Identification of the settlement process of Cr in Jiaozhou Bay

Dongfang Yang[1, 2,3, a], Haixia Li [1,2], Jun Ding[1,2], Longlei Zhang[1] and Jiangmin Li[1]

[1] Center for Accounting and Auditing Informatics, Xijing University, Xian 710123, China

[2] Accountancy Shool, Xijing University, Xian 710123, China

[3] North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China

[a]dfyang_dfyang@126.com

Keywords: Cr; Horizontal distribution; Seasonal variation; Settlement process; Jiaozhou Bay.

Abstract: Understanding the settlement process of Cr in marine bay is essential to pollution control and environmental remediation. Jiaozhou Bay is a semi-closed bay located in Shandong Province, China. This paper analyzed the seasonal variations of Cr in bottom waters, and identified the settlement process. Results showed that Cr contents in bottom waters in spring, summer and autumn were 0.06-3.78 μg L^{-1}, 0.03-2.11 μg L^{-1} and 0.27-1.58 μg L^{-1}, respectively, indicating order of autumn > summer > spring. By means of the settlement process, there were four high Cr content regions in bottom waters of Jiaozhou Bay, i.e., 1) coastal waters in the west of the bay, 2) estuary of rivers in the east of the bay, 3) the center of the bay, and 4) the bay mouth. The input of Cr and the geomorphology of the bay were the mainly determining the settlement process of Cr, leading to the high Cr content regions mentioned above. Cr in surface waters was rapidly settling to bottom waters, and was accumulating in the bottom.

1. Introduction

Marine is the sink of pollutants, and many marine waters have been polluted by various pollutants due to the rapid increase of industry. Pollution in marine bays had been one of the critical and worldwide environmental issues [1-4]. Understanding the settlement process of pollutants in marine bay is essential to pollution control and environmental remediation.

Jiaozhou Bay is a semi-closed bay located in Shandong Province, eastern China, and has been polluted by various pollutants [5-8]. This paper analyzed the seasonal variations of Cr in Jiaozhou Bay based on investigation data on Cr in bottom waters during 1979-1983, reveal the settlement process of Cr, and provided scientific basis for pollution control.

2. Materials and method

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) is located in the south of Shandong Peninsula, eastern China. The area, bay mouth width and average water depth and average water depth are 390 km^2, 2.5 km and 7.0 m, respectively (Fig. 1). This bay is surrounding by cities of Qingdao, Jiaozhou and Jiaonan in the east, north and south, respectively. The bay mouth is located in the south of the bay, and is connected with the Yellow Sea. There are more than ten inflow rivers such as Loushan River, Licun River and Haibo River [9-10].

The investigation on Cr in surface waters in Jiaozhou Bay was conducted by North China Sea Environmental Monitoring Center. The investigation times were in August 1979, April and August 1981, April, July and October 1982, and May, September and October 1983, respectively [3-8], and the sampling sites were showed in Fig. 1. The investigation and measurement of Cr were following by National Specification for Marine Monitoring [11].

