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## Pb's Import-Export Process and Mechanism in Jiaozhou Bay

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### Abstract

This paper analyzed the import-export process of Pb in Jiaozhou Bay based on investigation of Pb in surface and waters in different seasons during 1979-1983. Results showed that the import-export process of Pb could be revealed by the horizontal distribution in surface and bottom waters. Once Pb contents were increasing from the bay to the open waters, it could be identified that Pb was importing from the open waters to the bay; once decreasing from the bay to the open waters, Pb was exporting from the bay to the open waters. The import-export process of Pb in surface and bottom waters were mainly determined by the input of Pb by these pollution sources, as well as the water exchange, sedimentation, and accumulation. On the basis of water exchange, once the source strengths of land-based sources were higher, Pb was tending to be exporting from the bay to the open waters; once the source strengths of marine current were higher, Pb was tending to be importing from the open waters to the bay.

### Keywords

Pb, Input, Output, Transferring process, Jiaozhou Bay.

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## 1. Introduction

A large amount of Pb-containing waste was discharging to the environment along with the rapid development of economic and population, and the Pb pollution has been one of the critical environmental issues in many marine bays since marine bay is the sink of various pollutants. In generally, Pb in a marine bay was mainly sourced from stream flow, atmosphere deposition and marine traffic etc. Meanwhile, marine current could be one of the major P sources since the relative high background value of Pb. Stream flow, atmosphere deposition and marine traffic could be considered as land-based pollution sources. Taking the bay mouth as the boundary, Pb could be imported to or exported from the bay. Hence, understanding the import-export 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 mechanism of the import-export process of Pb in this bay, and to provide scientific basis for environmental protection and the sustainable development of study area.

## 2. 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 River, Licun River, Dagu River, and Loushan River), 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].

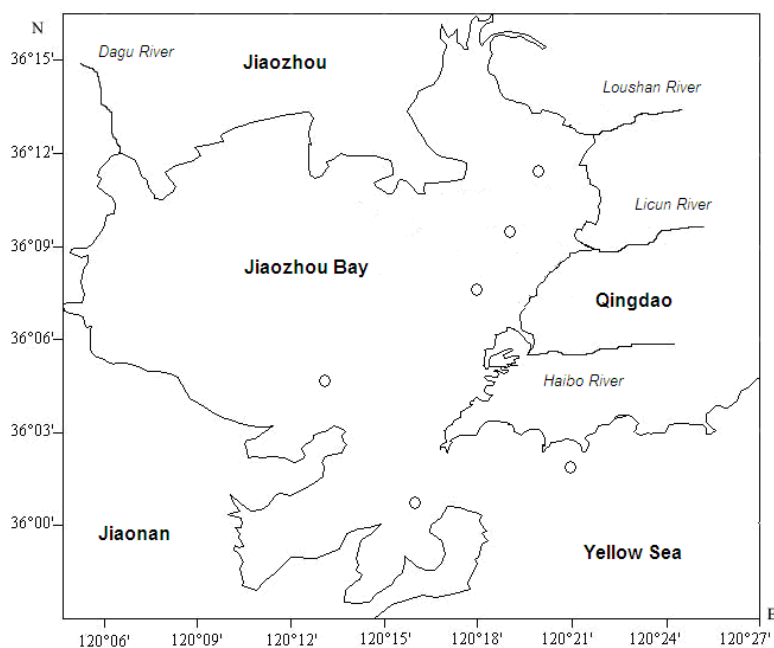


Fig.1 Geographic location and monitoring sites in Jiaozhou Bay

## 3. Results and discussion

The import-export process of Pb could be revealed by the horizontal distribution trends of Pb in surface and bottom waters. Once Pb contents were increasing from the bay to the open waters, it could be identified that Pb was importing from the open waters to the bay; once Pb contents were decreasing from the bay to the open waters, it could be identified that Pb was exporting from the bay to the open waters.

In according to the horizontal distribution trends of Pb in surface and bottom waters in 1979, it was found that, Pb in surface waters in May, August and October 1979 was exporting from the bay to the open waters, yet in bottom waters was importing from the open waters to the bay (Table 1).

Table 1 Import-export process of Pb in surface and bottom waters in 1979

Month	Surface waters	Bottom waters	Same or reverse
May	Exporting	Importing	Reverse
August	Exporting	Importing	Reverse
October	Exporting	Importing	Reverse

In according to the horizontal distribution trends of Pb in surface and bottom waters in 1980, it was found that, in April, July and September 1980, Pb in surface and bottom waters was importing from the open waters to the bay (Table 2). In October 1980, Pb in surface waters was importing from the open waters to the bay, yet in bottom waters was exporting from the bay to the open waters (Table 2).

