

## The impact of marine current to Cu contents in Jiaozhou Bay

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**Keywords:** Cu; Distributions; Sources; Pollution level; Marine current; Jiaozhou Bay.

**Abstract.** Based on the investigation data on Cu contents in different seasons in 1983 in surface waters in Jiaozhou Bay, we analyzed the contents, pollution level and distributions of Cu. Results showed that Cu contents in May, September and October were  $2.47\text{-}20.60 \mu\text{g L}^{-1}$ ,  $0.86\text{-}4.86 \mu\text{g L}^{-1}$  and  $0.77\text{-}3.00 \mu\text{g L}^{-1}$ , respectively. The major sources of Cu were marine current, stream flow, shipping, the top of the islands and overland runoff, whose source strengths were  $20.60 \mu\text{g L}^{-1}$ ,  $2.20\text{-}10.57 \mu\text{g L}^{-1}$ ,  $9.48 \mu\text{g L}^{-1}$ ,  $4.86 \mu\text{g L}^{-1}$  and  $2.28 \mu\text{g L}^{-1}$ , respectively. The influence of marine current to Cu contents in Jiaozhou Bay was strongest, indicated that the background pollution of Cu was the essential source in 1983.

### Introduction

A large amount of Cu-containing waste waters were generated along with the rapid increasing of industry and agriculture. The marine environment was finally polluted because ocean is the sink of various pollutants [1-2], and the pollution of marine environment could finally be harmful to human beings by means of food chain. Hence, it is necessary to understand the pollution level and sources of Cu 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 Cu [1-2]. Based on the investigation data on Cu waters in different seasons in 1983, the aim of this paper was to analyze the content, pollution level, and sources of Cu, and to provide basis for the research and pollution control countermeasures on Cu in Jiaozhou Bay.

### Materials and method

Jiaozhou Bay ( $35^{\circ}55'\text{-}36^{\circ}18' \text{N}$ ,  $120^{\circ}04'\text{-}120^{\circ}23' \text{E}$ ) is located in the south of Shandong Peninsula, eastern China. The area and average water depth are  $460 \text{ km}^2$  and 7 m, respectively, yet the bay mouth is only 2.5 km (Fig. 1). This bay is surrounded 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 [3-4]. The investigation on Cu in surface waters in Jiaozhou Bay was conducted by North China Sea Environmental Monitoring Center in May, September and October 1983 (Fig. 1). The investigation and measurement of Cu were followed by National Specification for Marine Monitoring [5].



Fig.1 Geographic location and sampling sites of Jiaozhou Bay

## Results and discussion

**Contents and pollution levels of Cu.** Cu contents in Jiaozhou Bay waters in May, September and October 1983 were  $2.47\text{-}20.60 \mu\text{g L}^{-1}$ ,  $0.86\text{-}4.86 \mu\text{g L}^{-1}$  and  $0.77\text{-}3.00 \mu\text{g L}^{-1}$ , respectively.

In according to the guide line of Grade I ( $5.00 \mu\text{g L}^{-1}$ ), Grade II ( $10.00 \mu\text{g L}^{-1}$ ) and Grade III ( $50.00 \mu\text{g L}^{-1}$ ) for Cu in National Standard of China for Seawater Quality (GB3097-1997), this bay was slightly contaminated by Cu in September and October in 1983, while was moderate contaminated in May (Table 1).

Table 1 The pollution level of Cu in Jiaozhou bay in May, September and October 1983

	May	September	October
Content / $\mu\text{g L}^{-1}$	2.47-20.60	0.86-4.86	0.77-3.00
Grade	I, II and III	I and II	I and II

