Dynamic Migration theory, put forward by Dongfang Yang, of Cd content in Jiaozhou Bay

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Abstract: Based on the horizontal and vertical matter content changing models proposed by the author himself, this article calculates the horizontal loss amount, vertical disputed amount and vertical sediment amount, and determines the block diagram of horizontal and vertical Cd content changing model, applying the investigation matters about the Cd content of Jiaozhou Bay in May, August, and October, 1992. According to the calculation results of horizontal loss amount and horizontal increase amount of Cd content in the bottom layer and the vertical disputed amount and vertical sediment amount of Cd content in the surface and bottom layer, the author proposes the dynamic migration process of Cd content in Jiaozhou Bay, pinpoint the migration direction and route of Cd content from southeast waters to the center waters of the bay in May, August and October: sources→surface layer of southeast water→bottom layer of southeast water→bottom layer of center water→surface layer of center water, and get the dynamic changing process of absolute and relative migration amount of Cd content.

1. Introduction
The Cd content undergoes horizontal migration and vertical migration, sinking from the surface layer to the bottom layer, and then rising to the surface layer of the ocean through the ocean current [1-6]. Therefore, this article displays the horizontal migration process and the vertical sediment process of Cd content in the waters of Jiaozhou Bay and illustrates the changing process of vertical sediment and horizontal migration of Cd content in the surface and bottom waters.

2. Survey waters and methods

2.1 The natural environment of Jiaozhou Bay. Jiaozhou Bay appeared the line connecting Tuan Island and Xuejia Island, and is connected to the Yellow Sea. With an area of about 446km² and an average water depth of about 7 m, it is a typical semi-enclosed bay. There are more than a dozen rivers which are all seasonal rivers, and the river hydrological characteristics have obvious seasonal changes [7, 8].

2.2 Methods. The survey data of Cd content in Jiaozhou Bay in May, August and October 1992 used in this study are contributed to the North Sea Monitoring Center of the State Oceanic Administration. In May, August and October, two stations were made in the waters of Jiaozhou Bay to get water samples: stations 55 and 60 (Figure 1). Sampling was conducted three times in May, August and October 1992, respectively. Water samples were got by the water depth (surface and bottom layers were got when the depth >10m, and only the surface layer was got when the depth <10m) for investigation and sampling. The survey of Cd content in Jiaozhou Bay water body was carried out by...
the national standard method, recorded in the national “Marine Monitoring Code” (1991) [9].

![Fig.1 Investigation sites in Jiaozhou Bay](image)

3. Results and Discussions

3.1 Horizontal and vertical variation of Cd content. In May, August and October, from the southeast waters to the central waters of Jiaozhou Bay, the horizontal loss amount of Cd content in the bottom layer is calculated. The vertical disputed amount and vertical sediment amount of Cd content in the surface and bottom layer are calculated.

On the spatial scale, in the waters from southeast to the center of Jiaozhou Bay.

In May, from the southeast waters of the bay through the bottom waters of the seabed to the central waters of the bay, the horizontal loss amount of Cd content in the bottom waters reaches a high value, 87.50% (Figure 2). In two water areas: the southeast waters and the central waters of the bay. The vertical sediment amount of Cd content in the surface and bottom layer is 68.05% in the southeast waters of the bay, and in the central waters of the bay, the vertical disputed amount of Cd content in the surface and bottom layer is 79.54% (Figure 2).

![Figure 2. Block diagram of Cd content horizontal and vertical changing model in May](image)

In August, the Cd content in the southeast waters pass through the bottom waters in the seabed to the central waters, which results the horizontal increase amount of Cd content in the bottom layer reaches a relatively high level, 87.03% (Figure 3). In the southeast waters of the bay, the vertical disputed amount of Cd content in the surface and bottom layer is 81.33%. The vertical sediment amount of Cd content in the surface and bottom layers has reached a very high level, 88.88%, in the central waters of Jiaozhou Bay (Figure 3).
Figure 3. Block diagram of Cd content horizontal and vertical changing model in August

In October, the Cd content in the southeast waters pass through the bottom waters in the seabed to the central waters, which results the horizontal loss amount of Cd content in the bottom layer reaches a relatively high level, 68.90% (Figure 4). In the southeast waters of the bay, the vertical sediment amount of Cd content in the surface and bottom layers is 57.14%. The vertical disputed amount of Cd content in the surface and bottom layers has reached a relatively high level, 58.42%, in the central waters of Jiaozhou Bay (Figure 4).

Figure 4. Block diagram of Cd content horizontal and vertical changing model in August

Therefore, in May and October, from the southeast waters to the central waters of the bay, the absolutely horizontal loss amount of Cd content in the bottom layer varies from 0.63 to 0.82 μg/L. The relatively horizontal loss amount of Cd content in the bottom layer varies from 68.90% to 87.50%. In August, the absolutely horizontal increase amount of Cd content in the bottom layer is 0.94μg/L, and the relatively horizontal increase amount of Cd content in the bottom layer is 87.03%.

