Analysis of Air Pollutant concentration change trend in Urumqi city under the condition of city closed in winter

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Abstract. During the epidemic period, Urumqi has been sealed off from the city's management, just as "suspended" state. From an environmental point of view, the reduction of energy consumption during the closure of the city can be considered as an energy control to study the resulting reduction of atmospheric pollutant concentration changes. In this paper, the monitoring data of air pollutant concentration in the same period of city closure and normal years are compared, and the results show that the air pollutant concentration has decreased in different degrees during the period of city closure. The largest decrease was 44.66% for NO₂, 40.13% for CO, 36.44% for PM_{2.5}, and the smallest was 2.06% for SO₂. Multivariate analysis of variance showed that energy control had a significant effect on the concentration of pollutants during the city closure, for example NO₂ ($F=128.96$, $\text{Sig.}=0.000$), PM₁₀ ($F=29.58$, $\text{Sig.}=0.000$), PM_{2.5} ($F=13.98$, $\text{Sig.}=0.000$), CO ($F=46.34$; $\text{Sig.}=0.000$). Through the analysis of the data, it can be concluded that the air quality of Urumqi in winter is poor and the concentration of pollutants is high. The energy control during the closing period played a positive role in pollutant emission reduction and effectively improved the quality of atmospheric environment.

1 Introduction

The formation and development of a city is a process in which all kinds of factors, such as human flow and material flow, gather together in a certain region, and it is also a dense area of human life and production. When the concentration of pollutants discharged into the atmosphere in the process of human life and production exceeds the threshold of the atmospheric environmental capacity in the region, the problem of atmospheric environmental pollution arises. This has become a common problem in many large and medium-sized cities, especially in developing countries with relatively backward economies. The status of air pollution is usually closely related to the city's geographical location, the city's development stage and the structure of energy consumption^[1].

Urumqi is the capital of Xinjiang, it is also the Center of the political, economic and Cultural of Xinjiang. In the course of urban development, it has also experienced serious atmospheric environmental problems, which are mainly related to the typical "valley-type" geographical position and energy structure^[2]. From the point of view of pollution status, the concentration of air pollutants in the city presents a "U"-shaped change trend, that is, the concentration of pollutants in the heating period is much higher than that in the non-heating period, and the difference of pollutant content in different regions shows that there are some differences of pollution sources in different regions, the quality of surrounding environment

is related to industrial production and transportation, while the urban area is mainly related to motor vehicle exhaust and social life^[3]. How much does the motor vehicle exhaust and social life in the city center have to do with air pollution? This is a question that environmental researchers have been thinking about, but it seems to be an incalculable problem, and social management during an epidemic provides an opportunity to study it.

From January 29 to March 4, 2020, the city of Urumqi was closed down due to the outbreak of the new crown disease. Other social production and living activities were "suspended" except those related to the national economy and the people's livelihood. This is an extremely disadvantageous state for economic and social development, but it also provides a rare opportunity for environmental research. In this paper, we compare the monitoring data of air pollutant concentration in the same period of epidemic time (energy control) and in the normal state, and discuss the air pollutant that the city life releases to the air environment.

2 Data acquisition and processing

In this paper, the daily average data of air pollutants in the same period in 2019 and 2020 from state-controlled environmental quality monitoring sites in Urumqi are selected as the analysis objects. Air Pollutants include (PM₁₀, PM_{2.5}, SO₂, NO₂, CO and O₃-8h). For ease of

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analysis, the areas covered by the monitoring points are divided into southern, central and northern urban areas (Figure 1). The samples were collected by Thermo Scientific1405 Particle Monitor. The data is the average value of 0-23 points per day. Using WPS and SPSS19.0 to analyze the data.

Figure 1 Monitoring point location area

3 Results

3.1 Changes in environmental quality

The statistics show that the environmental quality has improved significantly during the period of the city closure, with the I-class days appearing in different areas, moreover, the number of days of II environmental quality has also increased significantly, with 142% in the south area, 75% in the middle area, and 44.44% at the lowest in the north area. The days of III to VI levels of environmental quality showed a decreasing trend. Specific trends are shown in Table 1.

Table 1 Changes in air quality

Air Quality Rating	2019			2020			Rate of change(%)		
	Southern	Central	Northern	Southern	Central	Northern	Southern	Central	Northern
I				3	5	2			
II	7	8	9	17	14	13	142.86	75.00	44.44
III	12	11	8	8	8	6	-33.33	-27.2	-25.0
IV	5	7	5	4	4	6	-20.00	-42.86	20.00
V	10	7	10	3	3	6	-70.00	-57.14	40.00
VI	1	2	3		1	2	-100.00	-50.00	-33.3

3.2 Variation of pollutant concentrations in different regions

During the city's closure, all motor vehicles (except special vehicles), restaurants and small industrial enterprises have been closed, resulting in a reduction in emissions of pollutants (Table2).

