

## Vertical transferring process, mechanism and model of Pb in Jiaozhou bay

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**Abstract.** This paper analyzed the vertical transferring process, mechanism and model of Pb in Jiaozhou Bay based on investigation of Pb in surface and waters in different seasons during 1979-1983. Results showed that the Pb contents in surface waters were changing with seasons within year, and Pb contents in bottom waters were influenced by which in surface waters by means of vertical transferring. The mechanism of the vertical transferring process was revealed. The vertical transferring process was containing three stages as, 1)Pb was transferring to surface waters in the bay, 2)Pb was transferring to bottom waters, and 3) Pb was fixing to the sediment and leaving the waters. Furthermore, a block diagram model was established to describe the transferring process and variations of Pb in waters.

### Introduction

Environmental protection and remediation have been one of the important tasks in many countries and regions since the environment has been polluted by various pollutants. Marine bays are always heavy polluted areas due to many industries and cities are surrounding ye and a large amount of waste is discharging in. Understanding the transferring process and the mechanism was essential to marine environmental protection [1-6].

Jiaozhou Bay is a semi-closed bay located in south of Shandong Peninsula, eastern Chin. The aim of this paper was to analyze the import-export process of Pb in Jiaozhou Bay based on investigation of Pb in surface and waters in different seasons during 1979-1983, to reveal the vertical transferring process of Pb and the mechanism in this bay, and to provide scientific basis for environmental protection and the sustainable development of study area.

### Study area and data collection

Jiaozhou Bay (120°04'-120°23' E, 35°55'-36°18' N) is located in the south of Shandong Province, eastern China (Fig. 1). It is a semi-closed bay with the total area, average water depth and bay mouth width of 446 km<sup>2</sup>, 7 m and 3 km, respectively. There are more than ten inflow rivers (i.e., Haibo Rriver, Licun Rriver and Dagu Rriver,), most of which have seasonal features [7-8]. The data was provided by North China Sea Environmental Monitoring Center. The survey was conducted in different months during 1979-1983 [1-6]. Surface and bottom water samples were collected and measured followed by National Specification for Marine Monitoring [9].

### Vertical transferring process of Pb

In May, September and October 1979, Pb contents in surface waters in the open waters outside the bay mouth were higher than which in bottom waters, indicated that marine current was the major Pb source at this location. Meanwhile, Pb contents in surface waters in the bay mouth were lower than which in bottom waters, indicated that marine stream flow were the major Pb sources at this location. By means of the overlaying of the two sources, and the continuous sedimentation of Pb to bottom waters, Pb contents in surface waters were decreasing, yet in bottom waters were

increasing to even a high value.

In June, July and September 1980, Pb contents in surface waters were higher than which in bottom waters. However, in October 1980, Pb contents in surface waters were lower than which in bottom waters. These vertical variations were indicating that Pb from various sources would be transferred to surface waters originally, and Pb contents would be decreasing along with time due to sedimentation. Along with the accumulation, Pb contents in bottom waters were increasing, and reaching the peak in October.

In April 1981, Pb contents in surface waters were generally higher than which in bottom waters. Later, in August 1981, Pb contents in surface waters were generally lower than which in bottom waters. As time pass bay, in November 1981, Pb contents in surface waters were generally higher than which in bottom waters again.

In April 1982, Pb sources were located in the inner bay, and Pb contents in surface waters inside the bay were higher than which in bottom waters. In July 1982, Pb sources were located in the bay mouth, and Pb contents in surface waters in the bay mouth were higher than which in bottom waters. It could be found that Pb in the inner bay and the bay mouth were transferring from the surface waters to bottom waters. In October 1982, Pb sources were located in the top of the island, and Pb contents in surface waters in the top of the island were higher than which in bottom waters. However, in waters far away from the top of the island, Pb contents in surface waters in the top of the island were lower than which in bottom waters, and were indicating that Pb was settling from surface waters to bottom waters by transferring from the coastal waters of the top of the island to open waters far away the top of the island.

