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Causes of Haze Pollution Under the Regional Compound Environment and Legal Governance Countermeasures

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ABSTRACT

With the rapid growth of the Chinese economy and the accelerated progress of industrialization and urbanization, the country's natural resources are being developed irrationally and ineffectively, thus continuously strengthening haze pollution. Given the characteristics of haze pollution (i.e., large pollution area, many interest bodies and cross administrative regions), exploring the reasons behind haze pollution formation from the regional compound environment and regulating related legal governance countermeasures have become hot issues. This study reviews the domestic and foreign literature on the formation mechanism of haze pollution, explores the detailed reasons for haze pollution formation by analysing the collected data on haze-related environmental pollution, and proposes legal countermeasures for China's haze pollution. Research on the main origins for haze pollution formation indicates the following: large-scale coal burning, unrestricted vehicle exhaust, major discharge from industrial pollution, and significant dust output from the architecture industry. Haze treatment-related legal measures, such as improving the legal system, specifying legal principles, and strengthening legal implementation, can realize the effective management of haze pollution. These results can function as a reference for identifying the causes of haze formation, determining the defects and shortages in haze pollution legal measures, improving China's haze pollution prevention, and for perfecting China's haze prevention legal rules and regulations.

INTRODUCTION

With the rapid progress of industrialization and urbanization, the environmental problem of haze pollution has become increasingly more evident. The particulate matter of haze can be classified into two categories: natural particulate matter and man-made particulate matter. Naturally-generated tiny particles can form particulate matter, such as weathered materials of rock and soil on the surface of the Earth, desert, and volcanic ash. Conversely, tiny particles generated from different human activities, called man-made particulate matter, include exhaust gas of fossil fuels, vehicle exhaust, industrial dust, and waste burning emissions. Haze environmental pollution has become increasingly more serious in recent years. The percentage of man-made particulate matter has gradually elevated, and the quality of the breathing environment in cities has relatively deteriorated. Instead of simply coal smoke, a compound pollution source exists, consisting of coal smoke, re-entrainment of dust, industrial waste gas, and vehicle exhaust. Haze pollution is no longer the traditional regional pollution, but a new form of environmental pollution characterized as "regional and compound". Unlike traditional environmental pollution caused by a single pollution determinant, compound environmental pollution has stronger destructive power, whether from the extent or scope of its damage.

The formation of haze pollution in the regional compound environment occurs when human activities discharge various pollution factors in the environment directly or indirectly in two or more administrative regions at the same level. Such factors flow and interact with one another in different administrative regions. This scenario lowers the air quality in the area and even impacts the normal growth and development of humans and other organisms. Additionally, pollution factors exist in the air, soil, and water, such as the haze pollution formed by sulphur dioxide, oxynitride, and tiny particles. Traditional point source pollution is no longer limited to a relatively small area. Haze pollution is caused by diverse pollution factors discharged into the ecological environment. Such factors enter nearby or larger areas along with flowing environmental factors and have complicated reactions that lead to pollution in a larger area. Haze pollution does not follow administrative regional boundaries, breaching the supervision scope of the current Chinese environmental supervision system. This study analyses the detailed reasons for haze pollution formation and proposes legal countermeasures for haze pollution treatment by considering compound environmental pollution.

