Large amount of settlement brought by the river

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Abstract: Utilizing the survey dataset of Pb in waters from south of bay mouth to southeast of bay in October 1992, and applying the horizontal and vertical change models of matter content put forward by authors, we would calculate the horizontal loss amount, vertical diluted amount and vertical sediment amount of Pb in surface and bottom layers and set up the model diagram on the Pb content horizontal and vertical changes. The research results unveiled that in October, the absolutely horizontal loss amount of Pb content in surface layer and bottom layer was 3.58-7.89μg/L, and the relatively horizontal loss amount of Pb content in surface layer and bottom layer was 27.01-51.30%. In the southern waters of bay mouth, the absolutely vertical sediment amount of Pb was 2.13μg/L, and the relatively vertical sediment amount was 13.84%. In the southeastern waters of the bay, Pb content in the surface layer and bottom layer had an absolutely vertical diluted amount of 6.61μg/L and a relatively vertical diluted amount of 22.54%. In October, in the surface waters, after the main sea current brought high Pb content to the southern waters of the bay mouth, the Pb content began to settle to the seabed in large quantities, leading to a horizontal loss amount of almost one third 27.01% of the Pb content on surface when the current entered the bay. Pb content in the bottom layer of the seabed also reduced greatly by 51.30%, which was more than half. It revealed that Pb content in the surface layer could settle to the bottom rapidly and continuously when the current entered the bay, causing a large loss amount of Pb content in the surface layer. At the same time, the Pb content on the bottom was largely buried in the seabed, causing a lot of losses. In October, in the process of vertical migration, the vertical sediment amount of Pb in the surface and bottom layers 13.84% was shifted to the vertical diluted amount of Pb in the surface and bottom layers 22.54% before and after the main sea current entered the bay. The high Pb content transported by the main sea current had a large amount of settlement in the southern waters of the bay mouth and accumulated in the seabed. However, when the current reached the bay with Pb content, there was also a large amount of settlement in the southeastern part of the bay, but no accumulation in the seabed.

1 Introduction

In the surface waters of Jiaozhou Bay, the Pb content increased because of the high Pb content carried by the main sea current from the outside to the inside of bay through the bay mouth. When the current left the bay, Pb content passed through the water from the surface and settled to the seabed with its own horizontal and vertical migration, [1-8]. By applying the horizontal change model and the vertical change model of matter content, and analyzing the survey dataset on Pb content of the Jiaozhou Bay water in October 1992, the authors got the horizontal migration process and vertical subsidence process of Pb content when the current just entered Jiaozhou Bay and illustrating that Pb content derived from main currents migrated from the surface of one water body to that of another and then settled to the bottom of the sea, to provide scientific basis for the study of the Pb content's vertical settlement and horizontal migration in surface and bottom waters.

2 The Waters and Methods of the Survey

2.1 Natural Environment of Jiaozhou Bay. Jiaozhou Bay is between 120°04' - 120°23'E, 35°58' - 36°18'N, showing a semi-closed bay with the area about 446 km^2 and the average water depth about 7m. Moreover, the tunnel of the bay into the Yellow Sea presented the line between Tuan Island and XueJia Island. A dozen rivers into Jiaozhou Bay brought a large amount of the runoff and sediment concentration to the bay, such as Dagu River, Yang River, Haibo River, Licun River and Loushan River around Jiaozhou bay and in Qingdao urban area.

2.2 Materials and Methods. By investigation in October 1992, the North China Sea Environmental Monitoring Center provided the survey dataset of Pb in Jiaozhou Bay. By choosing the two stations: Stations 52 and 60 in the waters of Jiaozhou Bay, we got the water

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samples from the stations (Figure 1). In October 1992, we got the different water samples by utilizing the different depth of water (>10m, got from the surface and bottom layers ; <10m, only from the surface layer) for investigation. We collected the Pb survey dataset of Jiaozhou Bay water body by relying on the national standard method, included in the Specification for Marine Monitoring (1991) [9].

