

## Horizontal loss rate model for substance content in marine bay

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**Abstract.** Understanding the transferring process of substance content is meaningful for pollution control in marine bay. In order to reveal the unit-distance loss rate of substance contents in marine bay during the transferring process, this paper provided a horizontal loss rate model. Based on this model, we found the laws of horizontal loss rate of substance that, for a certain substance and in a same water body, if the relative unit-distance loss rate was stable and constant, the relative horizontal loss rate for a certain substance and in a same water body would be same and closed. Furthermore, we provided an example to show the performance of this model based on investigation data on Cr in May 1979 in Jiaozhou Bay, China. Results showed that from costal waters in the north to the center of the bay, Cr content lossed  $13.92 \mu\text{g L}^{-1}$  for each 1 km, while from the costal waters in the middle to the bay mouth in the south of the bay, Cr content lossed  $2.80 \mu\text{g L}^{-1}$  for each 1 km. In generally, this model example was confirming the laws of horizontal loss rate of substance.

### Introduction

Many marine bays have been polluted due to the rapid increasing of economic and population. Understanding the transferring process of substance content is meaningful for pollution control in marine bay. This paper provided a horizontal loss rate model to reveal the unit-distance loss rate of substance contents in marine bay during the transferring process. By means of this model the laws of horizontal loss rate of substance could be revealed. For a certain substance and in a same water body, if the relative unit-distance loss rate was stable and constant, the relative horizontal loss rate for a certain substance and in a same water body would be same and closed. Furthermore, we provided an example to show the performance of this model based on investigation data on Cr in May 1979 in Jiaozhou Bay, China. The results were confirming the laws of horizontal loss rate of substance. This model was helpful to understand the transferring process of substance content in marine bay, and was meaningful for pollution control and environmental protection.

### Materials and method

**Horizontal loss rate model.** The horizontal loss rate model for substance in marine bay includes an absolute horizontal loss rate model and a relative horizontal loss rate model. Suppose that the horizontal distance between position A and B is  $L$ , and the substance contents in A and B are  $a$  and  $b$ , respectively, the absolute horizontal loss rate is  $V_{asp}$ . The absolute horizontal loss rate model is described as:

$$V_{asp} = (a - b)/L \quad (1)$$

Meanwhile, the relative horizontal loss rate model is described as:

$$V_{rsp} = (a - b)/aL \quad (2)$$

These models reveal the unit-distance loss rate of substance contents in marine bay during the transferring process.  $V_{asp}$  represents the absolute unit-distance loss rate of substance contents, while

$V_{rsp}$  represents the relative unit-distance loss rate of substance content.

For a certain substance and in a same water body, the absolute unit-distance loss rate was depending on the changing of substance content in the starting point. Of course, for different substances and different water bodies, the absolute unit-distance loss rates were different.

For a certain substance and in a same water body, if the relative unit-distance loss rate was stable and constant, the relative horizontal loss rate for a certain substance and in a same water body would be same and closed. Hence, if the substance content in a position was known, the substance contents in different positons could be estimated by this model.

**Study area and data collection.** Jiaozhou Bay ( $35^{\circ}55'-36^{\circ}18' N$ ,  $120^{\circ}04'-120^{\circ}23' E$ ) is located in the south of Shandong, China. The area, bay mouth width and average water depth and average water depth are  $390 km^2$ , 2.5 km and 7.0 m, respectively (Fig. 1). There are more than ten inflow rivers such as Licun River and Haibo River, all of which are seasonal rivers [12-13]. The investigation on Cr in surface waters in Jiaozhou Bay was conducted by North China Sea Environmental Monitoring Center in May 1979 (Fig. 1). The investigation and measurement of Cr were following by National Specification for Marine Monitoring [14].

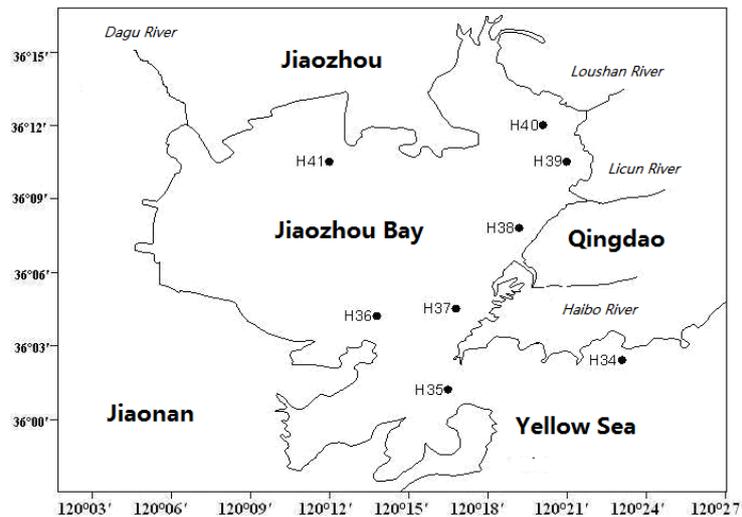


Fig.1 Geographic location and sampling sites of Jiaozhou Bay

## Results

**Horizontal distances of the sampling sites.** Three sampling sites (H34, H35 and H39) were selected. The positions and Cr contents of the sampling sites were listed in Table 1. The distance between H39 and H38 and the distance between H38 and H37 were named as  $L_1$  and  $L_2$ , respectively. In according to the longitude and latitude,  $L_1$  and  $L_2$  were both 6699.1m.

