The Horizontal Variation Process and Rule of Bottom Waters Impacted by Cd Contents from Sources

Dongfang Yang1,2,3,a, Chunhua Su1,2, Yunjie Wu1,2, Bailing Fan1,2, and Sixi Zhu1,2
1Research Center for Karst Wetland Ecology, Guizhou Minzu University, Guizhou Guiyang, Guizhou Guiyang, China
2College of Chemistry and Environmental Science, Guizhou Minzu University, Shanghai, 550025, China
3North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China
a dfyang_dfyang@126.com

Abstract: According to the investigation data of Jiaozhou Bay in 1991, the current content and horizontal distribution of Cd contents in bottom waters from central to southern Jiaozhou Bay were studied in this paper. The results showed that in May, Cd content in this area was 0.06-0.10μg/L, and Jiaozhou Bay was not polluted by Cd content. In August, the range was 0.06-0.38μg/L, and Jiaozhou Bay was not polluted by Cd content. In October, the range was 0.26μg/L, and there was no pollution of Cd content in Jiaozhou Bay. Hence, in May, August and October, Cd contents in this area were low, far lower than 1.00μg/L, the Case I Sea Water Quality Standard. In terms of Cd content, water is clean, not polluted by Cd content. In May, in surface waters of bay center, there is not source to transport Cd content. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.08μg/L in bay center to 0.06μg/L in northern bay mouth along with the gradients. In August, Cd was high as 0.40μg/L in surface waters of bay center, mainly from atmospheric sedimentation, which is relatively high. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.38μg/L in bay center to 0.16μg/L in northern bay mouth along with the gradients. In this paper, the impact of Cd contents from sources on bottom waters was studied. Besides, the horizontal variation of Cd contents disclose the variation of bottom waters influenced by Cd contents from sources.

1. Introduction
In the rapid development of industries, such as metallurgy, chemical engineering and electroplating, the Cd contents emitted and discharged by human are increasing. It is transported constantly in the environment, causing the changing quality of sea water [1-32]. Cd content reaches waters from surface. Through the vertical transportation of Cd content in waters, the changing Cd contents in bottom waters of bay mouth were shown. Therefore, this paper, according to investigation data of Cd content in Jiaozhou Bay in 1991, studied the volume, distribution and horizontal variation of Cd contents in bottom waters from bay center to bay mouth, and displayed the variation of waters impacted by Cd contents from sources, in order to provide scientific evidence for the studies on the existence and transport of Cd contents in bottom waters.

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2. Investigation Waters, Materials and Methods

2.1 Natural environment of Jiaozhou Bay
Jiaozhou Bay, located in southern Shandong Peninsula, is a typical semi-closed bay. The geographical location is 120°04′-120°23′E, 35°58′-36°18′N. Bounded by the line connecting Tuandao Cape and Xuejiadao Island, it connects with Yellow Sea, covering an area of about 446km², with the average depth of about 7m. There are dozens of rivers reaching the ocean in Jiaozhou Bay, among of which, the rivers with a larger volume of runoff and sand content include Dagu River, Yang River, Haibo River in Qingdao, Licun River, Loushan River and so on. These rivers are seasonal streams, and hydrological characteristics vary seasonally [33, 34].

2.2 Materials and methods
The materials about Cd in Jiaozhou Bay waters in May, August and October of 1991 was provided by North China Sea Environment Monitoring Center, State Oceanic Administration. In May, four sites were established for sampling in Jiaozhou Bay: 52, 55, 60 and 61; in August, four sites were established: 55, 60, 61 and 2106; in October, one site was established: 60. These are shown in Figure 1. Samplings were performed in May, August and October in 1991, respectively. According to the depth of water, sampling and survey were conducted (surface and bottom layers were sampled when the depth of water is more than 10m, but just surface layer when less than 10m). The survey on Cd of Jiaozhou Bay waters was in accordance with national standard method, which is included in The Specification for Marine Monitoring (1991) [35].

3. Results

3.1 The contents in bottom waters
In May, August and October, in bottom waters from bay center to southern bay, the variation range of Cd content was 0.06-0.38μg/L, in accordance with 1.00μg/L, the Case I Sea Water Quality Standard. In May, the range was 0.06-0.10μg/L, satisfying the Case I Sea Water Quality Standard. In August, the range was 0.06-0.38μg/L, satisfying the Case I Sea Water Quality Standard. In October, the range was 0.26μg/L, satisfying Case I Sea Water Quality Standard. In May, August and October, the variation range of Cd content was 0.06-0.38μg/L, in accordance with Case I Sea Water Quality Standard. It indicated that in May, August and October, in bottom waters from bay center to southern bay, there
was not any pollution of Cd, shown in Table 1.

|                | May       | August    | October  |
|----------------|-----------|-----------|----------|
| Cd content in sea water/μg·L⁻¹ | 0.06-0.10 | 0.06-0.38 | 0.26     |
| National Sea Water Standard | Case I Sea Water | Case I Sea Water | Case I Sea Water |

3.2 Horizontal distribution in bottom waters

In May and August, in bottom waters from bay center to northern bay mouth, the investigation was conducted in sites 55 and 60. The horizontal distribution of Cd content in bottom waters was presented.

