

A review on the spatial-temporal migration and transformation law of Pb in Jiaozhou Bay

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Keywords: Pb, Spatial-temporal, Migration, Transformation, law, Jiaozhou Bay.

Abstract. This paper provided a review on the spatial-temporal, migration, transformation of Pb and their law in Jiaozhou Bay based on investigation of Pb in surface and waters in different seasons during 1979-1983. The vertical transferring processes of Pb and mechanism, spatial-temporal migration law of Pb and spatial-temporal migration process of Pb were revealed and analyzed. Furthermore, in according to the spatial-temporal migration process of Pb, the land transferring process, the waters transferring process, and the waters settling process were defining. These finding would be helpful to better understanding the migration and transferring process of Pb and the mechanism in marine bay.

Introduction

Pb had been widely used in industry and agriculture, and a large amount of Pb-containing waste was discharged to the environment along with the rapid increasing of industry. Nowadays, many marine bays have been polluted by Pb, and remaining crisis to the health of ecology, as well as human. Hence, understanding the spatial-temporal, migration, transformation of Pb and their law is essential to environmental protection [1-6].

Jiaozhou Bay is a semi-closed bay located in south of Shandong Peninsula, eastern China. Previous studies showed that the waters in this bay had been polluted by Pb since the reform and opening-up [1-6]. The aim of this paper was to analyze the spatial-temporal variations of Pb in surface and bottom waters in Jiaozhou Bay based on investigation data in waters in different seasons during 1979-1983, to provided a comprehensive analysis on the spatial-temporal, migration, transformation of Pb and their law, 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 km², 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 May, September and October 1979; June, July and September 1980; April, August and November 1981; April, June, July and October 1982; and May, September and October 1983 [1-6]. Surface and bottom water samples were collected and measured followed by National Specification for Marine Monitoring [9].

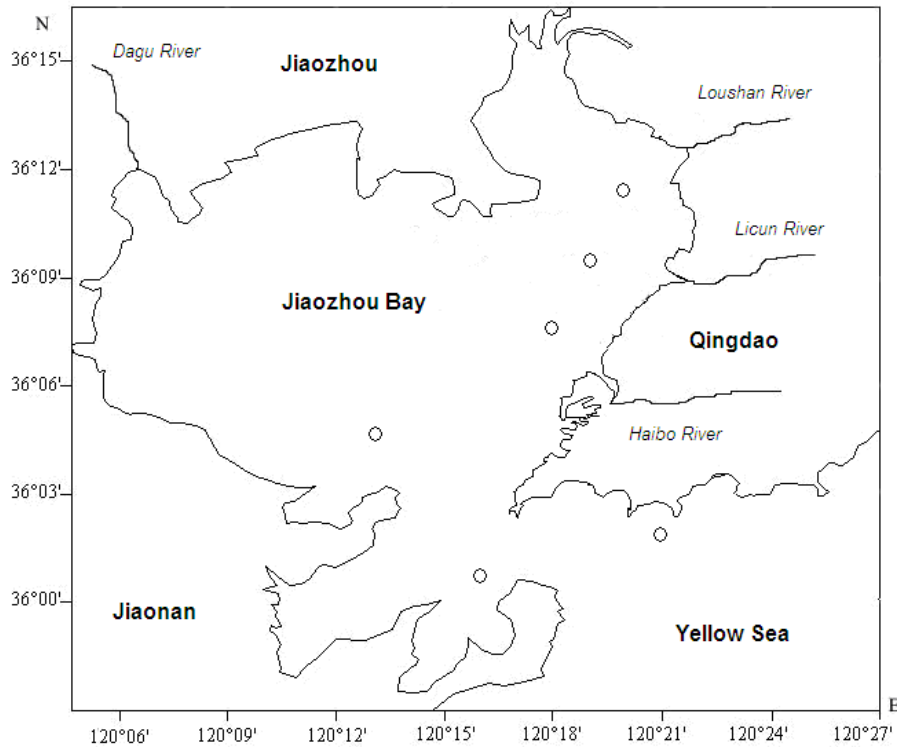


Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

Results and discussion

Vertical transferring processes of Pb and mechanism. At temporal scale, Pb contents in bottom waters were depending on which in surface waters, as well as the sedimentation, accumulation and fixing of Pb. During 1979-1983, there were three types of vertical migration processes of Pb in Jiaozhou Bay, i.e., peak type, lagged type and superposed type.

In according to the horizontal distribution of Pb, three horizontal distribution features of Pb contents in bottom waters were defined. Firstly, Pb was decreasing from the inside of the bay mouth to the outside of the bay mouth. Secondly, Pb was decreasing from the outside of the bay mouth to the inside of the bay mouth. Thirdly, Pb was decreasing from the bay mouth to the inside and outside of the bay mouth.

