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Research Article

Study on Spatial Temporal Distribution Characteristics of Air Quality Index in Beijing and Its Correlation with Local Meteorological Conditions

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The changing of AQI presented by historical observations has significant meaning to the urban air pollution prevention. In order to explore the correlation between air quality and meteorological condition in Beijing from 2014 to 2017, researchers processed 52165 sample data from 35 air monitor stations by means of R statistical software, analyzed the spatial temporal distribution characteristics of air quality index (AQI) with Kriging and mathematical statistics and did the research on correlation between spatial temporal distribution characteristics of AQI and meteorological condition. The results showed that (1) the spatial increasing trend of AQI is obvious from the north to the south in Beijing zone, representing that the air quality is getting worse from the north to the south; (2) the diurnal variation of daily AQI value reveals interannual periodic trend and a relatively great fluctuating range from 485 to 0. (3) The correlation coefficients of daily AQI mean with average temperature, specific humidity and wind speed are −0.116, −0.073 and −0.192 respectively, displaying that all of the three factors are negatively correlated with AQI and average temperature and wind speed are significantly negatively correlated. The results provide a reference for regional environmental management and pollution prevention and control.

1. Introduction

With the rapid development of economy and urbanization, the city air pollution has become one of the most severe environmental problems in China [1]. In recent years, air pollution like haze and dust-haze happened successively in some parts of China. For example, an extremely severe haze hit North China in January 2013, covering 15% of the land area and affecting nearly 800 million people [2]. Such pollution not only has an adverse impact on atmospheric visibility and regional climate, but also poses a great threat to public health and life [3]. Such pollution not only has an adverse impact on atmospheric visibility and regional climate but also poses a great threat to public health, life and biological processes [4]. In order to reflect air quality more accurately and facilitate citizens' understanding, air quality index (AQI) is adopted to replace air pollution index (API) and become the new assessment indices of air quality. According to that, the detection objects add PM2.5, CO and O_3 on the basis of PM10, SO_2, NO_2; In addition, it requires the pollutant concentration statistics to be published hourly rather than original once a day. The changes conduce to reflecting air quality timely and effectively, promoting domestic research and protecting public health.

At present, focus on domestic and abroad research on air quality is different. For example, developed countries mainly focus on the development of air quality model, the analysis and control of pollutant emission source, the forecasts and alerts of air quality [5, 6]. Among the most common developed air quality models, CMAQ (Community Multiscale Air Quality) is mainly used to simulate the discharge of urban particulate pollutants under certain meteorological conditions [7]. While developing countries such as Iran and India place emphasis on the changing trends and characteristics of major air pollutants [8–10]. Domestic related research mainly includes algorithm, change trend analysis, air quality assessment model, and the effects of air pollution on human health, etc. [11–14]. For example, Cai et al. [15] used WRF-CMAQ to make a staged systematic analysis of the influence of emission control sources on PM $_{2.5}$. Liu et al. [16] described and analyzed the spatial temporal characteristics of air quality via remote-sensing data and landscape indexes. Distinguished from former research where most investigated sites are limited in Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl Delta, the research on the spatial temporal distribution and causes of AQI today has become nationwide and been extended into municipalities and provincial capitals [17–22]. Related research has proved that the main factors affecting air quality are industrial emissions from urban areas and their surroundings [23]. Among those factors, meteorological condition is an influential one correlated with air pollutant concentration obviously, and its constitutive elements include relative humidity, wind speed, precipitation and atmospheric temperature, etc. [24]. Beijing, the political and cultural center of China, sustains large population and severe air pollution but lacks long-term scale research as well as the comparison between long- and short-term research due to the late application of AQI.

Therefore, in the current research, researchers take Beijing air quality and meteorological factors as objects, collect the 2014–2017 real time data of air quality index and related meteorological factors, analyze the spatial temporal distribution characteristics of Beijing AQI and its correlation with local meteorological factors via statistical analysis and Kriging method, refer to former research data and finally conclude the main factors influencing AQI. The significance of the research is to help the Beijing environmental governance.

2. Materials and Methods

2.1. Research Area. Because of its important human geography status, Beijing (E115.7°–117.4°, N39.4°–41.6°) is chosen as the research area in the current paper. Located in the north of North China Plain, Beijing is adjacent to Bohai Bay and covers 16410.54 square kilometers. Its terrain, average elevation 43.5 meters, is the northwest high and southeast low. Such geography makes it the typical sub-humid temperate and monsoonal climate with hot-rainy summers and cold-dry winters and the average annual sunshine are between 2000 and 2800 hours. Apart from those geographical features, the metropolis has mature infrastructure including 12 urban environmental evaluation sites, 11 suburban environmental evaluation sites, 1 urban clean reference sites, 6 regional background transmission sites, and 5 traffic pollution monitoring sites (shown in Figure 1).

2.2. Data Resources. The 35 real time AQI data from 2014.1.1 to 2017.12.31 in the current paper are from Beijing Municipal Environmental Monitoring Center Website (http://www.bjmemc.com.cn/index.jsp). And the hour data of meteorological elements such as temperature, wind speed, wind direction, specific humidity, etc. come from National Meteorological Information Center Website (http://data.cma.cn/).

Air Quality Index (AQI) is a dimensionless constant used by researchers to reflect air quality quantitatively. The air quality of one area during a certain period is described as the AQI categories: the larger value, equal to the higher grade, means the worse air quality and the greater harm to human health, and vice versa. The mass concentration limit refers to the second standard of GB 3095—2012 Ambient Air Quality Standards, which is shown in Table 1.

2.3. Methods. Use interpolation method by ArcGIS10.3 to analyze the spatial distribution regularities. Make a data preprocessing with R statistical software to delete data gaps and count valid data so as to conclude temporal distribution regularities of the Beijing air quality. Do a correlation analysis on AQI and meteorological elements to identify their correlation with the method of Pearson correlation coefficient.

After comparing different methods used in former related research, it is found that Kriging method is an ideal method to study the spatial distribution of air quality. According to the Kriging method, when the structural component of the spatial variable is determined, the residual difference belongs to the type of homogeneous change, and the difference between different positions is only a function of distance. And the computational formula is as follows:

$$z(x_0) = \sum_{i=1}^{n} \lambda_i z(x_i), \tag{1}$$

where, $z(x_0)$ is the estimated value at x_0, $z(x_i)$ is the observed value at x_i, λ_i is Kriging weight coefficient, and n represents the number of observation sites.

Pearson correlation coefficient is a statistical index to reflect the close degree of correlation between variables, and the correlation degree between any two variables is reflected by the product of two deviation. And the method of Pearson correlation coefficient r is:

$$r = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \times \sum_{i=1}^{n} y_i}{\sqrt{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i^2\right)^2} \times \sqrt{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i^2\right)^2}}, \tag{2}$$

where, n is sample size, x means the observed value of variable and y represents the mean value of variable.

3. Results and Discussion

3.1. Analysis of Spatial Feature. The 2014–2017 AQI spatial distribution by Kriging method is revealed in Figure 2.

Figure 2(a) shows the spatial distribution of 2014 AQI mean, ranging from 93 to 157. The minimum value of 92.9 appears in the northernmost area, Miyun Reservoir. And the maximum, 157.1, shows in the southwest area, Liuli River. The 2014 AQI mean in the southern region ranges from 140 to 150, and that of the central urban area is from 110 to 130. From the Figure 2(a), it is observed that the annual AQI mean in the northern regional monitoring sites is significantly smaller than that in the central and southern regions, and the AQI in the west of Beijing is significantly smaller than that in the eastern part of the city. The AQI value, which increases from the north to the south, illustrates the air quality becomes worse from the north to the south.

