

# The reduction process of petroleum content in marine oil spill in Jiaozhou Bay

Dongfang Yang<sup>1,2,\*</sup>, Haixia Li<sup>1</sup>, Dong Lin<sup>1</sup>, Yuan Zhang<sup>1</sup>, Qi Wang<sup>1</sup>

<sup>1</sup>Accountancy School, Xijing University, Xi'an 710123, China;

<sup>2</sup>North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China;

**Abstract:** According to the survey data about the waters of Jiaozhou Bay in May, September, and October 1993, this paper studies the content of PHC and its horizontal distribution in the surface waters of Jiaozhou Bay. The result shows that the range of PHC content in the waters of Jiaozhou bay is 4.16-51.00 $\mu\text{g/L}$ , which conforms to the national first, second and third water quality standards. In terms of PHC content, the water quality of Jiaozhou Bay is slightly polluted by PHC content in May, September and October. In May, the range of PHC content in the water of Jiaozhou Bay is 4.16-51.00 $\mu\text{g/L}$ , which is slightly polluted by PHC content. In the center of east waters, the water quality is slightly polluted by PHC content and the range of PHC content in other water fields of Jiaozhou Bay is 4.16-48.40 $\mu\text{g/L}$  which indicates that the water quality is not polluted by PHC content. In September, the range of PHC content in the waters of Jiaozhou Bay is 6.17-12.70 $\mu\text{g/L}$ , which is not polluted by PHC content. In October, the range of PHC content is 11.40-11.80 $\mu\text{g/L}$ , indicating that the waters of Jiaozhou Bay are not polluted by PHC. The content of PHC in the waters of Jiaozhou Bay only has one source, the transportation of marine oil spill, and the PHC content transported is 12.70-51.00 $\mu\text{g/L}$ . Therefore, as time changes, the ocean polluted by PHC content resulting from marine oil spill has gradually reduced over the course of the year. The marine oil spill has caused the waters in May to be slightly polluted by the PHC content. By September, the waters are not polluted by the PHC content. And then, in October, the marine oil spill has disappeared.

## 1 Introduction

On the eastern coast of Jiaozhou Bay, a terminal oil storage base has been established. As a result, there have been many oil tankers going to and from Jiaozhou Bay, resulting in the occurrence of marine oil spills. Then the marine oil spill transports the PHC content to the bay waters [1-11]. Based on the survey data in 1993, this paper analyzes the content, horizontal distribution and source of PHC in Jiaozhou Bay waters, studies the water quality, source and quantity of PHC in Jiaozhou Bay waters, and determines the PHC content in the waters of Jiaozhou Bay and the pollution degree, which provide a scientific theoretical basis for protecting the marine environment and maintaining sustainable ecological development.

## 2 Survey waters, materials and methods

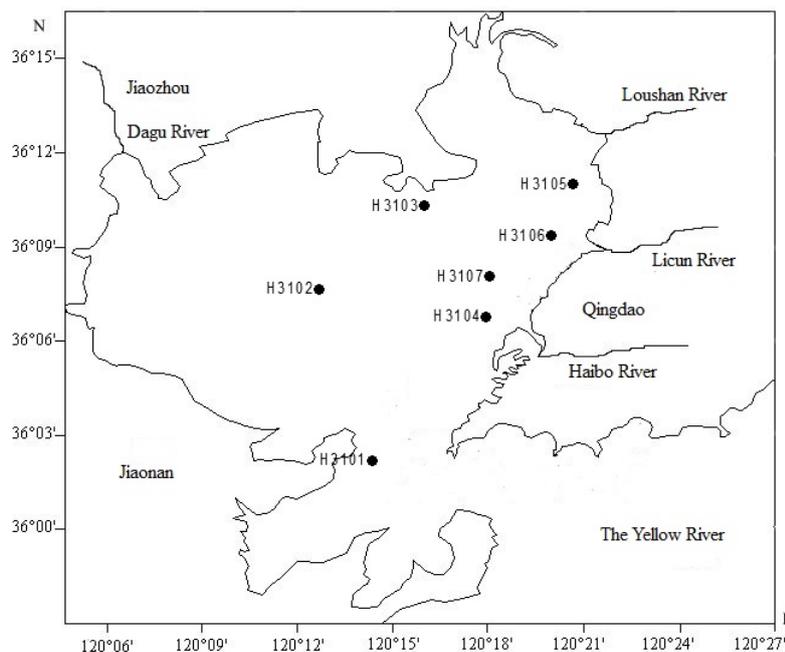
### 2.1 The natural environment of Jiaozhou Bay.

