The Cd Content Provided By Sources Affected the Bottom Waters in Various Ways

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Abstract: According to the investigation data of Jiaozhou Bay in 1992, this paper studies the
level of Cd content and its horizontal distribution in the bottom waters from the center of the
bay to the south of the bay mouth. The result indicates that the Cd content in the bottom waters
of the bay ranged from 0.09 to 0.72μg/L in May, 0.08 to 1.08μg/L in August and 0.30 to
1.19μg/L in October, which means that waters of the bay were not polluted at all by Cd in May
but some waters were mildly contaminated in both August and October. In a word, the bottom
bay waters from the center of the bay to the south of the bay mouth were slightly polluted or
not polluted at all by Cd in May, August and October. In May, surface runoff and rivers
together transported Cd content of 1.07-1.53μg/L to Jiaozhou Bay waters. In the bottom waters
from the southeast to the center of the bay, the Cd content decreased from 0.72μg/L to
0.09μg/L. The Cd content in the bottom waters of the southeast of the bay is relatively high for
the sources of Cd could reach its surface waters there. However, much little Cd content is
found in the bottom waters of the center of the bay due to the lack of Cd access to its surface
waters. In August, rivers and main sea currents together transported Cd content of
0.96-1.11μg/L to Jiaozhou Bay waters. According to transporting mechanism of substance
content in Jiaozhou Bay introduced by the author, high Cd content area of 1.08μg/L exists in the
bottom waters of the center of the bay, while low-content area of 0.08μg/L was in the
southwest of the bay where currents are about to leave the bay. In October, rivers transported
Cd content of 1.04-1.10μg/L to Jiaozhou Bay waters. The Cd content decreased from 1.19μg/L
to 0.30μg/L along the content gradient from the high-content area of the southeast of the bay to
the waters of the south of the bay mouth. In the waters of the southeast of the bay, relatively
high Cd content transported to the surface waters by sources leads to high level of Cd in its
bottom waters. It’s the exact opposite in the waters of the south of the bay mouth. The Cd
content provided by sources affects the law of the bottom waters in various ways, and the
horizontal variation of Cd content reveals its changing process in the bottom waters.

1. Introduction

Human emissions and releases of cadmium (Cd) have increased and accumulated rapidly on land and
soil. When the spring rainy season comes, a large amount of Cd content is washed away by rainwater,
collected into rivers, and transported to ocean water bodies, causing changes in ocean water quality
[1-13]. The Cd content goes from the surface to the water bodies, then it undergoes vertical migration,
showing the change of Cd content in the bottom waters from the center to the south of the bay mouth.
Therefore, through the investigation data of Cd content in Jiao Zhou Bay in 1992, the bottom waters from the center of the bay to the bay mouth are studied to determine the level, distribution and horizontal variation process of Cd content, and shows the variation process of the Cd content transported by the sources, thus providing a scientific basis for the research on the existence and transportation of Cd content in the bottom waters.

2. Investigated Waters & Materials and Methods

2.1 Natural Environment of Jiao Zhou Bay. Jiao Zhou Bay (120°04′-120°23′E, 35°58′-36°18′N) is a semi-closed bay, eastern China, bounded by Tuan Island and Xuejia Island, connects the Yellow Sea with the total area and average water depth of 446km², 7 m, respectively. There are more than ten inflow rivers, among which Dagu River and Yang River, Haibo River, Licun River and Loushan River in Qingdao city have greater runoff and sediment concentration. They are all seasonal rivers with obvious seasonal changes in hydrological characteristics of rivers. [14, 15]

2.2 Materials and Methods. The investigation data on Cd in Jiao Zhou Bay waters in May, August and October 1992 adopted by this research are provided by North China Sea Environmental Monitoring Center of the State Oceanic Administration. Sites 55 and 60 were set to take water samples in Jiao Zhou Bay waters in May, sites 53, 54, 55 and 60 were set in August; sites 52, 55 and 60 were set in October. (Figure 1) Three samples were taken according to depth for sample investigation in May, August, and October 1992, (surface and bottom waters were taken when >10m, and only surface waters were taken when <10m). The investigation of Cd in Jiao Zhou Bay waters is carried out in line with the national standard method which has been added in the Specification for Marine Monitoring (1991) [16].

