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Domestic and International Comparative Statistical Study of Air Quality Index

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ABSTRACT

Through the comparative study of domestic and international air quality index standards, including the development of air quality standards, pollutant projects, air quality index calculation methods and grading method, the existing problems of China's air quality index standard are found. The air quality indexes of major cities in China are calculated by the interpolation method, and then the spatial distribution of environmental pollution is studied. It was concluded that China's air quality index standards has essentially been brought in line with international standards, while the air quality of economically developed Beijing-Tianjin-Tangshan region is poor and must be harnessed.

1. Introduction

Air pollution is an important part of environmental pollution, and human activities are closely related to it. It is a serious threat to human life and health, many countries are trapped by control of air pollution. In 2016, the vast majority of countries formulated the ambient air quality standard based on their own environmental conditions, in which the pollutant item, the limit of pollutant concentration and the degree gradation of pollutant were defined and became the basis of the management and evaluation of air quality by these countries [1-3].

2. Method

There are two aspects of the study in this paper: (1) Conclude the problems of Chinese air quality standards through comparing the domestic and international air quality index data. (2) Analysis the distributed characteristics of the air quality of major cities in China by Spatial Interpolation Method.

(1)Domestic and international air quality index data comparison

Perform a comparative analysis from the different air quality index release situations, classification situations and caculation methods of different countries.

The World Health Organization (WHO) published the Air Quality Guidelines (AQG) in 1997, released a revised version in 2005, and drastically revised the limits for SO2, NO2, O3, and PM10. China revised the *Ambient Air Quality Standard* in 2012, which is in line with the *Air Quality Guidelines* published by WHO. In 2016, *Technical Regulation on Ambient Air Quality Index (on trial)* defined the classification scheme, computing method of the ambient air quality index and the content format and released the information of air quality [4-6].

As we can see from Table 1, the names, numbers, and items of air quality index and the sample time of each country are different. In the general trend, the numbers of index items of each country are gradually increasing, and the high-frequency evaluation items are SO2, NO2, PM10 (inhalable particles, aerodynamic equivalent diameter ≤10 micron particles), CO, O3. From the shortening of the evaluation time, every country have paid more and more attention to the evaluation of the acute effects of pollutants. For example, China has revised the index of S02-1 h and N02-1 h to prevent the damage of short-term high concentrations of SO2 and NO2.

Table 1. Air Quality Index of Different Countries

Country	Name of Index	Scalar of index	Items of Index and Sample Time
China**Error! Reference source not found.Error! Reference source not found.**	API（1997-1999）	3	SO_2-24h、NOX-24h、TSP-24h
	API（2000-2011）	5	SO_2-24h、NO_2-24h、PM_{10}-24h、CO-1h、O_3-1h
	AQI（2012-）	10	CO-1h、CO-24h、O_3-1h、O_3-8h、SO_2-1h、SO_2-24h、NO_2-1h、NO_2-24h、PM_{10}-24h、$PM_{2.5}$-24h
The US[000]	PSI（1976-1996）	5	CO-8h、O_3-1h、SO_2-24h、NO_2-1h、TSP-24h
	PSI（1994-1998）	5	CO-8h、O_3-1h、SO_2-24h、NO_2-1h、PM_{10}-24h
	AQI（1999-2010）	7	CO-8h、O_3-1h、O_3-8h、SO_2-24h、NO_2-1h、PM_{10}-24h、$PM_{2.5}$-24h
	AQI（2011-）	8	CO-8h、O_3-1h、O_3-8h、SO_2-1h、SO_2-24h、NO_2-1h、PM_{10}-24h、$PM_{2.5}$-24h
The UK[0]	AQI（1998-2011）	6	NO_2-1h、O_3-1h、O_3-8h、SO_2-15min、CO-8h、PM_{10}-24h
	DAQI（2012-）	5	NO_2-1h、O_3-8h、SO_2-15min、PM_{10}-24h、$PM_{2.5}$-24h

The classification situation of air quality index of each country is different, but their classification theories are basically the same, and they all classify the air qualify index based on the degree of excellence of air quality. Among them, the US air quality is start from excellent, while the UK start from mild, low risk and so on. China uses two methods to classify, which

are air quality index level (i.e. from 1 to 6 of a total of 6) and the air pollution level (i.e. from excellent to serious of a total of 6). In most countries, the air quality is classified directly using qualitative descriptions of air quality conditions (e.g. mild pollution, severe pollution, etc.). If using the digital level (e.g. level 1, level 2, etc.), the qualitative description will also be used, so that the classification can be more intuitive and clear.

Different countries and regions may select different pollutant projects when they caculate the air quality index, because they select pollutant projects based on projects related to their own ambient air quality standards. Table 2 include some projects that are caculated by several countries. It can be seen from the Table 2, due to the current limitations of monitoring technology, such as benzene, lead and other harmful substances are not accepted as the air quality index of the evaluation index though they are parts of the air quality standards, for it is difficult to meet the needs of real-time information release [7, 8].

