Analysis of the Causes of Frequent Hazy Weather in the Beijing-Tianjin-Hebei Region

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Abstract — In China, hazy weather is most serious in the Beijing-Tianjin-Hebei region. Therefore, how to prevent the hazy weather in this region has become an important task of China's current environmental management. However, in order to prevent the hazy weather in the Beijing-Tianjin-Hebei region, the priority is to analyze the causes of its hazy weather. The paper comprehensively analyzes the causes of the hazy weather in the Beijing-Tianjin-Hebei region with literature analysis, field research and other methods and gives the main causes. These include: i) there is a large number of civilian vehicles as well as large emissions of automobile exhaust, ii) economic development mode is simple and extensive, iii) highly-polluted secondary industry accounts for a large proportion, iv) industrial distribution and regional self-purification capacity do not match, v) regional industrial planning is unreasonable, etc. It is hoped that it can be helpful for China’s prevention and control of regional hazy weather.

Keywords - component; Beijing-Tianjin-Hebei Region; Frequent Hazy Weather; Analysis of the Causes

I. INTRODUCTION

In recent years, with the boost of China's large-scale industrialization and urbanization and the rapid development of industry, transportation and so on, a large number of gas pollutants are discharged into the air, creating favorable conditions for the formation of hazy weather. Coupled with the global warming and significant changes in meteorological conditions, the gas pollutants accumulated in the air cannot diffuse in time, resulting in the frequent occurrence of massive hazy weather in China[1]. Undoubtedly, the hazy weather in the Beijing-Tianjin-Hebei region is a primary battle of China's current "touch fight" to prevent and control air pollution, which has caused widespread concern in the public and the media. China’s haze disasters have seriously affected people's daily life and production and brought enormous threats and challenges to the sustainable development of its society and economy. However, now the Beijing-Tianjin-Hebei region still faces grave fog and haze prevention and control situations. In recent years, some progress has been made in the research on fog and haze prevention and control and many scholars have conducted some exploratory researches on the causes of the hazy weather in the Beijing-Tianjin-Hebei region. For example, Zhang Liya et al [2] think that the causes of the hazy weather in the capital area are special geographical location and atmospheric circulation, simple and extensive mode of economic production, irrational energy consumption structure, large emissions of automobile exhaust, desertification and ground dust; Li Zheng[3] et al think that geopolitical factors, weather impact, industrial structure and external factors are the main causes of Beijing’s hazy weather; Wang Fang[4] thinks that the causes of the hazy weather in the Beijing-Tianjin-Hebei region are irrational energy consumption structure, rapidly increasing motor vehicles and serious building sewage; Zhang Tao et al[5] believe that the causes of Shijiazhuang’s hazy weather are meteorological and geographical factors, transportation of foreign pollutants, coal, dust and vehicle exhaust, irrational industrial structure and industrial layout and so on. At present, experts and scholars focus on several aspects when analyzing the causes of the hazy weather in the Beijing-Tianjin-Hebei region and they have not conducted comprehensive and systematic research.

II. THE FOG AND HAZE STATUS OF THE BEIJING-TIANJIN-HEBEI REGION

Fog and haze frequently occurred in Beijing in June 2013. According to the data released by National Climate Center of China Meteorological Administration on April 16, during the 100 days from January 1, 2013 to April 10, 2013, Beijing experienced 46 hazy days, which was 5.5 times more than the same period of previous years and was the most in the recent 60 years. However, Beijing experienced 18 hazy days in June, which was 6 days more than the same period. According to the information of Beijing Municipal Environmental Monitoring Center, at 10 o'clock of June 26, the whole city was heavily polluted to seriously polluted by the fine particulate matter PM2.5. Low-pressure weather continued in the city on June 27 and air diffusion conditions were generally unfavorable. Up to 10 o’clock, the air quality of the urban area and southern suburbs was at the level of heavy pollution; on the 28th day, the concentration of the fine particulate matter PM2.5 in the whole city continued to rise and all the monitoring stations showed level-6 serious pollution; on the 29th day, due to great humidity and small wind, the concentration of the fine particulate matter reached medium pollution level in the afternoon; at 9 o’clock of the 30th day, the city's air pollution level continued to rise and the concentration of the fine particulate matter in urban areas reached level-6 serious pollution.

