The Temporal and Spatial Shift of Vertical Quantity and Source of the PHC Content

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Abstract: According to the investigation data of PHC in Jiaozhou Bay in May, August and October, 1992, this article shows the source of PHC content in both surface and bottom of Jiaozhou Bay and the temporal and spatial shift of vertical content by comparing the horizontal and vertical changes of PHC content and the PHC content in the surface and bottom. Consequently, in May, August and October, the results from subtracting PHC content in surface and bottom was between -0.004 – 0.028 mg/L, which indicated that the PHC content in both surface and bottom was close. In May, the difference of PHC content between the surface and bottom was -0.004 – -0.020 mg/L, both were negative, in the central and estuary waters of Jiaozhou Bay. In August, the difference of PHC content between surface and bottom layer of all stations in Jiaozhou Bay was 0.007–0.021 mg/L, which was positive. In October, the difference of PHC content between the surface and bottom layer of all stations in Jiaozhou Bay was 0.010–0.028 mg/L, which was positive. On the spatial scale, with the PHC content far away from the source, there are spatial changes of PHC content. In the center of the Bay and the northern part of the bay mouth, the PHC content of the surface layer is less than that of the bottom layer. In August and October, the difference of surface and bottom layer contents of all stations in Jiaozhou Bay was positive, showing that the PHC content of surface layer was higher than that of bottom layer. On the temporal scale, with the change of time, the source of PHC content underwent changes, showing the temporal changes of PHC content in surface and bottom. From May to August, the source of PHC content in the transportation changed. And the PHC content in the surface layer and the bottom layer in the transportation decreased. From August to October, the source of PHC content in the conveying system changed further with more PHC content in the surface layer and in the bottom layer.

1. Introduction
Under the influence of Human activities, the discharged PHC content reaches the sea water through rivers and oil spills, and then settles to the sea floor through water effect. Therefore, it is very important to study the migration of PHC in water. This article focuses on the process that the PHC content from the ocean surface pass through the ocean water body to the seabed [1-11]. According to the investigation data of PHC in Jiaozhou Bay in May, August and October, 1992, this article shows the source of PHC content in both surface and bottom of Jiaozhou Bay and the temporal and spatial shift of PHC content from sources and provides scientific basis for the study of vertical settlement and horizontal migration of PHC content in the surface and bottom waters by comparing the horizontal and vertical migration of PHC content and the difference of PHC content in the surface and bottom of Jiaozhou Bay.
2. Investigation Waters, Data and Methods

2.1 Natural Environments of Jiaozhou Bay. In the south of Shandong Peninsula, Jiaozhou Bay location between Tuan island and Xuejia island is 120 °04′- 120 °23′ E, 35 °58′ - 36 °18′ N. Facing the Yellow Sea, covering an area of about 446km², Jiaozhou Bay is a typical semi closed Bay with an average water depth of about 7m. Flowing into Jiaozhou Bay, many rivers such as Dagu River, Yang River and Haibo River, Licun River and Loushan River are the ones with large runoff and sediment concentration. Further, The hydrological characteristics of these rivers can alter in different seasons [12, 13].

2.2 Data and Methods. In May, August and October 1992, the data on PHC in Jiaozhou Bay originated from the North Sea Monitoring Center of the State Oceanic Administration. In May, two stations were formed in Jiaozhou Bay to get water samples: 55 and 60 stations (Figure 1). In August and October, in 13 stations in Jiaozhou Bay taken were water samples: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 2104, 2105 and 2106 stations (Figure 1). The samples were got in May, August and October of 1992 respectively. By the water depth, got were water samples, if > 10m, surface layer and bottom layer to get water samples, and if < 10m, only surface layer. The PHC content of Jiaozhou Bay water body was investigated according to the national standard method, which was included in The specification for marine monitoring (1991) [14].

