The Only Source of Cu Content from River Flow in Jiaozhou Bay

Dongfang Yang\textsuperscript{1,2,4,a}, Wenliang Tao\textsuperscript{1,2}, Danfeng Yang\textsuperscript{3}, Sixi Zhu\textsuperscript{1,2}, and Ming Wang\textsuperscript{1,2,b}

\textsuperscript{1}Research Center for Karst Wetland Ecology, Guizhou Minzu University, Guiyang, 550025, China
\textsuperscript{2}College of Chemistry and Environmental Science, Guizhou Minzu University, Guiyang, 550025, China
\textsuperscript{3}College of Information Science and Engineering, Fudan University, Shanghai, 200433, China
\textsuperscript{4}North China Sea Environmental Monitoring Center, SOA, Qingdao 266033, China
\textsuperscript{a}dfyang_dfyang@126.com

Abstract: In August and October, 1991, the variation of Cu content in Jiaozhou Bay was 0.13-0.67μg/L, satisfying the Case I Sea Water Quality Standard. It showed that the water was not polluted by Cu content. Cu content was only transported by the river flow, specifically, 0.64μg/L from Haibo River, 0.59μg/L from Licun River and 0.67μg/L from Loushan River. The three rivers were not polluted by Cu content. The Cu content emitted by human was in the order of Loushan River, Haibo River and Licun River from high to low. However, the Cu contents in the three rivers were far less than 5.00μg/L, showing that the land was not polluted by Cu. Transported by different river flows, the Cu contents reaching the ocean were basically consistent, with a variation of 0.08μg/L. Further, the modelling diagram was established to display the transport path of Cu content to land, atmosphere and ocean in a quantitative way.

1. Introduction

In natural world, Cu exists extensively, including the land and ocean. In this way, Cu content was contained in river flow, bay and ocean [1-5]. Hence, the study on basic background value of Cu content in bay and ocean provides the scientific support for protecting the marine environment and maintaining the sustainable development of ecology. This paper, according to the investigation data of 1991, analyzed the Cu content, horizontal distribution and source, determined the water quality, source background and source amount of Cu and obtained the basic background values of Cu content in waters inside and outside Jiaozhou Bay, providing scientific theoretical reference for the study on the source, pollution and transport of Cu in Jiaozhou Bay.

2. Investigation Waters, Materials and Methods

2.1 Natural environment of Jiaozhou Bay

Jiaozhou Bay, located in southern Shandong Peninsula, is a typical semi-closed bay. The geographical location is 120°04'-120°23'E, 35°58'-36°18'N. Bounded by the line connecting Tuandao Cape and
Xuejiado Island, it connects with Yellow Sea, covering an area of about 446km², with the average depth of about 7m. There are dozens of rivers reaching the ocean in Jiaozhou Bay, among of which, the rivers with a larger volume of runoff and sand content include Dagu River, Yang River, Haibo River in Qingdao, Licun River, Loushan River and so on. These rivers are seasonal streams, and hydrological characteristics vary seasonally [6, 7].

2.2 Materials and methods
The materials about Cu in Jiaozhou Bay waters in August and October of 1991 was provided by North China Sea Environment Monitoring Center, State Oceanic Administration. In August, 2 sites were established for sampling in Jiaozhou Bay: 59 and 2104, shown in Figure 1. In October, 7 sites were established: 52, 53, 55, 58, 59, 2105 and 2106, shown in Figure 1. Samplings were performed for three times in August and October in 1991, respectively. According to the depth of water, sampling and survey 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 survey on Cu of Jiaozhou Bay waters was in accordance with national standard method, which was included in The Specification for Marine Monitoring (1991) [8].

3. Results
3.1 Cu content
The variation of Cu content was 0.64-0.67μg/L in August and 0.13-0.59μg/L in October, shown in Table 1. In August, the Cu content reached as high as 0.64-0.67μg/L in estuary of Haibo River and Loushan River, however, in October, it was as high as 0.59μg/L in estuary of Licun River, satisfying the Case I Sea Water Quality Standard (5.00μg/L). In other waters, it was less than 0.56μg/L, far lower than the Case I Sea Water Quality Standard.

Thus, in August and October, the variation of Cu content was 0.13-0.67μg/L, satisfying the Case I Sea Water Quality Standard. It indicated that the waters was not polluted by Cu, and the water was clean, shown in Table 1.

| Tab.1 The surface water quality in Jiaozhou Bay in August and October |
|-------------------------|-------------------------|
|                         | August                  | October                |
| Cu content/μg·L⁻¹       | 0.64-0.67               | 0.13-0.59              |
| Sea Water Quality Standard | Case I                   | Case I                 |
3.2 The horizontal distribution at surface
In August, Cu content reached high as 0.64-0.67μg/L in estuary nearshore waters of Haibo River and Loushan River, forming a series of semi-concentric circles with different gradients. It decreased from 0.64-0.67μg/L in the center to the periphery along with the gradients.

In October, Cu content reached high as 0.59μg/L in estuary nearshore waters of Licun River, forming a series of concentric circles with different gradients. It decreased from 0.59μg/L in the center to 0.13μg/L in bay center, 0.23μg/L in eastern bay and 0.29μg/L in southern bay mouth along with the gradients, shown in Figure 2.

4. Discussion

4.1 The water quality
In August and October, the variation of Cu content was 0.13-0.67μg/L, satisfying the Case I Sea Water Quality Standard. It indicated that the waters was not polluted by Cu.

