Spatial-temporal changes of Cr sources in Jiaozhou Bay

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Abstract. Cr pollution in marine bay is one of the environmental issues in many countries and regions, and the understanding of the spatial-temporal variation of Cr sources in marine bay is essential to pollution control. Based on investigation on Cr in surface waters, this paper analyzed distributions and spatial-temporal variations of Cr sources in Jiaozhou Bay, eastern China during 1979-1983. Results showed that for spatial variations, the strong Cr sources were in estuaries of the major inflow rivers (i.e. Haibo River, Licun River and Loushan River), and the source strengths were 4.17-112.30 μg L⁻¹. For temporal variations, the source strengths were changing from moderate stage (1979-1981) to slight stage (1982-1983), whose source strengths were 32.32-112.30 μg L⁻¹ and 4.17-19.76 μg L⁻¹, respectively. In general, the spatial-temporal variations of Cr sources in Jiaozhou Bay were significant, which should be taken into account for the countermeasures for pollution control.

1 Introduction

Marine is the sink of pollutants, and a lot of marine bay has been polluted due to the rapid increase of industry and population [1-4]. Cr is a widely used heavy metal in various industries, and Cr pollution in marine bay is one of the environmental issues in many countries and regions. Hence, understanding the spatial-temporal variation of Cr sources in marine bays are essential to pollution control.

Jiaozhou Bay is a semi-closed bay located in Shandong Province, eastern China, and has been polluted by various pollutants including Cr due to the rapid increasing of industry along with China’s Reform and Opening-up [5-8]. In order to better understand the spatial-temporal variation of Cr sources, this paper analyzed distributions and spatial-temporal variations of Cr sources in Jiaozhou Bay, eastern China during 1979-1983. The results provided basic information for pollution control and environmental remediation in this Bay.

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, bay mouth width and average water depth and average water depth are 390 km², 2.5 km and 7.0 m, respectively (Fig. 1). This bay is surrounding by cities of Qingdao, Jiaozhou and Jiaonan in the east, north and south, respectively. The bay mouth is located in the south of the bay, and is connected with the Yellow Sea. There are more than ten inflow rivers such as Loushan River, Licun River and Haibo River, all of which are seasonal rivers [9-10].

The investigation on Cr in surface waters in Jiaozhou Bay was conducted by North China Sea
Environmental Monitoring Center. The investigation times were in May and August 1979, April and August 1981, June 1982, and May, September and October 1983, respectively [1-8], and the sampling sites were showed in Fig. 1. The investigation and measurement of Cr were following by National Specification for Marine Monitoring [11].

3 Spatial variations of Cr source
In May 1979, high Cr contents were appearing the estuaries of Loushan River and Licun River, and the contour lines of Cr contents were a series of parallel lines that decreasing from the northeast of the bay (112.30 μg L⁻¹) to the bay mouth in the south (0.20 μg L⁻¹). In August 1979, high Cr contents were appearing the estuaries of Haibo River, and the contour lines of Cr contents were a series of parallel lines that decreasing from the east of the bay (1.40 μg L⁻¹) to the west of the bay (0.10 μg L⁻¹).

In April 1981, high Cr contents were appearing the estuaries of Haibo River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the east of the bay (32.32 μg L⁻¹) to the center of the bay (0.48 μg L⁻¹). Meanwhile, high Cr contents were appearing the estuaries of Loushan River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the northeast of the bay (25.40 μg L⁻¹) to waters around (0.88 μg L⁻¹). In August 1981, high Cr contents were appearing the estuaries of Haibo River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the east (1.85 μg L⁻¹) to the center of the bay (0.70 μg L⁻¹).

In June 1982, high Cr contents were appearing the estuaries of Loushan River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the northeast of the bay (9.76 μg L⁻¹) to the bay mouth (0.33 μg L⁻¹).

In May 1983, high Cr contents were appearing the estuaries of Loushan River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the northeast of the bay (3.96 μg L⁻¹) to the bay mouth (0.13 μg L⁻¹). In September 1983, high Cr contents were appearing the estuaries of Loushan River and Licun River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the northeast of the bay (3.78 μg L⁻¹) to the bay mouth (0.70 μg L⁻¹). In October 1983, high Cr contents were appearing the estuaries of Loushan River and
Licun River, and the contour lines of Cr contents were a series of semi-concentric circles that decreasing from the northeast of the bay (4.17 μg L\(^{-1}\)) to the bay mouth (1.44 μg L\(^{-1}\)).

In generally, the spatial distributions of Cr contents were indicating the spatial variations of Cr sources. In according to the spatial distributions of Cr contents, it could be defined that high value regions were appearing in the estuaries of the inflow rivers, particularly in Haibo River, Loushan River and Licun River, and the source strengths were ranging from 4.17-112.30 μg L\(^{-1}\).

### 4 Temporal variations of Cr source

In according to the spatial distributions of Cr contents in different years, the temporal variations of Cr source were also significant. In 1979, high Cr contents were appearing the estuaries of Haibo River, Loushan River and Licun River, and the source strength could be as high as 112.30 μg L\(^{-1}\). In 1981, high Cr contents were appearing the estuaries of Haibo River and Loushan River, and the source strength was 32.32 μg L\(^{-1}\). In 1982, high Cr contents were appearing the estuaries of Loushan River, and the source strength was 9.76 μg L\(^{-1}\). In 1983, high Cr contents were appearing the estuaries of Loushan River and Licun River, and the source strength was 4.17 μg L\(^{-1}\).

For temporal variations, the source strengths were changing from two stages of moderate to slight. The first stage was 1979-1981, whose source strengths were 32.32-112.30 μg L\(^{-1}\). The second stage was 1982-1983, whose source strengths were 4.17-19.76 μg L\(^{-1}\). In generally, the temporal variations of Cr sources in Jiaozhou Bay were also significant, which should be taken into account the countermeasures for pollution control.

### 5 Conclusion

This paper analyzed distributions and spatial-temporal variations of Cr sources in Jiaozhou Bay, eastern China during 1979-1983. The spatial variation of Cr sources was significant that high value regions were appearing in the estuaries of the inflow rivers, particularly in Haibo River, Loushan River and Licun River, and the source strengths were ranging from 4.17-112.30 μg L\(^{-1}\). For temporal variations, the source strengths were changing from moderate stage to slight. The first stage was 1979-1981, whose source strengths were 32.32-112.30 μg L\(^{-1}\). The second stage was 1982-1983, whose source strengths were 4.17-19.76 μg L\(^{-1}\). The spatial-temporal variations of Cr sources in Jiaozhou Bay were significant, which should be taken into account the countermeasures for pollution control.

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