Analysis on the Impact of Regional Air Quality in Industrial Cities: A Case Study of Huinong District of Shizuishan City

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Abstract. In order to explore the influencing factors of regional air quality in industrial cities, this paper takes Huinong District of Shizuishan City as the object for analysis. The author sets up monitoring points in Huinong District of Shizuishan City to monitor the gas emission of polluting enterprises in various industries, and then analyzes the impact of the industrial park and surrounding environment of Huinong District on the air quality in the urban area. The analysis results show that the hourly contribution values of SO₂ and PM₁₀ emitted by Hebin Industrial Park were 0.756 mg/m³ and 0.444 mg/m³, respectively, while that of sulfur dioxide and PM₁₀ emitted by heating companies were 0.865 mg/m³ and 7.629 mg/m³. These are the main causes of serious air pollution in the District.

1 Introduction

Shizuishan City, Ningxia Hui Autonomous Region is a city focusing on industrialization with an industrial structure based on the coal industry. Its climate is featured with low precipitation and extremely uneven seasonal distribution. Under the influence of meteorology and topography, the atmospheric inversion phenomenon in Shizuishan City in winter is obvious, leading to the gradual accumulation of air pollutants near the surface, which are difficult to diffuse and dilute [1]. The rapid industrial development has aggravated environmental pollution. The atmospheric environmental problems in the region are monitored, but not further researched or analyzed (such as traceability analysis) [2, 3]. Serious air quality problems will affect the city's economic development, people's health, and lead to corresponding social problems [4-6]. This paper studies and analyzes the air quality in the industrial park and surrounding area of Huinong District, Shizuishan City, with the purpose of revealing the influencing factors of air quality in industrial cities.

2 Research methods and treatment

Huinong District is located at the northern end of Shizuishan City, and its landform consists of the Yellow River alluvial plain, proluvial slope plain, and Helan hilly land. Its climate is characterized by sufficient light and large temperature differences between day and night. According to the Technical Guide for Analyzing the

Source of Atmospheric Particulate Matter (trial), the author sets up monitoring points at appropriate locations in Huinong District to monitor the gas emissions of polluting enterprises in various industries. Then, the author uses SPSS 16.0 statistical software and EIAProA 2008, a professional auxiliary system for atmospheric environmental assessment, to process the data, and analyzes the impact of the industrial park and surrounding environment in Huinong District on the air quality in the urban area.

3 Impact of Hebin Industrial Park on air quality in Huinong Urban District

Hebin Industrial Park is the major industrial park around Huinong District. It is located in the 2.5km due north away from the air automatic monitoring station in Huinong District. The statistics of the emission amount of major emission sources of the Hebin Industrial Park, sulfur dioxide and soot and the emission parameters are put together for analyzing and predicting the degree of impact on the environmental air quality of Huinong urban area by taking polluting enterprises as a point source, using atmospheric pollution forecasting software, and based on meteorological and topographical conditions. The analysis of SO₂ emissions from Hebin Industrial Park is made using the prediction software, as shown in Table 1. Figure 1 shows the one-hour mean concentration contour distribution of PM₁₀ in Hebin Industrial Park in the urban district; Figure 2 shows the 24-hour mean concentration contour distribution of PM₁₀ in Hebin Industrial Park in the urban district.

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Table 1. Forecast results of SO₂ diffusion in Hebin Industrial Park

SO ₂	1 hour average				24 hour average		
	Predictive value (mg/m ³)	Maximum background overlay value	Minimum background overlay value	Background values (mg/m ³)	Predictive value mg/m ³	Background overlay	Background values mg/m ³
Spread to monitoring site	0.756	1.023	0.793	Maximum background value: 0.267 Minimum background value: 0.037	0.043	0.18	0.137
	Predicted maximum contribution rate	2043%			Predicted contribution rate	31%	
	Predicted minimum contribution rate	283%					
Spread throughout the area	1.393	1.66	1.43		0.107	0.244	
	Predicted maximum contribution rate	3765%			Predicted contribution rate	78%	
	Predicted minimum contribution rate	522%					

In the most unfavourable situation, the predicted one-hour average concentration of SO₂ diffused from the Hebin Industrial Park to the automatic station in Huinong urban area is 0.756 mg/m³, which contributes 283% to the maximum background concentration value. After superimposing with the maximum background value, the predicted concentration can reach 1.023 mg/m³, the twice the secondary standard of the one-hour average concentration limit listed in the Air Quality Standard. The AQI score is 228, which can cause severe air pollution at this station. When the weather condition in our city is better (SO₂ concentration = 0.037 mg/m³), SO₂ in Taisha Industrial Park can cause the concentration in the monitoring station to be 0.793mg/m³, which is 1.5 times the one-hour average concentration limit of the Air Quality Standard. The AQI score is 150, which can cause moderate air pollution at this station. Therefore, in some cases, the Hebin Industrial Park can cause severe air pollution in Huinong urban area.

