Characteristic Analysis of Ambient Air Pollutants during Summer Season in Shenyang City

Cheng Liu, Zhonghu Yuan, Yingkui Du[*], *Chunhe Shi, Yutong Gao, Xiaoxuan Qi, Nan Wang, and Xiaowei Han*

Shenyang University, School of Information Engineering, Key Lab of Equipment Manufacturing Comprehensive Automation, 110044 Shenyang, China

Abstract. Shenyang City was the political, economic and cultural centre of the northeast China and was also a heavily polluted industrial city. The understanding of the distribution characteristics of air pollutants concentration and changes was still lacked. To reduce the impact of disturbing factors such as firecrackers in the traditional Chinese festivals, the observation period of the monitoring data was selected from 17th May to 21st July in 2016. The data sources were picked from eight national monitoring stations and the daily average concentration of the main air pollutants that included $PM_{2.5}$, PM_{10}, SO_2, NO_2 and O_3. The overall analysis of distribution characteristics of the air pollutant was shown that the principal pollutants with highest frequency were O_3 and PM_{10}, the average proportion was 74.1% and 20.8% respectively.

1 Page layout

Shenyang was a representative manufacturing industrial city with industry with heavy air pollution. The city was the political, economic and cultural center of the northeastern China and was located in the heart of the Northeast Asian economic circle and the Bohai Sea economic circle.

Shenyang City located in central region of Liaoning Province. The terrain was mainly consisted of flat plain. The average altitude was about 50 meters and the east region was lower than the west. The north of Shenyang City was close to the south Horqin desert of the Inner Mongolia Autonomous Province and was threatened by sandstorm. Shenyang belongs to the northern temperate monsoon-influenced semi-humid continental climate.

The industry of Shenyang City was mainly included the traditional heavy industry such as coal, metallurgy, power, chemical and machinery manufacturing. With the process of urbanization and the rapid economic development, serious environmental problems especially the compound air pollution were arisen[1]. As the Shenyang Environmental Status communique in 2014[2] shown, the annual concentration of PM_{10} and $PM_{2.5}$ has reached 124μg/m³ and 74μg/m³ respectively that were the 3.1 and 4.9 times of the Chinese ambient air quality standard respectively. The annual good quality air quality was only 191 days. The atmospheric environment qualities of Shenyang City were ranked the last 15th and the last 11th during the 74 key cities in 2013 and 2014 years.

The understanding of the distribution characteristics of air pollutant concentration and changes was still lacked[1,7]. This main contribution was to analyze the characteristics of primary air pollutions of the $PM_{2.5}$, PM_{10}, SO_2, NO_2 and O_3 during summer season in Shenyang that was driven by the data of daily average concentration released by Shenyang environmental monitoring stations.

2 Data and methods

The data referred to in this paper were the monitoring data of air pollution during the heating season of 8 Shenyang environmental air quality monitoring stations. The time period was from 17 May to 21 July in 2016, 65 days total.

The data mainly include the daily average concentrations of $PM_{2.5}$, PM_{10}, SO_2, NO_2 and O_3 of the eight national monitoring stations which were released by Dongling Road, Jing Shen Street, Xiaoheyan Road, Culture Road, Xinxiu Street, Hunnan East Road, Lingdong Street and Taiyuan Street.

The R language was selected as the tool to realize the analysis and graphing the results. The obvious advantages of the R language were that it was open source and free with Built-in utility function with a large number of dedicated for statisticians.

Statistical methods were utilized for the analysis of the contribution characteristics of ambient air pollution. The occurrence proportion was defined as the proportion of the number of days of air pollutant occurred in the total number of days of the sample data to evaluate the occurrence frequency of the primary air pollutions. The

* Corresponding author: Yingkui Du, syu_dyk@163.com

distribution characteristics of the main air pollutants were plotted and shown by the boxplot tools of the R language.