The variation of Cu content was 0.64-0.67μg/L in August and 0.13-0.59μg/L in October, indicating that Jiaozhou Bay was not polluted by Cu. The high Cu content of 0.64-0.67μg/L in estuary nearshore waters of Haibo River and Loushan River, and 0.59μg/L in Licun River showed that the water was not polluted by Cu. In other waters, the Cu content was lower, reaching the high quality. The water was clean, not polluted by Cu.

4.2 The source
In August, the Cu content of 0.64μg/L was high in estuary nearshore waters of Haibo River, and 0.67μg/L in Loushan River, and in October, it was high as 0.59μg/L in estuary nearshore waters of Licun River, indicating that Cu content was transported by river flow.

Hence, it satisfied the Case I Sea Water Quality Standard (5.00μg/L), shown in Table 2, and the three rivers were not polluted by Cu.

| Different river sources | Haibo River | Licun River | Loushan River |
|-------------------------|-------------|-------------|---------------|
| Cu content/μg·L⁻¹       | 0.64        | 0.59        | 0.67          |

4.3 The source and input
The only source of Cu content in Jiaozhou Bay was river flow. The Cu content of 0.64μg/L was transported by Haibo River, 0.59μg/L by Licun River and 0.67μg/L Loushan River. The values were
approximate, with a variation of 0.59-0.67μg/L. It indicated that transported by different river flows, Cu contents reaching ocean were basically same, with a variation less than 0.08μg/L, shown in Figure 3. Thus, the Cu content emitted by human to the land were basically same, transported by river flow, to have an important influence on Cu content in ocean.

The Cu content emitted by human was in the order of Loushan River, Haibo River and Licun River from high to low. However, the Cu contents in the three rivers were far less than 5.00μg/L, showing that the land was not polluted by Cu.

5. Conclusion
In August and October, the variation of Cu content was 0.13-0.67μg/L, satisfying the Case I Sea Water Quality Standard. It indicated that the waters was not polluted by Cu.

The variation of Cu content was 0.64-0.67μg/L in August and 0.13-0.59μg/L in October, indicating that Jiaozhou Bay was not polluted by Cu. The high Cu content of 0.64-0.67μg/L in estuary nearshore waters of Haibo River and Loushan River, and 0.59μg/L in Licun River showed that the water was not polluted by Cu. In other waters, the Cu content was lower, reaching the high quality. The water was clean, not polluted by Cu.

The only source of Cu content in Jiaozhou Bay was river flow. The Cu content of 0.64μg/L was transported by Haibo River, 0.59μg/L by Licun River and 0.67μg/L Loushan River. The three rivers were not polluted by Cu. The Cu content emitted by human was in the order of Loushan River, Haibo River and Licun River from high to low. However, the Cu contents in the three rivers were far less than 5.00μg/L, showing that the land was not polluted by Cu. Transported by different river flows, the Cu contents reaching the ocean were basically consistent, with a variation of 0.08μg/L. Further, the modelling diagram was established to display the transport path of Cu content to land, atmosphere and ocean in a quantitative way.

Acknowledgement
This research was sponsored by Doctoral Degree Construction Library of Guizhou Nationalities University, Education Ministry's New Century Excellent Talents Supporting Plan (NCET-12-0659), the China National Natural Science Foundation (31560107), Major Project of Science and Technology of Guizhou Provincial ([2004]6007-01), Guizhou R&D Program for Social Development ([2014] 3036) and Research Projects of Guizhou Nationalities University ([2014]02), Research Projects of Guizhou Province Ministry of Education (KY [2014] 266), Research Projects of Guizhou Province Ministry of Science and Technology (LH [2014] 7376).

References
[1] Dongfang Yang, Zhenqing Miao, Wenpeng Song, Zijun Xu, Xiao Geng. Research on the sources of Cu in Jiaozhou Bay [J]. Advanced Materials Research Vols.1092-1093. 2015, 1013-1016.
[2] Dongfang Yang, Zhenqing Miao, Wenlin Cui, Lin Zheng and Shengtao Chen. Input and transfer
processes of Cu in bay waters [J]. Advances in intelligent systems research. 2015, 17-20.

[3] Dongfang Yang, Fengyou Wang, Sixi Zhu, Yunjie Wu, Xiuqin Yang. A research on the vertical transfer process of Cu in Jiaozhou Bay [J]. Advances in Engineering Research. 2015, 31: 1284-1287.

[4] Dongfang Yang, Sixi Zhu, Yunjie Wu, Xiuqin Yang, Fengyou Wang. Aggregation, divergence and homogeneity of Cu in Marine bay bottom waters [J]. Advances in Engineering Research. 2015, 31: 1288-1291.

[5] Dongfang Yang, Sixi Zhu, Fengyou Wang, Mingzhong Long, Xiuqin Yang. The impact of marine current to Cu contents in Jiaozhou Bay [J]. Advances in Computer Science Research. 2015, 1765-1769.

[6] YANG D F, CHEN Y, GAO Z H, et al. SiLicon Limitation on primary production and its destiny in Jiaozhou Bay, China transect offshore the coast with estuaries [J]. Chin. J. OceanoL. LimnoL. 2005, 23(1): 72-90.

[7] Dongfang Yang, Fan Wang, Zhenhui Gao et al. Ecological phenomena of phytoplankton in Jiaozhou Bay [J]. Marine Sciences, 2004, 28(6): 71-74.

[8] State Oceanic Administration. The Specification for Marine Monitoring (HY003.4-91) [M]. Beijing: China Ocean Press, 1991: 205-282.