Spatial and temporal changes of Hg in Jiaozhou Bay 1990

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Abstract. Using investigation on Mercury (Hg) in May and August 1990, this paper analyzed the spatial and temporal variations of Hg contents in Jiaozhou Bay. Results showed that Cd contents in both surface and bottom waters were in order of spring > summer. In waters in the bay mouth, the variation ranges of Hg contents in surface waters (0.053-0.208 μg L⁻¹) were closed to what in bottom waters (0.053-0.204 μg L⁻¹) due to the rapid and continuous sediment of Hg to bottom waters. The source strength and occurring position of different Hg source were different. However, in any position and in any season, the horizontal distributions of Hg contents in surface waters and bottom waters were consistent. That’s the outcome of vertical water’s effect.

1. Introduction
Hg is widely used in various industries. The anthropogenic Hg-containing wastes were generated and discharged to the air, soil and water since the lagging of waste treatment to the rapid increasing of industry[1-2]. However, Hg is high toxic, and the excess existence of Hg in the environmental could result in health risk [5-6]. Nowadays, many marine bays have been polluted since ocean is the sink. Understanding the seasonal-temporal changes of Hg in marine bay is essential to environmental protection [7-10]. Jiaozhou Bay is a semi-closed bay located in Shandong Province, China. This bay is surrounded by cities of Jiaozhou, Jiaonan and Qingdao (Fig. 1). This bay has been polluted by various pollutants since the rapid development of industry and the lagging of waste treatment in mang countries and regions [11-14]. Using investigation on Hg in May and August 1990, this paper analyzed the spatial and temporal variations of Hg contents, as well as the mechanisms behind.

2. Study area and data source
2.1. Study area. Jiaozhou Bay (120°04′-120°23′ E, 35°55′-36°18′ N) is located in the south of Shandong Province, eastern China (Fig. 1). It is a semi-closed bay with the total area, average water depth and bay mouth width of 446 km², 7 m and 3 km, respectively. There are more than ten inflow rivers such as Haibo Rriver, Licun Rriver, and Loushan Rriver [15-16].

2.2. Data source. The data was provided by North China Sea Environmental Monitoring Center. The investigations were conducted in May and August 1990, respectively. Surface and bottom water samples in 2 sampling sites (i.e., 55 and 60) were collected and measured followed by National Specification for Marine Monitoring (Fig. 1) [17].
3. Results and discussion

3.1. Pollution level of Hg. The China Sea Water Quality Standard (GB 3097-1997) establishes guide lines for Hg (Table 1). Hg contents in surface waters and bottom waters in May 1990 were 0.194-0.208 μg L\(^{-1}\) and 0.189-0.204 μg L\(^{-1}\), compared with 0.053-0.055 μg L\(^{-1}\) and 0.053-0.063 μg L\(^{-1}\) in August 1990. The China Sea Water Quality Standard (GB 3097-1997) establishes guide lines for Hg (Table 1). For seasonal variation, the pollution level of Hg in May 1990 was moderate, compared with slight in August 1990. The reason was that the major Hg sources in May and August were both atmosphere deposition and the wharf, yet the source strengths in May were stronger than in August. For spatial variation, the pollution level of Hg in the bay center was heavy than in the bay mouth. The reason was that the bay center was strongly impacted bay atmosphere deposition whose source strength was stronger than the wharf which was major Hg source in waters in the bay mouth.

| Grade | I  | II  | III and V\(^b\) |
|-------|----|-----|-----------------|
| Content/μg L\(^{-1}\) | 0.05 | 0.20 | 0.50 |

\(^b\)Guide lines for Hg of Grade III and V are same.

3.2. Vertical water’s effect. Hg contents were changing a lot by means of vertical water’s effect [12–14]. The growth and reproduction of marine plankton are increasing from spring and reaching the climax in summer. The growth and reproduction of marine plankton are resulting in a large amount of colloids, which are able to enhancing the absorption ability of suspended particle matters [16]. As a result, a great deal of Hg is absorbed by the suspended particle matters and then is moving from surface water to bottom waters continuously by means of gravity and marine current. Therefore, by means of vertical water’s effect, Hg could be transported to sea bottom along with the continuous
sediment process. In general, the pollution level of Hg in this bay was the outcome of source input, gravity and marine current.

