Examination of Yang’s marine water filter phenomenon

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Abstract. This paper examined Yang’s Marine Water Filter Phenomenon based on a case study on plumbum (Pb) contents in Jiaozhou Bay 1988. Results showed that the horizontal absolute loss amounts of Pb in surface and bottom waters in Jiaozhou Bay in 1988 were 10.03-23.53 μg L\textsuperscript{-1}, and the horizontal relative loss amounts of Pb in surface and bottom waters were 39.36-89.08%. The vertical absolute dilution amount and the vertical relative dilution amount were 0.96-23.12 μg L\textsuperscript{-1} and 6.37-93.94%, respectively. The vertical absolute accumulation amount and the vertical relative accumulation amount were 1.67 μg L\textsuperscript{-1} and 9.96 μg L\textsuperscript{-1}, respectively. Once substances are transporting through a certain waters, the contents would be losing greatly, no matter from any direction, no matter in surface layer or bottom layer. This phenomenon was named as Yang’s Marine Water Filter Phenomenon. Finally, this phenomenon was examined and confirmed.

1. Introduction

Substance’s contents in marine bay would be accumulating or diluting during horizontal and vertical migrating processes [1-6]. Once substances are transporting through a certain waters, the contents would be changing. Identifying the reasons and the trends of the changes of substance’s contents is essential to scientific research. This paper analyzed the vertical and horizontal changes of Pb contents in Jiaozhou Bay, China in 1988. Based on this, definitions and calculating formulas for horizontal loss amount, vertical dilution amount and vertical dilution amount were provided. It was found that once substances were transporting through a certain waters, the contents would be losing greatly, no matter from any direction, no matter in surface layer or bottom layer. This phenomenon was named as Yang’s Phenomenon. Finally, this phenomenon was examined and confirmed.

2. Study area and data collection

Jiaozhou Bay is located in the south of Shandong Province, eastern China (35°55'-36°18' N, 120°04'-120°23' E). The total area and average water depth are 446 km\textsuperscript{2} and 7 m, respectively. The bay mouth is very narrow (3 km), and is connected to the Yellow Sea in the south. There are a dozen of rivers including Dagu River, Haibo Rriver, Licun Rriver, and Loushan Rriver etc., all of which are seasonal rivers [7-8]. The investigation on Pb in bottom waters in Jiaozhou Bay was carried on in
April and July 1988 in six monitoring sites (i.e., Site 34, Site 35, Site 36, Site 84, Site 85 and Site 90) (Fig. 1). Pb in bottom waters was sampled and monitored follow by National Specification for Marine Monitoring [9].

3. Results

3.1 Horizontal change of substance’s content. In Jiaozhou Bay, supposed that certain substance’s contents in surface waters in the outer side of the bay mouth is $A$, and in the center of the bay mouth is $B$. Taken from the open waters in the outer side of the bay mouth to the inner side of the bay mouth as the direction, the calculation formula is:

$$D = A - B, \quad E = (100 \times \frac{|A - B|}{\max(A, B)})\%$$

where, $D$ is the horizontal absolute loss amount in surface waters, $E$ is the horizontal relative loss amount in surface waters. If $D < 0$, the horizontal absolute loss amount from the inner side of the bay mouth to the outer side of the bay mouth is $-D$.

In Jiaozhou Bay, supposed that certain substance’s contents in bottom waters in the outer side of the bay mouth is $a$, and in the center of the bay mouth is $b$. Taken from the open waters in the outer side of the bay mouth to the inner side of the bay mouth as the direction, the calculation formula is:

$$d = a - b, \quad e = (100 \times \frac{|a - b|}{\max(a, b)})\%$$

where, $d$ is the horizontal absolute loss amount in bottom waters, $e$ is the horizontal relative loss amount in bottom waters. If $d < 0$, the horizontal absolute loss amount from the inner side of the bay mouth to the outer side of the bay mouth is $-d$.