Table 2 Import-export process of Pb in surface and bottom waters in 1980

Month	Surface waters	Bottom waters	Same or reverse
April	Importing	Importing	Same
July	Importing	Importing	Same
September	Importing	Importing	Same
October	Importing	Exporting	Reverse

In according to the horizontal distribution trends of Pb in surface and bottom waters in 1981, it was found that, in August and November 1981, Pb in surface and bottom waters was importing from the open waters to the bay (Table 3). In April 1981, Pb in surface waters was exporting from the bay to the open waters, yet in bottom waters was importing from the open waters to the bay (Table 3).

Table 3 Import-export process of Pb in surface and bottom waters in 1981

Month	Surface waters	Bottom waters	Same or reverse
April	Exporting	Importing	Reverse
August	Importing	Importing	Same
November	Importing	Importing	Same

In according to the horizontal distribution trends of Pb in surface and bottom waters in 1982, it was found that, in July and October 1982, Pb in surface waters was exporting from the bay to the open waters, yet in bottom waters was importing from the open waters to the bay (Table 4). In April 1982, Pb in surface waters was importing from the open waters to the bay, yet in bottom waters was exporting from the bay to the open waters (Table 4).

Table 4 Import-export process of Pb in surface and bottom waters in 1982

Month	Surface waters	Bottom waters	Same or reverse
April	Importing	Exporting	Reverse
July	Exporting	Importing	Reverse
October	Exporting	Importing	Reverse

In according to the horizontal distribution trends of Pb in surface and bottom waters in 1983, it was found that, in May and October 1983, Pb in surface was exporting from the bay to the open waters, yet in September 1983, Pb in surface waters was importing from the open waters to the bay (Table 5). In May and September 1983, Pb in bottom waters was exporting from the bay to the open waters, yet in October 1983, Pb was importing from the open waters to the bay (Table 5).

Table 5 Import-export process of Pb in surface and bottom waters in 1983

Month	Surface waters	Bottom waters	Same or reverse
May	Exporting	Exporting	Same
September	Importing	Exporting	Reverse
October	Exporting	Importing	Reverse

In different months during 1979-1983, Pb was importing from the open waters to the bay in some cases, yet was exporting from the bay to the open waters in some cases. In generally, the major sources of Pb in Jiaozhou Bay were stream flow, atmosphere deposition, and marine current and marine traffic. The import-export process of Pb in surface and bottom waters were mainly determined by the input of Pb by these pollution sources, as well as the water exchange, sedimentation, and accumulation.

Taking the bay mouth as a boundary, stream flow, atmosphere deposition and marine traffic could be considered as land-based pollution sources. Obviously, the source strengths of the land-based pollution sources were different in different seasons, yet the source strengths of marine current were relative stable. On the basis of water exchange, once the source strengths of land-based sources were higher, Pb was tending to be exporting from the bay to the open waters, and once the source strengths of marine current were higher, Pb was tending to be importing from the open waters to the bay. That was the mechanism of the import-export of Pb in marine bay.

#### 4. Conclusion

The import-export process of Pb could be revealed by the horizontal distribution in surface and bottom waters. Once Pb contents were increasing from the bay to the open waters, it could be identified that Pb was importing from the open waters to the bay; once decreasing from the bay to the open waters, Pb was exporting from the bay to the open waters. The import-export process of Pb in surface and bottom waters were mainly determined by the input of Pb by these pollution sources, as well as the water exchange, sedimentation, and accumulation. On the basis of water exchange, once the source strengths of land-based sources were higher, Pb was tending to be exporting from the bay to the open waters; once the source strengths of marine current were higher, Pb was tending to be importing from the open waters to the bay.

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#### References

- [1] Yang D F, Su C, Gao Z H, et al.: Chin. J. Oceanol. Limnol., Vol. 26(2008): 296-299.
- [2] Yang DF, Guo JH, Zhang YJ, et al.: Journal of Water Resource and Protection, Vol. 3(2011): 41-49.
- [3] Yang DF, Zhu SX, Wang FY, et al.: Applied Mechanics and Materials, Vol. 651-653(2014), p. 1419-1422.
- [4] Yang DF, Geng X, Chen ST, et al.: Applied Mechanics and Materials, Vol. 651-653 (2014), p. 1216-1219.
- [5] Yang DF, Ge HG, Song FM, et al.: Applied Mechanics and Materials, Vol. 651-653 (2014), p. 1492-1495.
- [6] Yang DF, Zhu SX, Wang FY, et al.: Applied Mechanics and Materials, Vol.651-653 (2014), p. 1292-1294.
- [7] Yang DF, Chen Y, Gao ZH, Zhang J, et al.: Chinese Journal of Oceanology and Limnology, Vol. 23(2005): 72-90.
- [8] Yang DF, Wang F, Gao ZH, et al.: Marine Science, Vol. 28 (2004), p.71-74.
- [9] State Ocean Administration. The specification for marine monitoring: Beijing, Ocean Precess, (1991).