In the bay mouth and the inside of the bay mouth, the sedimentation rate of Pb was always very high, yet in the outside of the bay mouth the sedimentation rate of Pb was remaining in short time. By means of the overlay of the P sources of stream flow and marine current, there were high Pb sedimentation region in the bay mouth, that was the sedimentation mechanism of Pb in the bay mouth.

Spatial-temporal migration law of Pb. In according to the spatial-temporal distributions of Pb during 1979-1983, the migration law of Pb was revealed.

1) Pb has been used widely for a long time, and the soil, atmosphere, land surface, river, ocean have been polluted by Pb.

2) The long term discharging of Pb, leading to the slight polluted of the ocean for a long time, and the rivers have been changed from non-polluted to slight polluted.

3) Pb could be discharged to the environment suddenly, leading to the simultaneous slight polluted in the stream flow, atmosphere and the top of the island.

4) The development of marine traffic was also one of the reasons for Pb pollution in the ocean. 5) In generally, the pollution level of Pb in Jiaozhou Bay was slight, yet was deteriorating.

6) The major pollution sources of Pb in Jiaozhou Bay were stream flow, overland runoff, atmosphere deposition, marine curren, the top of the island and marine traffic.

7) Pb contents and their seasonal variations in marine waters were mainly determined by the

input of Pb by human activities.

8) By means of vertical water's effect, bottom waters were also being polluted by Pb, and the pollution level was moderate due to the accumulation of Pb in bottom waters.

9) The slight pollution level could be recovered to non-pollution, yet the moderate pollution level could only be recovered to slight pollution.

10) Pollution sources of marine current and stream flow were overlay in waters in the bay mouth, leading to the high sedimentation of Pb, and the sedimentation of Pb was enhancing the accumulation of Pb in bottom waters.

11) There were importing and exporting processes of Pb in the waters in the bay mouth.

12) Due to the different of the pollution sources in space and time, the horizontal distributions of Pb contents in surface and bottom waters were varying.

Spatial-temporal migration process of Pb. During 1979-1983, Pb contents in Jiaozhou Bay were changing significantly within year. Pb contents in surface waters in Jiaozhou Bay in 1979, 1980, 1981, 1982 and 1983 were $0.25-1.52 \mu\text{g L}^{-1}$, $0.07-2.71 \mu\text{g L}^{-1}$, $0.00-3.34 \mu\text{g L}^{-1}$, $0.30-3.35 \mu\text{g L}^{-1}$ and $0.58-2.34 \mu\text{g L}^{-1}$, respectively. In spring and autumn in the early stage, the pollution level of Pb could be as low as non-pollution, yet in spring and autumn in the later years, this bay was slight polluted by Pb. The major reason was that in discharging of Pb to Jiaozhou Bay was increasing year by year.

In according to the spatial-temporal migration process of Pb, 1) the land transferring process, 2) the waters transferring process, and 3) the waters settling process were defining. The land transferring process was the process of Pb from human activities to the ocean waters. This process was indicating that Pb contents in marine waters were mainly determined by the source strengths of the Pb sources and the frequency, and high Pb contents could be transferring to low contents by means of the moving of the waters.

The waters transferring process was including three steps as, 1) Pb was discharge to the bay by various sources, 2) Pb was diffusing to surface waters, and 3) Pb was settling to bottom waters from surface waters.

The waters settling process was also including three steps as, 1) Pb was input to surface waters, 2) Pb was settling to bottom waters from surface waters, and 3) Pb in bottom waters was fixing to sediment in sea bottom, and was removing from water body.

Conclusion

Based on investigation of Pb in surface and waters in different seasons Jiaozhou Bay during 1979-1983, a comprehensive review on the vertical transferring processes of Pb and mechanism, spatial-temporal migration law of Pb and spatial-temporal migration process of Pb were provided. Furthermore, in according to the spatial-temporal migration process of Pb, the land transferring process, the waters transferring process, and the waters settling process were defining. These findings would be helpful to better understanding the migration and transferring process of Pb and the mechanism in marine bay.

Acknowledgment

This research was sponsored by Doctoral Degree Construction Library of Guizhou Nationalities University, Education Ministry's New Century Excellent Talents Supporting Plan (NCET-12-0659), the China National Natural Science Foundations (31560107) and (31500394), Research Projects of Guizhou Nationalities University ([2014]02), Research Projects of Guizhou Province Ministry of Education (KY [2014] 266), Research Projects of Guizhou Province Ministry of Science and Technology (LH [2014] 7376).

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