The spatiotemporal migration process of Cd content and the theory developed

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Abstract: According to the survey data of Jiaozhou Bay water body from 1984 to 1988, this paper analyzed and explored the data of Cd content each year, and studied the sources, water quality, distribution and migration conditions of Cd content in the waters of Jiaozhou Bay from the perspectives of volume, horizontal distribution, vertical distribution, seasonal distribution, regional distribution, structural distribution and tendency distribution. On the time scale, there are five migration processes of Cd content in the waters of Jiaozhou Bay. The author proposed five material migration theories to present the dynamic migration process of material in the water body. These rules, processes and theories not only provide solid theoretical bases for the migration of Cd content in the waters, but also provide enlightenment for the study of the migration of other substances in water bodies.

1 Introduction

Cd is chemically stable, not easy to decompose, and is able to remain in the environment for a long time, which has a persistent toxic effect on the environment and human health [1-6]. Therefore, studying the spatiotemporal variation rules and process of Cd content in water bodies is of great significance to the study of the migration process of Cd content in water bodies.

According to the survey data of Jiaozhou Bay waters from 1984 to 1988, this paper studies the change process of Cd content in Jiaozhou Bay waters during the five-year period [1-6]. Studying the migration process and theory of Cd content in the Jiaozhou Bay water body to provide a theoretical basis for understanding the environment polluted by Cd content.

Jiaozhou Bay is located in the southern part of Shandong Peninsula. Its geographical position is between 120°04'-120°23'E and 35°58'-36°18'N. It is bounded by 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 (Figure 1). Rivers flow to Jiaozhou Bay include Haibo River, Licun River, Loushan River, etc that are all seasonal rivers and the river hydrological characteristics have obvious seasonal changes [7, 8].

2.2 Data source and method

The survey data used in this study are provided by the North Sea Monitoring Center of the State Oceanic Administration. The survey of Cd content in Jiaozhou Bay water body was carried out according to the national standard method, which was recorded in the national "Marine Monitoring Code" (1991) [9].

Conduct the survey of Cd content in the Jiaozhou Bay water body respectively in July, August, and October in 1984, April, July and October in 1985, April, July and October in 1986, May, July and November in 1987, and April, July and October in 1988 [1-6]. This study takes April, May, and June as spring, July, August, and September as summer, and October, November, and December as autumn.

2 Survey waters, materials and methods

2.1 The natural environment of Jiaozhou Bay

Fig.1 Jiaozhou Bay geography location

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3 Results and Discussion

3.1 Temporal migration process

According to the survey and analysis of the Cd content in the waters of Jiaozhou Bay from 1984 to 1988 [1-6], the results of the five-year study are shown as follows:

(1) In the entire Jiaozhou Bay water body, in terms of Cd content, the amount of Cd discharged to Jiaozhou Bay was increasing over time. The water body in Jiaozhou Bay was very clean originally, and then it developed to mild and moderate pollution with Cd content. After the self-purification process of the water body of Jiaozhou Bay, it was restored to a very clean water body. After that, the water body of Jiaozhou Bay was transported by human activities with Cd content, and mild pollution of Cd content appeared in the water body of Jiaozhou Bay. In this way, on the time scale, the Jiaozhou Bay water body had a change process of clean → mild and moderate pollution → clean again → mild pollution.

(2) The input of Cd content into the waters of Jiaozhou Bay was transformed from the original natural transportation to the transportation by human activities. The Cd content transported by ocean currents in the open sea was sometimes low and sometimes high. The Cd content transported by the river was from nothing, to relatively low, and then to a relatively high Cd content. The Cd content transported by atmospheric subsidence had been nothing at the beginning until it finally appeared. In this way, with the change of time, the source of Cd content was constantly appearing, and the channel of Cd content was constantly increasing, which present the change process of the source and way of Cd content.