The change of pollutant concentration is very obvious, the concentration of PM_{10} , in the particulate matter, showed a trend of low in the middle and high in the southern and north, with an average decrease of about 35%, showing as the northern area>southern>middle

area, that is $-35.72\% > -34.40\% > -34.33\%$. The spatial distribution of $PM_{2.5}$ is the same as that of PM_{10} , but the decreasing range shows the trend from south to north, which is southern>middle area>northern area, that is $-36.44\% > -28.48\% > -16.38\%$; Among the gaseous pollutants, the concentration of NO_2 decreased the most, and also showed a trend of decreasing from south to north, that is $-44.66\% > -37.90\% > -33.69\%$; The trend of CO change was basically the same as that of NO_2 , but the decrease of CO in the southern region was larger than that in the middle and north regions, that is $-40.13\% > -20.31\% > -20.69\%$. SO_2 decreases differently in different regions, but the overall magnitude is not large, ranging from -15% to -25%. However, O_3-8H is different from other pollutants, but shows an increase trend, the increase range is relatively large, all in 50%, from the spatial variation, the Southern > the Northern > the Central Zone, namely $81.64\% > 52.91\% > 51.93\%$.

Table2 variation of pollutant concentration in different regions

Unit: $\mu g/m^3$

Pollutants	Years	Southern	Central	Northern
PM_{10}	2019	127.51	125.54	134.23
	2020	83.65	82.44	86.29
	(%)	-34.40%	-34.33%	-35.72%
$PM_{2.5}$	2019	124.20	117.37	134.29
	2020	78.94	83.94	112.29
	(%)	-36.44%	-28.48%	-16.38%
SO_2	2019	6.37	10.94	11.31
	2020	4.83	8.26	9.57
	(%)	-24.22%	-24.54%	-15.40%
NO_2	2019	80.54	84.06	71.40
	2020	44.57	52.20	47.34
	(%)	-44.66%	-37.90%	-33.69%
CO	2019	2.29	2.01	1.82
	2020	1.37	1.60	1.45
	(%)	-40.13%	-20.31%	-20.69%
O_3-8H	2019	36.26	48.14	50.06
	2020	65.86	73.14	76.54
	(%)	81.64%	51.93%	52.91%

3.3 Results of multivariate analysis of variance

The statistical data show that the concentration of pollutants mainly showed a downward trend during the period of closure of the city, the environmental quality improved obviously, and the rate of decrease of the concentration of pollutants in different regions was different. Multiple factor difference test results, as shown in Table3, the most significant impact of energy control was NO_2 ($F = 128.96$, $Sig. = 0.000$), followed by CO ($F = 46.34$; $Sig. = 0.000$), PM_{10} ($F = 29.58$, $Sig. = 0.000$), $PM_{2.5}$ ($F = 13.98.65$, $Sig. = 0.000$), SO_2 ($F =$

48.38, Sig. = 0.000) and O₃-8H (F = 31.52, Sig. = 0.000) were the significant differences among the regions.

Table 3 Multivariate analysis of variance

Tests of Between-Subjects Effects										
Dependent Variable: PM ₁₀						Dependent Variable: PM _{2.5}				
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	115984.952a	5	23196.99	6.03	0	86838.667a	5	17367.733	4.10	0.001
			2351510.							
Intercept	2351510.876	1	88	611.3	0	2472389.505	1	2472389.505	584.27	0
			113774.0							
Energy control	113774.019	1	2	29.577	0	59136.076	1	59136.076	13.98	0
areas	2154.581	2	1077.29	0.28	0.756	22969.295	2	11484.648	2.71	0.069
Energy control										
* areas	56.352	2	28.18	0.007	0.993	4733.295	2	2366.648	0.56	0.572
Error	784734.171	204	3846.74			863239.829	204	4231.568		
Total	3252230	210				3422468	210			
Corrected Total	900719.124	209				950078.495	209			
a.R Squared = .122 (Adjusted R Squared = .100)						a.R Squared = .091 (Adjusted R Squared = .069)				
Dependent Variable: SO ₂						Dependent Variable: NO ₂				
Corrected Model	1158.195a	5	231.639	23.916	0	53282.895a	5	10656.579	27.90	0
			15342.97							
Intercept	15342.976	1	6	1584.129	0	842840.076	1	842840.076	2206.98	0
Energy control	2.1	1	2.1	0.217	0.642	49250.743	1	49250.743	128.96	0
areas	937.152	2	468.576	48.379	0	2750.467	2	1375.233	3.60	0.029
Energy control										
* areas	218.943	2	109.471	11.303	0	1281.686	2	640.843	1.68	0.189
Error	1975.829	204	9.685			77907.029	204	381.897		
Total	18477	210				974030	210			
Corrected Total	3134.024	209				131189.924	209			
a.R Squared = .37 (Adjusted R Squared = .345)						a.R Squared = .406 (Adjusted R Squared = .392)				
Dependent Variable: CO						Dependent Variable: O ₃ -8H				
Corrected Model	21.705a	5	4.341	11.89	0	68923.498a	5	13784.7	21.10	0
Intercept	647.683	1	647.683	1774.19	0	642528.052	1	642528.052	983.62	0
Energy control	16.915	1	16.915	46.34	0	15180.36	1	15180.36	23.24	0
areas	1.574	2	0.787	2.16	0.118	41181.349	2	20590.674	31.52	0
Energy control										
* areas	3.216	2	1.608	4.40	0.013	11300.933	2	5650.466	8.65	0
Error	74.472	204	0.365			156121.187	239	653.227		
Total	743.86	210				842344.05	245			
Corrected Total	96.177	209				225044.685	244			
a.R Squared = .226 (Adjusted R Squared = .207)						a.R Squared = .306 (Adjusted R Squared = .292)				

