

# Seasonal variations of Cu and the mechanisms in Jiaozhou Bay

Dong Fang YANG<sup>1, 2, 3, a</sup>, Jun DING<sup>1, 2</sup>, Hai Xia LI<sup>1, 2</sup>, Long Lei ZHANG<sup>2</sup>, Qi WANG<sup>2</sup>

<sup>1</sup> Center for Accounting and Auditing Informatics, Xijing University, Xi'an 710123, China;

<sup>2</sup> Accountancy Shool, Xijing University, Xi'an 710123, China;

<sup>3</sup> North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China  
dfyang\_dfyang@126.com

**Abstract.** Understanding the seasonal variation and the mechanism in marine bay is helpful to decision-making of pollution control practice. This paper analyzed the seasonal variations of Cu in Jiaozhou Bay during 1982—1986. Furthermore, the mechanisms of the seasonal variations were analyzed. Results showed that the variations of Cu contents in spring, summer and autumn were relying on the source inputs of Cu. As a whole, the change process of Cu contents in Jiaozhou Bay were determined by the terrestrial transport process and oceanic transport process jointly.

## 1 Introduction

Cu is widely existing in the whole world, and has been exploited for thousands of years. After the industrial revolution, the exploitation and utilization of Cu were increasing rapidly, and a large amount of Cu-containing wastes were generated and discharged to the environment. Many marine bays have been polluted by Cu since ocean is the sink of pollutant [1-8]. Hence, understanding the seasonal variation of Cu and the mechanism in marine bay is helpful to decision-making of pollution control practice.

Jiaozhou Bay is a semi-closed marine bay in Shandong Province China, in where the pollution issue has been arising after the reform and opening-up [9-16]. This paper analyzed the seasonal variations of Cu and the mechanisms in Jiaozhou Bay during 1982—1986, revealed that transported processes of Cu, and 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<sup>2</sup>, 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 [17-18].

The investigation on Cd in surface waters in Jiaozhou Bay was carried on in 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 [19]. For seasonal division in study area, April, May and July are spring, July, August and September are summer, October, November and December are autumn, respectively.

