Mercury's source input paths to Jiaozhou Bay

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Abstract. This paper analyzed the source input paths of mercury (Hg) in Jiaozhou Bay using investigation data in surface waters in April, July and October 1989. Results showed that Hg contents in surface waters in the whole year ranged from 0.002-0.449 μg L-1, and in April, July and October were 0.035-0.449 μg L-1, 0.002-0.059 μg L-1 and 0.002-0.028 μg L-1, respectively. The pollution levels of Hg in April, July and October were moderate, slight and little, respectively. River discharge, atmosphere deposition and marine current were the three major Hg sources, whose source strengths were 0.026-0.449 μg L-1, 0.059 μg L-1 and 0.026-0.028 μg L-1, and the pollution levels were moderate, slight and little, respectively. In general, the pollution level of Hg in surface waters in Jiaozhou Bay were mainly determined by source inputs. Furthermore, a block diagram model was provided to demonstrate the input paths of Hg to Jiaozhou Bay.

1 Introduction

Along with the rapid development of industry, a large amount of Hg was used and a great deal of Hg-containing wastes were discharged to air, soil and water, resulted in the Hg pollution in many marine bays around the world [1-3]. Understanding the pollution level, distribution and source of Hg in marine bay is essential to marine environmental protection. Jiaozhou Bay is a semi-closed bay located in south of Shandong Peninsula, eastern China. This bay has been polluted by various pollutants due to the rapid increasing of industry since China's Reform and Opening-up [1-3]. In order to provide scientific basis for the research on the source, pollution level and transfer process, this paper analyzed the source input paths of Hg in Jiaozhou Bay using investigation data in surface waters in April, July and October 1989. Results showed that River discharge, atmosphere deposition and marine current were the three major Hg sources, the pollution levels were moderate, slight and little, respectively. The pollution level of Hg in surface waters in Jiaozhou Bay were mainly determined by source inputs, and the source control is an essential countermeasure.

2 Study area and data collection

Jiaozhou Bay (120°04′-120°23′ E, 35°55′-36°18′ N) is located in the south of Shandong Province, eastern China (Fig. 1). It is a semi-closed bay with the total area, average water depth and bay mouth width of 446 km2, 7 m and 3 km, respectively. There are more than ten inflow rivers such as Haibo Rriver, Licun Rriver, Dagu Rriver, and Loushan Rriver etc., most of which have seasonal features [1-3].

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Data on PHC contents in surface waters in Jiaozhou Bay was provided by North China Sea Environmental Monitoring Center. The survey was conducted in April, July and October 1989. There were 10 sampling sites (04, 05, 06, 84, 85, 86, 87, 88, 89 and 90) in April and July compared to 7 sampling sites (84, 85, 86, 87, 88, 89 and 90) in October (Fig. 1). Surface water samples were collected and measured followed by National Specification for Marine Monitoring [4]

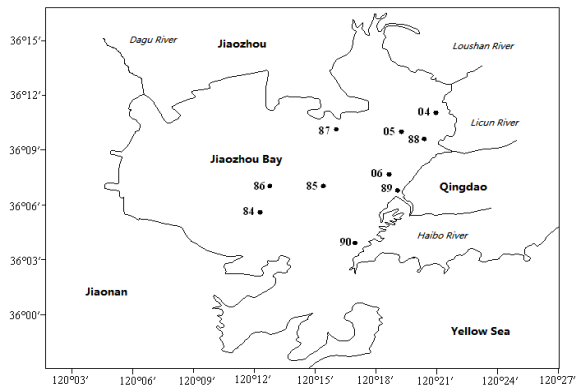

Fig.1 Geographic location and monitoring sites in Jiaozhou Bay

3 Results

Contents of Hg. In Chinese Sea Water Quality Standard (GB 3097-1997), there are 4 classes of water quality, and for Hg the guide lines of Class I, II, and IV (include III) are 0.05 μg L-1, 0.20 μg L-1 and 0.50 μg L-1, respectively. In April 1989, Hg contents were 0.035-0.449 μg L-1, and were Class I, II, and IV (include III). In July 1989, Hg contents were 0.002-0.059 μg L-1, and were Class I to II. In October 1989, Hg contents were 0.002-0.028 μg L-1, and were Class I. Hg contents in surface waters in the

whole year ranged from 0.020-0.474 μg L-1, and were were Class I to IV, and could be considered as seasonal changing.

