Horizontal migration process of Pb in bottom waters in Jiaozhou Bay 1989

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Abstract. This paper quantified the horizontal migration processes of Plumbum (Pb) in Jiaozhou Bay in 1989. Results showed that Pb contents in bottom waters in April and July 1989 were 8.15-10.10 μg L-1 and 3.39-7.15 μg L-1, respectively. The pollution level of Pb in bottom waters in April and July 1989 could be considered as heavy and moderate, respectively. In April 1989, Pb contents in bottom waters from the bay center to the bay mouth were decreasing from 10.10 μg L-1 to 8.15 μg L-1, indicating that the sedimentation rate was high in the bay center, yet was low in the bay mouth. In July 1989, Pb contents in bottom waters from the bay center to the bay mouth were decreasing from 7.15 μg L-1 to 3.39 μg L-1, also indicating that the sedimentation rate was high in the bay center, yet was low in the bay mouth. By means of source input and the vertical water’s effect, the sedimentation rate in the bay center was high via the rapid vertical sedimentation process. The major source of Pb were river runoff and atmosphere deposition, the sedimentation rate in the bay mouth was low due to the water exchange. By means of the vertical water’s effect and the water exchange process, Pb contents in marine bay were changing continuously.

1. Introduction
Pb has been widely used in many industries such as smelting, instrument and apparatus, brine electrolysis [1-2]. A large amount of Pb-containing wastes were generated and discharged to the environment along with the rapid development of industries[3-4], yet the waste treatment in many countries and regions is always lagging [5-6]. As a result, many marine bays have been polluted by Pb since ocean is the sink of pollutants [7-8]. Pb in the environment is harmful to organism and ecosystem and could be persistent in the environment, and therefore quantifying the migration processes of Pb is essential to pollution control[9-10].

Jiaozhou Bay is a semi-closed bay located in Shandong Province China, and has been polluted by various pollutants including Pb after the rapid increasing of industry the past three decades [9-12]. This paper quantified the horizontal and vertical migration processes of Pb in bottom waters in Jiaozhou Bay using investigation data in April and July 1989. The aim of this paper was to better understand the transporting processes of Pb in marine bay, and provide basis for scientific research and environment remediation.

2. Materials and method
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). The total area and average water depth are 446 km2 and 7 m, respectively. The bay mouth is very narrow (3 km), and is connected to the Yellow Sea in the
south. There are a dozen of rivers including Daguo River, Haibo River, Licun River, and Loushan River etc., all of which are seasonal rivers [10-11].

The investigation on Pb in Jiaozhou Bay was carried on by North China Sea Environmental Monitoring Center. In April and July 1989, Hg contents in bottom waters were measured in Site 85 and Site 90 in the bay center and the bay mouth, respectively (Fig. 1). Pb in waters was sampled and monitored follow by National Specification for Marine Monitoring [12].

3. Results and discussion

Contents and pollution level of Pb in bottom waters. Pb contents in bottom waters in April and July 1989 were 8.15-10.10 μg L⁻¹ and 3.39-7.15 μg L⁻¹, respectively (Table 1). The China Sea Water Quality Standard (GB 3097-1997) provides guidelines for Pb (Table 2). In April 1989 Pb contents were confirm to Grade III and V, while in July 1989 Pb contents were confirm to Grade II and III. In Jiaozhou Bay, Pb was mainly sourced from river runoff, as well as atmosphere deposition. In general, the source input process was that Pb was firstly arrived at surface waters, and then was transporting through the waterbody by means of vertical water’s effect, and was finally fixed in sea bottom [7-8]. Hence, the pollution level of Pb in bottom waters in April and July 1989 could be considered as heavy and moderate, respectively.

![Fig. 1 Geographic location and monitoring sites in Jiaozhou Bay](image)

Table 1 Contents and pollution level of Pb in bottom waters in Jiaozhou Bay 1989

|       | April    | July     |
|-------|----------|----------|
| Content/μg L⁻¹ | 8.15-10.10 | 3.39-7.15 |
| Grade    | III, V   | II, III  |

Table 2 China Sea Water Quality Standard (GB 3097-1997) guidelines for Pb

| Grade | I     | II     | III    | IV    |
|-------|-------|--------|--------|-------|
| Content/μg L⁻¹ | 1.00  | 5.00   | 10.00  | 50.00 |
3.1 Horizontal distributions of Pb in bottom waters.
Sampling Site 85 and Site 90 were located in the bay center and the bay mouth, respectively. In April 1989, the high value of Pb contents was in Site 85 in the bay center, and the contour lines of Pb contents were forming a series of parallel lines that decreasing from the bay center (10.10 μg L⁻¹) to the bay mouth (8.15 μg L⁻¹). In July 1989, the high value of Pb contents was also in Site 85 in the bay center, and the contour lines of Pb contents were forming a series of parallel lines that decreasing from the bay center (7.15 μg L⁻¹) to the bay mouth (1.39 μg L⁻¹). Pb contents in bottom waters were strongly impacted by surface waters by means of vertical waters’s effect, while Pb contents in surface waters were impacted by the major source input directly [7-8]. Hence, in according to the horizontal distributions of Pb in bottom waters, it could be identified that the major source of Pb in April and July 1989 were river runoff, as well as atmosphere deposition.

3.2 Horizontal migration process of Pb in bottom waters.
Jiaozhou Bay is a semi-closed bay, and Pb contents in bay waters were changing continuously along with the water exchange between open waters and the bay via the narrow bay mouth [13]. In April 1989, Pb contents in bottom waters from the bay center to the bay mouth were decreasing from 10.10 μg L⁻¹ to 8.15 μg L⁻¹, indicating that the sedimentation rate was high in the bay center, yet was low in the bay mouth. In July 1989, Pb contents in bottom waters from the bay center to the bay mouth were decreasing from 7.15 μg L⁻¹ to 3.39 μg L⁻¹, also indicating that the sedimentation rate was high in the bay center, yet was low in the bay mouth. By means of source input and the vertical water’s effect, the sedimentation rate in the bay center was high via the rapid vertical sedimentation process [7-8]. Since the major sources of Pb in April and July 1989 were river runoff and atmosphere deposition, yet the marine current was not the major Pb source, the sedimentation rate in the bay mouth was low due to the water exchange. As a whole, by means of the vertical water’s effect and the water exchange process, Pb contents in marine bay were changing continuously.

4. Conclusions
Pb contents in bottom waters in April and July 1989 were 8.15-10.10 μg L⁻¹ and 3.39-7.15 μg L⁻¹, respectively. The pollution level of Pb in bottom waters in April and July 1989 could be considered as heavy and moderate, respectively. In April 1989, Pb contents in bottom waters from the bay center to the bay mouth were decreasing from 10.10 μg L⁻¹ to 8.15 μg L⁻¹, indicating that the sedimentation rate was high in the bay center, yet was low in the bay mouth. In July 1989, Pb contents in bottom waters from the bay center to the bay mouth were decreasing from 7.15 μg L⁻¹ to 3.39 μg L⁻¹, also indicating that the sedimentation rate was high in the bay center, yet was low in the bay mouth.

By means of source input and the vertical water’s effect, the sedimentation rate in the bay center was high via the rapid vertical sedimentation process. The major sources of Pb were river runoff and atmosphere deposition, the sedimentation rate in the bay mouth was low due to the water exchange. By means of the vertical water’s effect and the water exchange process, Pb contents in marine bay were changing continuously.

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