![Figure 1 Investigation sites in Jiao Zhou Bay](image)

3. Results

3.1 Level of Bottom Content. In May, August and October, the Cd content in the bottom waters from the center of the bay to the south of the bay mouth varied from 0.08μg/L to 1.19μg/L, up to the national water quality standards of Class I with 1.00μg/L and II seawater with 5.00μg/L.

| Table 1 The surface water quality in Jiao Zhou bay in May, August and October |
|---------------------------------|----------|----------|----------|
| Cd content in ocean waters/μg L⁻¹ | May      | August   | October  |
| 0.09-0.72                        | 0.08-1.08| 0.30-1.19|
| National water quality standards of seawater | Class I | Class I and II | Class I and II |
In the bottom waters from the center of the bay to the south of the bay mouth, the variation ranges of the Cd content in May, August and October were 0.09-0.72μg/L, 0.08-1.08μg/L and 0.30-1.19μg/L, respectively, up to the national water quality standards of Class I and II seawater. This indicates that the quality of bottom waters there was slightly or not polluted by Cd. (Table 1)

3.2 Horizontal Distribution in the Bottom Waters. In May, the Cd content reached a relatively high level of 0.72μg/L at site 60 in the southeast waters of the bay, around which a high-content area is formed and presented in a series of parallel lines with different content gradients. The Cd content decreases from 0.72μg/L in the high-content area to 0.09μg/L in the central waters of the bay along the content gradient.

In August, the Cd content reached a relatively high level of 1.08μg/L at site 55 in the central waters of the bay, around which a high-content area is formed and presented in a series of semi-ovals with different content gradients. The Cd content decreases from 1.08μg/L in the high-content area to 0.08μg/L in the southwest waters of the bay along the content gradient. (Figure 2)

In October, the Cd content reached a relatively high level of 1.19μg/L at site 60 in the southeast waters of the bay, around which a high-content area is formed and presented in a series of parallel lines with different content gradients. The Cd content decreases from 1.19μg/L in the high-content area to 0.30μg/L in the south waters of the bay mouth along the content gradient. (Figure 3)
4. Discussion

4.1 Water Quality. Cd content in the waters of Jiaozhou Bay is mainly transported by surface runoff, rivers and main sea currents. Cd first comes to the surface waters, and then arrives at the bottom waters through the water bodies. The process of Cd variation in the bottom waters is presented under the vertical effect of water bodies. [7-9]

In May, surface runoff and rivers together transported Cd content of 1.07-1.53 μg/L to Jiaozhou Bay waters. In the bottom waters from the southeast to the center of the bay, the Cd content ranged from 0.09 μg/L to 0.72 μg/L, up to the water quality standards of Class I seawater (1.00 μg/L), suggesting that the water quality was not polluted by any Cd.

In August, rivers and main sea currents together transported Cd content of 0.96-1.11 μg/L to Jiaozhou Bay waters. The Cd content ranged from 0.08 to 1.08 μg/L in the bottom waters of the bay, indicating that the waters were slightly or not polluted by Cd. In the bottom waters from the center to the southwest of the bay, the Cd content reduced to less than 1.00 μg/L, upgrading its water quality standards of seawater to the class I. The mild contamination by Cd was eliminated to no pollution.

In October, rivers transported Cd content of 1.04-1.10 μg/L to Jiaozhou Bay waters. The Cd content ranged from 0.30 to 1.19 μg/L in the bottom waters of the bay, indicating that the waters was slightly or not polluted by Cd. In the bottom waters from the southeast of the bay to the south of the bay mouth, the Cd content reduced to less than 1.00 μg/L, upgrading its water quality standards of seawater to the class I. The mild contamination by Cd was eliminated to no pollution.

In May, August and October, the Cd content in Jiaozhou Bay transported by surface runoff, rivers and main sea currents ranged from 0.96 μg/L to 1.53 μg/L. In the bottom waters from the center of bay to the south of the bay mouth, the Cd content varied from 0.08 μg/L to 1.19 μg/L, up to the national water quality standards of Class I and II seawater, which indicates that waters in this area were mildly or not polluted by Cd.