Local and international scholars have conducted abundant research on the determinants of haze pollution formation and pertinent legal countermeasures. Given that developed nations such as European countries and the US have experienced severe haze pollution during the industrial revolution, they have matured experiences in haze pollution treatment. By contrast, China is still adopting detailed measures from advanced countries in haze pollution prevention and treatment. Several countries have produced numerous research findings on pollution treatment measures and legal mechanisms, which can serve as works of reference for haze pollution treatment in China. Regarding the reasons for haze pollution formation, Grivas analysed PM10 pollution and the deciding factor in Athens, Greece and found that the main reasons include increasing petroleum consumption, heating, and vehicle quantity (Grivas et al. 2008). Examining haze pollution in the Mediterranean, Kanakidou claimed that urban particulate matter pollution was caused by the large production activities of human beings (Kanakidou et al. 2011). Hanjin investigated the basis of haze formation in Puyang, China and revealed that an essential connection existed between haze pollution and economic development (Hanjin et al. 2014). Wang explained the effect of pollutant transportation on haze formation (Wang et al. 2014). Feng regarded family heating in winter as an important factor of haze pollution (Feng et al. 2014). According to Gao, the accumulated and transportation discharged pollutants in stagnant weather conditions were the primary sources of haze pollution in cities near Beijing (Gao et al. 2015). Wu posited an evident connection between PM2.5 and the industry percentage, and that a clear relevance existed between vehicle quantity and family natural gas consumption, and haze pollution (Wu et al. 2016). Regarding haze treatment measures, including legal measures, Stuart proposed that the haze pollution in unsupervised areas was worse than in areas with supervision and suggested that effective air supervision measures be implemented in rural areas (Stuart et al. 2009). In addition, Mohareb proposed the clean production and recycling of materials, instead of processing by burning and burying the waste (Mohareb et al. 2011). Nurhidayah also proposed a similar legal framework on countering the effects of cross-regional haze in the ASEAN area under the regional environmental governance mode (Nurhidayah et al. 2015). Feng examined the air pollution prevention and control measures in China and discussed achievements, challenges, and improvement in the China haze pollution treatment through law, legislation, plans, and policies (Feng et al. 2016). Using Linyi in Shandong Province as an example, Yi proposed pollution treatment measures from several aspects (i.e., government, enterprise, city transportation, and individuals) (Yi et al. 2016). Li analysed the current haze pollution control scenario in China and relevant improvement measures from the legal governance perspective (Li 2016). Gao claimed that organizations and government institutions could further propose detailed haze control measures and laws, and the wide application of public talks can become a policy tool for haze pollution treatment (Gao et al. 2017). The aforementioned literature shows that foreign countries also pursued fast economic development and overlooked the different harmful effects on the environment, which caused serious environmental pollution. However, western industrial countries have changed the environment and succeeded through a series of technological innovations, related legal support, and effective system reform. China has few studies that analyse the causes of haze pollution and the countermeasures from the legal system perspective. Therefore, the current study examines, why the haze pollution transpires under the regional compound environment. The advanced legal experiences of western industrial countries in haze treatment are referenced in the present research, which can play an active role in China's haze pollution treatment system and safeguards.

REASONS FOR HAZE POLLUTION FORMATION

Large-scale coal burning: Coal burning is the main source of China's haze fixed pollution and the primary aspect of haze pollution prevention. China has abundant coal, scant petroleum, and minimal gas; hence, coal is central to China's energy consumption structure. The total amount of energy consumption in China increases continuously for a certain period of time (Fig. 1). Although the percentage of coal in the total energy consumption has decreased, it remains approximately 64%. Coal's energy utilization structure necessarily results in burning, thus causing haze pollution. Coal burning results in the discharge of pollution matter, such as smoke, sulphur dioxide, oxynitride, and carbon dioxide. Particles generated after coal burning, such as smoke and dusk, increases the air pollutant concentration after being discharged. In Chinese industrial production and daily life, the production, transportation, and consumption of coal lack related environmental protection measures. In the northern part of China, coal usage is considerable and the air quality has decreased particularly during winter, causing serious seasonal coal burning pollution. The national coal consumption from 2005 to 2013 shows an increasing trend (Fig. 2), with a slight decrease in 2014. However, it remains responsible for 47% of the total global coal consumption, which is far higher than the average global coal level of 30%. Although coal usage in daily life has decreased, industry usage and PM2.5 caused by coal burning has increased. The haze pollution phenomenon is more frequent

in winter. Given that the highest peak of heating by coal burning in the northern part of China occurs in winter, the discharge of particulate matter during this season is clearly higher than in other seasons.

Unrestricted vehicle exhaust: Vehicle exhaust is regarded as the second source of haze pollution. Vehicle quantity in China has increased swiftly in the past 10 years. China's vehicle output has increased yearly by 16% from 2009 to 2013 (Fig. 3). Given the sizable population density of China, its total vehicle quantity has grown rapidly. Although several large cities have restraints on the purchase and usage of vehicles, China still encourages vehicle purchase in small and middle cities, because public transportation facilities cannot match the urban development in these cities. Moreover, vehicle and fuel quality are relatively low, which can directly affect the vehicle exhaust. China has begun to improve vehicle exhaust systems in recent years, but China-made vehicles still have high emissions. Emissions of new standard vehicles produced in China are still far higher than those of comparable vehicles produced in Europe and the US. Another reason for the high vehicle emissions is the low quality of fuel in China. The composition of vehicle exhaust is highly complicated. The main pollutants include suspended solid particles, carbon oxide, and carbon dioxide, as well as hydrocarbon, oxynitride, lead, and sulphur oxides. The sulphur compound is the chief component of vehicle exhaust pollutants. The transportation condition also impacts the vehicle exhaust to a large extent. Most Chinese city centres have high vehicle flow and traffic congestions. Vehicle fuel cannot be fully burned during traffic jams, which can cause higher pollutant concentrations from vehicle exhaust.