Figure 2(b) illustrates the spatial distribution of 2015 AQI mean. Obviously, the AQI value of the south is distinguished

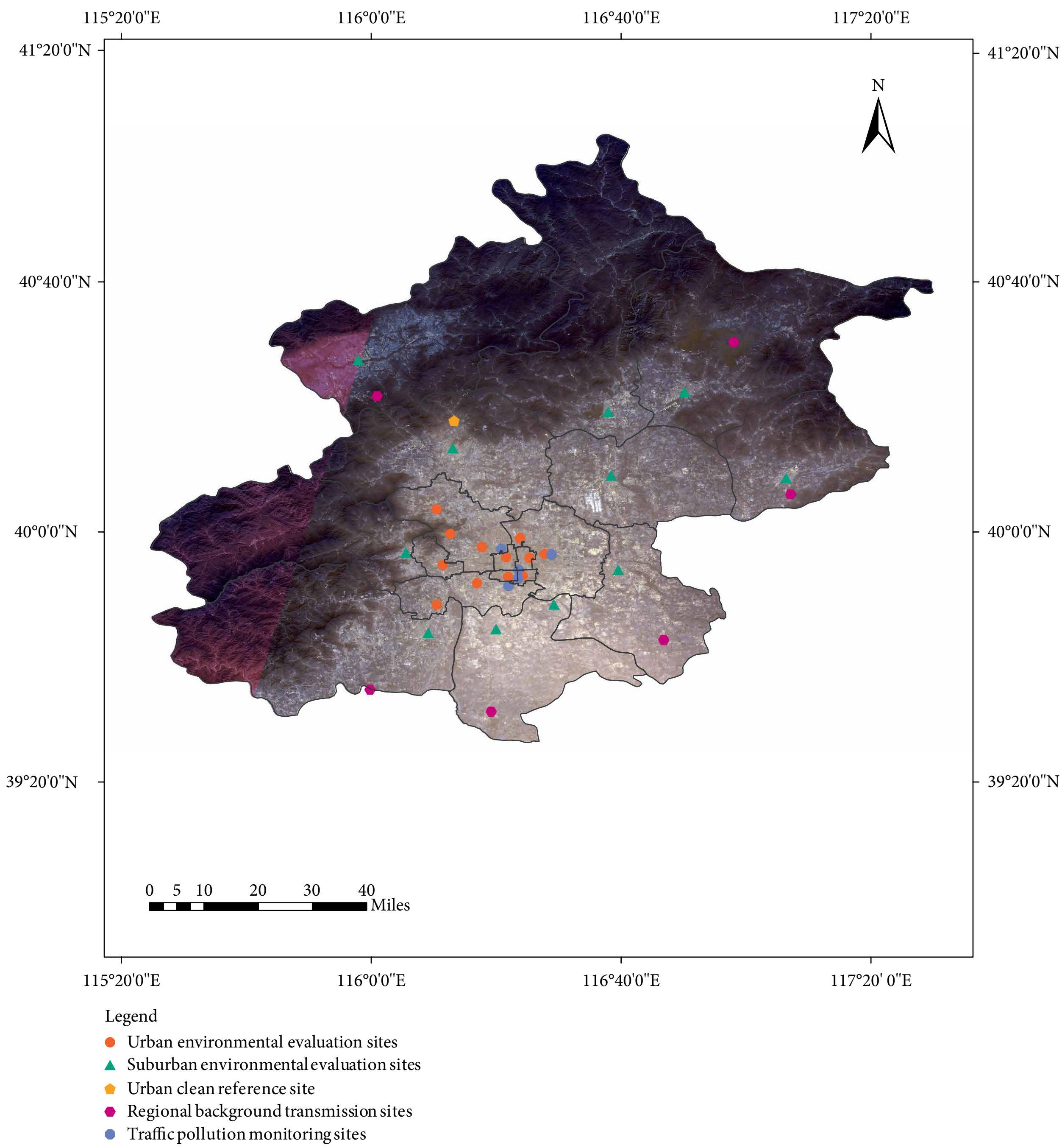
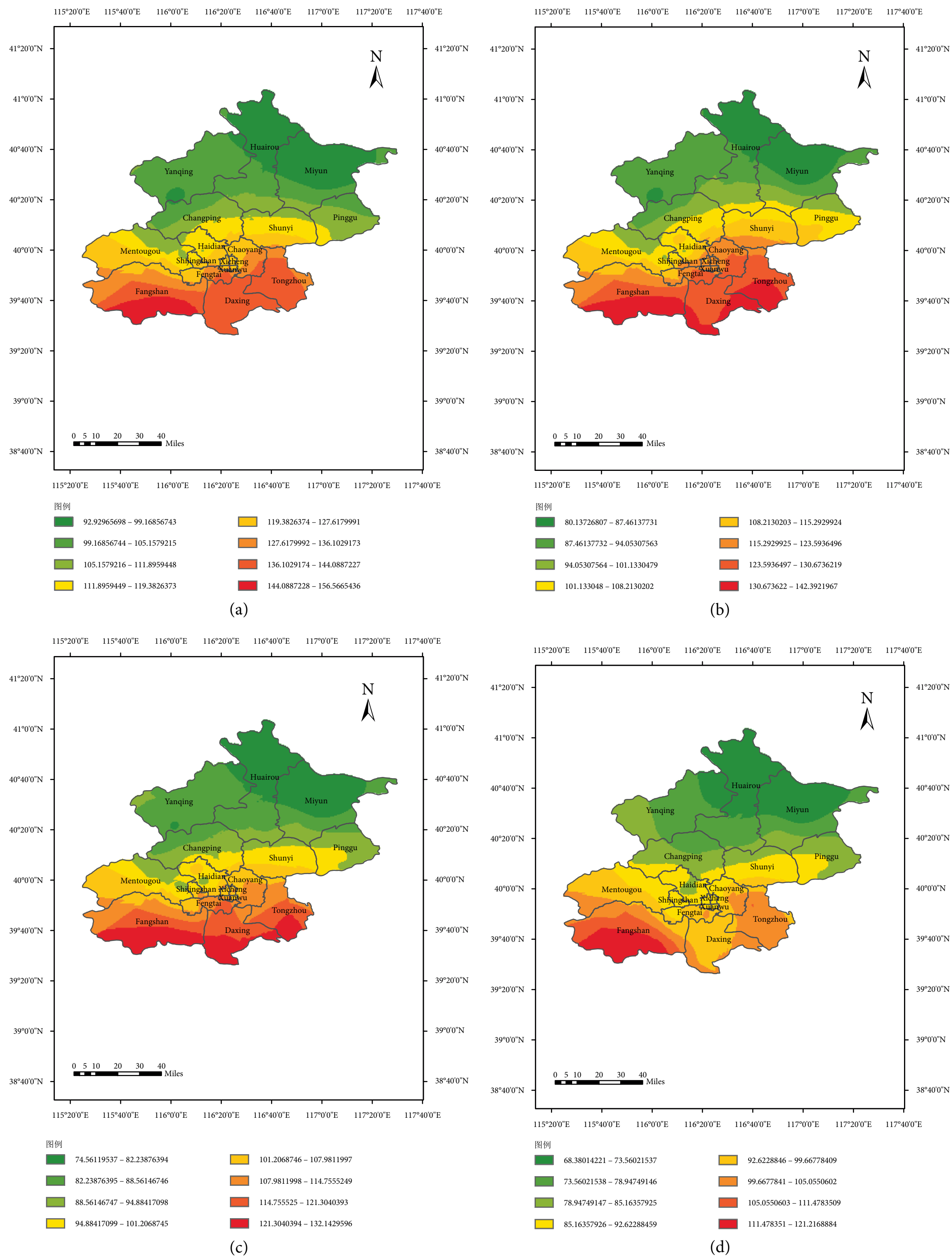


Figure 1: Spatial distribution of weather stations and AQI stations in Beijing.

