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Vertical Distribution, Seasonal Variation and the Mechanisms of Cd Contents in Jiaozhou Bay

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Abstract: Using investigation on Cd in surface waters in 1988 in Jiaozhou Bay, this paper researched the vertical distribution and seasonal variation of Cd contents, and defined the mechanisms. Results showed that Cd contents in surface waters and bottom waters in April 1988 were 0.09-0.12 μg L^{-1} and 0.08-0.10 μg L^{-1}, respectively, while in July 1988 were 0.10-0.45 μg L^{-1} and 0.09-0.18 μg L^{-1}, respectively. Cd contents in both surface and bottom waters in 1988 were also confirmed to Grade I, and the pollution level of Cd in1988 were still very slight. The seasonal variations of Cd contents were relative low, and were in order of spring < summer. Cd contents in bottom waters would be relative high/low in case of Cd contents in surface waters were relative high/low. The seasonal variation of Cd contents in surface waters was mainly determined by the variations of Cd input from the major Cd sources, while the seasonal variation of Cd contents in bottom waters was mainly determined by the changes of the dilution effect of vertical water body. Low Cd contents from surface waters has accumulation effect in bottom waters, while high Cd contents from surface waters has dilution effect in bottom waters.

Keywords: Cadmium (Cd), Vertical distribution, Seasonal variation, Mechanism, Jiaozhou Bay

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1. INTRODUCTION

Cd is widely used in industries. In everyday life, a great deal of Cd-containing products are commonly used [1-2]. As a result, a large amount of Cd-containing wastes are generating and discharging, and the surface waters of the ocean are polluted by Cd via atmospheric deposition,

stream flow discharge etc.[3-6]. By means of vertical migration, Cd in surface waters in the ocean is migrating to sea bottom [7-10]. Jiaozhou Bay is a semi-closed bay located in Shandong Province, China. Using investigation on Cd in surface and bottom waters in 1988 in Jiaozhou Bay, this paper researched the vertical distribution and seasonal variation of Cd contents, defined the seasonal variation, changing range and water's effect of Cd contents, and provided basis for research on the vertical sedimentation and horizontal migration of Cd in surface and bottom waters.

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), with the total area and average water depth of 446 km^2 and 7 m, respectively. The bay mouth is very narrow (3 km) between Tuandao and Xuejiadao, and is connected to the Yellow Sea in the south of the bay. There are a dozen of rivers including Dagu River, Haibo Rriver, Licun Rriver, and Loushan Rriver etc., all of which are seasonal rivers [11-12].

The investigation on Cd in Jiaozhou Bay was carried on in April and July 1988 in five monitoring sites (i.e., 35, 36, 84, 85, and 90) (Fig. 1). Cd in waters was sampled and monitored follow by National Specification for Marine Monitoring [13].