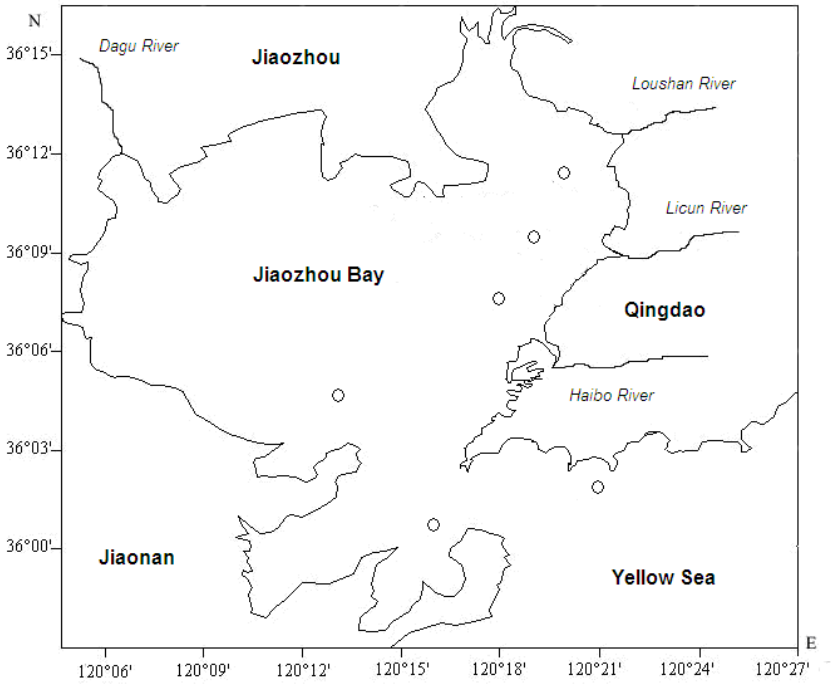

Fig.1 Geographic location and sampling sites of Jiaozhou Bay

3. Results and discussion

3.1 Seasonal variation of Cr.

In according to the climate in study area, April, May and June are spring, July, August and September are summer, and October, November and December are autumn, respectively. The investigation data on monthly highest Cr contents during 1979-1983 were listed in Table 1. Obviously, Cr contents in bottom waters in Jiaozhou Bay were showing seasonal variations that Cr contents in bottom waters in spring, summer and autumn were 0.06-3.78 μg L^{-1}, 0.03-2.11 μg L^{-1} and 0.27-1.58 μg L^{-1}, respectively, In generally, Cr contents were in order of autumn > summer > spring. In according to the guideline of Cr in National Standard of China for Seawater Quality (GB3097-1997) for Grade I (50 μg L^{-1}), Cr contents in bottom waters in different seasons in Jiaozhou Bay during 1979-1983 were very low, and the pollution level of Cr in Jiaozhou Bay was still very slight in the early stage of China's Reform and Opening-up.

Table1 Cr contents in bottom waters in Jiaozhou Bay during 1979-1983/μg L^{-1}

Year	April	May	August	September	October	November
1979			0.03-0.40			
1981	0.50-3.78		0.14-1.42			
1982	0.81-0.95		1.20-2.11			0.27-0.51
1983		0.06-1.08		0.46-1.17	0.63-1.58	

3.2 High value regions of Cr.

In according to the horizontal distributions of Cr in bottom waters in Jiaozhou Bay, it could be found that there were four high Cr content region in bottom waters of Jiaozhou Bay, i.e., 1) coastal waters in the west of the bay (Fig. 2a), 2) estuary of rivers in the east of the bay (Fig. 2b), 3) the center of the bay (Fig. 2c), and 4) the bay mouth (Fig. 2d). In August 1979, there was a high value region in coastal waters in the west of the bay, and Cr contents were decreasing from the high value center to the bay mouth (Fig. 2a). In April 1981, there was a high value region in the estuary of rivers in the east of the bay, and Cr contents were decreasing from the high value center to the

northwest of the bay (Fig. 2b). In October 1982, there was a high value region in the center of the bay, and Cr contents were decreasing from the high value center to the coastal waters in the west of the bay (Fig. 2c). In October 1983, there was a high value region in the bay mouth, and Cr contents were decreasing from the high value center to the open waters and the coastal waters in the east of the bay (Fig. 2d). The input of Cr and the geomorphology were the mainly determining the settlement process of Cr, leading to the high Cr content regions mentioned above.

