Transport process and block diagram of Cd in Jiaozhou Bay

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Abstract. Many marine bays have been polluted by various pollutants due to the rapid development of economic and population. Understanding the transport processes of pollutants in marine bays is essential to pollution control. This paper analyzed the transport processes of Cd in Jiaozhou Bay based on investigation data during 1979－1983. Results showed that the major transport processes of Cd included terrestrial transport process, atmospheric transport process and oceanic transport process, respectively. Furthermore, this paper provided the block diagrams for these transport processes, which were determining the migrating paths and traces of Cd.

1. Introduction

Many marine bays have been polluted by various pollutants due to the rapid development of economic and population. Understanding the transport processes of pollutants in marine bays is essential to pollution control. Jiaozhou Bay is a semi-closed bay located in Shandong Province, eastern China, and had been polluted by various pollutants including Cd since marine is the sink of pollutants. This paper analyzed the transport processes of of Cd in Jiaozhou Bay based on investigation data during 1979－1983 [1-12], and provided basis information to scientific research and pollution control practice.

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). The total area, average water depth and bay mouth width are 446 km^2, 7 m and 3 km, respectively. This bay is connected to the Yellow Sea in the south. There are a dozen of rivers, and the majors are Dagu River, Haibo Rriver, Licun Rriver, and Loushan Rriver etc., all of which are seasonal rivers [13-14].

The investigation on Cd content in surface waters in Jiaozhou Bay was conducted in May, August, and November 1979, June, July and September 1980, April, August and November 1981, April, June, July and October 1982, and, May, September and November 1983, respectively [1-10]. Cd in surface waters was sampled and monitored follow by National Specification for Marine Monitoring (Fig. 1)[15].

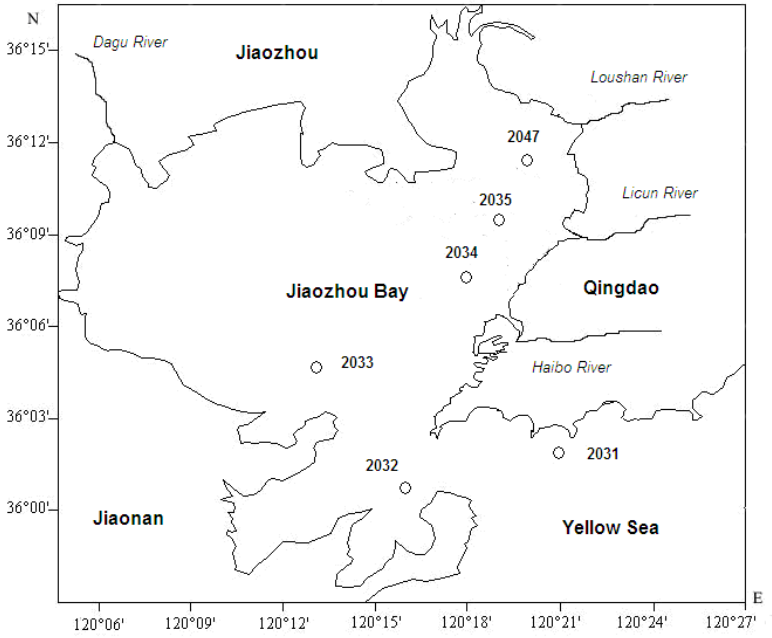

Fig. 1 Geographic location and sampling sites in Jiaozhou Bay

3. Results and discussion

3.1 Sources and source strengths of Cd

In according to the horizontal distributions particularly the high value regions of Cd contents in Jiaozhou Bay waters [1-12], it could be found that there were six Cd sources including marine current, river flow, island top, atmosphere deposition, overland runoff and wharf, whose source strengths were 0.12-0.25 μg L^{-1}, 0.07-0.85 μg L^{-1}, 0.48-3.33 μg L^{-1}, 0.14-0.55 μg L^{-1}, 0.38-0.53 μg L^{-1} and 0.16-1.50 μg L^{-1}, respectively (Fig. 2). The spatial-temporal variations of Cd in Jiaozhou Bay were mainly determined by the transport processes of these sources.