Environmental quality released in the Report on the State of the Environment in China showed that the compliance days of 13 prefecture-level cities and above of the Beijing-
Tianjin-Hebei region ranged between 10.4% and 79.2% in 2013 and the average was 37.5%; the days with serious pollution and above accounted for 20.7%. 10 cities were not up to standard during over 50% days of the year. PM2.5 was the primary pollutant among excessive substances, accounting for 66.6%, which was followed by PM10 and O3, respectively accounting for 25.2% and 7.6%. From the data and percentages, we can see that the Beijing-Tianjin-Hebei region suffered the most serious air pollution in the country. Among the 13 cities of the region, 11 ranked among the top 20 most heavily polluted cities of the country and 7 cities ranked among the top 10, and the air of some cities was seriously polluted or above for about 40% days of the year. According to the data of Ministry of Environmental Protection, in 2014, 8 cities of the top 10 cities with poor air quality were from the Beijing-Tianjin-Hebei region. In the first quarter of the year, the days with heavy pollution of the cities of the Beijing-Tianjin-Hebei region accounted for 6.9% and the days with serious pollution accounted for 1.2%. The percentage of days with heavy pollution or above was 5.8% higher than that of 74 cities[]. Figure 1 shows the changes in the air quality index of the Beijing-Tianjin-Hebei region, which was released in 2014. From the curve changes, we can see that the air quality index of Beijing, Tianjin and Shijiazhuang of Hebei Province was relatively high in 2014. The air quality index of Tianjin and Shijiazhuang ranged between 201 and 300, even above 300, in all the four quarters and air quality reached the level of heavy pollution and serious pollution. Shijiazhuang was especially serious. The changes of Beijing’s air quality index were relatively flat, but its air quality index also ranged between 101 and 200 and its air quality reached the level of medium pollution. Generally speaking, the air quality status of the Beijing-Tianjin-Hebei region was relatively poor, which had seriously affected people’s health and life and caused great harm to people’s daily life.

With the deteriorating air quality status, the hazy weather of the Beijing-Tianjin-Hebei region was also more and more serious. For example, the percentages of the main pollutants particulate matter (PM10) and fine particulate matter (PM2.5) of the 64 detected counties of Hebei Province in 2014 were as shown in Figure 2: from Figure 2, we can see that between the air pollutants PM10 and PM2.5 of Hebei Province, PM2.5 had a relatively higher proportion, which was always above 80% (serious pollution) except for May.
such terrain is not helpful for the diffusion of pollutants. Such terrain and climate, when there are easterly or southerly winds, the pollutants will gather over the terrain. When there are northerly winds at a medium or low altitude, the clean air of northern Beijing will be transported to Beijing, which will reduce its pollution level. Shijiazhuang is located in the south of Beijing. Its spring is dry, there is little rainfall and there are often 5-level or 6-level northerly or southerly breezes. In case of northerly winds, the air pollutants of Beijing will be brought to Shijiazhuang. Tianjin is located at the convergence of five tributaries of the Haihe River of North China Plain. It is adjacent to the Bohai Sea on the east and Yanshan Mountain on the north. Due to the action of southeast wind, the respirable particulate matters and other pollutants over Tianjin move westward with the wind and then move eastward and return home after being blocked by Taihang Mountains. In case of northwest wind, Taihang Mountains will intercept it and make it stay within Shanxi. Some pollutants cannot be blown away, so they can only stay over Tianjin. The cold air forces of the Beijing-Tianjin-Hebei region are weak, winds are small near the ground, atmospheric stratification is stable and air pollutant diffusion conditions are poor, resulting in agglomeration effect. Coupled with the destruction of the forests in the Beijing-Tianjin-Hebei region and coastal areas and little rainfall, the regional self-purification capacity of the Beijing-Tianjin-Hebei region is greatly reduced.

