Influence of marine current on vertical migration of Pb in marine bay

Influence of marine current on vertical migration of Pb in marine bay

Chen Yu [1, a], Ai Hong[1], Yang Danfeng [2], Zhao Huijuan[1], Yang Dongfang[3,4, b]

[1]College of Information, Shanghai Ocean University, Shanghai, 201306, China;
[2]College of Information Science and Engineering, Fudan University, Shanghai, 200433, China;
[3]College of Life Science, Shanghai Ocean University, Shanghai, 201306, China;
[4]North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China

[a]corresponding author yuchen@shou.edu.cn, [b] dfyang_dfyang@126.com

Abstract: This paper analyzed that vertical migration of Pb contents waters in Jiaozhou Bay, and revealed the influence of marine current on vertical migration process. Results showed that Pb contents in bottom waters of Jiaozhou Bay in April and July 1988 were 1.49-18.53 μg L^{-1} and 12.68/-27.64 μg L^{-1}, respectively. The pollution level of Pb in bottom waters was moderate to heavy, and were showing temporal variations and spatial heterogeneity. The vertical migration process of Pb in April 1988 included a drifting process from the southwest to the north by means of the marine current was rapid in this region. The vertical migration process of Pb in July 1988 in the open waters included no drifting process since the flow rate of marine current was relative low in this region. The vertical migration process of Pb was jointly determined by vertical water's effect, source input and water exchange, and the influence of marine current on the vertical migration of Pb in marine bay was significant.

1. Introduction

A large amount of Pb-containing wastes were discharged to the environment due to the rapid increasing of industry and the lagging of waste treatment. However, Pb is one of the critical heavy metal, and the excessive of Pb contents in the environment is harmful to ecosystem and human beings [1-2]. Many marine bays had been polluted b Pb since ocean is the sink of pollutants, and understanding the migration process of Pb in marine bays is essential to pollution control [3-5]. Vertical migration is one of the key migration process of pollutants in marine bays [7-8], and understanding the influence factors on vertical migration of Pb in meaningful. Jiaozhou Bay is a semi-closed bay located in Shandong Province, China, and has been polluted by various pollutants along with the rapid development of economic after 1980 [1-2]. Based on investigation data in April and July1988 in Jiaozhou Bay, the aim of this paper is to identify the influence of marine current on vertical migration process of Pb, and to provide basic information for scientific research and pollution control.

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), with the total area and average water depth of 446 km^2 and 7 m, respectively. The bay mouth is very narrow (3 km), and is connected to the Yellow Sea. There are a dozen of rivers including Dagu River, Haibo Rriver, Licun Rriver, and Loushan Rriver etc., all of which are seasonal

rivers [7-8]. The investigation on Pb in bottom waters in Jiaozhou Bay was carried on in April and July 1988 in six monitoring sites (i.e., 34, 35, 36, 84, 85 and 90) (Fig. 1). Pb in bottom waters was sampled and monitored follow by National Specification for Marine Monitoring [9].