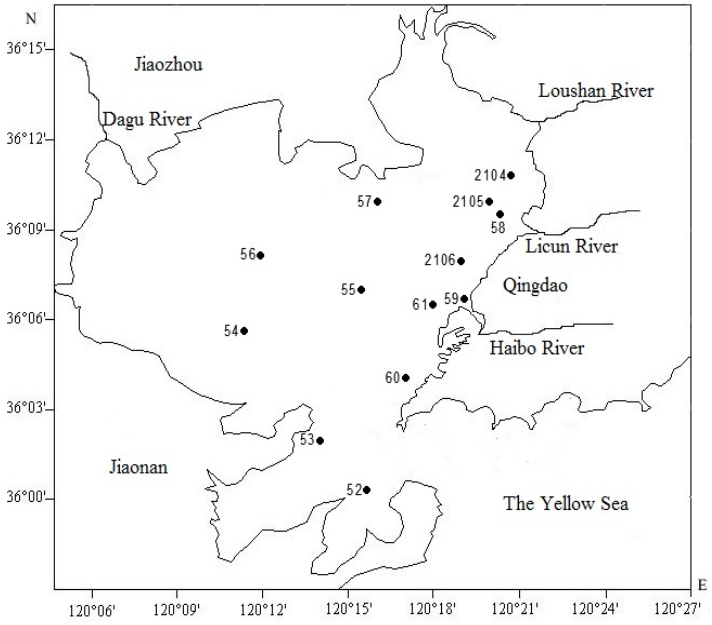

Figure 1 Survey stations in Jiaozhou Bay

3 Results

3.1 Waters from South of Bay Mouth to Southeast of the Bay. The main sea current carried high Pb content through the bay mouth into Jiaozhou Bay. It reached the southern part of the bay mouth then arrived at the southeastern waters of the bay.

Station 52 lies in the southern waters of bay mouth, and Station 60 in the southeastern waters of Jiaozhou Bay. In surface waters in October, the main sea current flowed into Jiaozhou Bay and passed the southern waters of the bay mouth. First, it reached station 52 where the Pb content was 13.25μg/L. Then the current arrived at station 60, with a Pb content of 9.67μg/L. Meanwhile, in the bottom waters, through the southern waters of the bay mouth, the current flowed and went into the bay. The main sea current first reached station 52 where the Pb content was the maximum value of 15.38μg/L, and then it at station 60 with the Pb content of 7.49μg/L.

3.2 Definition of Horizontal Substance Content Change. In Jiaozhou Bay, while the current transferred the matter content, the matter content decreased continuously with the current moving. the authors presented the definition and formula, then and calculated horizontal loss amount, vertical diluted amount and vertical sediment amount of matter content. Moreover, the authors further divided horizontal loss amount into absolutely horizontal loss amount and relatively horizontal loss amount. In the same way, the authors divided the vertical diluted amount into absolutely vertical diluted and sediment amount and relatively vertical diluted and sediment amount.

3.3 Formula for the Change of Horizontal Substance Content. In the surface waters from south of the bay mouth to southeast of Jiaozhou Bay, it is assumed that the content of matter (M) in the south of the bay mouth is A and that in the southeast of the bay is B.

From the southern waters of the bay mouth to the southeastern waters of the bay, the absolutely horizontal loss amount is regarded as $D > 0$. The relatively horizontal loss amount is regarded as E. When $D < 0$, absolutely horizontal loss amount of matter content in the waters from southeast of the bay to south of the bay mouth is $-D > 0$.

$$D = A - B,\ E = |A - B| / \max(A, B) \quad (1)$$

In a similar way, in the bottom waters from south of the bay mouth to southeast of Jiaozhou Bay, it is assumed that the material content in the south of bay mouth is a and that in the southeast of the bay is b.

From the southern waters of the bay mouth to the southeastern waters of the bay, the absolutely horizontal loss amount is $d > 0$, the relatively horizontal loss amount is e. When $d < 0$, the absolutely horizontal loss amount in the waters from southeast of the bay to south of the bay mouth is regarded as $-d < 0$.

$$d = a - b,\ e = |a - b| / \max(a, b) \quad (2)$$

3.4 Formula of Vertical Substance Content Change. In the waters from south of the bay mouth to southeast of Jiaozhou Bay, it is assumed that in the south of the bay mouth, the matter content of surface water is regarded as A, that of bottom water is regarded as a, and the station of the water area is regarded as n. From the surface waters to the bottom waters, the absolutely vertical diluted amount of material content is regarded as $Vna > 0$. The relatively vertical diluted amount of substance content is regarded as Vnr. When $Vna < 0$, the

absolutely vertical diluted amount of material content is regarded as –Vna> 0 and the relatively vertical diluted amount of substance content is regarded as Vnr.

$$Vna = A - a,\ Vnr = |A - a| / \max(A, a) \quad (3)$$

3.5 Horizontal Loss Amount of Surface Layer and Bottom Layer. Provided that movement from station 52 in the southern waters of the bay mouth to station 60 in the southeastern waters was compared to that from A to B and Pb content is the main part of matter content. Then the horizontal change of Pb content unveiled the horizontal loss amount of Pb content in the surface layer and the bottom layer.

