

Cause Analysis and Prevention Countermeasure of Air Pollution in Zhengzhou cityLe Yuan¹, Lijian Xue², Wenqian Huo¹, Yueqin Wang¹, Quanjun Lv¹, Yang Li¹, Huizhen Zhang^{1*}¹.College of Public Health, Zhengzhou University, Zhengzhou, Henan, 450001, China².Kaifeng Center For Disease Control & Prevention, Kaifeng, Henan, 475004, China

Abstract Objective: To analyze the causes of air pollution in Zhengzhou and put forward measures for preventing and controlling air pollution. **Methods:** Based on the data of ambient air quality monitoring in Zhengzhou from 2013 to 2016 and the emission of air pollutants from 2011 to 2015 in Zhengzhou, the energy utilization structure of Zhengzhou, the fuel type of urban residents, the fuel structure change, the emission intensity of the harmful material produced by combustion and the management measures were investigated and analyzed; **Results:** The energy consumption structure dominated by coal is the main cause of air pollution in Zhengzhou. The exhaust emissions, construction dust and straw burning aggravated the air pollution. It is recommended to adjust the energy structure, improve the law enforcement of environmental protection, develop the eco-industrial and recycling economy, and strengthen the eco-city planning.

Keywords: Zhengzhou city; Air pollution; Prevention and control measures

Clean air is the basic requirement for the comfort of urban residents. According to surveys conducted by 20 major cities in the world, WHO and the United Nations Environment Organization believe that air pollution has become an unavoidable reality in the lives of urbanite throughout the world [1]. In recent years, with the rapid economic development in our country, energy consumption is rising sharply, the number of motor vehicles is increasing dramatically, and urban air pollution has become very serious [2]. In the ranking of 74 key cities in China, according to the Comprehensive Environmental Air Quality Index by the Ministry of Environmental Protection, since 2013, the last ten cities are basically located in the Beijing-Tianjin-Hebei region and the surrounding areas. Zhengzhou is always at a situation of heavy pollution and it became more serious year by year, and it was the third worst in the first half of 2016 in China [3]. In recent years, Zhengzhou has made some progress in the comprehensive improvement of urban air pollution. However, the air pollution is still relatively serious, and it has been endangering the public's health seriously [1]. In order to improve the air quality and the living environment of urban residents, strengthening the control of air pollution and improving the quality of urban air environment have become a very urgent task.

1. Investigation on energy utilization structure of Zhengzhou

1.1 The fuel structure changes of urban residents in Zhengzhou

Zhengzhou City is located in the Central Plains. With the acceleration of urbanization, the level

of industrial development has been rapidly increasing [4]. The emission of environmental pollutants is on the increase, and the air pollution problem has become increasingly serious. Meanwhile, the government attaches more and more importance to the living environment of residents. Not only does the awareness of environmental protection is improved, but also residents' fuel consumption and fuel structure are quietly changing. Ten years ago, most families used coal as main fuel in Zhengzhou, a little family used liquefied petroleum gas and natural gas. In recent years, urban households mainly use natural gas, some family use liquefied petroleum gas, few family use the coal. According to the survey, the proportion of coal in the fuel structure of residents is declining. At the same time, the proportion of natural gas in the fuel structure of residents is gradually increasing. The change of fuel structure has made a great contribution to improve the urban environment, and it provides a good way for Zhengzhou to create a green environment-friendly city.

1.2 Investigation on the pollutants occurred by residents' living fuel in Zhengzhou

The coal burning consumes more than 30 million tons a year in Zhengzhou, accounting for more than 70 percent of energy consumption [5]. At present, the air pollution is still dominated by soot type in Zhengzhou [6]. Coal combustion plays a leading role in air pollution. Pollutants mainly come from the combustion of industrial coal; other pollutants come from coal-fired heating boilers and domestic stoves. The consumption of residential fuel is closely related to the environment. The current fuel types mainly

produce sulfur dioxide, nitrogen oxides, soot and even harmful substances such as carbon monoxide and formaldehyde [7]. These pollutants will aggravate the environment and further threaten people's health. The relevant emission values of major pollutants are shown in table 1.

From table 1, we can see that the coal produces more pollutants than other fuel in the combustion process. And the liquefied gas produces fewer pollutants than the coal. When the natural gas is burned, the types of harmful substances released are relatively few, and the concentrations of pollutants are few too. So the natural gas is a clean energy.

