Spatial-temporal migration laws of Cd in Jiaozhou Bay

Dongfang Yang1,2,3, a, Haixia Li1,Xiaolong Zhang1,Qi Wang1, Zhenqing Miao3,b,c
1Accountancy Shool, Xijing University, Xian 710123, China;
2North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China;
3College of Fisheries, Zhejiang Ocean University, Zhoushan, 316022, China.
adfyang_dfyang@126.com, bcorresponding author, cmzq@zjou.edu.cn.

Abstract. Many marine bays have been polluted by various pollutants, and understanding the migration laws is essential to scientific research and pollution control. This paper analyzed the spatial and temporal migration laws of Cd in waters in Jiaozhou Bay during 1979—1983. Results showed that there were twenty spatial-temporal migration law for the migration processes of Cd. These laws were helpful for better understanding the migration of Cd in marine bay, providing basis for scientific research and pollution control.

1. Introduction
Cd has been widely used in industries, and a large amount of Cd-containing wastes were discharged to the environment. However, Cd is high toxic and the excessive Cd contents in the environment could cause harmful to the ecosystem and human [1-10]. Many marine bays have been polluted by various pollutants, and understanding the migration laws is essential to scientific research and pollution control.

Jiaozhou Bay is a semi-closed bay located in Shandong Province, eastern China, and had been polluted by various pollutants including Cd [3-17]. This paper analyzed the spatial and temporal migration laws of Cd in waters in Jiaozhou Bay during 1979—1983. The research results were helpful for better understanding the migration of Cd in marine bay, providing basis 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). The total area, average water depth and bay mouth width are 446 km², 7 m and 3 km, respectively (Fig. 1). This bay is connected to the Yellow Sea in the south. 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 [18-19].

The investigation on Cd content 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 [3-17]. Cd in waters was sampled and monitored follow by National Specification for Marine Monitoring (Fig. 1)[20]. In study area, April, May and June are spring, July, August and September are summer, while October, November and December are autumn.
3. Results and discussion

In accordance to the investigation data on Cd in Jiaozhou Bay and previous studies [3-17], we further analyzed and summarize the spatial and temporal migration laws of Cd. Results showed that there were twenty law about the spatial and temporal migration process of Cd in Jiaozhou Bay.

1) Cd in Jiaozhou Bay were mainly sourced from Cd sources including marine current, river flow, island top, atmosphere deposition, overland runoff and wharf, respectively.

2) Cd contents in waters in Jiaozhou Bay undergone a process from inhomogeneous to homogeneous within year.

3) The human activities increase the input channels of Cd to marine bay.

4) Cd contents in the environment were increasing along with time.

5) The variation ranges of Cd contents in surface and bottom waters in the bay were basically consistent.

6) Cd contents in surface and bottom waters in the bay were closed and were tending to be consistent.

7) At spatial-temporal process, the input of Cd from the sources to the bay was experiencing a process from surface waters to bottom waters.

8) The spatial-temporal variations of Cd sources and the spatial geographic and geomorphic resulted in high sedimentation regions.

9) Cd contents in surface waters were decreasing along with the distance from the sources, and were decreasing along with the decreasing of the source strengths.

10) The seasonal variations of Cd in waters were determined by terrestrial migration process, atmospheric migration process and oceanic migration process.

11) The sedimentation of Cd was rapid, and the absolute sedimentation amount was strongly impacted by contents in waters.

12) Cd sources and source strengths were increasing along with time, and the area of the high sedimentation regions were also increasing.

13) The sedimentation of Cd was rapid, and the relative sedimentation amount was not impacted by
contents in waters.

14) There was accumulation process of Cd in bottom waters along with the continuous sedimentation of Cd.

15) Cd contents in waters were showing processes of appearance, disappearance, re-appearance and re-disappearance.

16) Once Cd contents in surface waters were disappear, Cd contents in bottom water would be disappear soon afterwards.

17) Along with time, the relative sedimentation amount and relative accumulation amount of Cd were big and stable.

18) The sedimentation of Cd was rapid and thorough, and the accumulation of Cd was stable and complete.

19) The changes of Cd contents in surface and bottom waters were determined by the source strengths and the distances of the migration process.

20) Once the input of Cd was stop, Cd contents in the whole waters would be disappear.

In accordance to the investigation data on Cd in Jiaozhou Bay and previous studies [3-17], we further analyzed and summarize the temporal migration laws of Cd. Results showed that the seasonal variations of Cd contents were changing with time during 1979—1983. Cd contents in spring were still very low during 1979—1983, Cd contents in summer and autumn were very low in the early stage, yet in the late stage were increasing to be slight polluted. Cd contents in Jiaozhou Bay was increasing during 1979—1983 in general, since the anthropogenic sources and inputs of Cd to the bay was increasing along with the rapid development of industry and population. In general, Cd contents during 1979—1981 could be considered as environment background values, while after 1982 Cd contents were increasing and indicating the strong impact of human activities on the bay. These results were useful as basic information for scientific research, and were pointing that source control of various pollutants was necessary.

4. Conclusion

This paper analyzed the spatial and temporal migration laws of Cd in waters in Jiaozhou Bay during 1979—1983. There were twenty law about the spatial and temporal migration process of Cd in Jiaozhou Bay. Cd contents in Jiaozhou Bay was increasing since the anthropogenic sources and inputs of Cd to the bay was increasing along with the rapid development of industry and population. Cd contents during 1979—1981 could be considered as environment background values since the impact of human activities was still weak. These results were useful as basic information for scientific research, and were pointing that source control of various pollutants was necessary.

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