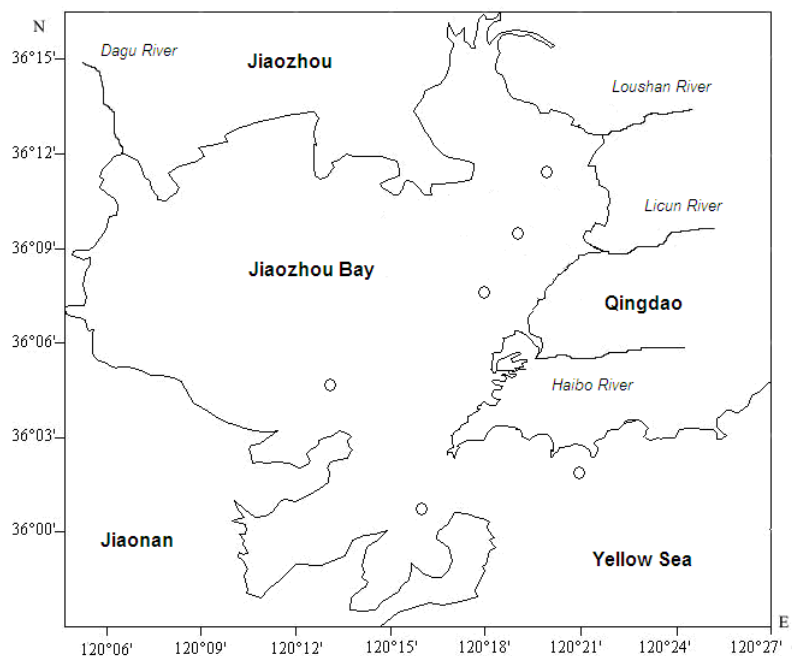


Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

### 3 Results and discussion

**In 1982.** Cu contents in surface waters in Jiaozhou Bay in July and October 1982 were  $0.15\text{--}2.33\ \mu\text{g L}^{-1}$  and  $2.22\text{--}3.56\ \mu\text{g L}^{-1}$ , respectively. The variations of Cu contents in 1982 were relative small as  $0.15\text{--}3.56\ \mu\text{g L}^{-1}$ . For seasonal variations in 1982, Cu contents in surface waters were in order of autumn > summer. Cu contents were relative low in summer, yet were increasing along with time within year, and were reaching the high value in autumn. Stream flow was the major Cu source in June and October, and the source strength was mainly determined by precipitation. However, the pollution level of Cu in streams in study years was still low, and the impact of stream flow on Cu contents in Jiaozhou Bay during 1982-1986 were still limited, resulted in relative slight pollution in waters.

**In 1983.** Cu contents in surface waters in Jiaozhou Bay in May, September and October 1983 were  $2.47\text{--}20.60\ \mu\text{g L}^{-1}$ ,  $1.28\text{--}4.86\ \mu\text{g L}^{-1}$  and  $0.77\text{--}2.28\ \mu\text{g L}^{-1}$ , respectively. The variations of Cu contents in 1983 were relative big as  $0.77\text{--}22.60\ \mu\text{g L}^{-1}$ . For seasonal variations 1983, Cu contents in surface waters were in order of autumn > summer > spring. Cu contents were relative high in May, and were increasing along with time within year, and were reaching the low value in October. The major Cu source in spring was marine current, whose source strength was relative high, resulted in relative high Cu contents in May. The major Cu source in summer was island top, whose source strength was relative low, resulted in relative low Cu contents in September. The major Cu source in autumn was stream flow, whose source strengths was lowest, resulted in the lowest Cu contents in October. By means of vertical water's effect [6] and the seasonal variations of Cu sources, Cu contents in surface waters in 1983 were in order of autumn > summer > spring.

**In 1984.** Cu contents in surface waters in Jiaozhou Bay in July, August and October 1983 were  $0.28\text{--}1.88\ \mu\text{g L}^{-1}$ ,  $1.60\text{--}4.00\ \mu\text{g L}^{-1}$  and  $0.90\text{--}2.00\ \mu\text{g L}^{-1}$ , respectively. The variations of Cu contents in 1983 were relative small as  $0.28\text{--}4.00\ \mu\text{g L}^{-1}$ . For seasonal variations in 1984, Cu contents in surface waters were in order of summer > autumn. Cu contents were relative high in summer, yet were

increasing along with time within year, and were reaching the low value in autumn. Stream flow was the major Cu source in summer in 1984, whose source strength was relative high, resulted in relative high Cu contents in summer. However, marine current was the major Cu sources in autumn in 1984, whose source strength was relative low, resulted in lower Cu contents in autumn. By means of vertical water's effect [6] and the seasonal variations of Cu sources, Cu contents in surface waters in 1984 were in order of summer > autumn.

**In 1985.** Cu contents in surface waters in Jiaozhou Bay in April, July and October 1985 were  $0.11\text{--}0.43\ \mu\text{g L}^{-1}$ ,  $0.10\text{--}0.38\ \mu\text{g L}^{-1}$  and  $0.18\text{--}0.39\ \mu\text{g L}^{-1}$ , respectively. The variations of Cu contents in 1983 were relative small as  $0.10\text{--}0.43\ \mu\text{g L}^{-1}$ . For seasonal variations in 1985, Cu contents in surface waters were in order of summer > autumn > spring. Cu contents were relative high in summer, yet were increasing along with time within year, and were reaching the low value in autumn. Stream flow and marine current were the major Cu sources in spring in 1985, whose source strengths were relative low, resulted in relative low Cu contents in spring. However, the source strengths of Cu were increasing in summer, and decreasing in autumn, resulted in Cu contents in order of summer > autumn. By means of vertical water's effect [6] and the seasonal variations of Cu sources, Cu contents in surface waters in 1985 were in order of summer > autumn > spring.