**Horizontal distributions of Cu.** In May, high value of Cu contents were occurred in Site H34 and H82 ( $1.75 \mu\text{g L}^{-1}$ ), and there was a high value region around the two Sites. A series of parallel lines were forming and were decreasing from the out side of the bay ( $20.60 \mu\text{g L}^{-1}$ ) to the inner side of the bay ( $2.47 \mu\text{g L}^{-1}$ ) along with the direction of the marine current (Fig. 2). Another high value region was occurred around Site H40 ( $10.57 \mu\text{g L}^{-1}$ ) near the estuary of Loushan River in the northeast of the bay. A series of semi-concentric circles were forming and were decreasing from the high value center to the bay mouth ( $4.75 \mu\text{g L}^{-1}$ ) along with the flow direction of the river. There was also a high value region around Site H37 in coastal area in the bay mouth ( $9.48 \mu\text{g L}^{-1}$ ), and a series of semi-concentric circles were forming and were decreasing from the high value center to the bay mouth ( $2.94 \mu\text{g L}^{-1}$ ) (Fig. 2). In September, a high value region was formed around Site H35 ( $4.86 \mu\text{g L}^{-1}$ ) in the bay mouth. A series of semi-concentric circles were forming and were decreasing from the bay mouth to the north of the bay ( $0.86 \mu\text{g L}^{-1}$ ) and the out side of the bay mouth ( $1.43 \mu\text{g L}^{-1}$ ) (Fig. 3). Another high value region was occurred around Site H38 between the estuaries of Licun River and Haibo River, and a series of semi-concentric circles were forming and were decreasing from the high value center to the north of the bay ( $0.86 \mu\text{g L}^{-1}$ ) (Fig.3). In October, a high value region was formed around Site H40 ( $3.00 \mu\text{g L}^{-1}$ ) in the estuary of Loushan River in the northeast of the bay. A series of semi-concentric circles were forming and were decreasing from the high value center to the bay mouth ( $0.77 \mu\text{g L}^{-1}$ ) (Fig. 4). Another high value region was occurred around Site H34 out side the bay mouth ( $2.28 \mu\text{g L}^{-1}$ ), and a series of semi-concentric circles were forming and were decreasing from the high value center to the south of the bay mouth

( $1.75 \mu\text{g L}^{-1}$ ) (Fig. 4). The horizontal distributions of Cu contents indicated that there were different pollution sources of Cu in the bay.

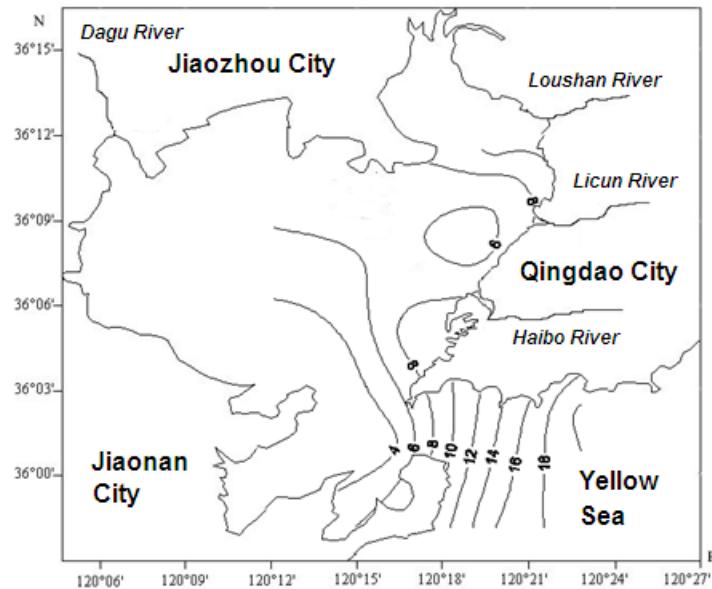


Fig. 2 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in May 1983/ $\mu\text{g L}^{-1}$

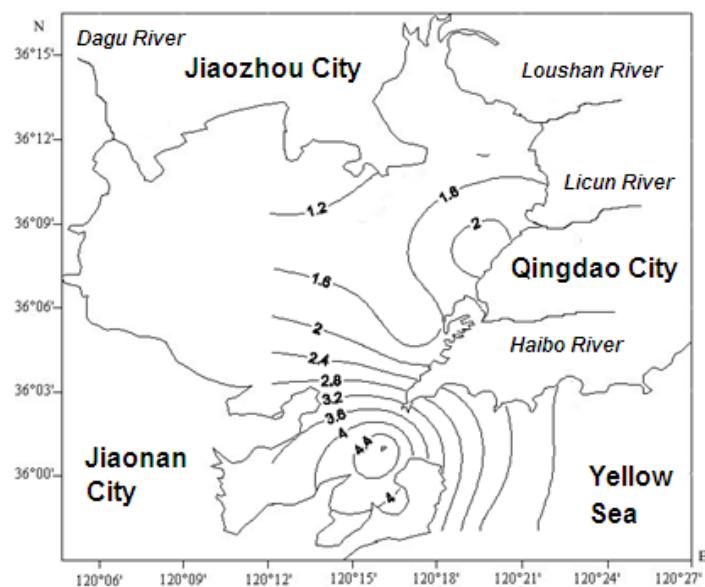


Fig. 3 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in September 1983/ $\mu\text{g L}^{-1}$

