Quantitative Hg Content Migration Process I. Yang Dongfang
Migration Model Calculation

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Abstract: Based on the investigation data of Jiaozhou Bay in May, August and October, 1992, the migration process of Hg content that came from atmospheric subsidence in Jiaozhou Bay was studied. In August, the central point 2016 in the east of Jiaozhou Bay was taken as the source of atmospheric subsidence, with the Hg content of 0.050 μg/L. A series of concentric circles with different gradients have been formed with station 2016 as the center. The Hg content decreased from 0.050 μg/L in the center to 0.021 μg/L in the center of the Bay, 0.037 μg/L in the northwest, 0.031 μg/L in the northeast and 0.033 μg/L in the southeast of the bay. According to the absolutely horizontal loss rate model of matter content, it was calculated that in August, in the eastern part of Jiaozhou Bay, from the eastern central water area to the central water area of the Bay, the absolutely horizontal loss rate of Hg content in the surface was 0.40 Yang Dongfang absolute number, 0.19 Yang Dongfang absolute number in the northwest water area of the bay, 0.45 Yang Dongfang absolute number in the northeast water area of the bay, 0.63 Yang Dongfang absolute number in the southeast water area of the Bay. According to the relatively horizontal loss rate model of matter content, it was calculated that in August, in the eastern part of Jiaozhou Bay, from the eastern central water area to the central water area of the Bay, the relatively horizontal loss rate of Hg content in the surface was 8.00 Yang Dongfang relative number, 3.80 Yang Dongfang relative number in the northwest water area of the Bay, 9.00 Yang Dongfang relative number in the northeast water area of the Bay, 12.60 Yang Dongfang relative number in the southeast water area of the bay.

1. Introduction
In Jiaozhou Bay, the mercury (Hg) released into the atmosphere by humans finally reached the ocean. In this way, the Hg content was transmitted to the whole bay through the ocean water [1-3]. Therefore, according to the survey data in 1992, the end-point value and process value of Hg content could be calculated by using the Dongfang Yang's horizontal loss rate model of substance content.

2. Investigation Waters and Methods
2.1 Jiaozhou Bay Environments
Jiaozhou Bay is a typical semi closed bay with 120 ° 04 ′ - 120 ° 23 ′ E, 35 ° 58 ′ - 36 ° 18 ′ N, covering an area of about 446km², with an average water depth of about 7m. There are Dagu River, Yang River and Haibo River, Licun River and Loushan River around Jiaozhou Bay, its horological characteristics of these rivers can alter in different seasons [4, 5].
2.2 Methods
By the application of the survey data on Hg in Jiaozhou Bay in May, August and October 1992, provided by the North Sea Monitoring Center of the State Oceanic Administration, 13 stations were set up in Jiaozhou Bay 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, 1992 respectively. The Hg content of Jiaozhou Bay water body has been got according to the national standard method being included in the Specification for Marine Monitoring (1991) [6].

3. Results
3.1 Sources
In August, at station 2016 in the central water area of the eastern Jiaozhou Bay, the Hg content reached a high level of 0.050 μg/L with the eastern central water area as the center, forming a high Hg content area. A series of concentric circles with different gradients were formed with the station 2016 as the center. The Hg content decreased from 0.050 μg/L in the center to 0.021 μg/L in the center of the bay, 0.037 μg/L in the northwest, 0.031 μg/L in the northeast, to 0.033 μg/L in the southeast of the Bay (Figure 2).

In August, a high Hg content area was formed in the water body in the Eastern Center of Jiaozhou Bay, which indicated that the source of Hg was atmospheric deposition, and the Hg content was 0.050 μg/L, which was very high. The Hg content decreased along the gradients, resulting in the Hg content decreasing to all sides along the gradients, to 0.021 μg/L in the central water area of the bay, to 0.037 μg/L in the northwest, to 0.03 μg/L in the northeast, to 0.033 μg/L in the southeast.
3.2 Distance from central station to surrounding stations

In August, in the central water area in the east of Jiaozhou Bay, taking station 2016 as the center, the four stations around it are station 55 in the bay center, station 57 in the northwest of the bay, station 2015 in the bay northeast and station 59 in the bay southeast (Figure 3). The values of Hg content at these five stations: 2016, 55, 57, 2015 and 59 were obtained (Table 1).

