

Sedimentation process and high sedimentation rate position of Cu in Jiaozhou Bay

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Abstract. Based on investigation data on Cu in surface and bottom waters, we analyzed the horizontal and seasonal variations of Cu in waters in the bay mouth of Jiaozhou Bay, eastern China in 1984. Results showed that, the seasonal variations of Cu contents in surface and bottom waters were consist that Cu contents were higher in summer than in autumn. In spatial scale, Cu contents in surface waters determined the horizontal distributions in surface and bottom waters were consist or not. In variation scale, the variation ranges of Cu contents in surface and bottom waters were closed in generally. However, in case of Cu was absorbed by marine organism and particulate matters yet the sedimentation rate was low, the distributions of Cu in surface and bottom waters were different. In regional scale, the sedimentation rate and position of Cu in surface waters were determined by sources of Cu.

Introduction

Cu in one of the a widely scattered metallic elements in both earth's crust and oceans. The major form of Cu is copper mineral. Cu is also one of the earliest metal used by human. The mining for copper has been begin as early as in prehistoric times, and products of craft weapon, instrument and vessel were obtained. The used of Cu is meaningful to the development of early human civilization. Nowadays, Cu is widely used in industry and agriculture. However, a large mount of Cu-containing waste water had been generated and discharged to the environment and leading to the water degradation in the ocean [1-2].

Based on investigation data on Cu in both surface and bottom waters in the bay mouth area of Jiaozhou Bay, this paper analyzed the vertical distributions and seasonal variations of Cu, defined the seasonal distributions, horizontal distributions, variation ranges and vertical variations, revealed the seasonal variation and sedimentation processes, and provided scientific basis for the research on the vertical sedimentation and horizontal migration of Cu.

Materials and method

Jiaozhou Bay is located in the south of Shandong Province, eastern China (35°55'-36°18' N, 120°04'-120°23' E), which is connected to the Yellow Sea in the south. This bay is a typical of semi-closed bay, whose total area, average water depth and bay mouth width are 446 km², 7 m and 3 km, respectively. There are a dozen of inflow rivers, and the majors are Dagu River, Haibo Rriver, Licun Rriver, and Loushan Rriver etc., all of which are seasonal rivers [3-4].

The investigation on Cu in surface and bottom waters in Jiaozhou Bay was carried on in July and October 1984 in three investigation sites namely 2031, 2032 and 2033, respectively (Fig. 1). Cu in surface and bottom waters were sampled and monitored follow by National Specification for Marine Monitoring [5].

