Influence of vertical migration process on seasonal variation and horizontal distribution of Pb in marine bay

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Abstract. This paper analyzed the seasonal variation, vertical variation and horizontal distribution of Pb in Jiaozhou Bay using investigation data in April and July 1989. Results showed that Pb contents in surface and bottom waters April 1989 were 9.96-11.03 μg L⁻¹ and 8.15-10.10 μg L⁻¹, respectively, while in July 1989 were 6.47-15.17 μg L⁻¹ and 3.39-7.15 μg L⁻¹, respectively. The pollution level of Pb in bottom waters in April and July 1989 could be considered as heavy and moderate, respectively. The seasonal variations of Hg in both surface and bottom waters were summer > spring. Hence, the seasonal variations of Hg in surface and bottom waters were same. The vertical migration processes of Pb in waters in April and July 1989 revealed the accumulation effect and dilution effect. The seasonal variations of Pb contents in surface waters were determined by the changes of the major Pb sources, while in bottom waters were determined by both the source input and vertical water’s effect. The horizontal distributions of Pb contents in surface and bottom waters were determined by the changes of the major Pb sources, while in bottom waters were determined by both source input and the inputting time.

1. Introduction

Pb has been widely used in many industries such as smelting, instrument and apparatus, brine electrolysis [1-2]. Pb is highly toxic and persistent in the environment, and the excessive Pb contents in the environment is harmful to organism and ecosystem. A large amount of Pb-containing wastes were generated and discharged to the environment along with the rapid development of industries, while the waste treatment in many countries and regions is always lagging [3-4]. As a result, many marine bays have been polluted by Pb since ocean is the sink of pollutants [5-6]. By means of vertical water’s effect [7-8], Pb contents in surface and bottom waters in marine bay were changing continuously. Hence analyzing the influence of vertical migration process on horizontal of Pb in marine bay is essential to pollution control[9-10].

Jiaozhou Bay is a semi-closed bay located in Shandong Province China. This bay is surrounding by cities of Qingdao, Jiaozhou and Jiaonan in the east, north and south, respectively. Along with the rapid increasing of industry the past three decades, this bay has been polluted by various pollutants including Pb after the rapid increasing of industry the past three decades [10-12]. This paper analyzed the seasonal variation, vertical variation and horizontal distribution of Pb in Jiaozhou Bay using investigation data in April and July 1989. The aim of this paper was to better understand the
transporting processes of Pb in marine bay, and provide basis for scientific research and environment remediation.

2. Materials and method
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 and average water depth are 446 km² and 7 m, respectively. The bay mouth is very narrow (3 km), and is connected to the Yellow Sea in the south. There are a dozen of rivers including Dagu River, Haibo River, Licun River, and Loushan River etc., all of which are seasonal rivers [7-8].

The investigation on Pb in Jiaozhou Bay was carried on by North China Sea Environmental Monitoring Center. In April and July 1989, Hg contents in surface and bottom waters were measured in Site 85 and Sit 90 in the bay center and the bay mouth, respectively (Fig. 1). Pb in waters was sampled and monitored follow by National Specification for Marine Monitoring [9].

3. Results
3.1. Contents and pollution levels of Pb.
In April 1989, Pb contents in surface and bottom waters were 9.96-11.03 μg L⁻¹ and 8.15-10.10 μg L⁻¹, respectively. In according to China Sea Water Quality Standard (GB 3097-1997) guide lines for Pb, the pollution level of Pb in April were confirm to Grade II and V. In July 1989, Pb contents in surface and bottom waters were 6.47-15.17 μg L⁻¹ and 3.39-7.15 μg L⁻¹, respectively. In according to China Sea Water Quality Standard (GB 3097-1997) guide lines for Pb, the pollution level of Pb in April were confirm to Grade II and III. In general, the pollution level of Pb in bottom waters in April and July 1989 could be considered as heavy and moderate, respectively.

| Grade | I   | II  | III | IV  |
|-------|-----|-----|-----|-----|
| Content/μg L⁻¹ | 1.00 | 5.00 | 10.00 | 50.00 |

3.2. Seasonal variations of Pb.
April and July are spring and summer in study area, respectively. In according to Pb contents in April and July 1989, the seasonal variations of Hg in both surface and bottom waters were summer > spring.
Hence, the seasonal variations of Hg in surface and bottom waters were same. Meanwhile, Hg contents in surface waters in April were relatively low (9.96-11.03 μg L⁻¹), and in bottom waters were also relatively high (8.15-10.10 μg L⁻¹). By contrast, Pb contents in surface waters in July were relatively high (6.47-15.17 μg L⁻¹), and in bottom waters were also relatively low (3.39-7.15 μg L⁻¹).

