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Baosteel emission control significantly benefited air quality in Shanghai

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A B S T R A C T

As the largest iron and steel producer in China, a part of Baosteel located in Baoshan District moved out of Shanghai deserves close attention due to its environmental impact. To understand the effect of Baosteel emission control on air quality in Shanghai, daily PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO were measured from 2010 to 2016. Concentrations of pollutants in Baoshan District presented a decreased trend during 2010–2016, with a reduction rate of 28.6% for PM_{10}, 67.3% for SO_2, 8.6% for NO_2 and 42.0% for CO. However, fine particle pollution in Baoshan District during 2012–2016 seems to become more prominent, with $PM_{2.5}$ concentration of 47 ± 28, 45 ± 33, 38 ± 24, 54 ± 41 and 51 ± 34 μg/m^3, respectively, indicating a slight increase of 8.5% in $PM_{2.5}$. Concentrations of PM_{10} and CO decreased by 12.5% and 33.8% in the second half year in 2016 (compared with that in 2015) probably due to closure of blast furnace of Baosteel. Baosteel was identified as the largest pollution source in Baoshan District. Emission from Baosteel accounted for 58.0% of SO_2, 43.6% of NO_2 and 79.3% of dust in total emission from Baoshan District during 2010–2015. Meanwhile, pollutant emission and coal consumption from Baosteel decreased by 52.0% for SO_2, 40.1% for NO_2, 15.7% for dust and 22% for coal consumption. Besides, energy consumption in Baoshan District reduced by 31% from 2011 to 2015. Air quality improvement in Shanghai was attributed to local emission reduction from Baosteel and Baoshan District, together with regional air quality improvement.

Introduction

With frequent occurrence of severe and persistent haze in China, air pollution has been the focus of scientific researchers, the Chinese government and the publics in recent years (Cao et al., 2017; Chen et al., 2017; Fu and Chen, 2017; Huang et al., 2015; Tao et al., 2017; G. Wang et al., 2016; Wang and Hao, 2012; Wang et al., 2014). Industrial process is one of the dominant contributors to atmospheric pollutants. For example, the emission of SO_2, NOx, CO, PM_{10} and $PM_{2.5}$ from industry sector accounted for 31.4%, 25.8%, 44.9%, 57.3% and 52.3% of total emission in China (Zhang et al., 2009). Industrial combustion and industrial process contributed 44.4% to SO_2 emission, 26.9% to PM_{10} emission and 28.9% to $PM_{2.5}$ emission in the Yangtze River Delta region (Fu et al., 2013). Iron and steel industry, of which energy structure is dominated by coal and coke, is one of energy-intensive and heavy-polluting industrial sub-sectors, *e.g.*, For example, smelting and pressing of ferrous metals

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consume 14%–20% of total energy consumption in China in 2000–2014 (China Energy Statistical Yearbook). CO_2 emission from iron and steel industry was responsible for about 7% of total global anthropogenic CO_2 emission (Kim and Worrell, 2002).

Baosteel Group Corporation (Baosteel), the most competitive iron and steel conglomerate in China, was established in 1978. Baosteel is located in Baoshan District, Shanghai. As a main industrial base in China, Baoshan District, with an area of 293.71 km^2, is located in the north of Shanghai. Although Baoshan District accounts for less than 5% of Shanghai's total areas, pollutants emission from Baoshan District shares one-third of Shanghai's total emission, particularly for soot and dust, which was resulted from large area of industry zone in Baoshan District (Chen et al., 2011). In 2014, crude steel production (433 million tons) of Baosteel ranked the 4th among the global steelmakers. Issued by American FORTUNE, Baosteel ranked 275th among the world's top 500 companies in 2016 and has been ranked among the top 500 companies in the world for 13 consecutive years. In 2016, a noticeable event happened for Shanghai, which is that stainless steel production of Baosteel relocated out of Shanghai to Zhanjiang, Guangdong Province. The 2500 m^3 blast furnace and stainless steel production of Baosteel closed down in 20 June, 2016. After the blast furnace power off, iron production of Baosteel will reduce by 2.5 million tons per year. The relocation of Baosteel will have a significant effect on air quality of Baoshan District and Shanghai. Thus, an investigation being focused on the air quality change in Baoshan District, Shanghai before and after the relocation of Baosteel was desirable.