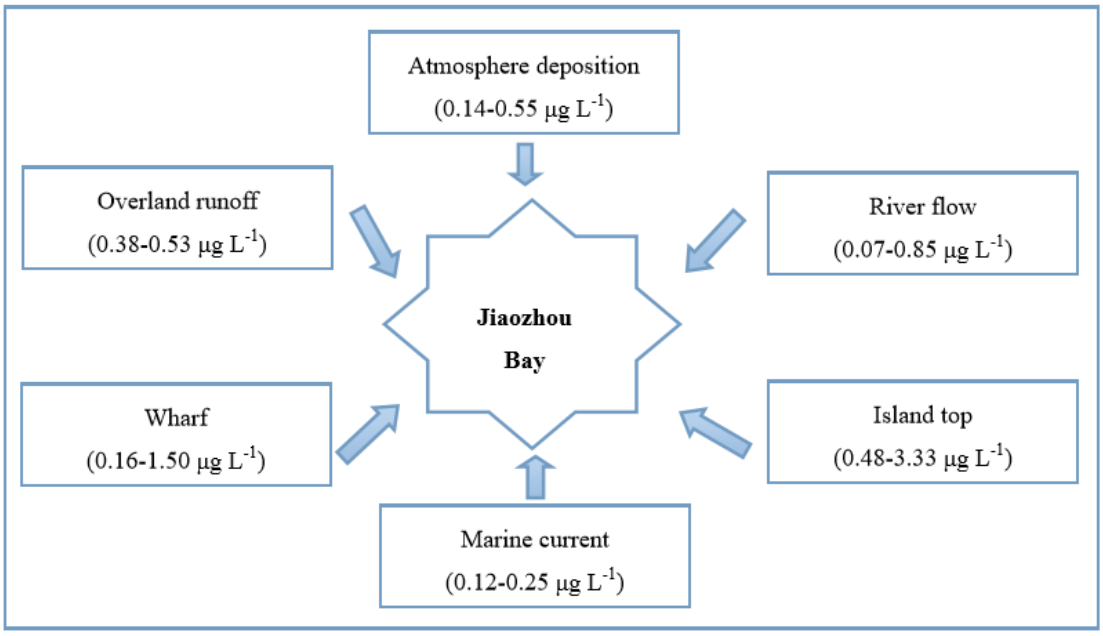

Fig. 2 Sources and source strengths of Cd in Jiaozhou Bay

3.2 Terrestrial transport process of Cd

Rivers were the major migrating paths of pollutants, and could be considered one of the pollution sources of marine bays. The Cd source strengths of river flow were 0.07-0.85 μg L^{-1}, and were relative low during 1979-1983. Cd was one of the widely used heavy metal in industry, and a large amount of Cd-containing wastes were discharged to the environment. The terrestrial transport process of Cd included three processes of 1) the existence and generation of Cd, 2) the discharging and leaching of Cd from soil and land surface, and 3) Cd was transported to marine bays via river flow. The block diagram of the terrestrial transport process of Cd was provided in Fig. 3. The spatial-temporal variations of Cd in estuaries of the major rivers in Jiaozhou Bay were mainly impacted bay the terrestrial transport process, and could be described by this block diagram.

