Inventory and Characteristics of Small-Scale PM2.5 in a District of Tianjin

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Abstract. Based on the activity level data of PM2.5 pollution sources in a certain area around Tianjin City, corresponding emission factors were selected to construct a 0.5km×0.5km small-scale PM2.5 emission inventory for the area in 2017. The results showed that in 2017, an area around the city of Tianjin emitted 3,509.91 tons of PM2.5. According to the emission inventory of PM2.5, in terms of the emission categories of pollution sources, the emission proportion of dust sources, process sources, road mobile sources and fixed combustion sources is 48%, 38%, 6% and 5% respectively. From the perspective of pollution sources, steel emissions accounted for 35% of the overall PM2.5 emissions, and road dust emissions accounted for 25.4% of the overall emissions. In addition, spatial distribution results show that there are pollution sources such as 1 boiler, scattered coal, some enterprises, several main roads, several construction sites and a large number of restaurants within a 3-kilometer radius of a monitoring station in a district around the city of Tianjin. The PM2.5 emitted by these pollution sources will directly affect the PM2.5 concentration in the district. There are still some uncertainties in this list, so the data of activity level, such as road traffic flow, need to be further detailed, and the localization study of emission factors should be further carried out, so as to provide a scientific basis for the formulation of regional pollution prevention strategies.

Keywords: PM2.5, emission inventory, fine scale, spatial distribution, uncertainty assessment.

1. Introduction
Since 2013, “smog” has gradually become the focus of people’s attention across the country. Large-scale haze weather has occurred in the Beijing-Tianjin-Hebei, Pearl River Delta, and Yangtze River Delta. The process lasts for a long time, has a wide range of influence, high intensity, and low visibility. It has a very serious impact on people's lives, and the formation of haze mainly comes from the impact of fine particulate matter PM2.5. Therefore, many experts have begun to study PM2.5, analyzing its source, impact and prevention measures [1, 2]. In recent years, various districts and counties of Tianjin have made unprecedented efforts to control air pollution. They have made
unremitting efforts to improve the ambient air quality in the region, increase the number of days air quality meets the standard, and reduce the comprehensive air quality index and PM$_{2.5}$ concentration. Since 2017, in order to continuously improve air quality, all districts will continue to promote the "Four Cleans and One Green" action, and strive to achieve substantial improvements in the Air Quality Index (AQI) and PM$_{2.5}$ on the basis of 2016, with more vigorous and wider adoption, More targeted measures. The refined air pollution source analysis technology based on the air pollutant emission inventory is a comprehensive statistical technology of environmental pollution information that has emerged in China in recent years and has been maturely applied abroad. It outputs different pollutant emission inventory products of different pollution sources. And the refined source analysis results of air pollution can be directly applied to the refined management of the environment, or applied to the cause analysis of environmental pollution, to provide scientific and effective methods for the identification and quantification of the characteristics of pollutant emission sources in the process of air pollution prevention and control. Solution [3, 4]. Carry out air pollution source small-scale refined PM$_{2.5}$ source analysis work, through data investigation, emission factor localization, and air pollutant emission accounting, build a refined air pollution source emission inventory in the area, and distribute the PM$_{2.5}$ emission inventory spatially. And through GIS to characterize the areas with high pollution emissions, quantify and refine the causes and sources of atmospheric PM$_{2.5}$ pollution in a certain area around the city of Tianjin [5, 6].

2. Materials and Methods

2.1. Compilation range
An area around the city of Tianjin is located in the southeast of Tianjin. This area contains 8 streets and towns, 117°13′E~117°33′E; 38°50′N~39°4′N, covering an area of 420 km$^2$. The industry in this area is rich in types, covering 13 types of pollution sources (of which there are 8 types of PM$_{2.5}$ emissions, and each industry is distributed in Tianjin). The pollution sources are comprehensive and the types of pollution sources can reflect the industry characteristics of Tianjin. The research results can provide constructive plans for the management of PM$_{2.5}$ in the area around the city and Tianjin. The emission sources of PM$_{2.5}$ include three types: point source, line source and non-point source. The pollution sources involved include stationary combustion sources, process sources, dust sources, road mobile sources, non-road mobile sources, catering sources, and biomass combustion.