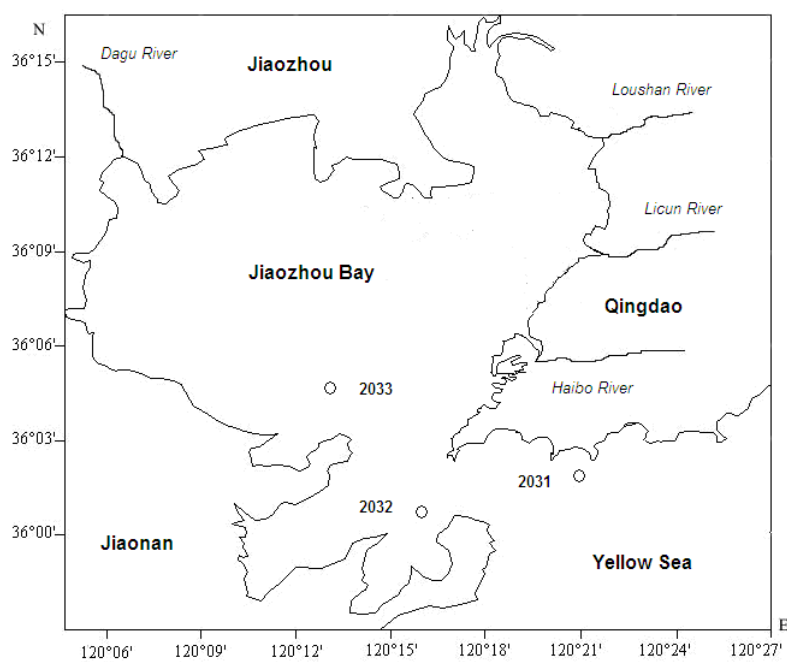


Fig.1 Investigation sites in Jiaozhou Bay

Results and discussion

Seasonal variations of Cu. Cu contents in surface waters in July and October in Jiaozhou Bay in 1984 were $0.28\text{--}4.00\ \mu\text{g L}^{-1}$ and $0.90\text{--}2.00\ \mu\text{g L}^{-1}$, respectively, while in bottom waters were $0.13\text{--}2.97\ \mu\text{g L}^{-1}$ and $0.40\text{--}0.61\ \mu\text{g L}^{-1}$, respectively. July and October were summer and autumn in study area. Cu contents in both surface and bottom waters were in order of summer > autumn. Hence, the seasonal variations of Cu contents in surface and bottom waters were consistent.

Horizontal variations of Cu. The three sampling Sites of 2031, 2032 and 2033 were located in the outside of the bay mouth, the bay mouth and the inside of the bay mouth, respectively. Stream flow was the major Cu source in summer. Cu contents in surface waters were decreasing from the inside of the bay mouth ($1.83\ \mu\text{g L}^{-1}$) to the bay mouth ($0.28\ \mu\text{g L}^{-1}$), yet in bottom waters were increasing from the inside of the bay mouth ($0.36\ \mu\text{g L}^{-1}$) to the bay mouth ($2.97\ \mu\text{g L}^{-1}$). Ocean current was the major Cu source in autumn and Cu contents in surface waters were decreasing from the outside of the bay mouth ($0.20\ \mu\text{g L}^{-1}$) to the bay mouth ($0.90\ \mu\text{g L}^{-1}$), yet in bottom waters were also decreasing from the outside of the bay mouth ($0.61\ \mu\text{g L}^{-1}$) to the bay mouth ($0.40\ \mu\text{g L}^{-1}$). In generally, the horizontal distributions of Cu contents in surface and bottom waters in summer were reverse in summer, while in autumn were consistent.

Vertical variations of Cu. Cu contents in surface waters in July were relative low ($0.28\text{--}1.83\ \mu\text{g L}^{-1}$), yet in bottom waters were relative high ($0.13\text{--}2.97\ \mu\text{g L}^{-1}$). Meanwhile, Cd contents in surface waters in October were relative high ($0.90\text{--}2.00\ \mu\text{g L}^{-1}$), yet Cd contents in bottom waters were also relative low ($0.40\text{--}0.61\ \mu\text{g L}^{-1}$). Furthermore, the variation range of Cu contents in July were $0.28\text{--}2.00\ \mu\text{g L}^{-1}$, which was a little lower than but very closed to the variation range of Cu contents in October ($0.13\text{--}2.97\ \mu\text{g L}^{-1}$). It could be found that Cu contents in bottom waters were relative high/low in case of Cu contents in surface waters were relative low/high. The contents of Cu in surface waters in the three sampling sites in July and October 1984. For the whole year, the subtraction of Cu contents in surface from which in bottom waters ranged from -2.69 to $1.47\ \mu\text{g L}^{-1}$, indicated that Cu contents in surface and bottom waters were very closed. In July, the differences ranged from -2.69 to $1.47\ \mu\text{g L}^{-1}$, and the differences were positive in Site 2031 and 2033, and were negative in Site 2032 (Table 1). In October, the differences ranged from 0.50 to $1.39\ \mu\text{g L}^{-1}$, and the differences were positive in Site 2031 and 2032 (Table 1).

Table 1 Results of subtracting Cu contents in surface waters from which in bottoms in the three sampling sites in July and October 1983

Month	2031	2032	2033
July	Positive	Negative	Positive
October	Positive	Positive	

Discussion

Sedimentation process of Cu. Cu contents were changing while transferring through the water body by means of vertical water's effect [6]. Copper iron is strong hydroponic, and could be absorbed by phytoplankton and suspended particulate matters. In summer, the activities of zooplankton and phytoplankton were increasing [4], and the adsorption capacities of suspended particulate matters were enhancing due to the large production of colloid. Hence, a large amount of Cu in waters was absorbing and settling to the sea bottom under the force of gravity and current [1-2]. This was the horizontal settling process of Cu.

