PHC Content of the Sources Affecting the Whole Waterbody

Dongfang Yang\textsuperscript{1,2,3\textsuperscript{a}}, Chunhua Su\textsuperscript{1,2}, Yunjie Wu\textsuperscript{1,2}, Ming Wang\textsuperscript{1,2}, and Sixi Zhu\textsuperscript{1,2}

\textsuperscript{1}Research Center for Karst Wetland Ecology, Guizhou Minzu University, Guiyang, 550025, China
\textsuperscript{2}College of Chemistry and Environmental Science, Guizhou Minzu University, Guiyang, 550025, China
\textsuperscript{3}North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China
\textsuperscript{a}dfyang_dfyang@126.com

Abstract: Based on the survey data of Jiaozhou Bay in May, August and October 1992, the current content and horizontal distribution of PHC in the bottom waters of Jiaozhou Bay were studied. The results showed that in May, the content of PHC in the bottom water of Jiaozhou Bay ranged from 0.014 to 0.062mg/l, and the water of Jiaozhou Bay was slightly polluted by PHC. In August, the content of PHC in the bottom water of Jiaozhou Bay was 0.007-0.035mg/l. The foot water of Jiaozhou Cove was not contaminated by PHC. In October, the substance of PHC within the foot water of Jiaozhou Cove was 0.018-0.047mg/l. The foot water of Jiaozhou Inlet was not contaminated by PHC. All in all, in May, the foot waters of Jiaozhou Narrows was contaminated by PHC in May; in Admirable and October, the quality of the foot waters of Jiaozhou Cove come to the course I and course II seawater quality measures in China in terms of the PHC substance, which demonstrated that there was no pollution of PHC within the waters. In the surface waters of central Jiaozhou Bay in May, the central surface waters of the eastern Jiaozhou Bay and northwest Jiaozhou Bay in August and the surface waters of northeast Jiaozhou Bay and the bay mouth in October, the PHC content in the sources was relatively high. And this was also the case in the bottom water, which indicated that the PHC in the surface waters would descend rapidly to the bottom of the sea, and further indicated that there were high PHC content area in both surface waters and bottom waters. Considering these, the authors put forward the law about how the PHC from sources affects bottom water. They believe that high PHC content in surface water means high PHC content in a whole waterbody.

1. Introduction

In Jiaozhou Inlet, waterways brought petroleum (PHC) to the coastal waters of Jiaozhou Bay. There were numerous ships coming and aiming to Jiaozhou Narrows, and there were also oil spills. Abundant PHC in open seas were transported to Jiaozhou Bay through currents. In this way, PHC content was transmitted to the Gulf waters through the transportation of rivers, the offshore oil spills and the transportation of offshore currents [1-5]. PHC spread from the surface waters to the whole waterbody through vertical migration, showing the PHC content variation in the bottom water at the bay mouth of Jiaozhou Bay. Therefore, basing on the investigation data of PHC content in Jiaozhou Bay in 1992, the authors carried out a study on the bottom waters of Jiaozhou Bay, identified the amount, distribution and horizontal variation of PHC, and revealed the variation process of the effect of PHC content on the waters, which provides a scientific basis for the study of the existence and migration of PHC in the bottom waters.
2. Materials and methods
The study information of PHC in Jiaozhou Inlet in May, Admirable and October 1992 were from the North Ocean checking center of the State Maritime Organization. In Jiaozhou Bay, 13 stations are set to take water samples: 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 2104, 2105 and 2106 stations (Figure 1). The samples were taken in May, August and October of 1992 respectively. According to the water depth, water samples were taken (> 10m, surface layer and bottom layer, and < 10m, only surface layer). The PHC of Jiaozhou Cove water body was explored concurring to the national standard strategy, which was included within the national marine checking code (1991) [5].

3. Results
3.1 Content in the Bottom Waters
The national water quality standards for class I and class II sea water (0.05mg/L), class III sea water (0.30mg/L) and class IV sea water (0.50mg/L) with PHC content in the sea waters are proposed.

In May, August and October, the variety run of PHC substance within the foot of Jiaozhou Inlet was 0.007-0.062mg/l, which adjusted to the national water quality standard of course III ocean water (0.30mg/l). In May, the PHC content in Jiaozhou Bay was between 0.014-0.062mg/l, which accorded with the national water quality standard of class III sea water (0.30mg/l). In August, the PHC content of Jiaozhou Bay water area was between 0.007-0.035mg/l, which was in line with the national water quality standard for class I and class II seawater (0.05mg / L). In October, the PHC content of Jiaozhou Bay water area was between 0.018-0.047mg/l, which met the national water quality standards for class I and class II sea water. In this manner, in May, Admirable and October, the alter extend of PHC substance in Jiaozhou Cove water body was 0.007-0.062mg/l, which adjusted to the national water quality benchmarks of lesson I, II and III ocean water. This appeared that in terms of PHC substance, in May, Eminent and October, within the foot waters of Jiaozhou Cove, the water quality was marginally contaminated by PHC (Table 1).