3 Results and discussion

3.1. Overall distribution characteristics

The daily average concentrations of $PM_{2.5}$, PM_{10}, SO_2, NO_2 and O_3 air pollutants in Shenyang summer period were shown in Fig 1. The proportions of the number of days of the primary air pollutants occurred in the total number of days were calculated at the beginning and the distribution of the main pollutants as the primary pollutant was analyzed.

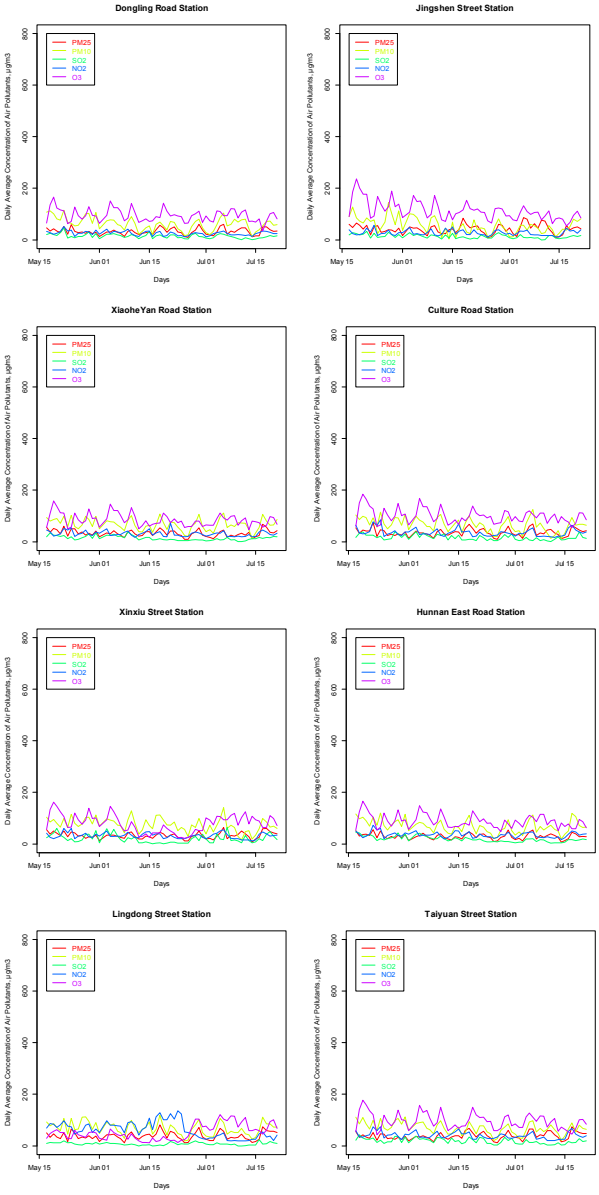

Fig. 1. Daily average concentration of pollutants during summer season

For the quantitative analysis that was shown in Table.1, the proportion of the number of days of occurrence of primary air pollutants includes two types: the independent proportion of each monitoring point and the average proportion. The principal pollutants with highest frequency were O_3 and PM_{10}, the average proportion was 74.1% and 20.8% respectively. The number of days that O_3 appears as the primary pollutant were 58, 63, 49, 57, 31, 51, 22 and 57respectively, and the proportions were 89.3%, 95.5%, 74.2%, 87.8%, 48.4%, 78.5%, 32.9% and 86.4% respectively, the mean was74.1%.

The PM_{10} was the 2nd pollutant in the sample data of 8 national monitoring stations The number of days was 7, 2, 17, 7, 34, 14, 20 and 9, the proportion was 10.7%, 3.0%, 25.8%, 10.7%, 51.6%, 21.5%, 29.8% and 13.6% respectively.

