

Homogeneity of Cd contents in Jiaozhou Bay waters

Dongfang Yang^{1,2,3,a}, Fengyou Wang^{1,2,b,c}, Sixi Zhu^{1,2}, Ming Wang^{1,2}
and Xiuqin Yang^{1,2}

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, ^bcorresponding author; ^cfyywang@163.com.cn

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Abstract. Based on the investigation data on Cd in waters in Jiaozhou Bay in April, July and October 1985, we analyzed the contents, pollution levels, and distributions of Cd. Results showed that Cd contents in Jiaozhou Bay in 1985 were $0.03\text{-}0.44 \mu\text{g L}^{-1}$, and were much lower than guide line of Cd in Grade I ($1.00 \mu\text{g L}^{-1}$) of National Sea Water Quality Standard (GB 3097-1997), indicated that the pollution level of Cd in this bay in 1985 was very low. Steam flow was the only source of Cd, whose source strength was $0.21\text{-}0.41 \mu\text{g L}^{-1}$. The horizontal distributions of Cd revealed the effects of tide and marine current of leading Cd contents in waters being homogeneous; particularly in case of Cd contents were low in waters. Furthermore, we proposed ‘homogeneous law of substances in waters’.

Introduction

Cd is one of the widely used heavy metal elements in industry and agriculture. The ocean has suffered Cd pollution for a long time due to the rapid development of industry and agriculture [1-2]. Moreover, Cd is highly toxic and is recognized as one of the critical environment pollutants. For instance, Itai-itai disease caused by Cd-polluted sea food in Japan is a painful lesson. Hence, understanding the pollution level and source of Cd is essential to marine environment protection and the maintaining of ecological sustainable development [3-7]. This paper analyzed the content, horizontal distribution and pollution source of Cd in Jiaozhou Bay in 1985, discussed the water quality, background pollution source and source strength of Cd, provide information for research and comprehensive analysis on source and source strength of Cd, and basis for pollution control and environmental remediation.

Materials and method

Jiaozhou Bay is located in the south of Shandong Province, eastern China ($35^{\circ}55'\text{-}36^{\circ}18' \text{ N}$, $120^{\circ}04'\text{-}120^{\circ}23' \text{ E}$), 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 major ones 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 out in April, July and October 1985 in six investigation sites namely 2031, 2032, 2033, 2034, 2035 and 2047, respectively (Fig. 1). Pb in waters was sampled and monitored following National Specification for Marine Monitoring [10].