4.2 The Cd Content Provided by Sources Affected the Bottom Waters. In May, surface runoff and rivers together transported Cd content of 1.07-1.53 μg/L to Jiaozhou Bay waters. In the bottom waters from the southeast to the center of the bay, the Cd content decreased from 0.72 μg/L to 0.09 μg/L. The Cd content in the bottom waters of the southeast of the bay is relatively high for the sources of Cd could reach its surface waters there. However, much little Cd content is found in the bottom waters of the center of the bay due to the lack of Cd access to its surface waters. This indicates that the Cd content quickly settles to the ocean floor.

Figure 4 Sediment of the high content of substance carried by the main sea current in Jiaozhou Bay

In August, rivers and main sea currents together transported Cd content of 0.96 μg/L-1.11 μg/L to Jiaozhou Bay waters. According to transporting mechanism of substance content in Jiaozhou Bay introduced by the author, main sea currents with high level of Cd go around the offshore waters, during which Cd sediment is formed on the ocean floor and is transported to bottom waters of the
center of the bay, thus making a high-content area of 1.08μg/L Cd there. (Figure 4) In the southwest waters of the bay, the currents are about to leave the bay, thus ending up with a low-content area of 0.08μg/L, which in turn, confirms the authors' transporting mechanism.

In October, rivers transported Cd content of 1.04-1.10μg/L to Jiaozhou Bay waters, which affected the surface waters of the southeast of the bay. On top of that, it is closer for rivers to reach the southeast waters of the bay than the south waters of the bay mouth. Therefore, the Cd content decreased from 1.19μg/L to 0.30μg/L along the content gradient from the high-content area of the southeast of the bay to the south waters of the bay mouth. In the waters of the southeast of the bay, the relatively high Cd content transported to the surface waters by sources leads to a high level of Cd in its bottom waters. It's the exact opposite in the south waters of the bay mouth. This indicates that the Cd content quickly settles to the ocean floor.

5. Conclusion
Cd content in the waters of Jiaozhou Bay is mainly transported by surface runoff, rivers and main sea currents. Cd first comes to the surface waters, and then arrives at the bottom waters through the water bodies. The process of Cd variation in the bottom waters is presented under the vertical effect of water bodies.

The Cd content in the bottom waters of the bay ranged from 0.09 to 0.72μg/L in May, 0.08 to 1.08μg/L in August and 0.30 to 1.19μg/L in October, which means that waters of the bay were not polluted at all by Cd in May but some waters were mildly contaminated in both August and October. Therefore, in May, August and October, the Cd content in Jiaozhou Bay transported by surface runoff, rivers and main sea currents ranged from 0.96μg/L to 1.53μg/L. In the bottom waters from the center of bay to the south of the bay mouth, the Cd content varied from 0.08μg/L to 1.19μg/L, up to the national water quality standards of Class I and II seawater, which indicates that waters in this area were mildly or not polluted by Cd.

In May, surface runoff and rivers together transported Cd content of 1.07-1.53μg/L to Jiaozhou Bay waters. In the bottom waters from the southeast to the center of the bay, the Cd content decreased from 0.72μg/L to 0.09μg/L. The Cd content in the bottom waters of the southeast of the bay is relatively high for the sources of Cd could reach its surface waters there. However, much little Cd content is found in the bottom waters of the center of the bay due to the lack of Cd access to its surface waters. This indicates that the Cd content quickly settles to the bottom of the sea.

In August, rivers and main sea currents together transported Cd content of 0.96-1.11μg/L to Jiaozhou Bay waters. According to transporting mechanism of substance content in Jiaozhou Bay introduced by the author, high Cd content area of 1.08μg/L existed in the bottom waters of the center of the bay, while low-content area of 0.08μg/L was in the southwest of the bay where currents are about to leave the bay.

In October, rivers transported Cd content of 1.04-1.10μg/L to Jiaozhou Bay waters. The Cd content decreased from 1.19μg/L to 0.30μg/L along the content gradient from the high-content area of the southeast of the bay to the waters of the south of the bay mouth. In the waters of the southeast of the bay, the relatively high Cd content transported to the surface waters by sources leads to a high level of Cd in its bottom waters. It's the exact opposite in the waters of the south of the bay mouth. This indicates that the Cd content quickly settles to the bottom of the sea.

In May, August and October, the horizontal variation of Cd content reveals its changing process in the bottom waters from the center of the bay to the south of the bay mouth.

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