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Source input and storage of petroleum hydrocarbon in Jiaozhou Bay

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Abstract. This paper analyzed the source input and storage of petroleum hydrocarbon (PHC) in Jiaozhou Bay during 1984-1988. Results showed that PHC contents in different seasons in this bay were all determined bay source input of PHC via river discharge. For seasonal variation, PHC contents were in order of summer > spring > autumn. Precipitation determined the river discharge, river discharge determined the source input of PHC, resulted in the seasonal variations of PHC in Jiaozhou Bay waters. By means of the continuous source input of PHC from river discharged, and the continuous accumulation of PHC in waters, a great deal of PHC was stored in Jiaozhou Bay, resulted in the increasing trend of PHC contents in waters. In case of little source input, the background value of PHC in this bay was 0.005 mg L^{-1}, while in case of source input from marine current was responsible the high value was 0.122 mg L^{-1}. Furthermore, a block diagram model was provided to demonstrate that PHC contents in marine waters were increasing continuously by means of continuous source input. Hence, the control and management of anthropogenic source input of PHC in marine bay was necessary.

1. Introduction

Ocean is a large 'sink' of various pollutants, and many marine bays have been polluted by various pollutants along with the rapid development of industry and economic [1-2]. Understanding the source input and storage processes of pollutants is essential to pollution control and environmental remediation in marine bays [3-4]. Jiaozhou Bay is a semi-closed bay located in south of Shandong Peninsula in eastern China, and is surrounded by cities of Jiaozhou, Jiaonan and Qingdao in the north, west and east, respectively. Previous studies showed that this bay has been polluted by various pollutants including PHC since 1980s [5-6]. This paper analyzed the source input and storage processes of PHC in Jiaozhou Bay using investigation data during 1984-1988. The aim of this paper was to provide basis for environmental management decision-making.

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 km^2, 7 m and 3 km, respectively. There are more than ten inflow rivers such as Haibo

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Rriver, Licun Rriver, Dagu Rriver, and Loushan Rriver etc., most of which have seasonal features [7-8]. In study area, April, May and June belong to spring, July, August and September belong to summer, October, November and December belong to autumn, and January, February and March belong to winter.

Data on PHC contents in surface waters in Jiaozhou Bay was provided by North China Sea Environmental Monitoring Center. The survey was conducted in July, August and October 1984, April, July and October 1985, April, July and October 1986, May, July and November 1987, and April, July and October 1988. Surface water samples were collected and measured followed by National Specification for Marine Monitoring [9].