Table 1 positions and Cr contents of the sampling sites

Sampling site	Longitude	Latitude	Cr content/ $\mu g L^{-1}$
H37	$120^{\circ}17'$	$35^{\circ}05'$	0.20
H38	$120^{\circ}19'$	$35^{\circ}08'$	19.00
H39	$120^{\circ}21'$	$35^{\circ}11'$	112.30

**Horizontal distribution of Cr content.** The horizontal distribution of Cr content was showed in Fig.2. It could be seen that the highest value was in H39 between the estuaries of Loushan River and Licun River, and the lowest value was in H37 in the south of the bay (Fig. 2). The contour lines of Cr content were forming a series of parallel lines that decreasing from the coastal waters in the northeast to the south of the bay (Fig. 2).

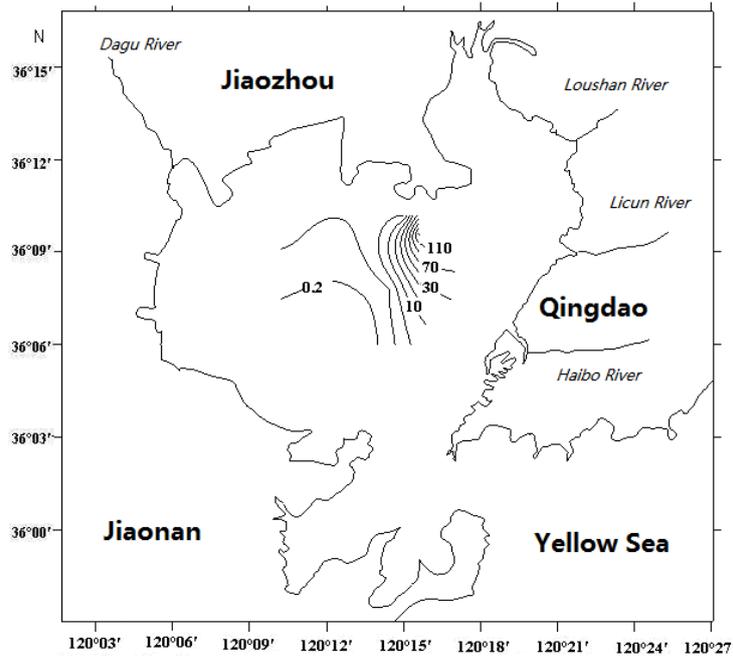


Fig. 2 Horizontal distributions of Cr in surface waters in Jiaozhou Bay in May 1979

**Discussions**

**Horizontal loss rate of Cr content.** Based on Eq. (1) and Eq. (2), distance between and Cr contents in the three sampling sites, both absolute and relative horizontal loss rate of Cr content could be calculated (Table 2). The absolute horizontal loss rate ( $V_{asp}$ ) and relative horizontal loss rate ( $V_{rsp}$ ) in water body from H39 to H38 were  $1392.72 \times 10^{-5} \mu\text{g L}^{-1}$  and  $12.40 \times 10^{-5}$ , respectively. While in water body from H38 to H37, the absolute horizontal loss rate ( $V_{asp}$ ) and relative horizontal loss rate ( $V_{rsp}$ ) were  $280.63 \times 10^{-5} \mu\text{g L}^{-1}$  and  $14.77 \times 10^{-5}$ , respectively.

Table 2 Absolute and relative horizontal loss rate of Cr content

Water body	$V_{asp} / \mu\text{g L}^{-1} \text{m}^{-1}$	$V_{rsp} / \text{m}^{-1}$
H39 to H38	$1392.72 \times 10^{-5}$	$12.40 \times 10^{-5}$
H38 to H37	$280.63 \times 10^{-5}$	$14.77 \times 10^{-5}$

**Simplifying the unit.** Since the unit and numerical value of  $V_{asp}$  and  $V_{rsp}$  were too complex, a symbol namely YDF was used to take the place of  $10^{-5} \text{m}^{-1}$ . Therefore, the absolute and relative horizontal loss rate of Cr content could be simplified and listed in table 3. By means of YDF, the absolute and relative horizontal loss rates were more brief.

Table 3 Absolute and relative horizontal loss rate of Cr content based on YDF

Water body	$V_{asp} / \text{YDF} \mu\text{g L}^{-1}$	$V_{rsp} / \text{YDF}$
H39 to H38	1392.72	12.40
H38 to H37	280.63	14.77

**Horizontal changes of substance content.** By means of horizontal loss rate models, the substance contents in different positions could be estimated. Based on the absolute horizontal loss rate model, Cr content was losing  $13.92 \mu\text{g L}^{-1}$  for each 1 km from costal waters in the north to the center of the bay in May 1979, and was losing  $2.80 \mu\text{g L}^{-1}$  for each 1 km from the costal waters in the middle to the bay mouth in the south of the bay. Based on the relative horizontal loss rate model, Cr content was losing 13.92 YDF from costal waters in the north to the center of the bay in May 1979, and was losing 2.80 YDF from the costal waters in the middle to the bay mouth in the south of the bay. The results confirmed the laws of horizontal loss rate of substance that, for a certain

substance and in a same water body, if the relative unit-distance loss rate was stable and constant, the relative horizontal loss rate for a certain substance and in a same water body would be same and closed.

## Conclusions

The horizontal loss rate model was useful to reveal the unit-distance loss rate of substance contents in marine bay during the transferring process. The laws of horizontal loss rate of substance could be revealed by this model. For a certain substance and in a same water body, if the relative unit-distance loss rate was stable and constant, the relative horizontal loss rate for a certain substance and in a same water body would be same and closed.

This model was helpful to understand the transferring process of substance content in marine bay, and was meaningful for pollution control and environmental protection. Based on the relative horizontal loss rate model, Cr content was losing 13.92 YDF from costal waters in the north to the center of the bay in Jiaozhou Bay May 1979, and was losing 2.80 YDF from the costal waters in the middle to the bay mouth in the south of the bay.

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