2.2. Method overview
Based on the "Technical Manual of Urban Air Pollutant Emission Inventory Compilation" (edited by He Kebin) [8] and "Technical Method and Application Examples of Urban High-resolution Air Pollutant Emission Inventory Compilation" (edited by Sun Ren et al.) [9]. In the medium method, the activity levels of point sources such as enterprises, boilers, restaurants, and waste treatment stations, residents, and non-point sources such as dust are obtained by field investigation, and satellite remote sensing interpretation is used for roads. This study uses 2017 as the base year to obtain activity levels such as enterprise product output, boiler fuel consumption, restaurant stove number, traffic flow, and number of households through a bottom-up approach, and obtain road location and length through satellite image interpretation. Level data, select the corresponding emission factors and end treatment technical efficiency, calculate the PM$_{2.5}$ emissions of a certain area around the city in Tianjin, establish a small-scale PM$_{2.5}$ emission inventory in a certain area around the city, and use GIS software to complete 0.5 Grid distribution of 0.5 km × 0.5 km.

2.3. Activity level collection and emission factor selection
2.3.1. Collection of activity levels. In the process of constructing this small-scale refined air pollution source emission inventory, the activity level is defined as: in the base year 2017, the amount of
production or consumption activities related to PM$_{2.5}$ emissions in a certain area around Tianjin City [10]. Before compiling a small-scale and refined PM$_{2.5}$ inventory of a certain district around the city in Tianjin, we determined 2017 as the activity level year, and the survey data is based on 2017. The survey method adopts statistical survey method and satellite remote sensing method. Point sources and non-point sources other than agricultural land, forest land and grassland are investigated through statistical investigation methods, and agricultural land, forest land, and grassland are all obtained by satellite remote sensing.

The method of obtaining the activity level is carried out in a coordinated "district-sub-district-community" approach. The survey scope includes pollution sources related to PM2.5 emissions in a certain area around the city of Tianjin. The types of pollution sources involved include enterprises, boilers, residents, and bulk coal, Restaurants, construction sites, bare land, storage yards, roads, and other sources of pollution. We designed a complete set of "Pollution Source Information Questionnaire" based on the characteristics of various pollution sources to ensure the comprehensiveness and meticulousness of pollution sources. Create a questionnaire from the perspective of the elements of the survey, fully consider the influencing factors of each type of source, ensure the landing of the questionnaire, and include the level of activity required for each type of pollution source to ensure the meticulousness of the investigation. The district environmental protection bureau is responsible for the coordination of the entire pollution source investigation, the district construction committee is responsible for the investigation of the construction site, the traffic team is responsible for the investigation of road construction and road traffic information, the city appearance and gardening committee is responsible for the investigation of the garden site and road cleaning information, and the housing management bureau is responsible for the demolition of the site. Investigation, each street, town, and park is responsible for the investigation and positioning of enterprises, boilers, construction sites, bare land, storage yards, residents' information, and restaurants.

The investigation method of the relevant commissions and bureaus is mainly to sort out existing data, supplemented by field surveys, while the streets and towns mainly rely on field surveys, supplemented by sorting out existing data. When conducting the survey, the survey object will be located with a unified positioning software on-site to ensure the accuracy of the positioning. The total number of pollutant sources surveyed is 17,569, including 11,653 households with 27 scattered coal, 56 boilers, 1722 enterprises, 111 storage yards, 87 construction sites, 94 bare land, 1283 restaurants, and 271 roads, 20 construction sites, 152 residential villages and communities, 2 waste disposal sources, 36 free-range breeding and 1,906 farmland. In aowei, the pollution sources are located and distributed in space. There are 3,063 point sources, 718 area sources, and 271 roads.