3.3. Seasonal changes in the bay center. In study area, May and August belongs to spring and summer, respectively. In the center of the bay, Hg contents in surface waters in May 1990 were in order of spring > summer. The major Hg source in spring was atmosphere deposition whose source strength was relative strong, resulted in relative high of Hg contents in waters. In summer, the major Hg source was also atmosphere deposition yet whose source strength was relative weak, resulted in relative low of Hg contents in waters. By means of vertical water’s effect[12-14], there were dilution effect and accumulation effect in bottom waters. Hence, Hg contents in the center of the bay were decreased from 0.208 μg L⁻¹ in May to 0.055 μg L⁻¹ in August, and therefore showing seasonal variation of spring>summer.

3.4. Seasonal changes in the bay mouth. In the bay mouth, Hg contents in surface waters in May 1990 were in order of spring > summer. The major Hg source in spring was the wharf in the east of the bay whose source strength was relatively strong, resulted in relatively high of Hg contents in waters. In summer, the major Hg source was also the wharf in the east of the bay yet whose source strength was relatively weak, resulted in relatively low of Hg contents in waters. By means of vertical water’s effect[12-14], there were dilution effect and accumulation effect in bottom waters. Hence, Hg contents in the center of the bay were decreased from 0.189 μg L⁻¹ in May to 0.053 μg L⁻¹ in August, and therefore showing seasonal variation of spring>summer.

3.5. Spatial changes in May. In May 1990, atmosphere deposition was the major source input in the bay center, while the wharf in the east of the bay was responsible in the bay mouth. The source strength of atmosphere deposition was relatively high compared to the wharf. Hg contents in May was relatively high, and the horizontal distributions of Hg contents in surface waters were that decreasing from the bay center (0.208 μg L⁻¹) to the bay mouth (0.194 μg L⁻¹). Due to the growth and reproduction of marine plankton, a large amount of Hg was absorbed by the suspended particle matters and then is moving from surface water to bottom waters continuously by means of gravity and marine current. By this way, the horizontal distributions of Hg contents in bottom waters were that decreasing from the bay center (0.204 μg L⁻¹) to the bay mouth (0.189 μg L⁻¹).

3.6. Spatial changes in August. In August 1990, atmosphere deposition was the major source input in the bay center, while the wharf in the east of the bay was responsible in the bay mouth. The source strength of atmosphere deposition was relative high compared to the wharf. Hg contents in August was relative high, and the horizontal distributions of Hg contents in surface waters were that decreasing from the bay center (0.055 μg L⁻¹) to the bay mouth (0.053 μg L⁻¹). However, the difference was very small, indicated that the horizontal changes was very small in surface waters. By means of the growth and reproduction of marine plankton, a large amount of Hg was absorbed by the suspended particle matters and then is moving from surface water to bottom waters continuously by means of gravity and marine current. By this way, the horizontal distributions of Hg contents in bottom waters were tending to be consistent with what in surface waters. By this way, the horizontal changes of Hg contents in bottom waters were also very small, i.e., Hg contents in Site 55 in the bay center and Site 60 in the bay mouth were that decreasing from the bay center (0.063 μg L⁻¹) to the bay mouth (0.053 μg L⁻¹).

4. Conclusion
Hg contents in surface waters and bottom waters in May 1990 were 0.194-0.208 μg L⁻¹ and 0.189-0.204 μg L⁻¹, compared to 0.053-0.055 μg L⁻¹ and 0.053-0.063 μg L⁻¹ in August 1990. The pollution level of Hg in May 1990 was moderate, compared with slight in August 1990. The pollution level of Hg in this bay was the outcome of source input, gravity and marine current.

By means of vertical water’s effect, Hg could be transported to sea bottom along with the
continuous sediment process. Hg contents in both surface and bottom waters were in order of spring > summer. In waters in the bay mouth, the variation ranges of Hg contents in surface waters were closed to what in bottom waters due to the rapid and continuous sediment of Hg to bottom waters. The source strength and occurring position of different Hg sources were different. In any position and in any season, the horizontal distributions of Hg contents in surface waters and bottom waters were consistent.

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