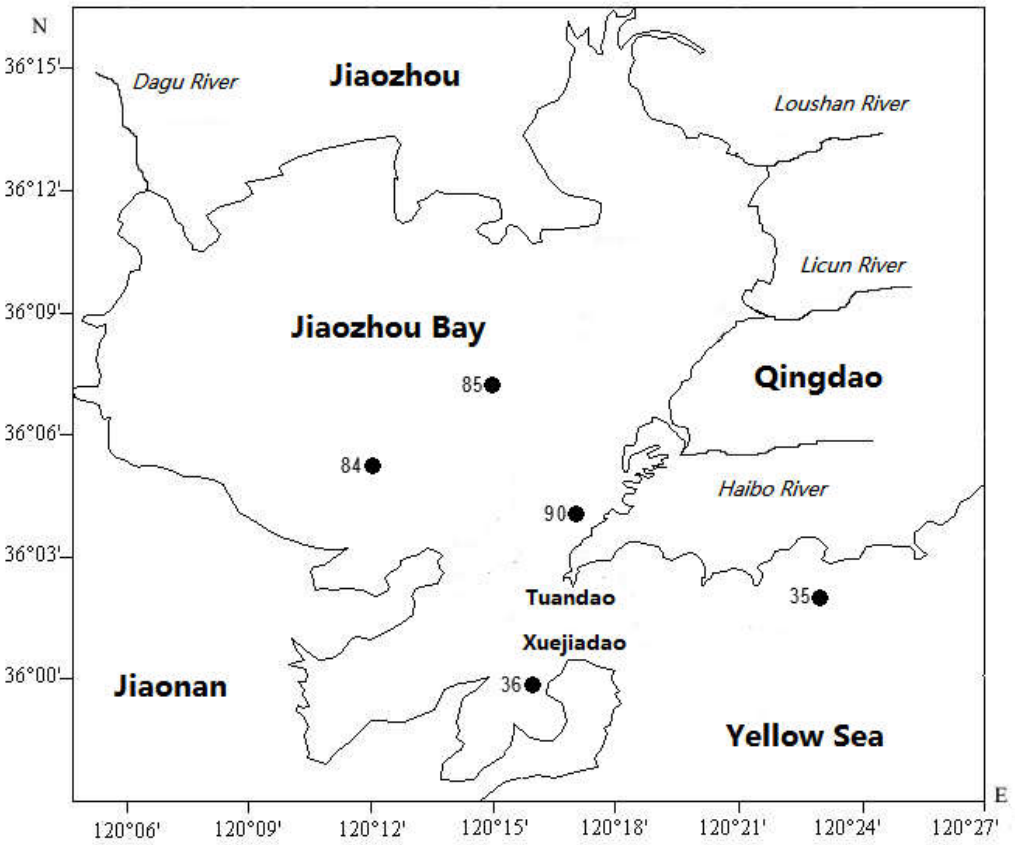

Fig. 1 Geographic location and sampling sites of Jiaozhou Bay

3. RESULTS

3.1 Cd contents in surface and bottom waters

In April 1988, Cd contents in surface waters and bottom waters were 0.09-0.12 μg L^{-1} and 0.08-0.10 μg L^{-1}, respectively (Table 1). In according to Sea Water Quality Standard (GB3097-1997), the Cd contents in both surface and bottom waters in April 1988 were confirmed to Grade I (1.00 μg L^{-1}). In July 1988, Cd contents in surface waters and bottom waters were 0.10-0.45 μg L^{-1} and 0.09-0.18 μg L^{-1}, respectively (Table 1). In according to Sea Water Quality Standard (GB3097-1997), the Cd contents in both surface and bottom waters in April 1988 were also confirmed to Grade I (1.00 μg L^{-1}). In general, the pollution level of Cd in April and July 1988 were very slight.

Table 1 Cd contents and pollution levels in surface waters in Jiaozhou Bay 1988

Month	April		July	
Water layer	Surface	Bottom	Surface	Bottom
Cd content/μg L^{-1}	0.09-0.12	0.08-0.10	0.10-0.45	0.09-0.18
Grade	I	I	I	I

3.2 Seasonal variation of Cd contents in surface and bottom waters

April and July belong to spring and summer in study area. In surface waters, the change range of Cd contents in April and July were 0.09-0.45 μg L^{-1}, and the seasonal variation of Cd contents was in order of spring < summer (Table 1). In bottom waters, the change range of Cd contents in April and July were 0.08-0.18 μg L^{-1}, and the seasonal variation of Cd contents was also in order of spring < summer (Table 1). In general, the seasonal variations of Cd contents were in order of spring < summer.

3.3 Change range of Cd contents in surface and bottom waters

In April 1988, Cd contents in surface waters were relative low (0.09-0.12 μg L^{-1}), and Cd contents in bottom waters were also relative low (0.08-0.10 μg L^{-1}). In July 1988, Cd contents in surface waters were relative high (0.10-0.45 μg L^{-1}), and Cd contents in bottom waters were also relative high (0.09-0.18 μg L^{-1}). Meanwhile, Cd contents in surface waters were 0.09-0.45 μg L^{-1}, and were higher than in bottom waters (0.08-0.18 μg L^{-1}). Therefore, it could be found that Cd contents in bottom waters would be relative high/low in case of Cd contents in surface waters were relative high/low (Table 1).

