

## Gravity Characteristic and Sedimentation on As in Jiaozhou Bay

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**Abstract:** Using investigation data on As in Jiaozhou Bay in 1982, this paper analyzed the seasonal variation, vertical variations and horizontal distributions of As, and revealed the gravity characteristic and sedimentation of As. Results showed that As's contents in surface and bottom waters in July 1982 were 0.36-2.80  $\mu\text{g L}^{-1}$  and 0.88-4.48  $\mu\text{g L}^{-1}$ , respectively, while in October 1982 were 0.58-1.62  $\mu\text{g L}^{-1}$  and 0.84-1.16  $\mu\text{g L}^{-1}$ , respectively. The pollution of As in Jiaozhou Bay 1982 was very slight. For seasonal variation, As's contents in surface waters were in order of summer>autumn, while in bottom waters were also in order of summer>autumn. In case of As contents in surface waters were relative high/low, As contents in bottom waters were also relative high/low. That was the result of gravity characteristics. The variations of As contents in surface waters were mainly determined by the changes of source input of river runoff, while the variations of As contents in bottom water were mainly determined by vertical water's effect. The sedimentation process of As could be summarized that As was transferred to surface waters in marine bay from river runoff, was absorbed or assimilated by suspended particular matters or marine organism, and then was transported to bottom waters, and was finally fixed in sediments in sea bottom.

### 1. Introduction

As has been widely used industry and agriculture, and the discharge of As-containing waste was increasing along with the rapid development of economic in the past four decades. However, the excessive existence of As in the environment is harmful to organism and ecosystem since As is high toxic [1]. The terrigenous As was discharged or washed to rivers and streams, and emitted to atmosphere, etc., and as a result many marine bays have been polluted by As since ocean is the sink of pollutants [3-4]. By means of vertical water's effect [5-6], the sedimentation process of As was strongly impacting the distributions of As.

Jiaozhou Bay is a semi-closed bay located in Shandong Province China, and has been polluted by various pollutants including As in the past three decades [1-2]. This paper analyzed the seasonal variation, vertical variations and horizontal distributions of As, and revealed the gravity characteristic and sedimentation of As in Jiaozhou Bay, and provided basis for scientific research and environment remediation.

### 2. Materials and method

Study area and data collection. Jiaozhou Bay is located in the south of Shandong Province, eastern China (35°55'-36°18' N, 120°04'-120°23' E). The total area, average water depth and the width of the bay mouth are 446 km<sup>2</sup>, 7 m and 3km, respectively. The bay mouth is connecting to the Yellow Sea in the south, and is surrounded by Qingdao, Jiaozhou and Jiaonan in the east, north and

west, respectively (Fig. 1). This bay has 12 major inflow rivers including Dagu River, Haibo River, Licun River, and Loushan River etc., all of which are seasonal rivers [8-9].

The investigation on As in surface waters in Jiaozhou Bay was carried on in July and October 1982 in four sampling sites (i.e., 083, 084, 122 and 123) that were located in coastal waters in the southwest of the bay and the bay mouth (Fig. 1). As in waters was sampled and monitored follow by National Specification for Marine Monitoring [10].

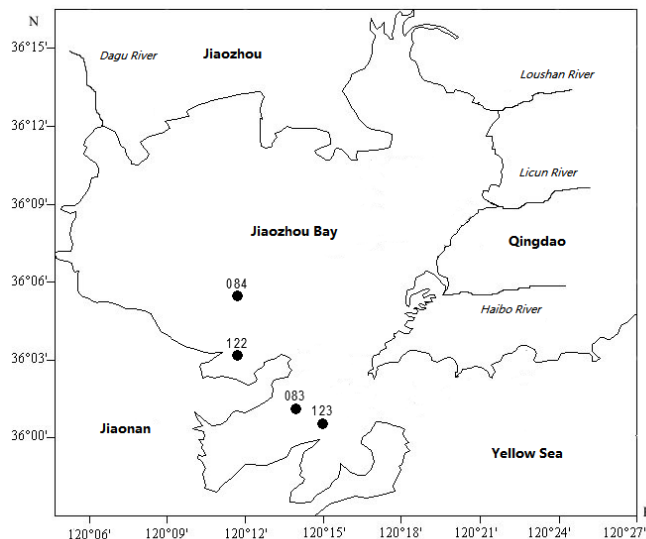


Fig. 1 Geographic location and monitoring sites in Jiaozhou Bay

### 3. Results

#### 3.1 Contents of As

In July 1982, As's contents in surface and bottom waters were  $0.36\text{-}2.80\ \mu\text{g L}^{-1}$  and  $0.88\text{-}4.48\ \mu\text{g L}^{-1}$ , respectively. In October 1982, As's contents in surface and bottom waters were  $0.58\text{-}1.62\ \mu\text{g L}^{-1}$  and  $0.84\text{-}1.16\ \mu\text{g L}^{-1}$ , respectively. In according to Sea Water Quality Standard (GB 3097-1997) for As, As's contents were much lower than the guide line of Grade I for As ( $20.00\ \mu\text{g L}^{-1}$ ). The pollution of As in Jiaozhou Bay 1982 was very slight.