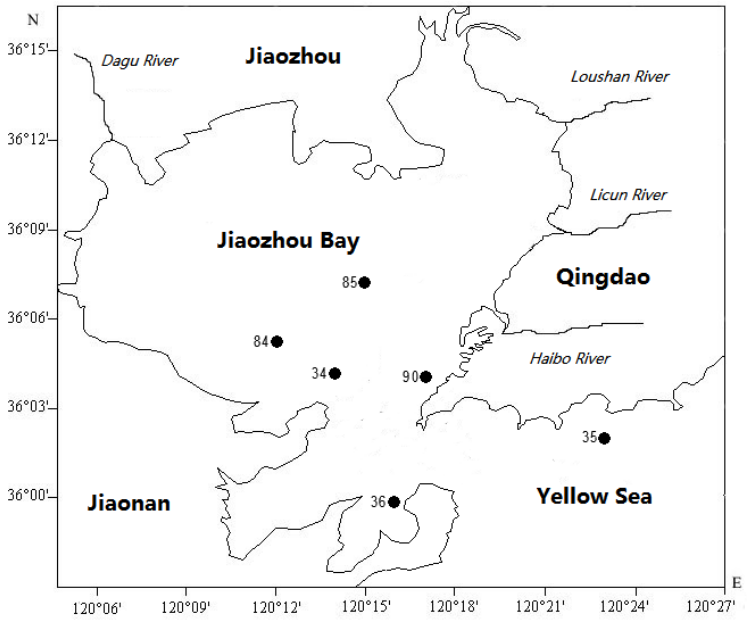

Fig. 1 Geographic location and sampling sites of Jiaozhou Bay

3. Results and discussion

Contents and horizontal distribution of Pb. Pb contents in bottom waters in Jiaozhou Bay in April and July 1988 were 1.49-18.53 μg L^{-1} and 12.68/-27.64 μg L^{-1}, respectively. In general, the pollution level of Pb in bottom waters in April 1988 was moderate, while in July 1988 were heavy. In April 1988, high value (18.53 μg L^{-1}) of Pb contents in bottom waters was occurring in Site 85 in the center of the bay, and Pb contents were decreasing from the center of the bay to the bay mouth in the south of the bay(16.27 μg L^{-1}) and to the open waters (13.65 μg L^{-1}) (Fig. 2). In July 1988, high value (27.64 μg L^{-1}) of Pb contents in surface waters was occurring in the open waters out side the bay mouth, and Pb contents were decreasing from the open waters to the bay mouth (16.76 μg L^{-1}), and to the center of the bay (14.75 μg L^{-1}) (Fig. 3). Hence, it could be found that the pollution level of Pb in bottom waters in Jiaozhou were showing temporal variations and spatial heterogeneity.

Table 1 Guidelines for Pb in Sea Water Quality Standard (GB3097-1997)

Class	I	II	III	IV
Pb content/μg L^{-1}	1.0	5.0	10.0	50.0

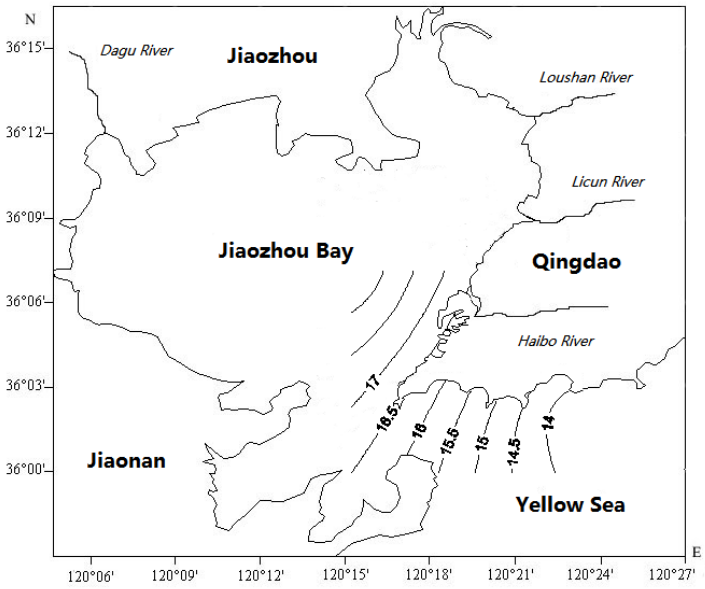

Fig. 2 Horizontal distribution of Pb contents in bottom waters in Jiaozhou Bay in April 1988 /μg L^{-1}

