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The first official city ranking by air quality in China — A review and analysis

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ABSTRACT

Frequent regional haze and fog episodes in China force the central government to adopt air quality as a key indicator to assess the performance of provincial and local governors. The 74 key cities have been selected as pilot cities to carry out real-time air quality monitoring according to the new ambient air quality standards, in which $PM_{2.5}$ is for the first time included as one of the six compulsory items. The air quality ranking of the 74 cities has been released in the monthly report by the Ministry of Environmental Protection since January 2013. This is the first official city ranking by air quality in China, which makes air quality to be an important aspect of city branding and city competition. The information disclosure puts political pressure on city and provincial governments as their air quality will be watched by the public and the media. The present study provides a review and analysis of air pollution in China from city scale to regional scale based on the monthly reports in 12 months from August 2013 to July 2014. The official air quality rankings of the 74 cities are discussed from the aspects of geographical location, economic development mode and regional air quality management. The air quality rankings of the 74 cities provide the evidence that improvement of air quality requires industrial restructuring and sustainable development strategy. In addition, joint prevention and regional emission control are also essential.

1. Introduction

With rapid industrialization and urbanization since the reform and opening-up policy in 1978, China's air quality has been deteriorating in city scale (Du et al., 2012; Hao, Hu, & Fu, 2006; Wang et al., 2010; Xue et al., 2014; Yang, Wu, Davis, & Hao, 2011), in regional scale (Ding, Fu, et al. 2013; Ding, Wang, & Fu, 2013; Hao & Wang, 2012; Li & Shao, 2009; Shao, Tang, Zhang, & Li, 2006; Zhang et al., 2010), and in national scale (Fang, Chan, & Yao, 2009; Lu & Tian, 2007; Lu et al., 2010; Zhang, Geng, Wang, Richter, & He, 2012; Zhang, Streets, He, & Klimont, 2007; Zhang, Streets, He, Wang, et al., 2007). Frequent regional haze and fog episodes have caught the attention of Chinese and international media. The primary indicator of haze pollution is $PM_{2.5}$, fine particles with aerodynamic diameter of 2.5 μm or less, which can penetrate deeper into the lungs and give a 36% increase in lung cancer per 10 μg/m^3 (Raaschou-Nielsen et al., 2013). Reporters have compared $PM_{2.5}$ level in China with international standards to provide a dramatic contrast. For instance, in the 2014 Beijing International Marathon, the concentration of $PM_{2.5}$ was reported to be as high as 400 μg/m^3 as the runners lined up for the start in Tiananmen Square and the daily concentration reached 238 μg/m^3, while the World Health Organization recommended daily maximum average exposure is 25 μg/m^3 only (Ministry of Environmental Protection, 2014a; Tianqihoubao, 2015). A number of local and foreign athletes wore masks to run the race and the situation has been widely reported in the international media (The Daily Mail, 2014), see Fig. 1.

Brown haze episodes in China usually cover a wide area. One of the recent brown haze episode on February 22–23, 2014 covered as large as one million square kilometers in the north part of China, mainly in the capital of Beijing and a number of adjacent provinces such as Hebei, Shanxi, Shandong, Henan, and Liaoning (Ministry of Environmental Protection, 2014b). In the event of heavy pollution, according to the Ministry of Environmental Protection (MEP) in China, vulnerable populations including the children, seniors, and patients diagnosed with cardio-cerebrovascular diseases and respiratory tract diseases are advised to stay indoors and cut outdoor activities; and the general population is advised to reduce outdoor activities and operations. Considering the large number of exposed population in the area of one million square kilometers, it is no doubt that the impact of haze episodes on China is huge, and the public has expressed deep concern for monitoring and controlling air pollution.

Environmental problems in China force the central government to alter the model of economic development which pursues rapid industrialization at a cost of deteriorating urban environment (Sheng & Tang, 2013). In February 2012, the MEP in China released new ambient air quality standards, namely GB 3095-2012, which set limits for the first time on $PM_{2.5}$ (Ministry of Environmental Protection, 2012a). The new air quality standards take effect nationwide in 2016, but many cities and regions in China are required to implement the standards earlier than the national timeline. In particular, 74 key cities including all municipalities and provincial capitals as well as cities in the three key

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Fig. 1. Participants wearing masks against serious pollution in the 2014 Beijing International Marathon.
Source: Reuters.

regions of Beijing–Tianjin–Hebei (also named Jing-Jin-Ji Region), Yangtze River Delta and Pearl River Delta are required to implement the new standards by the end of 2012 (Ministry of Environmental Protection, 2012b).