3. Results

3.1 Horizontal Distribution of Surface Layer. In May, in the east of Jiaozhou Bay, in the coastal waters of Haibo River Estuary, the PHC content reached a high level of 0.070mg/L. The coastal waters of Haibo River Estuary were a high PHC content area, forming a series of concentric semicircles with different gradients. PHC content decreased from the high content of 0.070mg/L in the center along the gradient (Figure 2). In the central water area of Jiaozhou Bay, the PHC content was 0.042mg/L. And the central water area of Jiaozhou Bay was a high PHC content area, forming a series of concentric circles with different gradients. PHC content decreased from 0.042mg/L of high content in the center along the gradient (Figure 2).
In August, the concentration of PHC in the eastern central waters of Jiaozhou Bay reached a high level of 0.056mg/L. A series of concentric circles with different gradients were formed in the eastern central water area. PHC content decreased from the high content of 0.056mg/L in the center along the gradients (Figure 3). In the northwest of Jiaozhou Bay, in the coastal waters of Dagu River Estuary, the PHC content was higher than 0.046 mg/L, and the Northeast coastal waters were the high PHC content area, forming a series of parallel lines with different gradients. PHC content decreased along the gradient from 0.046mg/L of high content in the center (Figure 3).

In October, in the northeast of Jiaozhou Bay, in the coastal waters of Loushan River Estuary, the PHC content reached a high level of 0.075mg/L. A series of parallel lines with different gradients were formed in the coastal waters of Northeast China, where PHC content was high. PHC content decreased from 0.075mg/L of high content in the center along the gradients (Figure 4). In the south of Jiaozhou Bay, the content of PHC in the water area of the bay mouth was quite high, reaching 0.054mg/L. The...
eastern coastal water area was the high content area of PHC, forming a series of parallel lines with different gradients. PHC content decreased along the gradient from 0.054mg/L of high content in the center (Figure 4).

![Fig.4 PHC content distribution at the surface in Jiaozhou Bay in October (mg/L)](image)

3.2 Vertical Changes of the Surface and Bottom Layer. In May, there were two stations in Jiaozhou Bay: 55 and 60. In August and October, there were 13 stations in Jiaozhou Bay waters: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 2104, 2105 and 2106 stations (Figure 1). In May, August and October, results from subtracting PHC content in bottom of that in surface was: -0.004 – 0.028 mg/L, which indicated that the surface and bottom content of PHC were close.

In May, there were two stations in Jiaozhou Bay: 55 and 60. The results from subtracting PHC content in surface and bottom of PHC was between -0.004 – -0.020 mg/L. Results of 55 station in the central waters and 60 station in the northern waters of the bay mouth were both negative.

In August, there were 13 stations in Jiaozhou Bay including 52,53,54,55,56,57,58,59,60,61,2104, 2105, and 2106 stations. The results from subtracting PHL content inthe surface and bottom were 0.007 – 0.021 mg/L. In the whole Jiaozhou Bay water area, the results from subtracting PHL content in the surface and bottom layer was positive.

In October, there were 13 stations in Jiaozhou Bay: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 2104, 2105 and 2106. The results from subtracting PHC contents in the surface and bottom were 0.010 – 0.028 mg/L. In the whole Jiaozhou Bay water area, the results from subtracting PHC contents in the surface and bottom were positive.

4. Discussion

4.1 Changes of Substance Content. In the process of migration, the content of substance underwent changes. Based on the principle of material vertical water body effect, material horizontal water body effect and water body effect proposed by the author [15-17], in the surface water body of Jiaozhou Bay mouth water area, due to the adsorption of PHC ion on the surface of a large number of suspended particles, PHC continuously settles to the seabed under the action of gravity and water flow. Under the effect of vertical water body, the change of PHC content in surface determines the change of PHC content in bottom.
4.2 Sources. In May, August and October, there were three sources of PHC content in Jiaozhou Bay waters, including transportation of oil spills, offshore currents and rivers.

In May, a high concentration area of PHC was formed in the coastal waters of Haibo River Estuary in Jiaozhou Bay, which indicated that the source of PHC was Haibo River, with PHC content of 0.070mg/L that was relatively high. In the central water area of Jiaozhou Bay, a high concentration area of PHC was formed, which indicated that the source of PHC was the transportation of oil spills on the sea. The PHC content was 0.042mg/L that was also relatively high.

