# Aggregation process of Cr in bottom waters in Jiaozhou Bay

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**Abstract.** This paper analyzed the content and distribution of Cr in bottom waters in Jiaozhou Bay in 1983. Results showed that Cr contents ranged from 0.06-1.58 μg $L^{-1}$, and were confirmed with Grade I(50 μg $L^{-1}$) in according to Chinese Sea Water Quality Standard (GB 3097-1997), indicated that the pollution level of Cr in bottom waters in this bay was very low in 1983. We found that there were high value (0.99-1.58 μg $L^{-1}$) regions in bottom waters in the bay mouth in different seasons. The reason was that the flow rate was high in the bay mouth, resulted aggregation process by means of the movement of the water body.

## Introduction

The environmental problems has been increasing along with the rapid development of industries after the reform and opening-up in China. Cr has been widely used in metallurgy, electroplating, chemistry etc. Cr is one of the critical heavy metal, which is toxic and harmful to human beings as well as the ecological environment. Marine environment particularly marine bays have long been suffering from various pollutants including Cr [1-4]. Understanding the pollution level and transfer process in bay waters is essential to environment protection en ecological remediation. Based on the investigation data on Cr in bottom waters in Jiaozhou Bay, Shandong Province, eastern China in 1983, this paper tried to analyze the content and transfer process of Cr, and to provide basic information of Cr pollution level in the early stage of reform and opening-up.

## Study area and data source

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) is located in Shandong Province, eastern China (Fig. 1). It is a semi-closed bay, whose total area, bay mouth width, and average water depth are 446 $km^2$, 2.5 km, and 7 m respectively. In the east, north and west of the bay are cities of Qingdao, Jiaozhou and Jiaonan, while the bay mouth is located in the south of the bay, and is connected with the Yellow Sea. This bay has more than ten inflow rivers, whose hydrology are strongly determined by rainfall-runoff, and are showing significant seasonal features [5-6].

The data was provided by North China Sea Environmental Monitoring Center, State Ocean Administration. The investigation on Cr in bottom waters at nine sampling sites was carried on in May, September and October 1983. The measurement of Cr was following by Chinese Specification for Marine Monitoring [7].

 

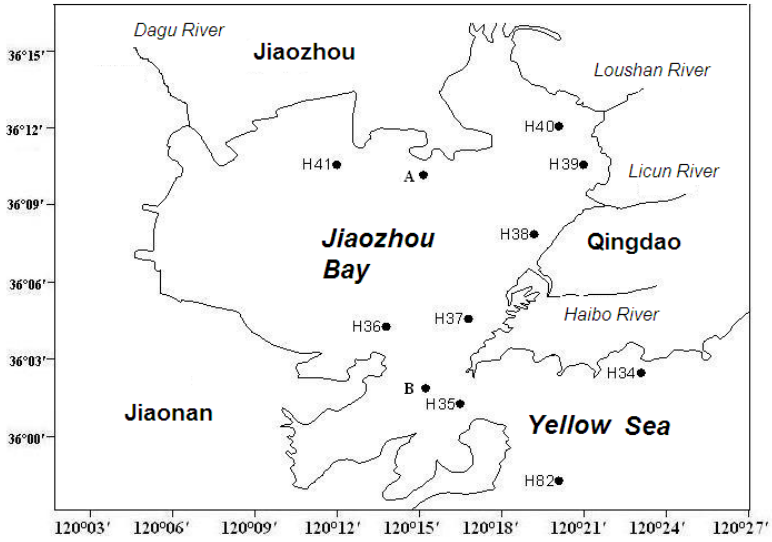


Fig.1 Geographic location and sampling sites of Jiaozhou Bay

## Cr content and pollution level in bottom waters

Cr contents in bottom waters in the 9 sampling sites ranged from 0.06-1.58 μg $L^{-1}$, and were confirmed with Grade I(50 μg $L^{-1}$) in according to Chinese Sea Water Quality Standard (GB 3097-1997). Inflow rivers were the major input channels of Cr to the bay. Once Cr was transferring from the surface waters to the bottom waters, the dilution effect of the vertical water body was generating [7], and therefore Cr in bottom waters was as low as about 2 percent of the guide line of Grade I. It could be seen from Table 1 that the ranges of the Cr contents were very close in different seasons, indicated that the seasonal variations of Cr was not significant. In generally, the pollution level of Cr in Jiaozhou Bay was very low in the early stage of reform and opening-up.

