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The Increasing Pb Content Transported to Sea

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ABSTRACT. *According to the investigation data of Jiaozhou Bay in May, August and October of 1991, the Pb content and horizontal distribution at surface were studied. The results showed that the variation of Pb content was 4.09-31.66μg/L, which satisfies the Case II, III and IV Sea Water Quality Standard., showing that Jiaozhou Bay was mildly, moderately and severely polluted. Pb content in Jiaozhou Bay was mainly transported by ships and wharfs, overland runoffs and river flows, to be more specific, 12.74-31.66μg/L, 30.47μg/L and 11.46-16.04μg/L, respectively, showing the severe pollution. The three transport paths could be displayed by modelling diagram. The transport rule of matter content that the farther transport of matter content, the more loss in the way, proposed by the author was verified in this paper. Besides, the transport process of Pb content from the source to the ending was proposed by the author. Thus, human activities on the land and at sea caused the increasing Pb content transported to sea, and the space-time transport of Pb content caused the pollution to the environment and ecology.*

KEYWORDS: *Pb content; source; land and sea; the path, rule and process of transport; Jiaozhou Bay*

With the developing and expanding industry, heavy metal, Pb is widely applied, causing the pollution of Pb content to global environment and ecology. In the transport from the source to the ending, Pb content caused pollution to surrounding environment and environment [1-6]. Thus, it is important to study the pollution of Pb content, pollution source and transport process [1-6] to protect marine environment and maintain the sustainable development of ecology. In this paper, according to the investigation data in 1991, the Pb content, horizontal distribution and source were analyzed, and the water quality, source background, source amount and frequency, transport path, process and rule were studied, to provide scientific theoretical reference for the source, pollution and transport process of Pb in Jiaozhou Bay.

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1. Investigation Waters, Materials and Methods

1.1 Natural environment of Jiaozhou Bay

Jiaozhou Bay, located in southern Shandong Peninsula, is a typical semi-closed bay. The geographical location is 120°04′-120°23′E, 35°58′-36°18′N. Bounded by the line connecting Tuandao Cape and Xuejiadao Island, it connects with Yellow Sea, covering an area of about 446km^2, with the average depth of about 7m. There are dozens of rivers reaching the ocean in Jiaozhou Bay, among of which, the rivers with a larger volume of runoff and sand content include Dagu River, Yang River, Haibo River in Qingdao, Licun River, Loushan River and so on. These rivers are seasonal streams, and hydrological characteristics vary seasonally [7, 8].

1.2 Materials and methods

The materials about PHC in Jiaozhou Bay waters in May, August and October of 1991 was provided by North China Sea Environment Monitoring Center, State Oceanic Administration. 13 sites were established: 52. 53, 54, 55, 56, 57, 58, 59, 60, 61, 2104, 2105 and 2106, which are shown in Figure 1. Samplings were performed for three times in May, August and October in 1991, respectively. According to the depth of water, sampling and survey were conducted (surface and bottom layers were sampled when the depth of water is more than 10m, but just surface layer when less than 10m). The survey on Cu of Jiaozhou Bay waters was in accordance with national standard method, which was included in The Specification for Marine Monitoring (1991) [9].

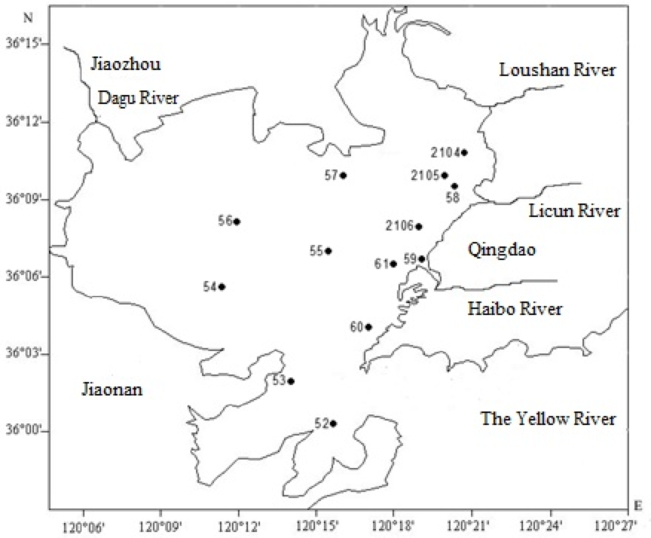

Fig.1 Investigation sites in Jiaozhou Bay

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2. Results

2.1 The Pb content

The Case I Sea Water Quality Standard of Pb content in sea water (1.00μg/L), Case II (5.00μg/L), Case III (10.00μg/L) and Case IV (50.00μg/L) were put forward by the nation. In May, August and October of 1991, the variation of Pb content in Jiaozhou Bay was 4.09-31.66μg/L, which satisfies the Case II, III and IV Sea Water Quality Standard.