4 Analysis and Discussion

4.1 The change of PM₁₀ and PM_{2.5}

In winter, the air pollution in Urumqi is serious, mainly because the heating consumes a lot of fossil energy, at the same time, the motor vehicle hot-running time is long, the driving speed is slow, which causes a lot of tail gas emissions. Under normal conditions, the concentration of particulate pollutants appears to be high in the north and south area, and low in the middle area, which is directly related to the surrounding environment of the monitoring point. The North and south points are

at both ends of the city, and on the one hand they are easily affected by the urban heat island effect, on the other hand, the main factors that affect the concentration of pollutants are the exposed ground surface in the suburbs and the dust produced by vehicles entering the city^[4].

During the period of the city closure, PM₁₀ decreased considerably. From the point of view of the extent of the decrease, namely the north > the south > the central, mainly after the closure of the city, the most important change was the total suspension of motor vehicles (except working vehicles and special vehicles), therefore, the dust generated by motor vehicle operation

has been contained and reduced to the lowest point, and the large drop in the northern area is due to its high concentration in the early stage, and the concentration of PM_{10} in the three monitoring sites after the closure of the city is very close, you could say it represents the background value of the city in winter.

The concentration of $PM_{2.5}$ decreased obviously, but the average decrease was smaller than that of PM_{10} . The main reason was that the ambient concentration of $PM_{2.5}$ was almost the same as that of PM_{10} under normal conditions. Although the emission of motor vehicle exhaust was greatly reduced after the closure of the city, it might be affected by the inversion layer in winter, the ability of reducing pollutants is still limited, and the trend of $PM_{2.5}$ is the same as that of PM_{10} , which is consistent with the conclusion of the former study^[5].

The results of variance analysis also showed that city closure had significant effect on controlling PM_{10} and $PM_{2.5}$, and the effect on PM_{10} was greater than that on $PM_{2.5}$.

4.2 The change of SO_2 and NO_2 .

The decrease rate of SO_2 is obviously lower than that of NO_2 , which is mainly due to the adjustment of energy structure such as "coal to gas", the production of SO_2 emissions is almost reduced to a minimum.

The concentration of NO_2 , the main pollutant of motor vehicle emission, has the biggest reduction. Under normal conditions, vehicle exhaust is the main pollution source of NO_2 in urban area. After the closure of the city, motor vehicle exhaust emissions will almost reach zero, and the concentration of pollutants will also decrease, with the largest decrease in the southern area, mainly due to the complete shutdown of the passenger stations near the monitoring points, combined with a sharp decline in the number of vehicles on the nearby city's high-speed roads, the central district followed, with the northern district having the lowest rate of decline, also reaching-33.69%. The results of variance analysis showed that the effect of urban closure on NO_2 was the most significant, which indicated that the concentration of NO_2 in Urumqi urban area in winter was about 40%.

4.3 The change of CO and O_3-8H

During the period of city closure, the CO reduction from south to North showed a decreasing trend. From the concentration point of view, the concentration in the south and the north of city was close to each other. But from the pollutant concentration point of view, the concentration value itself was low, and it was difficult to have a higher reduction. The analysis of variance showed that the effect of city closure on CO reduction was significant. O_3-8H is the main air pollutant, and it is also the only one whose concentration increased after the closure of the city, with an average increase of over 50%. It can be concluded that the atmospheric environmental quality is improved, the atmospheric radiation is enhanced and the concentration of O_3-8H is

increased due to the reduction of the overall pollutant emission. This is basically consistent with the conclusion that particles in the atmosphere during the heating period help to increase the diffraction and scattering of light.

5 Conclusion

The air pollution of Urumqi is serious in winter, and the concentration of pollutants is high. After the closure of the city, the concentration of pollutants showed a decreasing trend.

On the premise of constant consumption of conventional energy sources such as industrial production and heating, the concentration of pollutants caused by motor vehicles has dropped remarkably, it is shown that proper traffic diversion and control of the number of motor vehicles are effective means to improve the atmospheric environment quality.

The change range of different pollutants in the atmospheric environment is quite different from that of energy control and regional types. For example, the reduction of motor vehicles has the biggest effect on NO_2 and the second effect on the concentration of atmospheric particulate matter, SO_2 and O_3-8H require regional energy regulation.

City closed is an effective means to control the spread of the epidemic, which is extremely disadvantageous to economic and social development, but it is a rare opportunity to study the state of air pollution. However, due to the lack of previous experimental preparation and experience, there are some scientific problems, didn't take advantage of the opportunity to figure it out.

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