Jiaozhou Bay is located in the southern part of Shandong Peninsula. Its geographical position is between 120°04'-120°23'E and 35°58'-36°18'N. It is bounded by

the line connecting Tuan Island and Xuejia Island, and is connected to the Yellow Sea. With about 446km<sup>2</sup> in the area and about 7 m in the average water depth, it is a typical semi-enclosed bay. There are more than a dozen rivers entering the sea in Jiaozhou Bay, among which the Dagu River, Yang River and the Haibo River, Licun River and Loushan River in Qingdao City with larger runoff and sand content [12, 13].

**2.2 Materials and methods.** The survey data of PHC content in Jiaozhou Bay in May, September and October 1992 used in this study are provided by the North Sea Monitoring Center of the State Oceanic Administration. Seven stations were set up in the waters of Jiaozhou Bay to take water samples: stations H3101, H3102, H3103, H3104, H3105, H3106 and H3107 (Figure 1). They got water samples three times in May, September and October 1993, respectively. Got were water samples by the water depth (two water samples from the surface and bottom layers when the depth >10m, and only ones from the surface layer when the depth <10m) for investigation and sampling. The survey of PHC content in Jiaozhou Bay water body was conducted by the national standard method, recorded in the national "Marine Monitoring Code" (1991) [14].

\* Corresponding author: \*dfyang@gzmu.edu.cn



**Fig.1** Investigation sites in Jiaozhou Bay

### 3 Results

**3.1 PHC content.** In terms of PHC content in the ocean, the nation has put forward the national water quality standards for Class I and Class II seawater (50µg/L), Class III (300µg/L) and Class IV (500µg/L).

In May, the PHC content in the waters of Jiaozhou Bay ranges from 4.16 to 51.00 µg/L, which meets the water quality standards of Class I, II, and III. In September, the PHC content in the waters of Jiaozhou Bay ranges from 6.17 to 12.70 µg/L, which meets the

national water quality standards for Class I and II seawater. In October, the PHC content in the waters of Jiaozhou Bay ranges from 11.40 to 11.80µg/L, which meets the national water quality standards for Class I and II seawater. Therefore, in May, September and October, the content of PHC in the waters of Jiaozhou Bay ranges within 4.16-51.00µg/L, which meets the national water quality standards of Class I, II, and III. This shows that in terms of PHC content, the water quality of the entire Jiaozhou Bay is slightly polluted by PHC in May, September and October (Table 1).

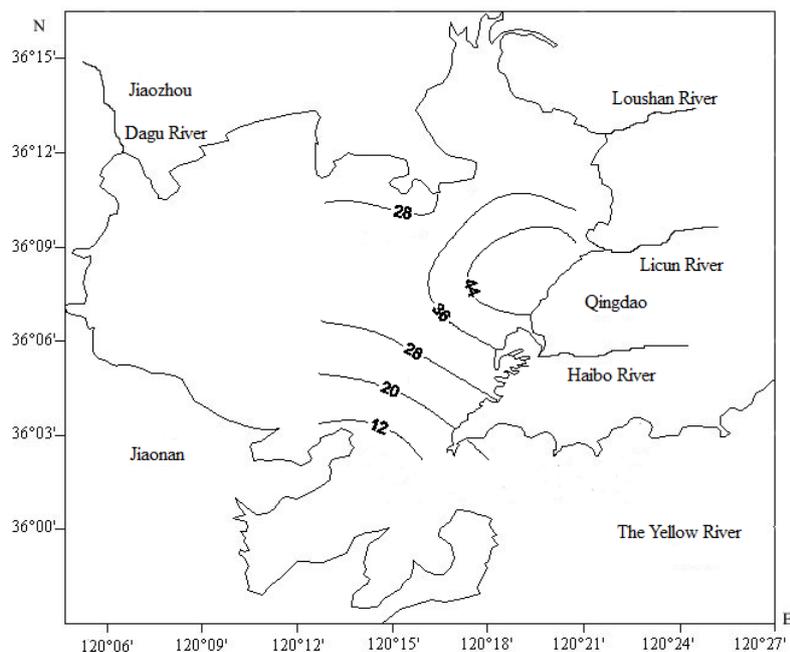
**Tab.1** The surface water quality in Jiaozhou bay in May, September and October