In October, in the surface waters of Jiaozhou Bay from the south of the bay mouth to the southeast of the bay, the Pb content changed greatly when the current left the bay. The formula (1) by calculation gave the horizontal loss amount of Pb content in the surface waters (Table 1).

Table 1 Horizontal loss amount of Pb content in the surface layer

From A to B	D	E	E
October	3.58	0.2701	27.01%

At the same time, in the bottom water of Jiaozhou Bay from station 52 to Station 60, the Pb content also changed greatly when the current left the bay. With formula (2), the horizontal loss amount of Pb in the bottom water was calculated (Table 2).

Table 2 Horizontal loss amount of Pb content in the bottom layer

From A to B	d	e	e
October	7.89	0.5130	51.30%

3.6 Vertical Diluted and Sediment Amounts. The matter content in this paper was regarded as the Pb content. The vertical variation of Pb content disclosed the vertical diluted and sediment amounts of Pb in surface layer and bottom layer.

In October, in the waters from the south of the bay mouth to the southeast of Jiaozhou Bay, Pb content in both surface and bottom waters changed greatly. The formula (3) showed vertical diluted and sediment amounts of Pb content in the bottom layer (Table 3).

Table 3 Vertical diluted and sediment amounts of Pb content in the surface and bottom layer

time	water	Vna	Vnr	Vnr
October	waters of southern bay mouth	-2.13	0.1384	13.84%
	waters of southeastern bay	2.18	0.2254	22.54%

4 Discuss

4.1 Changes in the Substance Content of the Current Track in the Bay. In the waters of Jiaozhou Bay, Pb content 13.25μg/L was derived from the main sea current in October. The main sea current carried high Pb content into Jiaozhou Bay and surrounded the nearshore waters of the bay and then left (Figure 2). The current passed through the water body in the south of the bay mouth (station 52) and reached the water body in the southeast of the bay (station 60). Using the horizontal matter content change model and vertical matter content change model quantitatively determined the horizontal and vertical migration of Pb content in the waters from south of the bay mouth to southeast of the bay.

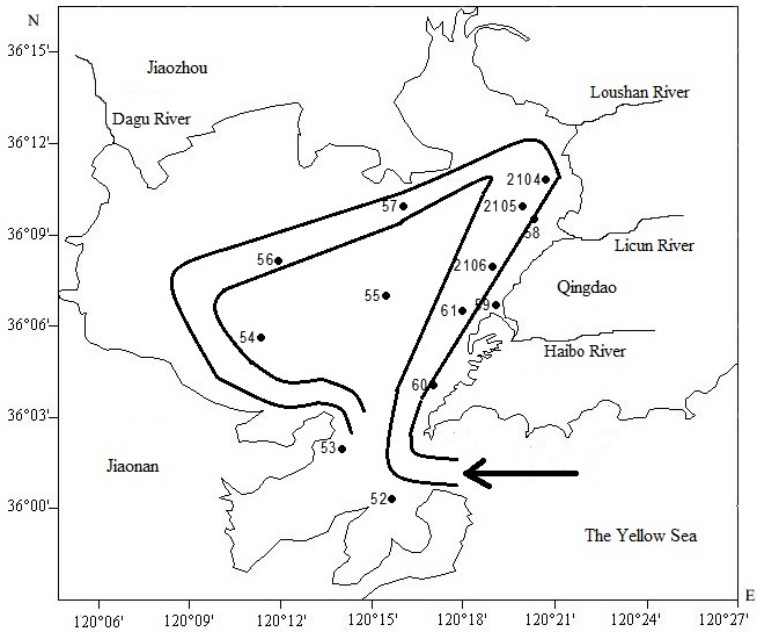

Figure 2 The flow path of the main sea current with a high content of Pb in Jiaozhou Bay (μg/L)

4.2 Horizontal and Vertical Variations of Pb Content. Pb content 13.25μg/L in the waters from the south of the bay mouth to southeastern Jiaozhou Bay in October was derived from main sea current transport. In the waters of Jiaozhou Bay, Pb content decreased along the gradient under the action of tides and currents.