Horizontal distribution of Hg. In April 1989, high value region occurred in Site 04 in the northeast of the bay, and the contour lines were forming a series of semi-circle lines that were decreasing from the high value center (0.449 μg L-1) to the southeast of the bay (0.018 μg L-1) (Fig. 2). In July 1989, high value region occurred in Site 06 in the eastern coast of the bay, and the contour lines were forming a series of circle lines that were decreasing from the high value center (0.059 μg L-1) to the bay mouth (0.0.005 μg L-1), and to the in the northeast of the bay (0.002 μg L-1) (Fig. 3). In October 1989, one high value region occurred in Site 84 and 90 in the north of the bay mouth, and the contour lines were forming a series of parallel lines that were decreasing from the high value center (0.028 μg L-1) to the bay center (0.015 μg L-1), and to north of the bay (0.002 μg L-1) (Fig. 4). Meanwhile, another high value region occurred in Site 88 in the estuary of Licun River in the northeast of the bay, and the contour lines were forming a series of parallel lines that were decreasing from the high value center (0.026 μg L-1) to the north of the bay (0.002 μg L-1) (Fig. 4).

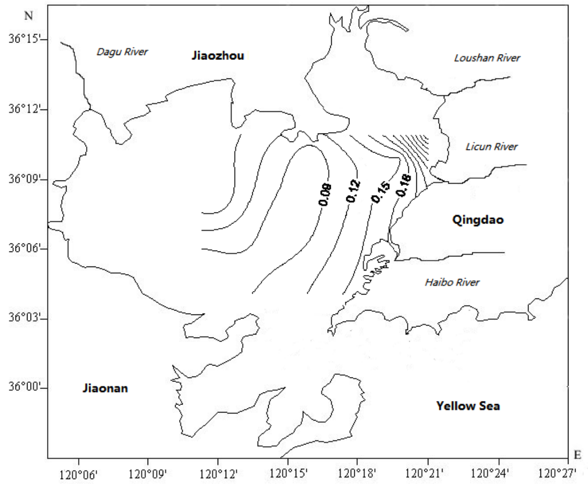

Fig. 2 Distributions of Hg in surface waters in Jiaozhou Bay in April 1989/mg L^{-1}

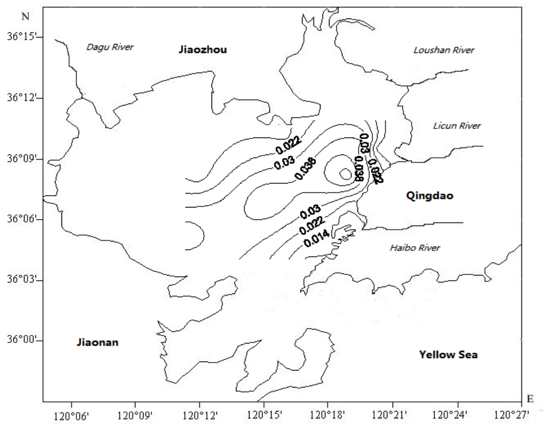

Fig. 3 Distributions of Hg in surface waters in Jiaozhou Bay in July 1989/mg L^{-1}