Table 1 Cr contents and pollution levels in bottom water in Jiaozhou Bay in 1983

| Time | May | September | October |
|---|---|---|---|
| Concentration/μg $L^{-1}$ | 0.06 to 1.08 | 0.46 to 1.17 | 0.63 to 1.58 |
| Grade | I | I | I |

## Horizontal distributions of Cr in bottom waters

The horizontal distributions of Cr in bottom waters in Jiaozhou Bay in May, September and October 1983 were showed in Fig. 2, Fig. 3 and Fig. 4, respectively. In May, The highest value of Cr contents was occurred in Site H37 (1.08 μg $L^{-1}$) in the east of the bay mouth, while low values were occurred in the bay mouth (0.11 μg $L^{-1}$). Cr contents in bottom waters were decreasing from the waters in the east of the bay mouth to the west of the bay mouth. A relative high value was occurred in Site H 35 in the bay mouth (0.4 μg $L^{-1}$), forming a high value center, and the contents were decreasing from the high value center to waters far away from the bay mouth (Fig. 2). In September, The highest value of Cr contents was occurred in Site H34 (1.17 μg $L^{-1}$) in the east of the bay, while low values were occurred in the southwest of the bay (0.11 μg $L^{-1}$). Cr contents in bottom waters were decreasing from the waters in the east of the bay mouth to the west of the bay mouth. A relative high value was occurred in Site H 35 in the bay mouth (1.12 μg $L^{-1}$), and the contents were decreasing from the high value center to the south far away from the bay mouth (Fig. 3). In October, the highest value was occurred in Site H35 in the bay mouth (1.58 μg $L^{-1}$), forming a high value center. Contents were decreasing from the high value center to the waters in the north of the bay. Meanwhile, there were a series of semi-concentric circles in the bay mouth, which were decreasing from the high value center to the waters outside the bay mouth (Fig. 4).

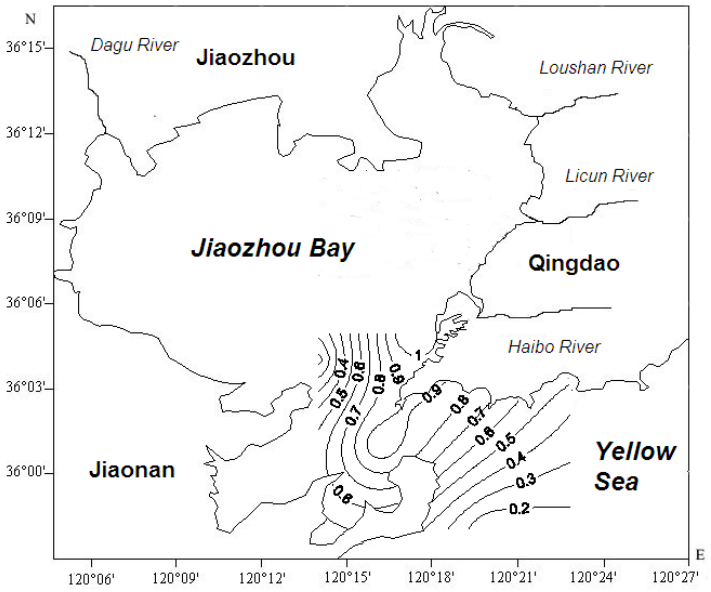


Fig. 2 Cr distributions in bottom waters in Jiaozhou Bay in May (μg $L^{-1}$)

