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Original Research Paper

Analysis on Haze Pollution and Legal Regulations in China based on Controlling Industrial Waste Gas Emission

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ABSTRACT

This paper utilizes the emission data of four kinds of waste gas which are closely linked with haze pollution from 2012 to 2013 in China (total emission of industrial sulphur dioxide, industrial smoke dust, industrial dust, and industrial waste gas) and analyses the fluctuation of industrial waste gas emission within the period, as well as the differences in spatial distribution in the 31 provinces, cities, and autonomous regions to understand the correlations between waste gas emission and the degree of haze pollution and between the industrial development levels of different provinces and haze pollution during the industrial development in China. The studies indicate that haze pollution is mainly caused by industrial waste gas discharge resulting from unreasonable industrial energy consumption structure. The yearly emission of industrial waste gas increases nearly five times greater in 2013 than in 2000. However, the emission of industrial smoke, dust, and industrial dust yearly decline, thereby reducing haze pollution. The emission of industrial sulphur dioxide slightly fluctuates, negatively affecting haze pollution reduction. The unequal development of Chinese industrial regions causes unequal haze pollution in regions. The provinces with a substantial share of heavy industry in economics have more serious haze pollution. This research improved our understanding of the correlation between waste gas discharged by industries and haze pollution. The conclusions obtained in this study can be used to explore energy conservation and emission reduction in industrial manufacturing to reduce haze pollution and guide the outline of specific legal regulations in controlling haze pollution.

INTRODUCTION

Chinese economics and society have been rapidly developing in recent years amid a new era of industrialization, followed by tremendous environmental problems. China is a country that consumes a great deal of industrial energy; however, the single energy structure depends on coal and petroleum. In industrial production, coal is the primary energy. Fossil fuel, especially coal, is directly burned for energy, which directly aggravates haze pollution during the industrial development of China. In China, haze weather disastrously haunts most districts in autumn and winter. Pollution is closely linked to China's energy structure, which relies on coal. With the development of social economy, the industrial energy consumption grows, especially coal consumption, thereby leading to an increase in pollution. Essentially, no other industrial energy consumption accounts for such a substantial share of the national economy and environmental pollution, which is the root of haze pollution. Industrial coal heating, industrial vehicle waste gas, and coal electricity generation weigh on the environment, thereby accelerating the worsening of air quality. Haze pollution spreads in numerous cities of China. Simultaneously, industrial energy is continually and substantially consumed, thereby increasing industrial carbon emission. Therefore, improving the environment is urgent. The industry also consumes a substantial amount of resources and energy when providing raw materials and products for economic and social development. In industrial development, gaseous pollutants, such as sulphur dioxide and nitric oxide, construction waste and dust, vehicle emission and dust, and the emission of industrial waste gas, are the major reasons of haze pollution.

Studies show that industrial waste gas is the main source of waste gas in air, which is the fundamental cause of haze and directly leads to ecological pollution (De et al. 2001, Verhoef et al. 2002, Birdsall et al. 1993). On this basis, this paper analyses the emission of major waste gas generated by industrial manufacturing, explores the internal relation between industrial waste gas emission and haze in China, and finally proposes specific legal regulations to control haze from the perspective of controlling industrial waste gas emission. This paper hopes to provide a basis for investigating the time and spatial change law of haze pollution caused by industrial waste gas and for the decision-making

of legal regulations in preventing and controlling industrial waste gas pollution.

