Investigation and Analysis of Water Environment of Dalian

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Abstract. Water environment of Dalian is investigated and analyzed. Firstly, water samples are collected from different areas of Dalian, including Bohai Sea, Huanghai Sea and two reservoirs. Secondly, a series of tests are conducted to measure PH, NH$_3$-N, COD and SS of the water samples. Finally, by the comparison with water environmental quality standards stipulated by China, the water quality in Dalian region is assessed.

1. Introduction
With the rapid development of industry, the environment pollution has become worse and worse, such as air pollution, water pollution, soil pollution, light pollution and acoustic pollution. The water resource is an important component part of ecosystems, and its pollution problem has been attracting considerable attention.

IPCC has been researching the problem of ocean acidification. According to its fifth assessment report, in the pre-industrial era, the average PH of surface ocean was 8.179; and in the 1990s, the PH fell about 0.075; and at present the PH is 8.069 [1]. Zhang et al. investigated the influence of ocean acidification on phytoplankton in Zhanjiang Bay, and found out that the relationship between the species of phytoplankton and PH follows a rule of convex parabola [2]. Zhu et al. calculated the water environmental capacity of the Xiangjiang River, including the COD capacity and the NH$_3$-N capacity, and the capacities could describe the quantity of pollutants which can be naturally degraded [3]. Yu et al. divided Bohai Sea into four zones and analyzed the water quality of the four zones according to the COD concentration [4]. Tayeb et al studied the impact of industrial pollutants and household garbage on the coastal marine environment in Algeria [5]. Li looked into the water pollution of Qingshan reservoir, and pointed out the main pollutant sources were high density poultry farms and discharge of pollutants from factories along the reservoir [6]. Zhao et al investigated consequences of China’s water pollution regulation, and pointed out that the water environment had been improved under stringent regulations [7].

The research mainly addresses the pollution problem of Dalian water environment. By a series of tests, parameters of water samples from different areas of Dalian are measured and calculated, including the PH, the NH$_3$-N content, the COD and the SS content, and then, based on the result data and water environmental quality standards of China, the water quality Of Dalian is analyzed and assessed.

2. Test and analysis
In order to make conclusions more reliable and credible, some water samples are collected from different areas of Dalian, and the collecting locations are marked by red five-pointed stars in the Dalian map, as shown in Fig.1.
2.1. PH test and analysis

The scale of PH indicates the acidity of water samples and is defined as

\[ \text{PH} = -\log_{10}[\text{H}^+] \]  (1)

The test data of water samples are shown in Table 1. For the convenience of analysis and comparison, these data are expressed in Fig. 2, where the horizontal axis is the serial number of water samples, and the vertical axis is the PH scale of water samples.

According to the sea water quality standard [8], the lower and upper limits of PH are 6.8 and 8.8, which are expressed by two red horizontal straight lines in Fig. 2; for the environmental quality standards for surface water [9], the limits are 6.0 and 9.0. Seeing from Fig. 2, it is obvious that all the water samples meet these criteria. However, by comparing the PH mean values of the seawater samples and the global average PH of surface ocean, it could be found that the PH of Dalian is 0.357 units lower than 8.069, as shown in Fig. 3, which means that the problem of ocean acidification in Dalian is worse.

| Samples | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| PH      | 7.51| 7.37| 7.11| 7.77| 7.24| 8.05| 8.04| 7.60| 8.32| 8.11|

Fig. 1. Water Samples

Fig. 2. PH Test
2.2 NH$_3$-N test and analysis

The NH$_3$-N content is an important parameter for evaluating the pollution level of water environment. In the Lab, the Nessler’s Reagent Spectrophotometry Method is employed to measure NH$_3$-N contents of the water samples.

The NH$_3$-N content of a water sample can be calculated by the formula [10]

$$C_{NH} = \frac{(3.0546366 \times A + 0.013467) \times 50}{V} \quad (2)$$

where, "C$_{NH}$ (mg/L)" is the NH$_3$-N content of the water sample; "A" is the absorbance measured by a visible spectrophotometer; and "V (mL)" is the volume of the water sample.

The test data of water samples are shown in Table 2, including "V", "A" and "C$_{NH}$". For the convenience of analysis and comparison, the result data are expressed in Fig.4, where the horizontal axis is the serial number of water samples, and the vertical axis is "C$_{NH}$".