(3) The change of Cd content in the Jiaozhou Bay water body was determined by the land migration process, atmospheric migration process, and ocean migration process and it determined the path and trajectory of Cd content. The content of Cd in the ocean was relatively high; the content of Cd transported by rivers was grown from nothing and then from low to high, showing an increasing trend; Cd content also appeared in the atmosphere. The Cd content produced by human activities had a huge impact on the ocean, land and atmosphere, and there had been diversified ways to transport Cd content to the waters of Jiaozhou Bay: ocean, land and atmosphere. In the waters transported by ocean currents in the open sea, rivers and atmospheric subsidence, the highest content of three sources of transport was determined by the Cd content transported by the offshore ocean current. Moreover, the proportion of maximum transportation capacity occupied in the three transportation sources was determined by the Cd content of the offshore ocean currents. Therefore, on the time scale, the offshore ocean current transportation always occupied the highest volume of transportation content and the highest transport capacity.

(4) The river transportation of Cd content to Jiaozhou Bay and the offshore ocean current transportation showed that the Cd content was rapidly sinking and had a process of accumulation at the bottom. The Cd content transported by the river can sink to the bottom waters

inside the bay mouth, bay mouth and outside the bay mouth. The Cd content transported by ocean currents in the open sea can sink to the bottom waters inside and outside the bay mouth. During this five-year period, the river transports for four years, and the offshore ocean current transports for five years. When the Cd content transported by the offshore ocean currents was relatively high, the high subsidence area was in the bottom waters outside the bay mouth. When the Cd content transported by the river was relatively high, the high subsidence area was in the bottom water area inside the bay mouth. Therefore, through the vertical sedimentation process of the Cd content, with the change of time, the offshore ocean currents and rivers had been transporting the Cd content to the bottom waters outside and inside the bay mouth respectively.

(5) The author proposed Yang Dongfang horizontal distribution trend process. On the time scale, the vertical subsidence process has three forms: 1) The Cd content subsidence did not reach the seabed. 2) The Cd content had rapidly subsided and reached the seabed. 3) The sedimentation of Cd content not only reached the seabed, but also had the accumulation of Cd content on the seabed. According to Yang Dongfang horizontal distribution trend process, it revealed that the horizontal distribution trend of Cd content in the surface and bottom layers have three manifestations. No matter how time changes, the vertical sedimentation process of Cd content is one of these three manifestations, which fully demonstrates the migration trend of Cd content that changes in time and space.

Therefore, as time changes, the above study results reveal the migration process of Cd content in water bodies.

3.2 Theory of material content uniformity

Based on the survey data of Jiaozhou Bay waters in April, July and October 1986, this paper studies the content changes and horizontal distribution of Cd in the waters of Jiaozhou Bay. The results show that: on a spatial scale - in the entire waters of Jiaozhou Bay and the mouth of the bay, and on the time scale - from April to October, the variation range of Cd content in waters was 0.01-0.94 $\mu\text{g/L}$. This shows that the Cd content maintains the uniformity of the water body as time and space change, and reveals that under the action of tides and currents in the ocean, the ocean had the characteristics of uniformity. It confirms the theory of uniformity proposed by the author: the substance is uniform in seawater, especially when the substance is low in content, the uniformity of the water body is maintained. This shows that under the effect of tides and ocean currents, the substance will present uniformity especially when the substance content is low. Therefore, the spatial and temporal variation of Cd content in the water body confirms the uniformity theory proposed by the author, and the water of the bay has material uniformity. When the material content was transported to the bay, the bay would become uneven, and it was the transportation source that transport the unevenness to the bay.

On the spatial scale, in July 1986, a high Cd content area of $6.48\mu\text{g/L}$ was formed in the eastern coastal waters outside Jiaozhou Bay. Through the mouth of the bay, the Cd content in the water body of Jiaozhou Bay was continuously decreasing from the outer seas along the direction of the current from outside the bay to the bay, which indicates that in the waters of Jiaozhou Bay, the source of Cd was the transportation of ocean currents in the open sea, and its Cd content was $6.48\mu\text{g/L}$. And the content of delivery was relatively high. Although the Cd content transported by the offshore ocean current reached $0.73\mu\text{g/L}$ in the bay mouth waters, the entire water area of Jiaozhou Bay and the bay mouth waters were not affected by the Cd content transported by the offshore ocean currents. However, as the Cd content transported by the offshore ocean currents increased, the Cd content in the entire waters of the Jiaozhou Bay and the bay mouth waters would be affected by the Cd content transported by the offshore ocean currents. In this way, the uniformity of Cd content in Jiaozhou Bay would be destroyed by the Cd content transported by the offshore ocean currents, resulting in the non-uniformity of Cd content in Jiaozhou Bay. Therefore, the bay has material uniformity. Under the transported material content, the bay would become non-uniform, and it is the source that transported the non-uniformity to the bay.

