Variations of pollution sources of Cu in Jiaozhou Bay 1982－1986

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Abstract. Cu pollution in marine bays has been one of the critical environmental issues in the whole world, and understanding the variations of the pollution sources is essential to environmental protection. This paper identified the sources of Cu in Jiaozhou Bay during 1982－1986, and revealed the variations of the sources. Results showed that there were five Cu sources during study years including marine current, stream flow, island top, overland runoff and marine traffic, respectively, whose source strengths were varying from 0.39－ 20.60 μg L^{-1}, 0.37－10.57 μg L^{-1}, 0.77－4.86 μg L^{-1}, 2.28－3.56 μg L^{-1}, 9.48 μg L^{-1}, respectively. These findings were helpful information in decision-making of pollution control and environmental remediation practice.

1. Introduction

A large amount of pollutants were generating and discharging to the environment in the past four decades after the reform and opening-up due to the rapid development of industrialization and urbanization in China. Hence, many marine bays have been polluted since ocean is the sink of pollutant [1-6]. Therefore, identification the sources of pollutants and their variations 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 their variations of Cu in Jiaozhou Bay during 1982－1986, and major sources were identified and their variations were revealed. 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 km^2, 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, July and October 1982, May, September and October 1983, July, August and October 1984, April, July and October 1985, and April 1986, respectively (Fig. 1).

Cu in waters was sampled and monitored follow by National Specification for Marine Monitoring [17].

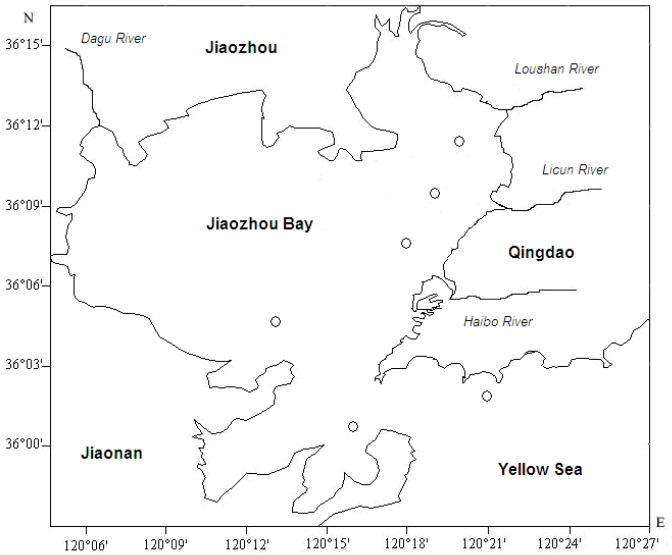

Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

3. Results and discussion

Spatial distribution of Cu. The spatial distributions of Cu contents were key evidences for identification of Cu sources and the source strengths in marine bays. In general, the spatial distributions of Cu contents in Jiaozhou Bay were varying in different sampling dates, and therefore the major sources and their variations could be identified. The positions of the high values, low values and decreasing directions of Cu contents in different months during 1982－1986 were listed in Table 1 to Table 5. In according to the spatial distributions of Cu contents in different months during 1982－1986, it could be found that the major Cu sources were varying along with time, and the source strengths were showing spatial-temporal variations. In general, it could be identified that there were five Cu sources during study years including marine current, stream flow, island top, overland runoff and marine traffic, respectively, whose source strengths and their variations were analyzed in the next section.

