

A study on the characteristics of diatoms and ecological environment pollution in the main water of Tianjin, China

Sugur Enh¹, Jing Fang^{1*}, Pengyi Ma¹, Bo Liu¹, Heng Zhang¹, Dexuan Lan¹, Ziyao Yang¹, PingCuoDolka¹, Zhifei Wang¹

¹school of Geography and Environmental Science Tianjin Normal University Tianjin, China

Abstract. Twenty lake bottom surface layers mud and water samples in the Qilihai Wetland and the Beidagang Reservoir in Tianjin were taken to do diatoms analysis. More than 6000 diatoms were identified and divided into 117 species and 28 genera. Based on the calculation of DAIPo (Diatom Assemblage to organic water pollution), the water pollution level of the Beidagang Reservoir can be divided into: Xenosaprobic, β -oligosaprobic, α -oligosaprobic, β -mesosaprobic, from clear to slightly cloudy water. The water pollution level of Qilihai wetland can be divided into: extremely oligarchy dirt belt, β oligarchy dirt belt, α oligarchy dirt belt, β Medium dirt belt, that is, the water quality is clear to slightly turbid. The water quality of the Beidagang Reservoir is clearer than that of the Qilihai Wetland. The physical and chemical indexes such as EC, pH, TN, TP and COD_{Mn} were determined for the water samples, and the correlation between DAIPo and these measured values was analyzed. The results showed that the degree of water pollution detected was consistent with the conclusion obtained by diatom analysis. The results show that the water quality of the Beidagang Reservoir and the Qilihai Wetland was mildly polluted in the spring and summer of 2019, but the eutrophication is more serious.

1 Introduction

Many scholars analyzed the ecological changes of water environment by using the characteristics of diatom species and their community combinations, and combine the nutritional status index, sediment pollution degree, total phosphorus content, EC, pH and other water environment factors, as well as the main component analysis method, to analyze and evaluate the aquatic ecological environment. In the 1990s, Van Dam et al. revealed that the diatoms are very effective in indicating pH, salinity, organic nitrogen, oxygen saturation, humus, and eutrophication (Van Dam H, et al. 1994). Watanabe et al. (1986) proposed a calculation method, DAIPo, based on adhesion diatoms to evaluate water pollution. With DAIPo, the degree of organic pollution of fresh water can be calculated, and the water pollution situation can be compared with spatiotemporal analysis (Watanabe et al. 1986a). Since then, the effectiveness of DAIPo in different environments, such as rivers and lakes, had been validated (Watanabe et al. 1988).

The Qilihai Wetland and the Beidagang Reservoir are important wetlands in the Tianjin Plain in China. In recent years, many scholars have made many achievements in the study of Tianjin's wetland environment by different methods. Diatom analysis has been widely used in the restoration of paleoenvironment of the coastal plains of China, but it has been applied less in the monitoring and evaluation of water quality, especially in North China.

Based on the sediment sampling of the Qilihai Wetland and the Beidagang Reservoir, diatom species were identified. By summarizing the genus of diatoms, DAIPo (Diatom Assemblage Index to organic water pollution) was calculated, and through the pollution index, the pollution degree of different water bodies in the same period is classified quantitatively.

2 Research areas and methodology

The Qilihai wetland is located in the northeast of Tianjin, the geographical coordinate is 39°17'N, 117°47'E, with a total area of about 95km². It formed by the land and sea changes, originally part of the ancient Bohai Sea, and then retreated through the Bohai Sea. Because of low-lying terrain, today's wetland landscape was formed. It is also a transit point for migratory birds, inhabiting and breeding more than 200 species of birds, with very important ecological and conservation value (Wang et al., 2005).

The Beidagang wetland is located in the southeast of Tianjin Binhai New Area, the geographical coordinates is 38°36'N~38°50'N, 117°11'E~117°37'E, an area of 34887hm², and it is the largest area of *the Wetland Nature Reserve in Eastern Asia*, which is of great significance to the ecological protection of migratory birds.