However, when the current reached the south of the bay mouth, Pb content in surface water decreased significantly. At the same time, Pb content in the bottom

water decreased enormously. It indicates that from the south of the bay mouth to the southeast of the bay especially when the current entered the bay, the Pb content of surface water had a lot of settlement.

During the current movement, Pb content in surface layer with the absolutely horizontal loss amount was 3.58μg/L and bottom layer with the absolutely horizontal loss amount was 7.89μg/L decreased significantly. It reveals that some of the high Pb content transported to Jiaozhou Bay by the main sea current was left on the bottom when the current got into the bay.

In October, from the waters in the south of the bay mouth to the waters in the southeast of the bay, the horizontal loss amount of Pb content in the surface layer reached 27.01% when the current entered the bay. Similarly, the horizontal loss amount of Pb content in the bottom layer reached a high value of 51.30%. (Figure 3). In southern waters of the bay mouth, the vertical sediment amount of Pb content in the surface layer and bottom layer was relatively low, reaching 13.84%. While in southeastern waters of the bay, the vertical diluted amount of Pb content 22.54% in the surface layer and bottom layer was relatively low (Figure 3).

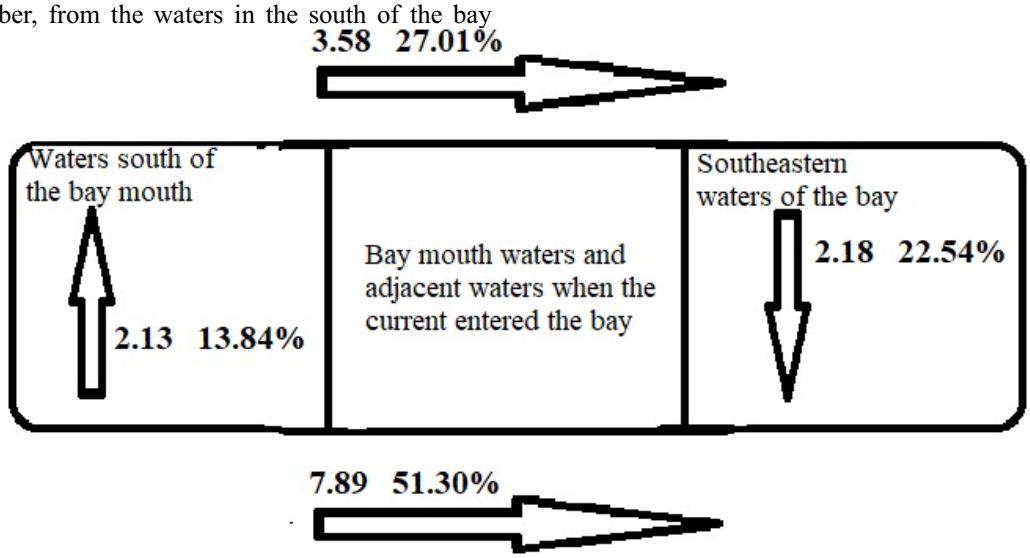

Figure 3 Model block diagram of horizontal and vertical changes of Pb content in October

In conclusion, in October, the absolutely horizontal loss amount of Pb in the surface layer and the bottom layer was 3.58-7.89μg/L and the relatively horizontal loss amount was 27.01-51.30%. In the southern waters of the bay mouth, the Pb content in the surface layer and the bottom layer showed an absolutely vertical sediment amount of 2.13μg/L and a relatively vertical sediment amount of 13.84%. Meantime, in the southeastern waters of the bay, the Pb content in the bottom layer had an absolute vertical diluted amount of 6.61μg/L and a relative vertical diluted amount of 22.54%.

4.3 Horizontal Loss Amount. In October, the horizontal loss amount of Pb content in the surface layer 27.01% reached a relatively high level (Table 1), nearly a third, from the south of the bay mouth to the southeast of the bay. It indicates that when the current got into the bay, a large amount of Pb content in the surface layer rapidly and continuously deposited to the bottom of Jiaozhou Bay.