3.3. Horizontal distributions of Pb.
In April 1989, Pb contents in surface waters were decreasing from the bay mouth to the bay center, while in bottom waters were increasing from the bay mouth to the bay center. In July 1989, Pb contents in surface waters were increasing from the bay mouth to the bay center, and in bottom waters were also increasing from the bay mouth to the bay center. Hence, the horizontal distributions of Pb in surface and bottom waters in April 1989 were opposite, yet the horizontal distributions of Pb in surface and bottom waters in July 1989 were consistent.

4. Discussion

4.1. Vertical migration of Pb.
Pb contents in waters were changing a lot during the transporting process through the waters by means of vertical waters’ effect [7-8]. The growth and reproduction of marine zooplankton and phytoplankton were increasing from spring to summer [6], and a great deal of colloid which was able to enhance the absorption capacity of suspending particular matters. Hence, a big part of Pb was absorbed to the suspending particular matters and transported to sea bottom continuously by means of gravity force and marine current [7-8].

4.2. Influence of vertical water’s effect on the seasonal variation of Pb.
In April and July 1989, the seasonal variations of Hg in both surface and bottom waters were summer > spring. In spring, the major Pb sources in Jiaozhou Bay was river flow, whose source strengths were relatively weak, and Pb contents in surface waters were relatively low. However, by means of vertical water’s effect [7-8], Pb was transporting and accumulating in bottom waters along with time continuously, resulting in Pb contents in bottom waters were in order of summer > spring. In summer, the major Pb source were river flow and atmosphere deposition, and the source strength was relative strong, and therefore Pb contents in surface waters were relative high. By means of vertical water’s effect [7-8], a big part of Pb was transporting to sea bottom, resulted in Pb contents in bottom waters were in order of summer > spring. The vertical migration processes of Pb in waters in April and July 1989 revealed the accumulation effect and dilution effect. The seasonal variations of Pb contents in surface waters were determined by the changes of the major Pb sources, while in bottom waters were determined by both the source input and vertical water’s effect.

4.3. Influence of vertical water’s effect on the horizontal distribution of Pb.
The horizontal distributions of Pb in surface and bottom waters in April 1989 were opposite, yet in July 1989 were consistent. The rainfall-runoff in study was increasing in spring and reaching the high value in summer. In April 1989, the source input of Pb was just beginning and the source strength was still relatively weak, and contents in surface waters were decreasing from the bay mouth to the bay center, the reason was that the major source of Pb was river runoff and Pb contents were decreasing from the source to open waters along with the water exchange process. However, Pb contents in bottom waters in April 1989 were increasing from the bay mouth to the bay center, the reason was that the sedimentation of Pb was just beginning, and the vertical accumulation of Pb in sea bottom was still too weak to promote the horizontal distribution of Pb in bottom waters to be consistent with in surface waters. The source input of Pb to Jiaozhou Bay in July 1989 was relative strong, and Hg contents in surface waters were also decreasing from the bay center to the bay mouth. However, a big part of Pb had been transported to sea bottom by means of the continuous sedimentation process, resulting in the horizontal distributions of Pb in surface and bottom waters in July were consistent. As a whole, the
horizontal distributions of Pb contents in surface waters were determined by the changes of the major Pb sources, while in bottom waters were determined by both source input and the inputting time.

5. Conclusions

Pb contents in surface and bottom waters April 1989 were 9.96-11.03 µg L⁻¹ and 8.15-10.10 µg L⁻¹, respectively, while in July 1989 were 6.47-15.17 µg L⁻¹ and 3.39-7.15 µg L⁻¹, respectively. The pollution level of Pb in bottom waters in April and July 1989 could be considered as heavy and moderate, respectively.

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References

[1] Yang DF, Su C, Gao ZH, 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, et al.: Chinese Journal of Oceanology and Limnology, Vol. 23(2005), p. 72-90.
[8] Yang DF, Wang F, Gao ZH, et al. Marine Science, Vol. 28 (2004), p. 71-74.
[9] China's State Oceanic Administration: The specification for marine monitoring (Ocean Press, Beijiang 1991), p.1-300
[10] Yang DF, Miao ZQ, Xu GZ, et al.: Proceedings of the 2015 international symposium on computers and informatics, 2015, p. 2655-2660.
[11] Yang DF, Wang FY, Zhao XL, et al.: Sustainable Energy and Environment Protection, 2015, p. 191-195.
[12] Yang DF, Yang XQ, Wu YJ, et al.: Advances in Computer Science Research, 2015, p. 2352: 198-204.