The diffusion of PHC from Jiaozhou Bay to the open waters

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Abstract. Based on investigation data on petroleum hydro-carbon (PHC) in April, July and October 1985 in Jiaozhou Bay, we analyzed the content, pollution level and diffusion of PHC. Results showed that PHC contents were ranging from 0.010-0.124 mg L^{-1}, indicating that this bay had been moderate polluted by PHC, yet the water quality was showing spatial-temporal variations. Taking the estuary of Haibo River as a boundary, it could be found that the waters in the northeast of Haibo River was moderate polluted by PHC, yet waters in the southwest of Haibo River was slight polluted by PHC. The source strengths Haibo River and Licun River were 0.124 mg L^{-1} and 0.064-0.121 mg L^{-1}, respectively, both of which were meeting Grade III. Along with the flow direction, PHC contents in waters were diffusing and decreasing.

Introduction

The increasing of the development and use of petroleum with the rapid increasing of economic and population has been caused many environmental problems, due to the excess PHC in the environment could cause harms to ecosystem and organism. The ocean is the ‘sink’ of various pollutants including PHC, and had been polluted by PHC due to the discharge of PHC-containing waste water and gas [1-5]. Hence, understanding the pollution level and the migration of PHC in marine bay is essential to marine environment protection. Based on investigation data on PHC in 1985, this paper analyzed that content, water quality, source and diffusion of PHC in Jiaozhou Bay, a semi-closed bay in China, and to provide basis for marine environment protection.

Material and method

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) 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 km^2, 7 m and 3 km, respectively, and is connect to Yellow Sea in the south. There are more than ten inflow rivers (e.g., Haibo Rriver, Licun Rriver, Dagu Rriver, and Loushan Rriver), most of which have seasonal features [6,7]. The data was provided by North China Sea Environmental Monitoring Center. The survey was conducted in April, July and October 1985 (Fig. 1). PHC was sampled and monitored follow by National Specification for Marine Monitoring [8].

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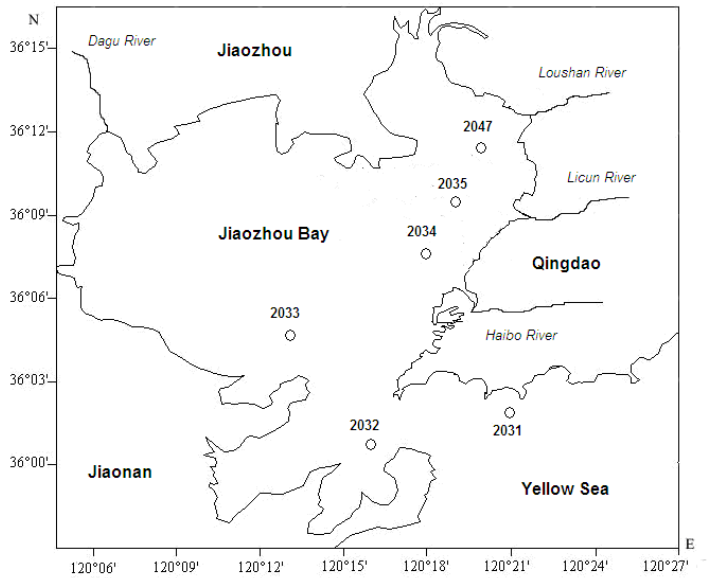

Fig.1 Investigation sites in Jiaozhou Bay

Results

Contents of PHC. In National Sea Water Quality Standard (GB 3097-1997), the guide line of Grade I, II and III for PHC are 0.05 mg L^{-1}, 0.05 mg L^{-1} and 0.30 mg L^{-1}, respectively. PHC contents in surface waters of Jiaozhou Bay were 0.010-0.124 mg L^{-1} (Table 1), meeting Grade I, II and III in according to National Sea Water Quality Standard (GB 3097-1997). In April, PHC contents were 0.025-0.064 mg L^{-1}, meeting Grade I, II and III; in July, PHC contents were 0.059-0.124 mg L^{-1}, meeting Grade III; and in October, PHC contents were 0.010-0.121 mg L^{-1}, meeting Grade I, II and III. In generally, this bay had been moderate polluted by PHC.

