

Spatial-Temporal Changes of Cd in Jiaozhou Bay

Dongfang Yang^{1,2,3,a}, Sixi Zhu^{1,2}, Zhikang Wang^{1,2}, Xiuqin Yang^{1,2}, Fengyou Wang^{1,2,b,*}

¹Research Center for Karst Wetland Ecology, Guizhou Minzu University, Guiyang 550025,
China

²College of Chemistry and Environmental Science, Guizhou Minzu University, Guiyang
550025, China

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

^adfyang_dfyang@126.com, ^bfywang@163.com.cn

Abstract: Based on the investigation data on Cd in waters in Jiaozhou Bay in April, July and October 1986, we analyzed the contents, pollution levels, and distributions of Cd. Results showed that Cd contents in Jiaozhou Bay in 1986 were 0.01-0.94 $\mu\text{g L}^{-1}$, and were showing homogeneities at both spatial and temporal scales. These findings were approving that the ocean has feature of homogeneity, and substance in marine bay has feature of homogeneity. In case of there was input of substance to the marine bay from source, substance in marine bay waters would be heterogeneous.

Keywords: Cd, Distribution, Spatial, Temporal, Homogeneity, Jiaozhou Bay

1. INTRODUCTION

The rapid increasing of industry and agriculture is from early-1980s, in benefit from Chinese reform and opening-up [1-2]. Cd is one of the widely used and critical heavy metal elements in industry and agriculture. Hence, a large amount of Cd-containing wastes were generated and discharged to the environment along with the rapid development of industry and agriculture, and the marine bay was polluted by Cd since ocean was the sink of various pollutants [3-7].

Hence, understanding the existence and distribution of Cd is essential to marine environment protection and the maintaining of ecological sustainable development. This paper analyzed the existence and distribution of Cd in Jiaozhou Bay based on investigation data on Cd in surface waters in 1986, provided information and basis for pollution control and environmental remediation.

2. MATERIALS AND METHOD

Jiaozhou Bay is located in the south of Shandong Province, eastern China ($35^{\circ}55'-36^{\circ}18' N$, $120^{\circ}04'-120^{\circ}23' E$), which is connected to the Yellow Sea in the south. This bay is a typical of semi-closed bay, and 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. There are a dozen of rivers, and the majors are Dagu River, Haibo River, Licun River, and Loushan River etc., all of which are seasonal rivers [8-9].

The investigation on Cd in Jiaozhou Bay was carried on in April, July and October 1986 in six investigation sites namely 2031, 2032, 2033, 2034, 2035 and 2047, respectively (Fig. 1). Pb in waters was sampled and monitored follow by National Specification for Marine Monitoring [10].

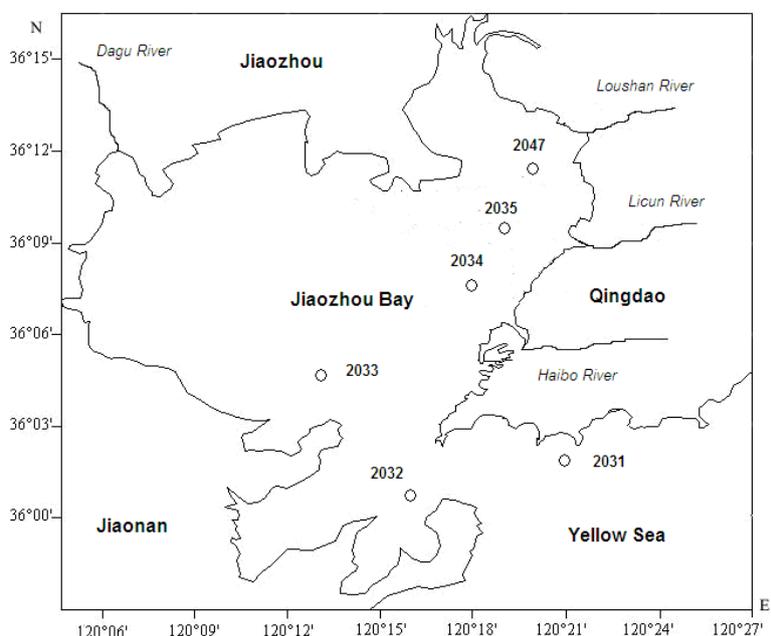


Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

3. RESULTS

In April 1986, Cd contents in waters in the northeast inside the bay were $0.32-0.94 \mu\text{g L}^{-1}$, in waters in from the coastal waters in the southwest of the bay to the bay mouth were $0.01-0.94 \mu\text{g L}^{-1}$, while in the open waters was $0.38 \mu\text{g L}^{-1}$. In generally, in April 1986, Cd contents in waters inside the bay mouth were $0.01-0.94 \mu\text{g L}^{-1}$, while in the open waters was $0.38 \mu\text{g L}^{-1}$. In July 1986, Cd contents in waters inside the bay mouth were $0.10-0.73 \mu\text{g L}^{-1}$, while in the open waters was $6.48 \mu\text{g L}^{-1}$. In October 1986, Cd contents in waters in the whole study area were $0.19-0.75 \mu\text{g L}^{-1}$. In July 1986, high Cd content value were occurring in Site 2031 in the open waters, and there was a high value region the coastal waters in the east of the open waters,

which were decreasing from the high value center ($6.48 \mu\text{g L}^{-1}$) to the bay mouth ($0.73 \mu\text{g L}^{-1}$) (Fig. 2).