Table 1 Position of high value and low value, and decreasing direction of Cu contents in1982

Month	Position of high value	Position of low value	Decreasing trend
June	Bay mouth	Northeast of the bay	Along with flow direction of marine current
July	Bay mouth	Center of the bay	Along with flow direction of marine current
October	Coastal waters in the southwest of the bay	Center of the bay	Along with overland runoff

Table 2 Position of high value and low value, and decreasing direction of Cu contents in 1983

Month	Position of high value	Position of low value	Decreasing trend
May	Open waters closed to the bay mouth	Center of the bay	Along with flow direction of marine current
	Estuary of Loushan	Bay mouth	Along with flow

	River		direction of river
	Coastal port in the east of the bay	Bay mouth	Along with the distance to the port
September	Bay mouth	North of the bay	Along with the distance to the island top
	Estuary of Licun River and Haibo River	North of the bay	Along with flow direction of river
October	Estuary of Loushan River	Bay mouth	Along with flow direction of river
	Open waters closed to the bay mouth	Open waters	Along with overland runoff

Table 3 Position of high value and low value, and decreasing direction of Cu contents in 1984

Month	Position of high value	Position of low value	Decreasing trend
July	Estuary of Haibo River	Bay mouth	Along with flow direction of river
August	Estuary of Licun River	Northeast of the bay	Along with flow direction of river
October	Open waters outside the bay mouth	Bay mouth	Along with flow direction of marine current

Table 4 Position of high value and low value, and decreasing direction of Cu contents in1985

Month	Position of high value	Position of low value	Decreasing trend
April	Estuary of Licun River	Southwest of the bay	Along with flow direction of river
	Coastal port in the east of the bay	Southwest of the bay	Along with the distance to the port
July	Estuary of Haibo River	Bay mouth and the open waters	Along with flow direction of river
October	Open waters outside the bay mouth	Southwest of the bay	Along with flow direction of marine current

Table 5 Position of high value and low value, and decreasing direction of Cu contents in1986

Month	Position of high value	Position of low value	Decreasing trend
April	Coastal waters closed to the island top in the bay mouth	Center of the bay	Along with the distance to the island top

Spatial distribution of Cu. In according to the positions of the high values, low values and decreasing directions of Cu contents in Jiaozhou Bay in different months during 1982－1986 (Table 6 to Table 10), the major Cu sources were identified. Furthermore, the source strengths of marine current, stream flow, island top, overland runoff and marine traffic, could also be revealed. The source strengths of Cu in different months during 1982－1986 were listed in Table 7 to Table 11. In general, the source strengths of marine current, stream flow, island top, overland runoff and marine traffic were varying from 0.39－20.60 μg L^{-1}, 0.37－10.57 μg L^{-1}, 0.77－4.86 μg L^{-1}, 2.28－3.56 μg L^{-1}, 9.48 μg L^{-1}, respectively. The significant variations of Cu sources indicated that different pollution control countermeasures should be applied in different seasons and locations.

Table 6 Major Cu source and source strength in 1982

Month	Source	Source strength/μg L^{-1}
June	Marine current	5.31
July	Marine current	2.33
October	Overland runoff	3.56

Table 7 Major Cu source and source strength in 1983

Month	Source	Source strength/μg L^{-1}
May	Marine current	20.67
	Stream flow	10.57
	Marine traffic	9.48
September	Island top	4.86
	Stream flow	2.20
October	Stream flow	3.00
	Overland runoff	2.28

Table 8 Major Cu source and source strength in 1984

Month	Source	Source strength/μg L^{-1}
July	Stream flow	1.88
August	Stream flow	4.00
October	Marine current	2.00

Table 9 Major Cu source and source strength in 1985

Month	Source	Source strength/μg L^{-1}
April	Stream flow	0.43
	Marine current	0.39
July	Stream flow	0.37－0.38
October	Marine current	0.39

Table 10 Major Cu source and source strength in 1986

Month	Source	Source strength/μg L^{-1}
April	Island top	0.77

4. Conclusions

The major Cu sources in Jiaozhou Bay during 1982－1986 included marine current, stream flow, island top, overland runoff and marine traffic, respectively, and their source strengths were varying from 0.39－20.60 μg L^{-1}, 0.37－10.57 μg L^{-1}, 0.77－4.86 μg L^{-1}, 2.28－3.56 μg L^{-1}, 9.48 μg L^{-1}, respectively. Cu contents and pollution conditions were mainly determined by the seasonal, temporal and spatial variations of the sources. The variations of Cu sources indicated that different pollution control countermeasures should be applied.

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