To assess air quality according to the new standards GB 3095-2012, ambient air monitoring networks have being established or reconstructed. As the monitoring data is used as an indicator to assess the performance of provincial and local governors, the MEP has implemented a number of measures to ensure the quality of monitoring data and prevent data manipulation and falsification, including (1) unified supervision of the construction of local air quality monitoring stations, (2) routine inspection of the operation of local air quality monitoring stations, (3) real-time on-line monitoring of air quality data that is released hourly on the internet, and (4) comparing data from neighboring cities to determine whether any abnormal situations exist. These measures, particularly releasing hourly monitoring data on the internet, have been appreciated by local and foreign researchers who have been tracking air quality in China. This batch of official air quality data could be considered as the most representative under the most stringent supervision so far, therefore it is well worth to organize and analyze the data carefully.

This study will analyze the air quality data released officially by the MEP in China since 2013. The data covers the 74 key cities which are the first batch to carry out real-time monitoring according to the new ambient air quality standards GB 3095-2012. Considering that the air quality monitoring is supervised by a single department of the MEP, the air quality data of the 74 cities are expected to have high comparability. With data analysis in both city scale and regional scale, the spatial and temporal distributions of six major air pollutants including $PM_{2.5}$, fine particles with aerodynamic diameter of 10 μm or less (PM_{10}), ozone (O_3), sulfur dioxides (SO_2), nitrogen dioxides (NO_2), and carbon monoxide (CO) are analyzed and discussed in this paper. In addition, since 2013, the MEP has released the monthly air quality ranking of the 74 cities. The ranking is based on the city's air quality comprehensive index (AQCI) which measures levels of the six major air pollutants. This study will analyze the official monthly rankings of the 74 cities in 12 months and compile an annual air quality ranking based on the average AQCI of each city.

Noticeably, the present study focuses on urban policy rather than atmospheric science or chemical analysis. In particular, considering that city ranking by air quality has a significant impact on city branding and city competition, the present study will highlight possible factors affecting the air quality rankings of the 74 cities. The paper also provides a review and analysis of air pollution in China from city scale to regional scale. The results could be used as a good reference for related research on different air pollutants in different spatial scales. In the following section, the evolution of ambient air quality standards in China is first introduced. The implementation scheme of the new ambient air quality standards is then introduced in Section 3. Section 4 analyzes the monthly variations of the six major air pollutants in the 74 cities and the three key regions during the past 12 months. Particularly, the official air quality rankings of the 74 cities are discussed in Section 5. Finally, the conclusions are given in Section 6.

2. Evolution of ambient air quality standards in China

The evolution of ambient air quality standards in China has been highly related to the process of city development. In the initial stage of the reform and opening up in China, cities generally selected rapid industrialization as an engine of economic growth and environmental protection was not a major concern. The increased use of coal contributed significantly to the deterioration of air quality, and a few years later air pollution became one of the major problems faced by the urban area. In 1982, China adopted the first ambient air quality standards GB 3095-82 (Siddiqi & Zhang, 1984), which covered six pollutants including total suspended particulates (particulates less than 100 μm in diameter or TSP), airborne dust (particulates less than 10 μm in diameter or PM_{10}), nitrogen oxides (NO_x), SO_2, CO, and O_3.

Considering the special condition in China, the first air quality standards GB 3095-82 set three classes of limited values for three types of areas (Siddiqi & Zhang, 1984). The highest standard, i.e. Class-I standard, was set for nature conservation areas, tourist resorts, and historical monuments. The Class-II standard was set for residential, commercial, cultural and rural areas. The Class-III standard was the lowest standard designed for industrial districts and traffic centers with the problem of heavy pollution. It should be noted that the major target in the initial stage of the reform and opening up in China was to attract foreign investment, and a stringent air quality standard for industrial districts might not be suitable in the eyes of decision makers.

After two decades of reform and opening up, vehicle-based pollution started to appear with the increase of vehicle ownership. In 1996, the ambient air quality standards GB 3095-82 were amended as GB 3095-1996 (TransportPolicy.net, 2015) to consider both coal-based and vehicle-based pollutants. Four more pollutants namely NO_2, lead (Pb), fluorides (F) and benzo(a)pyrene (BaP) were added in the standards. In addition, the areas with the Class-III standard were reduced while those with the Class-II standard were increased. In particular, general industrial areas adopted the Class-II standard instead of the Class-III standard, while the Class-III standard was only for specific industrial zones. The new standards GB 3095-1996 were more stringent than the first version GB 3095-82. However, in 2000, the air quality standards GB 3095-1996 were revised to cancel the NO_x pollutant and relax the limits for NO_2 and O_3, so as to facilitate the rapid economic and social development.