The Vertical Migration Characteristics of Zn in Jiaozhou Bay

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Abstract. Based on the investigation data on Zn in waters in May, September and October in 1983, were analyzed the horizontal distribution, seasonal variation and settling process of Zn in water in the bay mouth of Jiaozhou Bay, eastern China in 1983. Results showed that Zn contents in surface waters in May, September and October in the bay mouth of Jiaozhou Bay in 1983 were 1.96-117.50 μg L^{-1}, 7.14-42.50 μg L^{-1} and 2.36-14.00 μg L^{-1}, respectively, while in bottom waters were 1.24-120.66 μg L^{-1}, 6.67-17.78μg L^{-1} and 4.72-20.44 μg L^{-1}, respectively. Hence, Zn contents in surface waters were in orders of spring > summer > autumn, while in bottom waters were in orders of spring > autumn > summer. The variations of Zn contents in bottom waters were consitent with in surface waters. In spatial scale, the contents and the variations of Zn in surface and bottom waters were closed. In regional scale, Zn contents in surface waters were higher than in bottom waters in case of high Zn contents, yet Zn contents in surface waters were lower than in bottom waters in case of low Zn contents. The vertical distributions and seasonal variations of Zn were the products of horizontal and vetical water's effects.

Introduction

Zn has been one of the pollutants in marine environment due to the excessive Zn contents are harmful to organisms [1-2]. The research on the seasonal variations and spatial distributions of Zn in marine bay is essential to understanding the transfer process of Zn, and to provide basis for pollution control and environmental remediation. Jiaozhou Bay is a semi-closed bay located in Shandong Province, eastern China. Due to the rapid development of industrialization and urbanization, this bay had been polluted by various pollutants including Zn [1-2]. Based on investigation data on Zn in waters in Jiaozhou Bay in 1983, eastern China, this paper analyzed the spatial distributions, seasonal variations of Zn in the bay mouth, and revealed the characteristics of vertical migration processes of Zn.

Materials and method

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) is located in Shandong Province, eastern China, and is surrounding by cities of Qingdao, Jiaozhou and Jiaonan. The bay mouth is connected to the Yellow Sea in the south (Fig. 1). The size of the bay is 446 km^2, yet the width of the bay mouth is only 2.5 km. There were more than ten inflow rivers such as Dagu River, Haibo River, Licun River and Loushan River etc., most of which are seasonal rivers whose hydrological characteristics are mainly impacted by rainfall [3-4].

The data was provided by North China Sea Environmental Monitoring Center. The survey was conducted in May, September and October 1983. Surface and bottom water samples in five sampling sites (H34, H35, H36, H37 and H82) were collected and measured followed by National

Specification for Marine Monitoring [5]. The seasons in study area in May, September and October could be considered as spring, summer and autumn, respectively.

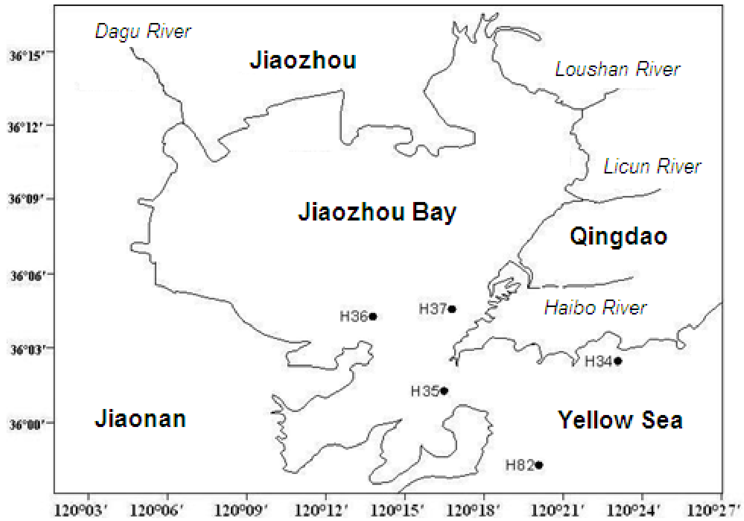

Fig. 1 Geographic location and sampling sites of Jiaozhou Bay

Results

Seasonal variations of Zn. Zn contents in surface waters in May, September and October in the bay mouth of Jiaozhou Bay in 1983 were 1.96-117.50 μg L^{-1}, 7.14-42.50 μg L^{-1} and 2.36-14.00 μg L^{-1}, respectively, while in bottom waters were 1.24-120.66 μg L^{-1}, 6.67-17.78μg L^{-1} and 4.72-20.44 μg L^{-1}, respectively. Hence, Zn contents in surface waters were in orders of spring > summer > autumn, while in bottom waters were in orders of spring > autumn > summer. In according to the seasonal variations, the variations of Zn contents in bottom waters were consitent with in surface waters.

Hozizontal distributions of Zn. Among the five sampling Sites, Site H36 and H37 were located in the inner side of the bay mouth, Site H35 was located in the middle of bay mouth, and Site H34 and H82 were located in the ouside of the bay mouth. In May, Zn contents in both surface and bottom waters were decreasing from the inner side to the out side. In September, Zn contents in both surface and bottom waters were also decreasing from the inner side to the out side. In October, Zn contents in surface waters were increasing from the inner side to the out side, yet in bottom waters were decreasing from the inner side to the out side. Hence, the distributions of Zn contents in surface and bottom waters in May and September were consistent, while in October were reverse.

