Aggregation, divergence and homogeneity of Cu in Marine bay bottom waters

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Abstract. Based on the investigation data on Cu in surface and bottom waters in the bay mouth of Jiaozhou Bay in 1983, we analyzed the contents, pollution levels, and distributions of Cu. Cu contents in Jiaozhou Bay bottom waters in May, September and October 1983 were ranged from 0.86-3.95 μg L^{-1}, 1.31-1.90 μg L^{-1} and 0.24-2.00 μg L^{-1}, respectively, and were ranged from 0.24-3.95 μg L^{-1} in the whole year, indicated that the pollution levels of Cu in this bay in 1983 were very low. There were aggregation and divergence processes of Cu in the bay. Cu contents in marine current were as high as 20.60μg L^{-1}, yet in waters inside the bay were 2.47-10.57 μg L^{-1}. By means of vertical water's effect, high value regions were formed in waters around Site H37 and Site H36 in coastal waters of the south and northwest of the bay. The substances could be transported to every where even in shallow bay due to the homogeneity of the ocean.

Introduction

Cu has been widely used in industry and agriculture, and the Cu-containing waste water has caused many environmental problems in many countries and regions. The Cu pollution in the marine environment could finally be harmful to human by means of food chain. Jiaozhou Bay is a semi-closed bay located in the south of Shandong Peninsula, eastern China, and had been polluted by Cu [1-2]. This paper analyzed the contents, pollution levels, and distributions of Cu in this bay based on the investigation data on Cu in bottom waters. The main object of this paper was to provide basis for transfer processes of Cu in bottom waters.

Materials and method

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) is located in the south of Shandong Peninsula, eastern China. The area and and average water depth are 460 km^2 and 7 m, respectively, yet the bay mouth is only 2.5 km (Fig. 1). This bay is surrounding by cities of Qingdao, Jiaozhou and Jiaonan in the east, north and south, and is connected with the Yellow Sea in the south. There are more than ten inflow rivers such as Loushan River, Licun River and Haibo River, all of which are seasonal rivers [3-4].

The investigation on Cu in five sampling sites (H34, H35, H36, H37 and H82) in Jiaozhou Bay waters was conducted by North China Sea Environmental Monitoring Center in May, September and October 1983 (Fig. 1). The investigation and measurement of Cu were following by National Specification for Marine Monitoring [6]. We defined May, September and October as spring, summer and autumn, respectively.

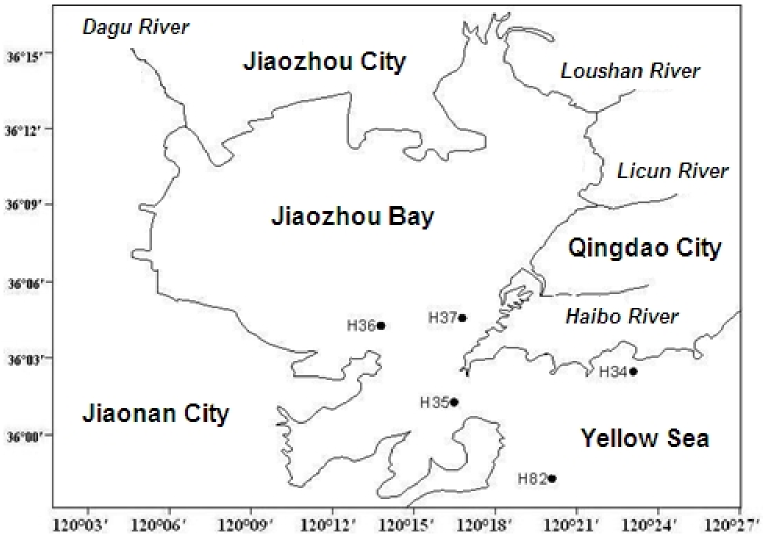

Fig.1 Geographic location and sampling sites of Jiaozhou Bay

Results and discussion

Contents and pollution levels of Cu in bottom waters. Cu contents in Jiaozhou Bay bottom waters in May, September and October 1983 were ranged from 0.86-3.95 μg L^{-1}, 1.31-1.90 μg L^{-1} and 0.24-2.00 μg L^{-1}, respectively, and were ranged from 0.24-3.95 μg L^{-1} in the whole year. In according to the guide line of Class I for Cu (5.00 μg L^{-1}) in National Standard of China for Seawater Quality (GB3097-1997), the pollution levels of Cu in this bay in 1983 were very low. The major sources of Cu in this bay were stream flow, overland flow, marine current and marine terminals. In a source to sink perspective, Cu was originally discharged to the surface waters in the bay, and were transferred to the sea bottom through the water body finally. By means of the vertical water's effect [6], Cu contents in the bottom waters in this bay was very low, and the bay was slightly contaminated by Cu in 1983.

Aggregation and divergence processes of Cu. The five sampling sites were located in the inner side (H36 and H37), middle (H35) and out side (H34 and H82) of the bay mouth. There was a high value center in Site (H37) in the coastal waters in the east of the bay in May (Fig. 2a). A serious of parallel lines were forming around the high value center, and were decreasing trend from the high value center (3.88 μg L^{-1}) to the out side of the bay (0.86 μg L^{-1}) . There was also a high value center in Site (H37) in the coastal waters in the east of the bay in September (Fig. 2b). A serious of parallel lines were forming around the high value center, and were decreasing trend from the high value center (1.90 μg L^{-1}) to the out side of the bay (1.31 μg L^{-1}) . A high value center was occurring in Site (H36) in the coastal waters in the southwest of the bay in October (Fig. 2c). A serious of parallel lines were forming around the high value center, and were decreasing trend from the high value center (1.90 μg L^{-1}) to the out side of the bay (1.31 μg L^{-1}) .