Table 1 The positions of five stations: 2016, 55, 57, 2015 and 59 and the values of Hg content

| Stations | Longitude | Latitude | Hg content(μg/L) |
|----------|-----------|----------|-----------------|
| 2016     | 120°19′0" | 36°08′0" | 0.050           |
| 55       | 120°15′18"| 36°07′06"| 0.021           |
| 57       | 120°16′0" | 36°10′06"| 0.037           |
| 2015     | 120°20′0" | 36°10′0" | 0.031           |
| 59       | 120°19′12"| 36°06′42"| 0.033           |

Fig.3 Connecting lines from central station to each station in the east of Jiaozhou Bay

The distance between the central station 2016 in the east of Jiaozhou Bay and the central station 55 in the bay was calculated:

Assuming that the distance between station 2016 and station 55 was L1, according to 1′= 1858m, the L1 was calculated as

\[ L_1^2 = [(18-15+60/60-18/60) \times 1858]^2 + [(7-7+60/60-6/60) \times 1858]^2 \]

\[ L_1 = 3.80 \times 1858 = 7075.05 \text{(m)} \]

The distance between the central station 2016 in the east of Jiaozhou Bay and the Northwest Station 57 were calculated:

Assuming that the distance between station 2016 and station 57 was L2, according to 1′= 1858m, the L2 was calculated as

\[ L_2^2 = [(19-16+0/60-0/60) \times 1858]^2 + [(8-10+0/60-6/60) \times 1858]^2 \]

\[ L_2 = 3.66 \times 1858 = 6803.93 \text{(m)} \]

The distance between the central station 2016 in the east of Jiaozhou Bay and the Northeast station 2015 were calculated:

Assuming that the distance between station 2016 and station 2015 was L3, according to 1′= 1858m, L3 was calculated as

\[ L_3^2 = [(19-20+0/60-0/60) \times 1858]^2 + [(8-10+0/60-0/60) \times 1858]^2 \]

\[ L_3 = 2.23 \times 1858 = 4154.61 \text{(m)} \]

The distance between the central station 2016 in the east of Jiaozhou Bay and the southeast station...
59 was calculated:
Assuming that the distance between station 2016 and station 59 was $L_4$, according to $1' = 1858\text{m}$, $L_2$ was calculated as

$$L_4^2 = [(19-19+0/60-12/60) \times 1858]^2 + [(8-6+0/60-42/60) \times 1858]^2$$

$$L_4 = 1.44 \times 1858 = 2686.07(\text{m})$$

3.3 Yang Dongfang’s Horizontal loss rate model of substance content

The author put forward the Yang Dongfang’s horizontal loss rate model of substance content, which consisted of the absolutely horizontal loss rate model of substance content and the relatively horizontal loss rate model of substance content.

Absolutely horizontal loss rate model of substance content: assuming that the matter content in surface decreases from value $a$ of point $A$ to value $b$ of point $B$, and the distance between point $A$ to $B$ is $L$, the absolutely horizontal loss rate of matter content is $V_{SP}$. Then, the absolute horizontal loss rate model of matter content is obtained:

$$V_{ASP} = \frac{(a-b)}{L} \quad (1)$$

So, we get the substance. Then the relatively horizontal loss rate of matter content is $V_{SP}$.

Relatively horizontal loss rate model of content:

$$V_{rsp} = [\frac{(a-b)/a}{L}] = \frac{(a-b)}{a} \times L \quad (2)$$

In terms of spatial scale, this model reveals the loss per unit distance of matter content in the process of horizontal migration. The absolutely horizontal loss rate of matter content indicates the absolute loss per unit distance, and the relatively horizontal loss rate of matter content indicates the relative loss per unit distance.

3.4 Simplified Units

The units of absolutely horizontal loss rate and relatively horizontal loss rate are complex and need to be simplified. Therefore, the author calls $\times 10^{-5} (\mu g/\text{L})/\text{M}$ Yang Dongfang number, which can also be used in English as ydf.