4. DISCUSSION

4.1 Settlement process of Cd content

By means of vertical water's effect, Cd contents would change a lot after transported through water body [8-10]. The growth and reproduction of marine organism are increasing from spring to summer, and at the same time a lot of colloids are generating that increasing the absorption capacity of suspending particular matters [12]. As a result, a big part of Cd are absorbed to the suspending particular matters and are transferring to sea bottom continuously by means of gravity force and marine current [1-7]. This continuous settlement process are exhibiting the vertical migration process of Cd.

4.2 Seasonal changing process of Cd content

In surface waters, Cd contents in April 1988 were relative low (0.12 μg L^{-1}), yet were increasing to a relative high level in July (0.45 μg L^{-1}). The reason was that the major Cd source in spring was marine current whose source strength was relative weak, while the major Cd source in summer was river flow whose source strength was relative strong. Hence, Cd contents were in order of spring < summer. By means of vertical water's effect, horizontal water's effect and water's effect, Cd contents in bottom waters in April 1988 were also relative low (0.10 μg L^{-1}), and were also increasing to a relative high level in July (0.18 μg L^{-1}), and resulted in Cd contents were in order of spring < summer. In general, the seasonal variation of Cd contents in surface waters was mainly determined by the variations of Cd input from the major Cd sources, while the seasonal variation of Cd contents in bottom waters was mainly determined by the changes of the dilution effect of vertical water body.

4.3 Mechanism of the seasonal variation Cd content

At spatial scale, the major Cd source in April 1988 was marine current, and he input direction of Cd was from the open waters to the bay. By means of gravity force and marine current, the settlement process of Cd was drifting, and resulting in a relative high value region in the bottom waters in the bay mouth and the center of the bay. The major Cd source in July 1988 was river flow in the northeast of the bay, and he input direction of Cd was from the northeast of the bay to the bay mouth. By means of gravity force and marine current, the settlement process of Cd was also drifting, and resulting in a relative high value region in the bottom waters in the inner side of the bay mouth. At temporal scale, the change range of Cd contents in surface and bottom waters were relative low in both April and July, and Cd contents in surface and bottom waters were both in order of April < July. This were fully demonstrating the gravity effect of Cd, was well as the rapid settlement of Cd.

4.4 Mechanism of the vertical variation Cd content

For vertical distribution, Cd contents in bottom waters would be relative high/low in case of Cd contents in surface waters were relative high/low. The reason was that the changes of Cd contents in bottom waters were able to consist with Cd contents in surface waters by means of rapid and continuous settlement process. In according to vertical water's effect, horizontal water's effect and water's effect [8-10], low Cd contents from surface waters has accumulation effect in bottom waters, while high Cd contents from surface waters has dilution effect in bottom waters. Hence, the change range of Cd contents in surface waters were higher than in bottom waters. The low value in surface waters was higher than which in bottom waters, while high value in surface waters was lower than in bottom waters.

5. CONCLUSION

Cd contents in both surface and bottom waters in April 1988 were also confirmed to Grade I, and the pollution level of Cd in April and July 1988 were very slight. The seasonal variations of Cd contents were relative low, and were in order of spring < summer. Cd contents in bottom waters would be relative high/low in case of Cd contents in surface waters were relative high/low. The seasonal variation of Cd contents in surface waters was mainly determined by the variations of Cd input from the major Cd sources, while the seasonal variation of Cd contents in bottom waters was mainly determined by the changes of the dilution effect of vertical water body. Low Cd contents from surface waters has accumulation effect in bottom waters, while high Cd contents from surface waters has dilution effect in bottom waters.

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