Seasonal variations process of Cu. Cu contents in surface water in July were relative high ($4.00 \mu\text{g L}^{-1}$), and were decreasing from July to October ($2.00 \mu\text{g L}^{-1}$). The major source of Cu in this bay in summer was stream flow, whose source strength was relative high; yet the major source of Cu in autumn was ocean current, whose source strength was relative low. That was the reason that Cu contents in summer was higher than which in autumn. During the settling process of Cu, the variations of Cu contents in bottom waters were determined by which in surface waters, and Cu contents in bottom waters were also in order of summer > autumn. Therefore, the seasonal variations of Cu contents in surface and bottom waters were consist.

Spatial sedimentation process of Cu. In spatial scale, Cu contents in surface waters in July were relative high due to the source strength of stream flow was relative high, and the horizontal distributions of Cu contents in surface and bottom waters were reverse. Cu contents in surface waters in July were decreasing from the inside of the bay mouth to the outside of the bay mouth, yet Cu could be absorbed, transferred and settled to the bottom waters far away from the bay mouth, resulting in the reversed horizontal distributions of Cu contents in bottom waters.

In October, Cu was mainly sourced from ocean current whose source strength was relative low, and horizontal distributions of Cu contents in surface and bottom waters were consist that were decreasing from the outside of the bay mouth to the bay mouth. The reason was that Cu was absorbed by phytoplankton and suspended particulate matters, and were transported to areas closed to the bay mouth, and were settled to the bottom waters by means of gravity and current.

In spatial scale, Cu contents in surface waters determined the horizontal distributions in surface and bottom waters were consist or not. In case of Cu contents were relative low in surface waters, the horizontal distributions of Cu in surface and bottom waters were reverse; while in case of Cu contents were relative high in surface waters, their distributions were consist. That was the spatial sedimentation processes of Cu.

Vertical sedimentation process of Cu. For variation scale, the variation ranges of Cu contents in surface and bottom waters were closed. However, Cu contents in bottom waters were relative high/low when Cu contents in surface waters were relative low/high. These phenomenon revealed that a big part of Cu was absorbed bay phytoplankton and suspended particulate matters, yet the sedimentation of Cu to bottom waters was not rapid enough, leading to the reverse of the variations of Cu contents in surface and bottom waters.

Regional sedimentation process of Cu. The subtractions of Cu contents in surface waters from which in bottom waters were changing along with time, indicating the variations of Cu contents in surface and bottom waters. Once Cu was inputted to the bay, which was originally arrived at the surface waters, and than was settling to the bottom waters rapidly and continuously by means of horizontal water's effect.

The major source of Cu in July was stream flow whose source strength was relative strong, leading to the higher contents in surface than in bottom waters in the inside of the bay mouth, lower

contents in surface than in bottom waters in the bay mouth, and higher contents in surface than in bottom waters in the outside of the bay mouth. The major source of Cu in October was stream flow whose source strength was relative weak, leading to the higher contents in surface than in bottom waters in the whole study area.

A large amount of Cu was inputted by stream flow in July, and the high Cu-containing surface waters were covering from the inside of the bay mouth to the bay mouth, and the sedimentation rate of Cu in the bay mouth was relative high. A little amount of Cu was inputted by ocean current in October, and the low Cu-containing surface waters were covering from the outside of the bay mouth to the bay mouth, in where there was no high sedimentation rate.

Conclusion

Cu contents in both surface and bottom waters were in order of summer > autumn. The seasonal variations of Cu contents in surface and bottom waters were consistent by means of vertical water's effect.

In spatial scale, Cu contents in surface waters determined the horizontal distributions in surface and bottom waters were consist or not. In case of Cu contents were relative low in surface waters, the horizontal distributions of Cu in surface and bottom waters were reverse; while in case of Cu contents were relative high in surface waters, their horizontal distributions were consist. That was the spatial sedimentation processes of Cu.

In variation scale, the variation ranges of Cu contents in surface and bottom waters were closed. A big part of Cu was absorbed bay phytoplankton and suspended particulate matters, yet the sedimentation of Cu to bottom waters was not rapid enough, leading to the reverse of the variations of Cu contents in surface and bottom waters.

In regional scale, a large amount of Cu was inputted by stream flow in July, and the high Cu-containing surface waters were covering from the inside of the bay mouth to the bay mouth, and the sedimentation rate of Cu in the bay mouth was relative high. A little amount of Cu was inputted by ocean current in October, and the low Cu-containing surface waters were covering from the outside of the bay mouth to the bay mouth, in where there was no high sedimentation rate.

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