**Pollution sources and source strengths.** In according to the horizontal distributions of Cu in surface waters, we found that there were some relative high value regions in different seasons. In May, Cu contents were decreasing from the out side of the bay to the center of the bay along with the direction of the marine current, indicated that marine current was one of the major source of Cu. Meanwhile, there was high value regions near the estuaries of the major rivers in the northeast of the bay, indicated that stream flow was another major source of Cu in May. In September, there was a high value region in the coastal area in the bay mouth, indicated a part of Cu was discharged from the top of the islands. High value regions were also occurred in the estuaries of the river in the northeast of the bay, indicated that stream flow was also one of the major sources of Cu in September. In October, high value regions were also occurred in the estuaries of the river in the northeast of the bay, and in coastal area in the northeast of the bay, indicated that stream flow and overland runoff were major source of Cu. Meanwhile, a high value region was occurred the the north out side the bay, indicated shipping was also one of the major source of Cu. Hence, it could be

concluded that the major sources of Cu were marine current, stream flow, shipping, the top of the islands and overland runoff, whose source strengths were  $20.60 \mu\text{g L}^{-1}$ ,  $2.20\text{-}10.57 \mu\text{g L}^{-1}$ ,  $9.48 \mu\text{g L}^{-1}$ ,  $4.86 \mu\text{g L}^{-1}$  and  $2.28 \mu\text{g L}^{-1}$ , respectively (Table 2). We defined marine current was natural source, while the other sources were anthropogenic sources, it was clear that the impacts of natural source were responsible for Cu pollution in 1983.

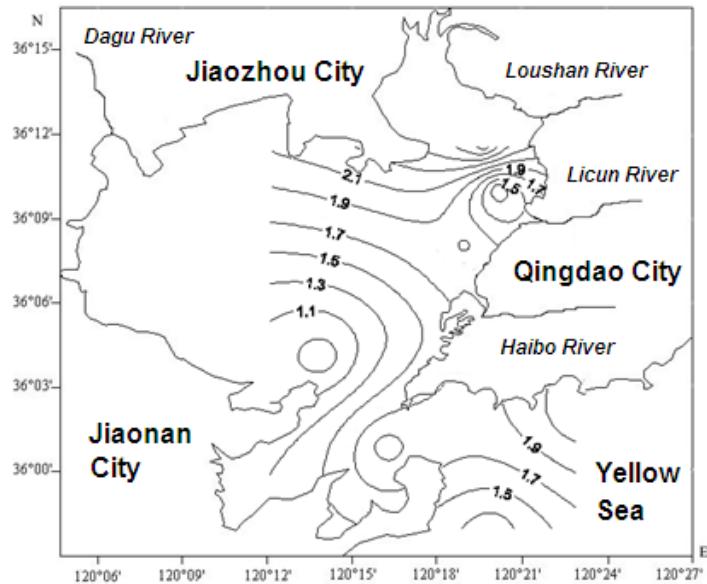


Fig. 4 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in October 1983/ $\mu\text{g L}^{-1}$

Table 2 Source strengths of different pollution sources for Cu in Jiaozhou bay

Source	Marine current	Stream flow	Shipping	The top of the island	Overland runoff
Source strength/ $\mu\text{g L}^{-1}$	2.58–3.38	2.25–2.60	1.90	2.50	1.75

## Conclusions

Cu contents in May, September and October were  $2.47\text{-}20.60 \mu\text{g L}^{-1}$ ,  $0.86\text{-}4.86 \mu\text{g L}^{-1}$  and  $0.77\text{-}3.00 \mu\text{g L}^{-1}$ , respectively. This bay was slightly contaminated by Cu in September and October in 1983, while was moderate contaminated in May. The major souces of Cu were marine current, stream flow, shipping, the top of the islands and overland runoff, whose source strengths were  $20.60 \mu\text{g L}^{-1}$ ,  $2.20\text{-}10.57 \mu\text{g L}^{-1}$ ,  $9.48 \mu\text{g L}^{-1}$ ,  $4.86 \mu\text{g L}^{-1}$  and  $2.28 \mu\text{g L}^{-1}$ , respectively. The impacts of natural source were responsible for Cu pollution in 1983.

## Acknowledgement

This research was sponsored by Doctoral Degree Construction Library of Guizhou Nationalities University, Education Ministry's New Century Excellent Talents Supporting Plan (NCET-12-0659), Education Ministry's New Century Excellent Talents Supporting Plan (NCET-12-0659), Project of Outstanding Technological Educators of Governor of Guizhou ([2012]71), Project of Low Carbon Technology Plan of Guiyang (2012205), Project of Science and Technology Foundation of Guiyang (LKM[2012]05), Special Research Projects of High Level Talents of Guizhou Province (TZJF-2011-44), the China National Natural Science Foundation (31560107) and Research Projects of Guizhou Nationalities University ([2014]02), Research Projects of Guizhou Province Ministry of Education (KY [2014] 266), Research Projects of Guizhou Province Ministry of Science and Technology (LH [2014] 7376).

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