Fig. 1. One-hour mean concentration contour distribution of PM₁₀ of Hebin Industrial Park to Huinong Urban District

Fig. 2. 24-hour mean concentration contour distribution of PM₁₀ of Hebin Industrial Park to Huinong District

Under the most unfavourable conditions, the 24-hour average concentration of SO₂ diffused by the Hebin Industrial Park to the automatic air station in Huinong urban area is 0.043 mg/m³, which contributes 31% to the average daily concentration. The superimposed concentration value is 0.18 mg/m³, and AQI score is 105, which can cause slight air pollution at this station.

4 Impact of mining at Zhengyiguan Mine on air quality in Huinong District

Zhengnongguan Mine is located in the northwest of Huinong District, 12 kilometers away from the environmental monitoring station in this District. The author calculates the amount of dust produced during mining and uses the value to predict the impact of PM₁₀ on Huinong District. The analysis results are shown in Table 2. The distribution of the 1-hour mean concentration contour of the mine non-point source to PM₁₀ in Huinong

urban area is shown in Figure 3; the distribution of the 24-hour mean concentration contour of the mine non-point

source to PM₁₀ in Huinong city is shown in Figure 4.

Table 2. Prediction results of PM₁₀ diffusion value in Zhengyiguan Mine

SO ₂	1 hour average				24 hour average		
	Predictive value (mg/m ³)	Maximum background overlay value	Minimum background overlay value	Background values (mg/m ³)	Predictive value mg/m ³	Background overlay	Background values mg/m ³
Spread to monitoring site	0.003	0.289	0.045	Maximum background value: 0.286 Minimum background value: 0.042	0.0002	0.1442	0.144
	Predicted maximum contribution rate	7%			Predicted contribution rate	0	
	Predicted minimum contribution rate	1%					
Spread throughout the area	0.017	0.303	0.059		0.002	0.146	
	Predicted maximum contribution rate	40%			Predicted contribution rate	1%	
	Predicted minimum contribution rate	6%					

In the most unfavourable situation, the predicted one-hour average concentration of PM₁₀ emitted by the mine to the Dawukou Automatic Air Station is 0.003 mg/m³. After the superposition with the maximum background value, the concentration reaches 0.289 mg/m³, which can cause moderate air pollution at this station. When the air quality in the city is good (PM₁₀ concentration value = 0.042 mg/m³), the superimposed value of the minimum contribution concentration of PM₁₀ to Huinong urban area is 0.045 mg/m³, which does not affect the air quality of Huinong District.

Table 3. SO₂ diffusion prediction of Hongguozi central heating boiler

SO ₂	1 hour average				24 hour average		
	Predictive value (mg/m ³)	Maximum background overlay value	Minimum background overlay value	Background values (mg/m ³)	Predictive value mg/m ³	Background overlay	Background values mg/m ³
Spread to monitoring site	0.865	1.132	0.902	Maximum background value: 0.286 Minimum background value: 0.042	0.079	0.216	0.137
	Predicted maximum contribution rate	2338%			Predicted contribution rate	57%	
	Predicted minimum contribution rate	324%					
Spread throughout the area	0.638	0.905	0.675		0.057	0.194	
	Predicted maximum contribution rate	1724%			Predicted contribution rate	42%	
	Predicted minimum contribution rate	239%					

This paper uses prediction software to predict and analyze the SO₂ emitted by the heating boiler in Hongguozi Town, as shown in Table 3.

In the most unfavourable situation, the predicted one-hour average concentration of SO₂ diffused from the central heating boiler to the automatic station in Huinong urban area is 0.756 mg/m³, which contributes 324% to the maximum background concentration. After superimposing with the maximum background value, the predicted concentration can reach 1.132 mg/m³, 1.3 times higher than the secondary standard of the one-hour average concentration limit listed in the Air Quality Standard. The AQI score is 228, which can cause severe air pollution at this station. When the weather condition in our city is better (SO₂ concentration = 0.037 mg/m³), SO₂ in central boiler can cause the concentration in the monitoring station to reach 0.902mg/m³, 1.8 times the limit of the Air Quality Standard. The AQI score is 213, which can cause severe air pollution at this station. Therefore, the sulphur dioxide hour value of Hongguozi central heating boiler is one of the main reasons leading to

the serious air pollution in winter in Hongguozi Town.

