Identification of Cu’s sources in Jiaozhou Bay

Dongfang Yang¹,²,³, a, Haixia Li¹,², Jun Ding¹,², Longlei Zhang², Jiangmin Li²
¹Center for Accounting and Auditing Informatics, Xijing University, Xian 710123, China;
²Accountancy Shool, Xijing University, Xian 710123, China;
³North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China
adf yang_dfyang@126.com

Abstract. Many marine bays have been polluted by Cu along with the rapid development of industry, economy and population size, and identification the sources of Cu is essential to environmental protection. This paper identified the sources of Cu in according to the horizontal distribution in Jiaozhou Bay during 1982—1986. Results showed that there were five Cu sources during study years including marine current, stream flow, island top, overland runoff and marine traffic, respectively. These findings were helpful information in decision-making of pollution control and environmental remediation practice.

1. Introduction
The industry, economy and population size were increasing rapidly in the past four decades, and a large amount of pollutants were generating and discharging to the environment. Nowadays, many marine bays have been polluted by Cu since ocean is the sink of pollutant [1-6]. Hence, identification the sources of Cu in marine bay is essential to marine environment protection and the maintaining of ecological sustainable development.

Jiaozhou Bay is a semi-closed marine bay in Shandong Province China, which has been polluted by various pollutants including Cu after the reform and opening-up [7-14]. This paper identified the sources of Cu in according to the horizontal distribution in Jiaozhou Bay during 1982—1986, and the results showed that there were five Cu sources. This findings provided information for scientific research and pollution control and environmental remediation.

2. Study area and data collection
Jiaozhou Bay is located in the south of Shandong Province, eastern China (35°55′-36°18′ N, 120°04′-120°23′ E). The total area, average water depth and bay mouth width are 446 km², 7 m and 3 km, respectively. This bay is a typical of semi-closed bay which is connected to the Yellow Sea in the south. There are a dozen of rivers, and the majors are Dagu River, Haibo Rriver, Licun Rriver, and Loushan Rriver etc., all of which are seasonal rivers [15-16].

The investigation on Cd in surface waters in Jiaozhou Bay was carried on in June 1982, May 1983, July 1984, July 1985 and April 1986, respectively (Fig. 1 and Table 1). Cu in waters was sampled and monitored follow by National Specification for Marine Monitoring [17].
3. Results and discussion

The horizontal distributions of Cu contents in surface waters were important evidences for identifying the sources of Cu. In June 1982, there was a high value center in the bay mouth (5.31 μg L\(^{-1}\)), and the contour lines of Cu contents were forming a series of parallel lines that decreasing from the bay mouth to the northeast of the bay (0.86 μg L\(^{-1}\)) (Fig. 2). In general, Cu contents were decreasing along with the flow direction of the marine current, this indicated that marine current was the major Cu source in June 1982.

In May 1983, there were three high value centers of Cu contents (Fig. 3). Firstly, there was a high value center in the open waters outside the bay mouth (20.60 μg L\(^{-1}\)), and the contour lines were forming a series of parallel lines that decreasing from the high value center to the center of the bay along with the flow direction of the marine current (2.47 μg L\(^{-1}\)) (Fig. 3), indicated that marine current
was one of the major Cu sources. Secondly, there was a high value center in the estuary of Loushan River (10.57 μg L⁻¹), and the contour lines were forming a series of semi-circles that were decreasing from the high value center to the bay mouth (4.75 μg L⁻¹) (Fig. 3), indicated that stream flow was one of the major Cu sources. Thirdly, there was a high value center in the coastal port in the eastern of the bay (9.48 μg L⁻¹), and the contour lines of Cu contents were forming a series of semi-circles that decreasing from the high value center to the bay mouth (2.94 μg L⁻¹) (Fig. 3), indicated that marine traffic was one of the major Cu sources.

![Fig. 3 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in May 1983/μg L⁻¹](image)

In July 1984, there was a high value center of Cu contents in the estuary of Haibo River in the northeast of the bay (1.88 μg L⁻¹) (Fig. 4). The contour lines were forming a series of parallel lines that decreasing from the high value center to the bay mouth (0.28 μg L⁻¹) (Fig. 4). This indicated that stream flow was the major Cu source.

![Fig. 4 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in July 1984/μg L⁻¹](image)

In July 1985, there was also a high value center of Cu contents in the estuary of Haibo River in the
northeast of the bay (0.38 μg L⁻¹) (Fig. 5). The contour lines were forming a series of parallel lines that decreasing from the high value center to the bay mouth (0.22 μg L⁻¹) and the open waters (0.10 μg L⁻¹) (Fig. 5). This indicated that stream flow was the major Cu source.

Fig. 5 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in July 1985/μg L⁻¹

In April 1986, there was also a high value center of Cu contents closed to the island top in the bay mouth (0.77 μg L⁻¹) (Fig. 6). The contour lines were forming a series of parallel lines that decreasing from the high value center to the north of bay (0.18 μg L⁻¹) and the open waters (0.23 μg L⁻¹) (Fig. 6). This indicated that island top was the major Cu source.

Fig. 6 Horizontal distribution of Cu in surface waters in Jiaozhou Bay in April 1986/μg L⁻¹

In general, in according to the horizontal distribution of Cu contents in surface waters in Jiaozhou Bay, five major Cu sources were identified.

4. Conclusions

Five Cu sources were identified in according to the horizontal distribution of Cu contents in surface waters in Jiaozhou Bay. These sources were including marine current, stream flow, island top,
overland runoff and marine traffic, respectively. Cu contents and pollution conditions were mainly determined by the seasonal, temporal and spatial variations of the sources. These findings were helpful information in decision-making of pollution control and environmental remediation practice.

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