Water's effect of benzene hexachloride

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Abstract. This paper analyzed the change of benzene hexachloride (HCH) content in Jiaozhou Bay during 1979-1989, and further expatiated theories of water's effect, vertical water's effect, and horizontal water's effect, as well as the definitions, processes, and the model diagrams. Furthermore, these theories were applied in the quantitative expatiation of the water's effect on the HCH in Jiaozhou Bay, eastern China. Results showed that the model diagrams were able to show the change of HCH through water body, and to unveil the change law of HCH under the action of the water body. Once HCH was transferring along the vertical direction, the high content of HCH in the surface was decreasing, yet the low content of HCH in surface waters was increasing. In case of HCH was transferring along the horizontal direction, both high and low contents of HCH in surface waters were decreasing. These theories were successfully applied in the quantitative expatiation the transferring processes of HCH, as well as the vertical water's effect and horizontal water's effect.

Introduction

HCH is a broad spectrum insecticide which has been widely used in 20th century. Nowadays, HCH is still used in some developing countries, though has been banned or curtailed in developed countries. It is well known that HCH is one of the Persistent Organic Pollutants (POPs), and the remaining of HCH in the environment is still making harms to human life and the ecosystem. HCH can be delivered to the ocean by rainfall-runoff, atmosphere deposition, etc., and the contents of HCH are changing during the transfer processes [1-13]. Understanding the change of HCH in these processes is essential to environmental protection.

In order to reveal the change law of HCH during the transfer process in water body, this paper put forward the theories of water's effect, vertical water's effect, and horizontal water's effect, as well as the definitions, processes, and the model diagrams. Furthermore, there theories were applied in the quantitative expatiation of the water's effect on the HCH in Jiaozhou Bay, eastern China based on investigation data on HCH during 1979-1989. The aim of this paper was to provide theoretical basis for the research on the transfer processes of HCH in waters.

Study area and data source

Jiaozhou Bay (35°55′-36°18′ N, 120°04′-120°23′ E) is located in the south of Shandong Peninsula, eastern China. It is a semi-closed natural bay, whose area, average water depth and maximum water depth are 390 km^2, 7 m and 50 m, respectively. It is surrounding by cities of Qingdao, Jiaozhou and Jiaonan in the east, north and south, respectively (Fig. 1). The bay mouth is located in the south, which is only 2.5 km width, and is connecting to the Yellow Sea. There are more than ten inflow rivers, including Dagu River, Haibo River, Licun River, Loushan River, etc.

The data was provided by North China Sea Environmental Monitoring Center. The surveys were conducted in May, August and November 1979, April and August 1981, April, June, July and October 1982, May, September and October 1983, July, August and October 1984, April, July and October 1985, April, July and October 1986, May, July and November 1987, April, July and October 1988, April, Autumn, September and October 1989 [1-13]. Surface and bottom water samples in Jiaozhou Bay were collected and measured followed by National Specification for Marine Monitoring [14]. We defined April, May and June as spring, July, August ans September as summer, and October, November and December as autumn.

Fig.1 Geography location ofJ iaozhou Bay

Water body effect

Background

The motion curve of HCH in waters could be clearly revealed by the transfer process [2]. HCH is difficult to dissolve in water, yet is able to be absorbed by suspended particulate matter, plankton and sediment [15]. The reproduction of marine organism are increasing rapidly in May (spring) and the biomass is also increasing rapidly, both the reproduction and biomass are reaching the climax in August (summer) [16]. A large amount of colloid are generated along with the growth and reproduction of marine organism, and the adsorption capacity of the suspended particulate matter is enhancing, and the sedimentation of HCH is also enhancing. Once HCH is transferring through the water body, the contents are changing. In order to quantify the changing processes, we provided the theory of water's effect.

HCH contents in surface waters and bottom waters are closed and the vertical distributions of HCH contents are homogeneous. Moreover, HCH contents in both surface and bottom waters in summer are higher than in spring [3]. Hence, by means of sedimentation, the higher HCH contents in surface waters the higher HCH contents in bottom waters. Once HCH is transferring from surface waters to bottom waters, the contents are changing. In order to quantitatively reveal this vertical changing process, the vertical water's effect was proposed.

