Study on Optimization of Automatic Monitoring Station for Urban Environmental Air Quality Assessment: A Case Study of Pingshan District, Shenzhen

Zhao Kunrong[1], Wu Shuang[2], Xu Wenjun[2], Jia Yan[1, *]

[1] No.16-18 Ruihe Road, Huangpu District, Guangzhou，PR China

[2]No.7 Courtyard, Yuancun West Street, Tianhe District, Guangzhou, PR China

jiayan@scies.org

*Corresponding author

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Abstract. The design of environmental air quality monitoring network should be able to objectively reflect the impact of environmental air pollution on human living environment, and based on the environmental air quality status and changing trend, industrial and energy structure characteristics, population distribution, topography and meteorological conditions in Pingshan New area for many years, the representativeness, integrity, feasibility, comparability and foresight of the monitoring data are fully considered.

1. Introduction

With the expansion of Pingshan New area and the increase of population, it is necessary to supplement the original monitoring point. Therefore, in order to make the new monitoring points more representative, typical, feasible and economical, it is necessary to arrange the new environmental monitoring points reasonably, that is, to add those points that can represent the characteristics of pollution behavior in the new (expanded) construction area from the existing monitoring points in Pingshan New area, and strive to obtain the maximum benefit with the least investment. As the national control monitoring point, the monitoring station of Xia Pozi Station constitutes the environmental air quality monitoring network of Shenzhen City through strict demonstration and setting up, and together with 10 monitoring points in other areas. As a point to reflect the environmental air quality in the core area of Pingshan New area, Ping Shanzi Station has a good representativeness. Therefore, based on the two existing environmental monitoring points, how to select four stations to compare and select, and put forward the optimization scheme of adding two new points, which is of great significance to promote the development of environmental air monitoring and strengthen the management of environmental air quality in Pingshan New area.

2. Data sources

From April 21, 2016 to May 8, 2016, the continuous automatic monitoring method was used to monitor the ambient air quality in Tianxin Community and Tangkeng Community for a period of 18 days, and from May 14, 2016 to June 12, 2016, the two pre-selected sites in Jolongshan and Xiushan Village were monitored for a period of 30 days. Combined with the two existing automatic ambient air monitoring stations, a total of 4608 sets of NO2, PM10, PM2.5 and O3 were collected.

3. Analytic procedure

According to the requirements of the Code for Environmental Air quality Monitoring (trial), the data are statistically calculated according to the following steps:

（1）For each monitoring item （NO2、O3、PM2.5、PM10）, the daily mean of six monitoring points in Pingshan New area, the daily mean and total mean during the monitoring period, and the 30, 50, 80 and 90percentile of the total daily mean are calculated respectively to characterize the distribution of the data.

（2）The "2+1" monitoring points were combined with the existing monitoring points according to three points, that is, {Pingshan, Xiapo, pre-selected points X} as a group, with a total of 4 groups.

（3）For each monitoring item, the daily mean of each group and the daily mean of the group during the monitoring period were calculated respectively, and the 30, 50, 80 and 90 percentile of all the daily mean values in the group were calculated.

（4）The relative errors between the daily mean and the total mean of each group (hereinafter referred to as the group mean error) are calculated respectively, and the relative errors of the 30, 50, 80 and 90percentile of the daily mean and the corresponding percentile of all the daily mean (referred to as the percentile error of the group) are calculated.

（5）For each monitoring item, the correlation parameters: a, b and r (hereinafter referred to as group related parameters), between the daily mean in group Tianxin's detection period, group Tangkeng's detection period (as dependent variable) and the daily mean in Pingshan New area's (as independent variable) detection period are calculated respectively. For each monitoring item, the correlation parameters: a, b and r (hereinafter referred to as group related parameters), between the daily mean in group Julongshan's detection period, group Xiushancun's detection period (as dependent variable) and the daily mean in Pingshan New area's (as independent variable) detection period are calculated respectively.

（6）All groups are screened, and the selected groups must meet the following conditions for each monitoring item at the same time.

The absolute value of the mean relative error of the group is less than 10%, and the absolute value of the percentile error of each group is less than 15%.