### 2.3.2. Selection of emission factors.

When calculating emissions, we use the emission factor method, but the emission factors in the inventory guidelines are only the national average emission factors. Specific to a district or county in Tianjin, it does not reflect the actual local emissions. Therefore, we have constructed the Tianjin City Ring The localized emission factor for a district. We adopted four methods of localization: actual measurement, online monitoring, inventory guide, and scientific research literature. Pollution sources such as boilers, loose coal, motor vehicles, road deposition load, dust and other pollution sources related to the local motor vehicle structure, meteorological conditions, and fuel types have local characteristics. Field measurement can ensure that the inventory results reflect the actual local conditions. Steel and unorganized emissions of enterprises use online monitoring to obtain emission factors, and select representative companies to monitor and calculate emission factors, which can reflect the actual local conditions. For emission factors of other industrial enterprises, refer to the inventory guidelines. For biomass combustion, the emission factor of the source is investigated by literature, and the relevant literature of the corresponding biomass emission factor is selected. According to the literature factor, the emission factor of the biomass combustion source in a certain area around the city of Tianjin can be objectively reflected [11]. For catering sources, waste treatment sources and non-road mobile sources are referred to the emission factors of the inventory guidelines. The inventory guidelines give corresponding introductions to catering
sources, waste treatment sources, and non-road mobile sources. These types of pollution sources in a certain area around the city of Tianjin. This type of pollution source is basically the same as that in the whole country, so the direct use of the factors in the inventory guide can reflect the actual situation in a certain area around the city of Tianjin.

3. Results and discussion

3.1. 2017 PM$_{2.5}$ emission inventory in a district around Tianjin

Based on the above emission calculation method, the 2017 PM$_{2.5}$ emission inventory of a district around the city of Tianjin is shown in Table 1. The annual emission of PM$_{2.5}$ is 3509.91 tons. Among them, the major pollution sources are dust sources, process sources, road mobile sources, and stationary combustion sources. The main reason is that the district is a transportation hub between the central city of Tianjin and the Binhai New Area, with more transportation channels and more large vehicles. There is a steel company and related supporting companies in this area, and the pollutant emissions are relatively large. The research results are consistent with the research results of Tang Ling and Liu Jiahong [12-13].

| Emission source category                  | PM$_{2.5}$ (Ton) |
|------------------------------------------|-----------------|
| **Stationary combustion source**         |                 |
| The heating unit                          | 30.27           |
| Civil combustion sector                   | 137.90          |
| total                                     | 168.17          |
| **Process source**                        |                 |
| Steel industry                            | 1251.63         |
| Non-metallic mineral products industry    | 10.09           |
| Metal products industry                   | 32.56           |
| Chemical raw materials and chemical products manufacturing | 2.73 |
| Furniture manufacturing                   | 2.91            |
| Agricultural and sideline food processing industry | 0.03 |
| Other manufacturing                       | 0.37            |
| Petroleum processing, coking and nuclear fuel processing industries | 0.33 |
| Food manufacturing                        | 0.04            |
| Non-ferrous metal smelting and rolling processing industry | 26.09 |
| other                                     | 4.82            |
| total                                     | 1331.59         |
| **Dust source**                           |                 |
| Soil dust                                 | 680.79          |
| Road dust                                 | 879.32          |
| Construction dust                         | 74.87           |
| Yard dust                                 | 39.59           |
| total                                     | 1674.58         |
| **Road movement source**                 |                 |
| Primary road                              | 54.95           |
| Secondary road                            | 90.64           |
| Tertiary road                             | 73.02           |
| Four-level road                           | 1.13            |
| total                                     | 219.74          |
### Table 1: Emission source category and PM$_{2.5}$ (Ton)

| Emission source category       | PM$_{2.5}$ (Ton) |
|-------------------------------|-----------------|
| Non-road mobile source        |                 |
| Construction machinery        | 6.08            |
| Agricultural machinery        | 3.05            |
| Production machinery          | 0.84            |
| total                         | 9.97            |
| Food source                   |                 |
| Social Dining                 | 31.38           |
| Urban residents dining        | 47.99           |
| Rural residents catering      | 5.68            |
| total                         | 85.05           |
| Biomass combustion source     | 17.49           |
| Waste treatment source        | 3.31            |
| Total emissions               | 3509.91         |

3.1.1. *Emission source sharing rate.* Figure 1 shows the distribution of PM$_{2.5}$ emission sources in a certain area around the city in Tianjin throughout the year. The top four sources of PM$_{2.5}$ emissions in a certain area around the city in Tianjin are dust sources, process sources, road mobile sources, and stationary combustion sources. Figure 2 shows that the highest emission of dust sources is road dust, followed by soil dust. According to Table 1, it can be seen that the largest emission source of PM$_{2.5}$ among process sources is steel, which accounts for 93.9% of the total process sources and 35.6% of the total emissions.

