Different types of seasonal changing processes of Pb in Jiaozhou bay

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Abstract. This paper analyzed the seasonal variations of Pb in surface and bottom waters in Jiaozhou Bay based on investigation of Pb in surface and waters in different seasons during 1979-1983. Results showed that at temporal scale, Pb contents in bottom waters were more or less increasing/decreasing along with the increasing/decreasing of Pb contents in surface waters. Meanwhile, the sedimentation, accumulation and fixing of Pb were also important factors influencing the seasonal changing of Pb in waters. The seasonal changing of Pb contents within year in surface and bottom waters was forming different curves, i.e., Peak type, Lagged type and Superposed type. These findings would be helpful to understand the influences of the variations of Pb contents in surface to which in bottom waters, as well as the seasonal variations of Pb contents in both surface and bottom waters.

Introduction

Ocean is the sink of various pollutants. Marine bays are always surrounding by many industries and cities, and therefore the pollution of marine bays has been one of the critical environmental issues. Due to the complex and variation of input-output of Pb in marine bay, water exchange, sedimentation, accumulation, fixing, the seasonal transferring process of Pb in Bay waters would be complex. However, understanding the seasonal transferring process is essential to 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 seasonal variations of Pb in surface and bottom waters in Jiaozhou Bay based on investigation data in surface waters in different seasons during 1979-1983, and to reveal the seasonal changing process of Pb in both surface and bottom waters 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^2, 7 m and 3 km, respectively. There are more than ten inflow rivers (i.e., Haibo Rriver, Licun Rriver, Dagu Rriver, and Loushan 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 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].

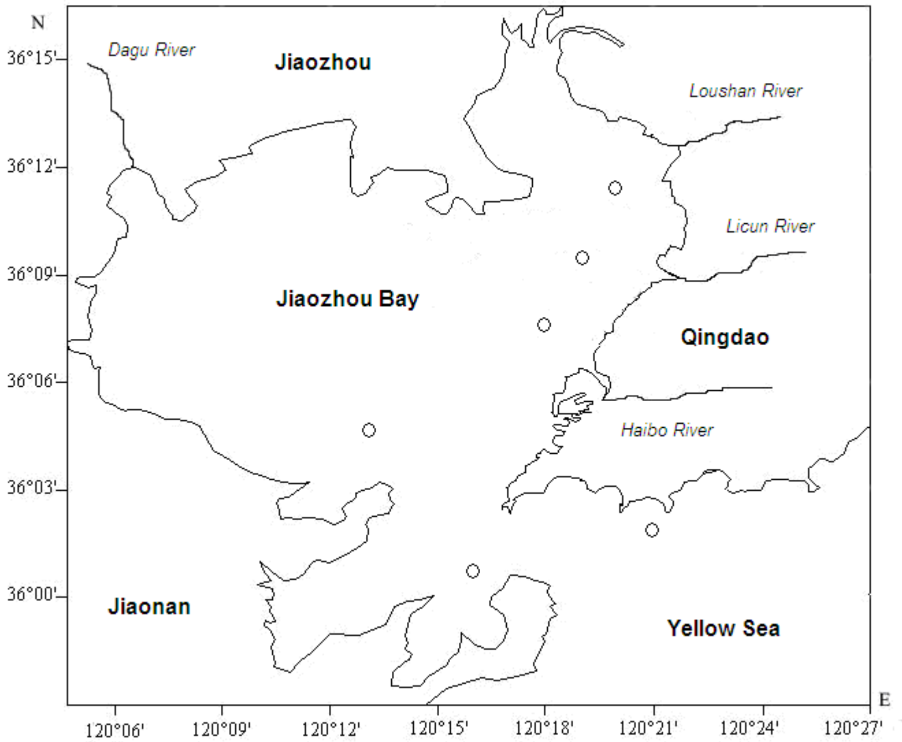

Fig.1 Geographic location and monitoring sites in Jiaozhou Bay

Results

In study area, April, May and June were spring; July, August and September were summer; October, November and December were autumn. The seasonal changing of Pb contents within year in surface and bottom waters was forming different curves.

In 1979, Pb contents in surface waters in May, September and October were 0.54-0.81 μg L^{-1}, 0.32-1.52 μg L^{-1} and 0.35-0.75 μg L^{-1}, respectively; while in bottom waters were 0.45-0.72 μg L^{-1}, 0.45-7.00 μg L^{-1} and 0.46-0.55 μg L^{-1}, respectively. The dynamic seasonal changing of Pb contents in surface waters was forming a peak curve, due to the input of Pb was also reaching the climax in summer and beginning to decrease in autumn. Meanwhile, the dynamic seasonal changing of Pb contents in bottom waters was forming a peak curve, same as which in surface waters, due to the sedimentation of Pb from surface water to bottom waters and the accumulation of Pb in bottom waters.