On the time scale, from April to October, the variation range of Cd content was $0.01\text{--}0.94\mu\text{g/L}$ in the entire waters of Jiaozhou Bay and the mouth of the bay. This reveals that under the action of tides and currents in the ocean, the ocean had the characteristics of uniformity. As Yang Dongfang pointed out: the ocean tides and currents agitated and transported all substances in the ocean, so that the content of all substances in the ocean was very evenly distributed in the ocean water body [11]. In the shallow sea near the coast, the tide played the main effect; in the deep sea, the ocean current played the main effect. Of course, there were other auxiliary functions, such as storm surges and submarine earthquakes. Therefore, as time went by, the ocean was as uniform as possible to distribute the content of all substances in the seawater, so the ocean had uniformity [11]. In 1986, the temporal and spatial changes of Cd content in water bodies fully demonstrated the uniformity of materials in the ocean. The horizontal distribution and movement process of these substances fully showed that the ocean made all substances uniform in the water body, and made all substances diffuse and move toward uniformity in the water body. Therefore, the temporal and spatial changes of Cd content in water bodies showed the uniform distribution of substances in the ocean. The author proposed that the substance is uniform in seawater, especially when the substance is low in content, the uniformity of the water body is maintained. This shows that under the effect of tides and ocean currents, the uniformity of material presents more obvious when the content is low.

On the scale of temporal and spatial changes, once there are external sources to transport Cd content to the waters of Jiaozhou Bay, the uniformity of Cd content in Jiaozhou Bay will be destroyed. For example, the ocean currents transported Cd content to Jiaozhou Bay resulting

in the non-uniformity of Cd content in the bay. Therefore, the bay had material uniformity. Under the transported material content, the bay will become non-uniformity, and it is the transportation sources that transport the non-uniformity to the bay.

The author proposed the definition, model and classification standard of Yang Dongfang water material content uniform. The Yang Dongfang water material content uniform is defined as the degree of difference between high and low water material content. Yang Dongfang also proposed the two concepts of non-uniform column of water material content and uniformity of water material content. These two concepts are used to describe the uniformity of water material content. At the same time, the author proposed a model of water material content uniform, which is composed of a non-uniform column model of water material content and a uniformity model of water material content. The uniform model of water material content is described as follows: 1. the variation range of material content; 2. the uniformity of material content in the water body. The author further proposes the classification standard of Yang Dongfang material content uniformity, which is divided into six parts with the description of uniformity: the most non-uniform, non-uniform, low-level uniform, significantly uniform, highly uniform, and most uniform. According to the definition, model and classification standard of Yang Dongfang water material content uniform, it fully quantifies the change process of material content in time and space.

3.3 Source theory of material content

The author put forward the theory of sources of material content in water bodies, established a comprehensive analysis theory of horizontal distribution, trend changes and surrounding environmental conditions of material content in water bodies, and determined the locations, input channels and input amounts of various sources of material content in water bodies. Therefore, in the process of temporal and spatial changes, it is possible to determine the change process of various sources of material content in the water area, regional changes and the conversion of channels, which provides scientific basis for determining the variation degree of source location, channels and input material content in the water area.