3.1.2. *Spatial distribution characteristics.* Table 2 shows the distribution of total PM$_{2.5}$ emissions in various neighborhoods and towns around the city in Tianjin. The neighborhood where PM$_{2.5}$ contributes the most is Gegu Town, with emissions of 2025.25 tons and a sharing rate of 57.70%; the second is salty. The sharing rates of Shuigu Town and Shuanggang Town were 8.70% and 8.65%, respectively. The remaining five towns had smaller emissions, and the sum of the sharing rates was 24.95% of the total. The total PM$_{2.5}$ emissions of different streets and towns are quite different, and the composition is different. The largest emissions in Gegu Town are process sources, dust sources and road mobile sources, accounting for 61.95% and 30.83 of the total emissions in Gegu Town, respectively. And 6.80%, mainly because the town has a steel company and related supporting enterprises, and there are many transportation channels in the adjacent Binhai New Area. Xianshuigu Town discharges the largest amount of fugitive dust, accounting for 69.70% of the town’s total emissions. The town is a central built-up area of a certain district around the city in Tianjin. As a result, the dust source in the town became the main source of pollution. The major source of pollution in Shuanggang Town is the dust source, which accounts for 91.23% of the total amount of the town, and the main contributing source is the soil dust.
Figure 1. Annual PM$_{2.5}$ emissions by various emission sources

Figure 2. Emissions from dust sources.

Table 2. Emission contributions of towns in PM$_{2.5}$.

| Town               | Emissions | Contribution rate |
|--------------------|-----------|-------------------|
| Balitai Town       | 147.54    | 4.20%             |
| Beizhakou Town     | 143.21    | 4.08%             |
| Gegu Town          | 2025.25   | 57.70%            |
| Shuanggang Town    | 303.56    | 8.65%             |
| Shuangjiaohe Town  | 215.78    | 6.15%             |
| Xianshuigu Town    | 305.41    | 8.70%             |
| Xiaozhan Town      | 237.26    | 6.76%             |
| Xinzhuang Town     | 131.91    | 3.76%             |

Figure 3 shows the spatial distribution characteristics of small-scale PM$_{2.5}$ emissions in a certain area around Tianjin. Based on the distribution of PM$_{2.5}$ emission sources in a certain area around Tianjin, this paper divides a certain area around Tianjin into 0.5 km$^2$. For a 0.5 km grid, point sources are imported into the grid according to latitude and longitude data, road movement sources are distributed in the grid according to line sources, and construction sites, bare land, and residents are distributed in the grid according to area sources. The spatial distribution of PM$_{2.5}$ is the sum of the
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spatial distribution of 8 types of sources: stationary combustion sources, process sources, road mobile sources, non-road mobile sources, dust sources, catering sources, biomass combustion sources, and waste treatment sources. It can be seen from the grid graph that the areas with large PM$_{2.5}$ emissions are more scattered, and some of the point sources and line sources emit relatively large amounts. These areas are also concentrated in major roads, construction sites, bare land, steel and other industries area.

![Figure 3. Emission grids of PM$_{2.5}$](image)

3.1.3. Uncertainty analysis. In the compilation of regional PM$_{2.5}$ emission inventories, the emission factor method is used to calculate. Due to the insufficient representation of key activity levels and emission factors, the results of the emission inventory are uncertain. The uncertainty assessment of the emission inventory mainly adopts Quantitative analysis and qualitative analysis [14-15].

The main uncertainties in this study are: residents, biomass burning, and off-road mobile sources all adopt a top-down approach to obtain activity levels, and the uncertainty is high; the road traffic flow is obtained by field sampling. There is a certain degree of uncertainty.

4. Conclusions
(1) PM$_{2.5}$ emissions in an area around the city in Tianjin in 2017 were 3509.91 tons.
(2) From the perspective of emission sharing rate, the major primary pollution sources are dust sources, process sources, road mobile sources, and stationary combustion sources. The main secondary pollution sources are the steel industry, soil dust and road dust industries; In terms of spatial distribution, the top three streets and towns for discharge are Gegu Town, Xianshuigu Town and Shuanggang Town.
(3) The uncertainty of the source list in a certain area around the city of Tianjin is mainly due to the imprecision of the activity levels of a few pollution sources.
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