HCH are mainly sources from the stream flow discharges. HCH contents are decreasing drastically along the transferring processes from the estuaries, coastal, bay, and bay mouth. Moreover, HCH contents surface waters are always in order of summer > spring > autumn [4]. Hence, HCH contents in surface waters are decreasing along with the path of estuaries - coastal - bay - bay mouth over time within the year. Once HCH in surface waters is transferring from the estuaries to the bay mouth, the contents are changing. To quantitatively reveal this horizontal changing process, the horizontal water's effect was proposed.

Definition

When HCH is transferring through the water body, the contents are changing. While HCH is transferring from place A to Place B, the waters is considered as a rectangular section. Once HCH is transferring through the waters, a parabolic trajectory is projected in the rectangular section. The parabolic trajectory in the two-dimensional coordinate plane (X0Y) could be divided into components as 0X and 0Y (Fig. 2). The 0X component and 0Y component represent the horizontal water's effect and vertical water's effect, respectively. That is the HCH contents are changing by mean of the effect of water body. Hence, we defined this phenomenon water's effect.

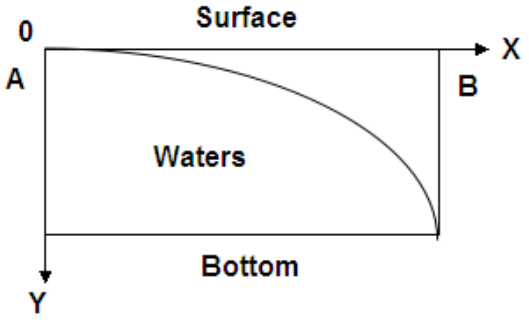

Fig.2 The water's effect of HCH

Vertical water's effect

Definition of vertical water's effect

The vertical water's effect could be further defined into vertical water's dilution effect and vertical water's accumulation effect. Once HCH contents are decreasing or increasing along which the process from surface waters to bottom waters, this phenomenon is defined as vertical water's dilution effect or vertical water's accumulation effect (Fig. 3).

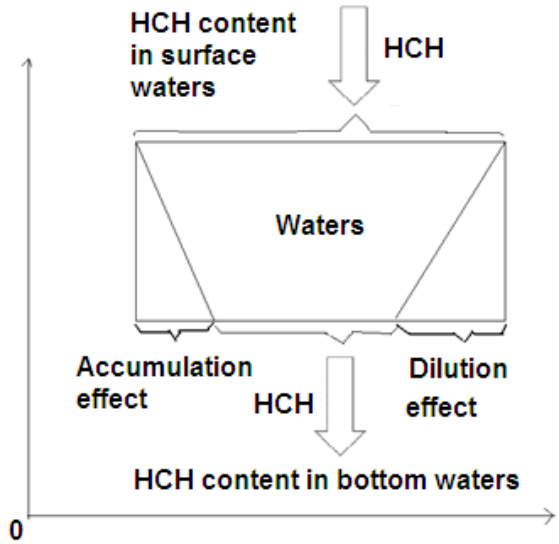

Fig.3 The vertical water's effect of HCH

Function of vertical water's effect

Once HCH is transferring from surface waters to bottom waters, it is necessary to understand the effects of water body on HCH contents. By means of the theories of vertical water's effect, vertical water's cumulative effect, and vertical water's dilution effect, the changing of HCH contents could be easily to be determined in according to the HCH contents in surface waters and bottom waters.

Theory of vertical water's effect

If HCH contents in surface waters (a) are lower than in bottom waters (b). The reason is that a lot of HCH is settled to the bottom waters along with the suspended particulate matters. Hence, a lot

of HCH is accumulated in bottom waters, leading the increasing of HCH contents in bottom waters. The vertical water's cumulative effect is that, HCH contents are increasing from low value in surface waters to high value in bottom waters. If HCH contents in surface waters (a) are higher than in bottom waters (b). The reason is that in addition of the sedimentation of HCH, a large amount of HCH is removed from water body, leading to a small part of HCH is accumulated in bottom waters. The vertical water's dilution effect is that, HCH contents in waters are decreasing from high value in surface waters to low value in bottom waters.