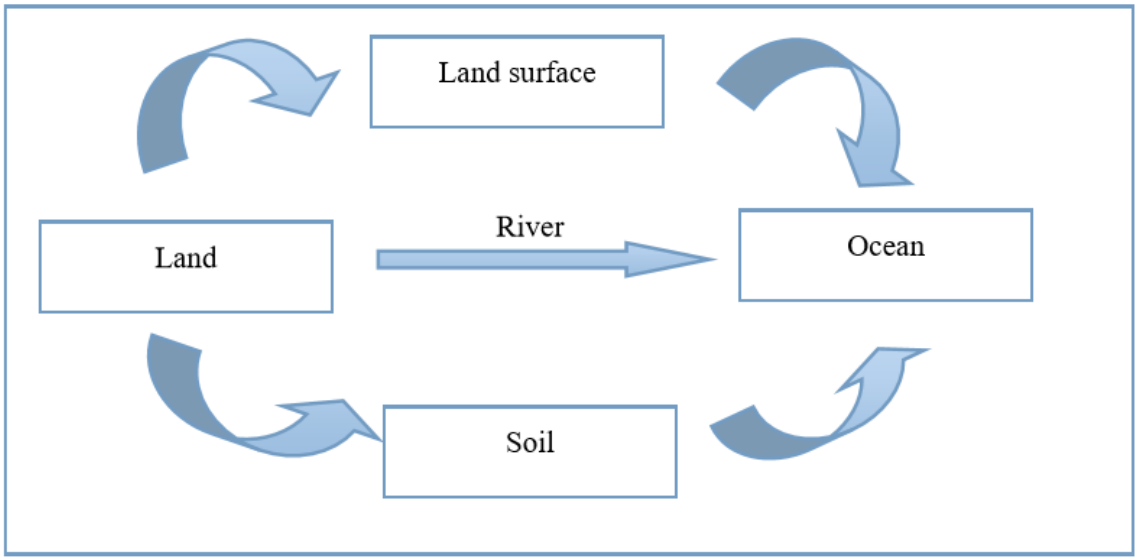

Fig. 3 The block diagram of the terrestrial transport process of Cd

3.3 Atmospheric transport process of Cd

Atmosphere was one of the major source of Cd to marine bays since Cd-containing waste gas were discharged to air and could be settling again. The Cd source strengths of atmosphere were 0.14-0.55 μg L^{-1}, and were also relative low during 1979-1983. The atmospheric source of Cd could be input to marine bays directly. Meanwhile, atmospheric source of Cd could be added to the land surface and soil, and was transported to marine bays via river flow. The atmospheric transport process of Cd included three processes of 1) the existence and generation of Cd in atmosphere, 2) the direct deposition of Cd to ocean, 3) the deposition of Cd the land, and 4) the transport of Cd from land to ocean via river flow. The block diagram of the atmospheric transport process of Cd was provided in Fig. 4. The spatial-temporal variations of Cd in the center of Jiaozhou Bay were mainly impacted bay the atmospheric transport process, and could be described by this block diagram.

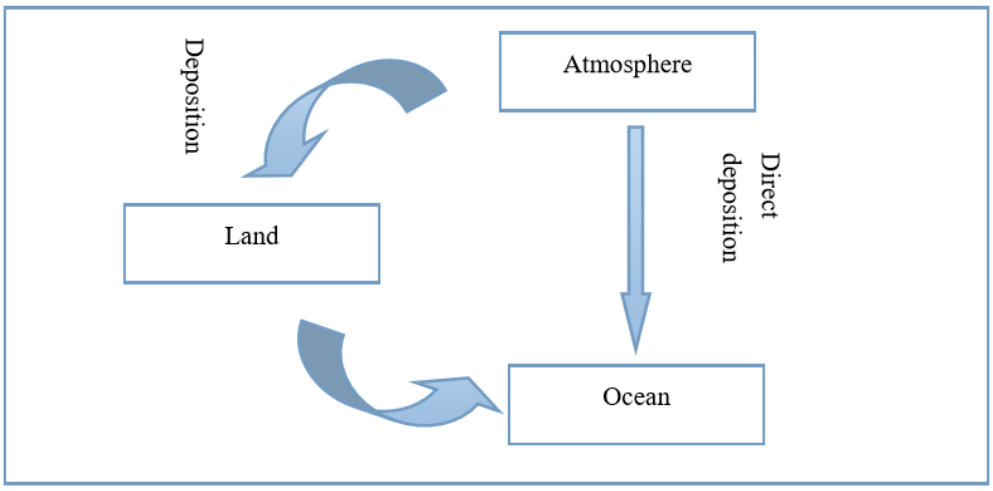

Fig. 4 The block diagram of the atmospheric transport process of Cd

3.4 Oceanic transport process of Cd

The oceanic transport process of Cd the Jiaozhou Bay was mainly determined by marine current, island top and wharf, whose source strengths were 0.12-0.25 μg L^{-1}, 0.48-3.33 μg L^{-1} and 0.16-1.50 μg L^{-1}, respectively (Fig. 2). In general, the source strength of wharf was relative high and were increasing during 1979-1983 due to the development of marine traffic. The oceanic transport process of Cd included three processes of 1) the relative strong marine current source of Cd was transported to low Cd containing regions, 2) Cd-containing wastes were discharged to marine bays via island top directly, and 3) Cd-containing wastes were discharged to marine bays via marine traffic. The block diagram of the oceanic transport process of Cd was provided in Fig. 5. The spatial-temporal variations of Cd in waters closed to the bay mouth, island top and harbor were mainly impacted bay the atmospheric transport process, and could be described by this block diagram.