Table 2. The Pollutant Projects Be Used by Different Countries

Country/Region	Pollutant Projects
China	CO、SO_2、NO_X、NO_2、O_3、TSP、PM_{10}、$PM_{2.5}$、Pb、BaP
The US	CO、SO_2、NO_2、O_3、PM_{10}、$PM_{2.5}$、Pb
The UK	CO、SO_2、NO_2、O_3、PM_{10}、$PM_{2.5}$、Pb、PAH、Benzene、1,3-butadiene

Different countries have different methods of air quality index calculation, and the main methods are interpolation method (US, China, EU, and South Korea), concentration interval control method (UK) and health risk calculation method (Canada). The interpolation method is the most common method, and the critical values and grading standards both are defined by relevant standards when using the interpolation method. The US Environmental Protection Agency (EPA) limit the PM2.5 [9] as shown in Table 3:

Table 3 .The US AQI Grade Critical Value（Take PM2.5-24h concentration as an example）

Air Quality Index I	$PM_{2.5}$-24h/（μg·m3）	Air pollution level
0-50	0.0-15.4	Good
51-100	15.5-40.4	Moderate
101-150	40.5-65.4	Unhealthy for sensitive groups
151-200	65.5-150.4	Unhealthy
201-300	150.5-250.4	Very Unhealthy
301-400	250.5-350.4	Hazardous
401-500	350.5-500.4	Hazardous

(2) Air quality index I is calculated as follows:

$$I = \frac{(I_{high}-I_{low})(C-C_{low})}{C_{high}-C_{low}} + I_{low} \quad (1)$$

In the formula:

I=Air Quality Index(AQI);

C= Contaminant Concentration;

C_{low}= Equal or Less than the concentration limits of C, as a constant;

C_{high}= Equal or greater than the concentration limits of C, as a constant;

I_{low}= Corresponds to the Index limits of Clow, as a constant;

I_{high}= Corresponds to the Index limits of Chigh, as a constant.

According to C that is the concentration of pollutants can calculate the value of air quality index I easily. For example, calculate the value of the air quality index corresponding to the PM2.5 concentration is 68.5μg / m3, and we can see from Table3, the corresponding C_{low} = 65.5, C_{high} = 150.4, corresponding I_{low} = 151, I_{high} = 200. From formula (1):

(200-151）/（150.4-65.5）*（68.5-65.5）+151=152.73

The rounded number is 153(air quality index will be release as integer). After calculating the various AQI values, the AQI value, which is the largest value, is the AQI value that is finally reported. The $PM_{2.5}$ that has the largest AQI is known as the primary pollutant. The AQI that is corresponded by $PM_{2.5}$ is calculated by the 24-hour average concentration of $PM_{2.5}$. For calculate easily, AQI is usually calculated based on the 24-hour average concentration that be seemed as real-time $PM_{2.5}$.

The classification of cities refers to *Technical Regulation on Ambient Air Quality Index (on trial)* (HJ 633-2012) which we can see from Table 4, and the results are shown in Figure 1.

Table 4. The Grade of Air Quality Index

Grade	AQI	PM_{10}	$PM_{2.5}$	Pollution Level
1	0-50	0-50	0-35	Good
2	51-100	51-100	36-75	Moderate
3	101-150	101-150	76-115	Lightly Polluted
4	151-200	151-200	116-150	Moderately Polluted
5	201-300	201-300	151-250	Heavily Polluted
6	>300	>300	>250	Severely Polluted

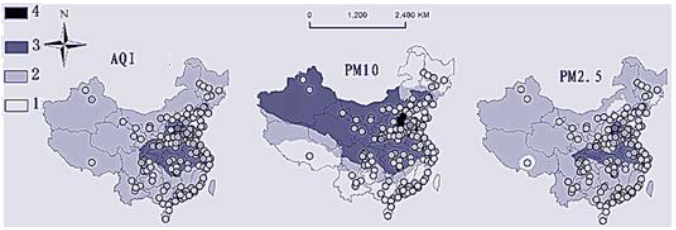

Figure 1. Distribution Characteristics of Air Quality in Major Cities in China
data sources: http://datacenter.mep.gov.cn/

Figure 1 shows that from the annual average, there is only one first-tier city, and second-tier cities that are mainly distributed in the northeast areas, southwest areas and the southeast coastal areas. And the third-tier cities are mainly distributed in the Yangtze-Huaihe River basin and the North China Plain while the fourth-tier are mainly distributed in the Beijing-Tianjin-Tangshan region. For the PM_{10}, there are two first-tier cities and second-tier cities mainly distributed in the Liaodong Peninsula, the southwest areas and the southeast coast. The third-tier cities are mainly distributed in the middle and lower reaches of the Yangtze River, the Yellow River basin and the Northwest areas, and the fourth-tier cities are major distributed in the North China areas while the fifth-tier cities in Shandong, Hebei and other places.

3. Results

By comparing and analyzing the air quality index, the pollutant projects, the grading schemes and calculation methods of some countries and regions, we can see that Chinese air quality index standards are basically in line with the international standards. The weakness: The particulate is calculated using the average of 24-hour concentration value, which has certain hysteresis. And the part of the air quality index category is unreasonable, air quality index classification is not clear.

It is found that PM2.5 is the primary pollutant by distribution characteristics calculus of air quality in major cities in China, and the distribution area of PM2.5 is basically the same as the AQI distribution. PM_{10} pollution area is much larger than the area of AQI and $PM_{2.5}$, and the areas of high $PM_{2.5}$ pollution is the smallest. Beijing, Tianjin, Tangshan and North China, Huaihe River Basin and other regional pollution is more serious, while the northeast area, Southwest area and southeast coastal area generally have better air quality [10].

4. Conclusions

It is suggested to comprehensively govern the Beijing-Tianjin-Tangshan region, the North China area and the Huaihe River Basin and other areas where the pollution of the urban agglomeration is more serious.

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