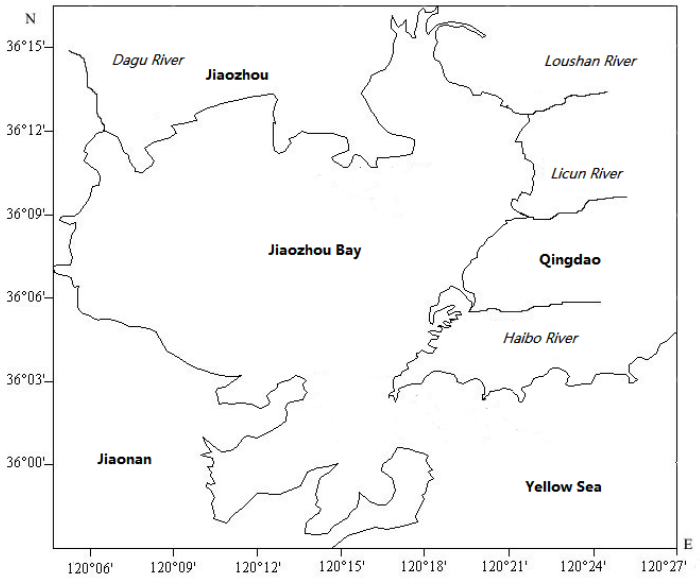


Fig. 1 Geographic location of Jiaozhou Bay

3. Results and discussion

3.1 Source input of PHC. In July, August and October 1984, the high value regions of PHC contents were in the estuary of Haibo River (0.060 mg L^{-1}), estuary of Loushan River (0.160 mg L^{-1}) and estuary of Loushan River (0.050 mg L^{-1}), respectively. These indicated river discharge is the major source of PHC in different seasons in 1984, and the source strengths were in order of summer > autumn. In April, July and October 1985, the high value regions of PHC contents were in the estuary of Licun River (0.064 mg L^{-1}), estuary of Haibo River (0.124 mg L^{-1}) and estuary of Licun River (0.121 mg L^{-1}), respectively. These indicated river discharge is the major source of PHC in different seasons in 1985, and the source strengths were in order of summer > spring > autumn. In April, July and October 1986, the high value regions of PHC contents were in the estuary of Loushan River (0.066 mg L^{-1}), open waters (0.122 mg L^{-1}) and estuary of Licun River (0.017 mg L^{-1}), respectively. These indicated river discharge is the major source of PHC in spring and autumn 1986, while marine current was the major source in summer, and the source strengths were in order of summer > spring > autumn. In May, July and November 1987, the high value regions of PHC contents were in the southwest coast in where there was important harbour (0.060 mg L^{-1}), estuary of Loushan River (0.066 mg L^{-1}) and the southwest coast in where there was important harbour (0.091 mg L^{-1}), respectively. These indicated marine traffic was the major source of PHC in spring and autumn 1987, while in summer river discharge was responsible, and the source strengths were in order of autumn > summer > spring. In April, July and October 1988, the high value regions of PHC contents were in the estuary of Licun River (0.064 mg L^{-1}), estuary of Haibo River (0.178 mg L^{-1}) and estuary of Haibo River (0.169 mg L^{-1}), respectively. These indicated river discharge is the major source of PHC in different seasons in 1988, and the source strengths were in order of summer > autumn > spring. In general, river

discharge was the most important source of PHC in Jiaozhou Bay, while marine current and marine traffic had been non-negligible sources (Fig. 2).

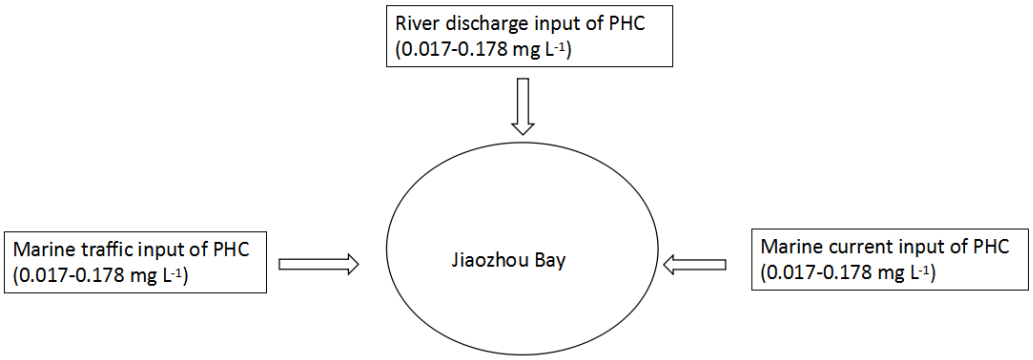


Fig.2 Source input processes of PHC in Jiaozhou Bay

3.2 Seasonal variation of PHC's source input. During study time period, the seasonal variation of precipitation was very significant (Fig. 3). The peak and the valley of precipitation were occurring in summer and winter, respectively. For monthly variations, the precipitation was lowest in January (11.8 mm), and was increasing to relative high value in April (33.4 mm), and was increasing to the peak in August (150.3 mm), and then was decreasing to a relative low value in November (23.4), and finally was decreasing to the valley in January again. In general, the precipitations were in order of summer > spring > autumn > winter, resulting in river discharge were also in order of summer > spring > autumn > winter. Since rain-fall runoff was the major force of various pollutants to marine bay, the source input of PHC was also in order of summer > spring > autumn > winter. This was the major reason to explain the seasonal variations of PHC contents in Jiaozhou Bay.