The substance concentrations in Jiaozhou Bay were decreasing continually by means of water exchange [7]. The distributions of Cu in bottom waters in May, September and October were showing the high sedimentation rate in side the bay and low sedimentation rate out side the bay. The flow rate in the bay mouth was relative low, while in areas out side the bay mouth was relative high. The transfer of Cu in this waters was depended on the flow rate. Hence, there were high value regions inside the bay, yet were low value regions out side the bay. It could be concluded that there were aggregation and divergence processes of Cu in the bay.

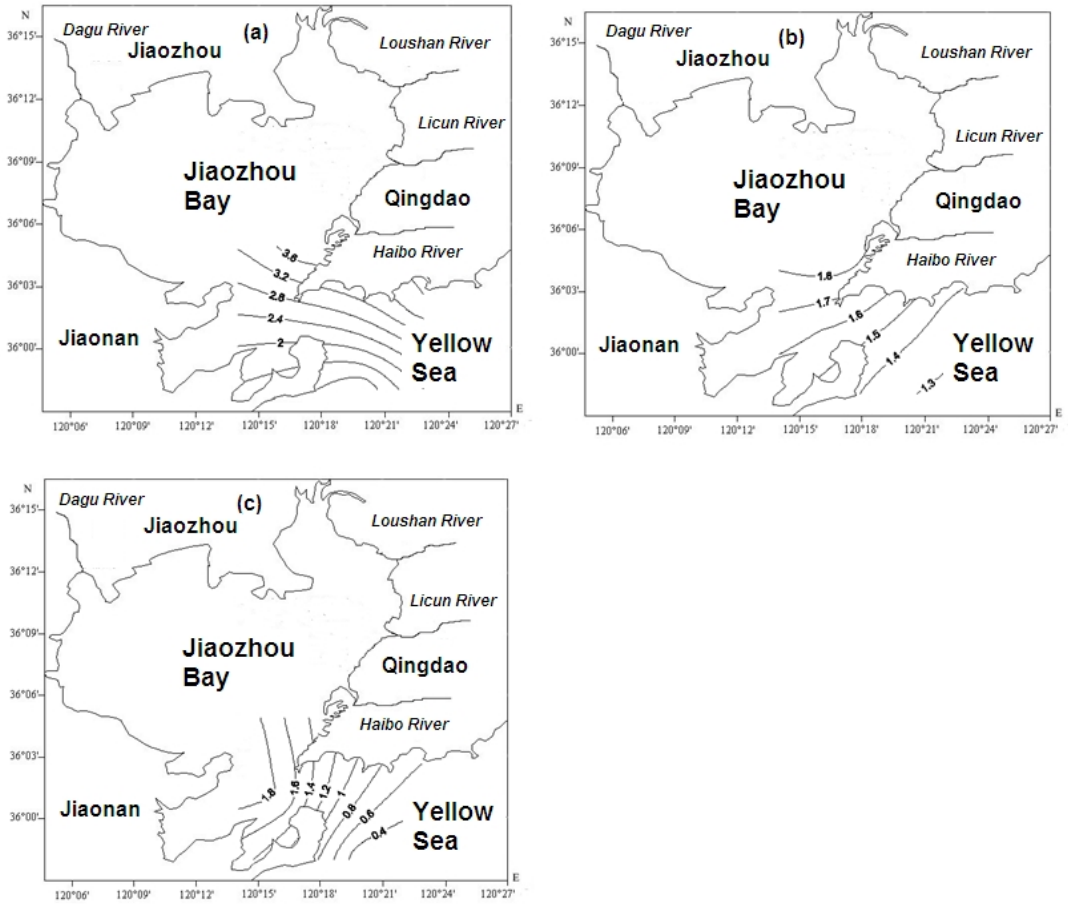

Fig. 2 The distributions of Cu in bottom waters in Jiaozhou Bay in (a) May, (b) September and (c) October/μg L^{-1}

Homogeneity of Cu. The substances in the bay were continually stirred and transported by tide and current. The tide was playing the dominant role in coastal waters. For the deep sea, the the main role was marine current, as well as the consistent from storm tide and submarine earthquake. Hence, the distributions of the substance concentrations were finally homogeneous [8]. Cu contents in marine current were as high as 20.60μg L^{-1}, yet in waters inside the bay were 2.47-10.57 μg L^{-1}. By means of vertical water's effect [6], high value regions were formed in waters around Site H37 and Site H36 in coastal waters of the south and northwest of the bay (1.90-3.88 μg L^{-1}). By means of the homogeneity of the ocean, the substances could be transported to every where even in shallow bay.

Conclusion

Cu contents in Jiaozhou Bay bottom waters in May, September and October 1983 were ranged from 0.86-3.95 μg L^{-1}, 1.31-1.90 μg L^{-1} and 0.24-2.00 μg L^{-1}, respectively, and were ranged from 0.24-3.95 μg L^{-1} in the whole year, indicated that the pollution levels of Cu in this bay in 1983 were very low. There were high value regions inside the bay, yet were low value regions out side the bay, due to the aggregation and divergence processes of Cu in the bay. Cu contents in marine current were as high as 20.60μg L^{-1}, yet in waters inside the bay were 2.47-10.57 μg L^{-1}. By means of vertical water's effect, high value regions were formed in waters around Site H37 and Site H36 in coastal waters of the south and northwest of the bay. The substances could be transported to every where even in shallow bay due to the homogeneity of the ocean.

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