Table 1 The quality of the bottom waters of Jiaozhou bay in May, August and October

| PHC content in seawater /mg·L⁻¹ | May           | August         | October        |
|---------------------------------|---------------|----------------|----------------|
| seawater standard in China      | 0.014-0.062   | 0.007-0.035    | 0.018-0.047    |
| first-class and third-class seawater | first-class and second-class seawater | first-class and second-class seawater |

Fig.1 Investigation sites in Jiaozhou Bay
3.2 Horizontal Distribution in the Bottom Layer

In May, within the bottom water zone of Jiaozhou Bay, at station 55 within the central water zone of Jiaozhou Narrows, the PHC substance came to a high level of 0.062mg/l. Taking the water area in the center of the Bay as the center, a high PHC content area was formed, forming a series of parallel lines with different gradients. PHC content decreased from 0.062mg/l in the high concentration area of the central water area to 0.014mg/l in the water area from the south to the north of the bay mouth along the gradient (Figure 2).

In May, at Station 2106 that within the central waters of eastern Jiaozhou Bay, PHC substance within the foot water was 0.035mg/L, a moderately tall level. A high concentration area of PHC was formed in the eastern central water area, and a series of semi concentric circles with different gradients were formed with the station 2016 as the center. PHC content decreased from 0.035mg/l in the center to 0.014mg/l in the central water area of the Bay, 0.007mg/l in the northern water area of the Bay and 0.016mg/l in the southeast water area of the Bay (Figure 3). In the northwest of Jiaozhou Bay, at station 56 near the Dagu river estuary, the PHC content reached a high of 0.029mg/l. Taking the northwest coastal waters as the center, a high PHC content area was formed. Taking the high PHC content area as the center, a series of parallel lines with different gradients were formed. PHC content decreased from 0.029mg/l in the center to 0.014mg/l in the central water area of the Bay, 0.007mg/l in the northern water area of the Bay and 0.016mg/l in the southeast water area of the Bay (Figure 3).

In October, in the bottom water range in the northeast of Jiaozhou Cove, at station 2104 within the coastal water region of Loushan River estuary, the PHC substance came to a high of 0.047mg/l, and a high PHC substance zone was shaped with the coastal water region within the northeast as the center, and a arrangement of parallel lines with distinctive slopes were shaped with the tall PHC substance region as the center. PHC content decreased outward along the gradients from 0.047mg/l of the high content in the center to 0.034mg/l of the coastal waters of the estuary of Licun River, 0.026mg/l of the coastal waters of the estuary of haipo River, 0.022mg/l of the central waters of the Bay, and 0.018mg/l of the coastal waters of the north of the Bay (Figure 4). The PHC substance of station 52 within the foot water range of Jiaozhou Inlet mouth was higher than 0.034mg/l. The high PHC substance range was shaped with the narrows mouth water zone as the center, and a arrangement of parallel lines with diverse slopes were shaped with the tall PHC substance range as the center. PHC content decreased from the high content of 0.034mg/l in the center to 0.023mg/l in the northern water area of the bay.

![Fig.2 PHC content distribution at the bottom in Jiaozhou Bay in August (mg/L)](image-url)
mouth, 0.022mg/l in the central water area of the bay mouth and 0.029mg/l in the western water area of the bay mouth (Figure 4).

![Fig.3 PHC content distribution at the bottom in Jiaozhou Bay in October (mg/L)](image)

4. Discussion

4.1 Water quality
In May, August and October, PHC in the waters of Jiaozhou Bay waters were brought by oil spill transportation, open sea currents transportation and river flow transportation. The PHC first flow to the surface water and then descend to the bottom. Under the effect of vertical water body, the variation range of PHC content in the bottom water area of Jiaozhou Bay was 0.007-0.062mg/l, which conformed to the national water quality standards of class I, II and III sea water. This appeared that in terms of PHC substance, within the foot waters of Jiaozhou Cove, the water quality was somewhat contaminated by PHC substance.

In May, the PHC substance within the foot waters of Jiaozhou Narrows was between 0.014mg/L to 0.062mg/L, which uncovered that the water was contaminated somewhat. At station 55 in the central water area of the Bay, the change range of PHC content was 0.062mg/l, which indicated that the water quality of this water area, in terms of PHC content, has reached the water quality standard of three types of seawater, and the PHC content was higher than 0.050mg/l, so the water quality was slightly polluted by PHC. In Jiaozhou Bay, except for the central water area of the Bay, the change range of PHC content was 0.014mg/l, which indicated that the water quality of this water area, in terms of PHC content, has reached the water quality standard of class I and class II sea water. The water was not contaminated by PHC, and the water was clean. In Admirable, the PHC substance within the bottom of Jiaozhou Narrows extended from 0.007mg/L to 0.035mg/L, which demonstrated that there was no contamination of PHC. PHC substance within the foot waters of Jiaozhou Inlet were underneath 0.40mg/L, which shown that the quality of these waters come to the first-class seawater quality standard in terms of PHC substance which there was no contamination of PHC.