On June 1 and 2, 2019, 20 different sites, including the surface mud and water samples of the lake, were collected at the edge of the water body and the estuary of

* Corresponding author: mdfangjing@163.com

the river, respectively, in the Qilihai Wetland, Northeast of Tianjin and the Beidagang Reservoir, Southeast of Tianjin(Fig.1).

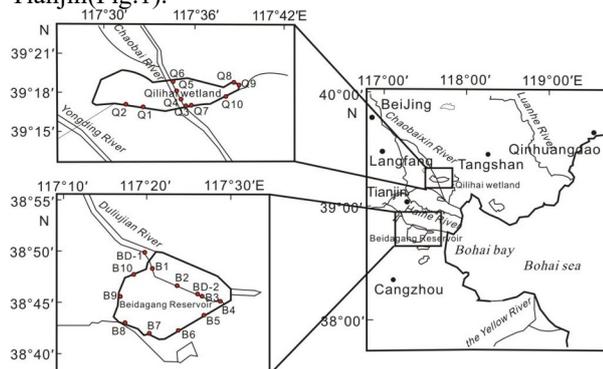


Fig.1. Research area location map

Based on the sediment sampling of the Qilihai Wetland and the Beidagang Reservoir, diatom species were identified. By summarizing the genus of diatoms, DA_{Ipo} (Diatom Assemblage Index to organic water pollution) was calculated, and through the pollution index, the pollution degree of different water bodies in the same period is classified quantitatively.

Diatom identification is based on Watanabe et al.(2005) to be named. Diatoms were divided into three groups, such as Saprophylic taxa, Eurysaprobic taxa, and Saproxenous taxa, and the relative percentage content of 3 species was calculated, and the number of diatoms (DA_{Ipo}) based on the attached diatom population in Watanabe et al. (2005) was calculated according to its share(Watanabe et al.,2005).

The search for the value of DA_{Ipo}:

$$DA_{Ipo} = 50 + (A - B) / 2 \quad (1)$$

A: The relative frequency (%) of all occasional stoic species that appear at the survey site.

B: The relative frequency (%) of all Saprophylic taxa that appear at the survey site.

The physical and chemical indexes such as EC, pH, TN, TP and COD_{Mn} were determined for the water samples.

3 Results and discussion

3.1 Diatoms from the Beidagang reservoir and Qilihai wetland

20 surface mud samples (10 in the Qilihai wetland, 10 in Beigang reservoir) were collected on the edge of the Qilihai wetland and the Beidagang reservoir to do diatoms analysis and identification. More than 6000 diatoms were identified and divided into 117 species and 28 genera.

Among them, the diatoms' advantage synods in the Beidagang Reservoir are mainly Navicula, Nitzschia. Saproxenous taxa includes Achnanthes conspicua, Achnanthes marginulata, Navicula pseudoreinhardtii, Comphoneis pseudokunoi, Diploneis interrupta, Encyonopsis minuta, Eunotia veneris, Fragilaria capitellata, Navicula cincta, Stephanodiscus pseudosuzukii and other 16

species. Saprophylic taxa includes Cyclotella delicatula, Cyclotella meneghiniana, Navicula confervacea, Navicula pupula, Nitzschia amphibia. Eurysaprobic taxa includes Aulacoseira islandica, Brachysira brebissonii, Cyclotella ocellata, Gyrosigma procerum, Navicula aryptocephala, Neidum ampliatus, Peronia fibula, Stephanodiscus hantzschii, Tabularia fasciculata, Synedra ulna and other 24 species.

The advantages of diatoms in the Qilihai Wetland are mainly: Navicula, Nitzschia, Achnanthes. Saproxenous taxa includes Achnanthes clevei, Diploneis interrupta, Encyonopsis minuta, Fragilaria capitellata, Gomphonema olivaceum, Hannaea arcus, Navicula contenta, Navicula cryptotenella, Nitzschia tabellaria, Synedra inaequalis and other 28 species. Saprophylic taxa includes Cyclotella meneghiniana, Eunotia asterionelloides, Navicula pupula, Navicula subminuscula, Nitzschia amphibia. Eurysaprobic taxa includes Aulacoseira Canadensis, Diatoma hyemalis, Gyrosigma procerum, Hantzschia amphioxys, Navicula amphiceropsis, Nitzschia filiformis, Rhopalodia gibba, Stephanodiscus alpinus, Surirella bifrons, Synedra ulna and other 19 species(Fig.2).