In May 1983, Pb sources were located in the eastern of the inner bay, and Pb contents in surface waters in the eastern of the inner bay were higher than which in bottom waters, yet in other locations were lower, indicating that Pb were transferring from surface waters to bottom waters in the inside of the bay mouth and the bay mouth. In September 1983, Pb sources were located in the bay mouth, and Pb contents in surface waters in the bay mouth were higher than which in bottom waters, yet in other locations were lower, indicating that Pb were transferring from surface waters to bottom waters in the bay mouth. In October 1983, Pb sources were located in the open waters, and Pb contents in surface waters in the open waters were higher than which in bottom waters, yet in other locations were lower, indicating that Pb were transferring from surface waters to bottom waters in the open waters.

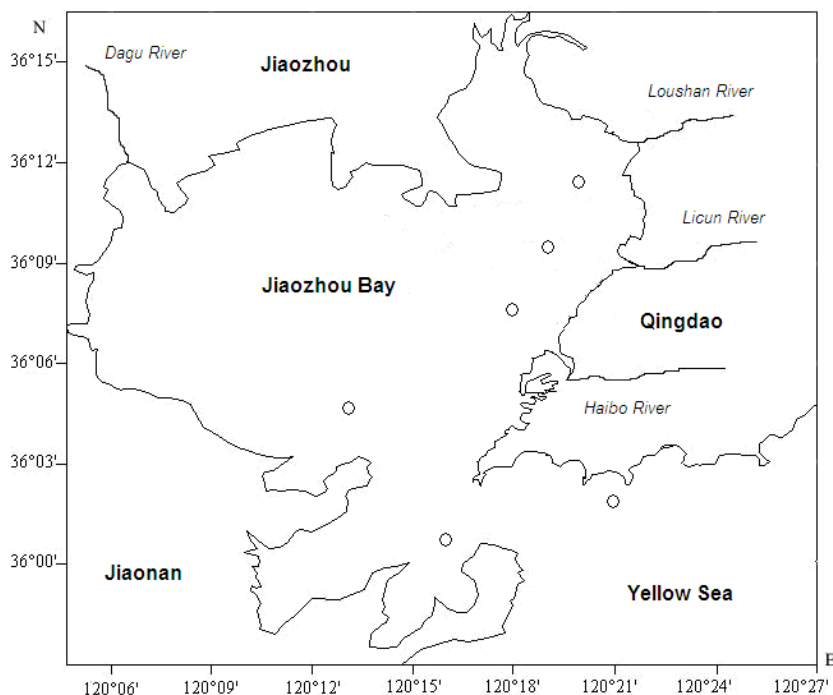


Fig.1 Geographic location and monitoring sites in Jiaozhou Bay

### Mechanism of vertical transferring process of Pb

The Pb sources were importing Pb to the bay by emission of Pb to surface waters, and Pb in surface waters were settling to bottom waters continuously along with time. In case of the amount of the input of Pb was large than the sedimentation of Pb, Pb contents in surface waters would be increasing continuously. In case of the amount of the input of Pb was equal to the sedimentation of Pb, Pb contents in surface waters would be stable. In case of the amount of the input of Pb was smaller than the sedimentation of Pb, Pb contents in surface waters would be decreasing.

Pb in surface waters were settling to bottom waters continuously, and Pb contents in bottom waters would be accumulating and increasing. Meanwhile, Pb in bottom waters were also fixing and leaving waters continuously, and Pb contents in bottom waters could also be decreasing. In case of the amount of the accumulation of Pb in bottom waters was bigger than the removal of Pb from waters, Pb contents in bottom waters would be increasing. In case of the amount of the accumulation of Pb in bottom waters was equal to the removal of Pb from bottom waters, Pb contents in bottom waters would be stable. In case of the amount of the accumulation of Pb in bottom waters was smaller than the removal of Pb from waters, Pb contents in bottom waters would be decreasing.