The variation range of Pb content was 4.27-16.04μg/L in May, shown in Table 1. It was high in site 59 and 60 in eastern nearshore waters, reaching16.04μg/L and 16.00μg/L, respectively. In site 59, 61 and 60, the variation of Pb was 14.44-16.04μg/L, which satisfies the Case IV Sea Water Quality Standard. It was low in site 53, 54, 55 and 2106 in northern bay mouth, southwestern bay and bay center, and the variation was 4.27-4.86μg/L, which satisfies the Case II Sea Water Quality Standard. In other waters, it was higher and the variation was 5.11-7.54μg/L, which satisfies the Case III Sea Water Quality Standard. Hence, in May, it was high and the variation was 4.27-16.04μg/L, which satisfies the Case II, III and IV Sea Water Quality Standard.

The variation range of Pb content was 7.87-31.66μg/L in August, shown in Table 1. It was high in site 57 and 60 in southeastern and northern bay, reaching 30.47-31.66μg/L, respectively, which satisfies the Case IV Sea Water Quality Standard. It was low in site 58 and 59 in eastern bay, and the variation was 7.87-8.56μg/L, which satisfies the Case III Sea Water Quality Standard. In other waters, such as southwestern and northeastern bay, it was higher, which satisfies the Case III Sea Water Quality Standard. Hence, in August, it was high and the variation was 7.87-31.66μg/L, which satisfies the Case III and IV Sea Water Quality Standard.

The variation range of Pb content was 4.09-12.74μg/L in October, shown in Table 1. It was high in site 58, 59, 60 and 54, in eastern and southwestern bay, reaching 11.01-12.74μg/L, respectively, which satisfies the Case IV Sea Water Quality Standard. It was low in site61, 55 and 2104, in eastern bay, and the variation was 4.09-4.66μg/L, which satisfies the Case II Sea Water Quality Standard. In other waters, such as bay mouth and northeastern bay, it was higher, which satisfies the Case III Sea Water Quality Standard. Hence, in October, it was low and the variation was4.09-12.74μg/L, which satisfies the Case II, III and IV Sea Water Quality Standard.

In short, the variation was 4.09-31.66μg/L in May, August and October, which satisfies the Case II, III and IV Sea Water Quality Standard, indicating that there was mild, moderate and severe pollution of Pb in Jiaozhou Bay, shown in Table 1.

Tab.1 The surface water quality in Jiaozhou Bay in May and August

	May	August	October

Pb content/μg·L^{-1}	4.27-16.04	7.87-31.66	4.09-12.74
National Sea Water Quality Standard	Case II, III and IV	Case III and IV	Case II, III and IV

2.2 The distribution at surface layer

In May, in site 59 in the estuary of Haibo River, Pb reached highest as 16.04μg/L, and in site 60 in eastern nearshore waters, it reached highest as 16.00μg/L. It was high in eastern nearshore waters, forming a series of semi-rectangles with different gradients. It decreased from 14.44-16.04μg/L in the center to 4.27μg/L in bay center, 4.68μg/L in southwestern bay and 4.86μg/L in western bay mouth, shown in Figure 2.

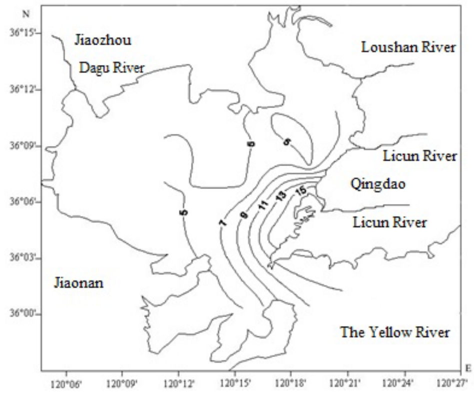

Fig.2 The distribution of Pb content at the surface in Jiaozhou Bay in May(μg/L)

In August, in site 60 in southeastern bay, Pb content reached highest as 31.66μg/L, forming a series of semi-circles with different gradients. It decreased from 31.66μg/L in the center to 17.85μg/L in bay center, 14.71μg/L in southwestern bay and 24.54μg/L in western bay mouth, shown in Figure 3. In site 57 in northern bay, Pb content reached highest as 30.47μg/L, forming a series of semi-circles with different gradients. It decreased from 30.47μg/L in the center to 21.22μg/L in southwestern bay, 17.85μg/L in bay center and 16.34μg/L in eastern bay, shown in Figure 3.