Table 1: The categories of AQI.

Air quality index range	Air quality level	Air quality index category	Represent color
0~50	Level one	Excellent	Green
50~100	Level two	Good	Yellow
100~150	Level three	Mild pollution	Orange
150~200	Level four	Moderate pollution	Red
200~300	Level five	Heavy pollution	Purple
>300	Level six	Severe pollution	Maroon



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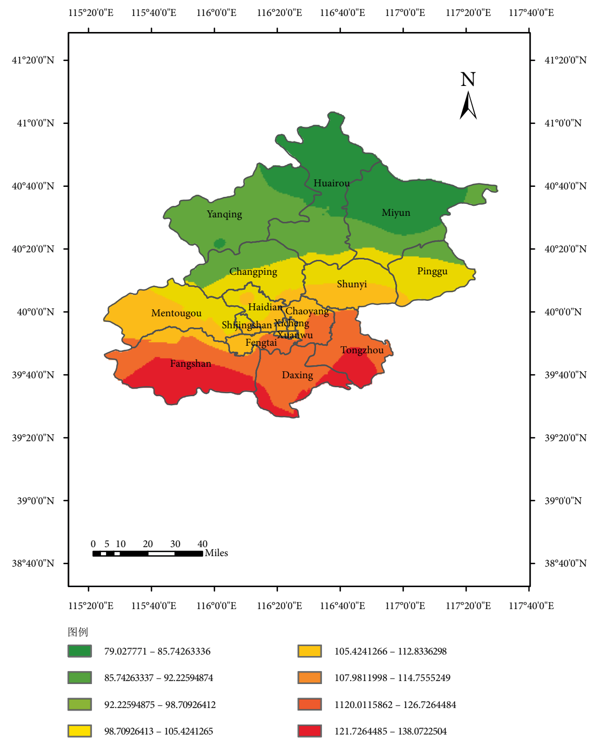


(e)

Figure 2: Spatial distribution of annual mean AQI of 35 monitoring stations in Beijing area. (a) AQI of 2014, (b) AQI of 2015, (c) AQI of 2016, (d) AQI of 2017, and (e) AQI of 2014–2017.

from that of the north. The AQI mean in the south is about 131; that in the north is 98; so the difference between the south and the north is 33; while the AQI mean in the central urban area is 117. Therefore, the AQI mean in 2015 is in the range of 80 and 142.

Figure 2(c) shows that the 2016 AQI mean, gained from Beijing urban air quality monitoring sites, is between 100 and 110 except the botanical garden, but a large difference exists between the southern and northern suburbs. The AQI in the southern suburbs is between 110 and 132, and that in the northern suburbs is from 74 to 98; the minimum annual average AQI is 74.5 in Miyun Reservoir, and the maximum value is 132.6 in Liuli River.

Figure 2(d) shows that the 2017 annual AQI mean of each site is between 68 and 121, an improvement of air quality compared with that in 2016. Among them, the AQI values of central urban area and southern suburbs show more concentrated, for example, the AQI of the South third Ring Road is 102, and Tongzhou is 105. Compared with the values of 2014 (Figure 2(a)), 2015 (Figure 2(b)) and 2016 (Figure 2(c)), it is found that a downward trend of annual AQI mean year by year no matter the minimum or maximum, and the spatial distribution of AQI value is higher in northwest than that in the southeast. The annual AQI mean of most sites are above 100, all of which are in air pollution.

Figure 2(e) is the spatial distribution map of 2014–2017 Beijing AQI mean. From it, it can be observed that the southern suburb AQI is obviously higher than that of the northern suburb; the AQI mean of the southern suburb is about 124, and that of the northern suburb is about 94, an obviously increasing trend of AQI from north to south, so the air quality gradually becomes worse from north to south. The AQI mean in the central city is between 105 and 117, and the west of the city is lower than the east. The overall 2014–2017 AQI decline year by year, indicating that air quality is improving year by year.

According to Figure 2, it is found that the annual AQI mean of Beijing increases from northwest to southeast. The spatial difference of air quality is caused by many factors, such as topography, climate, human activities, etc. The west and northeast of Beijing are mountainous and hilly; the southeast is plain; thus the terrain is tilted from northwest to southeast, which makes the valley wind obvious. Because of the unique topography, a tuyere is formed in the northwest with a large wind speed spreading the air pollution materials, making air quality better. Coupled with the control of the Siberian cold air mass in winter, the northwest wind prevails in Beijing, and the air pollutants are blown to the south, which leads to the accumulation of pollution in the south. In addition, reservoirs are widely distributed in the northern suburbs of Beijing such as Miyun Reservoir, etc., which are beneficial to the atmosphere's self-regulation. As well, the urban area of central Beijing is densely-populated, and full of various heavily man-made emissions such as gasoline combustion, coal-fired heating and others. And because the southern region is close to the Beijing-Tianjin-Hebei industrial development zone, factory emissions in the region lead to more air pollution.