### Model of vertical transferring process of Pb

The mechanism of the vertical transferring process was revealed, and the vertical transferring process was containing three stages. Firstly, Pb was transferring to surface waters in the bay. Secondly, Pb was transferring to bottom waters. Thirdly, Pb was fixing to the sediment and leaving the waters. Furthermore, a block diagram model was established to describe the transferring process and variations of Pb in waters. Supposed that Pb content of the input of the sources was A, Pb content of the sedimentation was B, Pb content of the removal was C, Pb contents in surface waters and bottom waters were n and m, respectively, and the changing curve of Pb contents in surface and bottom waters were Curve n and Curve M, respectively. The changing of Pb in surface and bottom waters and the vertical transferring process could be described in the block diagram model in Fig. 2.

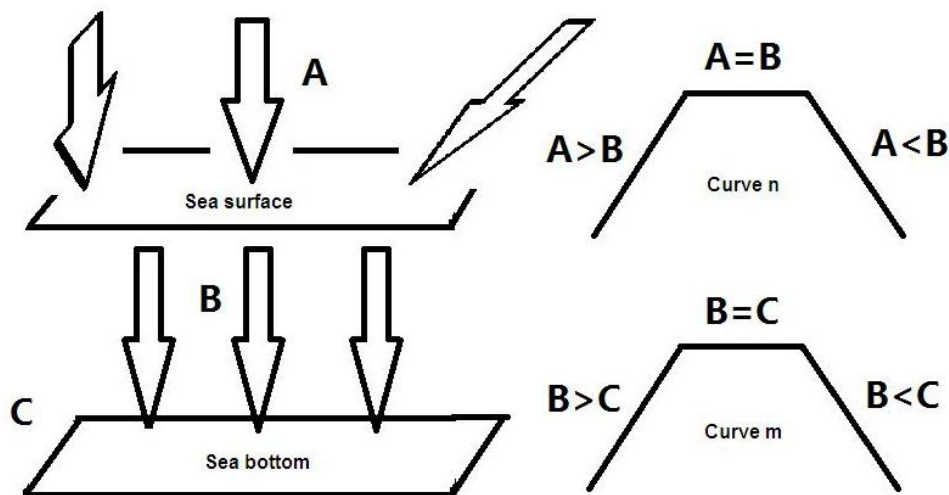


Fig. 2 The block diagram model for the vertical transferring process of Pb

In surface waters, the changing of Pb and the vertical transferring process could be described as:

In case of  $A > B$ , the Curve n was increasing (i.e.,  $t_1 > t_2$ ,  $n_1 > n_2$ ),  $n_k$  was Pb contents in surface waters in  $t_k$  time,  $k=1, 2$ .

In case of  $A = B$ , the Curve n was not changing (i.e.,  $t_1 > t_2$ ,  $n_1 = n_2$ ),  $n_k$  was Pb contents in surface

waters in  $t_k$  time,  $k=1, 2$ .

In case of  $A < B$ , the Curve  $n$  was decreasing (i.e.,  $t_1 > t_2$ ,  $n_1 < n_2$ ),  $n_k$  was Pb contents in surface waters in  $t_k$  time,  $k=1, 2$ .

In bottom waters, the changing of Pb and the vertical transferring process could be described as:

In case of  $B > C$ , the Curve  $n$  was increasing (i.e.,  $t_1 > t_2$ ,  $m_1 > m_2$ ),  $m_k$  was Pb contents in bottom waters in  $t_k$  time,  $k=1, 2$ .

In case of  $B = C$ , the Curve  $n$  was not changing (i.e.,  $t_1 > t_2$ ,  $m_1 = m_2$ ),  $m_k$  was Pb contents in bottom waters in  $t_k$  time,  $k=1, 2$ .

In case of  $B < C$ , the Curve  $n$  was decreasing (i.e.,  $t_1 > t_2$ ,  $m_1 < m_2$ ),  $m_k$  was Pb contents in bottom waters in  $t_k$  time,  $k=1, 2$ .

## Conclusion

Pb contents in surface waters were changing with seasons within year, and Pb contents in bottom waters were influenced by which in surface waters by means of vertical transferring. The vertical transferring process was containing three stages. Firstly, Pb was transferring to surface waters in the bay. Secondly, Pb was transferring to bottom waters. Thirdly, Pb was fixing to the sediment and leaving the waters. The changing of Pb in surface and bottom waters and the transferring process could be described in the block diagram model.

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