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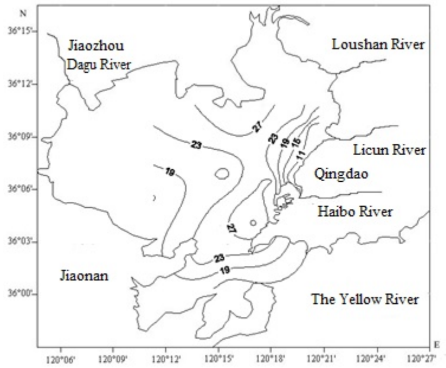

Fig.3 The distribution of Pb content at the surface in Jiaozhou Bay in August(μg/L)

In October, in site 60 in southeastern bay, Pb content reached highest as 12.74μg/L, forming a series of semi-circles with different gradients. It decreased from 12.74μg/L in the center to 4.54μg/L in bay center, 11.01μg/L in southwestern bay and 7.36μg/L in western bay mouth, shown in Figure 4. In site 59 in the estuary of Haibo River, Pb reached highest as 12.74μg/L, forming a series of semi-circles with different gradients. It decreased from 12.44μg/L in the center to 4.54μg/L in bay center, 11.01μg/L in southwestern bay and 7.25μg/L in northern bay, shown in Figure 4. In site 58 in the estuary of Licun River, Pb reached highest as 11.46μg/L, forming a series of semi-circles with different gradients. It decreased from 11.46μg/L in the center to 4.54μg/L in bay center, 7.25μg/L in northern bay and 4.66μg/L in northeastern bay, shown in Figure 4.

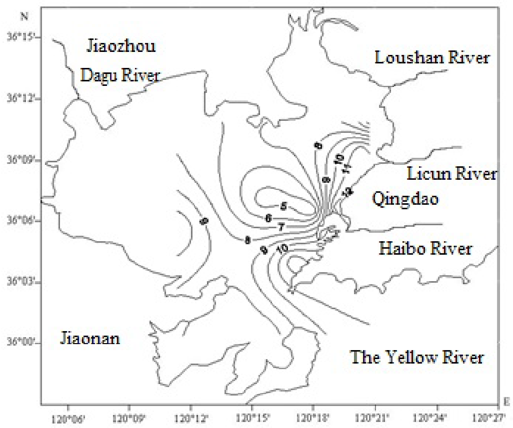

Fig.4 The distribution of Pb content at the surface in Jiaozhou Bay in October (μg/L)

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3. Discussion

3.1 The water quality

The variation was 4.09-31.66μg/L in May, August and October, which satisfies the Case II, III and IV Sea Water Quality Standard, indicating that there was mild, moderate and severe pollution of Pb in Jiaozhou Bay.

The variation range of Pb content was 4.27-16.04μg/L in May, so Jiaozhou Bay was mildly, moderately and severely polluted by Pb. The variation of Pb was 14.44-16.04μg/L in eastern bay, which satisfies the Case IV Sea Water Quality Standard, indicating that the waters was severely polluted by Pb. In northern bay mouth, southwestern bay and bay center, Pb content was low, and the variation was 4.27-4.86μg/L, which satisfies the Case II Sea Water Quality Standard, indicating that the waters was mildly polluted by Pb. In other waters, the variation was 5.11-7.54μg/L, which satisfies the Case III Sea Water Quality Standard, indicating that the waters was moderately polluted by Pb.

In August, the variation of Pb was 7.87-31.66μg/L in Jiaozhou Bay, which satisfies the Case III and IV Sea Water Quality Standard, indicating that the waters was moderately and severely polluted by Pb. The variation of Pb was 7.87-8.56μg/L in eastern bay, which satisfies the Case III Sea Water Quality Standard, indicating that the waters was severely polluted by Pb. In other waters, it satisfies the Case III Sea Water Quality Standard, and the waters was moderately polluted by Pb. Especially, in southwestern and northern bay, the variation was 30.47-31.66μg/L, indicating that the waters was severely polluted by Pb.