In October the PHC substance within the foot waters of Jiaozhou Narrows extended from 0.018mg/L to 0.0547mg/L, which shown that there was no contamination of PHC. PHC substance within the foot waters of Jiaozhou Inlet were underneath 0.40mg/L, which showed that the quality of these waters come to the first-class seawater quality standard in terms of PHC substance which there was no contamination of PHC.

In outline, in May, foot waters of Jiaozhou Inlet was somewhat contaminated by PHC; in Eminent
5. Conclusion

In May, August and October, in Jiaozhou Bay waters, PHC content came from the transportation of oil spills, offshore currents and rivers. PHC content first came to the surface of the water, and then, passed through the water from the surface to the bottom. Under the effect of vertical water body, PHC content showed that the variation range of PHC content in the bottom water of Jiaozhou Bay was 0.007-0.062 mg/L, which was in line with the national water quality standards of class I, II and III sea water. This shows that in terms of PHC content, in the bottom waters of Jiaozhou Bay, the water quality of these waters come to the first-class and second-class seawater quality standard in terms of PHC substance which there was no contamination of PHC.

The authors put forward the law about how PHC content in sources affects the bottom waters: when PHC transported to the surface is relatively much, PHC content at the bottom is also relatively high; when the PHC transported to the surface is relatively little, PHC content at the bottom is relatively lower. This reveals that the PHC settles on the bottom in a short time, and leads to the conclusion that high PHC content area form both in the surface and at the bottom. Thus, when PHC transported to the surface is relatively much, the PHC content in the whole water body is relatively high.
quality is slightly polluted by PHC content.

In May, within the foot waters of Jiaozhou Inlet, the content of PHC within the waters of Jiaozhou Cove extended from 0.014 to 0.062mg/l. The waters of Jiaozhou Narrows were somewhat contaminated by PHC. In Admirable, the substance of PHC within the foot water of Jiaozhou Narrows was 0.007-0.035mg/l. The foot water of Jiaozhou Narrows was not contaminated by PHC. In October, the content of PHC in the bottom water of Jiaozhou Bay was 0.018-0.047mg/l. The bottom water of Jiaozhou Bay was not polluted by PHC. Therefore, in May, the bottom water of Jiaozhou Bay was slightly polluted by PHC content. In August and October, in the bottom water area of Jiaozhou Bay, in terms of PHC content, the water quality standard of class I and class II seawater was met, the water was not polluted by PHC, and the water was clean.

In May, when PHC was transported to the central surface water of Jiaozhou Bay, PHC content at the bottom reached a extremely high level. This revealed that the PHC must have settled on the bottom in a short time and accumulated, which led to the result that PHC content at the bottom was much higher than that in the surface.

In August, when PHC was transported to the central surface water of eastern Jiaozhou Bay, PHC content at the bottom reached a extremely high level. This revealed that the PHC must have settled on the bottom in a short time, which led to the result that high PHC content area formed both at the bottom and in the surface. When PHC was transported to the surface water of northwest Jiaozhou Bay, PHC content at the bottom reached a relatively high level. This revealed that the PHC must have settled on the bottom in a short time, which led to the result that high PHC content area formed both at the bottom and in the surface.

In October, when PHC transported to the surface water of northeast Jiaozhou Bay was relatively much, PHC content at the bottom reached a relatively high level. This revealed that the PHC must have settled on the bottom in a short time, which led to the result that high PHC content area formed both at the bottom and in the surface. When PHC transported to the surface water at the bay mouth of Jiaozhou Bay was relatively much, PHC content at the bottom reached a relatively high level. This revealed that the PHC must have settled on the bottom in a short time, which led to the result that high PHC content area formed both at the bottom and in the surface.

The authors put forward the law about how PHC content in sources affects the bottom waters: when PHC transported to the surface is relatively much, PHC content at the bottom is also relatively high; when PHC transported to the surface is relatively little, PHC content at the bottom is relatively lower.

Acknowledgement
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).

References
[1] Dongfang Yang, Youchi Zhang, Jie Zou, et al. Contents and distribution of petroleum hydrocarbons (PHC) in Jiaozhou Bay waters [J]. Open Journal of Marine Science, 2011, 2(3): 108-112.
[2] Dongfang Yang, Peiyian Sun, Chen Chen, Hongyan Bai, Qing Zhou. Pollution Source and Distribution of PHC in the Jiaozhou Bay Waters [J]. Coastal Engineering, 2013, 32(1): 60-72.
[3] D F YANG, Y CHEN, Z H GAO, et al. Silicon Limitation on primary production and its destiny in Jiaozhou Bay, China IV transect offshore the coast with estuaries [J]. Chin. J. Oceanol. Limnol. 2005, 23(1): 72-90.
[4] Dongfang Yang, Fan Wang, Zhenhui Gao, et al. Ecological Phenomena of Phytoplankton in Jiaozhou Bay [J]. Marine Science, 2004, 28 (6): 71-74.
[5] State Oceanic Administration. The Specification for Marine Monitoring [Z]. Beijing: China Ocean Press, 1991.