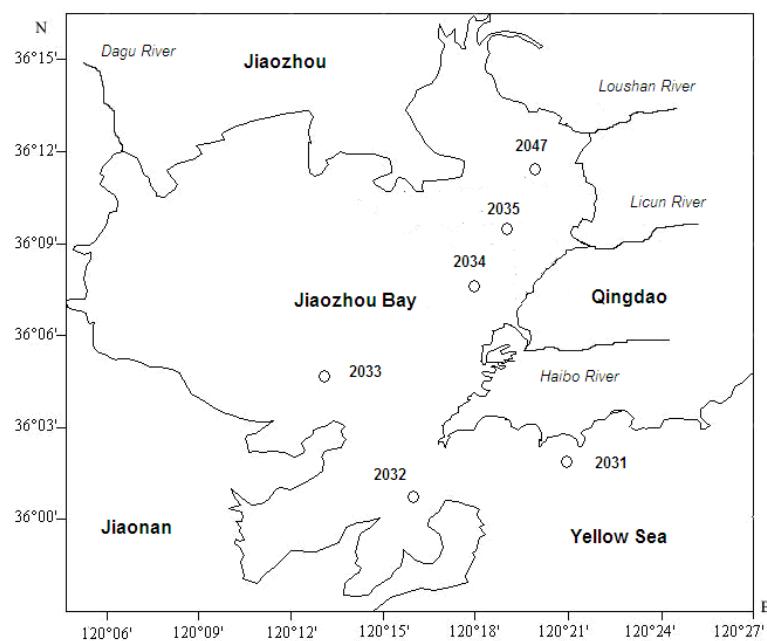


Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

Results and discussion

Content and pollution level of Cd. The contents of Cd in waters in April, July and October were $0.19\text{-}0.44 \mu\text{g L}^{-1}$, $0.16\text{-}0.21 \mu\text{g L}^{-1}$ and $0.03\text{-}0.39 \mu\text{g L}^{-1}$, respectively (Fig. 2). In according to the guide line of Cd in Grade I ($1.00 \mu\text{g L}^{-1}$) of National Sea Water Quality Standard (GB 3097-1997), the contents of Cd in 1985 in Jiaozhou Bay were still very low, indicated that this bay was very slightly polluted by Cd in the early stage of Reform and Opening. In April, Cd contents in the northeast of the bay were $0.39\text{-}0.44 \mu\text{g L}^{-1}$, while in the coastal in the south and the bay mouth were $0.19\text{-}0.21 \mu\text{g L}^{-1}$, and in the east of the bay was $0.33 \mu\text{g L}^{-1}$. In July, Cd contents in the bay mouth and the outside of the bay mouth were $0.16 \mu\text{g L}^{-1}$, while in the inside of the bay were $0.17\text{-}0.21 \mu\text{g L}^{-1}$. In October, Cd contents were relative high ($0.39 \mu\text{g L}^{-1}$) in the estuary of Licun river in the northeast of the bay, while in other regions were as low as $0.03\text{-}0.16 \mu\text{g L}^{-1}$. Although Cd contents were different in different seasons and regions, the pollution levels were all very low.

Table 1 Cd contents in surface water in Jiaozhou Bay in April, July and October 1985

Time	April	July	October
Content/ $\mu\text{g L}^{-1}$	$0.19\text{-}0.44$	$0.16\text{-}0.21$	$0.03\text{-}0.39$
Grade	I	I	I

Distributions and sources of Cd. In April, there was a high value region ($0.44 \mu\text{g L}^{-1}$) around Site 2035 in the estuary of Licun River, and there were a series of semi-concentric circles decreasing from the high value center to the estuary of Haibo River ($0.19 \mu\text{g L}^{-1}$), indicating that stream flow from Licun River was the major source in April (Fig. 2). In July, there was a high value region around ($0.21 \mu\text{g L}^{-1}$) Site 2035 and 2034 in the estuary of Licun River and Haibo River, and there were a series of gradient parallel lines decreasing from the high value center to the estuary of the bay mouth ($0.19 \mu\text{g L}^{-1}$), indicating that stream flow from Licun River and Haibo River was the major source in July (Fig. 3). In October, there was a high value region around ($0.39 \mu\text{g L}^{-1}$) Site 2035 in the estuary of Licun River, and there were a series of semi-concentric circles decreasing from the high value center to the estuary of the bay mouth ($0.03 \mu\text{g L}^{-1}$) and the estuary of Loushan River ($0.03 \mu\text{g L}^{-1}$), indicating that stream flow from Licun River was the major source in October (Fig.4).

In generally, steam flow was the only source of Cd, whose source strength was 0.21-0.41 $\mu\text{g L}^{-1}$.

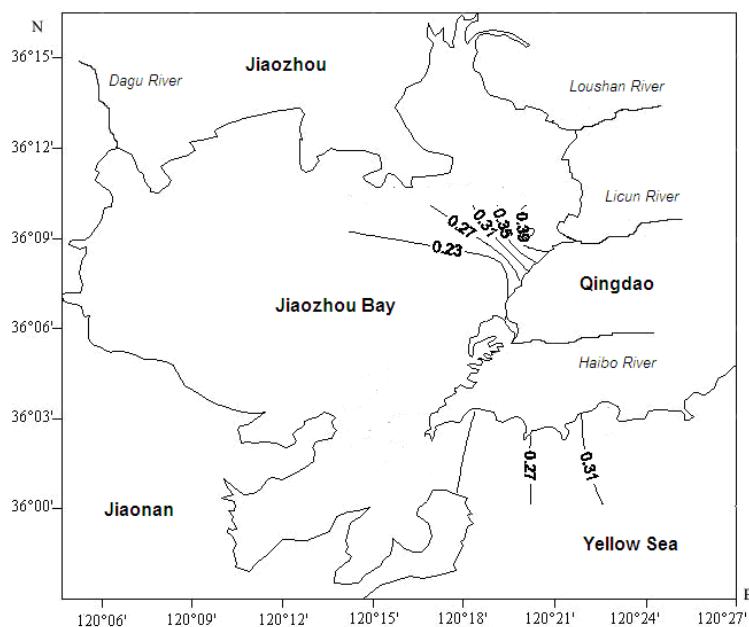


Fig. 2 Horizontal distribution of Cd in Surface waters in Jiaozhou Bay in April 1985/ $\mu\text{g L}^{-1}$

