

## Seasonal-vertical variations of Pb and their mechanisms in marine bay

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**Abstract.** This paper analyzed the content, distribution, seasonal and vertical variations of Pb in Jiaozhou Bay based on investigation data in surface and bottom waters in different seasons in 1982 and 1983. Results showed the seasonal variations of Pb contents in surface and bottom waters were consist in generally. However, in case of Pb contents were high enough in summer, a large amount of Pb was absorbing and settling to the sea bottom under the force of gravity and current was the horizontal settling process of Pb, resulting in the higher Pb contents in bottom waters in autumn. The seasonal variations of Pb content in surface waters in Jiaozhou Bay were mainly determined by the variations of Pb source, while in bottom waters were determined by the Pb contents in surface waters and the vertical water's effect.

### Introduction

Along with the rapid development of economic and population, the Pb pollution has been one of the critical environmental issues on a worldwide scale. In nowadays, many marine bays had been polluted by Pb [1-6], and many serious or essential eco-environmental risks were remaining. Understanding the seasonal and vertical variations of Pb in marine bay, as well as their mechanisms was essential to marine environmental protection.

Jiaozhou Bay is a semi-closed bay located in south of Shandong Peninsula, eastern Chin. The aim of this paper was to analyze the content, distribution, seasonal and vertical variations of Pb in Jiaozhou Bay based on investigation data in surface and bottom waters in different seasons in 1982 and 1983, and to provide scientific basis for the research on the source, pollution level and transfer process, and for the sustainable development of study area.

### Material and method

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 such as Haibo Rriver, Licun Rriver, Dagu Rriver, and Loushan Rriver etc., most of which have seasonal features [7-8].

The data was provided by North China Sea Environmental Monitoring Center. The survey was conducted in April, July and October 1982, and May, September and October 1983 [1-6]. Surface and bottom water samples in six stations (i.e. 2031, 2032, 2033, 2034, 2035 and 2047) were collected and measured followed by National Specification for Marine Monitoring [9].

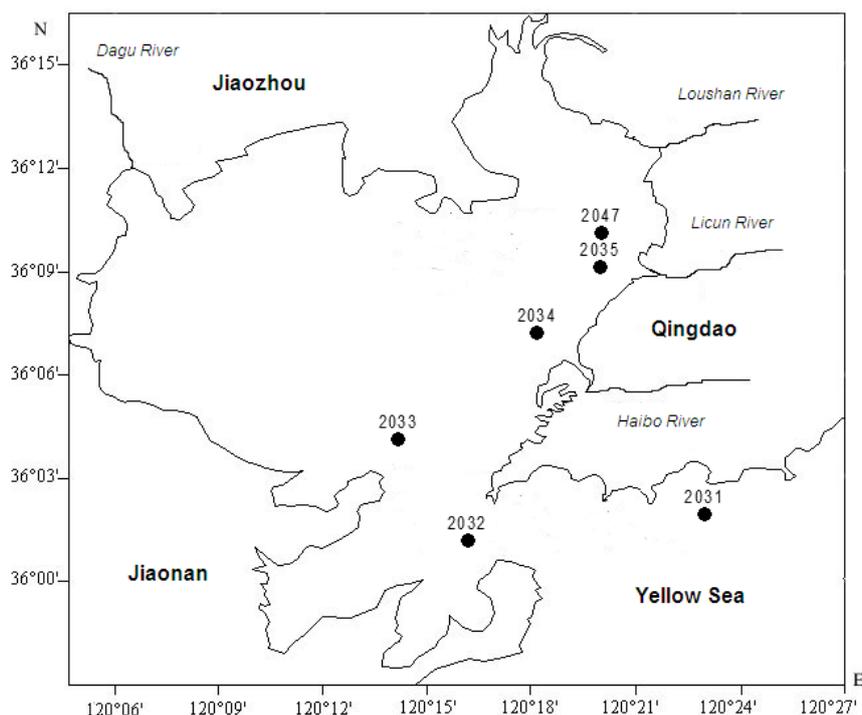


Fig.1 Geographic location and monitoring sites in Jiaozhou Bay

## Results

For seasonal division in study area, April, May and June were spring, July, August and September were summer, and October was autumn. In April, July and October 1982, Pb contents in surface waters were  $0.49\text{--}3.25\ \mu\text{g L}^{-1}$ ,  $0.30\text{--}2.67\ \mu\text{g L}^{-1}$  and  $0.33\text{--}0.67\ \mu\text{g L}^{-1}$ , respectively; while in bottom waters were  $0.52\text{--}1.03\ \mu\text{g L}^{-1}$ ,  $0.30\text{--}1.00\ \mu\text{g L}^{-1}$  and  $0.33\text{--}1.00\ \mu\text{g L}^{-1}$ , respectively. In generally, Pb contents in both surface and bottom waters in 1982 were in order of spring > summer > autumn (Table 1). Hence, it could be found that the seasonal variations of Pb contents in surface and bottom waters in 1982 were consist. In according to the vertical variations, it was seemed that the Pb contents in bottom waters were determined by which in surface waters.