Substantial industrial pollution emission: With the rapid industrialization and urbanization in China, different industries (i.e., heavy industries) currently consume significant amounts of resources and energy and discharge many pollutants. Several of these pollutants are particulate matter, such as PM2.5, whereas others can generate PM2.5 indirectly. The main contents of industrial waste gas are sulphur dioxide, smoke, dust and oxynitride. The discharge of these industrial waste gas pollutants in China is constantly elevated, although the discharge of industrial sulphur dioxide has decreased in recent years. The discharge amount of industrial oxynitride has also grown swiftly. Furthermore, coal consumption for thermoelectricity power generation is high. As a vital element of the building material industry, cement releases a large amount of dust. The steel and metal smelting industries are also large industrial waste gas discharge industries. Similarly, the machinery and electronics industries are sources of industrial production pollution.

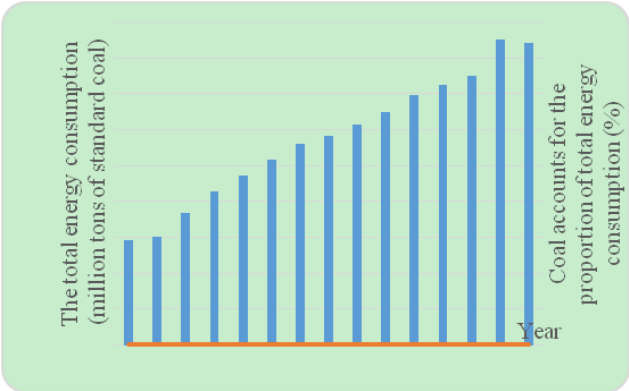

Fig. 1: Total amount of China's energy consumption and percentage of coal consumption from 2000 to 2015. (Data from "China Energy Statistical Yearbook" 2001-2016).

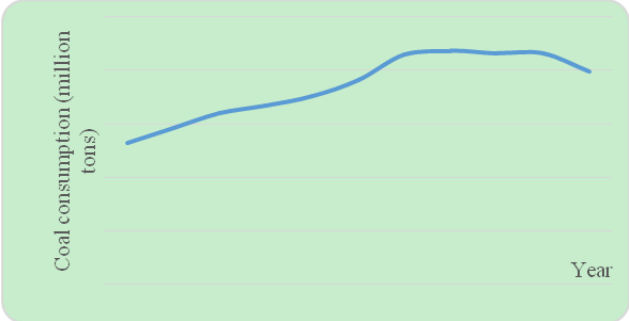

Fig. 2: Total amount of China's coal consumption from 2005 to 2015. (Data from "China Energy Statistical Yearbook" 2006-2016).

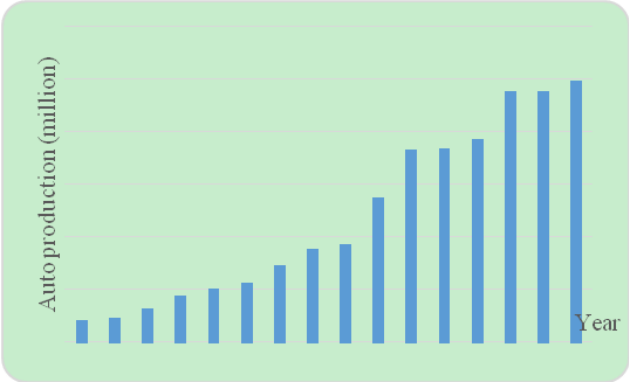

Fig. 3: China vehicle output from 2000 to 2015. (Data from "China Statistical Yearbook" 2001-2016).

Non-coal-burning industrial pollution sources, such as industrial smoke, dust and different volatilizable organic matter, are the chief causes for haze pollution. The main waste gas discharge in Chinese provinces in 2004 is listed in Table 1.

Table 1: Main waste gas discharge in Chinese provinces.