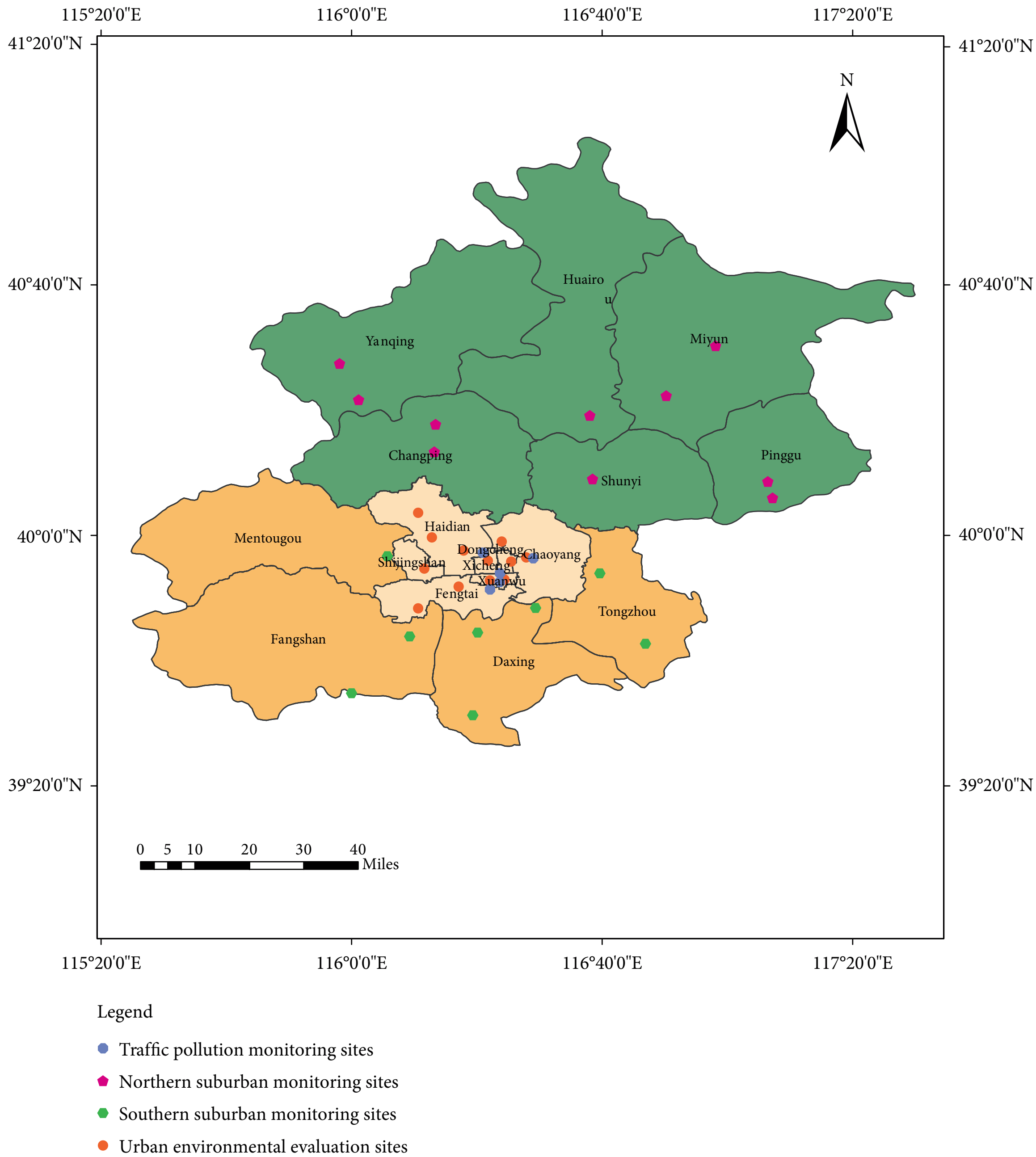
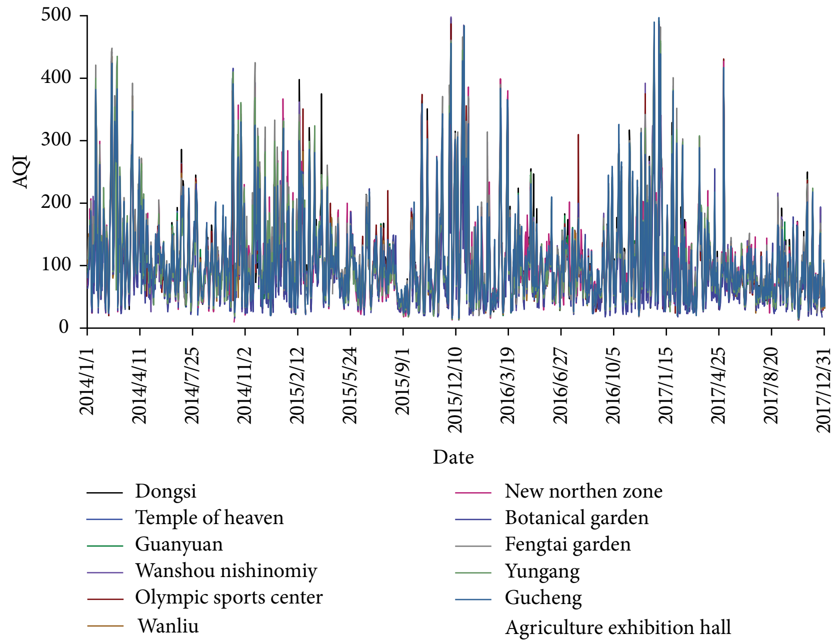


Figure 3: The study area, its categories and the monitoring stations of the air quality index (AQI) to be used.

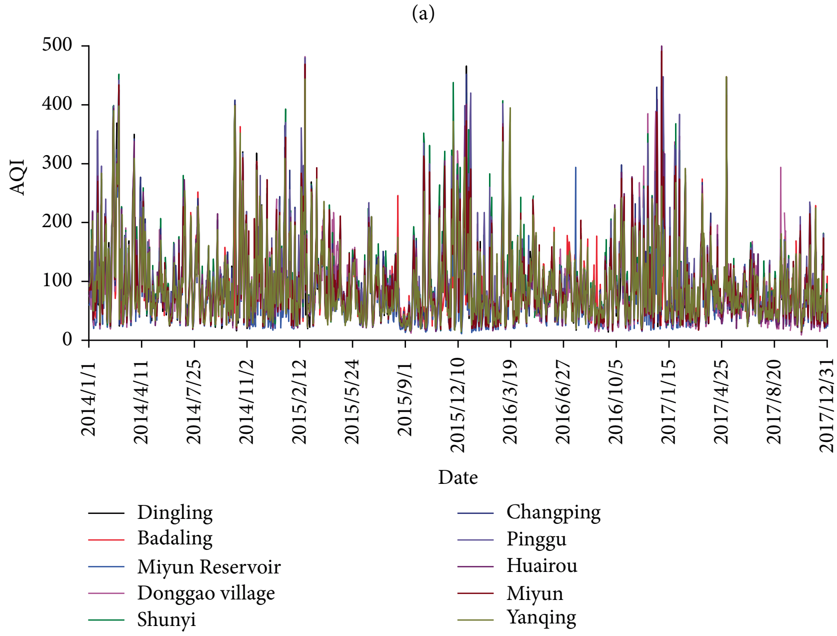
3.2. Analysis of Temporal Feature. In order to facilitate the research on 2014–2017 Beijing temporal variation trend and air quality characteristics, 35 air quality monitoring points in Beijing area are reclassified into northern suburban monitoring points, urban environmental assessment points, traffic pollution monitoring points and southern suburban monitoring points (Figure 3), in accordance with the classification of air quality monitoring points and the obvious difference of annual AQI mean between north and south suburbs and urban areas.

Figure 4 shows the 2014–2017 diurnal variation trend of AQI which are collected from urban environmental assessment points, northern suburban monitoring points, southern suburban monitoring points and traffic pollution monitoring points.

Figure 4(a) shows the fluctuation ranges of the daily AQI mean in urban environmental assessment points that are similar, basically ranging from 40 to 200, which indicates that there is no significant difference in air quality at different monitoring points in urban areas. Among them, the daily AQI fluctuation range of Fengtai Garden monitoring point is the largest, the maximum value close to 500, but the minimum value near 0.5%. Generally speaking, the air quality in urban area shows obvious interannual periodic variation, and the fluctuation amplitude is large. The peak of AQI appears in winter and the nadir is in summer.

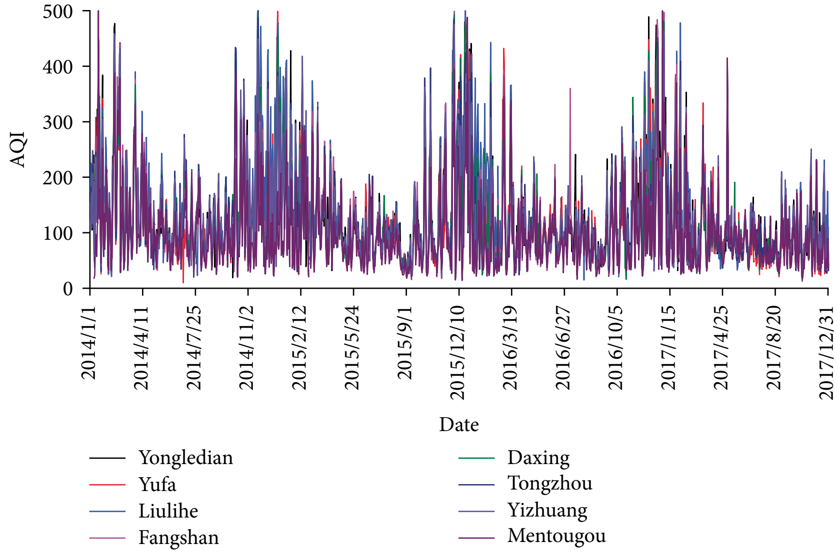


(a)



(b)

FIGURE 4: Continued.