	May	September	October
PHC content in seawaters/µg·L <sup>-1</sup>	4.16-51.00	6.17-12.70	11.40-11.80
National water quality standards	Class I, II, III	Class I, II	Class I, II

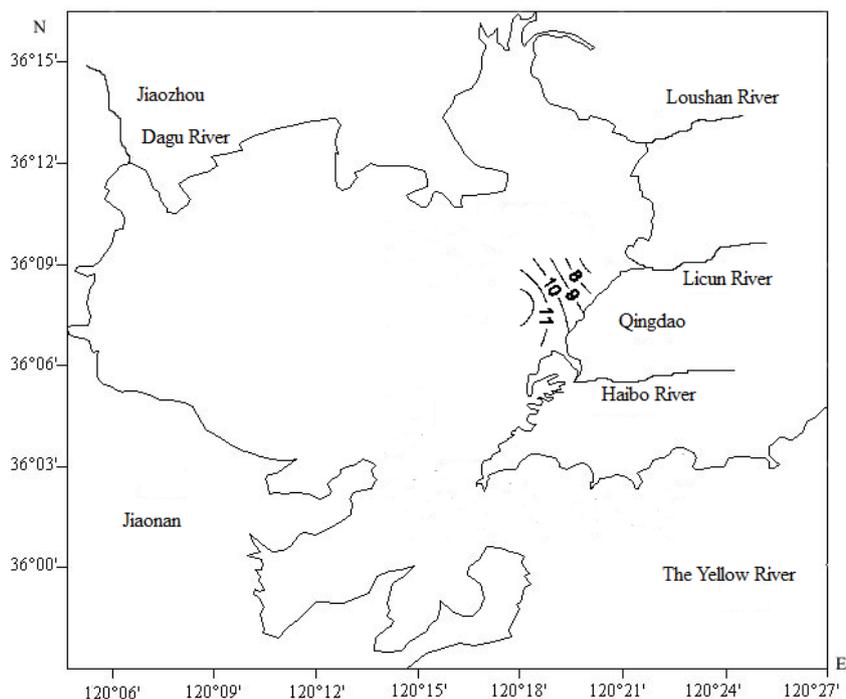
### 3.2 Horizontal distribution in the surface later.

In May, in the eastern part of Jiaozhou Bay, the PHC content reaches a high level of 51.00µg/L at H3107 station in the eastern central waters, forming a high content area of PHC with H3107 station as the center and

a series of concentric circles with different gradients. The PHC content decreases from the high content of 51.00µg/L in the center to the surroundings along the gradient, to 31.60µg/L in the central waters of the bay, 27.00µg/L in the northern waters of the bay, and 4.16µg/L in the waters of the bay mouth (Figure 2).



**Fig.2** PHC content distribution in the surface waters of Jiaozhou Bay in May ( $\mu\text{g/L}$ )



**Fig.3** PHC content distribution in the surface waters of Jiaozhou Bay in September ( $\mu\text{g/L}$ )

In September, in the eastern part of Jiaozhou Bay, the PHC content reaches a high level of  $12.70\mu\text{g/L}$  at H3107 station in the eastern central waters, forming a high content area of PHC with H3107 station as the center and a series of concentric circles with different gradients. The PHC content decreases from the high content of  $12.70\mu\text{g/L}$  in the center along the gradient to the surroundings, to  $6.17\mu\text{g/L}$  in the northeast waters of the bay, and  $11.40\mu\text{g/L}$  in the southeast waters of the bay (Figure 3).

