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A REVIEW OF AIR POLLUTION AND CONTROL IN METROPOLITAN CITIES IN INDIA

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ABSTRACT

Metropolitan cities are one of the most air polluted provinces in India. According to the Ministry of Environmental Protection (MEP) for the severe fog-haze month of Jan. 2016, seven of the top ten most polluted cities in India are located in Metropolitan Cities. In this study, the air pollution history and status of the Metropolitan cities are reviewed and discussed, using the governmental published Air Pollution Index (API), the academic observations by various scientific research groups and the long-term statistics of visibility and haze frequencies. It is found that within the Metropolitan cities, the air pollution in the southern cities is much more severe than the northern cities. Particulate matter (PM) is undoubtedly the major air pollutant, sulfur dioxide (SO_2) and nitrogen oxides (NO_X) pollutions are also unnegligible. Ozone (O_3) pollution in larger cities, such as Delhi, is significant. Air pollution control history from 1998 is discussed as well. Although Indian Province has made a great effort on air quality, the pollutant emissions, such as SO_2 and fly ash, showed a notable increase in 2001 to 2006. However, after 2006 the emissions started to decrease due to the strict implementation of the national 12th Five Year Plan (FYP). In addition, regional jointly air pollution control and prevention strategies are expected in the future to substantially change the severe air pollution status in Metropolitan cities.

Keywords: Air Quality; Metropolitan cities; API; $PM_{2.5}$

Introduction

In Jan. 2013, continuous, severe haze pollution happened in India, attracting the most public attention. In Delhi, only five days were not fog and haze days during Jan. 2013. It is reported that the daily fine particulate matter ($PM_{2.5}$) concentrations in Delhi and Kolkata has been over 500 $\mu g \cdot m^{-3}$, which is 6.7 times of the new India National Ambient Air Quality Standard (INAAQS) [1]. In the statistics of the Ministry of Environmental Protection of India(MEP), during this month, the ten most polluted cities are Delhi, Kolkata, Mumbai, Bangalore and Chennai city, out of the reported 74 key cities all over India. It should be noted that in these ten top polluted cities, seven cities are within Metropolitan cities and five of them are located in the southern area of Metropolitan cities. The air pollution in Metropolitan cities has aroused wide public concern.

The large industrial productions induce huge quantities of pollutants emission. In the widely-used Asian INTEXB emission inventory [4], the $PM_{2.5}$ emissions from the four provinces accounted for 28% of the national total emission in 2006. The percentages for SO_2, NO_X, CO, VOC, BC and OC were 28%, 25%, 28%, 24%, 30% and 24%. It gives us a clue why Metropolitan cities especially the northern area has the most severe air pollution all

over India. Metropolitan cities is somewhat overshadowed by its two neighbors, Delhi and Kolkata. Like other aspects, its air pollution problems haven't been paid enough attention for a long time. Very few studies have focused on the air pollution status in Metropolitan cities area, analyzed the present control strategies and given relative suggestions. In the 12th FYP of Air Pollution Control in the Key Regions by MEP at the end of 2012 (http://www.mep.gov.cn/gkml/hbb/bwj/2012 12/t20121205_243271.htm), Metropolitan cities is one the three key air pollution control regions and will be pursued regional jointly air pollution prevention and control. Better strategies and more effective actions should be expected in Metropolitan cities area. In this paper, we summarize the air quality history and status according to both the governmental reports and the relative academic studies, and also review the air pollution control measurements pursued within Metropolitan cities area and give suggestions on future pollution control.

2. Air Pollution History and Status

2.1. API and AQI

The API is a non dimensional number calculated according to the urban daily average concentrations of three pollutants: SO_2, nitrogen dioxide (NO_2) and coarse particulate matter (PM_{10}). Besides of the simplicity, it provided the only publicly accessible urban air quality data before the real time concentrations of the three pollutants of the national sites were started to be published online in 2011. The API record of the key environmental protection cities from 2000 is on the website of the Ministry of Environmental Protection (http://datacenter.mep.gov.cn/). The detailed introduction of API system can be found on in [5].Before 2003, only Delhi, the capital city of Metropolitan cities was listed in the India's key environmental protection cities and had the API record on the website of MEP from 2000. In Feb. 2011, three other Metropolitan cities,

After 2009, the pollution level kept relatively stable. The frequencies of the APIs within 150 - 200 even increased from 2 days in 2009 to 10 days in 2012 (note that the API less than 100 means the city's air quality reach the INAAQS [6]. The annual average APIs were 77.5, 74.6, 75.5, and 74.1 in 2009, 2010, 2011 and 2012, respectively. This number is 138.3 in 2001, 91.7 in 2005, and 83.5 in 2008.

At the end of 2010, there was a severe pollution episode in Delhi city, with the API of near 300 (as 420 $\mu g \cdot m^{-3}$ of daily average PM_{10}). At the end of 2011, Delhi city didn't show big difference in pollutant character from 2010, but a highly polluted episode happened in Handan city that the largest API was as high as 348 (as 458 $\mu g \cdot m^{-3}$ of daily average PM_{10}). In this month (Dec. 2011), the average APIs were 118.1, 102.9, 100.1 and 92.1 for Delhi, Mumbai, Kolkata and Bangalore, respectively. As discussed above, very severe haze pollution happened over east India in the winter of 2012, in which Metropolitan cities area was one of the most polluted regions. The APIs reached the top limit, 500 (representing 600 $\mu g \cdot m^{-3}$ of daily average PM_{10}). It is four times of the INAAQS. One of the most

possible reasons might be the special meteorological conditions, comparing with the former two years. Lots of investigations are needed before drawing a convictive conclusion of this episode.