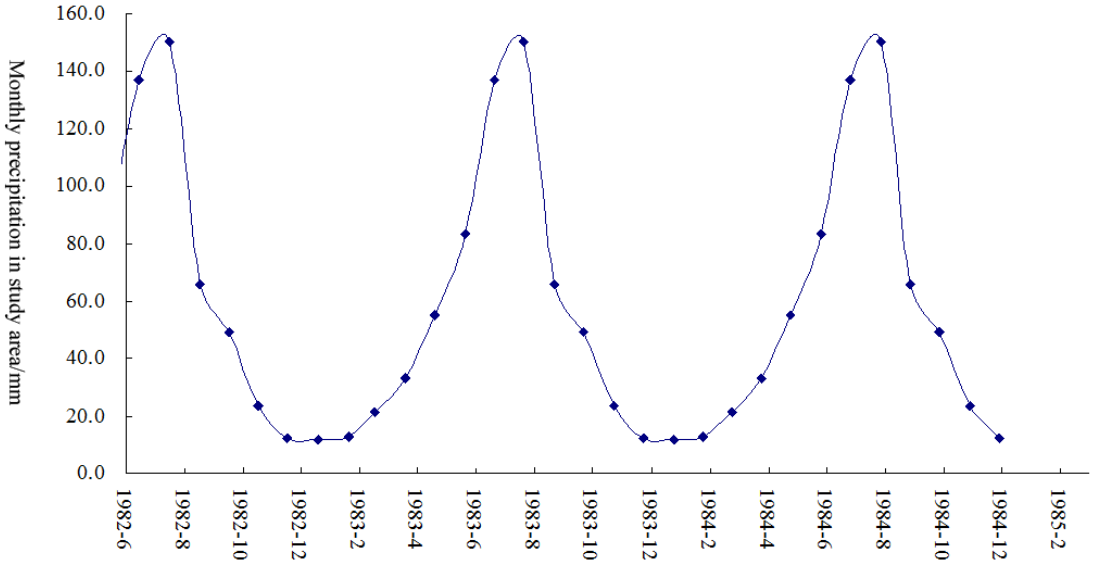


Fig. 3 Monthly precipitation in study area/mm

3.3 Storage of PHC. In general, precipitation determined the river discharge, river discharge

determined the source input of PHC, resulted in the seasonal variations of PHC in Jiaozhou Bay waters. By means of the continuous source input of PHC from river discharged, and the continuous accumulation of PHC in waters, a great deal of PHC was stored in Jiaozhou Bay, resulted in the increasing trend of PHC contents in waters. However, in 1987, PHC contents in waters were mainly impacted bay source input of marine traffic, resulted in different seasonal distribution patterns. In case of little source input, the background value of PHC in this bay was 0.005 mg L^{-1}, while in case of source input from marine current was responsible the high value was 0.122 mg L^{-1}. In consideration that the background value of PHC was 0.005 mg L^{-1} and the background value of PHC in marine was mg L^{-1}, the increase of PHC contents in the ocean could be calculated as 0.122-0.005=0.117 mg L^{-1}. This was the results of the storage of PHC in ocean. Furthermore, a block diagram model was provided to demonstrate that PHC contents in marine waters were increasing continuously by means of continuous source input (Fig. 4). Hence, the control and management of anthropogenic source input of PHC in marine bay was necessary.

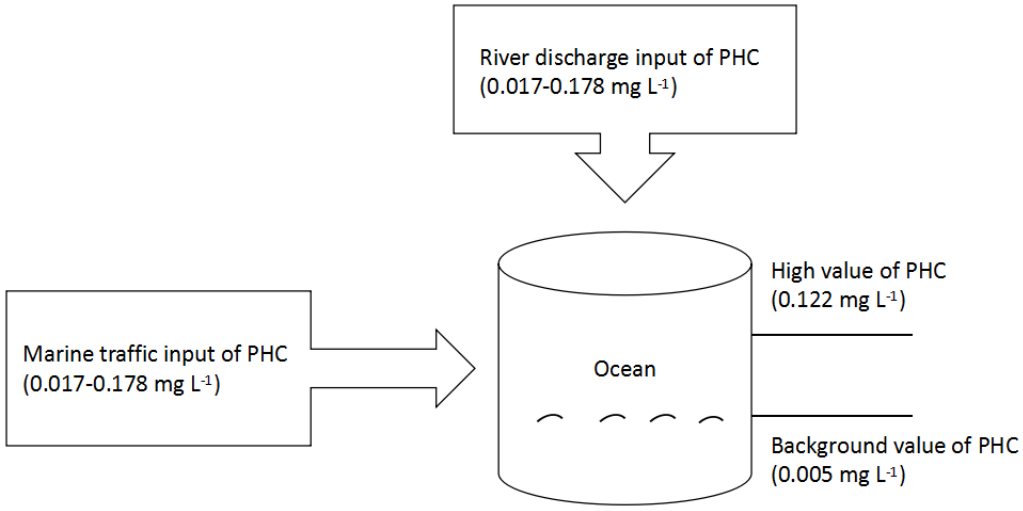


Fig.4 Block diagram model for the influence of PHC input on marine PHC content

4. Conclusion

River discharge is the most important source of PHC in Jiaozhou Bay, while marine current and marine traffic had been non-negligible sources. Precipitation determined the river discharge, river discharge determined the source input of PHC, resulted in the seasonal variations of PHC contents in Jiaozhou Bay as summer > spring > autumn > winter in general. By means of the continuous source input of PHC from river discharged, and the continuous accumulation of PHC in waters, a great deal of PHC was stored in Jiaozhou Bay, resulted in the increasing trend of PHC contents in waters. In case of little source input, the background value of PHC in this bay was 0.005 mg L^{-1}, while in case of source input from marine current was responsible the high value was 0.122 mg L^{-1}. Hence, the increase of PHC contents in the ocean could be calculated as 0.122-0.005=0.117 mg L^{-1}. This was the results of the storage of PHC in ocean. The control and management of anthropogenic source input of PHC in marine bay was necessary.

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