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Urgency, development stage and coordination degree analysis to support differentiation management of water pollution emission control and economic development in the eastern coastal area of China

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ABSTRACT

The eastern coastal areas of China have high-density population, developed society and economy, and large water pollution emissions. How to reduce water pollution and realize the coordinated development of the economy and environment has become the national focus. Effective environmental policies should consider regional differences in development stage and sustainability performance. Here, we first analyzed the water pollution emissions intensity of the eastern coastal areas of China and the urgency of emissions reduction using 8-year environmental statistics from 2003 to 2010. We characterized development stages of the eastern coastal areas based on the relationships between water pollution emissions intensity and economic development. Further, we built a coordination degree index of economic development and water environment protection as a measure of sustainability. Results show that water pollution emissions intensity decreases as the economy grows from 2003 to 2010. The less-developed regions have a better coordination degree than some more-developed regions, especially those most-developed ones (e.g., Shanghai show more pressures on long-term sustainability than Hebei). The less-developed regions should take advantage of economic growth to invest more advanced environment protection technologies. The more-developed regions need to upgrade its economic structures and municipal infrastructures. Overall, the study provided a comprehensive approach to understand regional difference in development stage and sustainability performance in the eastern coastal region of China as well as the need of different environmental policies to reduce water pollution emissions.

1. Introduction

The eastern coastal areas of China have the most developed economy, the most concentrated population, and the highest level of social development in the country. The Gross Domestic Product (GDP) of eastern coastal areas rose from 5.23 trillion Yuan (2003) to 25.05 trillion Yuan (2010), with an average annual growth rate of 24.7% and the proportion of the total country's economy increased from 61.7% (2003) to 63.4% (2010) (CSY, 2012). However, during the same period, the total coastal wastewater emission increased from 22.8 billion tons to 33.1 billion tons (MEP, 2012b). The proportion of the coastal area's wastewater in total emissions of China remains high, rising from 50.1% (2003) to 60.8% (2010) (MEP, 2012a). How to reduce total pollutant emissions maximally in coastal areas have become the concern of China, neighboring countries and the world.

Many countries are likely to adopt the "one size fits all" policies in the early days because these policies are relatively easy to implement. However, the adoption of "one size fits all" policy may fail to protect the environment. The early version of United Nations Reducing Emissions from Deforestation and Forest Degradation (UN-REDD) program proposed incentives for reducing emissions from deforestation and forest degradation in developing countries. However, the public criticized the subsidy, as it is likely to encourage countries to maintain a high deforestation rate

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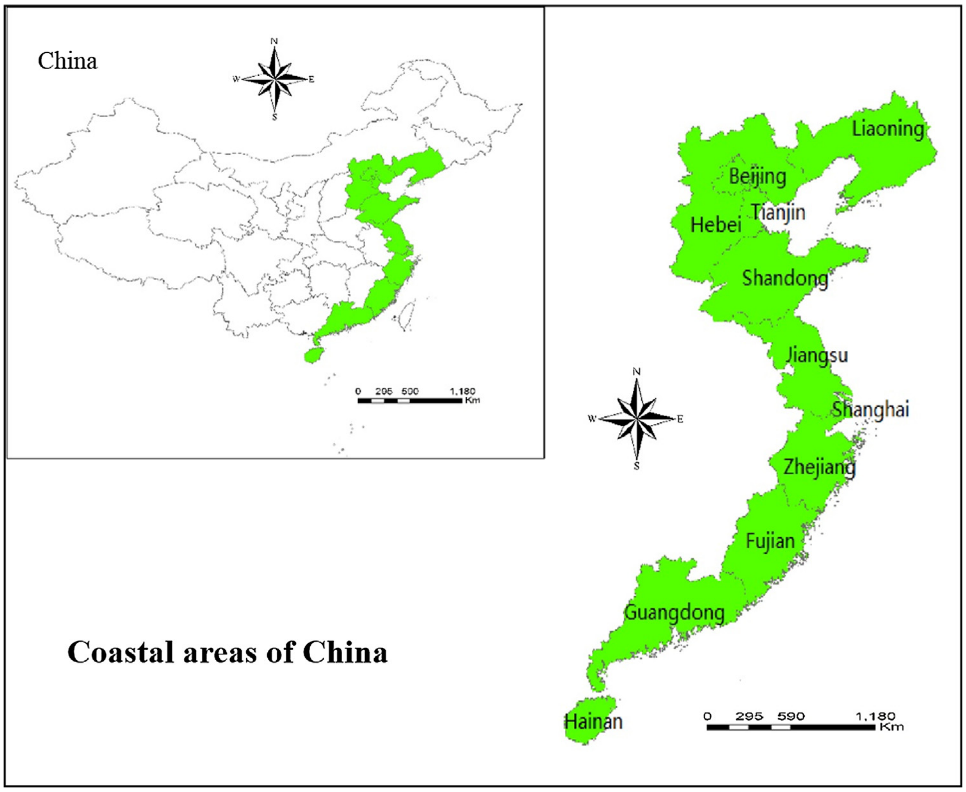