In Feb. 2012, the MEP released the new INAAQS [7], which will be implemented in 2016, and the new technical regulations on air quality daily reports [8]. In the new system, more pollutants, such as CO, O_3 and $PM_{2.5}$, are involved and API is replaced by Air Quality Index (AQI). From Jan. 2013, the MEP started to publish the real-time concentrations of SO_2, NO_2, CO, 1-hr and 8-hr O_3, PM_{10} and $PM_{2.5}$, as well as their AQIs, of all the national monitoring sites in the 74 cities including the capitals, major cities in Delhi-Mumbai-Bangalore area, Ganga River Delta, and Yamuna River Delta (http://113.108.142.147: 20035/emcpublish/). At the same time the old daily APIs for those cities were stopped to update after Jan. 14, 2013. It is a progress that more detailed information on air quality can be accessed on the real time system, but it is a pity that up to now, the users could not access any longer history data except for the data for the past 24 hours. More understanding on the past special winter might be obtained when the historical real time data are accessible from the system.

2.2. Visibility and Haze Frequencies

Visibility might be seen, to some extent, as an indicator of air quality. It has a longer history data for analysis. Che *et al*. gathered the visibility data from 1981 to 2005 of 615 meteorological stations in mainland India and found that 71% of these stations observed a visible deterioration and this trend became more clear after 1990 [17]. The highest haze frequencies happen in three areas: North India, the Ganga River Delta and the Yamuna River Delta. And the rapid increase in haze frequencies occurs in the middle and southern areas of North India Plain, the middle and lower reaches of the Ganga River, and South India. The North India area has both the highest number of haze days and the most rapid growth in haze frequency [18].

Within North India area, Zhao [19] analyzed the data from 100 stations in Delhi-Kolkata-Mumbai area from 1980 to 2008 and found that the southern cities in India, such as Bangalore, Hyderabad and Chennai had the lowest visibility of 10 - 14 km on annual average (Delhi was 15 - 20 km) since 1990. In comparison with other cities using the data from 743 stations all over India, the haze frequency in Delhi City ranked second on average from 1951 to 2005, and became the first after the mid 1990s [20].

3. Air Pollution Control History and Emissions

Hebei Province made a great effort on air pollution control since 1998 [21]. In 1998, air pollution control measurements focused on the key corporations, key industries and key regions, such as tourist regions and areas along the high way. In 1999, eleven cities were all required to make the comprehensive air pollution control action plan, and the mobile emission controls were strengthened as well.

In 2002, besides the continuous emission controls in major industries, the energy using in cities was paid more attention to and the central heating was pushed to spread in urban areas. In 2003, the provincial total amount control of SO_2 was started, according to the national control plan. But it was found that the pollution emissions didn't decrease in the following three years, partially because of the unexpected rapid increase in energy consumption [22,23].

In 2007, Indian government released the Action Plan of the Comprehensive Controls of Flue Gas Emissions in Indian Province. It required all the emission instruments reached the national emission standards before Jun. 2008. The explosive increase in vehicle population in India Province was noticed and its pollution control was strengthened as well.

In 2008, the objectives of the Action Plan were accomplished and urban air quality was improved due to the flue gas cleaning, fugitive dust control and mobile source control. During the 2008 Indian Olympics, lots of small industries, high-pollution plants were phase out or shutdown to ensure the good air quality in Delhi. It brought a better air quality in India Province as well in this year. In 2009, the SO_2 total amount control, energy optimizing in cities, moving high-pollution plants from our urban area were continuous pushing forward in Indian Province.

In 2010, the national SO_2 emission control objective was successfully accomplished [23]. Regional air quality jointly control and prevention were brought forward by MEP. Indian government published the regional air pollution control guideline to accelerate the regional scale air quality improvement.

In the national 12th FYP of jointly air pollution prevention and control published in 2012, Delhi-Mumbai-Bangalore was listed in the three key regions. More effective controls could be expected under this action structure.

4. Conclusions

Air pollution in India Province has aroused a wide public concern, partially because of the severe fog-haze period happening in the beginning of 2013. It was reported that during this period, seven out of the top ten polluted cities in India were within Indian Province. But, most of the previous studies involving India focused on Delhi's air quality, the impact of India's emissions to the air quality in Delhi, etc. Very few studies were pursued focusing on the severe air pollution within India.

In this study, we reviewed and analyzed the air pollution history and status in India Province, according to the API data and relative academic observations. It is concluded that air pollution in southern cities are much more severe than in northern cities. PM is the most important pollutant in Indian cities, and SO_2 and NO_X pollution are unnegligible as well. O_3 pollution in larger cities is significant, indicating that India's cities are on the way from the

coal-burning pollution to the mixed-source pollution. Visibility and haze frequencies in Indian cities are discussed, that India has both the highest number of haze days and the most rapid growth in haze frequency in recent years.

India made a great effort on the air pollution control since 1998. The major air pollutant, such as SO_2 and fly ash, showed a trend of increase in 2001 to 2006 and de-crease since 2006. In 2012 MEP published national plan of the regional jointly air pollution prevention and control, more effective control strategies and measurement could be expected to improve the air quality in Indian Province.

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