Table 1 The emission value of harmful substances produced by fuel combustion in the atmosphere

Fuel	Hazardous substances produced by burning (mg/kg)			
	Sulfur dioxide	Nitrogen dioxide	Carbon monoxide	Formaldehyde
Coal	306.3	385	4105	5.62
Liquefied gas	0	1040	1267	21.7
Natural gas	100	0	1267	0

1.3 Investigation of the measures taken to control the pollutants generated by various energy sources

Henan is rich in coal resources. In Zhengzhou city, the coal-based energy consumption pattern will not change obviously over a long period of time [8]. In response to the pollutants generated after burning, the current management measures mainly include the deep processing of fuel and the technology of fuel pollution control. The technologies of coal deep processing mainly include coal washing, screening technology, developing coal technology, the development of power coal blending technology, liquefaction technology of coking coal and the application of coal-water slurry technology. The technologies of pollutant controlling include sulfur dioxide control technology, nitrogen oxide control technology and smoke control technology [9-10]. There is no a very effective way to control the pollutants generated by civilian fuels. Therefore, to strengthen residents' awareness of environmental protection and guide residents to choose clean energy maybe a good choice. Furthermore, in order to achieve the purpose of protecting the atmosphere, we can improve the

efficiency of and take fuel saving measures to reduce pollutant emission.

2. The investigation of existing air pollution in Zhengzhou

2.1 Investigation of existing air pollution sources in Zhengzhou

According to the major pollution sources and the emission of major air pollutants from 2011 to 2015 obtained by Zhengzhou Environmental Protection Bureau [11], the main sources of air pollutants in Zhengzhou include industrial sources, urban living sources, motor vehicles and centralized management facilities. The specific pollutant emissions of various sources from 2011 to 2015 are shown in table 2.

Table 2 showed that the emission of major air pollutants in Zhengzhou in recent years. According to the emission of pollutants from various sources, the emission of pollutants produced by industrial sources is relatively higher than that produced by other pollution sources. And the emission of pollutants produced by industrial sources is at a larger share of all pollutants. From the perspective of pollution sources, the air pollution is mainly caused by industrial production in Zhengzhou.

Table 2 The annual average emissions of pollutants from 2011 to 2015

Pollution source	The emissions of pollutants (ton/year)					
	Sulfur dioxide		Nitrogen oxides		Smoke dust	
	ton/year	percentage	ton/year	percentage	ton/year	percentage
Industrial sources	99399.07	90%	128967.53	67.55%	38631.98	71.39%
Urban living sources	11379.57	10%	1918.04	1.00%	9640.00	17.82%
Motor vehicles	---	0	60015.92	31.45%	5836.89	10.79%
Centralized management facilities	6.89	0	9.66	0	2.51	0
Total	110785.53	100%	190911.15	100%	54111.38	100%

2.2 The situation of the main air pollutants in Zhengzhou

The current situation of air pollution presents a trend of changing from soot to a compound type in

Zhengzhou [12]. The annual emissions of air pollutants are larger, mainly include sulfur dioxide, nitrogen oxides and smoke dust. The total emissions of pollutants from 2011 to 2015 are shown in table 3.

Table 3 The total discharge of pollutants from 2011 to 2015

Time (year)	The emissions of pollutants (ton year ⁻¹)		
	Sulfur dioxide	Nitrogen oxides	Smoke dust
2011	116870.44	210232.51	53011.64
2012	119453	216123	39007.91
2013	118100.01	197400.04	48756.85
2014	104621.62	178315.25	62591.46
2015	94882.61	152484.94	67189.03
Average	110785.54	190911.15	54111.38

2.3 Comprehensive analysis of existing air pollution sources in Zhengzhou

The figure 1~3 shows the pollutant emission of various pollution sources in Zhengzhou, the proportion of pollutants produced by industrial sources is relatively high, and the amount of pollutants produced by urban living sources is slightly lower than that produced by industrial sources. The amount of nitrogen oxides produced by motor

vehicles is higher than that produced by other pollution sources, and motor vehicles sources do not produce sulfur dioxide. The proportion of pollutants produced by centralized governance facilities is relatively small. Comprehensive comparison of these pollution sources, the pollutants produced in the process of industrial production have a greater influence on the air pollution in Zhengzhou.

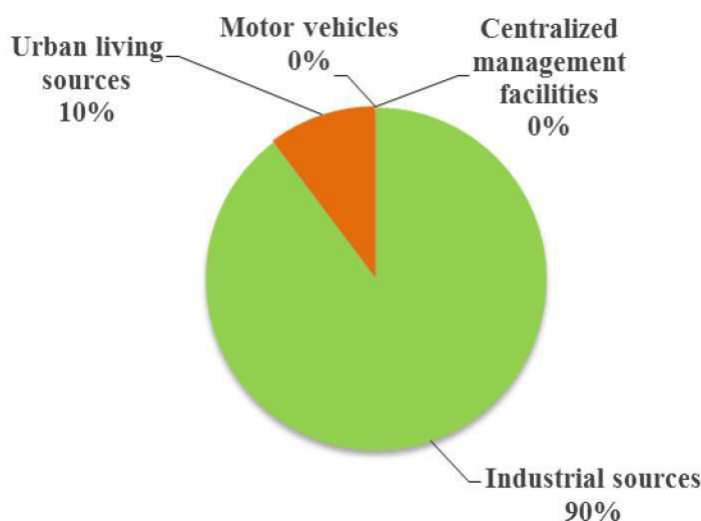


Figure 1 The scale map of sulfur dioxide emissions from various pollution sources

