Study on water quality of Xiamen sea area

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Abstract. With the rapid development of the economy, it has brought huge pollution load pressure to the marine environment quality. The land-based pollutants have increased year by year, and the marine pollution problem has become more and more serious. The governance of the marine environment has become a serious problem. This paper investigated the water quality of Xiamen. The results showed that the average concentration of heavy metals was $2.16 \times 10^{-3}$ mg/L for copper element, $2.84 \times 10^{-5}$ mg/L for lead element, $7.61 \times 10^{-5}$ mg/L for cadmium element, $1.97 \times 10^{-3}$ mg/L for arsenic element and $3.66 \times 10^{-3}$ mg/L for zinc element. The monitoring concentration of mercury element at each monitoring point is lower than $1 \times 10^{-5}$ mg/L. The main pollutants in the general indicators are active phosphate and inorganic nitrogen. This paper can provide data support for the future management of marine environmental problems in Xiamen Government, and it has positive significance for its future governance.

1 Introduction

China is a large ocean country with 32,000 kilometers of ocean lines and abundant marine resources. Since the 1980s, China's marine economy has increased year by year and has gradually occupied a large part of GDP\textsuperscript{[1]}. However, with the continuous improvement of the marine economy, varieties of marine environmental pollution problems have followed it. In 2017, various types of marine disasters caused a total economic loss of 6 billion yuan. Among them, a total of 68 times red tide disasters caused by marine environmental problems were found, with a total area of 3,679 square kilometers\textsuperscript{[2]}. While the problem of marine pollution has increased year by year, China has also continuously strengthened its work on marine environmental protection. However, the issue of marine environment is still an urgent and big problem. The rapid development of society has destroyed the original ecological balance between human and nature. A large amount of nutrients such as nitrogen and phosphorus enter the waters of rivers, lakes, and reservoirs. Under the condition of sufficient nutrients, algae and other planktons multiply and water quality deteriorates\textsuperscript{[3]}. The heavy metal pollution in the water mainly comes from industrial chemical enterprises or pesticides. It exists in various forms, mainly invading into the human body through diet, which seriously affects its health and even causes metal poisoning\textsuperscript{[4]}. The heavy metal pollution in the water mainly consists of suspended solids and sediments, which cause pollution to water bodies. The recovery period is long and difficult, and the pollution may bio-accumulated in marine organisms and cause damage to them\textsuperscript{[5]}. Xiamen City occupies an important strategic position in the social and economic development of China. With the continuous development of the marine economy, the various marine pollution problems that accompany it have gradually attracted people's attention. Therefore, the indicators of seawater in the coastal waters of the city were investigated, and the pollution status of conventional indicators and heavy metal pollutants in seawater were studied. The purpose of this research is to
investigate and study the water pollution of Xiamen's sea area. It can provide scientific information for 
the governance of marine environmental.

2 Materials and methods

2.1 The arrangement and sampling of the monitoring point
The water samples were collected from seven sites of Xiamen City, as shown in Figure 1, labeled 1 to 
7. The total number of samples is 156. The water samples were collected from the surface layer 
(0-10m), the middle layer (10-20m) and the bottom layer (20-30m). If the seawater depth is less than 
20m or 10m, only the surface layer and the middle layer or surface layer was sampled. The sampling 
time was March, July and November in 2017.

Figure 1. Sampling sites in Xiamen sea area

2.2 Sample Analysis
The water sample is stored in a polyethylene bottle and seal back to the laboratory. The sample is first 
filtered with a 0.45 μm filter, and the filtered sample is acidified by adding 1% pure nitric acid, 
followed by heavy metal analysis. The instrument Agilent 7500ce ICP-MS was used for heavy metal 
analysis to analyze six elements of mercury, copper, lead, cadmium, zinc and arsenic in the sample. 
The method of analysis was carried out according to the standard method of EPA 200.8 in the United 
States, and the standard materials for analysis were all Agilent's multi-metal mixed standard solutions. 
After each standard curve was completed, the accuracy of the experiment was checked with the 
domestic environmental standard sample GSBS 5009-88 (200928) to ensure that the measured values 
of the samples were within the true value.

3 Results and discussion

3.1 General indicators
The monitoring time is March, July and November, corresponding to the three periods ——wet season, level period and dry season of the Xiamen sea area. General indicators were determined for water samples from seven monitoring points. The water quality of the coastal waters in Xiamen is listed in Table 1.