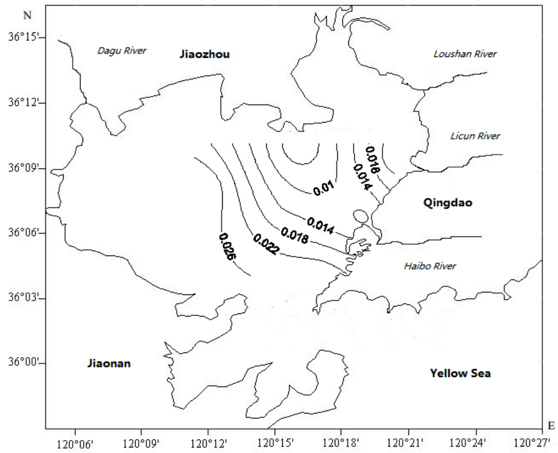

Fig. 4 Distributions of Hg in surface waters in Jiaozhou Bay in October 1989/mg L^{-1}

4 Discussion

Spatial distribution of water quality. In April 1989, Hg contents were 0.035-0.449 μg L-1 as a whole, and there was a high value region in eastern coastal waters in where Hg contents were >0.20 μg L-1 and the water quality was moderate polluted as Class IV, Hg contents were Class I in northwest, while in other regions was Class II. In July 1989, Hg contents were 0.002-0.059 μg L-1 as a whole, and there was a high value region in eastern coastal waters in where Hg contents were >0.05 μg L-1 and the water quality was moderate polluted as Class II, while in other regions was Class I. In October 1989, Hg contents were 0.002-0.028 μg L-1 as a whole, and the water quality was Class I. In general, the pollution levels of Hg in Jiaozhou Bay 1989 were showing both seasonal and spatial variations (Table 1).

Source input of Hg. In general, there might be different sources in different seasons that resulted in horizontal variations of water quality. In according to the spatial distributions of Hg in surface waters (Fig. 2 to Fig. 4) and the horizontal variations of water quality, it could be found that river discharge was the major source in April, atmosphere deposition was responsible in July 1989, while river discharge and marine current were responsible together in October 1989. In according to the high value regions of Hg contents in surface water, it could be found that the source strengths of river discharge, atmosphere deposition and marine current were 0.026-0.449 μg L-1, 0.059 μg L-1 and 0.026-0.028 μg L-1, respectively (Table 1). For seasonal variation, the high value of source input strengths in April, July and October were 0.449 μg L-1, 0.059 μg L-1 and 0.028 μg L-1, respectively, and were in order of April > July > October. For different sources, the high value of source input strengths of river discharge, atmosphere deposition and marine current were 0.449 μg L-1, 0.059 μg L-1 and 0.026 μg L-1, respectively, and were in order of river discharge > atmosphere deposition > marine current. However, by means of the continuous anthropogenic source input of Hg to the ocean, Hg contents in marine waters could be increasing since ocean is the 'sink' of pollutants [15-17]. In general, the pollution level of Hg in surface waters in

Jiaozhou Bay were mainly determined by source inputs. As a whole, the pollution level of Hg in Jiaozhou Bay could be considered as slight/moderate in 1989, yet the source control should be taken in account in environmental management decision-making.

Table 1 Source and source strengths of Hg in Jiaozhou bay 1989

Month	April	July	October	
Source	River discharge	Atmosphere deposition	River discharge	Marine current
Strength/μg L-1	0.449	0.059	0.026-0.028	0.026
Class	IV	II	I	I

5 Conclusion

Hg contents in surface waters in April, July and October 1989 in Jiaozhou Bay were 0.035-0.449 μg L-1, 0.002-0.059 μg L-1 and 0.002-0.028 μg L-1, respectively. The pollution level of Hg in surface waters was slight/moderate, and could be considered as seasonal changing. The major Hg sources were river discharge, atmosphere deposition and marine current, and their source strengths were 0.026-0.449 μg L-1, 0.059 μg L-1 and 0.026-0.028 μg L-1, respectively. For different seasons, the source input strengths were in order of April > July > October. For different sources, the source input strengths were in order of river discharge > atmosphere deposition > marine current. In general, the pollution level of Hg in surface waters in Jiaozhou Bay were mainly determined by source inputs, and therefore source control of anthropogenic sources is essential to pollution control and environmental remediation.

Acknowledgment

This research was sponsored by 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).

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