Application of vertical water's effect

Taking HCH contents in Jiaozhou Bay in 1982 as an example [3]. There was vertical water's accumulation effect in April, while was vertical water's dilution effect in July and October. HCH contents in surface waters and bottom waters in April, July and October 1982 ranged from 0.065-0.409 μg L^{-1} and 0.072-0.302 μg L^{-1}, respectively. The vertical water's cumulative effect was 0.072-0.065=0.007 μg L^{-1}. For highest values, the vertical water body's was cumulative, that was 0.409-0.301=0.108 μg L^{-1}. The vertical water's cumulative effect was higher than the vertical water's dilution effect. Hence, it could be concluded that there were vertical water's cumulative effect for low content HCH, and vertical water's dilution effect for high content HCH.

Horizontal water's effect

Definition of horizontal water's effect

The horizontal water's effect could also be further defined into horizontal water's dilution effect and horizontal water's accumulation effect. Once HCH contents are decreasing or increasing from A place to B place along which the horizontal direction, this phenomenon is defined as horizontal water's dilution effect or horizontal water's accumulation effect (Fig. 4).

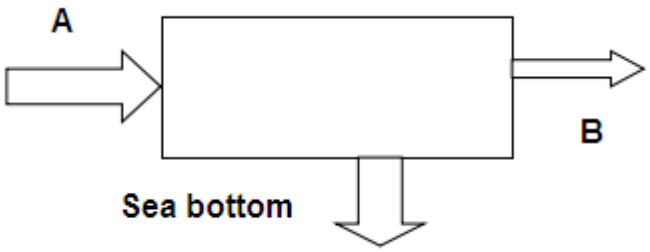

Fig.4 The horizontal water's effect of HCH

Function of horizontal water's effect

Once HCH is transferring from A place to B place along which the horizontal direction, it is necessary to understand the effects of water body on HCH contents. By means of the theories of horizontal water's effect, horizontal water's cumulative effect, and horizontal water's dilution effect, the changing of HCH contents could be easily to be determined in according to the HCH contents in A place to B place.

Theory of horizontal water's effect

If HCH contents in A place (a) are lower than in B place (a). The reason is that a lot of HCH is settled to the bottom waters along with the suspended particulate matters. Hence, a lot of HCH is accumulated from A place to B place, leading the increasing of HCH contents in B place. The horizontal water's cumulative effect is that, HCH contents are increasing from low value in A place to high value in B place. If HCH contents in A place (a) are higher than in B place (a). The reason is that in addition of the sedimentation of HCH in A place, a large amount of HCH is removed from water body; leading to a small part of HCH is accumulated in B place, and the decreasing of HCH contents in B place. The vertical water's dilution effect is that, HCH contents are decreasing from high value in A place to low value in B place.

Application of horizontal water's effect

Taking HCH contents in Jiaozhou Bay in 1983 as an example [4]. In according to HCH contents in surface waters from the estuaries to the bay mouth, there was no horizontal water's accumulation

effect, and the horizontal water's dilution effect was 0.317-0.443 μg L^{-1}. In spring, HCH contents were diluted from low value to lower value in horizontal direction while HCH contents were diluted from high value to low value in summer, and HCH contents were diluted from moderate value to low value in autumn. The dilute strengths in spring, summer and autumn were 69%, 58% and 72%, respectively. Hence, HCH contents were decreasing continually along which the horizontal direction and the dilute strengths were high or low in case of the HCH contents were low or high.

