The Controlled Mechanism of Hg Content Varying at Surface and Bottom

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Abstract: By the investigation dataset of Jiaozhou Bay in 1991, the vertical distribution and seasonal variation of Hg content at surface and bottom from bay center to northern bay mouth was studied, and seasonal distribution, variation extent and horizontal distribution trend of Hg content at surface and bottom were determined. The results showed that in May and August, the variation of Hg content at surface and bottom from bay center to eastern nearshore waters was 0.016-0.081μg/L, showing that the water quality was mildly or not polluted by Hg. From May to August, in bay center, Hg content at surface and bottom was low in spring and high in summer; in eastern nearshore waters, Hg content at surface was high in spring and low in summer, whereas, Hg content at bottom was low in spring and high in summer. The seasonal variation-controlled mechanism of Hg content indicated that Hg content at surface was not controlled by season, but source transport, and Hg content at bottom was not controlled by season, but cumulative and disputed effect of Hg content reaching seafloor. Therefore, from bay center to eastern nearshore waters, the horizontal distribution trend of Hg content at surface and bottom was consistent in May and contrary in August, which unveiled that at bottom, if without the cumulative matter content, the gravity feature of Hg content determined the consistent horizontal distribution trend of matter content at surface and bottom. In other words, in any waters, at any time, by different sources, the horizontal distribution trend of Hg content at surface and bottom was consistent.

1. Introduction
Hg content was discharged by human activities to the ocean, atmosphere and land. Transported by the land, ocean and atmosphere, a large amount of waste water and waste gas and waste particles containing Hg reached the surface of ocean and seafloor through vertical waters [1-14]. By the investigation dataset of Jiaozhou Bay in 1991, the vertical distribution and seasonal variation of Hg content at surface and bottom from bay center to northern bay mouth was studied, seasonal distribution, variation range and horizontal distribution trend of Hg content at surface and bottom were determined, and the seasonal variation and vertical sedimentation of Hg content were displayed, to provide scientific reference for the vertical sedimentation and horizontal transport of Hg at surface and bottom waters.

2. Investigation Waters, Materials and Methods
2.1 Natural environment of Jiaozhou Bay
Jiaozhou Bay, located in Shandong Province, is a typical semi-closed bay with 120°04'-120°23′E, 35°58'-36°18'N. It connects with Yellow Sea, covering an area of about 446km², with the average depth of about 7m. There are many rivers reaching the ocean in Jiaozhou Bay, such as Dagu River, Yang River, Haibo River in Qingdao, Licun River, Loushan River and so on. These rivers are seasonal streams [15, 16].

2.2 Materials and methods
The Hg dataset in Jiaozhou Bay waters in May and August of 1991 was provided by North China Sea Environment Monitoring Center, State Oceanic Administration. Sites 55 and 61 were shown in Fig. 1. Samplings were performed for two times in May and August in 1991, respectively. By the depth of water, investigation samplings 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 Hg investigation of Jiaozhou Bay waters was set by the national standard method, which was included in The Specification for Marine Monitoring (1991) [17].

3. Results

3.1 The surface and bottom waters
In May, from the bay center to the eastern nearshore waters, Hg content was 0.020-0.041μg/L at surface and 0.016-0.051μg/L at bottom. The former was less than 0.05μg/L, which satisfies the Case I Sea Water Quality Standard, showing that the water quality was not polluted by Hg. However, the latter in the bay center was lower than 0.05μg/L, which satisfies the Case I Sea Water Quality Standard, showing that the water quality was not polluted by Hg content. the latter in the eastern nearshore waters was larger than 0.05μg/L, which satisfies the Case II Sea Water Quality Standard, showing that the water quality was mildly polluted by Hg content.

In August, it, correspondingly, was 0.021-0.081μg/L at surface and 0.032-0.054μg/L at bottom. The former was larger than 0.05μg/L in bay center and less than 0.05μg/L in eastern nearshore waters, showing that the water quality was mildly polluted by Hg in bay center, but not polluted in eastern nearshore waters. The situation was quite contrary for the latter one.