IV. THE INDUSTRIAL PLANNING OF THE BEIJING-TIANJIN-HEBEI REGION IS UNREASONABLE

The industrial layout of the Beijing-Tianjin-Hebei region is unreasonable. Beijing positioned itself as a “national capital” and an “international metropolis” in the “Twelfth Five-Year Plan”. However, due to various impact of historical economic development center, a lot of industrial enterprises with high resource and energy consumption gather here. Fundamentally speaking, such heavy chemical industry does not comply with the characteristics of Beijing’s resources and environment, but increases the pressure on resource supply and environmental pollution and brings future adjustment of industrial structure with great difficulties. Tianjin is positioned as an international port city and ecological city. However, compared with Beijing, Tianjin does not have advantages as economic center. As an international port city, the development of its modern service industry is relatively backward; Hebei Province proposed the strategic objective of building a coastal province with powerful social and economic development, but the development of its marine economy is very backward and heavy industries with serious air pollution throughout. In addition, Beijing’s urban functions are too concentrated and metropolitan diseases are obvious; the positions of Beijing, Tianjin and Hebei Province are not clear enough, the division is not reasonable and regional development gap is relatively large. Besides, cities are dense in the region, but the development of small, medium and large cities are not harmonious and the leading role of central cities is weak. Beijing and Tianjin are the core cities of the region, but their urban primacy index is low, there is a lack of a leading city independently driving regional development and there are no

### TABLE 1  STATISTICS OF CIVILIAN VEHICLES IN THE BEIJING-TIANJIN-HEBEI REGION FROM 2009 TO 2014 UNIT: VEHICLE

<table>
<thead>
<tr>
<th>Year</th>
<th>Beijing</th>
<th>Tianjin</th>
<th>Hebei Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>3720945</td>
<td>1300000</td>
<td>3958000</td>
</tr>
<tr>
<td>2010</td>
<td>4528670</td>
<td>1582400</td>
<td>4928800</td>
</tr>
<tr>
<td>2011</td>
<td>4705341</td>
<td>1907754</td>
<td>6071907</td>
</tr>
<tr>
<td>2012</td>
<td>4935600</td>
<td>2211200</td>
<td>7285100</td>
</tr>
<tr>
<td>2013</td>
<td>5189000</td>
<td>2733100</td>
<td>8162934</td>
</tr>
<tr>
<td>2014</td>
<td>5324000</td>
<td>2848900</td>
<td>9970000</td>
</tr>
</tbody>
</table>

#### C. Industrial distribution and regional self-purification capacity do not match

The Beijing-Tianjin-Hebei region is typical dustpan-shaped terrain. Such terrain is not helpful for the diffusion of air pollutants. Coupled with the architectural layout of Beijing where there are many tall buildings, under different weather conditions, the spatial structure and terrain of such urban buildings are important factors that influence the spread of urban air pollutants. The Beijing-Tianjin-Hebei region is located in the east coast of the Eurasian continent and its terrain is high in the northwest and low in the southeast. It has a temperate monsoon climate. It is dry in spring and humid in summer. Its annual rainfall ranges between 400mm and 800mm. Due to the collective effect of terrain and climate, when there are easterly or southerly winds at a medium or low altitude, the pollutants will gather at piedmont plains under the action of wind transport and the concentration of pollutants will increase; when there are northerly winds at a medium or low altitude, the clean air of northern Beijing will be transported to Beijing, which will reduce its pollution level. Shijiazhuang is located in the south of Beijing. Its spring is dry, there is little rainfall and there are often 5-level or 6-level northerly or southerly breezes. In case of northerly winds, the air pollutants of Beijing will be brought to Shijiazhuang. Tianjin is located at the convergence of five tributaries of the Haihe River of North China Plain. It is adjacent to the Bohai Sea on the east and Yanshan Mountain on the north. Due to the action of southeast wind, the respirable particulate matters and other pollutants over Tianjin move westward with the wind and then move eastward and return home after being blocked by Taihang Mountains. In case of northwest wind, Taihang Mountains will intercept it and make it stay within Shanxi. Some pollutants cannot be blown away, so they can only stay over Tianjin. The cold air forces of the Beijing-Tianjin-Hebei region are weak, winds are small near the ground, atmospheric stratification is stable and air pollutant diffusion conditions are poor, resulting in agglomeration effect. Coupled with the destruction of the forests in the Beijing-Tianjin-Hebei region and coastal areas and little rainfall, the regional self-purification capacity of the Beijing-Tianjin-Hebei region is greatly reduced.
secondary cities that can be connected with their industries around Beijing and Tianjin.

