Jiaozhou Bay and Its Coastal Waters Polluted by Pb

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Abstract

Based on the investigation data on Pb in Jiaozhou Bay in April, July and October 1986, we analyzed the contents, distributions, pollution levels and sources of Pb. Results showed that Pb contents were 12.63-44.12 μg L^{-1}, and were meeting Grade IV in according to National Standard of China for Seawater Quality (GB3097-1997), indicated that this bay had been heavily polluted by Pb in 1986. There were theree major sources of Pb, i.e., stream flow, the top of the island and marine current, whose source strengths were 25.82-44.12 μg L^{-1}, 34.91 μg L^{-1} and 25.60-27.40 μg L^{-1}, respectively. Jiaozhou Bay had been heavily polluted by Pb in the early stage of Chinese Reform and Opening-up, and the source control of Pb was necessary. Marine current had been one of the major Pb sources, indicating that the pollution control and environmental remediation of Pb in Jiaozhou Bay would be a long-time and hard task.

Keywords

Pb; Distributions; Sources; Pollution level; Jiaozhou Bay.

1. Introduction

Pb is one of the heavy metal widely used in industry, agriculture and everyday life. However, Pb is also one of the critical heavy metal due to the high toxicity. A large amount of Pb-containing wastes were generated along with the rapid increasing of industry and agriculture yet the waste treatment was always lagging. Hence, the marine environment was finally polluted since ocean is the sink of various pollutants [1-6]. Furthermore, the pollution of marine environment could finally be harmful to human beings by means of food chain.

Hence, it is necessary to understanding the distribution, pollution level and sources of Pb in the marine environment. Jiaozhou Bay is a semi-closed bay located in Shandong Province, eastern China, and has been polluted by various pollutants including Pb [1-7]. Based on the investigation data on Pb waters in April, July and October 1986 in Jiaozhou Bay, the aim of this paper was to analysis the content, pollution level, and sources of CPb, and to provide basis for the research and pollution control countermeasures on Pb.

2. Materials and method

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) is located in the south of Shandong Peninsula, eastern China. The area and and average water depth are 460 km^2 and 7 m, respectively, yet the bay mouth is only 2.5 km (Fig. 1). This bay is surrounding by cities of Qingdao, Jiaozhou and Jiaonan in the east, north and south, and is connected with the Yellow Sea in the south. There are more than ten

inflow rivers such as Loushan River, Licun River and Haibo River, all of which are seasonal rivers [7-8].

The investigation on Pb in surface waters in Jiaozhou Bay was conducted by North China Sea Environmental Monitoring Center in April, July and October 1986 (Fig. 1). The investigation and measurement of Pb were followed by National Specification for Marine Monitoring [9].

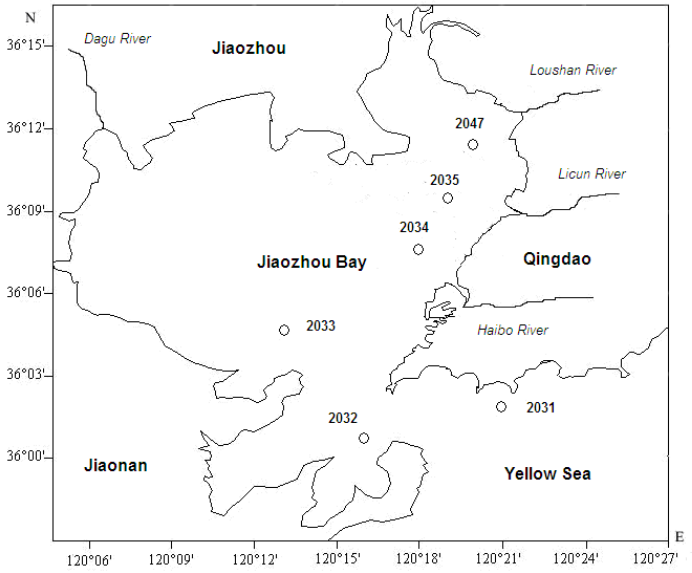

Fig.1 Geographic location and sampling sites of Jiaozhou Bay

3. Results

Contents and pollution levels of Pb. Pb contents in surface waters in Jiaozhou Bay in April, July and October 1986 were 12.63-25.60 μg L^{-1}, 25.57-44.12 μg L^{-1} and 15.26-27.80 μg L^{-1}, respectively (Table 1). In according to National Standard of China for Seawater Quality (GB3097-1997) (Table 2), this bay was heavy contaminated by Pb in different seasons in 1986 (Table 1).