In August, a high concentration area of PHC was formed in the central waters east of Jiaozhou Bay, which indicated that PHC came from the transportation of oil spills on the sea. The PHC content was 0.056mg/L, a relatively high level. In the northwest of Jiaozhou Bay, a high content area of PHC is formed in the coastal waters of Dagu River Estuary, which indicates that PHC was from the Dagu River. The PHC content was 0.046mg/L, which was relatively high.

In October, in the northeast of Jiaozhou Bay, in the coastal waters of Loushan River Estuary, a high content area of PHC was formed, which indicated that the PHC was from the Loushan river. The PHC content was 0.075mg/L, which was relatively high. In the south of Jiaozhou Bay, a high concentration area of PHC was formed in the water area of the bay mouth, which indicated that the PHC was from the offshore currents, and the PHC content was 0.054mg/L, a relatively high level.

Therefore, in May, PHC content was from the Haibo River and the oil spills on the sea. In August, PHC content came from the oil spills on the sea and Dagu River. In October, PHC content came from the Loushan River and the marine current over open seas.

4.3 Spatial Shift of Source and Vertical Quantity. In Jiaozhou Bay waters, with the spatial change, the results from subtracting PHC content between surface and bottom layer changed, indicating the change of PHC content between the surface and bottom. When the PHC content was input to Jiaozhou Bay, it reached the surface layer at first, and then rapidly and continuously settled to the seafloor, showing the variation of PHC content in the surface and bottom layer with the spatial change.

On the spatial scale, with the PHC content far away from the transport source, there was a spatial change of PHC content.

In May, in the central waters of Jiaozhou Bay, the PHC content was 0.042mg/L from the oil spills. From the center of the bay to the surface waters in the north of the bay mouth, the PHC content decreased along the gradient. In the center of the Bay and the northern part of the bay mouth, the PHC content of the surface layer was less than that of the bottom layer. This showed that from the center of the bay to the north of the bay mouth, the PHC content of the oil spill from the sea could settle to the sea floor in a large amount and continuously, and in the whole process of settling, it could accumulate rapidly in the sea floor.

In August, In the central waters east of Jiaozhou Bay, the PHC content was 0.056mg/L from the sea oil spill, and the transportation content was also relatively high. In the northwest of Jiaozhou Bay, in the coastal waters of Dagu River Estuary, PHC content was 0.046mg/L from Dagu River, and the transportation content was relatively high. In the whole Jiaozhou Bay water area, the results from subtracting PHC content between surface and bottom layer was positive, showing that the PHC content in the surface layer was higher than that in the bottom layer. This shows that in the central water area in the east of Jiaozhou Bay, the PHC content from the oil spill on the sea subsided to the bottom of the sea in a small amount. Similarly, in the coastal waters of Dagu River Estuary, the PHC content from Dagu River also slightly subsided to the sea floor. Moreover, in the whole Jiaozhou Bay, PHC content did not accumulate in the sea floor.

In October, In the northeast of Jiaozhou Bay, in the coastal waters of Loushan River Estuary, PHC content was 0.075mg/L from Loushan River, and the transportation content was relatively high. In the south of Jiaozhou Bay, the PHC content was 0.054mg/L from the ocean, and the transportation content is relatively high. In the whole Jiaozhou Bay water area, the results from subtracting PHC between surface and bottom layer was positive, showing that the PHC content in the surface layer was higher than that in the bottom layer. This showed that in the coastal waters of Loushan River Estuary, the PHC...
content from Loushan River subsides to the bottom of the sea in a small amount. Similarly, in the bay mouth waters, the PHC content from the open sea also slightly subsided to the bottom of the sea. Moreover, in the whole Jiaozhou Bay, PHC content did not accumulate in the sea floor.

4.4 Temporal Shift of Source and Vertical Quantity. On the temporal scale, with the temporal change, the source of PHC content altered, showing the variation of PHC content in the surface and bottom layer with the temporal change.

