Phytoplankton Community Structure and Water Quality Assessment in the Northwest of Liaoning Province Water Supply Project Waters

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Abstract. The current species composition, distribution and standing crop on the phytoplankton were investigated and studied in the waters of the Northwest of Liaoning Province water supply project, during May to June in 2010. The water supply project consists of the water supply (the middle and lower reaches of Yalu River) and water benefited areas (Liaohe and Dalinghe River). There were 241 species of phytoplankton, which belonged to 91 genera of 8 phyla. The overall evaluation suggested the water supply area could be poor and medium nourishment and the water was polluted slightly. However, the water benefited area could be medium-eutrophic, which was medium-polluted, and the eutrophication was more serious in some regional water.

1. Introduction
Phytoplankton is the primary producer of water and the main source of dissolved oxygen in the water body. The community composition, dominant species, pollution indicator species and diversity, and standing crops of phytoplankton are the important indicators of water pollution and nutritional levels [1].

This paper was mainly based on the aquatic ecological survey in the early stage of the northwest of Liaoning Province water supply project. The northwest of Liaoning Province water supply project was a project for the sake of solving the urban and rural life, production and ecological water shortage problems in the northwest of Liaoning Province and Liaohe River area. It was a large-scale inter basin water transfer project of transferring water from the abundant water area of Yalu River, the eastern part of Liaoning province. The northwest of Liaoning Province water supply project mainly involves three areas: the middle and lower reaches of Yalu River (water-supply area), Liaohe River Basin and Dalinghe River Basin (intake area).

So far, the aquatic ecological surveys about the three major basins mainly focus on the fish resources, plankton, periphytic algae, benthic animal, bacteria and water quality monitoring, etc, which belonged to several sections of rivers and the related reservoirs[2]. The complete survey of phytoplankton in the above three water areas were relatively fewer. This paper aimed at a comprehensive survey of phytoplankton community structure situation in northwest of Liaoning Province and related water areas, and discussed the population characteristics and ecological
significance of phytoplankton in the three water areas. On the one hand, it synthetically evaluated the water quality in combination with physical and chemical indexes, on the other hand, it provided references for the environmental planning of water supply projects.

2. Materials and methods

2.1. Sampling point setting

In May and June of 2010, according to the main water system component of the water supply project areas (Yalu River, Liaohe River, and Dalinghe River areas), phytoplankton sampling points were arranged. There were 7 water systems and 32 sampling sections (Figure 1).

![Figure 1. Sampling sites](image)

2.2. Sample collection, analysis and identification

Phytoplankton qualitative samples: phytoplankton is collected on the surface of the water by using 25# plankton net (mesh diameter 0.064mm) and fixed with 4% formalin solution, and then identified by indoor microscopy. Phytoplankton is identified as a genus or species[3].

Quantitative sample: 1L water samples are taken by conventional methods and fixed by 10mL Lugol's solution, and then preserved by concentration to 30mL after the settlement of 48h. Before counting, shake the sample to take 0.1mL and count 100 fields of vision under 400 times the mirror, then convert it into the number of algae in the water sample per liter.

2.3. Data analysis

The number of phytoplankton is calculated according to \( N = \frac{V_0}{V_1} \times n \), where \( N \) is the number of phytoplankton in 1 liters of water (/L); \( n \) is the number of phytoplankton counted; \( V_0 \) is the volume of 1 liters water sample after precipitation and concentration (mL); \( V_1 \) is the water volume (mL) of
counting samples. The calculation of phytoplankton biomass refers to the calculation of wet weight of related species, that is, the biomass conversion formula of phytoplankton is biomass (mg/L) = individual (cell) mean wet weight (mg/ind) × ind/L.

The diversity index [4] is calculated with two general-purpose indicators, the Shannon-Wiener index (H') and the Pielou index (J). Shannon-Wiener index is highly dependent on the number of species and species distribution uniformity. Pielou index can well reflect species evenness. The calculation formula is as follows:

\[ H' = \sum_{i=1}^{S} p_i \log_2 p_i, P_i=ni/N \]

\[ J = H'/\log_2 S \]

In the formula, S is the total number of species, N is the total number of individuals, and Ni is the number of the i species in the community.