Table 1. The pollution level of Pb in Jiaozhou bay in April, July and October 1986

	May	September	October
Content /μg L^{-1}	12.63-25.60	25.57-44.12	15.26-27.80
Grade	IV	IV	IV

Table 2. The guideline of Pb in National Standard of China for Seawater Quality (GB3097-1997)

Grade	I	II	III	IV
Guideline /μg L^{-1}	1.00	5.00	10.00	50.00

Horizontal distributions of Pb. In April 1986, high value of Pb contents were occurred in Site 2035 in the estuary of Licun River in the northeast of the bay (25.82 μg L^{-1}), and there was a high value region around Site 2035. The contour lines were forming a series of semi-concentric circles that decreasing from the high value center to the bay mouth (12.63 μg L^{-1}) (Fig. 2). Meanwhile, another high value of Pb contents were occurred in Site 2031 in the open waters outside the bay mouth (25.60 μg L^{-1}), and there was a high value region around Site 2031 in the coastal waters. The contour lines were forming a series of parallel lines that decreasing from the high value center to the bay mouth (12.63 μg L^{-1}) (Fig. 2).

In July 1986, high value of Pb contents were occurred in Site 2047 in the estuary of Loushan River in the northeast of the bay (44.12 μg L^{-1}), and there was a high value region around Site 2047. The contour lines were forming a series of semi-concentric circles that decreasing from the high value center to the estuary of Haibo River (25.57 μg L^{-1}) (Fig. 3). Meanwhile, another high value of Pb contents were occurred in Site 2032 in the bay mouth (34.91 μg L^{-1}), and there was a high value

region around Site 2032. The contour lines were forming a series of semi-concentric circles that decreasing from the high value center to the estuary of Haibo River (25.57 μg L^{-1}) (Fig. 3).

In October 1986, high value of Pb contents were occurred in Site 2035 in the estuary of Licun River in the northeast of the bay (27.80 μg L^{-1}), and there was a high value region around Site 2035. The contour lines were forming a series of semi-concentric circles that decreasing from the high value center to the estuary of Haibo River (15.26 μg L^{-1}) (Fig. 4). Meanwhile, another high value of Pb contents were occurred in Site 2031 in the open waters outside the bay mouth (27.40 μg L^{-1}), and there was a high value region around Site 2031 in the coastal waters. The contour lines were forming a series of parallel lines that decreasing from the high value center to the estuary of Haibo River (12.63 μg L^{-1}) (Fig. 4).

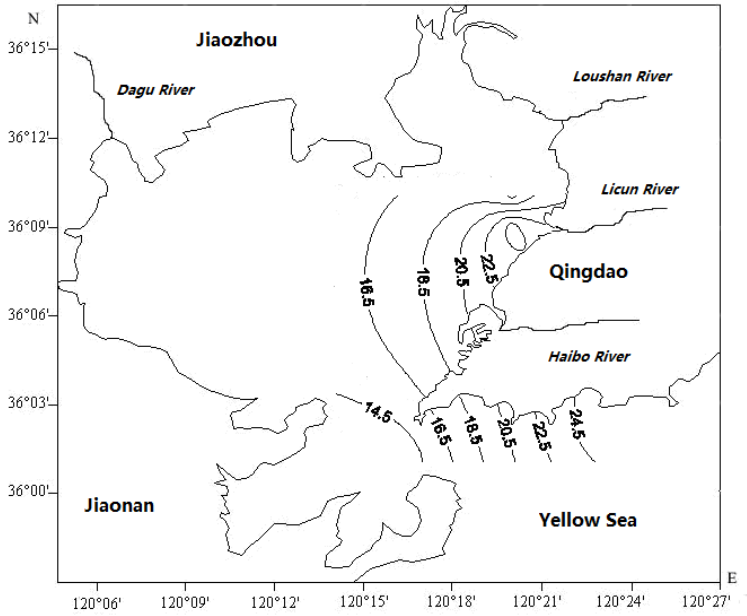

Fig. 2 Horizontal distribution of Pb in surface waters in Jiaozhou Bay in April 1986/μg L^{-1}

