The homogeneity changing process of Cu in Jiaozhou bay waters

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Abstract: Using investigation data on Cu in April, July and October 1985, this paper researched the horizontal distributions of Cd in Jiaozhou Bay. Results showed that there were two major Cd sources, i.e., river flow and marine current, and the waters in Jiaozhou Bay could be divided into two classes. On one hand, in case of there was Cu input, Cu contents in waters was non-homogeneous. On the other hand, in case of there was little input, Cd contents in waters was homogeneous. Along with time, Cu contents in waters were undergoing process from non-homogeneous to homogeneous. This revealed that ocean has feature of homogeneous by means of tide and current. Ocean makes all of the substances in waters to be homogeneous, and make all of the substances in waters to diffuse in tends of homogeneous.

1. Introduction
Cu is widely existing in the nature mainly in forms of sulphide and oxide ores, and has been exploited and used by human for thousands of years. However, the rapid development of industry is generating a large amount of Cu-containing wastes, resulting in Cu pollution in waters, soil, etc. Many marine bays have been polluted by Cu since ocean is the sink of pollutants [1–5]. Hence, researching the migration process of Cu in marine waters is essential to environmental protection. Using investigation data on cuprum (Cu) in April, July and October 1985, this paper researched the horizontal distributions of Cd in Jiaozhou Bay, defined the major sources of Cu and the background pollution, revealed the distribution and changing process of Cd, and provided basis for researching on the migration process of Cu in marine bay.

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 km² and 7 m, respectively. The bay mouth is very narrow (3 km) between Tuandao and Xuejiadao, and is connected to the Yellow Sea. There are a dozen of rivers, and the major rivers include Dagu River, Haibo River, Licun River, and Loushan River etc.. All of which are seasonal rivers strongly impacted by seasonal factors [6–7]. The investigation on Cu in surface waters in Jiaozhou Bay was carried on in April, July and October 1985 in six monitoring sites (i.e., 2031, 2032, 2033, 2034, 2035 and 2047) (Fig. 1). Cu in waters was sampled and monitored follow by National Specification for Marine Monitoring [8].
3. Results

3.1 Horizontal distributions of Cd in April 1985. In April 1985, the high value of Cu contents was occurring in Site 2035 (0.43 μg L\(^{-1}\)) in waters closed to the estuary of Licun River (Fig. 2). The contour lines of Cu contents were forming a series of semi-concentric circles, and were decreasing from the high value center to the coastal waters in the southwest of the bay (0.11 μg L\(^{-1}\)) (Fig. 2). Meanwhile, there was another high value center (0.39 μg L\(^{-1}\)) in the coastal waters in the east in the outer side of the bay mouth (Fig. 2). The contour lines of Cu contents were forming a series of parallel lines, and were decreasing from the high value center to the coastal waters in the southwest of the bay (0.11 μg L\(^{-1}\)) (Fig. 2).

3.2 Horizontal distributions of Cd in July 1985. In July 1985, there was a high value center (0.38 μg L\(^{-1}\)) in Site 2034 in the estuary of Haibo River in the coastal waters in the northeast of the bay (Fig. 3).
The contour lines of Cu contents were forming a series of parallel lines, and were decreasing from the high value center to the bay mouth (0.22 μg L⁻¹), and the open waters (0.11 μg L⁻¹) (Fig. 3).

3.3 Horizontal distributions of Cd in October 1985. In October 1985, there was a high value center (0.39 μg L⁻¹) in Site 2031 in the coastal waters in the east in the outer side of the bay mouth (Fig. 4). The contour lines of Cu contents were forming a series of parallel lines, and were decreasing from the high value center to the southwest of the bay (0.18 μg L⁻¹) (Fig. 4).

4. Discussion

4.1 Homogeneity of ocean. All of the substances in the ocean are stirring and transporting by tide and current, and the contents of the substances are tending to be very homogeneous. In the coastal waters, tide is playing the key role. In the deep sea, marine current is mainly responsible, while storm surge
and sea quake are assisting. As time going by, the ocean makes all of the substances to be homogeneous distributed. Therefore, ocean has feature of homogeneity. In according to the horizontal distribution of Cu in Jiaozhou 1985 (Fig. 2–4), it could be seen that the distributions Cu contents could be changing from non-homogeneous to homogeneous.