**In 1986.** Cu contents in surface waters in Jiaozhou Bay in April 1986 were  $0.18\text{--}0.77\ \mu\text{g L}^{-1}$ . Since there was only one voyage number, the seasonal variations of Cu contents in 1986 could not be defined.

#### 4 Conclusions

The seasonal variations of Cu contents in surface waters in Jiaozhou Bay were objective existing. By means of vertical water's effect [6] and the seasonal variations of Cu sources in different years, Cu contents in waters in different seasons were showing obvious variations. As a whole, the change process of Cu contents in Jiaozhou Bay were determined by the terrestrial transport process and oceanic transport process jointly. These information were helpful to scientific research and pollution control and environmental remediation.

#### Acknowledgment

This research was sponsored by the China National Natural Science Foundation (31560107), Doctoral Degree Construction Library of Guizhou Nationalities University, Education Ministry's New Century Excellent Talents Supporting Plan (NCET-12-0659) 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).

#### References

- [1] Yang DF and Miao ZQ: Marine Bay Ecology (I): Beijing, Ocean Precess, (2010), p. 1-320. (in Chinese)
- [2] Yang DF and Gao ZH: Marine Bay Ecology (II): Beijing, Ocean Precess, (2010), p. 1-330. (in Chinese)
- [3] Yang DF, Miao ZQ, Song WP, et al.: Advanced Materials Research, Vol.1092-1093 (2015), p. 1013-1016.
- [4] Yang DF, Miao ZQ, Cui WL, et al.: Advances in intelligent systems research, (2015), p. 17-20.
- [5] Yang DF, Wang FY, Zhu SX, et al.:Advances in Engineering Research, Vol. 31(2015): p. 1284-1287.
- [6] Yang DF, Zhu SX, Wu YJ, et al.:Advances in Engineering Research, Vol. 31(2015): p. 1288-1291.
- [7] Yang DF, Wang FY, Zhu SX, et al.: Materials Engineering and Information Technology Appllication, Vol. 2015, p. 554-557.
- [8] Yang DF, Zhu SX, Zhao XL, et al.: Advances in Engineering Research, Vol. 40 (2015), p. 770-775.
- [9] Yang DF, Zhu SX, Wang FY, et al.:Advances in Computer Science Research, Vol. (2015), p.

- 1765-1769.
- [10] Yang DF, Zhu SX, Wang FY, et al.: *Advances in Engineering Research*, Vol. 60(2016), p. 408-411.
  - [11] Yang DF, Zhu SX, Wang M, et al.: *Advances in Engineering Research*, Vol. 67(2016), p. 1311-1314.
  - [12] Yang DF, Yang DF, Wang M, et al.: *Advances in Engineering Research*, Vol. (2016), Part G, p. 1917-1920.
  - [13] Yang DF, Yang DF, He HZ, et al.: *Advances in Engineering Research*, Vol. 84 (2016), p. 852-856.
  - [14] Yang DF, He HZ, Wang FY, et al.: *Advances in Materials Science, Energy Technology and Environmental Engineering*, Vol. (2017), p. 291-294.
  - [15] Yang DF, Zhu SX, Yang DF, et al.: *Computer Life*, Vol. 4 (2016), p. 579-584.
  - [16] Yang DF, Yang DF, Tao XZ, et al.: *World Scientific Research Journal*, Vol. 22 (2016), p. 69-73.
  - [17] Yang DF, Chen Y, Gao ZH, et al.: *Chinese Journal of Oceanology and Limnology*, Vol. 23(2005), p. 72-90. (in Chinese)
  - [18] Yang DF, Wang FY, Gao ZH, et al. *Marine Science*, Vol. 28 (2004), p. 71-74. (in Chinese)
  - [19] China's State Oceanic Administration: *The specification for marine monitoring* (Ocean Press, Beijiang 1991), p.1-300. (in Chinese)