Processes of water's effect

Temporal and spatial changing processes

Taking HCH as indicator, the water's effect is working when HCH is transferring through waters. In Jiaozhou Bay, both the spatial changing of HCH from the estuaries to the bay mouth and the temporal changing of HCH from spring to autumn within year had revealed the transferring processes of HCH in waters, as well as the water's effect. The water's effect could be further divided into horizontal water's effect and vertical water's effect. Correspondingly, the horizontal water's effect could also be further defined into horizontal water's dilution effect and horizontal water's accumulation effect, and the horizontal water's effect could also be further defined into horizontal water's dilution effect and horizontal water's accumulation effect. We found that there were both horizontal water's dilution effect and horizontal water's accumulation effect in Jiaozhou Bay, yet there was only horizontal water's dilution effect. Water's effect is that the contents of the substances are increasing or decreasing when are transferring through the water body. In according to the temporal and spatial processes, the water's effect revealed that the low contents are increasing yet the high contents are decreasing when are transferring from the vertical direction, and both low and high values are decreasing when are transferring from the horizontal direction.

Characteristic of transferring processes

When HCH was transferring from surface waters to bottom waters along with the vertical direction, two results were leading to HCH contents in bottom waters. Firstly, in case of HCH contents were high in surface waters, in addition of the sedimentation of HCH, a large amount of HCH is removed from water body, leaving a small part of HCH was accumulated in the bottom waters, and the HCH contents reaching the bottom waters were decreasing. Secondly, in case of HCH contents were low in surface waters, most of HCH was settled to the bottom waters, and leading the increasing of HCH contents in bottom waters. The vertical water's cumulative effect is that, HCH contents are increasing from low value in surface waters to high value in bottom waters (Table 1). Once HCH was transferring along the vertical direction, the high content of HCH in the surface was decreasing, yet the low content of HCH in surface waters was increasing. When HCH was transferring from A place to B place along with the horizontal direction, HCH contents were decreasing due to the sedimentation of HCH (Table 1). When HCH was transferring along the horizontal direction, both high and low contents of HCH in surface waters were decreasing. The water's effect could be decomposed into vertical water's effect and horizontal water's effect. In another word, the sum of the vertical water's effect component and horizontal water's effect component was the water's effect. The changing processes of vertical water's effect and horizontal water's effect revealed the changing processes of water's effect: while HCH is transferring from surface water to the water body and finally the sea bottom, a parabolic trajectory was remaining.

Tab.1 The process of the water's effect of HCH in Jiaozhou bay

Changing process of water's effect		Vertical water's effect	Horizontal water's effect
Spatial	Temporal	Changing of contents from surface to bottom	Changing of contents from A place to B place
Surface→Bottom	Spring	Low→High	Low→Low
A place→B place	Summer	High→Low	High→Low
	Autumn	Low→High	Moderate→Low

Conclusions

Taking HCH as indicator, the water's effect is working when HCH is transferring through waters. We further expatiated the theories of water's effect, vertical water's effect, and horizontal water's effect, as well as the definitions, processes, and the model diagrams. These theories could be successfully applied in the quantitative expatiation the transferring processes of HCH, as well as the vertical water's effect and horizontal water's effect.

In according to the horizontal transferring processes of HCH, we provided the theories of horizontal water's effect, horizontal water's accumulation effect, and horizontal water's dilution effect, as well as the definitions, processes, and the model diagrams. Taking HCH contents in Jiaozhou Bay in 1982 as an example. There was vertical water's accumulation effect in April, which was vertical water's dilution effect in July and October. Once HCH was transferring along the vertical direction, the high content of HCH in the surface was decreasing, yet the low content of HCH in surface waters was increasing.

In according to the vertical transferring processes of HCH, we provided the theories of vertical water's effect, vertical water's accumulation effect, and vertical water's dilution effect, as well as the definitions, processes, and the model diagrams. Taking HCH contents in Jiaozhou Bay in 1983 as an example. There was no horizontal water's accumulation effect, and the horizontal water's dilution effect was 0.317-0.443 μg L^{-1}. Once HCH was transferring along the vertical direction, the high content of HCH in the surface was decreasing, yet the low content of HCH in surface waters was increasing.

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