For example, the absolutely horizontal loss rate value of Hg content is $V_{asp} = 30.84 \times 10^{-5} (\mu g/\text{L})/\text{M}$ which can be called as 30.84 Yang Dongfang absolute number, or 30.84 ydfa.

For example, the relatively horizontal loss rate value of Hg content is $V_{rsp} = 7.78 \times 10^{-5} (\mu g/\text{L})/\text{m}$ that can be called as 7.78 Yang Dongfang relative number, or 7.78 ydfr.

Therefore, in any water body, the unit of horizontal loss of any matter content can be measured by the Yang Dongfang absolute number and relative number or ydfa and ydfr.

3.5 Horizontal loss rate from east center to Bay Center

In August, at station 2016 in the water body at the eastern central area of Jiaozhou Bay, a high Hg content area was formed, which indicated that the source of Hg was atmospheric sedimentation, and the Hg content was 0.050 $\mu g/\text{L}$. In the central water area of the bay, from station 2016 to station 55, the Hg content in surface was 0.021 $\mu g/\text{L}$.

According to the Yang Dongfang horizontal loss rate model (1) and (2) of substance content, the absolutely horizontal loss rate and relatively horizontal loss rate of Hg content were calculated.

In August, the Hg content in surface in water decreased from 0.050 $\mu g/\text{L}$ at station 2016 to 0.021 $\mu g/\text{L}$ at station 55. The absolutely horizontal loss rate of Hg content $V_{asp} = (0.050-0.021) / 7075.05 = 0.40 \times 10^{-5} (\mu g/\text{L})/\text{M} = 0.40 \text{ ydfa}$.

$V_{asp} = 8.00 \times 10^{-5} (\mu g/\text{L})/\text{M} = 8.00 \text{ ydfr}.$

Then, in August, the source of Hg content in Jiaozhou Bay was the atmospheric deposition. In the central water area of the Bay, the Hg content in surface from station 2016 to station 55, the absolutely horizontal loss speed of Hg content was 0.40 Yang Dongfang absolute number, and the relatively horizontal loss rate of Hg content was 8.00 Yang Dongfang relative number.
3.6 Horizontal loss rate from the Eastern Center to the northwest of the Bay

In August, at station 2016, a high Hg content area was formed in the water body at the eastern center of Jiaozhou Bay, which indicated that the source of Hg was atmospheric sedimentation, and the Hg content was 0.050 μg/L. In the northwest waters of the Bay, the Hg content in surface was 0.037 μg/L from station 2016 to station 57.

According to the Yang Dongfang horizontal loss rate model of substance content, the absolutely horizontal loss rate and relatively horizontal loss rate of Hg content were calculated.

In August, the Hg content of surface in water decreased from 0.050 μg/L in station 2016 to 0.037 μg/L in station 57. The absolutely horizontal loss rate of Hg content $V_{asp} = (0.050-0.037) / 6803.93 = 0.19 \times 10^{-5}$ (μg/L)/M = 0.19 ydfr. The relatively horizontal loss rate of Hg content $V_{rsp} = 3.80 \times 10^{-5}$ (μg/L)/M = 3.80 ydfr.

Then, in August, the source of Hg content in Jiaozhou Bay was the atmospheric deposition. In the northwest water area of the bay, in the surface from station 2016 to station 57, the absolutely horizontal loss rate value of Hg content was 0.19 Yang Dongfang absolute number, and the relatively horizontal loss rate value of Hg content was 3.80 Yang Dongfang relative number.

3.7 Horizontal Loss Rate from the Eastern Center to the Northeast of the Bay

In August, at station 2016 that in the eastern center of Jiaozhou Bay, a high Hg content area was formed, which indicated that the source of Hg was the atmospheric sedimentation, and the Hg content was 0.050 μg/L. In the northeast waters of the Bay, Hg content in the surface was 0.031 μg/L from station 2016 to station 2015.

According to the Yang Dongfang's horizontal loss rate model of substance content, the absolutely horizontal loss rate and relatively horizontal loss rate of Hg content were calculated.