According to the environmental quality standards for surface water [9], the third level limit of NH$_3$-N content is 1.0mg/L, which is expressed by a red horizontal straight line in Fig.4. Although the NH$_3$-N content has not been included in the items of the sea water quality standard, when evaluating seawater quality in coastal areas, the NH$_3$-N content should not be ignored. Seeing from Fig.4, it could be found that, only Xishan Reservoir meets the criterion, in other words, Muchengzi Reservoir is polluted, and compared with the surface water standards, the NH$_3$-N contents of seawater samples are a little high.

| Samples | V (mL) | A   | C$_{NH}$ (mg/L) |
|---------|-------|-----|----------------|
| 1       | 5     | 0.029 | 1.021          |
| 2       | 5     | 0.054 | 1.784          |
| 3       | 5     | 0.030 | 1.051          |
| 4       | 5     | 0.033 | 1.143          |
| 5       | 5     | 0.062 | 2.029          |
| 6       | 5     | 0.056 | 1.845          |
| 7       | 10    | 0.066 | 1.075          |
| 8       | 10    | 0.082 | 1.320          |
| 9       | 10    | 0.045 | 0.755          |
| 10      | 10    | 0.077 | 1.243          |
2.3 COD test and analysis

COD means Chemical Oxygen Demand and is an important gauge of water quality. By COD tests, the amount of organic pollutants in water environment could be determined or evaluated. In the Lab, the Potassium Dichromate Method is employed to measure COD of the water samples.

When the chloride ion content of a water sample is less than 30mg/L, the COD of the water sample can be calculated by the formula [10]

\[
C_{COD} = \frac{(V_0 - V_1) \times C \times 8 \times 1000}{V}
\]

where, \(C_{COD}\) (mg/L)" is the COD of the water sample; "\(V_0\)(mL)" is the volume of ammonium ferrous sulfate solution depleted by the blank solution; "\(V_1\)(mL)" is the volume of ammonium ferrous sulfate solution depleted by the water sample solution; "\(C\)(mol/L)" is the concentration of ammonium ferrous sulfate solution; "\(V\)(mL)" is the water sample volume.

When the chloride ion content of a water sample is not less than 30mg/L, the COD should be calculated by the formula [11,12]

\[
C_{COD} = \frac{(V_0 - V_1) \times C \times 8 \times 1000}{V} - C_{COD}^{\text{Cl}}
\]

where, "\(C_{COD}^{\text{Cl}}\)(mg/L)", "\(V_0\)(mL)", "\(V_1\)(mL)", "\(C\)(mol/L)" and "\(V\)(mL)" have the same meanings as the symbols in the formula (3), "\(C_{COD}^{\text{Cl}}\)(mg/L)" is the COD of saline solution with the equal salinity to the water sample and can be calculated by the formula (3).

For the water samples from two reservoirs, No.9 and No.10, the COD values are calculated by the formula (3). However, because of the high chloride ion content of seawater, for the seawater samples from No.1 to No.8, the COD should be calculated by the formula (4). Specifically, a COD test of a seawater sample is carried out, and a COD is calculated by the formula (3) based on the test data; and meanwhile, a COD test of a saline solution with the equal salinity to the seawater sample is also done, and another COD is calculated by the formula (3) based on the test data, which is "\(C_{COD}^{\text{Cl}}\)(mg/L)"; and the COD of the seawater sample is the difference of the two COD values.

The test data of the water samples are shown in Table 3, including "\(V_0\)", "\(C\)", "\(V_1\)" and "\(C_{COD}^{\text{Cl}}\)". For the convenience of analysis and comparison, the result data are expressed in Fig.5, where the horizontal axis is the serial number of water samples, and the vertical axis is "\(C_{COD}\)".

According to the criterion of sea water quality [8], the third level limit of COD is 4mg/L, and for the criterion of surface water [9], the third level limit of COD is 20mg/L. In Fig.5, the two limits are expressed by two red horizontal straight lines. Viewing from Fig.5, it can be found that, except No.1 from Jinshitan Beach, all the seawater samples do not meet the quality standard, and the COD values of No.4, No.5, No.6, No.7 and No.8 are very high, about 100 times the limit of 4mg/L, which means the waters near Yanchang Beach, Military Harbor Beach, Heping Park Beach, Xiajiahezi Beach and Heishijiao Beach are seriously polluted; to make matters worse, Xishan Reservoir and Muchengzi
Reservoir are also polluted, whose COD values are 48mg/L and 123mg/L and about 2-6 times the limit of 20mg/L.