3. Results and analysis

3.1. The composition and distribution of phytoplankton species

A total of 241 species of phytoplankton belonging to 91 genera and 8 phyla had been identified. Among them, the most species were baoillariophyta and chlorophyta, 119 species and 74 species respectively, followed by 22 species of cyanophyta. There were 8 phyla, 68 genera, and 180 species of phytoplankton in the water-supply area of the middle and lower reaches of Yalu River, including 104 species of baoillariophyta, 43 species of chlorophyta, 14 species of cyanophyta, and others were distributed but less. There were 7 phyla, 65 genera, and 143 species of phytoplankton in the benefit area of Liaohe River, including 66 species of baoillariophyta, 50 species of chlorophyta, 14 species of cyanophyta. There were 6 phyla, 36 genera, and 60 species of phytoplankton in the Dalinghe River, including 24 species of baoillariophyta, 26 species of chlorophyta, 4 species of cyanophyta and 4 species of euglenophyta.

In the view of the species composition of phytoplankton, the water area above was a diatom-green algae type on the whole, which was consistent with the algal structure in the northeast waters of China summarized by Hongsong [5]. The waters of middle and lower reaches of Yalu River and Liaohe River both belonged to diatom-green algae type, while the waters of the Daling River belonged to green algae-diatom type. The distribution of species composition in the three major waters was obvious. The Yalu River waters were mainly composed of river water bodies, while the Liaohe River and Daling River waters were gradually transformed into lake water bodies. The dominant species of the phytoplankton in the Yalu River waters were diatoms, including Asterionella formosa, Fragilaria capucina, etc. The dominant species of the phytoplankton in the Liaohe River waters were mainly green algae, including Chlorella vulgaris, Chodatella quadriseta, etc. The dominant species of the phytoplankton in the Dalinghe River waters were Synedra acus, Ankistrodesmus, etc. The proportion of indicator species of pollution in the three major waters was mostly medium eutrophication and eutrophication.

3.2. Phytoplankton cell abundance

The distribution of phytoplankton cell abundance at different stations in the three large basins was shown in Figure 2. The phytoplankton cell abundance in the Yalu River basin of the water supply area was between 22.95 × 10^4 ind/L~621 × 10^4 ind/L, with an average of 184.14 × 10^4 ind/L. There were 7 categories of phytoplankton, and the number of diatoms was the most, with an average value of 105.14 × 10^4 ind/L, accounting for 57.1% of the total phytoplankton cell abundance, and secondly the average of green algae was 42.57 × 10^4 ind/L (accounting for 23.1%), and then the average of hidden algae and cyanobacteria were 19.68 × 10^4 ind/L (accounting for 8.2%) and 15.05 × 10^4 ind/L (accounting for 10.7%), but euglenophyta, chrysophytes and dinoflagellates were distributed on individual sites, but were less.
The water-supply area of Liaohe River phytoplankton cell abundance ranged from $55.8 \times 10^4$ ind/L to $2597.1 \times 10^4$ ind/L, and the cell abundance in Liaoyang County Hun River Bridge was to a maximum of $2597.1 \times 10^4$ ind/L, with an average value of $885.49 \times 10^4$ ind/L. There were 5 categories of phytoplankton. The number of green algae was most, and the average value of that was $618.7 \times 10^4$ ind/L, accounting for 69.9% of the total cell abundance, and next the average of diatoms and cyanobacteria were $170.32 \times 10^4$ ind/L (accounting for 19.2%) and $73.83 \times 10^4$ ind/L (accounting for 8.3%), and then cryptophyta distributed on individual sites but less. Euglenophyta cell abundance in Hunhe River in Shenyang Qijianfang was the greatest, up to $162 \times 10^4$ ind/L, and other waters less.

The water-supply area of Daling River phytoplankton cell abundance ranged from $310.5 \sim 1335 \times 10^4$ ind/L, with an average value of $757.17 \times 10^4$ ind/L. Daling River phytoplankton contained 6 categories. The number of diatoms was the largest, reaching $360.83 \times 10^4$ ind/L, accounting for 47.7% of the total cell abundances, and secondly the average of green algae and cyanobacteria were $241.08 \times 10^4$ ind/L (accounting for 31.8%) and $152.43 \times 10^4$ ind/L (accounting for 20.1%), and then hidden algae, euglenophyta and chrysophytes cell abundance were less.

From the abundance of phytoplankton cell, the Yalu River basin was mainly in poor and medium nutrition type by reference to the evaluation standard. The proportion of the biomass of cryptoalgae was up to 37%, because the cryptoalgae biomass in Huanren Reservoir in the upper reaches of the Hun River reached as high as 4.87 mg/L. Liaohe River Basin was subordinated to medium trophic type. Shenyang Qijianfang waters of the Hun River was euglena-chlorophyta type, which was highly nutritious, seriously polluted. It might be related to the pollution of industrial and domestic sewage from the riverbank town in the city of Fushun[6]. Shuangtaizi River wetland was the middle eutrophication type mainly, and Wolong Lake wetland was the poor nutrition type. Daling River was the main type of nutrition, and the estuary of Daling River was the middle eutrophication type. According to the comprehensive evaluation results of water quality, the water quality in the Yalu River basin was better than that of Liaohe and Dalinghe River basin.