In October, at H3103 station in the coastal waters of the northern Jiaozhou Bay, the content of PHC reaches a

high level of  $11.80\mu\text{g/L}$ , forming a high content area of PHC in the northern coastal waters. Taking the high content area of PHC as the center, it forms a series of parallel lines with different gradients. The content of PHC decreases from the high content of  $11.80\mu\text{g/L}$  in the center along the gradient to  $11.40\mu\text{g/L}$  in the southeast coastal waters.

## 4 Discussion

**4.1 Water quality.** In May, September and October, the content of PHC in the waters of Jiaozhou Bay ranges from 4.16 to 51.00 $\mu\text{g/L}$ , which are in line with the national water quality standards for Class I and Class II (50 $\mu\text{g/L}$ ) and the water quality standards for Class III (300 $\mu\text{g/L}$ ). This shows that in terms of PHC content, in May, August and October, the water quality of Jiaozhou Bay is slightly polluted by PHC.

In May, the content of PHC in the waters of Jiaozhou Bay ranges within 4.16-51.00 $\mu\text{g/L}$ , and the waters of Jiaozhou Bay are slightly polluted by PHC. At station H3107 in the eastern central water area, the PHC content is 51.00 $\mu\text{g/L}$ , which indicates that the water quality of this water area meets the water quality standards of Class III in terms of PHC content, and the PHC content is greater than 0.050 $\mu\text{g/L}$ , so the water quality is slightly polluted by PHC. In Jiaozhou Bay, except for the central waters in the east, the PHC content varies from 4.16 to 48.40 $\mu\text{g/L}$ , which indicates that the water quality of this water area meets the water quality standards of Class I and II in terms of PHC content. The water quality has not been polluted by PHC and has clean water quality (Figure 2).

In September, the content of PHC in the waters of Jiaozhou Bay ranges within 6.17-12.70  $\mu\text{g/L}$ , and the waters of Jiaozhou Bay are not polluted by PHC, which shows that the water quality of this water area, in terms of PHC content, meets the water quality standards of Class I and II, and the PHC content is far less than 50.00 $\mu\text{g/L}$ . Therefore, the water quality is not polluted by PHC and the water is clean (Figure 3).

In October, the content of PHC in the waters of Jiaozhou Bay ranges within 11.40-11.80 $\mu\text{g/L}$ , and the waters of Jiaozhou Bay are not polluted by PHC, which shows that the water quality of this water area, in terms of PHC content, meets the water quality standards of

Class I and II, and the water quality is not polluted by PHC. The water is clean. Moreover, the PHC content in the water body of Jiaozhou Bay is very uniform.

Therefore, in May, the water quality of the central waters in the east part is slightly polluted by PHC while in other waters of Jiaozhou Bay, the water quality is not polluted by PHC. In September and October, the water quality of Jiaozhou Bay is not polluted by PHC content.

**4.2 Sources.** In May, a high-content area of PHC is formed in the waters of eastern center of Jiaozhou Bay, which indicates that the source of PHC is the transportation of oil spilled at sea, and its PHC content is 51.00 $\mu\text{g/L}$ . The transported PHC content declines along the gradient, which leads to a decrease in the PHC content gradient to the surrounding area, reaching 31.60 $\mu\text{g/L}$  in the central waters of the bay, 27.00 $\mu\text{g/L}$  in the northern waters of the bay, and 4.16 $\mu\text{g/L}$  in the waters of the bay mouth.

In September, a high-content area of PHC is formed in the waters of eastern center of Jiaozhou Bay, which indicates that the source of PHC is the transportation of oil spilled at sea, and its PHC content is 12.70 $\mu\text{g/L}$ . The transported PHC content decreases along the gradient, which causes the PHC content gradient to decrease to the surroundings, reaching 6.17 $\mu\text{g/L}$  to the northeast waters of the bay and 11.40 $\mu\text{g/L}$  to the southeast waters of the bay.

In October, the change in PHC content does not exceed 0.50 $\mu\text{g/L}$  from the coastal waters in the northern part of Jiaozhou Bay to the coastal waters in the southeast, which shows that in the waters of Jiaozhou Bay, the PHC content is very uniform, and there is almost no source to transport PHC.

The PHC content in the waters of Jiaozhou Bay has only one source, which is mainly from the transportation of marine oil spill (Table 2). The PHC content from the oil spilled at sea is 12.70-51.00 $\mu\text{g/L}$ .

