Research on high-resolution water pollutant source list of Daqing River Basin (Baiyangdian)

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Abstract. With the refinement of water environment management in the basin, the work of Water Pollutant Source List (WPSL) has been carried out. The article separately calculates the pollution load of point sources and area sources, among which point sources include industry sources, sewage treatment plants, large-scale livestock and poultry farms, area sources include urban runoff, rural life, agricultural planting, and rural livestock and poultry farming. Pollutants include chemical oxygen demand (COD), ammonia nitrogen (NH₃-N), total nitrogen (TN), and total phosphorus (TP). Based on a certain spatial induction method, the pollution load is assigned to a grid of 1km×1km, and a high-resolution water pollution source list is established, which provides a refined basic database for environmental management.

1. Introduction
The Water Pollution Prevention Action Plan implemented in 2015 is a concrete manifestation of the shifting of the water environment of the river basin to refined management[1]. The water pollution source list refers to a comprehensive list of the types and quantities of various pollutants discharged from various sources in a specific geographic area and within a specific time interval. It is an important basis for studying the causes of water environment pollution, controlling pollutant discharge, and solving water environment problems[2].

The Daqing River originates from the Taihang Mountain and is one of the river systems in the Hehai Basin. The Daqing River system has a total length of 483 kilometers and a total area of 43060 km². The Daqing River system is divided into north and south branches, and the south branch merges into Baiyangdian. Baiyangdian is located in the center of Beijing - Tianjin - Shijiazhuang triangle. It is the most typical and representative shallow macrophytic lake of the northern part of China and it plays important role in adjusting the temperature and humidity, replenishing groundwater, maintaining ecological balance and conserving biological diversity[3].

The Daqing River Basin is the main river channel in the Beijing-Tianjin-Hebei region. It is also an important water replenishment corridor for the Xiong’an New Area and Baiyangdian. It is particularly important and urgent in the background[4].
2. Area of research
The scope of the Daqing River Basin (Baiyangdian) involves 8 cities (districts), 42 counties (districts), and 479 towns in Beijing, Tianjin, and Hebei Province. The scope of this research is mainly within the territory of Hebei Province, which including 29 four-level control units of water environment. The division of the four-level control unit of the Daqing River Basin (Baiyangdian) is shown in Figure 1.

![Figure 1. The division of the four-level control unit of the Daqing River Basin (Baiyangdian).](image)

3. Research methods
The list of water pollution sources includes point sources and area sources. Point sources include industrial sources, sewage treatment plants, and large-scale livestock and poultry farms. Area sources include urban runoff, rural life, agricultural planting, and rural livestock and poultry farming. Pollutants include chemical oxygen demand (COD), ammonia nitrogen (NH₃-N), total nitrogen (TN), and total phosphorus (TP).

The basic point source data comes from environmental statistics, and the rural non-point source data comes from Hebei Rural Statistical Yearbook. The rural non-point source calculation method is mainly derived from the inventory compilation method of the project team. The urban non-point source calculation method refers to an academic paper[5].

4. Research result

4.1. Point sources

4.1.1. Industrial sources. From 2009 to 2018, the drainage industry enterprises in the river basin dropped from 316 to 21; the discharge of wastewater from 74.47 million tons was reduced to 7.16 million tons. The COD, NH₃-N, TN, and TP emissions decreased respectively from 15031t, 1181t, 196t, and 69t to 276t, 8.3t, 54t, and 1.4t. The control units with large direct discharge of water pollutants mainly include: Jiaozhuang, Yanjiawu, Anzhou, Taitou, Wurenqiao, Pukou, Zhulong River, etc. The industries with the highest contribution to pollutant emissions are: machine-made paper and paper plate manufacturing, chemical fiber weaving processing, cotton printing and dyeing finishing, fur tanning processing, feather (velvet) processing, electronic components and components manufacturing, hair dyeing and finishing processing, photovoltaic equipment. And component manufacturing, nitrogen fertilizer manufacturing, coking, which accounting for more than 65% of total pollutant emissions.
4.1.2. Sewage treatment plants. From 2009 to 2018, the basin's sewage treatment plants increased from 19 to 87; wastewater discharge increased from 16.616 million tons to 55.783 million tons. The COD, NH\textsubscript{3}-N, TN, TP emissions Changed respectively from 8496t, 2096t, 2739t, 153t to 14147t, 533t, 4811t, 147t. The control units with large direct discharge of water pollutants mainly include: Jiaozhuang, Pokou, Wurenqiao, Dalituan, Beiqing, Anzhou, Shaochedian, Nanliuzhuang, Dongmaying, etc.

4.1.3. Large-scale livestock and poultry farms. From 2011 to 2018, the number of large-scale livestock and poultry farms in the basin fell from 2311 to 19. The COD, NH\textsubscript{3}-N, TN, and TP emissions decreased from 81250t, 4362t, 31592t, and 5338t to 3617t, 130t, 386t, and 28t, respectively.

4.1.4. Spatial expression. According to the geographical coordinates of the point source, it can be accurately summarized into space, and combined with the pollution information database, a list of point sources with high spatial resolution is formed. The spatial expression is shown in Figure 2.

Figure 2. The Spatial distribution of point source pollution in Daqing River Basin (Baiyangdian).

4.2. Area sources of agriculture

4.2.1. Rural life. In 2016, the emissions of COD, TN, NH\textsubscript{3}-N, and TP from rural life were 374772.59 t, 50279.69t, 10026.87t, 71060.02t, and the inflows to the river were 51211.86t, 12128.63t, 1368.07t, 15271.56t.

4.2.2. Agricultural planting. In 2016, the emissions of COD, NH\textsubscript{3}-N, TN, and TP from agricultural planting were 1,136.65t, 255.47t, 1348.55t, 78.99t, and the inflows to the river were 345.43t, 67.02t, 354.65t, 20.77t.

4.2.3. Rural livestock and poultry farming. In 2016, the emissions of COD, TN, NH\textsubscript{3}-N, and TP from rural livestock and poultry farming were 290.33 million tons, 64.65 million tons, 2.6484 million tons, 1.6054 million tons, and the inflows to the river were 2469.09t, 552.22t, 226.48t,134.43t.

4.2.4. Spatial expression. Agricultural planting is allocated according to the area of cultivated land in the land use type, rural livestock and poultry farming, rural life are allocated according to the rural
population, and a list of area source with high spatial resolution is obtained, which is shown in Figure 3.

![Figure 3. The Spatial distribution of area source pollution in Daqing River Basin (Baiyangdian).](image)

4.3. Area sources of urban runoff
In 2018, the inflows to the river of COD, TN, NH₃-N, and TP from urban runoff were 55.58t, 2.44t, 1.56t, 0.15t. The highest COD inflows is Hejian City (18.06t/a), the lowest is Lianchi District (0.54t/a), with an average value of 7.53t/a, the highest TN inflows is Hejian City (0.49t/a), the lowest is the Lianchi District (0.01t/a), with an average value of 0.21t/a, the highest TP inflows is Hejian City (0.05t/a), the lowest is Anguo City, Lianchi District, and Li County (0), with an average value of 0.02t/a.

5. Conclusions and discussions
By the above method, a high-resolution water pollution source list is established, which provides a refined basic database for environmental management. The minimum spatial grid of the point sources calculated is a point (Latitude and longitude), the minimum grid of area sources is 1km×1km. These are smaller than the area of the current water environmental control unit, which can guarantee the spatial accuracy. With the fine division of water environment control units, the statistical work is becoming more solid, the scientific and technological level is getting higher, the model calculation is more and more accurate, and the high-resolution requirements of the water pollution source list will be updated accordingly[6].

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