（7）Finally, the establishment of the optimization group is the best combination of representative points from the re-selected optimization group. The formula for calculating the correlation coefficient is as follows.

$$\text{Eq.1}\quad R = \frac{ILXY}{\sqrt{LXX * LYY}} \qquad (1)$$

$$\text{Eq.2}\quad \mathbf{LXY} = \sum_{i=1}^{n}(X_i - \overline{X}) \times (Y_i - \overline{Y})$$

$$\text{Eq.3}\quad LXX = \sum_{i=1}^{n}(X_i - \overset{-2}{X})$$

$$\text{Eq.4}\quad LXY = \sum_{i=1}^{n}(X_i - \overset{-2}{X})$$

R——Correlation coefficient between a certain group of pollutants and a pollutant in the whole area

Xi——The daily average concentration of a certain pollutant in a group.

x——Average concentration of a group of a pollutants during the monitoring period

Yi——The average concentration of a pollutant on a certain day in the whole area.

Y——Average concentration of a pollutant in the whole region during the monitoring period

The larger the R value, the more it can represent the changing law of pollutants in the jurisdiction, and priority should be given to the selection of points. When $R \geq 0.561$, the correlation is significant at $a \geq 0.01$ level. When $R > 0.444$, the correlation was significant at the level of $a \geq 0.05$.

（8）The data of the above primary groups are analyzed for optimal selection, and the following factors are taken into account:

1）Each point in the group should represent as many functional areas as possible.

2）The geographical location of each point in the group should be distributed as widely as possible in Pingshan New area.

3）The development planning of the city should be taken into account so that the monitoring points can be relatively stable.

4）It is necessary to retain a certain number of original monitoring points as much as possible in order to maintain the relationship before and after optimization, and the data are comparable to each other.

5）The daily mean value of the selected point should not be concentrated near the daily mean value.

6）The monitoring conditions of the selected points must be fully guaranteed and the monitoring must be as convenient and reliable as possible.

7）Meet the needs of environmental management, etc., as much as possible.

4. Data processing and analysis

4.1. Daily average of existing and budgeted points

In this study, the monitoring data of air pollutants in two existing stations and pre-selected sites in Pingshan New Area and the daily average of air pollutants in Pingshan New Area based on MODIS satellite data inversion and on-site monitoring were analyzed. Details are shown in tables 1 and 2.

Table 1　Statistics of daily mean values of air pollutants during the monitoring period between Tianxin and Tangkeng in Pingshan New area and the existing points mg / m^3

air pollutant / site	NO_2	O_3	$PM_{2.5}$	PM_{10}
Tianxin	0.012	0.066	0.027	0.045
Tangkeng	0.019	0.061	0.036	0.080
Xiapo	0.024	0.039	0.038	0.060
Pingshan	0.049	0.051	0.028	0.045
The average of four points	0.026	0.054	0.032	0.058

4.2. Percentile of air pollutants in the region

In this study, the percentile statistics of the daily mean of air pollutants during the monitoring period of two stations and pre-selected points in Pingshan New area are carried out, as detailed in tables 3 and 4.

Table 2 Daily mean Statistics of Air pollutants in Xiushan Village, Jolong Mountain and existing Point Monitoring periods in Pingshan New area mg / m^3

air pollutant / site	NO_2	O_3	$PM_{2.5}$	PM_{10}
Tianxin	0.020	0.075	0.013	0.047
Tangkeng	0.020	0.067	0.024	0.065
Xiapo	0.021	0.043	0.027	0.046
Pingshan	0.035	0.059	0.021	0.036
The average of four points	0.024	0.061	0.021	0.049

Table 3 Percentile of air pollutants in Tianxin and Tangkeng of Pingshan New Area. mg / m^3

air pollutant	Percentile						
	5	10	30	50	80	90	95
NO_2	0.005	0.007	0.016	0.023	0.039	0.053	0.058
O_3	0.019	0.023	0.034	0.047	0.073	0.103	0.124
$PM_{2.5}$	0.015	0.019	0.024	0.031	0.041	0.048	0.053
PM_{10}	0.032	0.034	0.041	0.055	0.074	0.090	0.101