**Tab.2** The PHC content in Jiaozhou Bay has the only source

The only source	Transportation of marine oil spill
PHC content / $\mu\text{g}\cdot\text{L}^{-1}$	12.70-51.00

**4.3 The change in the content of source.** In May, September and October, the PHC content in the waters of Jiaozhou Bay has the only source, mainly from the transportation of oil spilled at sea.

In May, the source of PHC content is the transportation of oil spilled at sea, and its PHC content is 51.00 $\mu\text{g/L}$ .

In September, the source of PHC content is the transportation of oil spilled at sea, and its PHC content is 12.70 $\mu\text{g/L}$ .

In October, there is no source of PHC content.

In different months, there is only one source of PHC content, that is, the transportation of oil spilled at sea. Moreover, as time changes, the PHC content of the oil spilled at sea gradually decreases until it disappears.

**4.4 The pollution degree of source.** The PHC content in the waters of Jiaozhou Bay has only one source, mainly from the transportation of oil spilled at sea (Table 2).

In May, the PHC content of marine oil spilled to the waters of Jiaozhou Bay exceeds the national seawater quality standards of Class I and II, 50 $\mu\text{g/L}$ , and meets the national seawater quality standard of Class III, 300 $\mu\text{g/L}$ . This indicates that the marine oil spill slightly causes the pollution of PHC content.

In September, the PHC content of the marine oil spilled to the waters of Jiaozhou Bay meets the national seawater quality standards of Class I and II, 50 $\mu\text{g/L}$ , which indicates that the marine oil spill does not lead to the pollution of PHC content.

In October, the PHC content of the marine oil spilled to Jiaozhou Bay has disappeared, indicating that there is

not contaminated by the PHC content caused by marine oil spill.

This shows that in a year, as time changes, the pollution of PHC content in the sea caused by marine oil spills have gradually reduced. From the slight pollution of PHC content caused by marine oil spill in May to the absence of PHC content pollution in September, and the disappearance of the marine oil spill in September, it shows that marine traffic has improved the awareness of marine environmental protection and minimized the PHC content pollution of marine waters.

## 5 Conclusion

In May, September and October, the content of PHC in the waters of Jiaozhou Bay ranges in 4.16-51.00  $\mu\text{g/L}$ , which conforms to the national seawater quality standards of Class I, II and III. This shows that in terms of PHC content, the waters of Jiaozhou Bay are slightly polluted by PHC content in May, September and October.

In May, the content of PHC in the waters of Jiaozhou Bay ranges from 4.16 to 51.00 $\mu\text{g/L}$ , and the waters of Jiaozhou Bay are slightly polluted by the PHC content. In the eastern central waters, the water is slightly polluted by the PHC content of 51.00 $\mu\text{g/L}$ . Except for the eastern central waters, the PHC content in other waters of Jiaozhou Bay ranges from 4.16 to 48.40 $\mu\text{g/L}$ , and the water is not polluted by the PHC content. In September, the content of PHC in the waters of Jiaozhou Bay ranges from 6.17 to 12.70  $\mu\text{g/L}$ , and the waters of Jiaozhou Bay are not polluted by PHC content. In October, the content of PHC in the waters of Jiaozhou Bay ranges from 11.40 to 11.80  $\mu\text{g/L}$ , and the waters of Jiaozhou Bay are not polluted by the content of PHC as well.

The content of PHC in the waters of Jiaozhou Bay has the only source that is the transportation of marine oil spills. In addition, the content of PHC from oil spills at sea is 12.70~51.00 $\mu\text{g/L}$ . In different months, there is only one source of PHC content, that is, the transportation of oil spilled at sea. Moreover, as time changes, the PHC content of the oil spilled at sea gradually decreases until it disappears. Therefore, over the course of the year, with the change of time, the degree of PHC pollution caused by marine oil spills has gradually decreased. From the slight pollution of PHC content caused by marine oil spill in May to the absence of PHC content pollution in September, and the disappearance of the marine oil spill in September. In this way, with the improvement of environmental protection awareness, the pollution of PHC content in the marine waters is gradually decreasing.

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