Vertical variations of Zn. In order to reveal the vertical variations of Zn, the contents in surface waters in the fiver sampling sites in May, September and October 1983. For the whole year, the subtraction of Zn contents in surface from which in bottom waters ranged from -10.59-31.39 μg L^{-1}, indicated that Zn contents in surface and bottom waters were very closed. In May, the differences ranged from -3.16-3.15 μg L^{-1}. Except in Site H34, the differences in the other four sampling sites were positive (Table 1). In September, the differences ranged from 1.64-31.39 μg L^{-1}, andwere positive in all of the five sampling sites (Table 1). In October, the differences ranged from -10.59-9.28 μg L^{-1}. The differences in Site H34 and H35 were positive, while in the other sampling sites were negative (Table 1).

Table 1 Results of subtracting Cd contents in surface waters from which in bottoms in the five sampling sites in May, September and October 1983

Month	H34	H35	H36	H37	H82
May	Negative	Positive	Positive	Positive	Positive
September	Positive	Positive	Positive	Positive	Positive
October	Positive	Positive	Negative	Negative	Negative

Discussion

Seasonal variations of Zn. Zn contents in surface waters in May, September and October were 1.96-117.50 μg L^{-1}, 7.14-42.50 μg L^{-1} and 2.36-14.00 μg L^{-1}, respectively, and are clearly showing that Zn contents were in orders of spring > summer > autumn. In spring in this bay, marine current was the major Zn source, whose source strength was relative high. Hence, Zn contents in spring in surface waters was highest in the whole year. The major Zn source in summer was marine terminals, whose source strength was relative low, and Zn contents in summer were relative low. The major Zn source in autumn was the input of the top of the small islands in the bay mouth, whose source strength was lowest, and therefore Zn contents in autumn were lowest. The seasonal varations process of Zn was mainly determined by vertical water's effect [6]. That was Zn in surface waters was absorbed and was settling to the sea bottom under the force of gravity and current, and was accumalated in bottom waters. Hence, Zn contents in bottom waters were highest in spring due to the high Zn contents in surface waters in spring. Zn contents in surface waters in summer and autumn were closed, yet Zn contents in bottom waters in autumn were higher than in summer. The reason was that a large amount of Zn was settling and accumulating in bottom waters as time pass bay.

Settling process of Zn. In summer, the activities of zooplankton and phytoplankton were increasing, which were able to enhencing the adsorption capacity of suspended particulate matters due to the large production of colloid [4]. Hence, Zn was absorbing and settling to the sea bottom under the force of gravity and current was the horizontal settling process of Zn [2, 6]. The horizontal distributions of Zn in surface and bottom waters were consistent in May, the reason was that the major source of Zn in May was marine current whose source strenth was high enough to matain same horizontal distribution trends in surface and bottom waters by means of vertical water's effect. Although the input of marine was stop in September, the sedimentation and accumulation of Zn in bottom waters were still able to keep a same horizontal distribution trends in surface and bottom waters. However, the horizontal distributions of Zn in surface and bottom waters were reverse in October. The reason was that the horizontal distributions of Zn in surface waters were changing due to the changing of major Zn source, yet horizontal distributions of Zn in bottom waters were consistent by means of sedimentation and accumulation.

The variations of settling process of Zn. In variation scale, the variation ranges of Zn contents in the waters in the bay mouth in surface and bottom waters were basically the same in May, September and October.In vertical scale, Zn contents in surface and bottom waters were very closed, indicated that there was little loss or accumulation of Zn. In case of high Zn contents, the loss of Zn was1.96-1.24=0.72 μg L^{-1}, and the lossing rate was 36.7%. In case of low Zn contents, the accumulation of Zn was 120-66-117.50=3.16 μg L^{-1}, and the lossing rate was 2.60%. In generally, the higher Zn contents in surface waters, the higher Zn contents in bottom waters. That was showing the rapid and continous settlement of Zn, and leading to the consistency of Zn contents in surface and bottom waters.

The regional variations of Zn. The subtrations of Zn contents in surface waters from which in bottom waters were also changing along with time. Once Zn was inputted to the bay, Zn was originally arrived at the surface waters, and than was settling to the bottom waters rapidly and continously by means of horizontal water's effect. The major source of Zn in May was marine current whose source strenth was very high, leading to the high Zn contents in surface waters, and Zn contents in surface waters in most of the sampling sites were higher than in bottom waters except in Site H34 in the outside of the bay mouth. Hence, it could be found that the sedimentation of Zn was significant in case of high Zn contents. Zn in September was mainly sourced from was marine terminals, whose source strength was relative low, and Zn contents in summer were relative low, however, Zn contents in surface waters were higher than that in bottom waters. The relative high Zn contents in surface waters were helpful to the growth and reproduction of marine organisms. Zn in October was mainly sourced from the input of the top of the small islands, whose source strength was very low. Hence, Zn contents in surface waters in most of the sampling Sites were lower than in bottom waters. The reason was the accumulation of Zn. The source strengths of marine current and marine terminals were very and relative high in May and Septemer, and Zn contents were generally higher in surface waters than in bottom waters in May and September. However, the source strengths of the input of the top of the small inslands was very week, so Zn contents were generally lower in surface waters than in bottom waters in October by means of sedimentation.

4 Conclusion

Zn contents in surface waters were in orders of spring > summer > autumn, while in bottom waters were in orders of spring > autumn > summer. The variations of Zn contents in bottom waters were consitent with in surface waters. The distributions of Zn contents in surface and bottom waters in May and September were consistent, while in October were reverse.The source strengths of marine current and marine terminals were very and relative high in May and Septemer, and Zn contents were generally higher in surface waters than in bottom waters in May and September. The source strengths of the input of the top of the small inslands was very week, so Zn contents were generally lower in surface waters than in bottom waters in October by means of sedimentation.

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