Table 1 Percentile Statistics of Air pollutants in Xiushan Village, Jolong Mountain and existing Point Monitoring periods in Pingshan New Area mg / m^3

air pollutant	Percentile						
	5	10	30	50	80	90	95
NO_2	0.011	0.013	0.018	0.023	0.032	0.038	0.042
O_3	0.020	0.027	0.045	0.056	0.083	0.099	0.120
$PM_{2.5}$	0.008	0.009	0.016	0.020	0.029	0.032	0.036
PM_{10}	0.025	0.029	0.038	0.044	0.063	0.078	0.085

4.3. Daily average and relative error of each group

In this study, the existing stations and pre-selected points were divided into four groups, and the daily mean values of air pollutants in each group were counted, as detailed in tables 5 and 6. On this basis, the relative error statistics between the air pollutants and the whole area of each group are carried out, which are detailed in Table 7 and Table 8. From the statistical results, the absolute value of the relative error between the air pollutants and the whole area in each group is less than 10%.

Table 5 Daily average statistics of air pollutants in Tianxin and Tangkeng groups

combination	NO_2	O_3	$PM_{2.5}$	PM_{10}
1,2,3	0.028	0.052	0.031	0.057
1,2,4	0.030	0.050	0.034	0.062
Regional average	0.027	0.054	0.032	0.058

Note: point 1: Pingshan; point 2: Xiapo; point 3: Tianxin; point 4: Tangkeng

Table 6 Daily average of air pollutants in Xiushan Village, Julongshan Group.

combination	NO_2	O_3	$PM_{2.5}$	PM_{10}
1,2,5	0.025	0.059	0.020	0.044
1,2,6	0.026	0.061	0.021	0.049
Regional average	0.024	0.061	0.021	0.049

Note: point 1: Pingshan; point 2: Xiapo; point 3: Xiushancun; point 4: Julongshan

Table 7 Statistics of daily mean value and relative error absolute value of Tanxin and Tangkeng formation

combination	NO_2	O_3	$PM_{2.5}$	PM_{10}
1,2,3	4.32%	4.58%	4.08%	2.74%
1,2,4	9.37%	7.07%	5.44%	7.13%

Table 8 Statistics of daily average value and relative error absolute value of Julongshan formation in Xiushan Village and Julongshan formation

combination	NO_2	O_3	$PM_{2.5}$	PM_{10}
1,2,5	5.29%	3.08%	4.85%	9.23%
1,2,6	5.88%	1.71%	1.53%	1.08%

4.4. Daily average percentile and relative error between each group and the whole area percentile

In this study, the daily mean value of air pollutants in each monitoring period was counted in percentile, as detailed in tables 9 and 10.

Table 9 percentile statistics of air pollutants in Tanxin and Tangkeng groups

combination	air pollutants	percentile statistics			
		30	50	80	90
1,2,3	NO_2	0.017	0.024	0.043	0.056
	O_3	0.032	0.046	0.072	0.102
	$PM_{2.5}$	0.024	0.031	0.040	0.044
	PM_{10}	0.039	0.055	0.073	0.091
1,2,4	NO_2	0.021	0.027	0.043	0.056
	O_3	0.031	0.038	0.070	0.102
	$PM_{2.5}$	0.026	0.032	0.042	0.050
	PM_{10}	0.047	0.060	0.085	0.097
Whole area	NO_2	0.016	0.023	0.039	0.053
	O_3	0.034	0.047	0.073	0.103
	$PM_{2.5}$	0.024	0.031	0.041	0.048
	PM_{10}	0.041	0.055	0.074	0.090

Table 10 percentile statistics of air pollutants in Julongshan formation, Xiushan Village

combination	air pollutants	percentile statistics			
		30	50	80	90
1,2,5	NO_2	0.018	0.023	0.035	0.038
	O_3	0.045	0.053	0.081	0.099
	$PM_{2.5}$	0.013	0.018	0.029	0.033
	PM_{10}	0.035	0.039	0.056	0.063
1,2,6	NO_2	0.020	0.023	0.035	0.039
	O_3	0.039	0.052	0.078	0.095
	$PM_{2.5}$	0.016	0.020	0.031	0.034
	PM_{10}	0.038	0.045	0.063	0.079
Whole area	NO_2	0.018	0.023	0.032	0.038
	O_3	0.045	0.056	0.083	0.099
	$PM_{2.5}$	0.016	0.020	0.029	0.032
	PM_{10}	0.038	0.044	0.063	0.078