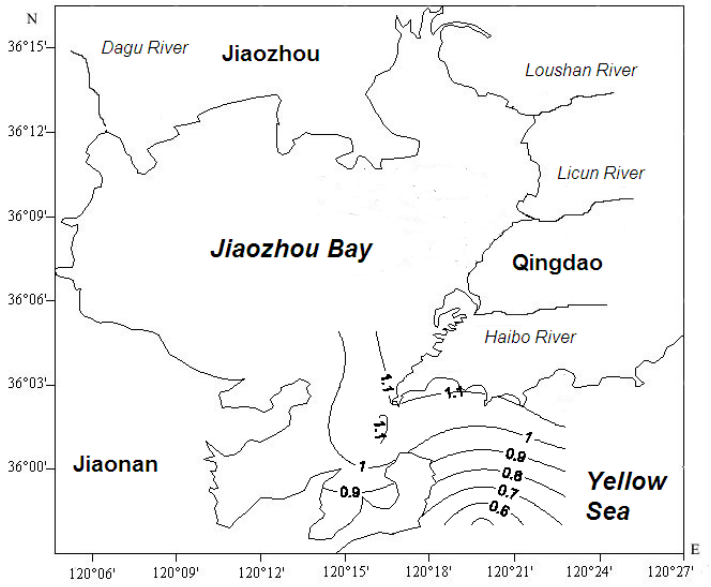


Fig. 3 Cr distributions in bottom waters in Jiaozhou Bay in September (μg $L^{-1}$)

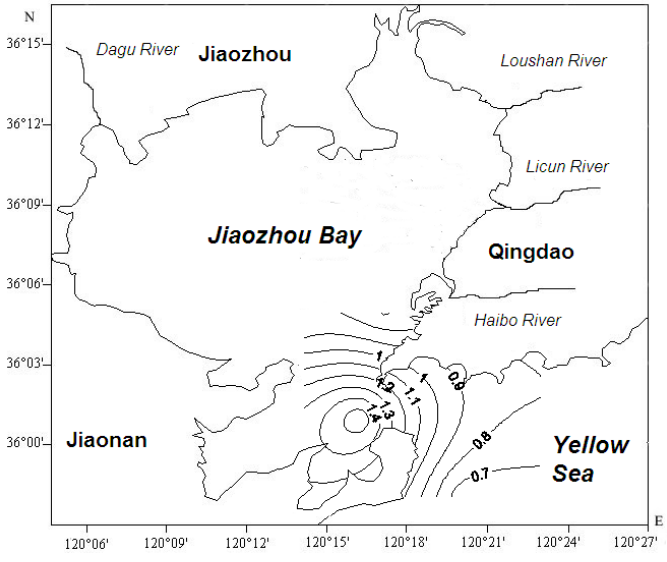


Fig. 4 Cr distributions in bottom waters in Jiaozhou Bay in October (μg $L^{-1}$)

## Aggregation process of Cr in bottom waters

Being a semi-closed bay, whose east-west width and north-south length are 27.8 km and 33.3 km, respectively. Actually, there are two bay mouths namely interior bay mouth and exterior bay mouth, respectively. Hence, there is a deep (40 m) water channel in the bay mouth. The tidal current in the water channel in the bay mouth is very strong, the amplitude of tidal current of $M_2$ is as high as 1m $s^{-1}$, and the instantaneous velocity of the flow in this water channel during the spring tide is 2.01 m $s^{-1}$ [8]. The high value regions of Cr contents in bottom waters were all occurred in Site H35 in the bay mouth in May, September and October, indicated that the high flow rate was high in the bay mouth, resulted aggregation process by means of the movement of the water body.

## Conclusions

Cr contents in bottom waters in Jiaozhou Bay ranged from 0.06-1.58 μg $L^{-1}$, and were confirmed with Grade I(50 μg $L^{-1}$) in according to Chinese Sea Water Quality Standard (GB 3097-1997). The high value regions of Cr contents in bottom waters were all occurred in Site H35 in the bay mouth in May, September and October, indicated that the high flow rate was high in the bay mouth, resulted aggregation process by means of the movement of the water body.

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