In short, in May and August, from bay center to eastern nearshore waters, from surface and bottom,
the variation of Hg content was 0.016-0.081μg/L, which satisfies the Case I and II Sea Water Quality Standard, showing that the water quality was mildly or not polluted by Hg.

3.2 The seasonal distribution at surface waters
At surface waters from bay center to eastern nearshore waters, the variation of Hg was 0.020-0.041μg/L in May and 0.021-0.081μg/L in August. It was low in May and high in August, so the seasonal variation was the order of spring and summer.

3.3 The seasonal distribution at bottom waters
At bottom waters from bay center to eastern nearshore waters, the variation of Hg was 0.016-0.051μg/L in May and 0.032-0.054μg/L in August. It was low in May and high in August, so the seasonal variation was the order of spring and summer.

3.4 The variation range at surface and bottom waters
In May, from bay center waters, site 55, to eastern nearshore waters, site 60, at surface, Hg content increased from 0.020μg/L to 0.041μg/L, and at bottom, it increased from 0.016μg/L to 0.051μg/L, showing that the horizontal distribution trend of Hg content at surface and bottom was consistent.

In August, the horizontal distribution trend of Hg content at surface and bottom was contrary.

In short, from bay center to eastern nearshore waters, the horizontal distribution at surface and bottom was consistent in May and contrary in August.

4. Discussion

4.1 The process of sedimentation
Under the effect of vertical waters [12-14], After Hg content sediments through waters, it changed greatly. The hydrophilia of Hg ion is so strong that it combined easily with zooplankton and phytoplankton, suspended particles in sea water. From spring to summer, then again to autumn, marine organism began to bloom with a rapidly increasing quantity [16]. With the blooming of plankton, the surface of suspended particles formed colloid with the strongest adsorption capacity to adsorb a great number of Hg ion and brought to surface waters. Due to gravity and flow, Hg was sedimented constantly to seafloor [1-11]. Therefore, the sedimentation of Hg from surface waters to seafloor showed the transport sedimentation of Hg content.

4.2 The seasonal variation in bay center
At surface waters of bay center, Hg content increased from 0.020μg/L in May to 0.81μg/L in August. So, it at surface was low in spring and high in summer.

In spring, there was no source to transport Hg content, so Hg content was lower in spring. In summer, Hg content was transported by the atmospheric sedimentation, so Hg content was higher in summer. The results showed that, because Hg was adsorbed to surfaces of many suspended particles, by the effect of gravity and flow, it was constantly sedimented to seafloor. Hg was influenced by vertical
waters effect, horizontal waters effect and waters effect [12-14]. It was impacted by cumulative effect and disputed effect when reaching seafloor, showing that Hg content at bottom was low in spring and high in summer. Thus, in bottom waters of bay center, Hg content increased from 0.016μg/L in May, to 0.032μg/L in August, and Hg at bottom was low in spring and high in summer.

In short, from May to August, in eastern nearshore waters, Hg content at surface and bottom was low in spring and high in summer.

4.3 The seasonal variation in eastern nearshore waters

At surface waters of eastern nearshore waters, Hg content decreased from 0.041μg/L in May, to 0.21μg/L in August. So, it at surface was high in spring and low in summer.

In spring, Hg content was transported by ships and wharfs from northern bay mouth, so Hg content was higher in spring. In summer, there is no source to transport Hg content, so Hg content was lower in summer. It showed that, because Hg was adsorbed to surfaces of many suspended particles, with the effect of gravity and flow, it was constantly sedimented to seafloor. Hg was influenced by vertical waters effect, horizontal waters effect and waters effect [12-14]. It was impacted by cumulative effect and disputed effect when reaching seafloor, showing that Hg content at bottom was low in spring and high in summer. Thus, in bottom waters of eastern nearshore waters, Hg content increased from 0.051μg/L in May, to 0.54μg/L in August, and Hg at bottom was low in spring and high in summer.