#### 3.2 Seasonal variations of As

July and October were summer and autumn, respectively. For seasonal variation, As's contents in surface waters were in order of summer>autumn, while in bottom waters were also in order of summer>autumn. The reason was that the source input of As in summer was stronger than in autumn since the terrigenous As was transferred to marine bay via rainfall-runoff.

#### 3.3. Vertical variations of As

In case of As contents in surface waters were relative high/low, As contents in bottom waters were also relative high/low. Meanwhile, the change range of As contents in surface waters ( $0.36\text{-}2.80\ \mu\text{g L}^{-1}$ ) were smaller than in botom waters ( $0.84\text{-}4.48\ \mu\text{g L}^{-1}$ ). This indicated that As in bottom waters was transferring from surface waters by rapid sedimentation and accumulation [5-7].

#### 3.4 Horizontal distributions of As

In July 1982, As's contents in surface waters were decreasing from the coastal waters in the southwest of the bay ( $2.80\ \mu\text{g L}^{-1}$ ) to the center waters in the southwest of the bay ( $0.36\ \mu\text{g L}^{-1}$ ), while in bottom waters were increasing from the coastal waters in the southwest of the bay ( $2.04\ \mu\text{g L}^{-1}$ ) to the center waters in the southwest of the bay ( $4.48\ \mu\text{g L}^{-1}$ ). In October 1982, As's contents in surface waters were decreasing from the coastal waters in the southwest of the bay ( $1.04\ \mu\text{g L}^{-1}$ ) to the center waters in the southwest of the bay ( $0.84\ \mu\text{g L}^{-1}$ ), while in bottom waters were increasing from the coastal waters in the southwest of the bay ( $0.84\ \mu\text{g L}^{-1}$ ) to the center waters in the

southwest of the bay ( $1.12 \mu\text{g L}^{-1}$ ). In July and October 1982, the horizontal distributions of As were reverse in surface and bottom waters.

## **4. Discussion**

### **4.1 Vertical sedimentation process of As**

By means of vertical water's effect, As's contents in waters were changing while were passing water body from surface waters to bottom waters [5-7]. The growth and reproduction of marine phytoplankton were increasing rapidly in summer, resulting in a great deal of colloids in waters that enhancing the absorption ability of suspended particular matters in waters [9]. Hence, a big part of As contents were absorbed to the suspended particular matters and transported sea bottom. Hence, As contents were settling to sea bottom continuously by means of gravity force and marine current.

### **4.2 Seasonal variation process of As**

In waters in coastal in the southwest of the bay and the bay mouth, As in surface waters was decreasing from  $2.80 \mu\text{g L}^{-1}$  in July to  $1.62 \mu\text{g L}^{-1}$  in October. The reason was that July was the wet season in study area, and the source input of As from river runoff was strong, resulted in relative high As contents in surface waters. However, October was dry season and the source input of As from river runoff was weak, resulted in relative low As contents in surface waters. By means of vertical water's effect [5-7], a big part of As in surface waters was transferred to bottom waters continuously. Hence, As contents in bottom waters was relative high ( $4.48 \mu\text{g L}^{-1}$ ) in July since As contents in surface water was relative high, and the sedimentation and accumulation of As contents in bottom waters were rapid. However, As contents in bottom waters was relative low ( $1.16 \mu\text{g L}^{-1}$ ) in October since As contents in surface water was relative low, and the sedimentation and accumulation of As contents in bottom waters were weak.

### **4.3 Horizontal variations processes of As**

In July and October 1982, the horizontal distributions of As in surface waters were decreasing from the coastal waters in the southwest of the bay to the center waters in the southwest of the bay, this indicated that the horizontal distributions of As in surface waters were mainly determined by the source input of As. However, in July and October 1982, the horizontal distributions of As in bottom waters were increasing from the coastal waters in the southwest of the bay to the center waters in the southwest of the bay, the reason was that there were accumulation effect and dilution effect in waters, this indicated that the horizontal distributions of As in bottom waters might be mainly determined by other factors, i.e., vertical accumulation effect and vertical dilution effect [5-7].

### **4.4 Gravity characteristic of As**

Jiaozhou Bay is a semi-closed bay in where the seasonal variations were indicating the gravity characteristic of As. As contents in surface were in order of summer>autumn, and in bottom were also in order of summer>autumn. Meanwhile, in case of As contents in surface waters were relative high/low, As contents in bottom waters were also relative high/low. That was the result of gravity characteristic. As a whole, the variations of As contents in surface waters were mainly determined by the changes of source input of river runoff, while the variations of As contents in bottom water were mainly determined by vertical water's effect [5-7]. The sedimentaion process of As could be summarized that As was transferred to surface waters in marine bay from river runoff, and then was absorbed or assimilated by suspended particular matters or marine organism, and then was transported to bottom waters, and was finally fixed in sediments in sea bottom.

## **5. Conclusions**

In July 1982, As's contents in surface and bottom waters were  $0.36\text{-}2.80 \mu\text{g L}^{-1}$  and  $0.88\text{-}4.48 \mu\text{g L}^{-1}$ , respectively. In October 1982, As's contents in surface and bottom waters were  $0.58\text{-}1.62 \mu\text{g L}^{-1}$

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