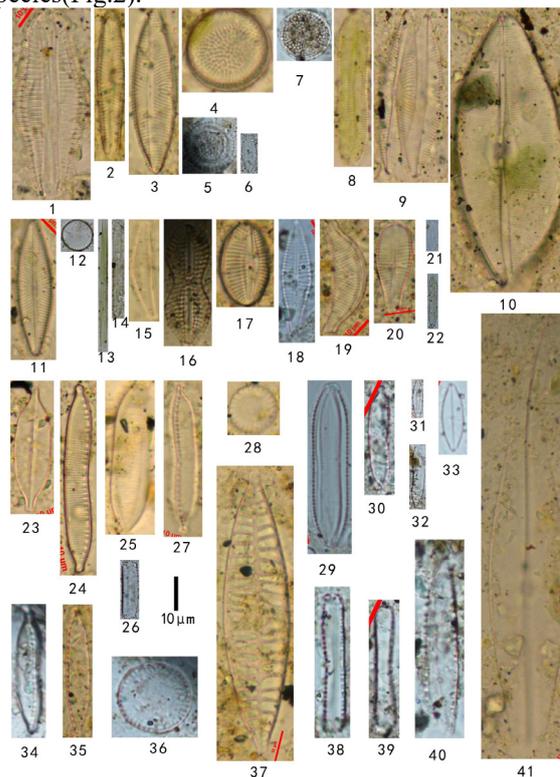


Fig.2. Photo of microscope diatom in the surface mud of the Beidagang Reservoir and the Qilihai Wetland.

(1)Rhopalodia gibba,(2)Achnanthes lanceolata,(3)Navicula delicatilineolata,(4)Orthoseira roeseana,(5)Cyclotella ocellata,(6)Achnanthes oestrupii,(7)Stephanodiscus pseudosuzukii, (8)Surirella andoi,(9)Pinnularia acidobionta,(10)Navicula confervacea,(11)Navicula cincta,(12)Cyclotella delicatula,(13)Peronia fibula,(14)Neidum ampliatus,(15)Eunotia veneris,(16)Diploneis interrupta,(17)Diploneis subovalis,(18)Navicu

notha,(19)Epithemia soresx,(20)Gomphonema
 olivaceum,(21)Achnanthes clevei,(22)Nitzschia
 tabellaria,(23)Navicula amphiceropsis,(24)Fragilaria
 capitella,(25)Achnanthes biasoletiana,(26)Eunotia
 ueneris,(27)Synedra inaequalis,(28)Cyclotella
 meneghiniana,(29)Nitzschia constricta,(30)Encyonopsis
 minuta,(31)Fragilaria capucina,(32)Hannaea

arcus,(33)Navicula subminuscula,(34)Hantzschia
 amphioxys,(35)Synedra ulna,(36)Stephanodiscus
 alpinus,(37)Surirella bifrons,(38)Navicula
 pupula,(39)Navicula contenta,(40)Nitzschia
 zvidoclinata,(41)Gyrosigma procerum.

The diatoms analysis results are shown in Fig. 3.

