Modeling of Anoxic Mineralization Processes in the Sediments of Eutrophic Littoral Regions of Osaka Bay

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ABSTRACT

Degradation of organic matters has a significant role in coastal biochemical process in littoral regions in eutrophic estuary. Dissolved reducing substances such as hydrogen sulfide generated with the mineralization of organic matters have a great impact on the marine environment. Laboratory experiments and construction of biogeochemical molar model of complicated material cycle in the sediments were conducted in the presented paper. The model considered in this study is a complex model containing many biochemical reactions, but can be applied to the sediments in which a lot of organic matters accumulated. Newly settled organic matters has a significant influence on the cycle of substance between a bottom water and sediment at a beach located behind a port in Osaka Bay, Japan.

KEY WORDS: benthic model; sediment; hydrogen sulfide; hypoxia; field survey; Osaka Bay.

INTRODUCTION

Enclosed bays adjacent to large cities tend to lack oxygen because of the following reasons: physical mechanisms such as density stratification resulting from freshwater discharge, high-nutrient loads from upstream rivers, bottom sediments, or deep-water topography caused by port construction. Consequently, it is important to determine how the sediments of such estuarine littoral regions affect water quality in the bay. The release of nutrient from the bottom sediments accumulates inorganic nutrient in the bottom layer and supplies to the surface layer, thereby contributing to the primary production in the waters. An on-site investigation and laboratory test were conducted to determine the mechanism of release. Further, the circulation of different substances in the bottom sediments and the water-to-bottom interaction were modeled. We once focused on the release rates of phosphorus and nitrogen in water and simulated oxygen depletion in the water using the benthic models which consists of 3 substances of organic, bottom-sediment-adsorbing inorganic phosphorus and nitrogen, and inorganic phosphorus and nitrogen in pore water. (Irie et al., 2004)

However, the accumulation of sulfides was observed in the innermost part of the bay. These sulfides resulted in the formation of blue tide. The production of hydrogen sulfide and other reducing substances and the release of these substances into the bottom water contribute to the oxygen deficiency and formation of anoxic zones in the bottom water, as well as to the consumption of oxygen in the bottom water and bottom sediments.

Mechanism of the production and release of hydrogen sulfide is one of complicated sediment systems. Pioneering research of dynamics of sulfur in surface sediment was conducted by Jørgensen (1977). Advanced understandings were developed by Aller et al.(1980), Aller et al.(1986), Berner (1980), Canfield(1989), Canfield et al.(1993), Thamdrup et al.(1994), van Cappellen and Wang (1996) and so on. One dimensional model of the complicated system was developed by Boudreau (1996), van Cappellen and Wang (1995, 1996), Wang and van Cappellen (1996). These models include the description of iron and sulfur cycling and are governed by the conservation of alkalinity in pore water. In contrast, Soetaert (1996a, 1996b) constructed another model which was mainly interested in cycling of carbon and nitrogen. Mineralization processes under anaerobic condition was lumped in this model. Wijsman et al. (2002) improved the model of Soetaert to fragment the mineralization processes. Fossing et al. (2004) extended the model of Wijsman to the cycling of phosphorus. In the Wijsman-Fossing type model pH is just a function and not conserved, but it can simulate the cycling of sulfur and estimate the production of hydrogen sulfide. Because it also can simulate dynamics of carbon, nitrogen, phosphorus, iron and manganese, applicability to a variety of sediments should be explored. This, however, is mostly applied to the coastal sediments located at a depth of more than tens of meters such as Anggara Kasih et al. (2009).

Hence, in the present study bottom sediments were sampled on the beach located in the innermost part of Osaka Bay, which is eutrophicated and forms an hypoxia during the summer periods, and laboratory analysis of the sediments was conducted. Furthermore, a vertical one-dimensional model of Fossing et al. (2004) which includes cycling of nitrogen, phosphorus, iron, manganese, and sulfur was