Temporal variations of Cu in Jiaozhou Bay 1982—1986

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Abstract. This paper analyzed the temporal variations of Cu in Jiaozhou Bay during 1982—1986. Results showed that Cu contents in study years were 0.15—5.31 μg L⁻¹, 0.77—20.60 μg L⁻¹, 0.11—4.00 μg L⁻¹, 0.10—0.43 μg L⁻¹ and 0.18—0.77 μg L⁻¹, respectively. The Cu pollution level in this bay was moderate during 1982—1983, yet for temporal variations Cu contents in surface waters were showing decreasing trend. Cu contents in spring, summer and autumn were 0.11—20.60 μg L⁻¹, 0.10—4.86 μg L⁻¹ and 0.11—3.56 μg L⁻¹, respectively. This bay was moderate pollution in spring in 1982—1983, while in other seasons in study years was still slight. These indicated that the temporal variations of Cu pollution in this bay should be taken in to account in decision-making of pollution control practice.

1. Introduction
The industry was increasing rapidly after the reform and opening-up, and a large amount of pollutants were generating and discharging to the environment. Cu pollution in marine bays has been one of the critical environmental issues since ocean is the sink of pollutant [1-6]. Hence, understanding the temporal variations of Cu in marine bay is essential to marine environment protection and the maintaining of ecological sustainable development.

Jiaozhou Bay is a semi-closed marine bay in Shandong Province China, in where the pollution issue has been arising after the reform and opening-up [7-14]. This paper analyzed the temporal variations of Cu in Jiaozhou Bay during 1982—1986, and provided information for scientific research and pollution control and environmental remediation.

2. Study area and data collection
Jiaozhou Bay is located in the south of Shandong Province, eastern China (35°55′-36°18′ N, 120°04′-120°23′ E). The total area, average water depth and bay mouth width are 446 km², 7 m and 3 km, respectively. This bay is a typical of semi-closed bay which is connected to the Yellow Sea in the south. There are a dozen of rivers, and the majors are Dagu River, Haibo River, Licun River, and Loushan River etc., all of which are seasonal rivers [15-16].

The investigation on Cd in Jiaozhou Bay was carried on in different seasons in during 1982—1986 (Fig. 1 and Table 1). Cu in waters was sampled and monitored follow by National Specification for
Table 1 Sampling time of Cd in Jiaozhou Bay

| Month | April | May | June | July | August | September | October |
|-------|-------|-----|------|------|--------|-----------|---------|
| 1982  | √     |     | √    |     |        |           |         |
| 1983  | √     |     | √    | √    |        |           |         |
| 1984  | √     |     | √    | √    |        |           |         |
| 1985  | √     |     | √    | √    |        |           |         |
| 1986  | √     |     | √    |     |        |           |         |

Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

3. Results and discussion

Contents and pollution levels of Cu. The contents of Cu in different months during 1982—1986 were listed in Table 2. In according to the guide line of Cu in National Sea Water Quality Standard (GB 3097-1997) (Table 2), and the contents of Cu in different months during 1982—1986 (Table 3), the pollution levels of Cu in different months during 1982—1986 were listed in Table 4. It could be found that the highest values of Cu contents in June 1982 and May 1983 were Grade II and Grade III, respectively, indicated that Cu pollution level in this bay was moderate during 1982—1983. However, Cu contents in different months during 1982—1986 were still relative low and were Grade I. In general, the pollution levels of Cu in Jiaozhou Bay could be considered as still slight during 1982—1986.