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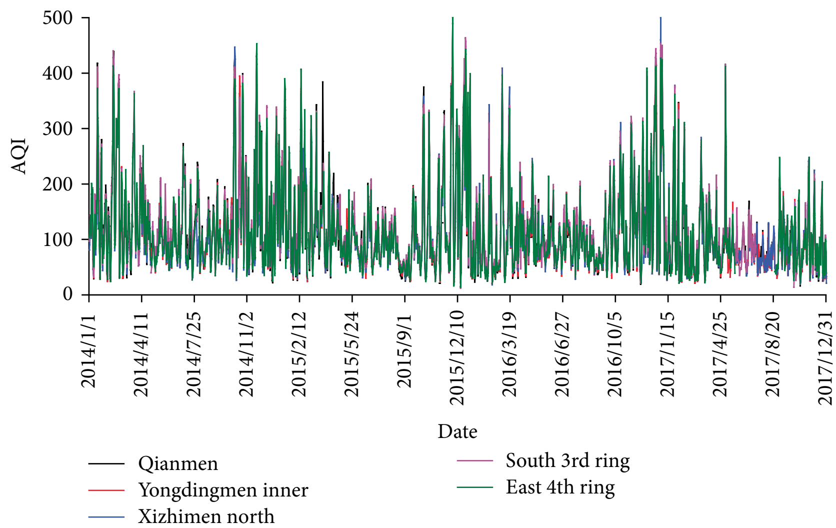

(d)

Figure 4: Daily AQI trend curves from 2014 to 2017. (a) urban monitoring stations, (b) traffic monitoring stations, (c) Northern suburb monitoring stations, and (d) Southern suburb monitoring station.

Figures 4(b) and 4(c) show the law of annual variation period. In Figure 4(b), the daily AQI mean of the northern suburb monitoring sites is basically less than 200, and the days when AQI value is greater than 300 are few, as well as the air pollution days. The statistics of Yanqing monitoring point is the most representative in this area, which can basically reflect the mean value of every station. However, the southern suburbs are with a high proportion of pollution days and large fluctuation range, and the daily AQI mean of which (Figure 4) is more than 200. Among these sites, the AQI of the Mentougou monitoring point is the smallest, and that of Liuli River is the largest. The reason for the difference is because the Mentougou monitoring point is located in the western suburbs of Beijing with less human activities than Liuli River and so air quality there is better. In addition, although the interannual variation of the two monitoring sites is the same, the fluctuation range of daily AQI mean in the southern suburbs is much larger, which indicates that the air quality change in southern Beijing is more unstable.

As shown in Figure 4(d), the days of extreme heavy pollution ($AQI > 400$) are few; the variation of daily AQI of every site is similar and the fluctuation range is small; the traffic pollution in different urban locations has little difference, and the air pollution is more stable. The stability benefits from the stabilized pollution emission from transportation hubs. And annual variation shows periodic peaks and troughs.

Figure 4 shows that the daily AQI mean has obvious interannual periodic changes with a large volatility, but it overall shows a downward trend. The fluctuation ranges and amplitudes of AQI value in different monitoring points are different.

An obvious monthly variation trend of AQI shown in Figure 5. Figure 4(a) is the 2014 radar map of AQI annual change of each site in Beijing. It can be seen that the change of monthly mean of each site in 2014 is between 80 and 200.

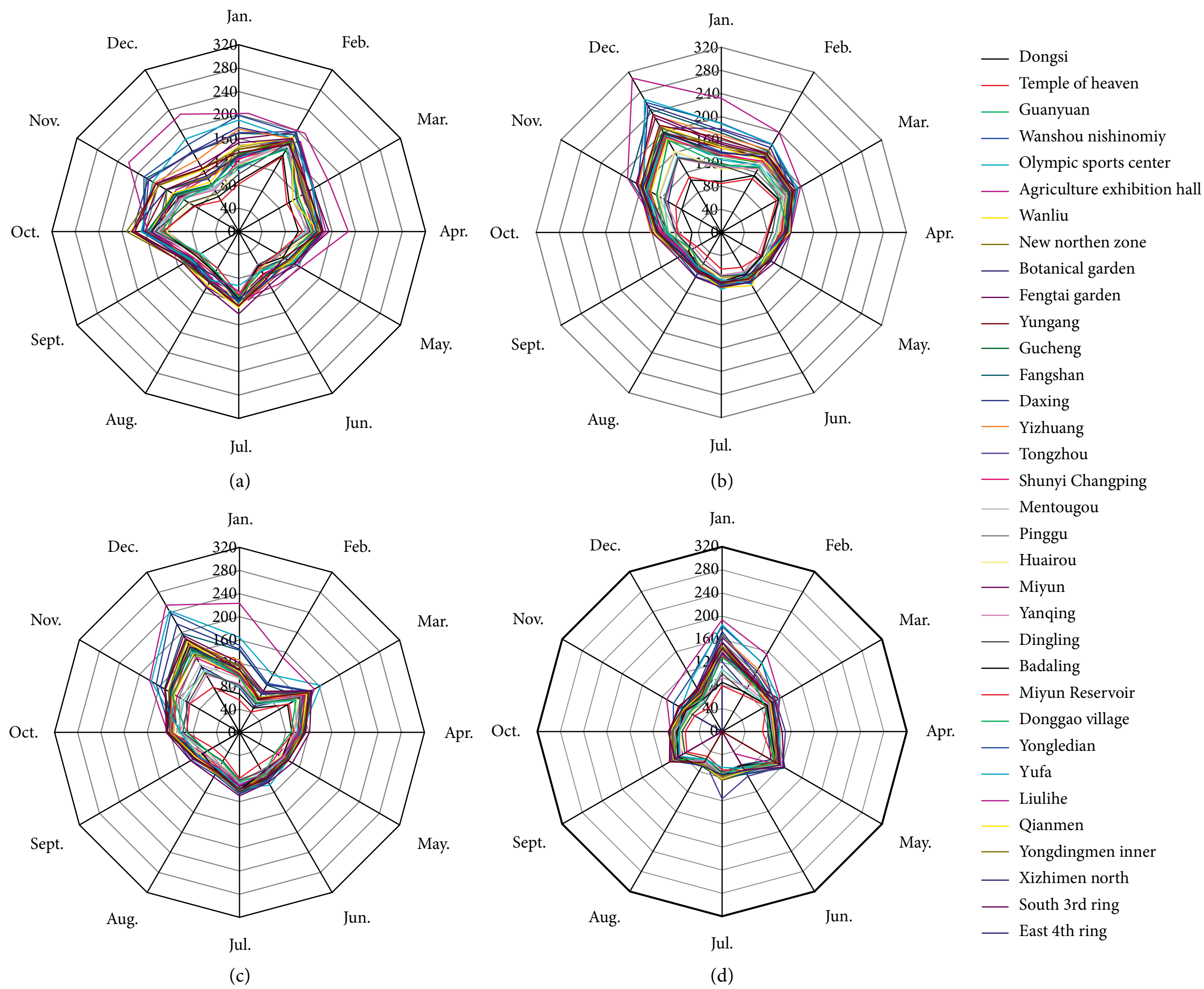

Figure 5: Monthly AQI radar map. (a) AQI of 2014, (b) AQI of 2015, (c) AQI of 2016, and (d) AQI of 2017.