	Total Discharge of Sulphur Dioxide (ton)	Total Discharge of Oxynitride (ton)	Total Discharge of Smoke and Dust (ton)	Discharge of Industrial Waste Gas (100 million m^3)
Beijing	78,906	150,955	57,372	3,569.20
Tianiin	209,200	282,300	139,511	8,800.00
Hebei	1,189,903	1,512,469	1,797,683	72,732.30
Shanxi	1,208,225	1,069,860	1,506,778	36,024.70
Inner Mongolia	1,312,436	1,258,281	1,021,510	36,116.50
Liaoning	994,597	901,964	1,120,701	34,527.50
Jilin	372,256	549,247	475,133	9,450.70
Heilongjiang	472,248	730,585	793,549	12,091.20
Shanghai	188,149	332,790	141,650	13,007.40
Jiangsu	904,741	1,232,552	763,678	59,652.70
Zhejiang	574,012	687,850	379,666	26,958.30
Anhui	492,966	807,305	652,782	29,232.60
Fujian	355,957	411,662	367,903	18,383.30
Jiangxi	534,415	540,115	462,331	15,613.40
Shandong	1,590,237	1,593,311	1,208,102	52,095.30
Henan	1,198,182	1,422,013	882,103	39,628.70
Hubei	583,759	580,222	504,006	21,701.80
Hunan	623,689	552,773	496,166	16,050.50
Guangdong	730,147	1,122,112	449,549	29,793.80
Guangxi	466,589	442,399	402,935	18,631.30
Hainan	32,564	95,002	23,171	2,638.20
Chongqing	526,944	355,018	226,131	9,289.60
Sichuan	796,402	585,439	428,630	20,053.70
Guizhou	925,787	491,071	377,856	23,207.90
Yunnan	636,683	498,880	366,819	16,664.10
Tibet	4,250	48,344	13,890	170.4
Shannxi	780,954	705,756	709,137	16,542.50
Gansu	575,649	418,400	345,811	12,290.30
Qinghai	154,276	134,518	239,867	6,439.40
Ningxia	377,056	404,032	239,171	10,717.00
Xinjiang	852,981	862,792	813,916	22,116.10

(Data from "China Environmental Statistical Yearbook" 2015).

Large amounts of dust in the construction industry: The swift urbanization in China has resulted in many house constructions as shown in Fig. 4. The resulting dust raising and pollution discharge are also considerable. However, the pollution standard for construction is obscure, and related management is loose. Therefore, construction in China causes severe pollution. Such projects can be classified into newly built residence communities, public buildings, and industrial factory buildings, as well as old building demolitions, transformations, and extensions. Given that the project management personnel lack awareness of modernized construction, they do not take effective measures to avoid dust raising during earth excavation, back-fill, transportation, construction site hardening and afforesting, construction material stocking, and construction rubbish cleaning and transportation. These activities result in the raising of dust and particulate matter pollution into the urban air. Construction dust mainly consists of silicon dioxide, calcium carbonate, iron oxide, and aluminium oxide, which can easily be transformed into particulate matter pollution along with sulphur dioxide and oxynitride generated by other pollutants in foggy weather. These suspended pollutants can chemically react in stable air and further prompt haze generation. The higher the buildings are in cities, the more limited the vertical movement of the haze layer in lower space. When air has low mobility, vertically and horizontally, haze expansion condition is also lower. Controlled by the statistic air of the near-surface area, the construction dust will form into suspended particulate matter in the air, which cannot easily expand into high space and be blocked in low space and near-surface areas. Consequently, it forms into haze.

HAZE POLLUTION LEGAL GOVERNANCE COUNTERMEASURES

Improving the haze treatment legislation system: Currently, the most direct law for haze pollution governance in China is the "Haze Pollution Prevention Law." This law points out that the most important sources of air pollution

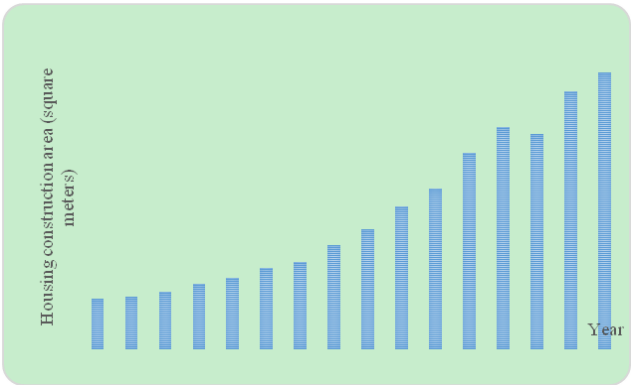

Fig. 4: House architecture construction area from 2000 to 2015. (Data from "China Statistical Yearbook" 2001-2016).