Table 1. Water quality status at seven monitoring points (the unit is mg/L).

| Monitoring points | Water temperature °C | salinity Cl‰ | Suspended matter (mg/L) | Dissolved oxygen (mg/L) | pH | Active phosphate (mg/L) | COD (mg/L) | Inorganic nitrogen (mg/L) |
|-------------------|----------------------|--------------|------------------------|------------------------|----|------------------------|-----------|-------------------------|
| S1                | 25.16±3.13           | 30.90±2.15   | 24.90±17.65            | 7.16±1.24              | 8.09±0.07 | 0.02±0.03 | 0.62±0.34 | 0.35±0.03 |
| S2                | 23.25±6.89           | 30.03±1.48   | 17.39±8.63             | 7.50±1.76              | 8.03±0.17 | 0.04±0.03 | 0.77±0.46 | 0.57±0.02 |
| S3                | 22.71±8.20           | 28.30±1.64   | 15.33±7.34             | 8.14±3.15              | 7.85±0.40 | 0.06±0.06 | 1.09±0.40 | 0.66±0.04 |
| S4                | 24.25±1.63           | 26.93±1.29   | 16.17±8.92             | 7.28±1.44              | 7.97±0.15 | 0.03±0.02 | 0.94±0.36 | 0.76±0.03 |
| S5                | 25.79±3.18           | 27.27±1.13   | 15.97±9.38             | 7.24±1.43              | 8.11±0.23 | 0.04±0.03 | 0.99±0.45 | 0.77±0.03 |
| S6                | 22.71±8.13           | 30.08±1.28   | 17.67±8.62             | 7.56±1.22              | 7.92±0.29 | 0.04±0.03 | 0.97±0.18 | 0.48±0.03 |
| S7                | 24.26±1.65           | 26.93±1.30   | 15.17±9.61             | 7.38±1.28              | 7.98±0.11 | 0.03±0.02 | 0.94±0.31 | 0.75±0.03 |

It can be seen from the table that the pH range is 7.92-8.09, dissolved oxygen (DO) concentration range is 7.16-8.14 mg/L, and chemical oxygen demand (COD) is in the range of 0.62-1.09 mg/L, each site meets the national first-class water quality standards. The active phosphate concentration range is 0.02-0.06 mg/L, and the sample sites 1, 4, and 7 meet the national second-class water quality standard. The concentration of inorganic nitrogen ranges from 0.35 to 0.77 mg/L, which exceeds the national water quality standards.

The above data shows that the excess substance in the coastal waters of Xiamen is mainly active phosphate and inorganic nitrogen. The sampling sites 1, 4 and 7 are relatively better. The reason may be the location of other sites that they were in the middle sea areas in Xiamen Island and Xiang’an District, Jimei District and Haicang District, and the superposition of land source inputs on both sides increases the pollutants discharged into the water body and causes an increase in the concentration of inorganic nitrogen and active phosphate.

Comparing the data of Xiamen conventional indicators in Wu's study[7] in 2016, the concentration of DO, active phosphate, COD and inorganic nitrogen increased; but pH decreased. The increase of active phosphate, COD and inorganic nitrogen concentration, has a great impact on water quality, which will cause pollution such as red tide and affect marine ecology and fishery.

Table 2. Water quality in coastal waters of different cities in 2017 [8-10]

| City       | pH    | DO (mg/L) | Active phosphate (mg/L) | COD (mg/L) | Salinity Cl‰ | Temperature °C | Suspended matter (mg/L) | Inorganic nitrogen (mg/L) |
|------------|-------|-----------|-------------------------|------------|--------------|-----------------|--------------------------|--------------------------|
| Xiamen     | 7.99  | 7.46      | 0.0360                  | 0.902      | 28.63        | 24.02           | 17.51                    | 0.620                    |
| Quanzhou   | 8.16  | 7.29      | 0.0165                  | 0.598      | 32.68        | 23.47           | 23.607                   | 0.193                    |
| Putian     | 8.14  | 7.41      | 0.0165                  | 0.611      | 31.75        | 22.2            | 32.63                    | 0.216                    |
| Ningde     | 7.85  | 7.57      | 0.0258                  | 0.589      | 29.208       | 22.59           | 40.926                   | 0.306                    |
| Fuzhou     | 8.14  | 7.68      | 0.0138                  | 0.617      | 29.611       | 22.44           | 28.198                   | 0.197                    |