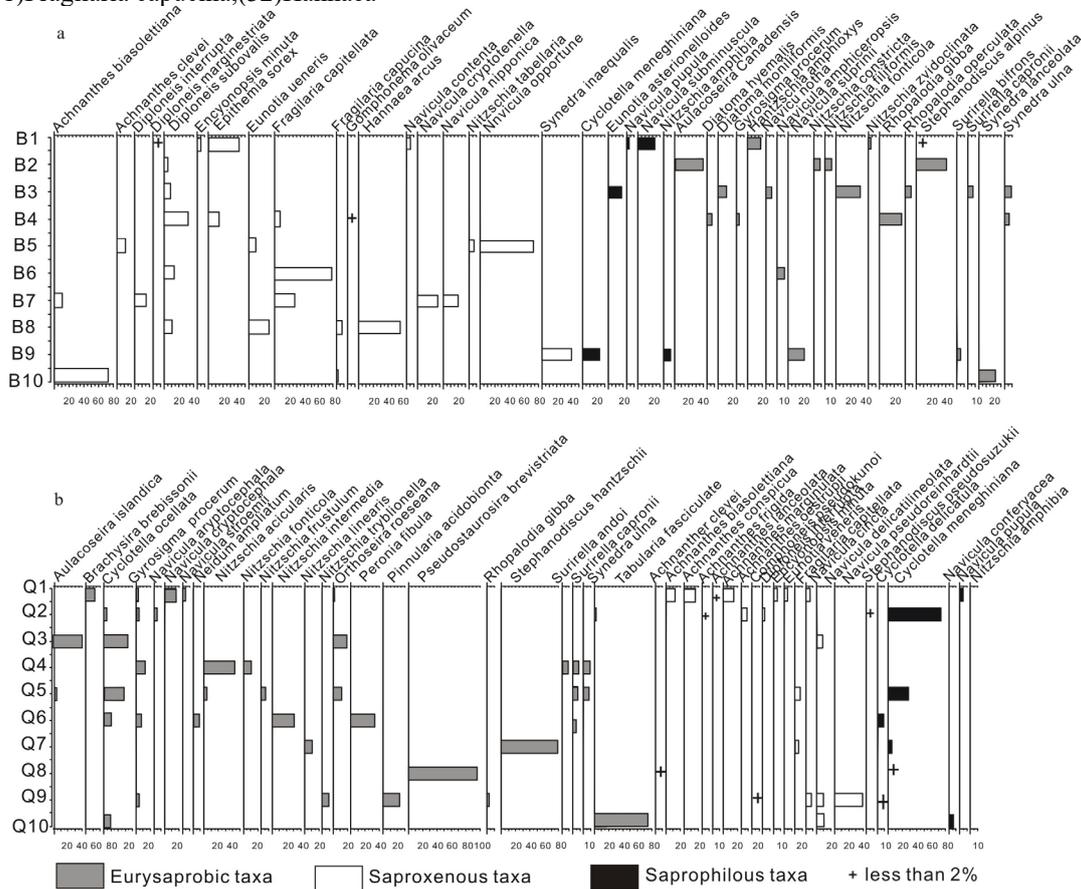


Fig.3. Results of diatoms in Beidagang reservoir(a) and Qilihai wetland (b)

3.2 EC、pH、DAI_{po}、TN、TP and COD_{Mn}

The diatom data of 20 samples of the Beidagang Reservoir and the Qilihai Wetland were substituted into the formula (1). The EC, pH, DAI_{po}, TN, TP and COD_{Mn} were measured for the samples of the Beidagang Reservoir and the Qilihai Wetland, shown in Fig. 4.

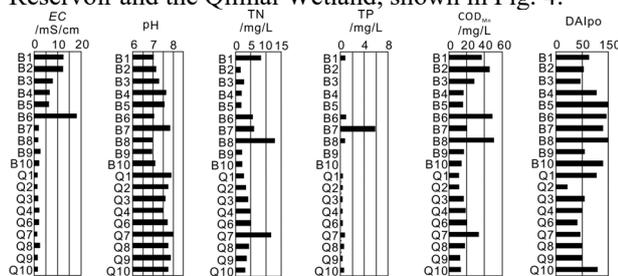


Fig.4. The Beidagang reservoir(B1-B10) and the Qilihai wetland(Q1-Q10) EC、pH、TN、TP、COD_{Mn} and DAI_{po}

3.3 Evaluation of water quality of the Beidagang reservoir and Qilihai wetland

3.3.1 Beidagang reservoir

Based on the DAI_{po}, the water quality pollution level of Beidagang reservoir can be divided into xenosaprobic, β-oligosaprobic, α-oligosaprobic, β-mesosaprobic, that is, the water quality is clear to slightly dirty. The EC value of Beidagang reservoir was higher, ranging from 1.61 to 18.18 mS/cm. The pH value was 6.95-7.81, which reached the weakly alkaline environment. Besides B7 exceeding the standard, the total phosphorus concentration in Beidagang water body was in the mesotrophic and meso-eutrophication state (50 - 1300 μg/L). According to the national evaluation criteria for lake eutrophication, the total nitrogen content of the three sampling points, B2, B4 and B5 in Beidagang reservoir, were eutrophication (less than 2.0mg/L), but all of them reached the state of hypereutrophication (more than 2.0mg/L). It was speculated that the main

reason was that, with the development of industrial and agricultural in this area chemical substances discharged into the water body, causing an explosion of green algae, cyanobacteria and other algae and other plankton, resulting in the degradation of the self-purification ability of the water ecology and the deterioration of the water quality.