Table 3. Data of COD (V=5mL)

| Samples | V₀ (mL) | C(mol/L) | V₁(mL) | C_COD (mg/L) |
|---------|---------|----------|--------|--------------|
| 1       | 21.10   | 0.04739  | 5.80   | 3            |
| 2       | 21.10   | 0.04739  | 4.60   | 94           |
| 3       | 21.10   | 0.04739  | 3.80   | 155          |
| 4       | 21.10   | 0.04739  | 1.00   | 367          |
| 5       | 21.10   | 0.04739  | 0.60   | 397          |
| 6       | 21.10   | 0.04739  | 0.15   | 432          |
| 7       | 23.50   | 0.04255  | 0.80   | 388          |
| 8       | 23.50   | 0.04255  | 0.00   | 443          |
| 9       | 23.50   | 0.04255  | 22.80  | 48           |
| 10      | 23.50   | 0.04255  | 21.70  | 123          |

Fig. 5. COD Test

2.4 SS test and analysis

The Suspended Solid content is an important item of the sea water quality standard. The Suspended Solid content can be calculated by the formula [10]

\[ C_{SS} = \frac{(m_2 - m_1) \times 10^6}{V} \]  (5)

where, "C_{SS} (mg/L)" is the Suspended Solid content of a water sample, "m₁(g)" is the total weight of the cup and the filter paper, "m₂(g)" stands for the total weight of the cup and the filter paper with the residual of water sample, and "V(mL)" represents the water sample volume.

The test data of the water samples are shown in Table 4, including "m₁", "m₂" and "C_{ss}". For the convenience of analysis and comparison, the result data are expressed in Fig.6, where the horizontal axis is the serial number of water sample, and the vertical axis is "C_{ss}".

According to the criterion of sea water quality [8], the forth level limit of SS content is 150mg/L, which is expressed by a red horizontal straight line in Fig.6. Because the SS content has not been included in the items of the environmental quality standards for surface water, No.9 and No.10 are not considered. Seeing from Fig.6, it could be found that, all the seawater samples do not reach the standard, and meanwhile, the SS content of No.8 is maximal and about 10 times the limit of 150 mg/L, the reason could be that Heishijiao Beach is located in downtown area and there are lots of people nearby, and the garbage pumped by the people could result in the high SS content.
Table 4. Data of SS (V=50ml)

| Samples | $m_1$(g) | $m_2$(g) | $C_{ss}$(mg/L) |
|---------|----------|----------|----------------|
| 1       | 25.741   | 25.759   | 360            |
| 2       | 27.990   | 28.032   | 840            |
| 3       | 28.043   | 28.081   | 760            |
| 4       | 26.831   | 26.863   | 640            |
| 5       | 23.839   | 23.900   | 1220           |
| 6       | 26.330   | 26.386   | 1120           |
| 7       | 20.873   | 20.917   | 880            |
| 8       | 43.271   | 43.344   | 1460           |
| 9       | 22.643   | 22.647   | 80             |
| 10      | 27.600   | 27.614   | 280            |

Fig. 6. SS Test

3. Conclusion

According to the investigation and analysis of water quality of seawater and reservoirs in Dalian city, the conclusions can be drawn as follows:

Firstly, the problem of ocean acidification in Dalian is worse. Although the PH values of all the seawater samples meet the sea water quality standard, the PH of Dalian is 0.357 units lower than the global average PH of surface ocean.

Secondly, seawater along seashores is polluted more seriously near downtown areas than near uptown areas. The result data of seawater samples show that the water quality of Jinshitan Beach is the best, such as the COD and the SS content as well as the NH$_3$-N content, which are the lowest, and comparatively speaking, the water quality of Heishijiao Beach is the worst. Heishijiao Beach is near the city centre and belongs to downtown areas, while Jinshitan Beach is located in uptown areas.

And also, two reservoirs do not meet the quality standards for surface water. The result data of Xishan Reservoir and Muchengzi Reservoir show that they are all polluted, whose COD values are 2-6 times the limit of 20mg/L.

Certainly, water pollution is more serious near the shore than away from the shore, because all the seawater samples in the research are collected at the seashore, the result data could be a little high, including the PH, the COD, the SS content and the NH$_3$-N content. Besides, the small size of water samples also leads to errors.

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