According to the horizontal distribution, trend changes and surrounding environmental conditions of the material content in the water body, it determined the source location, channels and input content of the material in the water area. 1) In July 1984, in the eastern coastal waters outside Jiaozhou Bay, the source of Cd content was the transportation of offshore ocean currents which was $0.17\mu\text{g/L}$. In October 1984, in the eastern coastal waters outside Jiaozhou Bay, the source of Cd was the transportation from the offshore ocean currents, which was $0.20\mu\text{g/L}$. 2) In April 1985, in the nearshore waters of the Licun River's estuary, the source of Cd was $0.44\mu\text{g/L}$ transported by the river, and the transported Cd content was relatively high. In July 1985, in the coastal

waters of Licun River and Haibo River, and the southwestern coastal waters, the source of Cd was the transportation of $0.21\mu\text{g/L}$ from rivers, and the Cd content of the transportation was relatively low. In October 1985, in the coastal waters of the Licun River's estuary, the source of Cd was $0.39\mu\text{g/L}$ transported from the river, and the transported Cd content was relatively high.

3) In April 1986, in the coastal waters of the Licun River's estuary, Cd was sourced from the transportation by the river at $0.94\mu\text{g/L}$, which was relatively low. In July 1986, in the eastern coastal waters outside Jiaozhou Bay, the Cd content was $6.48\mu\text{g/L}$ which was sourced from the transportation of offshore ocean currents, and the transported Cd content was relatively high. In October 1986, in the coastal waters near the estuary of the Licun River, the Cd content was $0.75\mu\text{g/L}$ transported from the river, and the transported Cd content was relatively low. 4) In May 1987, in the coastal waters of the Licun River's estuary, the source of Cd was $0.68\mu\text{g/L}$ transported by the river, and the transported Cd content was relatively low. In November 1987, in the coastal waters of the Haibo River's estuary, the Cd content was $0.12\mu\text{g/L}$ transported from the river, which was relatively low. 5) In April 1988, in the eastern coastal waters outside Jiaozhou Bay, the source of Cd was the transportation of $0.12\mu\text{g/L}$ from the offshore ocean currents, and it was relatively low. In July 1988, in the nearshore waters of the Haibo River in Jiaozhou Bay, the Cd content was $1.07\mu\text{g/L}$ from the river, relatively high. In October 1988, in the central waters of Jiaozhou Bay, Cd was sourced from atmospheric subsidence of $0.04\mu\text{g/L}$, which was very low.

The paper further determined the route and scope of the source of delivery. During the period from 1984 to 1988, the Cd content in the Jiaozhou Bay waters has three sources: the transportation of offshore ocean currents, the transportation of rivers, and the transportation of atmospheric subsidence. These three ways had brought Cd content to the entire waters of Jiaozhou Bay, and the Cd content ranged from 0.04 to $6.48\mu\text{g/L}$. Therefore, the horizontal distribution of Cd content in the entire waters of Jiaozhou Bay showed that high Cd content areas appear at the estuary of the river, the center of the bay, and outside the bay, which formed a series of different gradients, decreasing from the center and extended to the entire waters of Jiaozhou Bay along the gradient.

In the process of temporal and spatial changes, it is possible to determine the change process of various sources of material content in the waters, regional changes and the conversion of pathways. During the period from 1984 to 1988, there were three sources of Cd content in the waters of Jiaozhou Bay, the transportation of ocean currents in the open sea, rivers, and atmospheric subsidence. The transportation of ocean currents in the open sea began in the first year, and the transportation was intermittent. And the content of Cd delivered was sometimes low and sometimes high. It revealed that the offshore ocean currents were sometimes not polluted by Cd content, and sometimes lightly or moderately polluted by Cd content. There was no river transportation in the

first year, and it started from the second year. The river transportation had always existed after that, and the Cd content transported by the river had always been relatively low. As time changed, the Cd content transported by the river increased in oscillation. It revealed that from the absence of Cd content transported by rivers to the appearance of Cd content transported; and then from a low value of transported Cd content to a gradual increase, until it exceeded the first-class seawater quality standard, the river was slightly polluted by the Cd content. The Cd content transported by atmospheric subsidence did not exist from the first year to the fourth year, and the Cd content from atmospheric subsidence did not appear until the fifth year. And the Cd content from atmospheric subsidence was very low. It revealed that there was no Cd content in atmospheric subsidence during the first four years, and very little Cd content appeared in the fifth year. Therefore, during the period from 1984 to 1988, the transportation of ocean currents in the open sea, rivers, and atmospheric subsidence showed that the Cd content in the environmental field continues to increase over time. The Cd content produced by human activities had a great impact on offshore ocean currents, rivers, and atmospheric subsidence, and there were diversified ways to affect the environment, such as the transportation of offshore ocean currents, rivers, and atmospheric subsidence.