Table 3. The total proportion of the primary air pollutant

Station	$PM_{2.5}$		PM_{10}		SO_2		NO_2		O_3	
	D	P	D	P	D	P	D	P	D	P
Donglin g Road	——	——	7	10.7%	——	——	——	——	58	89.3%
Jingshen Street	1	1.5%	2	3.0%	——	——	——	——	63	95.5%
Xiaohey an Road	——	——	17	25.8%	——	——	——	——	49	74.2%
Culture Road	——	——	7	10.7%	——	——	1	1.5%	57	87.8%
Xinxiu Street	——	——	34	51.6%	——	——	——	——	31	48.4%
Hunnan East Road	——	——	14	21.5%	——	——	——	——	51	78.5%
Lingdon g Street	——	——	20	29.8%	——	——	25	37.3%	22	32.9%
Taiyuan Street	——	——	9	13.6%	——	——	——	——	57	86.4%

*The D denotes the total number of days; the P denotes the proportion of each pollutant occurred.

According to the above analysis, it can be seen that the O_3 was the most important air pollutant with the highest occurrence proportion during the summer season. According to the average proportion of the main air pollutants as the primary pollutants, the PM_{10} Particle matter was ranked as the second one.

It was necessary to carry out special case that the average daily concentration of NO_2 as the primary pollutant during the summer season was 25 days in the data of Lingdong Street national monitoring station.

3.2 Fluctuation characteristics of main air pollutants

As shown in Fig 2, the fluctuation characteristics of the main air pollutants was displayed and analyzed using the box diagram method. The $PM_{2.5}$, PM_{10}, SO_2 and NO_2 fluctuation characteristics were regular and stable.

From the Fig 2, it was obviously can be seen that the region that nearby the road with larger traffic flow was with the lower fluctuation of the daily average concentration of O_3, such as the stations of the Jing Shen Street, Culture Road, Hunnan East Road and Taiyuan Street. On the contrary, lower traffic flow was corresponding to higher concentration in the regions of Dongling Road, Xiaoheyan road, Xinxiu Street and

Lingdong Street. As were shown in Table 2. To understanding the characteristics of the spatial distribution, the comparative analysis of the data of the 8 national stations will be done.