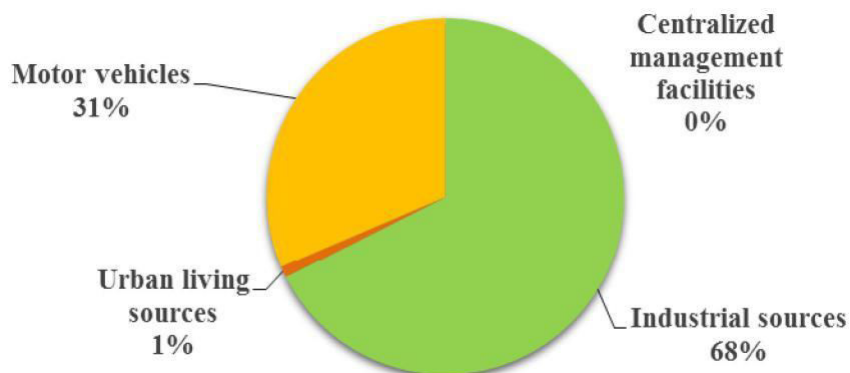


Figure 2 The scale map of nitrogen oxides emissions from various pollution sources

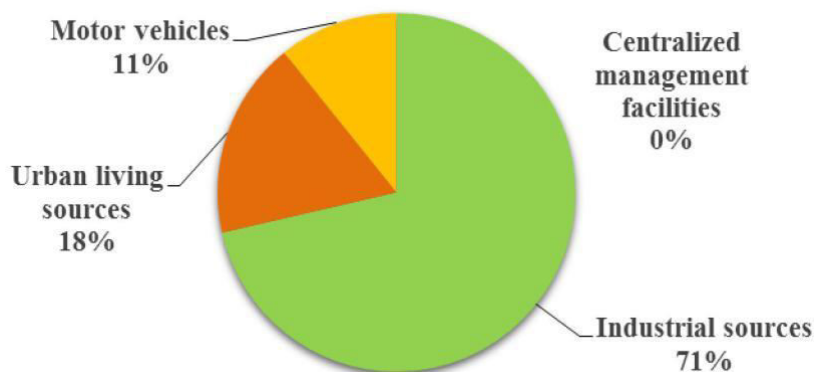


Figure 3 The scale map of smoke dust emissions from various pollution sources

3. Investigation and analysis of atmospheric pollutants monitoring in Zhengzhou for nearly four years

In order to understand the change of atmospheric environment in Zhengzhou, we collected the routine monitoring data of Zhengzhou from 2013 to 2016^[13]. The routine monitoring data mainly include the environmental quality index, sulfur dioxide concentration, nitrogen dioxide concentration and PM10 concentration, and the specific annual average data is shown in table 4. From table 4 and figure 4, we

can find that the annual mean of the AQI, NO₂ and SO₂ in Zhengzhou shows a downward trend during the period from 2013 to 2016. However, the concentration of NO₂ had been declining, the other three index had raised again in 2015. This change shows that the trend of air pollution control also has repeated phenomenon. Therefore, the air pollution control effect in Zhengzhou is not accomplished overnight, the comprehensive management of air pollution has a long way to go.

Table 4 The annual mean of atmospheric monitoring pollutants from 2013 to 2016

Time (year)	Annual average			
	AQI	SO ₂ (μg/m ³)	NO ₂ (μg/m ³)	PM10 (μg/m ³)
2013		2	2.2	
2014	122.83	145.33	1.80	87.83
2015	135.08	167.42	1.53	95.92
2016	123.92	144.50	1.49	78.58