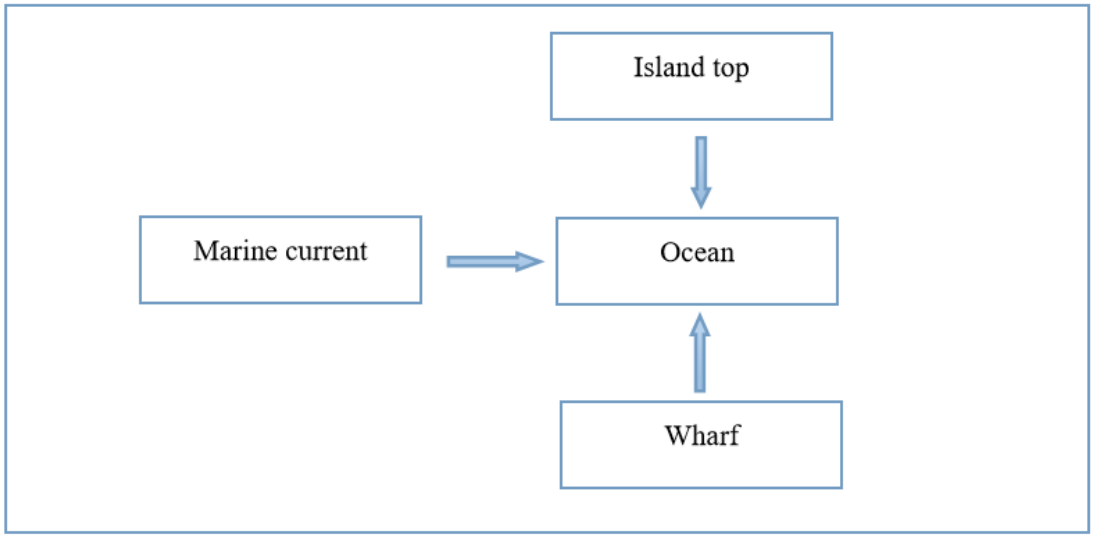

Fig. 5 The block diagram of the oceanic transport process of Cd

4. Conclusion

There were six major Cd sources including marine current, river flow, island top, atmosphere deposition, overland runoff and wharf, respectively. The spatial-temporal variations of Cd in Jiaozhou Bay were mainly determined by the transport processes of these sources. The major transport processes of Cd included terrestrial transport process, atmospheric transport process and oceanic

transport process, respectively. The block diagrams for these transport processes, which were determining the migrating paths and traces of Cd.

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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, Chen Y, Wang H, et al.: Coastal Engineering, Vol. 29 (2010), p. 73-82.
[4] Yang DF, Chen Y, Liu CX, et al.: Coastal Engineering, Vol. 32(2013), p. 68-78.
[5] Yang DF, Zhu SX, Wu YF, et al.: Applied Mechanics and Materials, Vol.644-650 (2014), p. 5325-5328.
[6] Yang DF, Wang FY, Wu YF, et al.: Applied Mechanics and Materials, Vol.644-650 (2014), p. 5329-5312.
[7] Yang DF. Chen Y, Gao ZH, et al.: Proceedings of the 2015 international symposium on computers and informatics. Vol.(2015), p. 2667-2674.
[8] Yang DF, Zhu SX, Yang XQ, et al.: Materials Engineering and Information Technology Apllication, Vol. (2015), p.558-561.
[9] Yang DF, Zhu SX, Wang FY, et al.: Advances in Computer Science Research, Vol. 2352(2015), p.194-197.
[10] Yang DF, Wang FY, Sun ZH, et al.:Advances in Engineering Research, Vol. 40(2015), p.776-781.
[11] Yang DF, Yang DF, Zhu SX, et al.:Advances in Engineering Research, Vol. Part B (2016), p. 403-407.
[12] Yang DF, Yang XQ, Wang M, et al.:Advances in Engineering Research. Vol. Part B(2016), p. 412-415.
[13] Yang DF, Chen Y, Gao ZH, et al.: Chinese Journal of Oceanology and Limnology, Vol. 23(2005), p. 72-90. (in Chinese)
[14] Yang DF, Wang FY, Gao ZH, et al. Marine Science, Vol. 28 (2004), p. 71-74. (in Chinese)
[15] China's State Oceanic Administration: The specification for marine monitoring (Ocean Press, Beijiang 1991), p.1-300. (in Chinese)