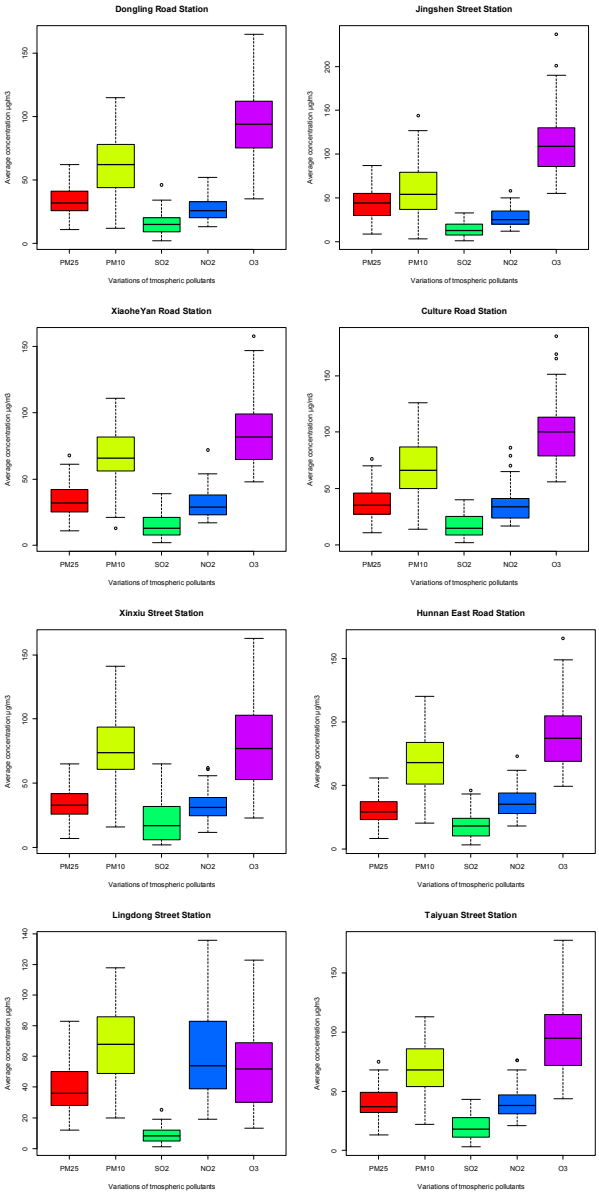

Fig. 2. Fluctuation characteristics of major air pollutants

Table 2. The statistical analysis in boxplots

	Dong ling Road	Jing shen Street	Xiao heyan Road	Culture Road	Xin xiu Street	Hunnan East Road	Ling dong Street	Tai yuan Street
1st Qu	75	86	65	79	53	69	30	72
Median	94	109	82	100	77	87	52	95
3rd Qu	112	130	99	113	103	105	69	115

3.3 Locations of the monitoring Station and corresponding urban areas

The locations of the 8 national monitoring stations involved in this paper and the corresponding urban area were shown in Table 3. The geographical location of each urban area was different, so its air pollution sources were largely different inevitably.

According to the results of the data analysis, the urban areas were divided into two types by the traffic flow that were denoted as the relative larger traffic flow urban area and the relative lower traffic flow urban area. The two types of urban area were referred to as larger flow area and lower flow area.

Table 3. The classification of urban corresponding to different monitoring station

Station	Urban Area	Location
Dongling Road	Qipanshan Development Dwastrict	3rd cyclic
Jing Shen Street	Shenbei New Dwastrict	3rd cyclic
Xiaoheyan road	Dadong Dwastrict	1st cyclic
Culture Road	Heping Dwastrict	1st cyclic
Xinxiu Street	Hunnan New Dwastrict	3rd cyclic
Hunnan East Road	Hunnan New Dwastrict	3rd cyclic
Lingdong Street	Huanggu Dwastrict	1st cyclic
Taiyuan Street	Heping Dwastrict	1st cyclic

3.4 Distribution characteristics of O_3 pollutant

As were shown in Table 4, the maximal daily average concentration of O_3 was 237μg/m³ in Jing Shen Street station, the minimum daily average concentration was 13μg / m³ in Lingdong Street station.

The maximal mean value of the daily average concentration of O_3 was 114.8μg/m³ in Jing Shen Street station, the minimum mean value was 54.6μg / m³ in Lingdong Street station. The mean value of the daily average concentration of O_3 in Jing Shen Street station was twice more than the mean value of Lingdong Street site.

Table 4. Primary air pollution distribution of the core area

National Monitoring Station	Daily Average Concentration of O_3 (μg/m³)		
	Max	Mean	Min
Dongling Road	165	96	35
Jing Shen Street	237	114.8	55
Xiaoheyan road	158	85.6	48
Culture Road	185	101.3	56
Xinxiu Street	163	80.3	23
Hunnan East Road	166	89.9	49
Lingdong Street	123	54.6	13

From the Table 4, it was obviously can be seen that the larger flow area was with the higher daily average concentration of O_3, such as the national monitoring stations of the Jing Shen Street, Culture Road, Hunnan East Road and Taiyuan Street.

On the contrary, lower flow area corresponding to the lower concentration. This type regions include Dongling Road, Xiaoheyan road, Xinxiu Street and Lingdong Street.

The mean value of the mean daily average concentration of O_3 in larger traffic flow region was 100.7μg/m³ and the mean value of the lower traffic flow region was 79.1μg/m³, which was lower about 21.4%.

4 Summary

The distribution characteristics of the major air pollutions in Shenyang City during the summer season were analyzed from different aspects. The overall analyzes of distribution characteristics of the air pollutant was shown that the principal pollutants with highest frequency were O_3 and PM_{10}. The mean proportion was 74.1% and 20.8% respectively. The regions that nearby the road with larger traffic flow can be confirmed with the lower fluctuation of the average concentration of O_3. It has active significance for the government decision making by providing necessary scientific basis and data support.

Acknowledgment

This work was supported by Science and Technology Program of Shenyang City (F16-155-9-00, 17-180-9-00) and Science and enterprise competitive selection project of Shenyang City (Study on the risk management and remediation technology of urban ecological environment).

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