Table 1 Contents of Pb in different seasons in Jiaozhou bay 1982/ $\mu\text{g L}^{-1}$

Water layer	Spring	Summer	Autumn
Surface waters	0.49-3.25	0.30-2.67	0.33-0.67
Bottom waters	0.52-1.03	0.30-1.00	0.33-1.00

In May, September and October 1983, Pb contents in surface waters were  $0.75\text{--}1.47\ \mu\text{g L}^{-1}$ ,  $0.67\text{--}2.33\ \mu\text{g L}^{-1}$  and  $1.00\text{--}2.22\ \mu\text{g L}^{-1}$ , respectively; while in bottom waters were  $0.95\text{--}1.15\ \mu\text{g L}^{-1}$ ,  $1.06\text{--}1.56\ \mu\text{g L}^{-1}$  and  $0.46\text{--}2.40\ \mu\text{g L}^{-1}$ , respectively. Pb contents in surface waters in 1983 were in order of summer > autumn > spring, while in bottom waters were in order of autumn > summer > spring. Hence, it could be found that the seasonal variations of Pb contents in surface and bottom waters in 1983 were not consist. In according to the vertical variations, however, it was seemed that the Pb contents in bottom waters were determined by which in surface waters.

Table 2 Contents of Pb in different seasons in Jiaozhou bay 1983/ $\mu\text{g L}^{-1}$

Season	Spring	Summer	Autumn
Surface waters	0.75-1.47	0.67-2.33	1.00-2.22
Bottom waters	0.95-1.15	1.06-1.56	0.46-2.40

## Discussions

The major sources of Pb in Jiaozhou Bay were stream flow, atmosphere deposition, marine current, etc. The seasonal variations of Pb contents were mainly determined by the variations of the sources strengths. In generally, the rainfall-runoff in study area was increasing in spring and reaching the climax in summer, and therefore Pb contents in surface waters in summer should be relative high. However, in 1982, the rainfall-runoff in summer was relative low, and Pb contents in summer and autumn were lower than in spring.

Once Pb was transferred to the surface waters, it could be absorbed, complex and co-precipitated by particulate and organic matters [11-12], so the Pb in surface waters was settling to the sea bottom under the force of gravity and current, and was accumulated in bottom waters. The seasonal variations of Pb were mainly determined by vertical water's effect [13], and the seasonal variations of Pb contents in surface and bottom waters were consist in generally. Hence, it could be found that Pb contents in both surface and bottom waters in 1982 were in order of spring > summer > autumn.

In summer, the activities of zooplankton and phytoplankton were increasing, which were able to increase the adsorption capacity of suspended particulate matters due to the large production of colloid [14]. In case of Pb contents were high enough in summer, a large amount of Pb was absorbing and settling to the sea bottom under the force of gravity and current was the horizontal settling process of Pb, resulting in the higher Pb contents in bottom waters in autumn. Hence, Pb contents in surface waters in 1983 were in order of summer > autumn > spring, yet in bottom waters were in order of autumn > summer > spring.

In generally, the seasonal variations of Pb content in surface waters in Jiaozhou Bay were mainly determined by the variations of Pb source, while in bottom waters were determined by the Pb contents in surface waters and the vertical water's effect. The vertical transfer process was one of the key processes of Pb in this bay, since a large amount of Pb could transferred from surface waters to bottom waters. However, the accumulation of Pb in bottom waters and sediments would be another environmental issue due to the high toxicity of Pb to the marine organism, and the essential harmful to human beings by means of food chain.

## Conclusions

The seasonal variations of Pb contents in surface and bottom waters were consist in generally. However, in case of Pb contents were high enough in summer, a large amount of Pb was absorbing and settling to the sea bottom under the force of gravity and current was the horizontal settling process of Pb, resulting in the higher Pb contents in bottom waters in autumn. The seasonal variations of Pb content in surface waters in Jiaozhou Bay were mainly determined by the variations of Pb source, while in bottom waters were determined by the Pb contents in surface waters and the vertical water's effect.

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