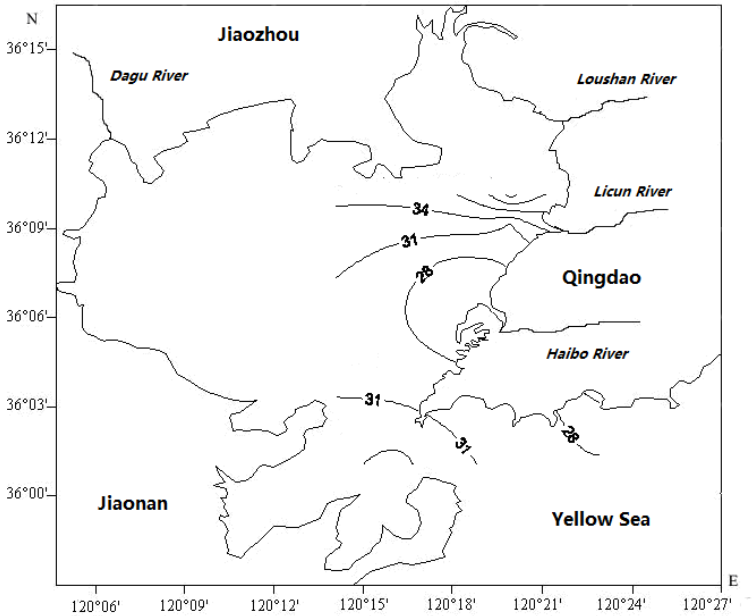

Fig. 3 Horizontal distribution of Pb in surface waters in Jiaozhou Bay in July 1986/μg L^{-1}

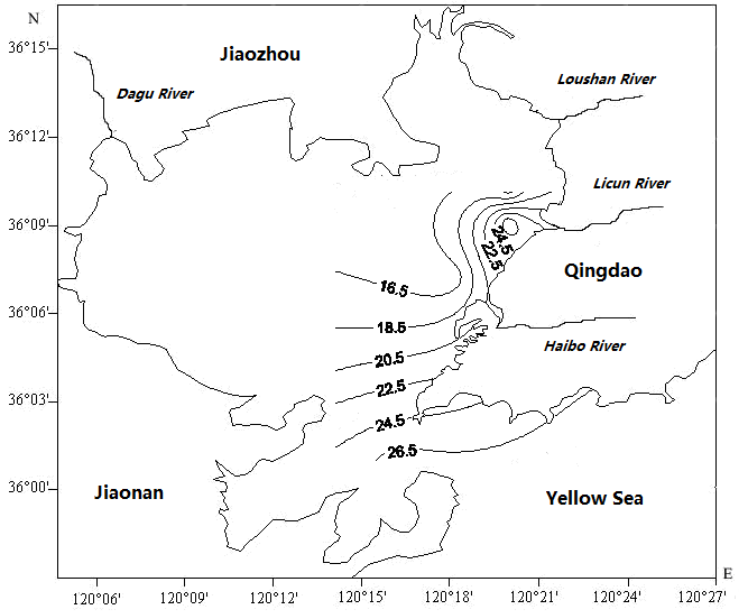

Fig. 4 Horizontal distribution of Pb in surface waters in Jiaozhou Bay in October 1986/μg L^{-1}

4. Discussion

Water quality of Pb. In April 1986, Pb contents were 12.63-25.60 μg L^{-1}, and were meeting Grade IV in National Standard of China for Seawater Quality (GB3097-1997), indicated that the whole study area including the bay, the bay mouth and the open waters were heavy polluted by Pb. Pb contents were relative high in the estuary of Licun River in the northeast of the bay, as well as in the open waters outside the bay mouth, indicated that the stream flow and the marine currents were heavy polluted by Pb in April 1986.

In July 1986, Pb contents were 25.57-44.12 μg L^{-1}, and were meeting Grade IV in National Standard of China for Seawater Quality (GB3097-1997), indicated that the whole study area including the bay, the bay mouth and the open waters were also heavy polluted by Pb. Pb contents were relative high in the estuary of Loushan River in the northeast of the bay, as well as in the bay mouth, indicated that the stream flow and the bay mouth were heavy polluted by Pb in July 1986.