In the worst case, the 24-hour average concentration of SO₂ diffused by the central heating boiler to the Hongguozi automatic air station is 0.079 mg/m³, which contributes 57% to the daily average concentration of this Town. The superimposed concentration value is 0.216 mg/m³, and AQI score is 110. The SO₂ contributed by the central heating boiler can cause slight air pollution. That may also be the reason for slight air pollution in Hongguozi Town in certain meteorological conditions, even when all polluting enterprises meet emission standards.

5.2 Prediction and analysis of PM₁₀ emitted by heating boilers in Hongguozi Town

This paper uses prediction software to predict and analyze the PM₁₀ emitted by the heating boiler in Hongguozi Town, as shown in Table 4.

Table 4. PM₁₀ diffusion prediction of Hongguozi central heating boiler

SO ₂	1 hour average				24 hour average		
	Predictive value (mg/m ³)	Maximum background overlay value	Minimum background overlay value	Background values (mg/m ³)	Predictive value mg/m ³	Background overlay	Background values mg/m ³
Spread to monitoring site	7.629	7.915	7.671	Maximum background value: 0.286 Minimum background value: 0.042	0.693	0.837	0.144
	Predicted maximum contribution rate	18164%			Predicted contribution rate	481%	
	Predicted minimum contribution rate	2667%					
	5.624	5.91	5.91		0.504	0.648	

Spread throughout the area	Predicted maximum contribution rate	13390%		Predicted contribution rate	350%	
	Predicted minimum contribution rate	1966%				

In the most unfavourable situation, the predicted one-hour average concentration of PM_{10} emitted by the boiler to the Hongguozi Automatic Air Station is 7.629 mg/m^3 . After superposition, the concentration reaches 7.915 mg/m^3 , which can cause severe air pollution at this station. When the air quality in the city is good (PM_{10} concentration value = 0.042 mg/m^3), the PM_{10} emitted by the central heating boiler contributes 2667% to the minimum background concentration in the urban area. The superposed concentration reaches 7.671 mg/m^3 and the AQI index is 3861, which can cause serious air pollution at this station.

In the most unfavourable situation, the predicted one-hour average concentration of PM_{10} diffused from the central heating boiler to the Dawukou automatic station is 0.693 mg/m^3 , which contributes 481% to the background concentration value. After superimposing with the maximum background value, the predicted concentration can reach 0.837 mg/m^3 , 4.6 times higher than the secondary standard of the one-hour average concentration limit of the Air Quality Standard. The AQI score is 444, which can cause severe air pollution at this station.

6 Conclusion

According to the forecast analysis, the one-hour contribution values of SO_2 and PM_{10} of the Hebin Industrial Park are 0.756 mg/m^3 and 0.444 mg/m^3 , respectively. After superposition, the concentration values reach 1.023 mg/m^3 and 0.730 mg/m^3 , exceeding the limits listed in Air Quality Standard, causing severe air pollution in Huinong District. That is the main reason for the serious air pollution in Huinong District in some time periods. Zhengyiguan has a little impact on the air quality in Huinong District, while Wusutai Industrial Park and Lazeng Temple Industrial Park in Wuhai City have a certain impact on the air quality in this District.

The municipal heating company of Hongguozi Town, Hui'an City is equipped with no desulfurization facilities for centralized heating boilers, therefore producing out-of-limit sulfur dioxide and smoke and dust, exerting a significant impact on the air quality of Hongguozi Town in Huinong District. According to the prediction analysis, the one-hour contribution values of sulfur dioxide and PM_{10} emitted by heating companies are 0.865 mg/m^3 and 7.629 mg/m^3 , respectively. After superimposition, the values reach 1.132 mg/m^3 and 7.915 mg/m^3 , respectively, exceeding the limit of Air Quality Standard, leading to severe air pollution at this station. That is the main cause of serious air pollution in Hongguozi Town during a certain period, especially during the heating nights. The 24-hour contribution values of sulfur dioxide and PM_{10} emitted by heating companies are 0.865 mg/m^3 and

0.693 mg/m^3 . After superimposition, the values reach 0.216 mg/m^3 and 0.837 mg/m^3 , respectively, exceeding the limits listed in Air Quality Standard, leading to severe air pollution at this station. That is the main reason for the severe air pollution in Hongguozi Town in winter.

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