Supposed that Site 35 and Site 34 were referring to A and B, the horizontal loss amount of Pb in Jiaozhou Bay in surface and bottom waters were calculated in listed in Table 1 and Table 2, respectively. It could be seen that Pb contents in surface and bottom waters were changing a lot during the migrating process from open waters to the bay [10].

| From A to B | $D/\mu g \cdot L^{-1}$ | $E/\%$ |
|------------|----------------------|--------|
| April      | -10.03               | 40.75  |
| July       | 23.53                | 60.92  |

Fig. 1 Geographic location and monitoring sites in Jiaozhou Bay
Table 2 Horizontal loss amount of Pb in bottom waters Jiaozhou Bay in 1988

| From A to B | $d/\mu g L^{-1}$ | $e/\%$ |
|------------|-----------------|--------|
| April      | 12.16           | 89.08  |
| July       | 10.88           | 39.36  |

3.2 Vertical change of substance’s content. For a certain sampling site ($n$) in open waters in the outer side of Jiaozhou Bay, supposed that substance’s contents in surface waters and bottom waters are $A$ and $a$, respectively. From the surface waters to bottom waters, the calculation formula for vertical change of substance’s content is:

$$V_{na}=A-a, \quad V_{nr}=(100 \times |A-a|/\max(A, a))\%$$

(3)

where, $V_{na}$ is the horizontal absolute dilution amount in waters, $V_{nr}$ is the horizontal relative dilution amount in waters. If $V_{na}<0$, the horizontal absolute dilution amount in waters is $-V_{na}$, and the horizontal relative dilution amount is $V_{nr}$.

Substance’s contents were changing while transporting from surface waters to bottom waters. In order to revealed the vertical changes, Pb contents in surface waters in each monitoring sites were subtracted from which in bottom waters, and the subtractions in April and July 1988 were ranging from -2.90 to 23.12 $\mu g L^{-1}$ and -6.69 to 10.98 $\mu g L^{-1}$, respectively (Table 3). Meanwhile, the horizontal dilution amount and horizontal accumulation amount of Pb in Jiaozhou Bay in 1988 were calculated in listed in Table 4. It could be seen that Pb contents in waters were changing a lot during the vertical migration process from surface waters to bottom waters [11-13].

Table 3 The difference between Pb contents in surface waters and bottom waters in Jiaozhou Bay in 1988

| Month | Site 84 | Site 85 | Site 34 | Site 90 | Site 36 | Site 35 |
|-------|--------|--------|--------|--------|--------|--------|
| April | Negative | Negative | Positive | Positive | Positive | Positive |
| July  | Negative | Positive | Negative | Positive | Positive | Position |

Table 4 Horizontal dilution amount and horizontal accumulation amount of Pb in Jiaozhou Bay in 1988

| Month | Waters                  | $V_{na}/\mu g L^{-1}$ | $V_{nr}\%$ |
|-------|-------------------------|-----------------------|-----------|
| April | Outer side of the bay mouth | 0.93          | 6.37     |
|       | Inner side of the bay mouth | 23.12          | 93.94    |
| July  | Outer side of the bay mouth | 10.98          | 28.43    |
|       | Inner side of the bay mouth | -1.67          | 9.96     |

4. Discussion

4.1 Horizontal and vertical change of Pb content. For a certain sampling site ($n$) in open waters in the outer side of Jiaozhou Bay, supposed that substance’s contents in surface waters and bottom waters are $A$ and $a$, respectively. From the surface waters to bottom waters, the calculation formula for vertical change of substance’s content is:

In waters in the outer side of the bay mouth, Pb contents were mainly from marine current from the open waters. In waters in the inner side of the bay mouth, Pb contents were mainly from atmospheric deposition. In waters in the bay mouth of Jiaozhou Bay, Pb contents were decreasing from the high value centers to the around by means of tide and current.

For horizontal change in April 1988 (Table 1 and Table 2), from the inner side of the bay mouth to the outer side of the bay mouth, the horizontal loss amount of Pb in surface waters was 40.75%, while from the outer side of the bay mouth to the inner side of the bay mouth, the horizontal loss amount of Pb in bottom waters was as high as 89.08% (Fig. 2). For horizontal change in April 1988 (Table 4), the vertical dilution amount in waters in the inner side of the bay mouth was as high as 89.08%, while
in the outer side of the bay mouth was relative low as 93.94% (Fig. 3).