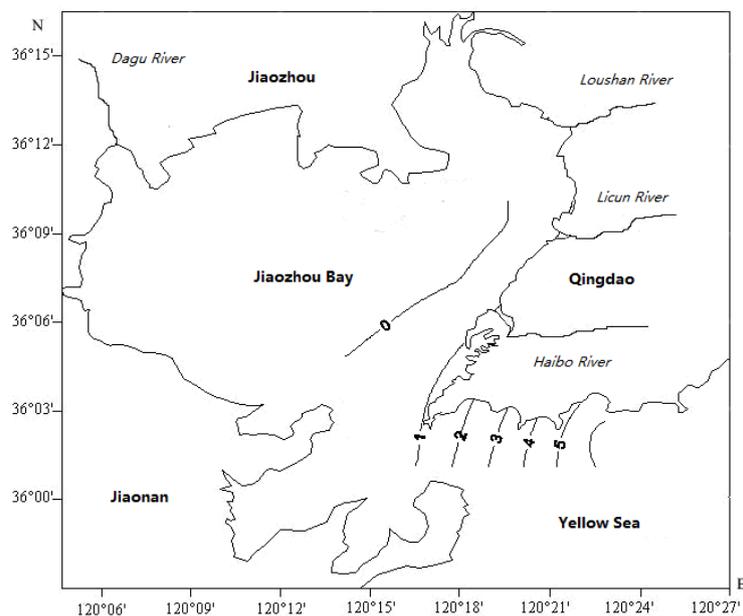


Fig. 2 Horizontal distribution of Cd in Surface waters in Jiaozhou Bay in July 1982/ $\mu\text{g L}^{-1}$

4. DISCUSSION

4.1 Homogeneity of spatial-temporal changes

The substances in the ocean are shaking and transporting by tide and marine current, leading to the spatial-temporal changes of the substances are very homogeneous. At temporal scale, Cd contents in April, July and October 1986 ranged from $0.01\text{-}0.94 \mu\text{g L}^{-1}$, $0.10\text{-}0.73 \mu\text{g L}^{-1}$ and $0.19\text{-}0.75 \mu\text{g L}^{-1}$, respectively, indicated that the distributions of Cd in waters in Jiaozhou Bay were homogeneous in different seasons. At spatial scale, Cd contents in waters ranged from $0.01\text{-}0.94 \mu\text{g L}^{-1}$ during April 1986 to October 1986, indicated that the distributions of Cd in waters in Jiaozhou Bay were homogeneous in different positions. In generally, Cd contents in Jiaozhou Bay waters were showing both spatial and temporal homogeneity.

4.2 Homogeneity of the substance

At spatial-temporal scale, Cd contents in Jiaozhou Bay waters in 1986 ranged from $0.01\text{-}0.94 \mu\text{g L}^{-1}$, revealed that the ocean had feature of homogeneity. Just as Yang's opinion that all of the substances in the ocean are shaking and transporting by tide and marine current, leading to the distributions of the substances are very homogeneous [11]. Hence, the spatial-temporal variations of Cd contents were showing the homogeneous distribution features of the

substances in the ocean. We proposed that the substances in the ocean is homogeneous, particularly in case of the contents were low the homogeneity of the waters was remained. Therefore, in case of low contents, the homogeneity was better revealed by means of the effects of tide and marine current. The substances in the ocean were continually stirred and transported by tide and current, leading to the homogeneity of the substances. The tide was playing the dominant role in coastal waters, while in the deep sea marine current, storm tide and submarine earthquake were responsible. Hence, the contents of the substances would be homogeneous distribution as time passes by, and the ocean has the characteristic of homogeneity [11], which was confirmed by the distributions of Cd in 1985 [12]. Furthermore, Cd contents in this bay was lower than $0.12 \mu\text{g L}^{-1}$, indicated the homogeneous distribution features [13]. The horizontal distribution and expanding process of Cd in 1985 revealed that the ocean had the feature of homogeneity by means of tide and marine current, while the spatial-temporal distribution of Cd revealed the substances in the ocean had feature of homogeneity. The horizontal distributions and extending processes of the substances clearly indicated that the ocean was making all of the substances being homogenous, leading to all of the substances were diffusing in trends of homogenous.

4.3 Heterogeneity of the input of the substance

In July 1986, there was a high value region ($6.48 \mu\text{g L}^{-1}$) in open waters outside the bay mouth, and Cd contents were decreasing from the open waters to the bay mouth and to the bay along with the flow direction of the marine current (Fig .2). It could be defined that marine current was the Cd source, whose source strength was $6.48 \mu\text{g L}^{-1}$. Cd contents inputted by marine current were decreased to $0.73 \mu\text{g L}^{-1}$ in the bay mouth, leading to the waters in the whole bay and the bay mouth were out of the influence of marine current. However, along with the increasing of the input of Cd from marine current, the influence of marine current to waters in the whole bay and the bay mouth would be also increasing. Therefore, the homogenous distribution feature of Cd in the bay could be destructed by marine current, leading to the heterogeneity of Cd contents in the bay. In generally, the ocean has feature of homogeneity, yet in case of the input of the substances by sources, substances in the marine bay would be heterogeneous.

5. CONCLUSION

At spatial-temporal scale, Cd contents in Jiaozhou Bay waters in 1986 ranged from 0.01 - $0.94 \mu\text{g L}^{-1}$, revealed that the ocean had feature of homogeneity. The spatial-temporal variations of Cd contents were showing the homogeneous distribution features of the substances in the ocean. We proposed that the substances in the ocean is homogeneous, particularly in case of the contents were low the homogeneity of the waters was remained. In case of low contents, the homogeneity was better revealed by means of the effects of tide and marine current. In

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