Meanwhile, from the waters in the south of the bay mouth tothe waters in the southeast of the bay, the horizontal loss amount of Pb content in the bottom layer 51.30% reached a relatively high level too (Table 2). The horizontal loss amount of more than half indicates that during the horizontal migration of Pb content in the bottom layer, Pb content in the surface layer rapidly and continuously sank to the seabed, buried beneath the ocean in the bottom layer.

Judging from these, in the surface water in October, the Pb content in the surface layer of the bay deposited to the bottom of the bay in large quantities after the main sea current came to the waters south of the bay mouth with high Pb content and entered the bay. As a result, during the horizontal migration of Pb content in the surface and bottom layers, the absolutely horizontal loss amount of Pb content in the surface layer reached 27.01% — almost one third. What's more, the Pb content at the bottom of the sea floor decreased greatly, reaching more than half 51.30%. It reveals that the high Pb content in the surface layer could rapidly and continuously settle to the seabed when the current got into Jiaozhou Bay, which caused a large amount of Pb content to be lost in the surface layer. At the same time, the Pb content in the bottom layer was largely buried in the seabed, resulting in a large loss amount of Pb content in the bottom layer.

4.4 Vertical Loss Amount. In Jiaozhou Bay, in October, the high Pb content transported by the main sea current first reached the waters south of the bay mouth where the vertical sediment amount of Pb content in the surface layer and bottom layer reached a low value of 13.84%. Then the main sea current entered the inner waters and reached the waters in the southeast of the bay where the vertical diluted amount of Pb content in the surface and bottom reached a low value of 22.54%. It reveals that when the current entered the southern part of the bay mouth, the Pb content in the surface layer could settle to the seabed rapidly and continuously, leaving

little sediment amount on the bottom. And when the current got into the southeastern waters of the bay, part of Pb content in the surface layer settles to the seabed, but there is no accumulation in the seabed. To put it in a nutshell, in October, in the vertical migration process, the vertical sediment amount of Pb content in surface and bottom layers 13.84% was changed to the vertical diluted amount of Pb content in surface and bottom layers 22.54% before and after the main sea current entered the bay. The high Pb content transported by the main sea current had a large amount of settlement in the southern waters of the bay mouth and accumulated in the seabed. However, when the current reached the bay with Pb content, there was also a large amount of settlement in the southeastern part of the bay, but no sediment in the seabed.

5 Conclusion

By utilizing the horizontal substance content change model and vertical substance content change model, the authors got the horizontal loss amount, vertical diluted amount and vertical sediment amount of Pb in the surface layer and bottom layer and determined the model block diagram of the horizontal and vertical variation of Pb content. In October, the absolutely horizontal loss amount of Pb content in surface layer and bottom layer was 3.58-7.89μg/L and the relatively horizontal loss amount was 27.01-51.30%. In the southern waters of the bay mouth, the absolutely vertical sediment amount of Pb content both in surface layer and bottom layer was 2.13μg/L, and the relatively vertical sediment amount was 13.84%. While in the waters southeast of the bay, the absolutely vertical diluted amount of Pb in the surface and bottom was 6.61μg/L, and the relative vertical diluted amount was 22.54%.

At the same time, during the horizontal migration of Pb content, from the southern part of the bay mouth to the southeastern part of the bay, a large amount of Pb content in the surface layer settled to the seabed as the current entered the bay. The loss amount of Pb content in the surface layer reached almost 30%. It discloses that the Pb content in the surface layer could rapidly and continuously settle to the seabed, left at the bottom of the bay mouth.In the horizontal migration process of Pb bottom layer content, there was a more than half of 51.30% reduction. Thus, the high Pb content in the surface layer can settle to the seabed rapidly and continuously, more than half — 51.30% of which was buried by the sea floor.

In the meantime, in the process of vertical migration, as ocean currents entered the waters south of the bay mouth, The Pb content in the surface layer could settle to the seabed rapidly and continuously, and there was a small sediment amount in the seabed, which was 13.84%. When the current got into the southeastern waters of the bay, the vertical diluted amount of Pb content on the surface and bottom reached a low value of 22.54%. Some Pb content in the surface layer settled on the seabed, but there was no sediment there.

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