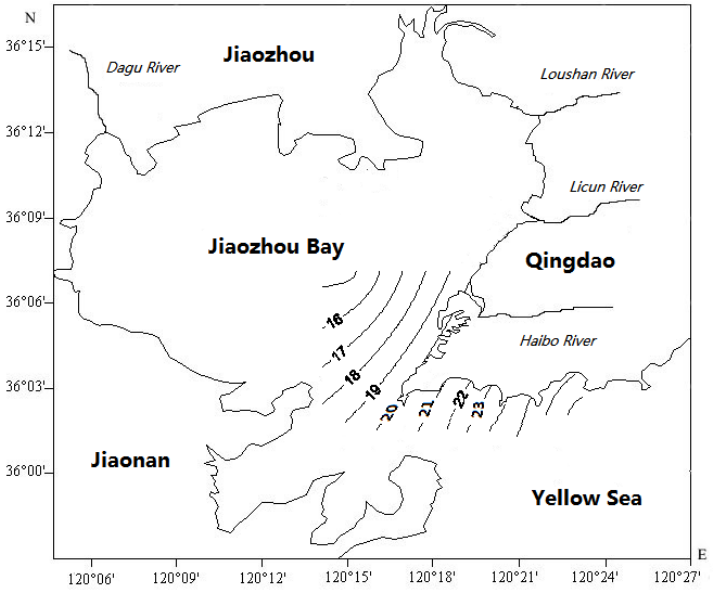

Fig. 3 Horizontal distribution of Pb contents in bottom waters in Jiaozhou Bay in July 1988 /μg L^{-1}

High sedimentation region of Pb. Pb contents in Jiaozhou Bay were mainly sourced from atmospheric deposition and marine current. By means of vertical water's effect [7-9], Pb contents would be migrating from surface waters to bottom waters. In April 1988, Pb contents were mainly sourced from atmospheric deposition, and were decreasing from the center of the bay to the inside of the bay mouth, and then to the bay mouth, and finally to the open waters, remaining a high sedimentation region in the center of the bay. In July 1988, Pb contents were mainly sourced from marine current, and were decreasing from the open waters to the bay mouth, and then to the inside of the bay mouth, and finally to the center of the bay, remaining a high sedimentation region in the open waters in the outside of the bay mouth. In general, there were different high sedimentation region in marine bay in different seasons.

Vertical migration process of Pb. It was found that atmospheric deposition and marine current were the major Pb sources in April and July 1988, respectively. In April 1988, the high value region of Pb contents in surface waters were in coastal waters in the southwest of the bay, yet the high value region of Pb contents in bottom waters were in the center of the bay. Hence, it could be defined that the vertical migration process of Pb included a drifting process, i.e., from the southwest to the north. The reason was that the flow rate of marine current in waters closed to the bay mouth was relative high, and a part of Pb contents were moved along with the flow direction (Fig. 4). In July 1988, the high value region of Pb contents in surface waters were in the open water, and the high value region of Pb contents in bottom waters were also in the open waters. This indicated that there was no drifting process in the vertical migration process of Pb. The reason was that the flow rate of marine current in the open waters outside the bay mouth was relative low, and few Pb contents were moved along with the flow direction (Fig. 5). The vertical migration process of Pb was jointly determined by vertical water's effect, source input and water exchange [10-13], and the influence of marine current on the vertical migration of Pb in marine bay was significant.

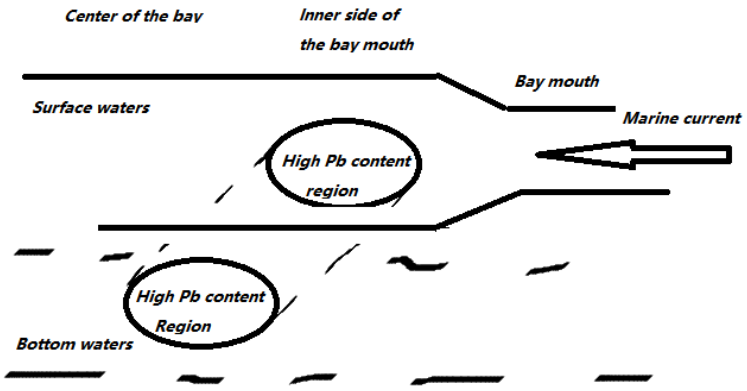

Fig. 4 Block diagram model of vertical migration of Pb in Jiaozhou Bay in April 1988