are the enterprise waste gas discharge, vehicle exhaust, and coal burning for heating. Complete improvement of air cleanliness is regarded as the primary target of haze pollution treatment. The law provides a set of strict legal measures, such as strengthening the local governments' responsibility for air pollution, establishing an environmental pollution assessment system, and compelling areas with excessive discharge amounts to reach the standard and improve their haze pollution treatment standards to new levels by combining the treatment condition and incorporating suggestions. The complete legislation system is the basis of haze pollution treatment. Different departments and procedure laws should make matching legal rules and regulations to form a complete haze pollution treatment legislation system. This system should not only have perfect legislation support, but also requires national institutions and departments to strictly implement the law to attain a suitable haze environment. Pollution supervision departments should constantly oversee activities. Pollution-causing enterprises should adjust their energy devices, improve their production technologies, add environmental protection and purification devices, and limit their pollutants discharge based on government regulations. The identification of environmental rights in legislation is a basic expression of a citizen's right to the environment, which allows every citizen to enjoy the right to protect their own environment. The law is the centralized reflection of the national ruler's will. Under the protection of national law, anyone who attempts to break the law and pollute the environment becomes hesitant out of fear, whereas citizens who are harmed by environmental problems can claim their own right under the law. Thus, the identification of environmental rights under the law can prevent pollution to the maximum extent.

Identification of haze pollution treatment legal principles: Shared, but different responsibilities are the basic principle in international law, which is also applicable in China. Protecting the environment is our shared mission and responsibility based on the integrity and publicity characteristics of haze environment. The current pollution scenario did not emerge in a day or because of any area or industry. It is the comprehensive result of industries, transportation, life heating, and construction dust raising. However, the pollutant contribution ratios for the distinct development and technology levels of the local economy differ, and having equal responsibility is unfair. Classifying the haze treatment responsibility, implementing the responsibilities of the local government and pertinent departments, and making pollution treatment and pollutant emission reduction as important indicators of the government performance assessment are necessary. In addition, a more detailed classification of enterprises' responsibility is also required. The action principles should be unified and coordinated. A unified guidance ideology and actions among the central and local governments, different areas, environmental protection departments, and other government functions on air pollution treatment are also essential. Provincial coordination meetings and a cross-department and industry expert team should be established to prompt the government to create policies scientifically. No boundary of haze pollution exists, and the causes are complicated. Therefore, if no agreed pace exists among diverse regions and departments, then the national legislation policy cannot be fully implemented, and the haze pollution treatment is a "cheap talk", if the central and local governments are inconsistent. Environmental information publicity of the environmental protection law of various countries is an indispensable system, which is especially vital in air treatment. Such publicity acknowledges the public's right to access environmental information and offer critiques. Public opinion and supervision will place pressure on environmental protection agents and producers of ecological damage. Protecting the public's right to environmental management and protection, encouraging the public to actively participate in environmental protection activities, and retaining their legal rights to supervising environmental pollution and damage behaviour are important. The public participation principle is the detailed requirement to protect environmental justice and improve environmental benefits.

Enlarging the haze treatment legal implementation power: The relevant environmental protection department should implement the law, which is the most fundamental aspect of legal implementation, to better emphasize the effect of such implementation. Augmenting the punishment for law breaking and increasing its cost will deter pollutant discharge behaviour, which disobeys the law. Such measures will also force enterprises to solve their own pollutant

discharge problems by improving their technologies. Immense benefit would be gained by the entire society participating in environment governance, the stimulation of the public's enthusiasm by setting an awards system, and by fully utilizing the public's power for haze pollution treatment. Intensifying the legal responsibility of pollutant discharge incurred by disobeying the law is an important method for haze pollution treatment. It can increase law-breaking cost and prevent excessive pollutant discharge. However, the punishment for enterprises with illegal pollutant discharge is lax, and the fine varies. New fines should be set according to the new economic condition. The legal responsibility of enterprises should be strengthened, and the administrative organization for law enforcement should provide evidence. Unlike other pollution types, haze pollution requires a 24-hour supervision system, and the improvement of such a system can guarantee the strict governance of haze pollution.

CONCLUSIONS

Unlike other environmental pollution types, the effects of haze pollution are direct and serious, because air is a basic factor for human survival. Haze pollution is caused by human activities, such as the unlimited consumption of resources during economic development and imperfect air pollution prevention laws. Research results show that the four main determinants for haze pollution formation are: large-scale coal burning, unrestricted vehicle exhaust, substantial industrial pollution discharge, and large amounts of generated construction dust. Finally, the following legal measures for haze pollution governance have been presented: improving the haze pollution treatment legislation system, specifying related haze pollution treatment legal principles, and enlarging the legal implementation of haze treatment. These findings can provide suitable reference to identify the causes for haze pollution formation, enrich the haze pollution treatment system, and improve haze prevention by introducing local and international advanced management systems and ideologies. Suggested future research areas include: establishing a regional joint control and prevention system for haze pollution, publicizing environmental public interest litigation, enriching control theory of the total amount of haze pollution, developing different discharge standards in diverse areas, and improving the practicality and fining degree of haze pollution treatment theory.

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