Overall, B10 in the northwest of the Beidagang Wetland and B5 in the southeast are very clear (the DAIPo index are both 100), indicating that the southern water body is clear (the DAIPo index is 100-89.93), the northeast and west side are mild-slightly polluted (DAIPo is 68.55-46.83), with pollution levels from low to high.

3.3.2 Qilihai wetland

Based on the DAIPo pollution index, the water quality pollution levels of the Qilihai wetland can be divided into β -oligosaprobic, α -oligosaprobic, β -mesosaprobic, α -mesosaprobic, that is, the water quality is clear to dirty. The EC of the Qilihai wetland was relatively low, all of which were Marine sediments between 1.13 and 2.4 mS/cm. The pH value was 7.49~7.95, which reached the weakly alkaline environment. The total phosphorus mass concentration in the Qilihai land was rich. According to the national evaluation standard for lake eutrophication, the total nitrogen content of the Qilihai wetland was all greater than 2 mg/L, which is ultra-eutrophication (Wang et al.2019). The main reason was that, under the influence of fish pond culture and human activities, nitrogen, phosphorus and other nutrients enter the water in large quantities, leading to eutrophication.

The above analysis showed that the water in the southern and eastern part of the Qilihai wetland was clear - slightly dirty (DAIPo was 77.76-50), and the water in the central part of the road passing through the Qilihai wetland was slightly polluted (DAIPo was 39.32-54.03). Among them, Q2 water at the sampling point at the inlet of Yongding river was seriously polluted (DAIPo was 19.9), which was speculated to be caused by the deposition of pollutants carried by the river in the lake.

Comparing Beidagang reservoir and Qilihai wetland ecology, Beidagang DAIPo index is slightly higher than the Qilihai point DAIPo index. Therefore, compared with the latter, the former has better water quality, less water pollution and better ecological environment protection. It shows that the pollution degree of Beidagang and Qilihai in 2019 is not serious, but mild, and the water quality is relatively stable.

4 Conclusion

By analyzing the diatoms in the surface mud samples of the lake bottom, which were collected from the surface layer of the lake bottom from the edge of the Qilihai Wetland, the Beidagang Reservoir in Tianjin and the Duliujian River, and the physical and chemical index such as EC, PH, TN, TP and COD_{Mn} were measured.

(1) According to the tolerance of different diatoms to pollution, the DAIPo of the Beidagang Reservoir and the

Qilihai Wetland was calculated. It was found that the DAIPo index of sample points was very different. The grade of water pollution in Beidagang reservoir can be divided into: xenosaprobic, β -oligosaprobic, α -oligosaprobic, β -mesosaprobic, from clear to slightly dirty water. The level of water pollution in Qilihai wetland can be divided into: β -oligosaprobic, α -oligosaprobic, β -mesosaprobic, α -mesosaprobic, that is, the water quality is clear to muddy. Compared with the Qilihai Wetland, the DAIPo index of the Beidagang Reservoir's sample points is slightly higher than that of the Qilihai Wetland's. Therefore, the water quality of the Beidagang Reservoir is better, the water pollution degree is lighter, and the ecological environment protection is better. The EC in the study area is higher, and the pH value reaches a slightly alkaline environment. The content of TP and TN is relatively high, showing a state of eutrophication. The results show that the degree of water pollution monitored by physical and chemical indicators is consistent with the conclusion obtained by diatom analysis.

(2) Based on the DAIPo index and other physical and chemical indexes, the comprehensive evaluation of the study area was conducted. The results showed that, in 2019, the water quality of the Beidagang Reservoir and the Qilihai Wetland was slightly polluted, but the eutrophication was serious.

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