4.2 Non-homogeneous distributions of Cu. In April 1985, high value of Cu contents was in the estuary of Licun River. This indicated that the major Cu source was river flow, and the source strength was relative strong as 0.43 μg L\(^{-1}\). Mean while, another high value of Cu contents was in the open waters. This indicated that another major Cu source was marine current, and the source strength was also relative strong as 0.39 μg L\(^{-1}\). The horizontal distributions revealed that the Cu contents in the while bay was non-homogeneous in April 1988 (Fig. 2). In July 1985, high value of Cu contents was in the estuaries of Haibo River, Licun River and Loushan River. This indicated that the major Cu source was river flow, and the source strength was relative strong as 0.37–0.38 μg L\(^{-1}\). The horizontal distributions revealed that the Cu contents in the while bay was non-homogeneous in July 1988 (Fig. 3). In October 1985, high value of Cu contents was in the open waters, and Cu contents were decreasing from the open water to the bay mouth and to the inner side of the bay. This indicated that the major Cu source was marine current, and the source strength was also relative strong as 0.39 μg L\(^{-1}\). The horizontal distributions revealed that the Cu contents in the while bay was non-homogeneous in July 1988 (Fig. 4).

4.3 Homogeneous distributions of Cu. In July 1985, in region from the coastal waters in the southwest of the bay to the bay mouth, the change range of Cu contents was 0.10–0.22 μg L\(^{-1}\). This indicated that Cu contents were relative low and there was little Cu input in this region (Fig. 3). It could be found that the distribution of Cu contents in region from the coastal waters in the southwest of the bay to the bay mouth was homogeneous. In October 1985, in waters in the inside of the bay, the change range of Cu contents was 0.18–0.20 μg L\(^{-1}\). This indicated that Cu contents were relative low and there was little Cu input in this region (Fig. 4). It could be found that the distribution of Cu contents in the whole waters inside the bay was homogeneous.

4.4 Changing of homogeneity. River flow and marine current were the two major sources of Cu in Jiaozhou Bay. In April 1985, there was Cu input from river flow in the northeast of the bay, and the horizontal distributions of Cu in this regions was non-homogeneous (Fig. 5). Meanwhile, there was Cu input from marine in the outer side of the bay, and the horizontal distributions of Cu in this regions was non-homogeneous (Fig. 5). In July 1985, there was Cu input from river flow in the northeast of the bay, and the horizontal distributions of Cu in this regions was non-homogeneous (Fig. 6). Meanwhile, there was little Cu input in region from the southwest of the bay to the open waters, and the horizontal distributions of Cu in this regions was homogeneous (Fig. 6). In October 1985, there was little Cu input in water inside the bay, and the horizontal distributions of Cu in this regions was homogeneous (Fig. 7). Meanwhile, there was Cu input from marine in the outer side of the bay, and the horizontal distributions of Cu in this regions was non-homogeneous (Fig. 7). In general, Cu contents in waters was non-homogeneous in case of there was Cu input, while Cu contents in waters was homogeneous in case of there was little Cu input. In the ocean, Cu contents in waters were undergoing process from non-homogeneous to homogeneous along with time. This revealed that ocean has feature of homogeneous by means of tide and current [6]. Ocean makes all of the substances in waters to be homogeneous, and make all of the substances in waters to diffuse in tends of homogeneous [9–11].
5. Conclusions
River flow and marine current were the two major sources of Cu in Jiaozhou Bay. Ocean has feature of homogeneous. Cu contents in waters was non-homogeneous in case of there was Cu input, while Cu contents in waters was homogeneous in case of there was little Cu input. Cu contents in waters in the ocean were undergoing process from non-homogeneous to homogeneous along with time. Ocean makes all of the substances in waters to be homogeneous, and make all of the substances in waters to diffuse in tends of homogeneous.

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