In this study, we measured air pollutants, including PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO, to investigate air quality trend in Baoshan District, Shanghai from 2010 to 2016. Pollutant emissions from Baoshan District, particularly Baosteel were studied. Besides, the driving factors of air quality change in Baoshan District were discussed. The current work firstly tried to investigate the effect of Baosteel emission control on air quality in Shanghai, providing a scientific basis for the local government to make control strategies in the future.

1. Experiment and methods

The measurements were conducted on the rooftop of a 5-floor building in Baosteel Shanghai Iron and Steel Research Institute (N31°22′, E121°28′, Fig. 1) from 1 January, 2010 to 31 December, 2016. The sampling site is mostly surrounded by industrial properties, which represents typical characteristics of Baoshan District. 24-hour average PM_{10} and $PM_{2.5}$ concentrations were measured with a TEOM Series 1400a and 1405F online particulate monitor (Thermo Scientific, USA) approved by US EPA (Meyer et al., 2000). Gaseous pollutants, including SO_2, NO_2 and CO, were measured by commercial online detectors (Teledyne API100E for SO_2, API200E for NO_2 and API300E for CO), with 1 hr time resolution (Hua et al., 2016). Daily concentrations of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 of Shanghai were obtained from the public website of Shanghai Environmental Monitoring Center (http://www.semc.gov.cn/aqi/home/Index.aspx). Concentration of $PM_{2.5}$ in Shanghai in 2012 was downloaded from the website of Shanghai US Consulate (http://www.stateair.net/web/historical/1/4.html). The information on the emission of SO_2, NO_2 and dust from Baoshan District and Baosteel was obtained from Baoshan Environmental Protection Bureau. Meteorological parameters in Baoshan District from 2010 to 2016 were sourced from Baoshan Statistical Yearbook, 2011–2016.

Potential source contribution function (PSCF) is a widely used method to determine the potential source area of pollutants at a receptor site (Cheng and Kabela, 2016; Jeong et al., 2013; Wang et al., 2006). PSCF calculates the probability that a source is located at latitude *i* and longitude *j*, described by Eq. (1):

$$PSCF_{ij} = \frac{m_{ij}}{n_{ij}} \quad (1)$$

where, n_{ij} is the total number of trajectory endpoints falling in the cell (*i*, *j*) and m_{ij} is the number of trajectory endpoints that the concentration of air pollutant (*e.g.*, SO_2, NO_2, $PM_{2.5}$, PM_{10}) at the receptor site is higher than a specified threshold when an air

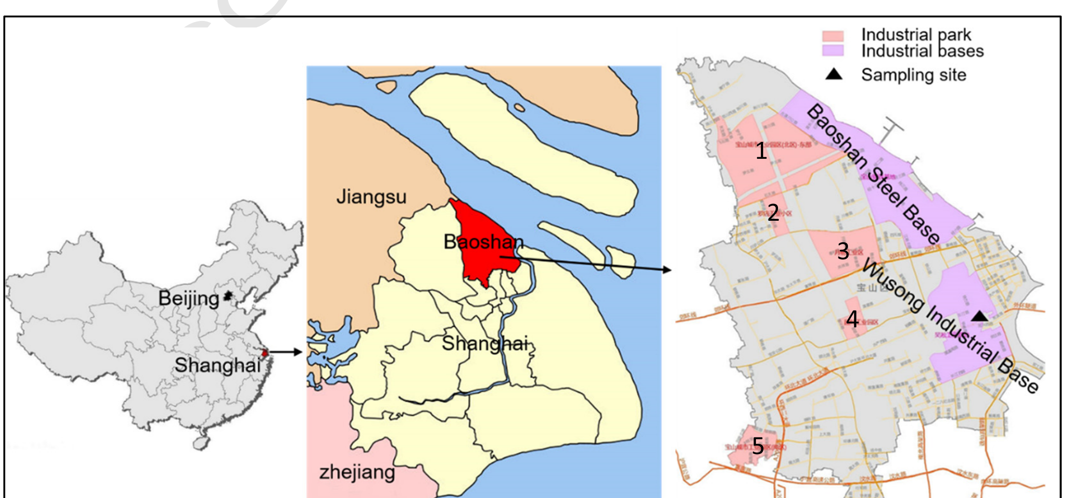

Fig. 1 – Map of industrial distribution in Baoshan District, Shanghai (1. Baoshan City Industrial Park-East, 2. Luodian Industrial Park, 3.Yueyang Industrial Park, 4.Gucun Industrial Park, 5. Baoshan City Industrial Park-South).

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