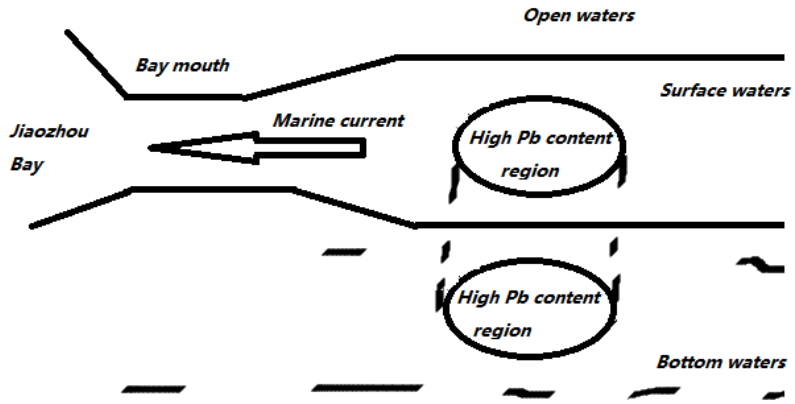

Fig. 5 Block diagram model of vertical migration of Pb in Jiaozhou Bay in July 1988

4. Conclusion

Pb contents in bottom waters in Jiaozhou Bay in April and July 1988 were 1.49-18.53 μg L^{-1} and 12.68/-27.64 μg L^{-1}, respectively. The pollution level of Pb in bottom waters was moderate to heavy, and were showing temporal variations and spatial heterogeneity. There were different high sedimentation region in marine bay in different seasons. The vertical migration process of Pb in April

1988 included a drifting process from the southwest to the north by means of the marine current was rapid in this region. The vertical migration process of Pb in July 1988 in the open waters included no drifting process since the flow rate of marine current was relative low in this region. The vertical migration process of Pb was jointly determined by vertical water's effect , source input and water exchange, and the influence of marine current on the vertical migration of Pb in marine bay was significant.

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 D F, Su C, Gao Z H, et al.: Chin. J. Oceanol. Limnol., Vol. 26(2008): 296-299.
[2] Yang DF, Guo JH, Zhang YJ, et al.: Journal of Water Resource and Protection, Vol. 3(2011): 41-49.
[3] Yang DF, Zhu SX, Wang FY, et al.: Applied Mechanics and Materials, Vol. 651-653(2014), p. 1419-1422.
[4] Yang DF, Geng X, Chen ST, et al.:Applied Mechanics and Materials, Vol. 651-653 (2014), p. 1216-1219.
[5] Yang DF, Ge HG, Song FM, et al.: Applied Mechanics and Materials, Vol. 651-653 (2014), p. 1492-1495.
[6] Yang DF, Zhu SX, Wang FY, et al.:Applied Mechanics and Materials, Vol.651-653 (2014), p. 1292-1294.
[7] Yang DF, Chen Y, Gao ZH, Zhang J, et al.:Chinese Journal of Oceanology and Limnology, Vol. 23(2005): 72-90.
[8] Yang DF, Wang F, Gao ZH, et al.: Marine Science, Vol. 28 (2004), p.71-74.
[9] State Ocean Administration. The specification for marine monitoring: Beijing, Ocean Precess, (1991).
[10] Yang DF, Wang FY, Yang XQ, et al.:Advances in Computer Science Research, 2015, p. 198-204.
[11] Yang DF, Wang FY, He HZ, et al.: Proceedings of the 2015 international symposium on computers and informatics,2015, p. 2655-2660.
[12] Yang DF, Wang FY, Zhao XL, et al.: Sustainable Energy and Enviroment Protection, 2015, p. 191-195.
[13] Yang DF, Miao ZQ, Xu HZ, et al.: Marine Environmental Science, Vol. 32 (2013), p. 373-380.