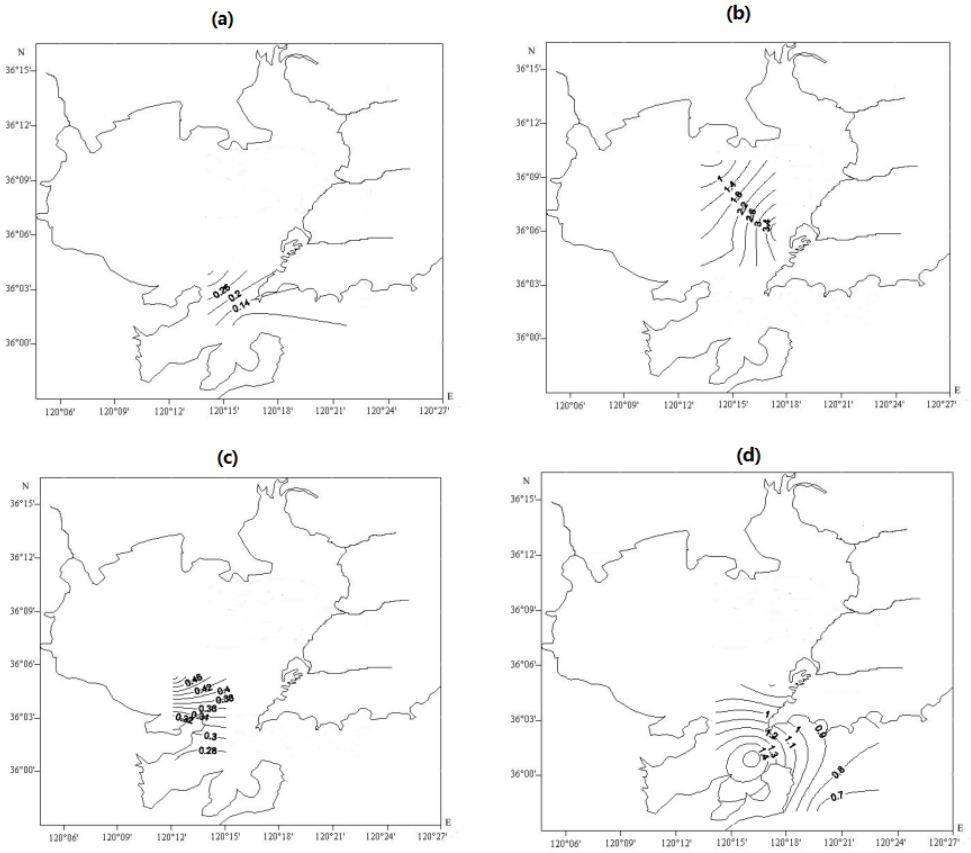

Fig. 2 Horizontal distributions of Cr in bottom waters of Jiaozhou Bay in (a) August 1979, (b) April 1981, (c) October 1982 and (d) October 1983.

3.3 Settlement process of Cr.

Settlement is one of the major transferring processes of Cr in marine bay. Once Cr had been inputted to the surface waters of the bay via stream flow, most of the Cr was transferred to the sediments in the sea bottom by means of gravity settlement, biodeposition, chemical action, etc. The growth and reproduction of marine organism in Jiaozhou Bay were increasing from spring and reaching the climax in autumn [8]. The increasing of the activities of zooplankton and phytoplankton resulted in a large amount of colloids in marine waters, which were able to enhance the absorption capacity of the suspended particulate matters. Hence, a large amount of Cr was absorbed to suspended particulate matters and transferred to the bottom waters and the sediment rapidly. By means of horizontal water's effect and vertical water's effect [12-14], leading to the horizontal distributions of Cr and the high Cr content regions mentioned above (Fig. 2). Cr in surface waters was rapidly settling to bottom waters, and was accumulating in the bottom.

4. Conclusions

Cr contents in bottom waters in Jiaozhou Bay in spring, summer and autumn were 0.06-3.78 μg L^{-1}, 0.03-2.11 μg L^{-1} and 0.27-1.58 μg L^{-1}, respectively, the pollution level of Cr in Jiaozhou Bay was still very slight in the early stage of China's Reform and Opening-up. There were four high Cr content regions in bottom waters of Jiaozhou Bay, i.e., coastal waters in the west of the bay, estuary of rivers in the east of the bay, the center of the bay and the bay mouth. By means of horizontal

water's effect and vertical water's effect, leading to the horizontal distributions of Cr and the high Cr content regions. In generally, Cr in surface waters was rapidly settling to bottom waters, and was accumulating in the bottom.

Acknowledgment

This research was sponsored by the China National Natural Science Foundation (31560107), Doctoral Degree Construction Library of Guizhou Nationalities University, 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, Gao ZH, Sun JY, et al.: Coastal Enginerring, Vol. 27 (2008), p. 48- 53. (in Chinese with English Abstract)

[4] Yang DF, Chen Y, Wang H, et al.: Coastal Engineering, Vol. 29 (2010), p. 73-82. (in Chinese with English Abstract)

[5] Yang DF, Chen Y, Liu CX, et al.: Coastal Engineering, Vol. 32(2013), p. 68-78. (in Chinese with English Abstract)

[6] Yang DF, Wang FY, He HZ, et al.: Applied Mechanics and Materials,Vol. 675-677 (2014), p. 329-331.

[7] Chen Y, Yu QH, Li TJ, et al.: Applied Mechanics and Materials, Vol.644-650 (2014), p. 5333-5335.

[8] Yang DF, Zhu SX, Wang FY, et al.: 2014 IEEE workshop on advanced research and technology industry applications. Part D, Vol. (2014), p. 1018-1020.

[9] Yang DF, Chen Y, Gao ZH, et al.: Chinese Journal of Oceanology and Limnology, Vol. 23 (2005), p. 72-90. (in Chinese with English Abstract)

[10] Yang DF, Wang F, Gao ZH, et al.: Marine Science, Vol. 28 (2004), p.71-74. (in Chinese with English Abstract)

[11] State Ocean Administration. The specification for marine monitoring: Beijing, Ocean Precess, (1991). (in Chinese)

[12] Yang DF, Wang FY, He HZ, et al.: Proceedings of the 2015 international symposium on computers and informatics, 2015, p. 2655-2660.

[13] Yang DF, Wang FY, Zhao XL, et al.: Sustainable Energy and Enviroment Protection, Vol. (2015), p. 191-195.

[14] Yang DF, Wang FY, Yang XQ, et al.: Advances in Computer Science Research, Vol. (2015), p. 198-204.