In 1980, Pb contents in surface waters in June, July, September and October were 0.26-0.88 μg L^{-1}, 0.51-2.71 μg L^{-1}, 0.33-1.59 μg L^{-1} and 0.07-0.89 μg L^{-1}, respectively; while in bottom waters were 0.12-1.49 μg L^{-1}, 0.24-0.85 μg L^{-1}, 0.26-0.75 μg L^{-1} and 0.07-1.60 μg L^{-1}, respectively. The dynamic seasonal changing of Pb contents in surface waters was forming a linear curve that increasing with time, due to the input of Pb was increasing along with season in this year. However, the dynamic seasonal changing of Pb contents in bottom waters was forming a linear curve that decreasing with time, due to the sedimentation of Pb from surface water to bottom waters and the accumulation of Pb in bottom waters had the lag effect.

In 1981, Pb contents in surface waters in April, August and November were 0.34-2.33 μg L^{-1}, 1.67-2.94 μg L^{-1} and 0.96-3.30 μg L^{-1}, respectively; while in bottom waters were 0.01-2.41 μg L^{-1}, 1.25-5.16 μg L^{-1} and 0.93-1.95 μg L^{-1}, respectively. The dynamic seasonal changing of Pb contents in surface waters was also forming a linear curve that increasing with time, due to the input of Pb was increasing along with season in this year. However, the dynamic seasonal changing of Pb contents in bottom waters was forming a peak curve, different which in surface waters. The reason was that Pb in bottom waters could be increasing by means of sedimentation and accumulation, and could be decreasing by means of the fixing of Pb in the sediment, which was the removal of Pb from waters.

In 1982, Pb contents in surface waters in April, July and October were 0.49-3.25 μg L^{-1}, 0.30-2.67 μg L^{-1} and 0.33-0.67 μg L^{-1}, respectively; while in bottom waters were 0.52-1.03 μg L^{-1}, 0.30-1.00 μg L^{-1} and 0.13-1.00 μg L^{-1}, respectively. The dynamic seasonal changing of Pb contents in surface waters was forming a linear curve that decreasing with time, due to the input of Pb was decreasing along with season in this year. However, the dynamic seasonal changing of Pb contents in bottom waters was forming no trend. The reason was that Pb in bottom waters could be increasing by means of sedimentation and accumulation.

In 1983, Pb contents in surface waters in May, September and October were 0.75-1.47 μg L^{-1}, 0.67-2.33 μg L^{-1} and 1.06-1.56 μg L^{-1}, respectively; while in bottom waters were 0.95-1.15 μg L^{-1}, 1.06-1.56 μg L^{-1} and 0.46-2.40 μg L^{-1}, respectively. The dynamic seasonal changing of Pb contents in surface waters was also forming a linear curve that decreasing with time during spring to summer, yet was remaining in a relative high stage in autumn. Since the sedimentation of Pb was contentious with time, Pb in bottom waters would be increasing.

Discussion

At temporal scale, Pb contents in bottom waters were more or less increasing/decreasing along with the increasing/decreasing of Pb contents in surface waters. However, the sedimentation, accumulation and fixing of Pb were also important factors influencing the seasonal changing of Pb in waters. During 1979-1983, there were three types of seasonal changing process of Pb in Jiaozhou Bay.

Peak type. Pb contents in surface waters were forming a peak curve along with month within year, as well as in bottom waters. Pb in surface waters were settling and accumulating to bottom waters continuously, leading to the peak value of Pb in bottom waters. However, by means of the fixing of Pb to sediment, a large amount of Pb was removed from waters, leading to the decreasing of Pb in bottom waters. Hence, Pb contents in both surface and bottom waters were increasing to a peak, and were decreasing later.

Lagged type. By means of the continuous sedimentation of Pb from surface waters to bottom waters, Pb contents would be decreasing along with seasons within year. However, the amount of the sedimentation of Pb could be not enough or not in time, leading to the seasonal changing of Pb contents bottom waters was lagging from which in surface waters.

Superposed type. Pb contents in surface waters were always lower than which in bottom waters, and was decreasing along seasons with year. The reason was that most of Pb was sourced by marine current from the open waters and stream flow. By means of the superposition of the input of Pb from both marine current and stream flow, Pb contents in bottom waters in the bay mouth would be relative high.

Conclusion

At temporal scale, Pb contents in bottom waters were more or less increasing/decreasing along with the increasing/decreasing of Pb contents in surface waters. However, the sedimentation, accumulation and fixing of Pb were also influencing factors influencing the seasonal changing of Pb. The seasonal changing of Pb contents within year in surface and bottom waters was forming different curves, i.e., Peak type, Lagged type and Superposed type. These findings would be helpful to understand the influences of the variations of Pb contents in surface to which in bottom waters, as well as the seasonal variations of Pb contents in both surface and bottom waters.

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