In May, in bottom waters from bay center to northern bay mouth, Cd content reached high 0.08μg/L in 55 site. Cd content was high in bay center, forming a series of paralleling lines with different gradients. Cd content decreased from 0.08μg/L in bay center to 0.06μg/L in northern bay mouth along with gradients, shown in Figure 2.

In August, in bottom waters from bay center to northern bay mouth, Cd content reached high 0.38μg/L in 55 site. Cd content was high in bay center, forming a series of paralleling lines with different gradients. Cd content decreased from 0.38μg/L in bay center to 0.16μg/L in northern bay mouth along with gradients, shown in Figure 3.
4. Discussion

4.1 Water quality

In Jiaozhou Bay, the source of Cd content was atmospheric sedimentation, from surface waters to bottom waters through the waters. In this way, influenced by vertical waters [12-14], the variation range of Cd content in bottom waters from bay center to southern bay mouth was 0.06-0.38μg/L, in accordance with Case I Sea Water Quality Standard, and the water was not polluted by Cd.

In May, in bottom waters from bay center to southern bay mouth, the variation range of Cd was 0.06-0.10μg/L, showing that Jiaozhou Bay was not polluted by Cd. In bottom waters from bay center to southern bay mouth, Cd content was less than 0.11μg/L, indicating that it reached Case I Sea Water Quality Standard, and the water was not polluted by Cd.

In August, in bottom waters from bay center to southern bay mouth, the Cd content was high in surface waters of bay center, mainly from atmospheric sedimentation. The Cd content was 0.40μg/L, high in volume. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.38μg/L in bay center to 0.16μg/L in northern bay mouth along with gradients. It indicated that in surface waters of bay center, when there was no source, Cd content was very low in bottom waters. In this way, Cd content was not sedimentated into seafloor rapidly, but changed slightly with the movement of waters. It was evenly mixed. The horizontal variation of Cd content was 0.02μg/L, which was minor.

4.2 Bottom waters impacted by Cd content from sources

In May, in surface waters of bay center, there was no source to transport Cd content. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.08μg/L in bay center to 0.06μg/L in northern bay mouth along with gradients. It indicated that in surface waters of bay center, when there was no source, Cd content was very low in bottom waters. In this way, Cd content was not sedimentated into seafloor rapidly, but changed slightly with the movement of waters. It was evenly mixed. The horizontal variation of Cd content was 0.02μg/L, which was minor.

In August, Cd content was high in the surface waters of bay center, mainly from atmospheric sedimentation. The Cd content was 0.40μg/L, high in volume. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.38μg/L in bay center to 0.16μg/L in northern bay mouth along with gradients. It indicated that in surface waters of bay center, when there was source to transport Cd, Cd content was relatively high in bottom waters. In this way, Cd was rapidly sedimentated into seafloor, and Cd content in bottom waters changed greatly with the movement of
waters. The horizontal variation of Cd content was 0.22μg/L, which was relatively great. Therefore, the variation of bottom waters impacted by Cd content from sources was concluded. When there was no source, Cd content was very low in waters. Cd content in bottom waters was evenly mixed. The horizontal variation of Cd content in bottom waters from bay center to northern bay mouth was minor. When there exist source, it was high with changing gradients, and the horizontal variation of Cd content was great.

5. Conclusion
In Jiaozhou Bay, the source of Cd content was atmospheric sedimentation, from surface waters to bottom waters through the waters. In this way, influenced by vertical waters, the variation range of Cd content was 0.06-0.38μg/L, in accordance with Case I Sea Water Quality Standard, and the water was not polluted by Cd.

In bottom waters from bay center to southern bay mouth, the variation range of Cd was 0.06-0.10μg/L in May, Cd content was 0.06-0.38μg/L in August, and Cd content was 0.26μg/L in October, indicating that Jiaozhou Bay was not polluted by Cd in May, August and October. Thus, in May, August and October, Cd content was low in bottom waters from bay center to southern bay mouth, less than 0.40μg/L, far lower than 1.00μg/L, Case I Sea Water Quality Standard. Water was not polluted by Cd content.

In May, in surface waters of bay center, there was no source to transport Cd content. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.08μg/L in bay center to 0.06μg/L in northern bay mouth along with gradients. It indicated that in surface waters of bay center, when there was no source, Cd content was very low in bottom waters, it was evenly mixed, and in bottom waters from bay center to northern bay mouth, the horizontal variation of Cd content was 0.02μg/L, which was minor.

In August, Cd content was high as 0.40μg/L in surface waters of bay center, mainly from atmospheric sedimentation. In bottom waters from bay center to northern bay mouth, Cd content decreased from 0.38μg/L in bay center to 0.16μg/L in northern bay mouth along with gradients. It indicated that in surface waters of bay center, when there was source to transport Cd, Cd content was relatively high in bottom waters. In bottom waters from bay center to northern bay mouth, the horizontal variation of Cd content was 0.22μg/L, which was relatively great.

In May and August, in bottom waters from bay center to southern bay mouth, the horizontal variation of Cd content disclosed the changing Cd content in bottom waters from sources.

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