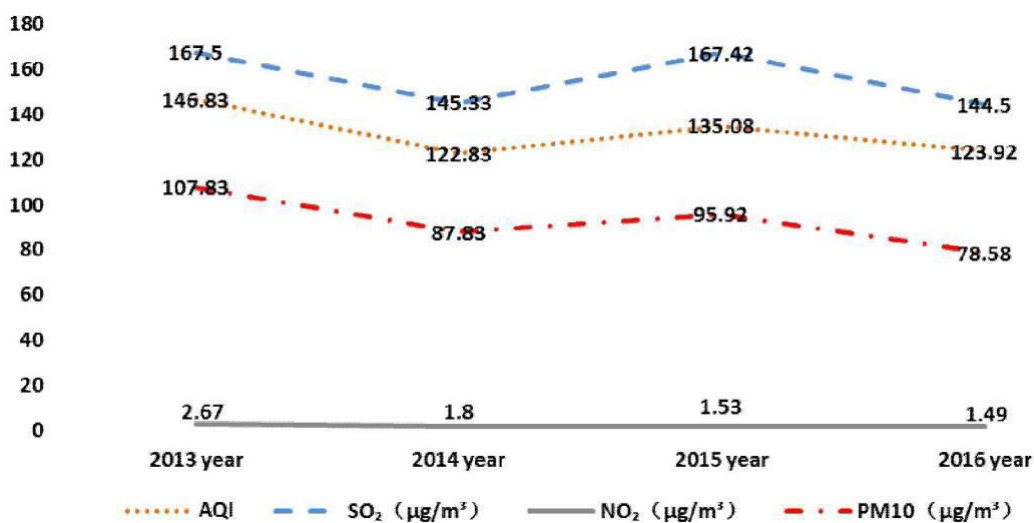


Figure 4 The annual average change of environmental air quality in Zhengzhou from 2013 to 2016

4. Analysis on the causes of atmospheric environment pollution in Zhengzhou and measures for prevention and control

4.1 Analysis on the causes of air pollution in Zhengzhou

The coal-based energy consumption structure is the main reason for air pollution in Zhengzhou. According to statistics, 87% of sulfur dioxide, 67% of nitrogen oxides and 60% of soot are from the coal burning [14]. The motor vehicle exhaust is another important reason for air pollution in Zhengzhou [15]. In addition, there are some other reasons for air pollution. To begin with, it is difficult for pollution control, and the pollution treatment facilities usually have the work stopping phenomenon. What's more, the underlying emissions phenomenon of pollutants is common. Straw burning is playing an important role that can not be ignored in air pollution in Zhengzhou. There has been a lot of research about the current comprehensive utilization of straw technology, but it hasn't been popularized. The phenomenon of straw burning is common, which can aggravate the air pollution [4]. Sandstorm and dust in the north are one of the important factors for air pollution in Zhengzhou. On the one hand, Zhengzhou is located in the south bank of the Yellow River beach with sandy soil. In addition, the spring is often affected by dust storms from the north, causing the dust on the ground to rise [16]. On the other hand, as the scale of the city expanding and the construction site increasing, the construction dust can be seen everywhere, which greatly aggravate the air pollution [5].

4.2 Prevention and control measures of air pollution in Zhengzhou

(1) There are some measures for prevention and control of air pollution, such as adjusting the energy structure rationally, speeding up the work of replacing coal with clean energy such as gas and electricity, improving the use of natural gas, promoting geothermal energy and solar energy steadily, and reducing the consumption of coal-fired power continually. Furthermore, we can improve the energy efficiency and adjust the energy consumption structure.

(2) The government should develop the eco-industry and circular economy energetically. So, apart from promoting waste recycling and reducing pollution emissions, it could maximize the use of materials and energy entering the system.

(3) In the straw burning pollution issue, we might find solutions from the perspective of problems of externality to find new ways of economic incentive to solve the problem, to realize the transition from the traditional concept of governance to a comprehensive utilization.

(4) The air pollution in Zhengzhou would be alleviated by the reasonable adjustment of urban industrial enterprises.

(5) We could further promote the use of natural gas vehicles and establish a high-quality and efficient public transport system to reduce the pollution of automobile exhaust.

(6) The government should strengthen environment protection enforcement and we should improve our environmental awareness.

(7) The government should step up efforts to control and reduce the pollution from the pollutant sources of factories and enterprises.

(8) Taking effective measures is a good way to control the generation and diffusion of building dust.

(9) The government should improve urban public facilities and increase green planting coverage.

5. Conclusion

The air pollution is the result of a combination of many factors in Zhengzhou. The prevention and control of air pollution is a complicated project. It involves urban planning, construction, municipal administration, transportation, energy, industry, agriculture and other sectors [17]. So, the government, enterprises, public institutions and the public should work together in the management of air pollution. Managers must start with the prevention and reduction of atmospheric pollutants, and take into account the expansion of atmospheric environment capacity. Furthermore, the managers also need improving the levels of prevention and treatment of urban air pollution constantly. Meanwhile, the government should set stricter control measures over the emission standards for pollution sources and strengthen supervision and punishment. Most importantly, everyone must attach importance to the problem of air pollution and raise their awareness of environmental protection. As long as everyone pays their own efforts for clean air, the problem of environmental pollution will be far away from us.

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