In August, the Hg content in the surface decreased from 0.050 μg/L in 2016 to 0.031 μg/L in 2015. The absolutely horizontal loss rate value of Hg content $V_{asp} = (0.050-0.031) / 4154.61 = 0.45 \times 10^{-5}$ (μg/L)/M = 0.45 ydfr. The relatively horizontal loss rate value of Hg content $V_{rsp} = 9.00 \times 10^{-5}$ (μg/L)/M = 9.00 ydfr.

Then, in August, the source of Hg content in Jiaozhou Bay was the atmospheric deposition. In the northeast water area of the bay, in the surface from station 2016 to station 2015, the absolutely horizontal loss rate value of Hg content was 0.45 Yang Dongfang absolute number, and the relatively horizontal loss rate value of Hg content was 9.00 Yang Dongfang relative number.

3.8 Horizontal Loss Rate from the Eastern Center to the Southeast of the Bay

In August, at station 2016 that in the eastern center of Jiaozhou Bay, a high Hg content area was formed, which indicated that the source of Hg was atmospheric sedimentation, and the Hg content was 0.050 μg/L. In the southeast water area of the Bay, the Hg content of the surface layer was 0.033 μg/L from station 2016 to station 59.

In August, the Hg content in the surface decreased from 0.050 μg/L in 2016 to 0.033 μg/L in 59. The absolutely horizontal loss rate value of Hg content $V_{asp} = (0.050-0.033) / 2686.07 = 0.63 \times 10^{-5}$ (μg/L)/M = 0.63ydf. The relatively horizontal loss rate value of Hg content $V_{rsp} = 12.60 \times 10^{-5}$ (μg/L)/M = 12.60 ydfr.

Then, in August, the source of Hg content in Jiaozhou Bay was the atmospheric deposition. In the southeast water area of the bay, in the surface from station 2016 to station 59, the absolutely horizontal loss rate value of Hg content was 0.63 Yang Dongfang absolute number, and the relatively horizontal loss rate value of Hg content was 12.60 Yang Dongfang relative number.

4. Conclusions

In August, the central station 2016 in the east of Jiaozhou Bay was taken as the source of atmospheric subsidence, with the Hg content of 0.050 μg/L. A series of concentric circles with different gradients have been formed with 2016 station as the center. The Hg content decreased from 0.050 μg/L in the center to 0.021 μg/L in the center of the Bay, 0.037 μg/L in the northwest, 0.031 μg/L in the northeast.
and 0.033 μg/L in the southeast of the bay.

According to the model of absolutely horizontal loss rate of matter content, it was calculated that in August, in the east of Jiaozhou Bay, from the central water area of the east to the central water area of the Bay, the absolutely horizontal loss rate of Hg content in the surface was 0.40 Yang Dongfang absolute number. In the northwest water area of the Bay, the absolutely horizontal loss rate of Hg content in the surface was 0.19 Yang Dongfang absolute number. In the northeast water area of the Bay, the absolutely horizontal loss rate of Hg content in the surface was 0.45 Yang Dongfang absolute number. In the southeast water area of the Bay, the absolutely horizontal loss rate of Hg content in the surface was 0.63 Yang Dongfang absolute number. Therefore, taking the central station 2016 in the east of Jiaozhou Bay as the source of atmospheric subsidence, the Hg content of the site decreased towards the surrounding waters, and the absolutely loss rate of the Hg content was 0.19-0.63 Yang Dongfang absolute number.

According to the relatively horizontal loss rate model of matter content, it was calculated that in August, in the eastern part of Jiaozhou Bay, from the eastern central water area to the central water area of the bay, the relatively horizontal loss rate of Hg content in the surface was 8.00 Yang Dongfang relative number. In the northwest waters of the bay, the relatively horizontal loss rate of Hg content in the surface was 3.80 Yang Dong relative number. In the northeast waters of the bay, the relatively horizontal loss rate of Hg content in the surface was 9.00 Yang Dongfang relative number. In the southeast of the bay, the relatively horizontal loss rate of Hg content in the surface was 12.60 Yang Dongfang relative number. Therefore, taking the central station 2016 in the east of Jiaozhou Bay as the source of atmospheric subsidence, the Hg content of the site decreased towards the surrounding area, and the relative loss rate of the Hg content was 3.80-12.60 Yang Dongfang relative number.

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