Table 1 Pollution level of PHC in April, July and October 1985

Month	April	July	October
Content/mg L^{-1}	0.025-0.064	0.059-0.124	0.010-0.121
Water quality grade	I, II and III	III	I, II and III

Horizontal distributions of PHC. In April, there was a high value (0.064 mg L^{-1}) in Site 2035 and a high value region in the coastal water in the northeast of the bay, and there were a series of parallel lines, which were decreasing from the high value center to the bay mouth (0.031 mg L^{-1}) and the open waters (0.025 mg L^{-1}) (Fig. 2). In July, there was a high value (0.16 mg L^{-1}) in Site 2034 and a high value region the coastal water in the northeast of the bay, and there were a series of parallel lines, which were decreasing from the high value center to the bay mouth (0.060 mg L^{-1}) and the open waters (0.059 mg L^{-1}) (Fig. 3). In October, there was a high value (0.121 mg L^{-1}) in Site 2035 and a high value region in the estuary of Licun River, and there were a series of parallel lines, which were decreasing from the high value center to the bay mouth (0.01 mg L^{-1}) (Fig. 4).

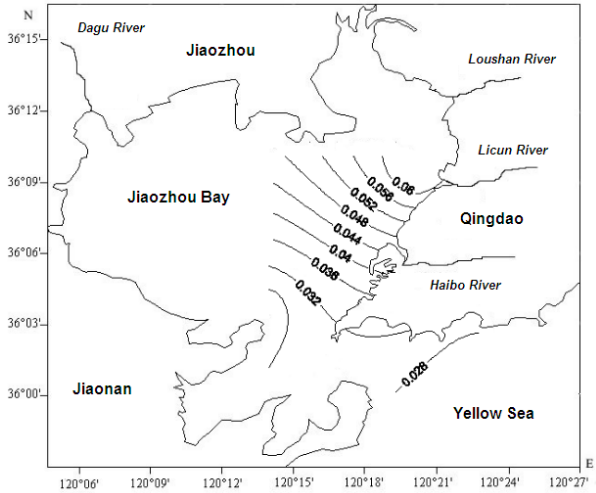

Fig. 2 Horizontal distribution of PHC in surface waters in April/mg L^{-1}

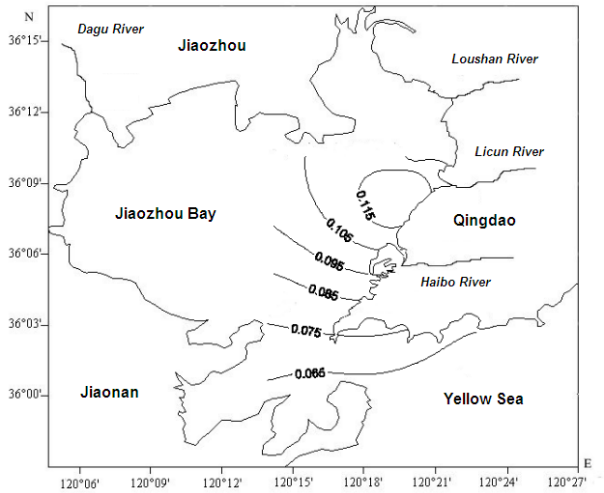

Fig. 3 Horizontal distribution of PHC in surface waters in July/mg L^{-1}

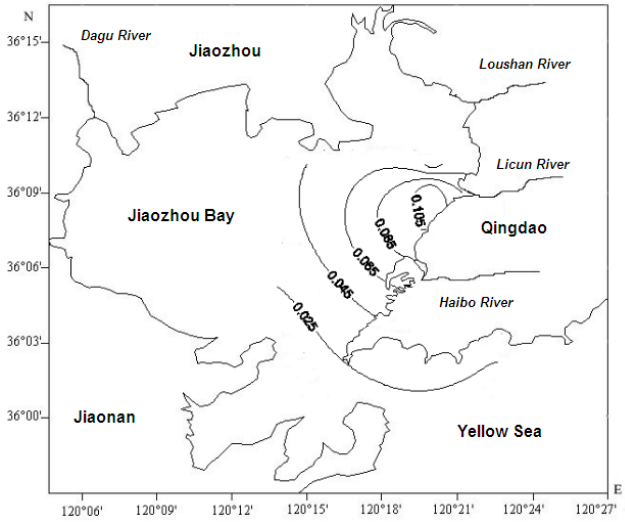

Fig. 4 Horizontal distribution of PHC in surface waters in October/mg L^{-1}

Discussion

Water quality of PHC. As a whole, this bay had been moderate polluted by PHC, yet the water quality was showing spatial-temporal variations. In April, PHC contents in waters between the estuary of Haibo River and the northeast of the bay were 0.054-0.064 mg L^{-1}, which were meeting

Grade III; while in waters between the estuary of Haibo River and the bay mouth in the southwest of the bay were 0.025-0.031 mg L^{-1}, which were meeting Grade I and II. In July, PHC contents in waters between the estuary of Haibo River and the northeast of the bay were 0.101-0.124 mg L^{-1}, which were meeting Grade III; while in waters between the estuary of Haibo River and the bay mouth in the southwest of the bay were 0.059-0.079 mg L^{-1}, which were meeting Grade III. In October, PHC contents in waters between the estuary of Haibo River and the northeast of the bay were 0.108-0.121 mg L^{-1}, which were meeting Grade III; while in waters between the estuary of Haibo River and the bay mouth in the southwest of the bay were 0.010-0.033 mg L^{-1}, which were meeting Grade I and II. Taking the estuary of Haibo River as a boundary, it could be found that the waters in the northeast of Haibo River was moderate polluted by PHC, yet waters in the southwest of Haibo River was slight polluted by PHC.