From May to August, the sources of PHC content transported to Jiaozhou Bay water area were different. The source of PHC content changed from Haibo River and offshore oil spill to the offshore oil spill and Dagu River. Moreover, the PHC content of surface layer decreased with time, and the PHC content changed from 0.042‒0.070 mg/L to 0.046‒0.056 mg/L. At the same time, the PHC content of the bottom layer decreased with time, and the PHC content changed from 0.014‒0.062 mg/L to 0.007‒0.035 mg/L.

From August to October, the sources of PHC content transported to Jiaozhou Bay water area were different. The source of PHC content changed from oil spills and Dagu River to the Loushan River and open seas. The PHC content of the surface layer increased with the change of time. The PHC content changed from 0.046‒0.056 mg/L to 0.054‒0.075 mg/L. At the same time, the PHC content of the bottom layer increased with time, and the PHC content changed from 0.007‒0.035 mg/L to 0.018‒0.047 mg/L.

Therefore, from May to August, over the time, the source of PHC content of transportation has changed, the PHC content of transportation in surface layer was decreasing, and the PHC content of transportation in bottom layer was also decreasing. From August to October, with the further change of the PHC content source, the PHC content of the surface layer and the bottom layer increased.

5.Conclusion
In May, PHC content was from the Haibo River and the oil spills on the sea. In August, PHC content came from the transportation of oil spills on the sea and Dagu River. In October, PHC content came from the of Loushan River and the marine current over open seas.

On the regional scale, in Jiaozhou Bay waters, as time went by, the surface and bottom contents of PHC decreased, and the difference also changed, which indicated the change of PHC content in the surface and bottom. In May, August, and October, the PHC content in surface and bottom decreased, the difference was between: -0.004‒0.028 mg/L, which indicated that the PHC content in surface and bottom were close. In May, in the central and estuary waters of Jiaozhou Bay, the results from subtracting PHC content in the surface and bottom was between 0.004‒0.020 mg/L, both negative. In August, the results from subtracting PHC content in the surface and bottom layer contents of all stations in Jiaozhou Bay were between 0.007–0.021 mg/L, which were positive. In October, the results from subtracting PHC content in the surface and bottom of all stations in Jiaozhou Bay was between 0.010‒0.028 mg/L, which were positive.

On the spatial scale, with the PHC content far away from the transport source, there were spatial changes of PHC content. In May, from the center of the bay to the northern part of the bay mouth, the PHC content from the oil spills on the sea can settle to the bottom of the sea in a large amount and continuously, and in the whole process of settlement, it accumulated rapidly in the bottom of the sea. In August, in the central waters of the eastern Jiaozhou Bay, a small amount of PHC from the oil spill settled to the sea floor. Similarly, in the coastal waters of Dagu River Estuary, the PHC content from Dagu River also slightly subsided to the sea floor. Moreover, in the whole Jiaozhou Bay, PHC content did not accumulate in the sea floor. In October, in the coastal waters of Loushan River Estuary, a small amount of PHC from Loushan River subsided to the seabed. Similarly, in the bay mouth waters, the PHC content from open seas also slightly subsided to the bottom of the sea. Moreover, in the whole Jiaozhou Bay, PHC content did not accumulate in the sea floor.

On the temporal scale, in Jiaozhou Bay, over the time, the source of PHC content underwent changes, and the PHC content in surface and bottom changed. From May to August, the source of PHC content
transported to Jiaozhou Bay water area changed. The source of PHC content changed from the Haibo River and offshore oil spill to the offshore oil spill and Dagu River, and the PHC content of surface (bottom) layer decreased with time. From August to October, the source of PHC content transported to Jiaozhou Bay water area changed. The PHC content changed from the transportation of oil spills and Dagu River to the transportation of Loushan River and the marine current over open seas, and the PHC content of the surface (bottom) layer increased with time.