In the southeast waters of the bay, in August, the Cd content in the surface and bottom layers has an absolutely vertical disputed amount of 0.61μg/L, and its relatively vertical disputed amount is 81.33%. In May and October, the Cd content in the surface and bottom layers has an absolutely vertical sediment amount of 0.49-0.68μg/L, and its relatively vertical sediment amount is 57.14-68.05%.

In the central waters of the bay, in August, the Cd content in the surface and bottom layers has an absolutely vertical sediment amount of 0.96 μg/L, and its relatively vertical sediment amount is 88.88%. In May and October, the Cd content in the surface and bottom layers has an absolutely vertical disputed amount of 0.35-0.52μg/L, and its relatively vertical disputed amount is within 58.42-79.54%.

3.2 Horizontal loss amount and horizontal increase amount. In May, the horizontal loss amount of Cd content in the bottom water is very high, 87.50%, where the bottom water in the southeast of the bay passes through the seabed to the center of the bay. In August, the horizontal increase amount of Cd content in the bottom layer reaches 87.03%, a high level. And the horizontal loss amount of Cd content
in the bottom in October is 68.90%.

In the migration from the bottom of southeast waters to the seabed and then to the bottom of central waters, either the horizontal loss amount or the horizontal increase amount of Cd content is very high, reaching 68.90-87.50%, which indicates that the horizontal migration of Cd content in the bottom water is rapid and large.

3.3 Vertical disputed amount and vertical sediment amount. In the southeast waters of the bay, the relatively vertical disputed amount of Cd content in the surface and bottom layer is 81.33%, and the relatively vertical sediment amount of Cd content in the surface and bottom layer is 57.14-68.05%, which shows that in the southeast waters of the bay, both vertical disputed amount and vertical sediment amount are very high during the vertical migration process of Cd content in the surface and bottom waters, reaching 57.14-81.33% and the vertical migration is rapid and large.

In the central waters of the bay, the relatively vertical sediment amount of Cd content in the surface and bottom layer is 88.88%, and the relatively vertical disputed amount of Cd content in the surface and bottom layer is within 58.42-79.54%, which shows that in the central waters of the bay, both vertical disputed amount and vertical sediment amount are very high during the vertical migration process of Cd content in the surface and bottom waters, reaching 58.42-88.88% and the vertical migration is rapid and large.

In the southeast and central waters of the bay, a large amount of Cd sediment appears on the seafloor over time. With the change of time, a large amount of Cd content subsided on the seafloor has disappeared. Therefore, the Cd content in the bottom layer shows that a large amount of sedimentation appeared, disappeared, then appeared once again, and then disappeared in the following.

3.4 Dynamic migration process. In May, August, and October, the offshore ocean currents carry Cd content into the waters of Jiaozhou Bay, passing through the southeast waters of the bay first, then surrounding the coastal waters within the bay, and leaving the bay finally. Taking the southeast waters of the bay as a representative of a circle of coastal waters, the vertical and horizontal dynamic migration process of Cd content can be revealed (Figure 5).

Fig.5 The matter content brought by offshore ocean currents subsides in nearshore waters and migrates to the bottom waters of the bay center
In May, the offshore ocean currents deliver the Cd content to the mouth of Jiaozhou Bay with the Cd content of 0.59μg/L. The ocean currents flow along the coast to the northeast direction and reach the southeast waters of the bay, carrying a Cd content of 0.23μg/L. In the coastal waters of the estuary of Haibo River, there is 1.07μg/L of Cd content transported from the Haibo River.

In May, the Cd content transported by the offshore ocean currents and the Cd content transported by the Haibo River subside in the southeast waters of the bay, reaching a relatively high level of vertical sediment amount, 68.05%. The Cd content subsided a lot on the seabed. Therefore, under the action of gravity and ocean currents, the Cd content in the bottom of the southeast waters of the bay migrates horizontally to the bottom of the central waters, providing Cd content to the bottom layer of central waters. The Cd content in the bottom layer of central waters provided by the waters in the bottom of southeast of the bay reaches 87.50%. At this time, the Cd content in the bottom of central waters is relatively low. In the central waters of the bay, the vertical disputed amount of Cd content in the surface and bottom layer is 58.42%, and the Cd content in the bottom layer does not subside.

In August, in the mouth waters of Jiaozhou Bay, there is a Cd content of 1.11μg/L transported by offshore ocean currents. In the southeast waters of Jiaozhou Bay, the Cd content is 0.75μg/L. In the coastal waters of the estuary of Haibo River, there is a Cd content of 0.11 μg/L from the Haibo River.

In August, the Cd content transported by the offshore ocean currents and Haibo River in the southeast waters of the bay occurs a large amount of subsidence, and the vertical disputed amount reaches a relatively high level of 81.33%. But no large amount of Cd content subsidence on the seabed. Under the action of gravity and ocean currents, a large amount of Cd content subsided in the bottom of the southeast waters of the bay has migrated horizontally to the bottom of the central waters, and the horizontal increase amount of Cd content in the bottom layer has increased by 87.03%, resulting a large amount of subsidence in the bottom layer of central waters. As a result, in the central waters of the bay, the vertical sediment amount of Cd content in the bottom layer reaches a very high level, 88.88%.