In October 1986, Pb contents were 15.26-27.80 μg L^{-1}, and were meeting Grade IV in National Standard of China for Seawater Quality (GB3097-1997), indicated that the whole study area including the bay, the bay mouth and the open waters were also heavy polluted by Pb. Pb contents were relative high in the estuary of Licun River in the northeast of the bay, as well as in the open waters outside the bay mouth, indicated that the stream flow and the marine currents were heavy polluted by Pb in April 1986.

In generally, Pb contents in 1986 were 12.63-44.12 μg L^{-1}, and were meeting Grade IV in National Standard of China for Seawater Quality (GB3097-1997), indicated that the whole study area including the bay, the bay mouth and the open waters were heavy polluted by Pb.

Pollution sources of Pb. In according to the horizontal distributions of Pb in surface waters in different seasons, the major pollution sources of Pb could be identified. In April 1986, high value of Pb contents were occurred in Site 2035 in the estuary of Licun River in the northeast of the bay (25.82 μg L^{-1}), indicated that stream flow was one of the major sources, and the sources strength was 25.82 μg L^{-1} (Fig. 2). Another high value of Pb contents were occurred in Site 2031 in the open waters outside the bay mouth (25.60 μg L^{-1}), indicated that marine current was one of the major sources, and the sources strength was 25.60 μg L^{-1} (Fig. 2).

In July 1986, high value of Pb contents were occurred in Site 2035 in the estuary of Loushan River in the northeast of the bay (44.12 μg L^{-1}), indicated that stream flow was one of the major sources, and the sources strength was 44.12 μg L^{-1} (Fig. 3). Another high value of Pb contents were occurred in

Site 2032 in the bay mouth (34.91 μg L^{-1}), indicated that marine current was one of the major sources, and the sources strength was 34.91 μg L^{-1} (Fig. 3).

In October 1986, high value of Pb contents were occurred in Site 2035 in the estuary of Licun River in the northeast of the bay (27.80 μg L^{-1}), indicated that stream flow was one of the major sources, and the sources strength was 27.80 μg L^{-1} (Fig. 4). Another high value of Pb contents were occurred in Site 2031 in the open waters outside the bay mouth (27.40 μg L^{-1}), indicated that marine current was one of the major sources, and the sources strength was 27.40 μg L^{-1} (Fig. 4).

In generally, there were theree major sources of Pb, i.e., stream flow, the top of the island and marine current, whose source strengths were 25.82-44.12 μg L^{-1}, 34.91 μg L^{-1} and 25.60-27.40 μg L^{-1}, respectively (Table 3).

Table 3. Source strengths of different Pb sources in Jiaozhou bay 1986

Source	Stream flow	The top of the island	Marine current
Source strength/μg L-1	25.82-44.12	34.91	25.60-27.40

Implication of pollution control. In according to the source strengths of the major Pb sources (Table 3), the source strengths of stream flow, the top of the island and marine currents were all higher than 25.00 μg L^{-1}, indicating that both land and marine were heavy polluted by Pb in 1986. These finding revealed that the rapid development of industry and agriculture, as well as the increasing of population, a large amount of Pb-containing wastes were generated and discharged to the environment including atmosphere, river, soil and ocean. It should be noticed that 1986 was the early stage of Chinese Reform and Opening-up, and the heavy pollution of Pb was warning that the source control of Pb was necessary. Furthermore, marine current had been one of the major Pb sources, indicating that the pollution control and environmental remediation of Pb in Jiaozhou Bay would be a long-time and hard task.

5. Conclusion

Pb contents in 1986 in different seasons were 12.63-44.12 μg L^{-1}, and were meeting Grade IV in National Standard of China for Seawater Quality (GB3097-1997), indicated that the whole study area including the bay, the bay mouth and the open waters were heavy polluted by Pb.

There were theree major sources of Pb, i.e., stream flow, the top of the island and marine current, whose source strengths were 25.82-44.12 μg L^{-1}, 34.91 μg L^{-1} and 25.60-27.40 μg L^{-1}, respectively, which were all higher than 25.00 μg L^{-1}, indicating that both land and marine were heavy polluted by Pb in 1986.

In the early stage of Chinese Reform and Opening-up, Jiaozhou Bay had been heavily polluted by Pb, and the source control of Pb was necessary. Marine current had been one of the major Pb sources, indicating that the pollution control and environmental remediation of Pb in Jiaozhou Bay would be a long-time and hard task.

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