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Review

Air pollution and control action in Beijing

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ABSTRACT

Beijing, the capital of China, has experienced rapid industrialization, urbanization and motorization in recent decades. Consequently, air pollution in Beijing, especially fine particulate matter ($PM_{2.5}$) pollution, has gradually become a severe environmental issue, due to the continuing growth in energy consumption and the resulting multiple pollutant emissions. In response to the increasingly serious $PM_{2.5}$ pollution, Beijing's government implemented a series of policies, measures and regulations on air pollution prevention and control and took some concrete actions to improve air quality. In this paper, firstly, we summarize China's ambient air quality standards, China's policies and regulations on air pollution prevention and control. Secondly, we illustrate historical evolution and current status of air pollution in Beijing. Finally, we introduce control measures and actions in Beijing and its surrounding areas. The paper aims to help environmental scientists and policy makers around the world understand the past and current air pollution in Beijing and control strategies and actions taken by Beijing's government.

1. Introduction

Over the past three decades, China has experienced rapid economic growth and ranked the position as the world's second largest economy. In 2013, the gross domestic product (GDP) reached 56.8 trillion RMB (~9.2 trillion US dollars) and the resulting total energy consumption was equivalent to 3.75 billion tons of coal (see Fig. 1). For the year 2013, fossil fuel consumption (coal and oil) was estimated to account for more than 88% of total energy consumption (Chinese National Bureau of Statistics, 2013). Fossil fuel consumption is the dominant emission contributor of anthropogenic air pollutants in China, which was reported in recent studies (Chan and Yao, 2008; Zhao et al., 2011; Wang et al., 2012). Therefore, along with fossil fuel consumption, air pollution has become one of key environmental issues in China, with which Chinese government will have to cope in the coming decades (Zhang et al., 2012).

In recent years, air pollution, especially fine particulate matter ($PM_{2.5}$) pollution, has become a serious environmental problem in

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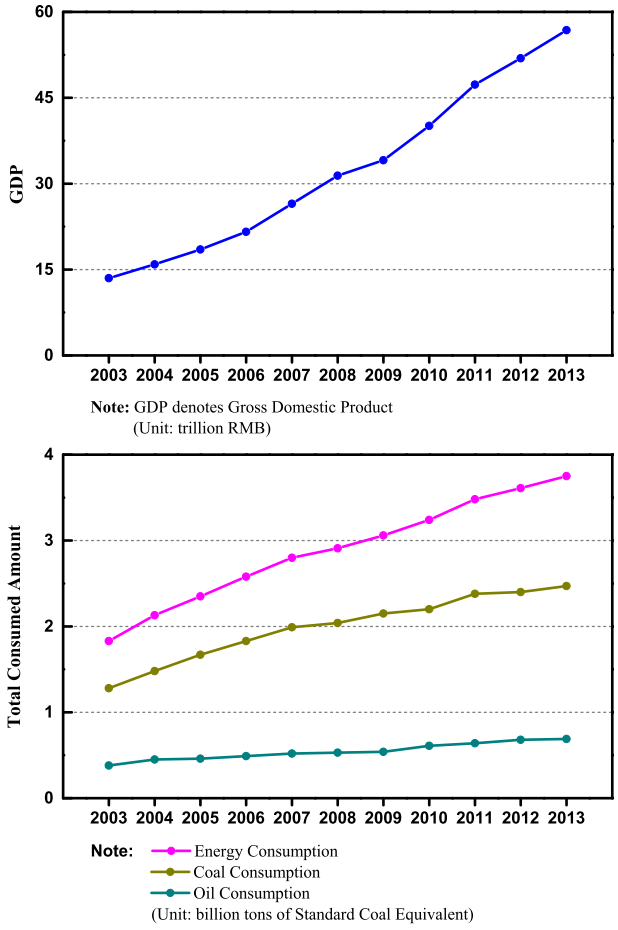

Fig. 1. Growth trends in GDP, energy consumption, coal consumption and oil consumption in China, 2003–2013. Data are from Chinese National Bureau of Statistics, 2013–2013 (http://www.stats.gov.cn/tjsj/ndsj).