EARLIER STUDIES

With regard to the haze caused by industrial waste gas emission and controlled by legal regulations, local and international studies focus on the following: (1) the causes of atmospheric haze which are continuously aggravated by industrial waste gas emission and the spatial distribution of haze; and (2) how to reduce haze caused by the industry with comprehensive legal regulations. The causes, economic loss, and spatial distribution are the focus of most international studies on the haze weather which is worsened by industrial waste gas emission. De chose 200 agglomeration areas of the European Union region and found that economic agglomeration is one important reason of atmospheric pollution (De et al. 2001). Verhoef considered that the investment of various production elements during industrial manufacturing yields not only products but also atmospheric pollution (Verhoef et al. 2002). Birdsall (1993) believes that globalization enables the industry which causes serious pollution to migrate to countries or regions with fewer environmental requirements. Therefore, environmental pollution easily and frequently occurs (Birdsall et al. 1993). Dong is convinced that industry cluster is a good way of spreading environmental protection ideas and promoting technique improvement, thus decreasing the emission of industrial pollution (Dong et al. 2012). Mirasgedis estimated the harm to human body and economic loss of crops and construction caused by the industrial waste gas during various large or medium-scale industrial activities and provided suggestions on environment policies (Mirasgedis et al. 2008). Cowell adopted the market value method to obtain the economic loss in building and material corrosion caused by acid air pollutants on behalf of SO_2 in Europe (Cowell et al. 1996). Mirshojaeian employed the spatial analysis method to analyse the internal relation between the industrial economy and haze pollution indicators (PM10) (Mirshojaeian et al. 2011). Considering the highly developed international economy, haze from the industry can be reduced by laws pertaining to collection of specific economic taxation, energy tax, and environmental tax or by government-mandated regulations. Liu considered that an effective energy-saving and emission reduction for decreasing haze pollution should be achieved by standardizing industrial construction, regulating product energy consumption standards, establishing access threshold, and standardizing production (Liu et al. 2002). Chen believed that the government must control industrial waste gas emission by implementing laws and recommended clean production and cyclic utilization without buried garbage disposal (Chen et al. 2008). Muller considered that an efficient environmental legislation can effectively reduce marginal cost of emission, resulting in a decrease in haze pollution (Muller et al. 2009). According to Mushkat, a legal mechanism of interregional cooperation in South East Asia can help control haze pollution (Mushkat 2014). Allan established the Computable General Equilibrium model of energy-economy-environment of Scotland in the year 2000 to analyse the effects of carbon tax on CO_2 emission and haze pollution (Allan et al. 2014). Soytas believed that effectively controlling energy consumption can reduce environmental pollution (Soytas et al. 2007). The preceding literature on haze aggravated by industrial waste gas emission and haze control with legal regulations indicate that apart from weather, haze is closely correlated with the major waste gas emission during industrial production. In different countries, haze pollution presents a regional imbalance with serious haze pollution in a few cities clustered by heavy industries. Therefore, the study of waste gas emission of Chinese industries from 2000 to 2013 and the analysis of the correlation between major pollutant emission and haze can help elucidate the aggravation of haze pollution by waste gas generated during the Chinese industrial production. Therefore, legal regulations for controlling haze pollution are proposed.

THE ANALYSIS OF INDUSTRIAL WASTE GAS EMISSION AND HAZE POLLUTION

The energy consumption of the Chinese industry: Industry consumes the most energy among the three types of industries in China. Especially since 1996, industrial production has accounted for more than 70% of the total energy consumption. The industrial energy consumption of China and the industrial GDP from 2000 to 2013 are shown in Figs.1 and 2. Fig. 1 indicates that Chinese industrial consumption has periodic features. From 2000 to 2008, the industrial consumption slowly grew with a slight change of total energy consumption approximately 1 to 2 billion standard coals. After 2008, the industrial energy consumption rapidly grew, reaching to approximately 3 billion standard coals in 2013. Fig. 2 shows that the industrial GDP of the same period is divided into two components with the year 2002 as the dividing point. It slowly increased before 2002 and then rapidly increased after 2002. In summary, the increase of industrial energy consumption in China is slower than that of the industrial GDP in the same period. The industrial energy consumption of 2003 is 3.29 times greater than that of 2000. However, GPD is 5.79 times greater. This result suggests that the industrial energy consumption intensity decreases, and the industrial production techniques increase. Based on the features and the structure shown in the economic and industrial development, industrial

Table 1: Industrial waste gas emission of China from 2000 to 2013.

Industrial discharge	Industrial sulphur dioxide emission amount (10,000 tons)	Industrial smoke and dust emission amount (10,000 tons)	Industrial dust emission amount (10,000 tons)	Industrial waste gas emission amount (100 million cubic meter)
2000	1613	953	1092	138145
2001	1566	852	991	160863
2002	1562	804	941	175257
2003	1792	846	1021	198906
2004	1891	887	905	237696
2005	2168	949	911	268988
2006	2235	865	808	330992
2007	2140	771	699	388169
2008	1991	671	585	403866
2009	1866	604	524	436064
2010	1864	603	449	519168
2011	2017	598	439	674519
2012	1912	567	425	635599
2013	1835	543	410	669418

(The data came from China Statistical Yearbook on Environment (2001-2015)).

economy still mainly comprise heavy industry which discharges a great deal of pollutants with limited ability of processing waste gas. Therefore, tremendous waste gas is directly discharged, resulting in haze pollution.