Different sites present similar variation law, the highest in October and February, and the lowest in June. And there exist peaks in February, April, July and October. Especially, monthly means of various sites are similar from April to October, but show a large difference in winter, early spring and late autumn. Among these sites, the AQI values of Liulihe, Yongledian and Yulao southern suburbs reach the maximum; that of the northern suburbs, such as Miyun Reservoir, Badaling and Dingling are the minimum; and that of urban monitoring points such as the ancient city and botanical garden are moderate.

Figure 5(b) shows the radar diagram of the 2015 monthly AQI mean. The AQI mean of different stations are obviously different in the months of November, December, January and February. But only in December, AQI mean value reaches its peak and exists as the largest dispersion degree of the whole year. The maximum value of approximate 320 appears in the Liuli River, which is located in southern suburb monitoring sites, and the minimum value of nearly 100 is in Badaling, a northern suburb monitoring site. However, the monthly AQI mean of the two monitoring sites in June-July is very close, approving that the difference between the north and the south in winter is more obvious.

The difference about AQI between 2016 (Figure 5(c)) and 2015 (Figure 5(b)) is that in February, 2016, the monthly AQI mean of each site in Beijing shows a significant downward trend, and overall, the monthly AQI mean in 2016 is smaller than that in 2015.

From Figure 5(d), it is found that in 2017, the monthly AQI mean of each site is within the range from 80 to 120 except winter months and the maximum value is in January. In summary, the AQI value in Beijing decreases year by year from 2014 to 2017, and the increasing sequence of monthly variation is as follows: summer months, late spring and early autumn months, early spring and late autumn months, winter months. In addition, according to the law of the larger AQI, the more obvious spatial difference, four divided parts in order of descending AQI value is listed as follows: southern suburban sites, traffic pollution monitoring sites, urban environmental evaluation sites and northern suburban sites, which is consistent with the results of diurnal variation.

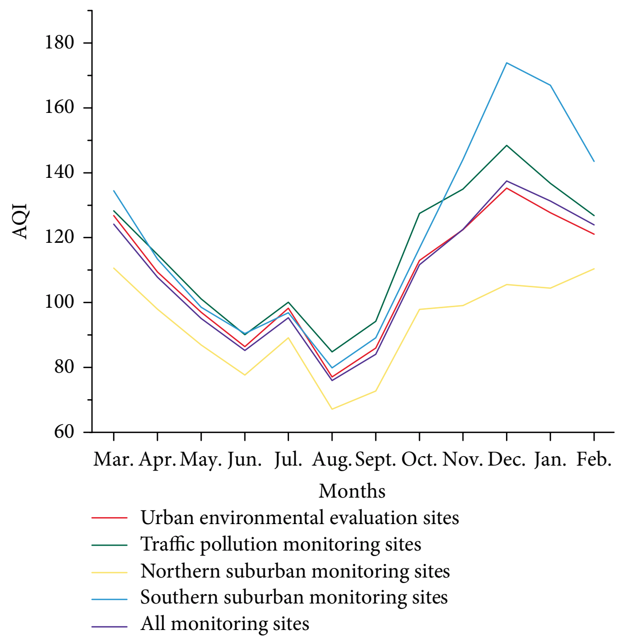

FIGURE 6: The variation curve of AQI month of different sites in Beijing area from 2014 to 2017.

Figure 6 is the monthly variation curve of AQI of different sites in Beijing area from 2014 to 2017. From it, it could be observed that from 2014 to 2017, every annual variation curve of AQI is with high values in winter but low values in summer, just like the letter U. Such variation is due to the large-scale particulate emissions and serious air pollution by increasing energy consumption in winter. However, there are also a small range of peaks in summer. The reason of the peaks is that July is the month with the highest temperature in one year, causing the most serious O_3 pollution. The O_3 pollution makes the air quality worse and the AQI value increased.

Apart from annual variation trend, it is also found that the variation trends of AQI values in urban environmental assessment sites, traffic pollution evaluation sites, northern suburbs monitoring sites and all other monitoring sites have much consistency, testifying that the data of urban environmental assessment sites is the most representative in the whole Beijing area. From Figure 6, it can also be seen that the curve of all monitoring sites in Beijing coincides with that of the urban environmental evaluation sites, with the minimum monthly AQI mean in August (<80), and the maximum in December (>130).

As well, the curve of the monitoring points in the southern suburbs above that of all the monitoring points means that the monthly AQI mean in the southern suburbs is lower than that in the southern suburbs. Similarly, the curve of the monitoring points in the northern suburbs below that of all the monitoring points reveals that the monthly AQI mean in the northern suburbs is significantly lower than that in other regions. From January to June, the curve of traffic monitoring point is basically the same as that of Beijing, but because of the traffic pollution, the AQI mean value in the second half of the year increases obviously. That means the effect of traffic pollution on AQI mean variation dominates that of spatial distribution in the period.

Figure 7 reveals the 2014–2017 monthly AQI data. From Figure 7(a), it is found that the excellent and good rate of air quality from May to August is 50–70%, and it is over 70% in June. On the contrary, the air pollution rate is the highest from January to April, at more than 60%. Severe and severely polluted weather is mainly concentrated in February, April, and October, 20–30%. Whereas Figure 7(b) shows that in 2015 the air quality excellent and good rate was the highest at around 70% from July to September. Air quality was relatively poor in January, February, November and December, with severe and heavily polluted weather accounting for 27% respectively. 30%, 23%, and 47%. The AQI value is the largest in December and the air quality is the worst.

The AQI curve of 2016 (Figure 7(c)) and that of 2015 (see Figure 7(b)) seems similar. The difference of both is that, the excellent and good rate in February 2016 is 70%, higher than that in February 2016. Figure 7(d) shows that in 2017, the excellent and good rate of air quality in all months is more than 50% except January, May and July with high pollution quality. Compared with the distribution of AQI in 2014, 2015, 2016 and 2017, it can be found that the air quality in Beijing is improved year by year and the proportion of qualified air quality has continued to increase, consistent with the data of the annual AQI mean from 2014 to 2017. The gradually decreasing ratio of air quality pollution reveals a good developing trend. Figure 7(e) shows that from 2014 to 2017, the excellent and good rate of AQI is up to 55%, and the heavy and severe pollution is about 20%.The grade frequency distribution map shows obvious wave peak distribution, that is, the air quality pollution rate is higher in January, February, November and December, and decreases in turn to the middle (July), on the contrary, the air quality pollution rate in January, February, November and December is higher than that in January, February, November and December. The proportion of air quality (grade 1–3) decreases from the middle to both sides. And there are obvious value peaks appearing in the months of January, February, November and December, consistent with the curve. However, in July, the proportion of air quality pollution increased with a partial AQI peak, which is due to the serious O_3 pollution in summer [25]. From the above analysis, it is concluded that AQI is decreasing with the air quality improving year by year. Basically, the AQI value presents *U*-shaped distribution every year, but there is a little range fluctuation that varies from year to year. The monthly AQI mean in 2017 is basically between 80 and 130. But the AQI value in December 2017 is obviously smaller than that in other years, indicating that the effect of atmospheric governance policy in 2017 is obvious.