In short, from May to August, in eastern nearshore waters, Hg content at surface was high in spring and low in summer. However, the situation was contrary at bottom waters.

4.4 The mechanism of seasonal variation

At surface waters of bay center, in spring, when there was no source, Hg content was lower; in summer, when there was a source, Hg content was higher. At surface waters of eastern nearshore waters, in spring, when there was a source, Hg content was higher; in summer, when there was no source, Hg content was lower. Hence, Hg content at surface was not controlled by season, but source transport.

In bottom waters of bay center, the seasonal variation of Hg content at bottom and surface was consistent, presenting the gravity feature of Hg. Hg content was rapidly and constantly sedimented to seafloor. By the theory of vertical waters effect, horizontal waters effect and waters effect [12-14], disputed effect made the seasonal variation of Hg content at bottom and surface showing consistent, when Hg content reaching seafloor.

In bottom waters of eastern nearshore waters, the seasonal variation of Hg content at bottom and surface was opposite, presenting the gravity feature of Hg. Hg content was rapidly and constantly sedimented to seafloor. By the theory of vertical waters effect, horizontal waters effect and waters effect [12-14], cumulative effect made the seasonal variation of Hg content at bottom and surface showing opposite, when Hg content reaching seafloor.

So, Hg content at bottom was not controlled by season, but cumulative effect and disputed effect when Hg content at surface reached seafloor.

4.5 The variation of sedimentation

In terms of variation, from bay center to eastern nearshore waters, in May and August, the variation range of Hg content at surface and bottom was basically same. When Hg content at surface was high(low), Hg content at corresponding bottom was high(low), which unveiled that Hg content was rapidly and constantly sedimented to seafloor, resulting in the consistent variation of Hg content at surface and bottom. The variation extent of Hg at surface was larger than that at bottom, which proved the theory of the vertical waters effect, horizontal waters effect and waters effect put forward by the author [12-14], further determining that the variation of Hg content at surface and bottom disclosed the disputed effect and cumulative effect of vertical waters.

4.6 The spatial sedimentation
In May, in eastern nearshore waters, Hg content was transported by ships and wharfs in northern bay mouth, and Hg content at surface and bottom was high. Whereas, in bay center, there was no source, so Hg content at surface and bottom was low. In this way, the horizontal distribution trend of Hg content at surface and bottom was consistent.

In August, in eastern nearshore waters, there was no source transporting Hg content, so it was low at surface. However, there was source transporting in May, so Hg content at surface was sedimented to seafloor from May to August, so it was high in August at bottoms. Whereas, in bay center, Hg content was transported by atmospheric sedimentation, however, Hg content was not fully cumulated in seafloor yet, so Hg content bottom was low. In this way, the horizontal distribution trend of Hg content at surface and bottom was contrary.

5. Conclusion

In May and August, the variation of Hg content at surface and bottom from bay center to eastern nearshore waters was 0.016-0.081μg/L, which satisfied the Case I and II Sea Water Quality Standard, showing that the water quality was mildly or not polluted by Hg.

From May to August, in bay center, Hg content at surface and bottom was low in spring and high in summer; in eastern nearshore waters, Hg content at surface was high in spring and low in summer, whereas, Hg content at bottom was low in spring and high in summer. The seasonal variation-controlled mechanism of Hg content indicated that Hg content at surface was not controlled by season, but source transport, and Hg content at bottom was not controlled by season, but cumulative and disputed effect of Hg content reaching seafloor.

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Therefore, from bay center to eastern nearshore waters, the horizontal distribution trend of Hg content at surface and bottom was consistent in May and contrary in August, which unveiled that at bottom, if without the cumulative matter content, the gravity feature of Hg content determined the consistent horizontal distribution trend of matter content at surface and bottom. In other words, in any waters, at any time, by different sources, the horizontal distribution trend of Hg content at surface and bottom was consistent.

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