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Risk-based air pollutants management at regional levels

Jianhua Xu [a,b], *Xuesong Wang* [c,*], *Shiqiu Zhang* [a]

[a] *Department of Environmental Management, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, PR China*
[b] *Center for Crisis Management Research, School of Public Policy and Management, Tsinghua University, Beijing 100084, PR China*
[c] *Department of Environmental Sciences, College of Environmental Sciences and Engineering, Peking University, Beijing 100871, PR China*

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ABSTRACT

The ultimate objective of abating air pollution is to protect the health and welfare of the public, while in the past, health and welfare are seldom used as the direct policy target. Often, emissions or concentrations are used as the direct target. In this paper, we put heavy weight on the justification of using a risk-based approach to address air pollution problems, and use a case study to demonstrate its technical feasibility in a Chinese setting. In the case, we study the health risks associated with SO_2 emissions from the different sectors in Beijing and its surrounding areas (the Beijing–Tianjin–Hebei region), to inform control responsibility assignment and control option design. The emission inventory was classified by sectors according to Chinese Standard Industrial Classification of All Economic Activities. The Community Multi-scale Air Quality (CMAQ) modeling system is used to simulate the fate and transport of SO_2 in the study region. Intake fraction, which is defined as the incremental intake per unit of pollutant released from a source or a category of sources, is borrowed to indicate the marginal risk posed by SO_2 from the major sectors. The results show that the intake fraction avoided per unit of SO_2 emissions abated from the four major sectors (power sector, smelting and pressing of ferrous metals, manufacture of non-metallic mineral products, and chemical industry) varies greatly, which implies that using a risk-based approach has the potential to help improve the efficiency in resource utilization for assigning pollutant control responsibilities and prioritizing pollutant control options.

1. Introduction

The ultimate objective of abating pollutant emissions is to protect the health and welfare of the public. Methods for estimating damages to health and welfare from air pollution are well established (e.g., USEPA, 1999; Bickel and Friedrich, 2005; Holland et al., 2005, 2011; Ho and Nielsen, 2007; Muller and Mendelsohn, 2007), while in practice, in assigning control responsibility and designing control options for conventional air pollutants, health and welfare were seldom used as the direct target, largely due to the huge amount of information needed to estimate damages to health and welfare and the inherent uncertainties embedded in such an estimation (Tietenberg, 1995). Often, emissions or concentrations are used as the direct target; handy examples include the pollution levy system and SO_2 total emissions control system in China and the SO_2 emission trading program in the United States. It should be kept in mind that policies as such were developed decades ago. As computing power increases, air pollutants' fate and transport modeling capabilities advance, and risk assessment evolves, it becomes more feasible than ever to use health risks posed by air pollutants as the direct policy target to improve the efficiency of society's resource utilization. Actually, risk-based approaches have been widely used to assess the impact of energy utilization and evaluate

* *Corresponding author*. Tel.: +86 10 62758784.
E-mail addresses: jianhua.xu@pku.edu.cn (J. Xu), xswang@pku.edu.cn (X. Wang), zhangshq@pku.edu.cn (S. Zhang).
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the cost and benefit of air pollution control policies in Europe (Bickel and Friedrich, 2005; Holland et al., 2005, 2011). Concerns on using health risks as the direct policy target includes unequal treatment of people exposed in polluted air as people in populous areas are given heavier weight (Tietenberg, 1995), and the tediousness and uncertainties in estimating risks incurred by individual sources (Wesson et al., 2010). In its 2004 report *Air Quality management in the United States*, the National Research Council (NRC, 2004) recommended a risk-based approach to enhance air quality management in the United States. Wesson et al. (2010) demonstrated the technical feasibility of applying a risk-based approach to address air pollution problems in the United States. In this paper, we use health risks as the direct policy target to inform air quality management in the Beijing–Tianjin–Hebei region (Fig. 1) as an exploration of its technical feasibility in a Chinese setting.