According to the source theory of material content in water bodies, it determined the locations, input pathways and input amounts of various sources of material content in water bodies and obtained the change process of various sources of material content in the water area, regional changes and the conversion of pathways during the changes of time and space. Take the source of Cd content in Jiaozhou Bay from 1984 to 1988 as an example.

According to the source theory of material content in water bodies, it determines the location, input pathways and input amounts of various sources of Cd content in Jiaozhou Bay through the horizontal distribution, trend changes and surrounding environmental conditions of Cd content in Jiaozhou Bay. In this way, it constitutes the change process, regional change and pathway conversion of various sources of Cd content in the waters of Jiaozhou Bay. Therefore, according to the source theory of material content in water bodies proposed by Yang Dongfang, the dynamic change process of material content in water can be formulated.

3.4 Migration theory of material content from sources to water bodies

The author puts forward the migration theory of material content from sources to water bodies. The change process of material content in Jiaozhou Bay water body is determined by land migration process, atmospheric migration process, and ocean migration process. And through various model block diagrams proposed by the author, it presents the land migration process, atmospheric migration process and ocean migration process of the material content, and determines the path

and the trajectory left by the material content. According to the migration theory of material content from sources to water bodies proposed by the author, the material content in Jiaozhou Bay water body is determined by the number of sources of material content and the input amount of sources.

According to the survey data of Jiaozhou Bay waters from 1984 to 1988, the migration theory of material content from sources to water bodies revealed that the Cd content of rivers was determined by the volume presented in nature, the Cd content of the atmosphere was also determined by the volume of nature, and the Cd content of the ocean was determined by the existence of nature and human activities. The change of Cd content in Jiaozhou Bay waters was determined by the number of sources and the change of source input.

During the period from 1984 to 1988, the Cd content in the Jiaozhou Bay waters had three sources, the transportation of ocean currents, rivers and atmospheric subsidence. These three ways brought the Cd content to the entire waters of Jiaozhou Bay, and the Cd content varied from 0.04 to 6.48 $\mu\text{g/L}$. With the change of time, the source of Cd in the waters of Jiaozhou Bay had undergone great changes.

During the period from 1984 to 1988, the content of Cd transported from the offshore ocean currents was within 0.12~6.48 $\mu\text{g/L}$. The transportation of ocean currents in the open sea began in the first year, and the transportation was intermittent. The content of Cd delivered had low value and high value as well.

During the period from 1984 to 1988, the content of Cd transported from rivers was 0.12~1.07 $\mu\text{g/L}$. There was no river transportation in the first year, and it only started in the second year. The river transportation had always existed, and the Cd content transported by river had always been relatively low. As time changed, the Cd content transported by the river increased in fluctuation.

During the period from 1984 to 1988, the content of Cd transported from atmospheric subsidence was 0.04 $\mu\text{g/L}$. The Cd content transported by atmospheric subsidence did not exist from the first year to the fourth year, and it did not appear until the fifth year, and the Cd content transported by atmospheric subsidence was very low.