The total amount of energy consumption of the industrial terminal (100 million standard coal)

The analysis of the amount of total emission of industrial waste gas: Generally, the discharge of industrial waste gas in China increases yearly with accelerating industrialization, as shown in Table 1. In 2013, the industrial waste gas emission is 66.9418 trillion cubic meter, which is five times greater than in 2000, whereas the sulphur dioxide emission of 2013 is also slightly greater than that of 2000. Accordingly, the emission of industrial waste gas and sulphur dioxide is the major cause of haze pollution. In contrast, the amount of industrial smoke dust and industrial dust emission slightly fluctuated. In the last 2 years of the 20th century, they sharply increase and decrease yearly, thereby maintaining approximately five million tons. In 2006, the binding index in which the major pollutant emission was reduced by 10% was proposed. Since then, the emission amount of industrial smoke dust and industrial dust significantly reduced. In summary, the industrial atmospheric pollution emission amount of China is substantial, whereas industrial waste gas emission volume grows yearly. Therefore, reducing waste gas emission during the industrial production is difficult, thus aggravating haze pollution.

The situation of industrial waste gas in Chinese provinces (Table 2): In 2013, Shandong, Inner Mongolia, Hebei, Shanxi, and Henan ranked the top five in industrial sulphur dioxide emission amount among the 31 provinces, cities, and autonomous regions, accounting for 33.26% of the total emission amount of the entire country; whereas Tibet, Hainan, Qinghai, Beijing, and Ningxia have the least emission amount. The districts ranking the top five in industrial smoke dust (dust) emission amount are Hebei, Shanxi, Inner Mongolia, Xinjiang, and Heilongjiang, accounting for 39.21% of the total emission amount, whereas Tibet, Tianjin, Shanghai, Hainan, and Beijing have the least emission amount. In summary, Shandong, Shanxi, Henan, and Hebei possess a substantial emission amount of industrial waste gas and various atmospheric pollutants, whereas Tibet, Hainan, Beijing, and Shanghai possess a small emission amount of atmospheric pollutants. Owing to the imbalanced regional development in industry and the significant difference of industrial regions, the environmental protection standards and policies of reducing industrial waste gas discharge also differ in regions, resulting in unequal regional haze pollution in the 31 provinces, cities, and autonomous regions.

LEGAL REGULATIONS OF CONTROLLING HAZE POLLUTION

Rational regulation of industrial structure and perfecting laws, policies, and plans in controlling haze: The irrational industrial structure is the root of over-discharged industrial waste gas and frequent haze weather. Accelerating the adjustment of industrial structure is necessary to better control haze. First, the industry in manufacturing with high pollution should be prohibited and the catalog should be made public. The projects related to cement and irons must be limitedly approved and high-tech manufacturing industries with little pollution are prioritized to be developed.

Table 2: Industrial waste gas emission of Chinese provinces in 2013.

Waste gas Region	Sulfur dioxide (10,000 tons)	Nitrogen oxides (10,000 tons)	Smoke dust (dust) (10,000 tons)
Beijing	8.7	16.63	5.93
Tianjin	21.68	31.17	8.75
Hebei	128.47	165.25	131.33
Shanxi	125.54	115.78	102.67
Inner Mongolia	135.87	137.76	82.21
Liaoning	102.7	95.54	67.06
Jilin	38.15	56.05	32.02
Heilongjiang	48.91	75.16	72.25
Shanghai	21.58	38.04	8.09
Jiangsu	94.17	133.8	50
Zhejiang	59.34	75.3	31.97
Anhui	50.13	86.37	41.86
Fujian	36.1	43.83	25.94
Jiangxi	55.77	57.04	35.63
Shandong	164.5	165.13	69.67
Henan	125.4	156.56	64.13
Hubei	59.94	61.24	35.95
Hunan	64.13	58.82	35.87
Guangdong	76.19	120.42	35.4
Guangxi	47.2	50.43	28.95
Hainan	3.24	10.02	1.8
Chongqing	54.77	36.2	19.12
Sichuan	81.67	62.43	29.6
Guizhou	98.64	55.73	30.13
Yunnan	66.31	52.37	38.69
Tibet	0.42	4.43	0.68
Shaanxi	80.62	75.89	53.77
Gansu	56.2	44.29	22.66
Qinghai	15.67	13.23	17.38
Ningxia	38.97	43.74	23.06
Xinjiang	82.94	88.69	75.59