Using risks posed by air pollutants as the direct policy target to address air pollution problems in China has been discussed in academia for a while. Florig et al. (2002) advocates the adoption of exposure-based controls of particulate emissions to improve the economic efficiency of public health protection, and proposes ways in which exposure-based controls might be applied under the current regulatory regime (e.g., setting atmospheric emission limits according to the size of the population affected). Florig et al. (2002) also mentioned that one of the barriers to exposure-based regulation is the paucity of data and limited local analytic capacity in modeling the fate and transport of air pollutants, especially in less developed regions. In the book *Clearing the Air: the Health and Economic Damages of Air Pollution in China* edited by Ho and Nielsen (2007), an analysis integrating economic growth, energy use, air pollution and health damages was depicted. It details the estimation of national health damages posed by total suspended particulate (TSP) and SO_2 emissions from different sectors (e.g., power plants, chemicals industry, and metals smelting and pressing). Facing the challenge of sparse pollution data and limited health studies in China, this research used the derived relationship between exposure risk and emission source characteristics in sampled cities to estimate the exposure risk in other parts of the country, avoiding the need to conduct air fate and transport modeling work. This work has great implications on attributing national health damage by sectors and setting national mitigation priorities regarding TSP and SO_2. Zhou et al. (2010) estimated the health risks posed by $PM_{2.5}$ and O_3 from four sectors (power plants, industrial sources, mobile sources, and domestic life) in the Yangzte River Delta and found that the health risks avoided per tonne of $PM_{2.5}$, NO_x, VOC or SO_2 emissions reduction in these sectors are quite different in this delta, which is informative for setting $PM_{2.5}$ and O_3 control strategies in the Delta.

Our study focuses on estimating health risks posed by SO_2 emissions from the different sectors at a regional level using a case study, which is expected to inform control responsibility assignment and control options prioritization for primary pollutants. In the following, we describe the case, depict the method, show the results as we go through the procedures in the method section, and then draw conclusions, followed by implications.

2. Case description – the Beijing–Tianjin–Hebei region

The Beijing–Tianjin–Hebei region is chosen to conduct the case study, because firstly this region is experiencing severe air pollution, secondly detailed pollutant emission data in this region is readily available, and thirdly policy makers in this region is soliciting suggestions on developing regional air quality management mechanisms.

The Beijing–Tianjin–Hebei region, consisting of Hebei province and the municipalities of Beijing and Tianjin (Fig. 1), is located in northeast China, and covers an area of 212,800 km^2 (about 2.2% of the total land area in China). There are 13 cities at a prefecture-level or above (the 11 cities in Hebei plus Beijing and Tianjin) in this region with 6 of them having a population over 1 million. The 13 cities are inter-linked by vibrant commercial activities and convenient transportation (Chen and Lu, 2008). This region has a population of about 100 million, accounting for 7.5% of the national total, and

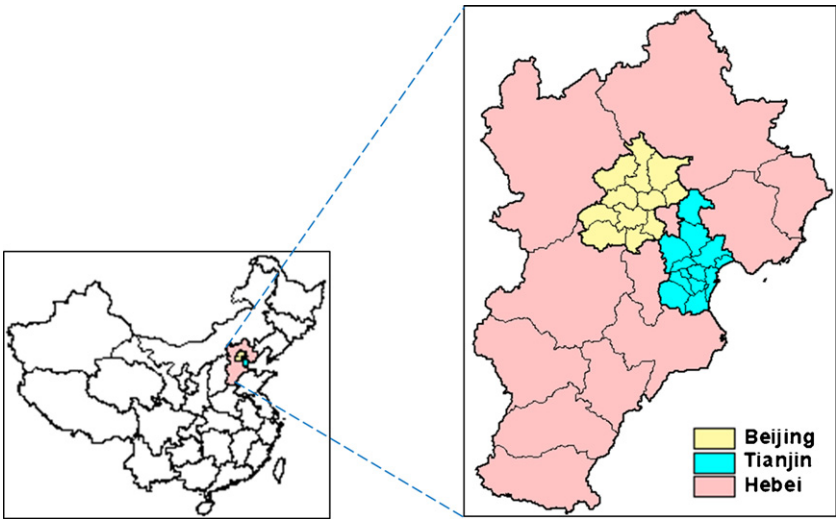

Fig. 1 – The Beijing–Tianjin–Hebei region and its location in China.