References

[1] Dongfang Yang, Zhenqing Miao, Sixi Zhu, Ming Wang, Xiuqin Yang. Impact of riverine input on PHC in Jiaozhou Bay [J]. Journal of Computing and Electronic Information Management, 2017, 4(5): 530-535.

[2] Dongfang Yang, Zhenqing Miao, Jianxun Chai, Ming Wang, Sixi Zhu. Migration paths of PHC in Jiaozhou Bay [J]. Advances in Engineering Research, 2018, 78: 534-538.

[3] Dongfang Yang, Haixia Li, Xiaolong Zhang, Lianguo Zhao, Qi Wang. Spatial distribution characters of petroleum hydrocarbon in Jiaozhou Bay 1989 [J]. Earth and Environment Science, 2018, 186(012057): 1-7.

[4] Dongfang Yang, Dong Lin, Yuan Zhang, Qi Wang, Haixia Li. Collaborative influence of river discharge and marine current on PHC in Jiaozhou Bay [J]. Earth and Environment Science, 2019, 218(012148): 1-5

[5] Dongfang Yang, Haixia Li, Dong Lin, Yuan Zhang, Qi Wang. Influence of source input on spatial-temporal variations of PHC in Jiaozhou Bay [J]. Advances in Computer, Signals and Systems, 2018, 8: 167-170.

[6] Yang Dongfang, Chengling Huang, Xiuqin Yang, Zhikang Wang, Zhu Sixi. the major source of PHC as Oil spills in Jiaozhou Bay 1991 [J]. Earth and Environment Science, 2019, 295(052025): 1-6

[7] Dongfang Yang, Hongmin Suo, Sixi Zhu, Ming Wang, Bailing Fan. Source input and storage of petroleum hydrocarbon in Jiaozhou Bay [J]. Earth and Environment Science, 2018, 382(052043): 1-6.

[8] Dongfang Yang, Sixi Zhu, Bailing Fan, Ming Wang, Xiaoye Gao. A comprehensive research on petroleum hydrocarbon’s migration processes in Jiaozhou Bay [J]. MATEC Web, 2018, 175(04018): 1-3.

[9] Dongfang Yang, Haixia Li, Xiaolong Zhang, Lianguo Zhao, Qi Wang. Changes of petroleum hydrocarbon in Jiaozhou Bay 1984-1988 [J]. APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 16(4):3969-3979.

[10] Dongfang Yang, Zhenqing Miao, Sixi Zhu, Wang Fengyou, Yang Xiuqin. Examination of Yang’s marine water filter phenomenon [J]. Earth and Environment Science, 2018, 153(062064): 1-7.

[11] Yang Dongfang, Gao Zhenhui, Zhang Jing, Cui Wenlin, Shi Qiang. Examination of Daytime Length’s Influence on Phytoplankton Growth in Jiaozhou Bay, China[J]. Chin. J. Oceanol. Limnol. 2004, 22(1): 70-82.

[12] Yang Dongfang, Gao Zhenhui, Chen Yu Wang Pei-gang, Sun Pei-yan. Examination of Seawater Temperature’s Influence on Phytoplankton Growth in Jiaozhou Bay, North China[J]. Chin. J. Oceanol. Limnol. 2004, 22(2): 166-175.

[13] State Oceanic Administration. The Specification for Marine Monitoring [Z]. Beijing: China Ocean Press, 1991.

[14] Dongfang Yang, Danfeng Yang, Fengyou Wang, Sixi Zhu, Xiuqin Yang. Definition and formula of substance content change in marine bay and the application [J]. Advances in Engineering Research, 2017, 118: 847-853.

[15] Dongfang Yang, Danfeng Yang, Fengyou Wang, Sixi Zhu, Ming Wang. Environmental dynamic value of substance in marine bay[J]. World Scientific Research Journal, 2016, 2(3): 191-196.

[16] Yang Dongfang, Lin Wang, Rong Zhang, Sixi Zhu, Hongmin Suo. The impacts of regional rainfall
and upstream effect on runoff of Xiangjiang River of Guizhou [J]. Meteorological and Environmental Research, 2017, 8(2): 79-84.