Diffusion of PHC. In April, there was a high value region in the coastal water of the estuary of Licun River, indicating that stream flow of Licun River was the major PHC source, and the source strength was 0.064 mg L^{-1}. Along with the flow direction, PHC contents were diffusing and decreasing to 0.025-0.031 mg L^{-1} in the bay mouth and the open waters. In July, there was a high value region in the coastal water of the estuary of Haibo River, indicating that stream flow of Haibo River was the major PHC source, and the source strength was 0.124 mg L^{-1}. Along with the flow direction, PHC contents were diffusing and decreasing to 0.059-0.060 mg L^{-1} in the bay mouth and the open waters. In October, there was a high value region in the coastal water of the estuary of Licun River, indicating that stream flow of Licun River was the major PHC source, and the source strength was 0.121 mg L^{-1}. Along with the flow direction, PHC contents were diffusing and decreasing to 0.064 mg L^{-1} in the bay mouth. In generally, stream flow was the major PHC source in Jiaozhou Bay. The source strengths Haibo River and Licun River were 0.124 mg L^{-1} and 0.064-0.121 mg L^{-1}, respectively, both of which were meeting Grade III (Table 2). Along with the flow direction, PHC contents in waters were diffusing and decreasing.

Table 2 Source strength of PHC

River	Haibo River	Licun River
Content/mg L^{-1}	0.124	0.064-0.121
Grade	III	III

Conclusion

In April, PHC contents were 0.025-0.064 mg L^{-1}, meeting Grade I, II and III; in July, PHC contents were 0.059-0.124 mg L^{-1}, meeting Grade III; and in October, PHC contents were 0.010-0.121 mg L^{-1}, meeting Grade I, II and III.

As a whole, this bay had been moderate polluted by PHC, yet the water quality was showing spatial-temporal variations. Taking the estuary of Haibo River as a boundary, it could be found that the waters in the northeast of Haibo River was moderate polluted by PHC, yet waters in the southwest of Haibo River was slight polluted by PHC.

The source strengths Haibo River and Licun River were 0.124 mg L^{-1} and 0.064-0.121 mg L^{-1}, respectively, both of which were meeting Grade III. Along with the flow direction, PHC contents in waters were diffusing and decreasing.

This research indicated that Jiaozhou Bay had been moderate polluted by PHC in 1985, and implied that people should reduce the consumption of petroleum hydrocarbon, and to develop and use green energy (e.g., solar energy, wind energy and tidal energy) to reduce the emission of PHC to the environmental.

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