For horizontal change in July 1988 (Table 1 and Table 2), from the outer side of the bay mouth to the inner side of the bay mouth, the horizontal loss amount of Pb in surface waters was 60.92%, while from the outer side of the bay mouth to the inner side of the bay mouth, the horizontal loss amount of Pb in bottom waters was as 39.36%. For horizontal change in July 1988 (Table 4), the vertical dilution amount in waters in the inner side of the bay mouth was 24.83%, while in the outer side of the bay mouth was relative low as 9.96% (Fig. 3).

In general, the horizontal absolute loss amounts of Pb in surface and bottom waters in Jiaozhou Bay in 1988 were 10.03-23.53 μg L⁻¹, and the horizontal relative loss amounts of Pb in surface and bottom waters in Jiaozhou Bay in 1988 were 39.36-89.08%. The vertical absolute dilution amount and the vertical relative dilution amount were 0.96-23.12 μg L⁻¹ and 6.37-93.94%, respectively. The vertical absolute accumulation amount and the vertical relative accumulation amount were 1.67 μg L⁻¹ and 9.96 μg L⁻¹, respectively.

4.2 Yang’s Phenomenon on Pb content. The horizontal relative loss amounts of Pb contents in surface and bottom waters in Jiaozhou Bay in 1988 were calculated and listed in Table 5. In surface waters in April 1988, from the inner side of the bay mouth to the bay mouth and to the outer side of the bay mouth, the horizontal relative loss amounts were 40.75% (Table 5).

In surface waters in July 1988, from the outer side of the bay mouth to the bay mouth and to the inner side of the bay mouth, the horizontal relative loss amounts were 60.92% (Table 5). Hence, the horizontal relative loss amounts of Pb in surface waters were ranging from 40.75-60.92%, no matter from the inner side of the bay mouth to the outer side of the bay mouth or reverse.

In bottom waters in April 1988, from the outer side of the bay mouth to the bay mouth and to the outer side of the bay mouth, the horizontal relative loss amounts were 89.08% (Table 5). In bottom waters in July 1988, from the outer side of the bay mouth to the bay mouth and to the inner side of the bay mouth, the horizontal relative loss amounts were 39.36% (Table 5). Hence, the horizontal relative loss amounts of Pb in bottom waters were ranging from 39.36-89.08%, no matter from the inner side of the bay mouth to the outer side of the bay mouth or reverse.

Table 5 The horizontal relative loss amounts of Pb contents in surface and bottom waters in Jiaozhou Bay in 1988

| Layer          | Month   | Starting point waters | Passing through waters | End point waters | Horizontal relative loss |
|----------------|---------|-----------------------|------------------------|-----------------|--------------------------|
|                |         |                       |                        |                 |                          |

Fig. 2 Block diagram model for horizontal and vertical changing of Pb in April 1988

Fig. 3 Block diagram model for horizontal and vertical changing of Pb in July 1988
In general, Pb contents would be losing while transporting through the bay mouth, no matter no matter from the inner side of the bay mouth to the outer side of the bay mouth or reverse, and no matter in surface waters or in bottom waters. Hereby, once substances are transporting through a certain waters, the contents would be losing greatly, no matter from any direction, no matter in surface layer or bottom layer. This phenomenon was named as Yang’s Marine Water Filter Phenomenon, the waters in this Phenomenon was was named as Yang’s Waters, and the substance’s contents in this phenomenon was named as Yang’s Substance’s Content. Yang’s Phenomenon revealed that, the certain waters is playing a role as a ‘parclose’ once substance’s contents were transporting through, and a big part of substances (e.g., Pb, Cr, Hg) were filtrated to the two sides of the parclose. In Jiaozhou Bay, Pb in the open waters was difficult to be transported to the inside of the bay, and Pb in the inside of the bay was also difficult to be transported to the open waters. In general, Yang’s marine water filter phenomenon was examined and confirmed in this research.

5. Conclusion
In Jiaozhou Bay, Pb in the open waters was difficult to be transported to the inside of the bay, and Pb in the inside of the bay was also difficult to be transported to the open waters. Pb contents would be losing while transporting through the bay mouth, no matter no matter from the inner side of the bay mouth to the outer side of the bay mouth or reverse, and no matter in surface waters or in bottom waters. Once substances are transporting through a certain waters, the contents would be losing greatly, no matter from any direction, no matter in surface layer or bottom layer. This phenomenon was named as Yang’s Marine Water Filter Phenomenon, which was examined and confirmed in this study.

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