In October, the variation of Pb was 4.09-12.74μg/L in Jiaozhou Bay, which satisfies the Case II, III and IV Sea Water Quality Standard, indicating that the waters was mildly, moderately and severely polluted by Pb. The variation of Pb was 11.01-12.74μg/L in eastern and southwestern bay, which satisfies the Case IV Sea Water Quality Standard, indicating that the waters was severely polluted by Pb. The variation of Pb was4.09-4.66μg/L in eastern bay, which satisfies the Case III Sea Water Quality Standard, indicating that the waters was mildly polluted by Pb. In other waters, the variation was 7.19-9.96μg/L, such as bay mouth and northeastern bay, which satisfies the Case III Sea Water Quality Standard, indicating that the waters was moderately polluted by Pb.

3.2 The source

The Pb content was high in the waters of ships and wharfs, specifically, 16.00μg/L in May, 31.66μg/L in August and 12.74μg/L in October, indicating that it was mainly transported by ships and wharfs. In the estuary of Haibo River, it was 16.04μg/L in May and 12.44μg/L in October, mainly from river flows. In northern bay, it was 30.47μg/L, mainly from overland runoffs. In the estuary of Licun River, it was 11.46μg/L, mainly from river flows.

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Hence, Pb content in Jiaozhou Bay was mainly from ships and wharfs, overland runoffs and river flows, specifically, 12.74-31.66μg/L, 30.47μg/L and 11.46-16.04μg/L.

The Pb contents were all more than 10.00μg/L, the Case IV Sea Water Quality Standard, but less than 50.00μg/L, the Case IV Sea Water Quality Standard, indicating that the transportation from ships and wharfs, overland runoffs and river flows was severely polluted by Pb content, shown in Table 2. Thus, the pollution source in Jiaozhou Bay was area pollution source.

Tab.2 The Pb contents from the different sources in Jiaozhou Bay

Sources	Ships and wharfs	Overland runoffs	River flows
Pb content/$\mu g \cdot L^{-1}$	12.74-31.66	30.47	11.46-16.04

3.3 The variation of Pb content transported by the sources

In Jiaozhou Bay, Pb content was mainly transported by ships and wharfs, river flows and overland runoffs. In this way, it was transported to the land and ocean by human activities in three ways.

The three paths were presented. Firstly, Pb content was directly discharged to the ocean by human activities, it was transported by ships and wharfs, reaching 12.74-31.66μg/L. Secondly, Pb content was discharged by human to the land, and it was transported to the ocean by overland runoffs, reaching 30.47μg/L. Finally, Pb content was discharged to the land, and it was transported by river flows to the ocean, reaching 11.46-16.04μg/L.

Thus, Pb content was transported to Jiaozhou Bay in three ways, shown in Figure 5, specifically ships and wharfs, overland runoffs and river flows from high to low. Whereas, when it reached the ocean from either way, it was similar. It could be found that the farther the transport path, the larger the loss in transportation. When reaching the ocean, it was low. In this way, the transport rule of Yang Dongfang matter content was verified. If matter content was from the same starting point, and to the same ending point, and it was same in the same point, the farther the matter content was transported, the lower the matter content in the ending point would be.

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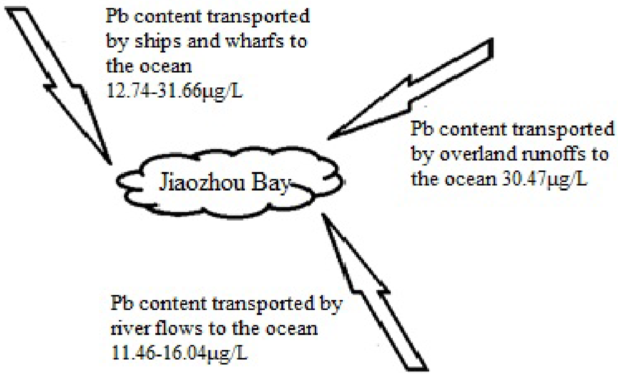

Fig.5 The transport paths of Pb contents into ocean

Pb content was transported to the ocean by ships and wharfs, overland runoffs and river flows. After the storage and dispute in the ocean, Pb content was further lower in the ocean.