In October, the offshore ocean currents first reach the southern waters of the mouth of Jiaozhou Bay with a Cd content of 0.39 μg/L, and then reach the southeast waters of Jiaozhou Bay with a Cd content of 0.51 μg/L. In the coastal waters of the estuary of Haibo River, there is a Cd content of 0.66 μg/L from the Haibo River.

In October, the Cd content transported by offshore ocean currents and the Haibo River appears a large amount of subsidence in the southeast waters of the bay, and the vertical sediment amount reaches a relatively high level, 57.14%. The Cd content subsided a lot on the seabed. Therefore, under the action of gravity and ocean currents, the Cd content in the bottom of the southeast waters of the bay migrates horizontally to the bottom of the central waters, providing Cd content to the bottom of central waters. The bottom layer in the southeast of the bay provides 68.90% of Cd content to the bottom of the central waters. At this time, the Cd content in the bottom of central waters is relatively low. In the central waters of the bay, the vertical disputed amount of the Cd content in the surface and bottom layer reaches a relatively high level of 58.42%, and no Cd content sediment in the bottom layer.

Therefore, the author determines the migration direction and route of Cd content through the horizontal matter content changing model and the vertical matter content changing model proposed by himself.

In May, August and October, the migration direction and route of Cd content in the waters from the southeast of the bay to the center of the bay: source→surface layer of southeast of the bay→bottom layer of the southeast of the bay→bottom layer of the center of the bay→surface of the center of the bay.

The changing process of the relative migration amount of Cd content: In May, sources → the surface layer of the southeast waters of the bay, 68.05% → the bottom layer of the southeast waters of the bay, 87.50% → the bottom layer of the central waters of the bay, 58.42% → the surface layer of the central waters of the bay (Figure 6). In August, sources → the surface layer of the southeast waters of the bay, 81.33% → the bottom layer of the southeast waters of the bay, 87.03% → the bottom layer
of the central waters of the bay, 88.88% → the surface layer of the central waters of the bay (Figure 7). In October, sources → the surface layer of the southeast waters of the bay, 57.14% → the bottom layer of the southeast waters of the bay, 68.90% → the bottom layer of the central waters of the bay, 58.42% → the surface layer of the central waters of the bay (Figure 8). In the process of horizontal and vertical migration, the relative migration of Cd content is very high, reaching 57.14-88.88%. Especially in the bottom of the seabed, the horizontal migration of Cd content has also reached 68.90-87.50%, indicating that the migration amount of Cd content is large and rapid.

The changing process of the absolute migration amount of Cd content: sources → the surface layer of the southeast waters of the bay → the bottom layer of the southeast waters of the bay, 0.72 μg/L → the bottom layer of the central waters of the bay → the surface layer of the central waters of the bay, 1.08 μg/L → the surface layer of the central waters of the bay (Figure 6). In August, sources → the surface layer of the southeast waters of the bay, 0.75 μg/L → the bottom layer of the southeast waters of the bay → the bottom layer of the central waters of the bay, 1.19 μg/L → the surface layer of the central waters of the bay, 0.89 μg/L (Figure 7). In May, the high-content water with 0.72 μg/L Cd reaches the bottom of the southeast waters of the bay. By August, the 1.08 μg/L Cd high-content water has migrated to the bottom of the bay center. At the same time, another new high-content water with 0.75 μg/L of Cd appears in the surface layer of the southeast waters of the bay. By October, the first high-content water block with 0.89 μg/L of Cd has migrated to the surface waters of the center of the bay. The second new high-content water with 1.19 μg/L of Cd has also reached the bottom of the southeast waters of the bay. Therefore, along the migration direction and migration route, the high content of Cd is continuously transported from the sources to the surface layer of the central waters of the bay. Moreover, as time changes, a high-content water of Cd is formed from sources, in the form of waves, passing along the migration route, and reaching the surface layer of the center of the bay.

Fig. 6 Block diagram of Cd content in the dynamic migration process in May
4. Conclusion
The calculation results of the vertical disputed amount and vertical sediment amount of Cd content in the surface and bottom layers show that a large amount of Cd content has subsided on the seabed over time, in the southeast and the central waters of the bay. With the changing of time, the Cd content subsided in a large amount on the seabed has disappeared. Therefore, the Cd content in the bottom layer appears a large sedimentation and then disappears. Then there is a variation process that a large amount of sedimentation appears and then disappears again.

The author proposes a dynamic migration theory of Cd content in Jiaozhou Bay, clarifies the migration direction and migration route of Cd content in May, August and October, from the southeast waters to the central waters of the bay: sources → the surface layer of the southeast waters of the bay → the bottom layer of the southeast waters of the bay → the bottom layer of the central waters of the bay → the surface layer of the central waters of the bay, and obtains the dynamic migration process of
the absolute migration and the relative migration of Cd content. It is believed that along the migration direction and migration route, the high content of Cd is continuously transported from the source to the surface layer of the center of the bay. Moreover, as time changes, a high-content water block of Cd is formed from the sources, in the form of waves, passing through the migration route, and reaching the surface layer of the center of the bay.

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