(The data came from China statistical yearbook on environment (2004)

Second, terrestrial heat, hydroelectricity, solar energy, and other clean energy projects would take precedence of development, whereas the quantity and scale of thermal power plant is strictly limited. Third, the government should economically compensate enterprises that withdraw from industries with pollution and establish an elimination mechanism of outmoded production engineering and facility to eliminate lagged output capacity to control industrial emission from the sources and prevent and control haze. To solve the problems in laws and policies of controlling haze, the State Council and other related departments must devise medium- and long-term plans for preventing and controlling haze with periodic missions. Based on the present situation of waste gas emission of industrial enterprises, the government should establish a timeline for emission reduction of pollutants which mainly cause haze and for reaching air quality standards. The missions of emission reduction should be subdivided to local governments, in which local governments make appropriate plans based on national laws and regulations, and national medium- and long-term plans and local atmospheric pollution situation to reasonably arrange emission reduction missions. In addition, local governments are supposed to encourage the development and utilization of new energy techniques, decrease the use of coal and its share in energy structure, promote natural gas, and support hydroelectricity, wind power, and nuclear power projects.

Legislative work of reducing industrial haze pollution and the establishment of ecological compensation mechanism: The legislative concept and principle must take environmental protection as a priority. The new situation of market economy in China also requires a change of economic priority in a planned economy. As a fundamental law on environmental protection, the environmental protection law should comprehensively guide other single laws to avoid conflict and repetition in the logical structure of the legal system. As the right of the citizens to the environment has been included in the constitution, its specific content would be stipulated. For example, citizens have the right to supervise environmental protection, the right to know the truth regarding environmental pollution, the right to claim compensation due to environment disruption, as well as the right to good ventilation and clean air and water. In addition, the ecological compensation system and environmental public interest litigation system should be established. Increasing the legal status of environmental protection laws and popularizing laws are necessary. Only when the laws are popularized with increased effects would the laws actually work in environmental protection. Apart from revising environmental protection laws, the Chinese government should also revise the Air Pollution Control Law to cope to the increasingly complex air pollution and haze. The international criteria of air pollutant emission and air and environmental quality should be formulated as soon as possible. PM2.5 must be included in the discharge list of pollutants. New air quality criteria must be carried out immediately. The government should take sweeping measures to air pollution and haze weather in cross-regional cooperation by promoting the cooperation of regional governments. Regional linkage will assist regional governments in monitoring and protecting the environment and handling severe emergencies of environmental pollution. The discharge of industrial waste gas should be controlled by strict production techniques and the elimination of outmoded devices in the Air Pollution Control Law. Production techniques and equipment should be transformed within a limited time because these would cause serious pollution, whereas the loss of enterprises should be appropriately compensated, and corresponding ecological compensation mechanism should be established.

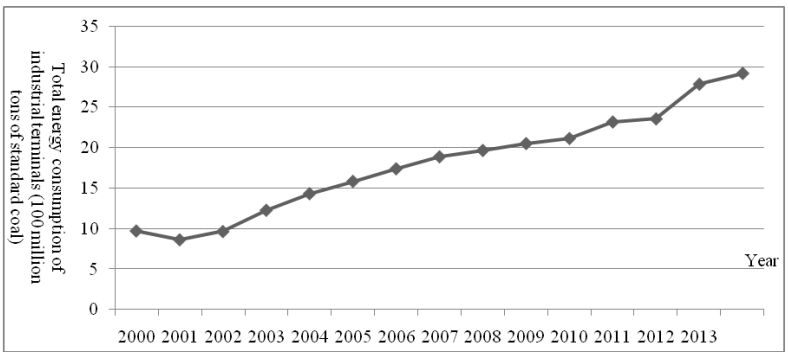

Fig.1: Industrial energy consumption from 2000 to 2013.
(The data came from China Statistical Yearbook on Environment (2001-2014).

