other months, it was found that the weather in spring and summer was significantly better than that in autumn and winter. Among the five selected monitoring points, the air quality in Decheng District is good, and the air quality in Xiajin County is poor. The reason analysis is that there are fewer pollutant factories in Decheng District, and the air quality control in Decheng District is relatively strong; the reasons for the poor air quality in Xiajin County is the air pollution caused by the local enterprises themselves, and the other is the Xingtai City, which is west of Xiajin County. The air quality ranks lower in Hebei Province. Due to the northwest wind direction in winter, it will also affect the air quality of Xiajin County.

(2) As the season changes, the primary pollutants in the air will change. The comprehensive pollution load factors are O₃-8h, PM2.5, PM10, SO₂ and NO₂. Ozone control is a worldwide problem. To reduce the concentration of ozone in the atmosphere, it is necessary to control the emission of NOx and VOC. The NOx is mainly from the combustion of fossil fuels, followed by the exhaust emissions of motor vehicles. Therefore, the Dezhou area can increase the management of coal-fired enterprises, install flue gas filtration and purification devices, accelerate the adjustment of energy structure, and vigorously promote clean production. Urban residents should actively respond to policies and complete the "coal to gas, coal to electricity" Strengthening the pollution control of motor vehicles, eliminating yellow-label vehicles within a time limit, not allowing vehicles with exhaust gas to reach the road, continuously improving fuel quality, and regularly restricting vehicles. The government should formulate corresponding policies to encourage the purchase of clean energy vehicles.

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