Eutrophication in the Yangtze River Estuary and Mitigation of Harmful Algal Blooms

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1. Introduction

As the economical developments and human activities increase, coastal eutrophication is getting more and more serious and quickly becoming an important marine environmental issue in the world. Yangtse River estuary is the biggest estuary in China, and it is also the most serious in eutrophication. Long term of eutrophication resulted in the changes in the function and structure of ecological system in the waters, characterized especially by the frequent outbreaks of harmful algal bloom (HAB). The study on eutrophication in the Yangtze River estuary and mitigation of harmful algal blooms (HAB) is introduced in the presentation. Based on the seasonal cruises, the eutrophication in the estuary and its adjacent waters was assessed. The formation mechanism of eutrophication in the estuary was also discussed. In addition, an effective method of HAB mitigation by means of modified clays was proposed with some successful applications.

2. Method

Eutrophication investigation: Seasonal cruises were done since 2003 on 40 survey stations in waters of 121.0° E~123.5° E、30.5° N~32.0° N. Related physical and chemical factors (T, salinity, pH, NO_3-N, NH_4-N, NO_2-N, PO_4-P, SiO_3-Si, TN, TP, DO, SS etc.), biological parameters (chl.*a*, phytoplankton, community structure, etc.), nutrient distribution and characteristic, as well as relationship among them were studied. The status and characteristics of eutrophication in the waters were assessed systematically. The influences of discharge from Yangtze river, the turbidity maximum, upwelling, atmospheric wet deposition and biological influence, on eutrophication in the waters were discussed.

HAB mitigation: Surface modification of clay was done by means of adsorption or insertion to improve the lower flocculation of original clay with HAB cells. The mitigation of HAB was practiced successfully both in coastal waters and lake waters by the modified clay method. The water quality (DO, pH, COD, transparency, Eh, TSI, TN, TP, nutrients, chl.*a*, phytoplankton, zooplankton, benthon and bacteria etc.) was monitored with no evidence of any negative impact on ecological environment.

3. Results

(1) Long term change of nutrients in Yangtze river estuary

Based on the previous data, some obvious changes were found in the concentration and ratio of nutrients in the Yangtze river estuary during the past few decades. The concentration of nitrate increased three times from 1960s to 2000s. Phosphate and silicate increased respectively 0.6 and 0.5 time from 1980s to 2000s. The N/P ratio increased from around 30 in 1960s up to around 100 in 2000s, steering far away from the Redfield ratio. Rapid increase of nitrogen in the waters is the major reason of eutrophication in Yangtze river estuary.

(2) Status and characteristics of eutrophication in Yangtze river estuary

Distribution of nutrients and COD in Yangtze river estuary was characterized by high values of nutrient and COD near the coast , with COD values that exceed 4.0 mg•L-1 in serious areas. The concentrations of nutrients in turbidity maximum zone were obviously higher than other areas. The higher values of chl.*a* was found in the east and north of investigated waters. There was also a larger anoxic zone where DO was lower than 2mg•L^{-1} in spring and summer seasons in the south east of investigated waters. Most stations within salinity 20 were assessed as high level of eutrophication.

(3) Eutrophication model in Yangtze river estuary

According to hydrodynamic and ecological processes in Yangtze river estuary, the nutrient transportation and hydrodynamic-chemistry-biology coupled models in the waters were built based on POM and NPDZ models.

(4) Mitigation of harmful algal blooms by modified clays

Surface modification of clay can obviously improve the capability of original clay to flocculate HAB cells. In 2005 and 2007, modified clay was successfully applied in the control of lake HAB and coastal HAB. The monitoring results showed that the average removal rate of HAB cells was more than 90% and that the coagulated cells were decomposed gradually. The quality of waters had shown significant improvement. The community structure of phytoplankton was changed. There was no fact showing any negative impact of the control method on ecologic environment of the waters, such as the presence of dead fish, shrimp or water plants.

4. Discussion

Eutrophication in the Yangtze River Estuary: Yangtse River estuary is the biggest estuary in China, and it is also the most serious coastal waters in eutrophication. According to the long term change of nutrients in the waters, the evolution of eutrophication in Yangtse River estuary is considered to be associated with terrestrial human activities. For example, amount of nitrogen fertilizer used in the area along Yangtse River increased 15 times from 1960’ to 1990’s. Another study has demonstrated that the nitrogen concentration in the river is positively related with the amount of N fertilizer used. The eutrophication in Yangtze river estuary is just characterized by high concentration of nitrate. In addition, the effect of discharge from Yangtze river on eutrophication is also demonstrated by that most survey stations within salinity 20 were assessed as high level of eutrophication. Therefore, human activities should be an important cause of eutrophication in the waters.

Mitigation of harmful algal blooms by modified clays: The high removal capability of modified clay are attributed to three factors, 1. the change in electrostatic interaction between clay particles and HAB dells; 2. increase in the Van der Waals interaction between clay particles

and HAB dells; 3. inhibition of cell movement capability by some modified compound. In addition, modified clay can not only control HAB by flocculating organism cells down to the bottom of waters, but also can improve water quality such as by increasing transparency, DO and by decreasing toxin, pH, COD, TSI, Eh, TP, TN and NH_4 by the unique adsorption property of modified clays. Generally, the biggest concern for a mitigation method is its impact on ecologic structure. The modified clay method was successfully proven to be helpful in the reestablishment of a normal ecology system.

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6. References

Chao Chai, Zhiming Yu, Xiuxian Song, Xihua Cao, 2006, The status and characteristics of eutrophication in the Yangtze River (Changjiang) Estuary and the adjacent East China Sea, China, *Hydrobiologia*, 563:313-328.

Shen Zhiliang, Zhou Shuqing, Pei Shaofeng, 2008, Transfer and transport of phosphorus and silica in the turbidity maximum Zone of Changjiang estuary, *Estuarine, Coastal and Shelf Science*, in press.

Liu Hao, Yin Baoshu, 2007, Annual cycle of carbon, nitrogen and phosphorus in the Bohai Sea: a model study, *Continental Shelf Research*, 27:1399-1407.

Zhiming Yu, Mario R. Sengco and Donald M. Anderson, 2004, Flocculation and removal of the brown-tide organism, *Aureococcus anophagefferens* (Chrysophyceae), using clays, *Journal of Applied Phycology*, 16:101-110.

Yu Zhiming, Sun Xiaoxia, Song Xiuxian and Zhang Bo, 1999, Clay surfaces modification and its coagulation of red tide organisms, *Chinese Science Bulletin*, 44(7): 617-620.