China's economically well-developed regions (Hu et al., 2014), such as Beijing-Tianjin-Hebei region, Yangtze River Delta region, and Pearl River Delta region, which not only influence regional and urban air quality but also has an adverse impact on human health and eco-environment (Brunekreef and Holgate, 2002; Nel, 2005; Li et al., 2011; Kan et al., 2012; Dominici et al., 2014; Li et al., 2014). For example, in January 2013, extremely severe and persistent haze pollution happened in Central, Northern and Eastern China, with high concentrations of $PM_{2.5}$ (sometimes $PM_{2.5}$ record-breaking) covering about 1.3 million km^2 and affecting approximately 800 million people (Huang et al., 2014). Since then, Chinese government has recognized that it is a key task to prevent and control air pollution in China. Correspondingly, a series of policies, regulations and laws on prevention and control of air pollution have been formulated and promulgated. For instance, to effectively improve regional and urban air quality in China, 'Action Plan on Prevention and Control of Air Pollution' (hereinafter referred to as Action Plan) was implemented in September 2013, which proposed the targets that by 2017, $PM_{2.5}$ concentrations in Beijing-Tianjin-Hebei region, Yangtze River Delta region, and Pearl River Delta region should be declined by 25%, 20%, and 15%, respectively. In addition to improving regional air quality, the Action Plan put forward the clear requirement for Beijing's air quality improvement that by 2017, annual average $PM_{2.5}$ levels should be kept within 60 $\mu g\ m^{-3}$.

Beijing (39°56′N, 116°20′E), the capital of China, is located on the northwest of Beijing-Tianjin-Hebei region, which is surrounded by the Yanshan Mountain in the west, north and northeast directions. In recent decades, with the rapid development of industrialization, urbanization and motorization (Han et al., 2014), Beijing's energy consumption and the resulting multiple pollutant emissions were increasing year by year, which had adverse impacts on air quality, human health and eco-environment (Li et al., 2011, 2014). In recent years, particulate pollution, especially high concentrations of $PM_{2.5}$ pollution, have been the foremost problem of Beijing's air pollution (Hu et al., 2014). In order to lower $PM_{2.5}$ pollution and improve air quality, Beijing's government had taken a series of strict control actions to prevent and control air pollution, which, to a large extent, set a good example for other urban air quality improvement in China and even in other countries around the world. Therefore, it is necessary to make a brief introduction about Beijing's air pollution and control actions taken by Beijing's government.

In this paper, we review recent advances about China's ambient air quality standards, policies and regulations on air pollution prevention and control in China, illustrate historical evolution and current status of Beijing's air pollution, and present control measures and actions taken by Beijing's government. This review is not intended to be exhaustive but to make a preliminary introduction about Beijing's air pollution and control action. Moreover, the information included in this review is limited to the official data published before 2014.

2. Ambient air quality standards, policies and regulations on prevention and control of air pollution in China

2.1. Ambient Air Quality Standards (AAQR) in China

Ambient Air Quality Standards (AAQS) in China were originally formulated in 1982 (Fig. 2), which was the first official document aiming to improve ambient air quality. The first amendment of AAQR was implemented in 1996, which included three Grade standards (I, II and III) and recommended the limit values of seven principal pollutants (SO_2, NO_x, NO_2, CO, O_3, PM_{10} and TSP) (See Table 1). The second amendment was made in 2000, which removed the standard of NO_x pollutant and relaxed the limit values of NO_2 (Grade II) and O_3 (Grade I and II) (See Table 2). In February 2012, the third amendment was made by Ministry of Environmental Protection (MEP), which added the standards of $PM_{2.5}$ and Max. 8-h O_3 pollutants and tightened the guideline values of NO_2 (Grade II and Grade I – 1-hr) and PM_{10} (Grade II – annual) (See Table 3). In the newly amended AAQR, the guideline values of Max. 8-h O_3, daily- $PM_{2.5}$ and annual-$PM_{2.5}$ are 100, 35 and 15 $\mu g\ m^{-3}$ for

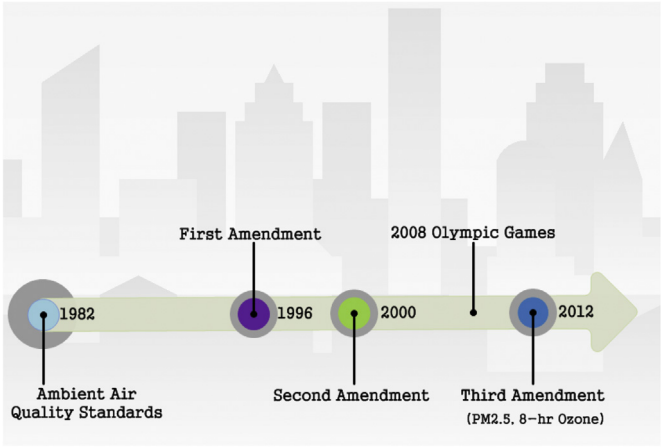

Fig. 2. Historic evolution of ambient air quality standards in China.