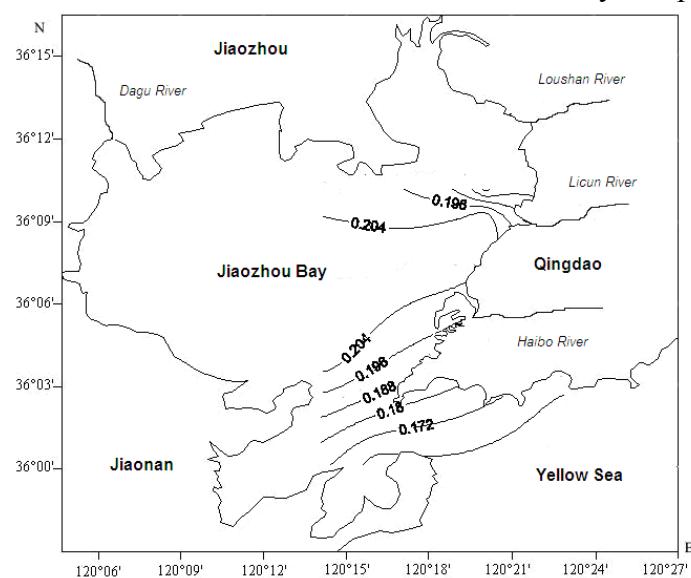


Fig. 3 Horizontal distribution of Cd in Surface waters in Jiaozhou Bay in July 1985/ $\mu\text{g L}^{-1}$

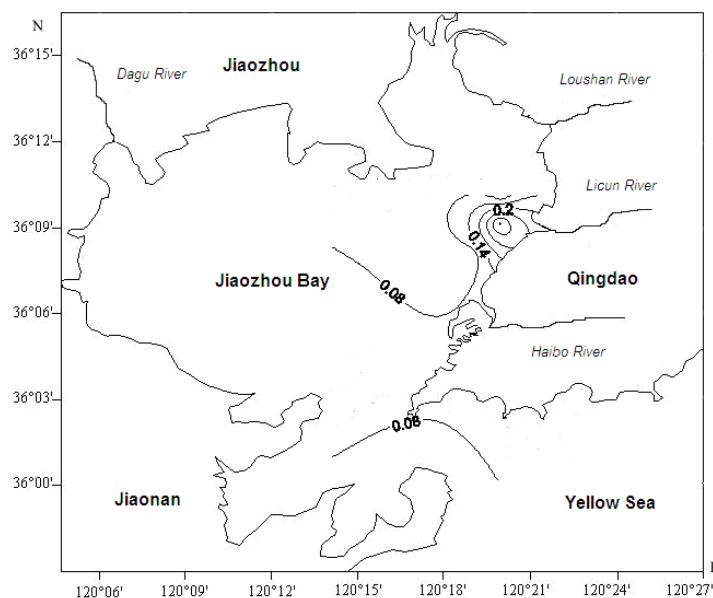


Fig. 4 Horizontal distribution of Cd in Surface waters in Jiaozhou Bay in October 1985/ $\mu\text{g L}^{-1}$

Homogeneity of Cd. Cd in waters was shaking continuously under effects of tide and marine current. The variation range of Cd contents in July were $0.17 \mu\text{g L}^{-1}$ in the coastal waters in the northeast and the, indicated the distribution of Cd in the northeast of the bay was homogeneous. Meanwhile, the variation range of Cd contents in the coastal waters in the east and the southwest was $0.21 \mu\text{g L}^{-1}$, indicated the distribution of Cd in these regions was homogeneous. Moreover, the variation range of Cd contents in the bay mouth and the outside of the bay mouth was $0.16 \mu\text{g L}^{-1}$, indicated the distribution of Cd in these regions was homogeneous. It could be found that the ocean has characteristic of homogeneity by means of tide and marine current. 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 distribution of Cd contents in July was showing the homogeneity clearly. We proposed that the ocean had the characteristic of homogeneity, especially in case of low Cd contents in waters. 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 the main role was marine current, as well as storm tide and submarine earthquake. 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, as well as in 1983 [12-13]. The horizontal distributions and motor processes of the substances fully indicated that the ocean was making all of the substances being homogenous, leading to all of the substances were diffusing in trends of homogenous.

Conclusion

The contents of Cd in waters in April, July and October were $0.19\text{-}0.44 \mu\text{g L}^{-1}$, $0.16\text{-}0.21 \mu\text{g L}^{-1}$ and $0.03\text{-}0.39 \mu\text{g L}^{-1}$, indicated that this bay was very slightly polluted by Cd in the early stage of Reform and Opening. Steam flow was the only source of Cd, whose source strength was $0.21\text{-}0.41 \mu\text{g L}^{-1}$. The ocean had the characteristic of homogeneity, especially in case of low Cd contents in waters. Furthermore, we proposed ‘homogeneous law of substances in waters’. The horizontal distributions and motor processes of the substances fully indicated that the ocean was making all of the substances being homogenous, leading to all of the substances were diffusing in trends of

homogenous.

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