3.3. Analysis of Correlation of AQI and Meteorological Factors. Meteorological factors play an important role in the diffusion and accumulation of pollutant concentrations [26]. When pollution sources are the same, meteorological factors will determine the concentration of pollutants. Some unfavorable meteorological factors will aggravate the pollution of particulate matter (PM).Therefore, it is necessary to

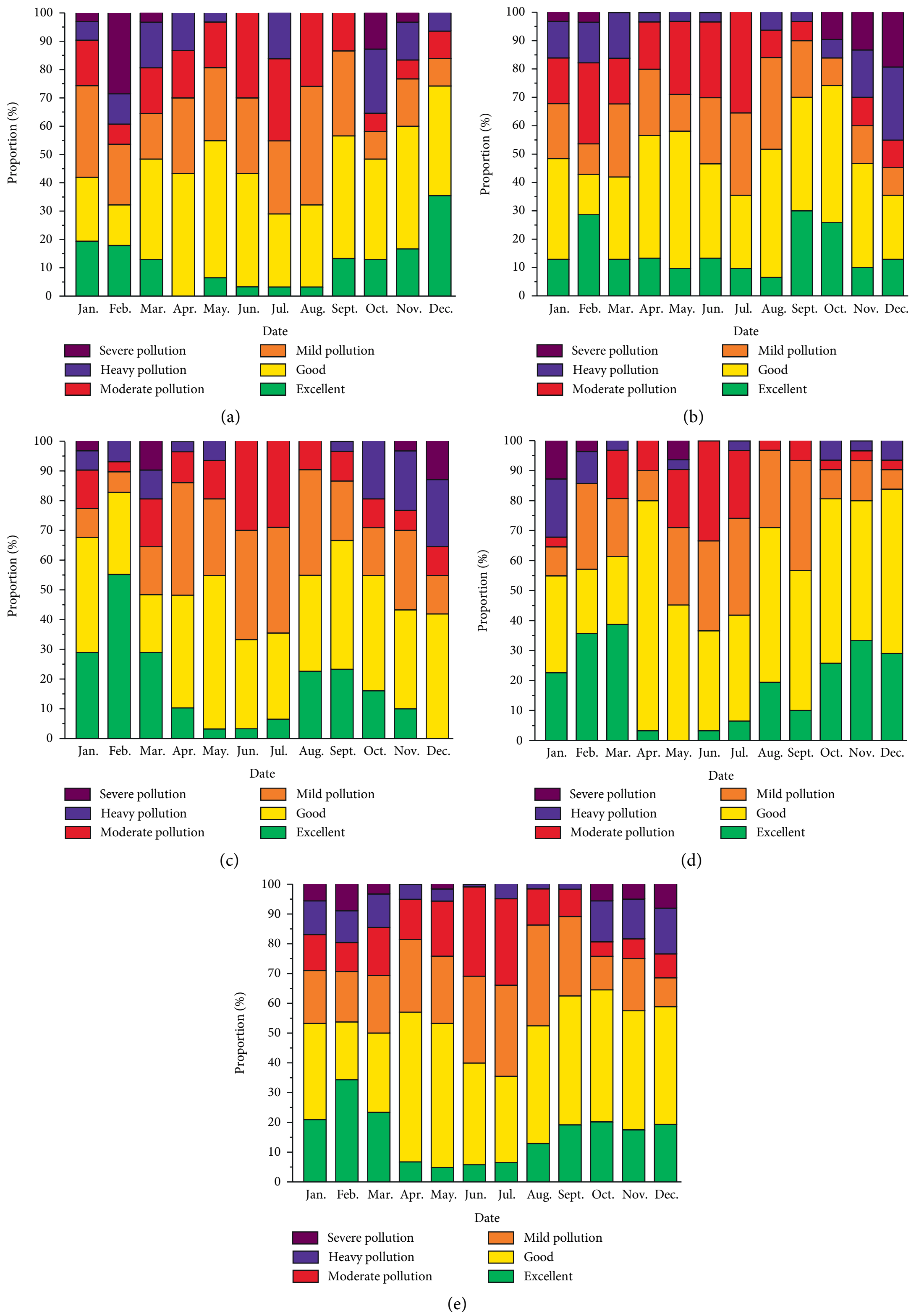

FIGURE 7: Monthly level of air quality in China. (a) AQI of 2014, (b) AQI of 2015, (c) AQI of 2016, (d) AQI of 2017, and (e) AQI of 2014–2017.

analyze the correlation of AQI and meteorological factors. In the study, the correlation between daily AQI mean and meteorological factors from 2016 to 2017 is analyzed (Figure 8) and it is found that the correlation coefficient between daily AQI mean and average temperature is −0.116, reaching significant correlation at the level of 0.01. The data means when compared with monthly AQI mean showed that the daily AQI variation is more easily affected by temperature.