During the period from 1984 to 1988, the transportation of ocean currents in the open sea, rivers, and atmospheric subsidence showed that the Cd content in the environmental field continued to increase over time. The ocean currents in the open sea were sometimes not polluted by Cd content, and sometimes lightly or moderately polluted by Cd content. From the absence of Cd content transported by rivers to the emergence of Cd content, and then from a low value of transported Cd content to a gradual increase until it exceeded the first-class seawater quality standard, the river was slightly polluted by the Cd content. In the first four years, there was no Cd content in atmospheric subsidence, and very little Cd content appeared in the fifth year. Therefore, during the period from 1984 to 1988, the Cd content transported by the offshore ocean currents was sometimes low and sometimes high. The Cd content transported by the river was from nothing to relatively

low, and then to a relatively high Cd content. The Cd content transported by atmospheric subsidence had been nothing at the beginning until it finally appeared. The Cd content produced by human activities is constantly increasing, which is continuously affecting the environment and the way to transport the Cd content.

The migration theory of material content from sources to water bodies shows that in a water body, the sources and input amount of each sources in the waters can be determined through the amount and horizontal distribution of material content in the water body. In this way, the change process of the material content of this water body can be obtained. Therefore, according to the migration theory of material content from sources to water bodies proposed by the author, the change process of the material content in the water body and the reason for the change of the material content in the water can be obtained.

3.5 Sedimentation and migration theory of material content

Based on the changes in the bottom content and bottom distribution of material content in the waters of Jiaozhou Bay, the author put forward the sedimentation and migration theory of material content in the waters, which includes the horizontal water body effect, vertical water body effect and water body effect theory of material content. The material content was rapidly transferred from the water phase to the solid phase through gravity sedimentation, biological sedimentation, chemical action, and finally into the sediment. Starting from May in spring, marine organisms multiply in large numbers and their numbers increase rapidly. By August in summer, they formed a high peak. Due to the reproductive activities of plankton, the surface of suspended particles formed colloids. At this time, the adsorption force was the strongest. A large amount of material content was absorbed, and rapidly sank to the seabed with suspended particles. In this way, in spring, summer and autumn, material content was input into the ocean, and particulate matter and organisms carry material content from the surface to the bottom. As a result, the material content had undergone horizontal water body effect, vertical water body effect, and water body effect, showing that the material content was high in the bottom waters of Jiaozhou Bay.

According to the sedimentation and migration theory of material content in the water area proposed by the author, the Cd content in the surface layer reached a higher level. After the vertical water body effect, the Cd content in the bottom layer also reached a higher level. During the period from 1984 to 1988 (lack of 1987), after the vertical water body effect, high Cd content areas appeared in different places in the bottom waters of the mouth of Jiaozhou Bay.

In the waters inside the bay mouth, there was a high sedimentation of Cd content, such as July 1984, and July 1988.

In the waters outside the bay mouth, there was a high sedimentation of Cd content, such as October 1984, April

and October 1985, and April and July 1986.

In the waters of the bay mouth, there was a high sedimentation of Cd content, such as July 1985, and April 1988.

In the central waters of the bay, there was a high sedimentation of Cd content, such as April 1988.

The author put forward the sedimentation characteristics of Cd content: under different sources, the Cd content would sink to the path along the transportation direction under the rising and falling tide. Thus, on this path, a place with high Cd content would appear. In this way, the high Cd content area in the surface layer appeared drift during the process of sinking to the seabed.

During the period from 1984 to 1988 (lack of 1987), in 1984, 1985, 1986 and 1988, there were high Cd settlements in the waters outside the bay mouth and the waters of the bay mouth, which revealed the occurrence in the mouth waters of Jiaozhou Bay, a blocking device was used to fully block the Cd content out of the bay mouth waters. Moreover, the Cd content had high sedimentation in different periods. Only a small amount of high Cd content settled in the waters inside the bay mouth. This shows the sedimentation mechanism of Cd content and the sedimentation mechanism in the bay mouth.

The author put forward the sedimentation and migration theory of material content in the waters, and the results were shown as follows: During the period from 1984 to 1988 (lack of 1987), various sources of Cd content transported to Jiaozhou Bay had shown that the Cd content was rapidly sinking and had a cumulative process in the bottom waters. This process reveals that as time changed, the transported Cd content was gradually increasing, and the source of the transported Cd content was gradually increasing as well. The high subsidence area that left at the seabed with Cd content was gradually increasing, and the Cd content in the high subsidence area was gradually increasing at the same time.