3.4 The source and ending of Pb content

Pb content in Jiaozhou Bay was mainly from ships and wharfs, overland runoffs and river flows, specifically, 12.74-31.66μg/L, 30.47μg/L and 11.46-16.04μg/L, larger than 10.00μg/L, indicating the severe pollution. When people use a large number of products containing Pb, waste water, gad and materials containing Pb are made and discharged to the atmosphere, land and ocean, causing severe pollution.

The transport process was that Pb content was discharged to the atmosphere, land and ocean when people used products containing Pb. Pb content was directly discharged to the ocean, or transported by ships and wharfs, overland runoffs and river flows. In this way, a part of Pb content was stored in the ocean, and the other part of Pb content was sedimented to the sea floor, presenting the transport process, shown in Figure 6.

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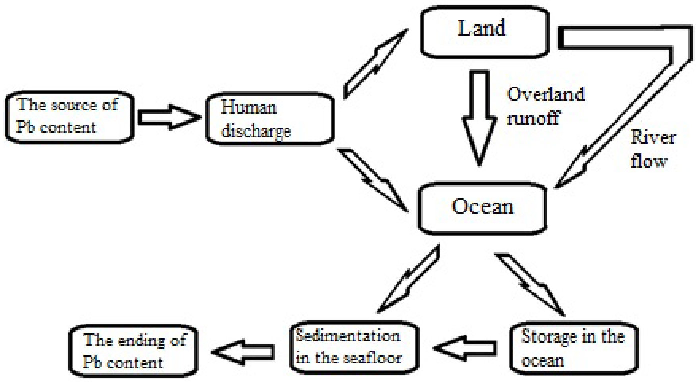

Fig.6 The transfer process of Pb content from the beginning to the end

3.5 The content and frequency

Pb content in Jiaozhou Bay was mainly from ships and wharfs in May, August and October, overland runoffs in August and river flows in May and October, specifically, 12.74-31.66μg/L, 30.47μg/L and 11.46-16.04μg/L.

It was believed that due to the increasing development of marine resources and usage of marine function, the expanding human activities at sea and the busy transport of ships and wharfs, Pb content transported to the ocean was increasing and the frequency was also rising, even higher than river flows. The transport of Pb content by ships and wharfs and overland runoffs were similarly high, showing the same busy human activities in the land and ocean, causing the high discharged of Pb to the land and ocean.

4. Conclusion

The variation of Pb content was 4.09-31.66μg/L in May, August and October, which satisfies the Case II, III and IV Sea Water Quality Standard., showing that Jiaozhou Bay was mildly, moderately and severely polluted

The variation range of Pb content was 4.27-16.04μg/L in May, so Jiaozhou Bay was mildly, moderately and severely polluted by Pb. The variation of Pb was 14.44-16.04μg/L in eastern bay, indicating that the waters was severely polluted by Pb. In northern bay mouth, southwestern bay and bay center, the waters was mildly polluted by Pb. In other waters, the waters was moderately polluted by Pb.

In August, the variation of Pb was 7.87-31.66μg/L in Jiaozhou Bay, indicating that the waters was moderately and severely polluted by Pb. In eastern bay, the waters was moderately polluted by Pb. In other waters, the waters was severely polluted by Pb. Especially, in southwestern and northern bay, the waters was

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severely polluted by Pb.

In October, the variation of Pb was 4.09-12.74μg/L in Jiaozhou Bay, indicating that the waters was mildly, moderately and severely polluted by Pb. In eastern and southwestern bay, the waters was severely polluted by Pb. In eastern bay, the waters was mildly polluted by Pb. In other waters, the waters was moderately polluted by Pb.

Pb content in Jiaozhou Bay was mainly from ships and wharfs, overland runoffs and river flows, specifically, 12.74-31.66μg/L, 30.47μg/L and 11.46-16.04μg/L, indicating the severe pollution.

Pb content in Jiaozhou Bay was mainly from ships and wharfs, overland runoffs and river flows, and the transport was disclosed by the modelling diagram. It could be found that the farther the transport path, the larger the loss in transportation. If matter content was from the same starting point, and to the same ending point, and it was same in the same point, the farther the matter content was transported, the lower the matter content in the ending point would be.

The transport process was that Pb content was discharged to the atmosphere, land and ocean when people used products containing Pb. Pb content was directly discharged to the ocean, or transported by ships and wharfs, overland runoffs and river flows. In this way, a part of Pb content was stored in the ocean, and the other part of Pb content was sedimented to the sea floor, presenting the transport process. Therefore, the spatial and temporal transport of Pb caused pollution to the environment and ecology.

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