The relative errors between percentile and whole area of air pollutants in each group are counted, as detailed in tables 11 and 12. The statistical results show that the absolute values of the atmospheric pollutants in {1,2,3}, {1,2,6} groups and the whole area are less than 15%. In {1, 2, 4} group, except NO2, the absolute error between {1, 2, 4} and the whole region was less than 15%. {1, 2, 5} group except PM10, the absolute error between {1, 2, 5} and the whole area is less than 15%.

Table 11 Statistics of absolute value of relative error between percentile and relative error of air pollutants in Tanxin and Tangkeng groups

combination	air pollutants	percentile statistics			
		30	50	80	90
1,2,3	NO_2	6.72%	5.77%	10.18%	5.71%
	O_3	5.49%	0.38%	1.56%	0.82%
	$PM_{2.5}$	2.84%	0.00%	3.01%	9.65%
	PM_{10}	4.42%	1.96%	1.33%	2.80%
1,2,4	NO_2	26.37%	16.45%	10.18%	5.71%
	O_3	8.65%	14.77%	3.91%	0.70%
	$PM_{2.5}$	7.40%	5.92%	3.04%	2.84%
	PM_{10}	14.40%	9.03%	13.85%	7.84%

Table 12 Statistics of absolute error between percentile and relative error of air pollutants in Julongshan formation in Xiushan Village and Julongshan formation

combination	air pollutants	percentile statistics			
		30	50	80	90
1,2,5	NO_2	1.55%	1.17%	7.73%	0.82%
	O_3	11.04%	5.73%	2.38%	0.10%
	$PM_{2.5}$	14.91%	12.19%	0.20%	2.27%
	PM_{10}	7.64%	10.19%	11.94%	18.77%
1,2,6	NO_2	9.58%	1.58%	9.17%	1.89%
	O_3	1.94%	8.34%	5.22%	4.04%
	$PM_{2.5}$	1.06%	1.52%	6.39%	5.09%
	PM_{10}	0.78%	2.03%	0.05%	1.42%

4.5. New monitoring site layout plan.

In this study, the correlation between air pollutants in group {1,2,3}, {1,2,4}, {1,2,5}, {1,2,6}and the air pollutants in the whole region was counted by formula 1, and the detailed results are shown in Table 13.

Table 13 Statistics of correlation coefficients between each group of air pollutants and the whole region

combination	NO_2	O_3	$PM_{2.5}$	PM_{10}
1,2,3	**0.925**	**0.927**	**0.818**	**0.907**
1,2,4	0.873	0.867	0.802	0.829
1,2,5	0.875	0.866	0.794	0.901
1,2,6	**0.915**	**0.916**	**0.804**	**0.911**

According to the statistical results, the correlation between air pollutants and air pollutants in {1, 2, 3} and {1, 2, 6} groups is the most significant, so this study suggests that Tianxin and Jolongshan should be added as environmental air quality assessment points in Pingshan New area.

5. Conclusion

According to the quantity requirements of ambient air quality evaluation points stipulated in the Technical Specification (trial implementation) of Environmental Air quality Monitoring points (HJ664-2013), four monitoring points should be set up in the whole area according to the area and population size of the existing built-up areas in Pingshan New area. At present, the existing monitoring points in Pingshan New area have not yet covered some built-up areas in the northeast. The project team adopts percentile mathematical statistics method and the mathematical statistical method of correlation analysis to determine the best point to reflect the pollution degree of each type. On this basis, through site investigation, Pingshan New District development planning and layout principle, this study selected Tian Xin and Jolongshan and the existing Pingshan, Xiapo monitoring station as the optimization scheme of environmental air quality evaluation point in Pingshan New area.

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