3.6 Theory of water migration tendency of material content

During the period from 1984 to 1988 (lack of 1987), on the spatial scale, the horizontal distribution trends of Cd content in the surface and bottom layers were consistent. On the variation scale, the variation range of Cd content in the surface and bottom layer was basically the same, and the variation range of Cd content in the surface layer was larger than that of bottom layer. The low Cd content in the surface layer reached the bottom of the sea and obtained the cumulative effect, and the high Cd content in the surface layer reached the bottom of the sea and obtained the dilution effect. On the vertical scale, no matter when the Cd content is high or low, the Cd content in the surface and bottom layer remained similar. On a regional scale, the river transported Cd content to Jiaozhou Bay, showing the vertical change of the Cd content in the surface and bottom layers.

In this regard, the author proposed the sedimentation process of Cd content, which fully reveals that in terms

of temporal and spatial changes, with the continuous subsidence inside the bay mouth, bay mouth and outside the bay mouth, the Cd content in the seabed was continuously increasing. Moreover, the author further proposed the vertical distribution process of Cd content in the surface and bottom layers, which fully reveals that the variation range of the difference between the surface and bottom layers of Cd content was expanding over time. However, the cycle restarted in the second year. Therefore, the vertical distribution and seasonal variation of Cd content present the horizontal water body effect and vertical water body effect, and also reveal the horizontal migration process and vertical sedimentation process of Cd content.

Through studying the vertical changes of Cd content in the surface and bottom waters of the mouth of Jiaozhou Bay, the author proposed the temporal and spatial variation and sedimentation process of Cd content in the surface and bottom layers. On the time scale, the Cd content appeared in three states during the sedimentation process: (1) When the source provided the Cd content, there had not been a large amount of sedimentation, so there was no accumulation on the seabed and the Cd content in the bottom layer was relatively low. It appeared that the Cd content in the surface layer was greater than that in the bottom layer. (2) When the source provided a large amount of Cd content, it would accumulate on the seabed after a long period of substantial sedimentation. It appeared that the Cd content in the bottom layer was greater than that in the surface layer. (3) When the source provided Cd content and it was not affected by the Cd content in the water area, the Cd content in the surface and bottom layers were uniformly mixed. On the spatial scale, the Cd content appeared in three states during the sedimentation process: (1) When the source provided Cd content, the Cd content in the surface waters near the source area is greater than that in the bottom layer. (2) When the source provided Cd content and it passed through a path of transportation, the Cd content in the bottom waters away from the source was greater than that in the surface layers. (3) When the source provided Cd content, the water area far away from the source and not affected by the Cd content showed that the Cd content in the surface and bottom layers were evenly mixed. In the waters of Jiaozhou Bay, according to the temporal and spatial variation of the Cd content and the sedimentation process, the temporal and spatial variation of Cd content and sedimentation rules proposed by the author have been shown, which is that the change in the surface and bottom layers of Cd content is determined by the content of the source and the distance of migration. Therefore, the change of Cd content in the surface and bottom layer reveals the water migration process of Cd content.

4 Conclusion

According to the survey data of Jiaozhou Bay water body from 1984 to 1988, and the studies on the migration process of substances HCH, PHC, Hg, Pb, Cr and Cd in the water body, the author put forward the material

theory: 1) The uniformity theory of material content; 2) The source theory of material content in water bodies; 3) The migration theory of material content from sources to water bodies; 4) The sedimentation and migration theory of material content; 5) Theory of water migration tendency of material content, which demonstrates the theories formed by the dynamic migration process of materials in water bodies.

These rules, processes and theories not only provide a solid theoretical basis for the study of the migration of Cd content in water bodies, but also give enlightenment to the study of the migration of other substances in water bodies.

Under the horizontal water body effect and the vertical water body effect, the trajectory of Cd content presented a horizontal migration process and a vertical settlement process. Therefore, the Cd content polluted the environment. After land migration, atmospheric migration, and ocean migration, it polluted land, rivers, lakes and ocean, and finally polluted the environment of human life and endangered human health.

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