![Figure 2. Curve: Horizontal distribution of phytoplankton abundance](image)

### 3.3. Phytoplankton diversity index
The Shannon-Wiener index and Pielou index of phytoplankton distribute at 32 different sites in the three big watersheds, as shown in Figure 3. Referring to the evaluation standard, Shannon-Wiener index and Pielou index are used to evaluate the water quality of the three big watersheds. The Shannon-Wiener index and Pielou index were as follows: The indexes of the main stream of the middle and lower reaches of Yalu River to Hunhe River waters are respectively 1.28~3.82, 0.34~0.81; the indexes of Liaohe River waters were respectively 0.17~4.02, 0.066~0.84; the indexes of the main stream of the Dalinghe River were 2.28~2.69, 0.59~0.64. The comprehensive evaluation results were as follows: the Yalu River waters was clean-less polluted-β mesosaprobic type, in which the middle and lower reaches of Yalu River waters to Hunhe River waters was mainly β mesosaprobic type, the water quality of the middle and lower reaches of Hunhe River was better and was mainly clean-less pollution type. The Liaohe River watershed was clean-α-medium pollution type, in which the Shuangtaizi River and Wolong Lake wetland were mainly clean-less pollution type; the Qinghe River was mainly β-medium pollution-α-medium pollution type, with poor water quality; The main streams of the Hunhe River, Taizihe River and Liaohe River were mainly clean-less pollution-β mesosaprobic type. The Dalinghe River was β mesosaprobic type.

Figure 3. Curve: Horizontal distribution of phytoplankton diversity index

3.4. Water quality parameters
Water quality parameters of each section were as shown in Table 1. According to the national surface water quality standard, the data of the the Yalu River River Basin showed that the water quality evaluation of the the Yalu River River ranged from III to IV, and the N/P range was 25.2~91.4, which was more than 20 for phosphorus limitation. So the possibility of algal blooms was relatively small. The water quality evaluation of the Liaohe River Basin and Daling River Basin ranged from IV to V. The N/P range was 8.0~17.6 in the middle and lower reaches of Liaohe River, where the cell abundance were up to 2597.1×10⁴/L, and obvious tendency to eutrophication were demonstrated. In general, the water quality in the water supply area should be better than that in the water receiving area.
Table 1. A table with the mass concentration of water nutrients.

| River system | The Yalu River Basin | Liaohe River Basin | Dalinghe River Basin |
|--------------|----------------------|--------------------|----------------------|
|              | The Yalu River main stream | Hunjiang River | Hunhe-Daliaohe River-Taizi River | Liaohe River main stream-Qinghe River |
| TN           | 0.87-1.97            | 0.83-1.97         | 2.09-4.05            | 1.87-2.47          | 2.0-2.72 |
| average      | 1.55                 | 1.41              | 3.206                | 2.07               | 2.65     |
| TP           | 0.02-0.077           | 0.005-0.0174      | 0.036-0.354          | 0.03-0.16          | 0.0137-0.143 |
| average      | 0.0355               | 0.0129            | 0.179                | 0.092              | 0.132    |
| N/P          | 25.2-91.4            | 63.8-372          | 8.0-70               | 11.7-62.4          | 16-146.5 |
| average      | 52.1                 | 127.3             | 28.8                 | 33.6               | 37.2     |

4. Conclusion

According to the comprehensive analysis of phytoplankton species composition, dominant species, cell abundance, diversity index and related physical and chemical indexes, the community structure of the phytoplankton in the middle and lower reaches of Yalu River was mainly diatoms - green algae type, which was the nutrient type in the poor, and the individual water bodies were on the trend of eutrophication. The community structure of the phytoplankton in Liaohe River water area and main stream of Dalinghe River water area were chlorophyta-diatom type, which was medium eutrophication and lake type water body.

All in all, the water quality of the middle and lower reaches of Yalu River was generally better than that of the Liaohe River and Daling River areas. Therefore, on the point of alleviating drought and water shortage, and improving the water quality of the northwest of Liaoning Province, the northwest of Liaoning Province water supply project was necessary. However, in the long run, in order to solve the problems of drought and water shortage, deterioration of water environment and wetland restoration in the northwest of Liaoning Province, we should strengthen the measures to protect and control the water environment in water-supply area or water receiving area, so as to prevent pollution from the source.

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6. References

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