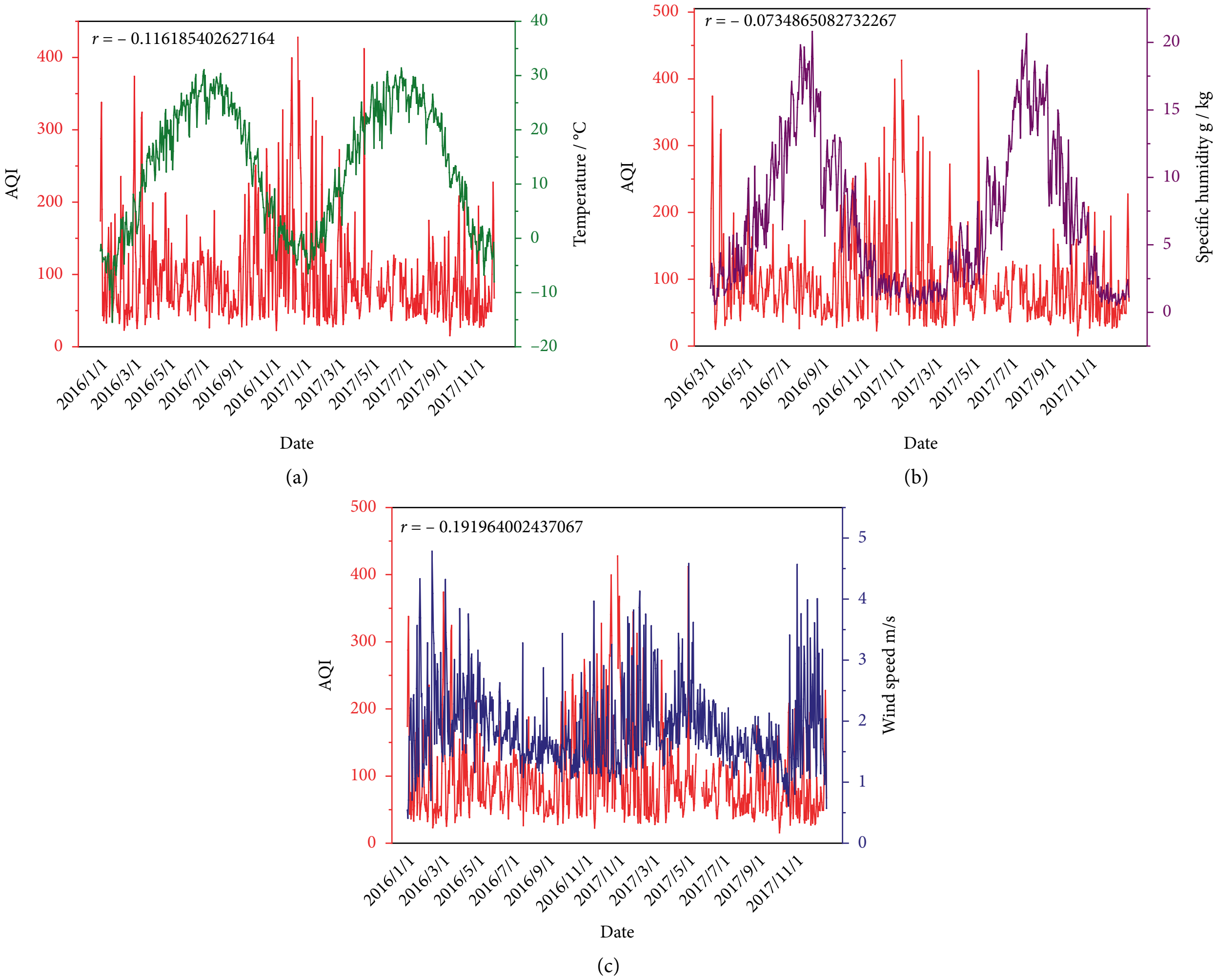

Figure 8: Temporal correlation analysis between daily meteorological factors and AQI in Beijing. (a) AQI and temperature, (b) AQI and specific humidity, and (c) AQI and wind speed.

The daily AQI mean is also negatively correlated with the average specific humidity, but the correlation is not significant and the correlation coefficient is −0.073. However, the variation of monthly AQI is negatively correlated with the average specific humidity, which indicates that the daily AQI mean is less affected by the specific humidity than the monthly AQI mean. In addition, the daily AQI mean is negatively correlated with the average wind speed, and the correlation coefficient is −0.192 at the 0.01 level. However, there is a slight positive correlation between the monthly AQI mean and the average wind speed, which indicates that the influence of wind speed on the diurnal variation of AQI is more obvious than on monthly variation. This is because the higher wind speed benefits the horizontal dilution and diffusion of pollutants, leading to lower pollutants concentration and lower AQI. It makes the air quality better.

Table 2 shows the correlation data between daily AQI and seasonal meteorological factors of Beijing in 2016 and 2017 by SPSS 22.0 software. It can be seen that in different periods, the correlations between daily AQI and varied seasonal meteorological factors are different. In different years, no matter in 2016 or 2017, the daily AQI mean and average temperature, average humidity and average wind speed are all negatively correlated, and the correlation with average wind speed and average temperature is significant. The correlation coefficients between daily AQI mean and average temperature, average specific humidity and average wind speed in 2016 are −0.127, −0.137 and −0.207 respectively, while the correlation coefficients between daily AQI mean and average temperature, average specific humidity and average wind speed in 2017 are −0.109, −0.053 and −0.176 respectively. The Pearson correlations in 2017 are smaller than that in 2016, in which AQI and specific humidity present significantly negative correlation in 2016, but not significantly in 2017. This shows that the correlation between AQI and meteorological factors in 2016 is greater than that in 2017, and the air quality in 2016 is more affected by meteorological factors. At the seasonal level, in spring 2016, AQI is negatively correlated with all meteorological factors except average specific humidity. And AQI had the greatest correlation with average wind speed when the correlation was not significant. In summer 2016, AQI is positively correlated with air temperature, specific humidity and wind speed, and significantly correlated with air temperature and specific

Table 2: Relationship between air quality index and meteorological elements on the scale of average solar terms from 2016 to 2017 in Beijing.

Year	Project	Average temperature	Average specific humidity	Average wind speed
2016	Pearson correlation coefficient	−.127*	−.137*	−.207**
	Significance level	0.016	0.017	0
	Number of samples	363	303	363
2017	Pearson correlation coefficient	−.109*	−0.053	−.176**
	Significance level	0.043	0.326	0.001
	Number of samples	347	347	347
2016-2017	Pearson correlation coefficient	−.116**	−0.073	−.192**
	Significance level	0.002	0.061	0
	Number of samples	710	650	710
2016-Spring	Pearson correlation coefficient	−0.124	0.065	−0.158
	Significance level	0.241	0.542	0.135
	Number of samples	91	91	91
2016-Summer	Pearson correlation coefficient	.219*	.378**	0.134
	Significance level	0.036	0	0.201
	Number of samples	92	92	92
2016-Autumn	Pearson correlation coefficient	−0.085	0.031	−0.19
	Significance level	0.423	0.768	0.071
	Number of samples	91	91	91
2016-Winter	Pearson correlation coefficient	.275**	.673**	−.381**
	Significance level	0.009	0	0
	Number of samples	89	29	89
2017-Spring	Pearson correlation coefficient	0.091	.226*	−0.087
	Significance level	0.416	0.041	0.44
	Number of samples	82	82	82
2017-Summer	Pearson correlation coefficient	.544**	.229*	0.144
	Significance level	0	0.036	0.192
	Number of samples	84	84	84
2017-Autumn	Pearson correlation coefficient	.274**	.450**	−.306**
	Significance level	0.009	0	0.003
	Number of samples	91	91	91
2017-Winter	Pearson correlation coefficient	0.025	.661**	−.373**
	Significance level	0.813	0	0
	Number of samples	90	90	90

Note: *Significant correlation at 0.05 level (bilateral). **Was significantly correlated at the .01 level (bilateral).

humidity. In autumn 2016, the correlation coefficient between AQI and meteorological factors is small, and the correlation is opposite to that in spring of 16 years. In winter 2016, AQI is significantly correlated with average temperature, average specific humidity and average wind speed, and the correlation coefficients are 0.275, 0.673 and −0.38.1 respectively. However, in spring 2017, AQI is positively correlated with average specific humidity and average temperature, but negatively correlated with wind speed and has little effect on AQI. In summer 2017, the correlation between AQI and three meteorological factors are positively correlated the same as that in 2016, and the correlation of AQI with temperature and specific humidity are significant, which indicate that the correlation between AQI and meteorological factors such as temperature and humidity in summer are higher than that in other seasons. However, in autumn 2017, AQI is significantly correlated with average temperature, average specific humidity and average wind speed, and only negatively correlated with average wind speed, same as that in 2016. In the winter of 2017, AQI is significantly correlated with average specific humidity and average wind speed, positively correlated with average specific humidity with correlation coefficient 0.661, negatively correlated with average wind speed with correlation coefficient −0.373, but not significantly correlated with average air temperature.

From the analysis, it is concluded that the correlation of daily AQI mean with average temperature, average specific humidity and average wind speed in different years is negative correlation, but the correlation sizes of different years are different, and the correlation of 2016 is greater than that of 2017.

4. Conclusions

The spatial distribution of AQI values in Beijing have gradient characteristics that the air quality index decreases from the north to the central region and then increases from the central region to the south, and such gradient characteristics are more obvious in winter than in spring. The collected data shows that in Beijing, the rate of AQI value in level two is the highest, up to about 30%; as well, the rate of AQI in level one is up to about 55%. The ratio of days with pollution is high in winter but low in summer. Generally, from 2014 to 2017, the air quality in Beijing area is improved year by year, with the AQI value decreasing year by year. From the analysis, it is concluded that the correlation of daily AQI mean with average temperature, average specific humidity and average wind speed in different years is negative correlation, but their correlation degree in different years are different. Overall, in 2016, the AQI value was largely influenced by the three factors while in 2017, the three factors affected the AQI value slightly. In addition, the correlation of AQI and meteorological factors is also different in different seasons of one year, for example, meteorological factors usually have more influence on daily AQI mean in summer and winter compared with spring and autumn.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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