Fig. 1. The study area in coastal China.

and threaten the conservation effects in more protected forest covers (Hal, 2014; Thompson et al., 2011). China has been managing the environmental protections in the coastal areas with a "one size fits all" policy. However, this policy was not fair and efficient. In the late 1980s and early 1990s the large-scale valley harnessing of rivers in China had been done in the mode of "non-difference" management, which had no significant effects (Chen, 1996). Although national policies are ambitious and comprehensive, there is an environmental implementation gap between the national and local levels without considering local conditions and the lack of local autonomy(Chen and Uitto, 2003; Kostka, 2014).

The "one size fits all" is not feasible. Instead, regional differentiation management policies should be adopted (Elgin and Oztunali, 2014; Van Rossum and Van De Grift, 2009). To support regional differentiation management, we first evaluated the urgency degrees of emissions reduction of eight provinces and three municipalities (i.e., eleven regions in total). Second, we went through the relationship between economic development and water pollution emissions like the research in 2014 (Zhang and Zou, 2014). We plotted the curves between water pollution emissions intensity and per capita GDP of eleven regions like the research in 2015 (Farhani and Ozturk, 2015). According to the "curves" for different regions, we determined the development stage of each region and quantified the sustainable performance using a coordination degree index. The coordination degree index measures the balance between water environment pollutions control and economic development. In the end, we moved forward to specific differentiation management strategies built upon development stage and sustainability performance (Lu and Li, 2007; Yong-Huan et al., 2013). Overall, the goal of this study is to provide a comprehensive analysis including urgency quantification, stage classification and coordination degree measurement to understand the policy need in each region for environmental protection and economic development.

2. Materials and methods

2.1. Study area

Our study areas include eight provinces (i.e., Liaoning, Hebei, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, and Hainan) and three municipalities directly under the Central Government (i.e., Beijing, Tianjin and Shanghai) (Fig. 1). Guangxi is not included, because not all boundaries are coastal, and this part shares a border with Vietnam. The total land area is about 1.07 million square kilometers and accounts for 11.11% of China's area.

2.2. Study method

We collected the statistical data of eight provinces and three municipalities about industrial and municipal water pollution emission, and the socioeconomic development from 2003 to 2010 (CSY, 2012; MEP, 2012a,b). We analyzed the regional difference in emission levels of water pollution using a set of indexes below.

2.2.1. Water pollution emission intensity

The equation of industrial and municipal water pollution emissions intensity is available below (Eqs. (2-1), (2-2)):

$$E_{industrial,i,t} = \frac{Q_{industiral,i,t}}{IAV_t} \tag{2-1}$$

Where,

$E_{industrial,i,t}$ = industrial water pollution emissions intensity in year t; i is the i^{th} type of water pollutants (i.e., wastewater volume, Chemical Oxygen Demand (COD), NH_3-N);

$Q_{industrial,i,t}$ = quantity of industrial water pollution emissions in year t;