Table 2 Guide line of Cu in National Sea Water Quality Standard (GB 3097-1997)

| Grade | I    | II   | III  | IV   |
|-------|------|------|------|------|
| Content/μg L⁻¹ | 5.00 | 10.00 | 50.00 |
Table 3 Cu contents in surface waters in different months during 1982－1986 in Jiaozhou bay/μg L⁻¹

| Month | April | May | June | July | August | September | October |
|-------|-------|-----|------|------|--------|-----------|---------|
| 1982  | 0.86-5.31 | 0.15-2.33 | 2.22-3.56 |
| 1983  | 2.47-20.60 | 0.86-4.86 | 0.77-3.00 |
| 1984  | 0.28-1.88 | 1.60-4.00 | 0.11-2.00 |
| 1985  | 0.10-0.38 | 0.18-0.39 |
| 1986  | 0.18-0.77 |         |         |

Table 4 Pollution levels of Cu in surface waters in different months during 1982－1986 in Jiaozhou bay/μg L⁻¹

| Month | April | May | June | July | August | September | October |
|-------|-------|-----|------|------|--------|-----------|---------|
| 1982  | I     | I   | I    | I    | I      | I         | I       |
| 1983  | I     | I   | I    | I    | I      | I         | I       |
| 1984  | I     | I   | I    | I    | I      | I         | I       |
| 1985  | I     |     | I    | I    | I      | I         | I       |
| 1986  | I     |     | I    | I    | I      | I         | I       |

Seasonal variation of Cd. For seasonal division in study area, April, May and July are spring, July, August and September are summer, October, November and Decemder are autumn. The contents of Cu in different seasons during 1982－1986 were listed in Table 5. For seasonal variations, Cu contents in spring, summer and autumn were 0.11－20.60 μg L⁻¹, 0.10－4.86 μg L⁻¹ and 0.11－3.56 μg L⁻¹, respectively. It could be found that this bay was moderate pollution in spring in 1982－1983, while the pollution levels in other seasons during 1982－1986 were still slight. These indicated that the seasonal variations of Cu pollution in this bay should be taken in to account in decision-making of pollution control and environmental remediation practice.

Table 5 Cu contents in surface waters in different seasons during 1982－1986 in Jiaozhou bay/μg L⁻¹

| Month | Spring | Summer | Autumn |
|-------|--------|--------|--------|
| 1982  | 0.86-5.31 | 0.15-2.33 | 2.22-3.56 |
| 1983  | 2.47-20.60 | 0.77-4.86 |
| 1984  | 0.11-0.43 | 0.10-0.38 | 0.18-0.39 |
| 1985  |        |        |         |
| 1986  | 0.18-0.77 |        |         |

Annual change of Cu. Cu contents in study years during 1982－1986 were 0.15－5.31 μg L⁻¹, 0.77－20.60 μg L⁻¹, 0.11－4.00 μg L⁻¹, 0.10－0.43 μg L⁻¹ and 0.18－0.77 μg L⁻¹, respectively. In according to the highest values of Cu contents in different seasons during 1982－1986 (Table 5). It could be found that the Cu pollution level in this bay was moderate during 1982－1983, yet for temporal variations during 1982－1986 Cu contents in surface waters were showing decreasing trend. Objectively speaking, the inputs of Cu to Jiaozhou Bay were increasing along with time since the industry was developing rapidly after reform and opening-up. The reason was that the changes of Cu in marine bay waters were strongly impacted by many factors including water exchange, and the response of Cu contents in waters in marine bay was lagging to the inputs of Cu.

4. Conclusions

Cu contents in Jiaozhou Bay during 1982－1986 were 0.15－5.31 μg L⁻¹, 0.77－20.60 μg L⁻¹, 0.11－4.00 μg L⁻¹, 0.10－0.43 μg L⁻¹ and 0.18－0.77 μg L⁻¹, respectively. The Cu pollution level in this bay was moderate during 1982－1983. Cu contents in spring, summer and autumn were 0.11－20.60 μg L⁻¹, 0.10－4.86 μg L⁻¹ and 0.11－3.56 μg L⁻¹, respectively. This bay was moderate pollution in spring in 1982－1983, while in other seasons in study years was still slight. The seasonal variations of Cu pollution in this bay should be taken in to account in decision-making of pollution control and environmental remediation practice.
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