V. CONCLUSIONS

Based on the characteristics of the hazy weather in the Beijing-Tianjin-Hebei region, coupled with the sources of current air pollution in the region, the article conducts targeted analysis of the causes of the hazy weather in the Beijing-Tianjin-Hebei region. It is hoped that it can provide some help for the prevention and control of China’s regional hazy weather and reducing the impact of hazy weather on people’s daily life and economic and social development.

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REFERENCES

This article through to the Beijing-Tianjin-Hebei Area haze related research are analyzed, and relevant management measures are put forward. Discover the world's research. 20+ million members. To make clarify the pollution mechanism of the fog which occurs in Yamase, which is a local weather phenomenon in summer of cold wind blown from the edge of the Okhotsk Sea high-pressure region to the northern Pacific coast of Japan, fog water samples were collected at Akita Hachimantai in 2003. The Yamase fog pollution level is lower than that of usual weather conditions. Synergistic analysis, using multisatellite datasets, air sounding and surface meteorological observations, indicated that there was a vertical overlap of fog and aerosol layers during the foggy haze episodes in the region. Fog appeared at a low level of the atmosphere. Abstract In January 2013, frequent episodes of intense air pollution occurred in the Beijing-Tianjin-Hebei area (BTH), China. Besides the occurrence of region-wide dry haze pollution, foggy haze conditions also developed across the region on numerous days, lasting into the afternoon. Synergistic analysis, using multisatellite datasets, air sounding and surface meteorological observations, indicated that there was a vertical overlap of fog and aerosol layers during the foggy haze episodes in the BTH region. The Beijing-Tianjin-Hebei region should strictly comply with the planning requirements of main functional areas and clearly define the industrial development direction in line with their respective functional positioning, energy conservation and environmental protection requirements. Beijing will focus on the disablement of industries that do not meet the capital's functional positioning, and give full play to the advantages of modern service industry, information industry and cultural and creative industry. Beijing, Tianjin and Shijiazhuang (the capital city of the Hebei Province) expanded from 801 km², 795 km², 682 km² to 2452 km², 3343 km² and 1699 km², respectively, since 30 years ago, which also led a significant LULC change. BTH is located in northern China (36°05′ to 42°40′ N and 113°27′ to 119°50′ E), as shown in Figure 1a. This is because the use of too many categories is not conducive for an analysis of the experimental results. To facilitate the analysis and highlight the experimental results, the LULC transfer matrix and other sections in this paper were based on the first-level classification of the RESDC. 3.2. WRF Simulation Scheme. It was mainly distributed in the southeastern and northwestern regions of the study area, which encompasses the North China Plain. Cause was that the increase in PM2.5 caused by meteorological conditions was greater than the decrease in PM2.5 caused by emission reductions. "Higher temperatures and relative humidity usually hasten the formation of secondary aerosols by accelerating chemical reactions", explains Prof. Zhang. "Meanwhile, the lower wind speed in the Beijing-Tianjin-Hebei region inhibits the diffusion of air pollutants and the lower planetary boundary layer height enhances atmospheric stability. These unfavorable meteorological conditions led to these haze events in the Beijing-Tianjin-Hebei region." Therefore, it is necessary to consider meteorological conditions when assessing the effectiveness of emission control policies on changes in air pollutants.