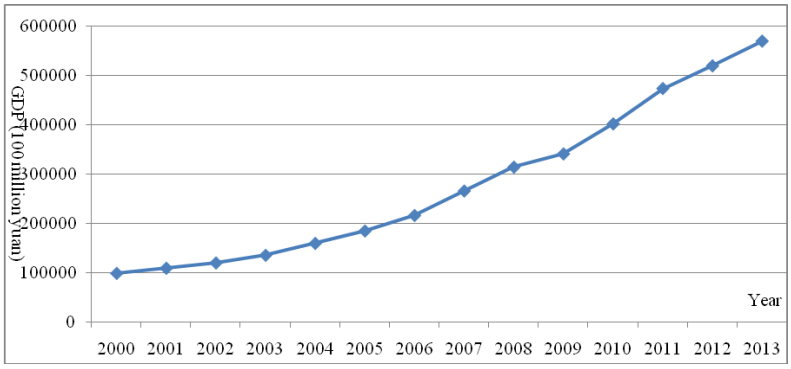

Fig. 2: GDP of China from 2000 to 2013.
(The data came from China Statistical Yearbook on Environment (2001-2014).

The joint defence of controlling haze pollution and the involvement of enterprises and the public: National organizations that control haze and specific agencies for controlling regional haze should be established. Regional haze control mechanism, completed policies, regional regulations, unified decision-making system, and the integration of the existing relationships will altogether promote the involvement of different stakeholders in controlling regional haze pollution. Based on regional social and economic development, the responsibility of controlling haze pollution should be subdivided. In addition, the joint defence mechanism calls for the cooperation and negotiation of different regional governments to economically benefit from each other. The enterprises and the public must carry the responsibility of environmental protection, which is conducive to restraining industrial waste gas emission and controlling haze. Industrial enterprises should undertake more responsibility because they are the major source of haze pollutants. On the one hand, the laws should supervise and define the responsibility of enterprises in environmental protection. By contrast, governmental macro-economic control should guide enterprises by charging them with carbon tax on discharging considerable pollutants causing haze, enabling them to carry the responsibility of environmental protection, thereby improving production techniques, adjusting production layouts, and reducing the discharge of industrial pollutants. Enterprises that discharge less or no pollutants should be encouraged by financial subsidies to promote clean production, energy saving, and emission reduction. Environmental self-discipline of the public is also vital for controlling haze. Environmental protection should be popularized to lead the public to live a healthy, green, and low carbon life. In the current Air Pollution Control Law, the public participation system should be completed with detailed regulations and supplementary measures, and the air condition must be reported to protect the right of citizens.

SUMMARY

A substantial share of heavy industry in industrial structure and high energy consumption are the root of over-discharged industrial waste gas and aggravated haze pollu-

tion. This paper utilizes the emission data of four kinds of waste gas discharged during the industrial production from 2000 to 2013 and analyses the industrial discharge situation in China within the period, as well as the spatial distribution differences in industrial waste gas that aggravate haze pollution among the 31 provinces, cities, and autonomous regions, finally making suggestions on legal regulations which will assist in controlling haze pollution from the perspective of reducing industrial waste gas discharge to understand the degree of haze pollution worsened by waste gas emission during the industrial development in China. The current research indicates that irrational industrial energy consumption structure maintains a high emission level of industrial pollutants, leading to haze pollution. The amount of industrial waste gas emission, which is five times greater in 2013 than in 2000, increases yearly. The industrial smoke and dust emission amount and industrial dust, which actively controls haze pollution, declines yearly. The industrial sulphur emission amount slightly increases. The unbalanced regional industrial development results in unequal haze pollution and the province with a substantial share of heavy industry in economy have more serious haze pollution. This paper aims to analyse the correlation between waste gas emission and haze pollution during the industrial development and control industrial waste gas by laws and regulations. Accordingly, future theoretical studies are advised to focus on the mechanism in which industrial waste gas emission aggravates haze pollution, whether industrial waste gas emission is spatially correlated with regional haze pollution, and the classification and comparison of haze pollution in different provinces for a more precise empirical study of the specific degrees in which industrial waste gas emission aggravates haze pollution in various provinces.

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