The data in Table 2 shows that the DO and COD in five cities in Fujian are all in line with the national first-class water quality standards. However, the active phosphate concentrations, inorganic nitrogen and COD in Xiamen is higher than the other four cities. Years of monitoring also showed that the main pollution in coastal waters in Xiamen is still inorganic nitrogen and active phosphate. It may be affected by the water quality of the Jiulong River. A large number of pollution sources in the Jiulong River Basin continue to bring total nitrogen and total phosphorus to Xiamen's waters, with contributions of about 70% and 30%. In addition, Xiamen sea area and Tongan Bay as semi-enclosed bays have relatively weak self-purification capacity, which is one of the reasons for the further deterioration of water pollution in Xiamen's coastal waters [11].Comparing with Rincon[12] which in Puerto Rico, Xiamen's DO is higher than Rincon. In contrast to the Arabian Gulf[13], Xiamen's DO are slightly higher than it, and active phosphate are lower than the Arabian Gulf. It indicated that the water...
quality in Xiamen is relatively good, getting better year by year.

3.2 Heavy metal

Heavy metals are mostly non-degradable toxic substances, and they do not have any natural purification ability. If they flow into the ecological environment, they will be difficult to eliminate from the ecological environment \cite{14}. The heavy metals studied in this paper are mercury, copper, lead, cadmium, arsenic and zinc. However, the content of mercury is far lower than the national standard of seawater standards and the impact of time and space is negligible. Therefore, the mercury element data is not list in the table. The average concentration of the other five elements during the measurement is shows in Figure 2.

From the data in Table 3, the concentration of copper is in the range of 1.31-2.9 \times 10^{-3} mg/L, lead is in the range of 3.93-8.08 \times 10^{-5} mg/L, and cadmium is in the range of 5.48-9.67 \times 10^{-5} mg/L. The concentration of arsenic is in the range of 1.78-2.16 \times 10^{-3} mg/L, and the concentration of zinc is in the range of 2.57-4.85 \times 10^{-5} mg/L. The concentration of these heavy metals is lower than the national first-class water quality standards, and it cannot constitute harm to the environment. As can be seen from the figure, the heavy metal content of S3 and S6 is higher than that of other sites, and it is speculated that the S3 and S6 have industrial wastewater discharge.

When compares with Quanzhou, Ningde, Putian and Fuzhou \cite{8-10}, the concentration of copper is higher in Quanzhou and lower in Fuzhou. The concentration of lead is highest in Ningde and lowest in Xiamen. The concentration of cadmium is highest in Putian and lowest in Xiamen. For the concentrations of zinc, Fuzhou is the highest and Quanzhou is the lowest. In general, Xiamen's heavy metal concentration is relatively good than other city. Comparing with the Rigs-to-Reefs region\cite{15}, the concentration of these five heavy metals in the Rigs-to-Reefs region was higher than that of Xiamen—the copper concentration is 2.5 \times 10^{-3} mg/L, the lead element concentration is 3.4 \times 10^{-4} mg/L, the cadmium element concentration is 4.35 \times 10^{-4} mg/L, the arsenic element concentration is 2.61 \times 10^{-5} mg/L, and the zinc element concentration is 7.4 \times 10^{-3} mg/L.
As shown in figure 3, zinc, arsenic and copper account for a large proportion of heavy metals in each period, while lead and cadmium account for a small proportion. The comparison of the three periods shows that the concentration of lead, cadmium and arsenic is dry season > level period > wet season; the concentration of copper is dry season > wet season > level period; the concentration of zinc is level period > dry season > wet season. The common point is that the concentration in the dry season is greater than that in the wet season. The presumed reason is that the heavy metal pollutants discharged into the water body are almost the same in each period, but only the rainwater in the wet season leads to a decrease in concentration.

4 Summary

In general, the concentration of heavy metal pollutants in the surface seawater of the coastal waters of Xiamen is far lower than the requirements of the national first-class seawater standards, and it cannot pose certain harm to the environment. Lead, cadmium and arsenic have great similarities in time distribution and spatial distribution, and seasonal and spatial changes have negligible effects. Lead and cadmium concentrations are mostly below $1 \times 10^{-4}$mg/L, the content of arsenic relative to lead and cadmium is high, and the annual average concentration is $195 \times 10^{-5}$mg/L, but it is still within the safe range.

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