SEDIMENT OXYGEN CONSUMPTION THROUGH THE SURFACE OF TIDAL FLATS IN ARIAKE SEA

by
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1. Introduction

The Ariake Sea is semi-closed sea located in Kyushu Island of Japan and has unique features. Its area is 1,700 m^2 and many rivers run into the east coast. Recently, the immoderate supply of nutrients from the rivers, the decrease of tidal flats due to the reclamation, the reduction of tidal exchange and so on cause the deterioration of coastal ecosystem. One of the most important reasons for the reduction of benthic organisms is the generation of oxygen- deficient water mass. It is well known that SOC (sediment oxygen consumption through the bed surface) plays a significant role in the formation of oxygen-deficient water mass. Consequently, quantifying the SOC through the bed surface is useful in predicting the generation of oxygen-deficient water mass.

In this study, the SOC of the tidal flats in the Ariake Sea is investigated through laboratory experiments and the relationship between the organic matter included in sediment and SOC rate is discussed.

2. Sediment Sampling and Experimental Methods

The Ariake Sea has the bay axis of 96km and an average width of 18km as shown in Fig. 1. The water is 20 m deep on an average. The area of tidal flats is approximately 207 km^2. Eleven sediment sampling sites are shown by black dots in Fig. 1. Three undisturbed sediment cores at each sapling site were sampled by using a core sampler. Their thickness and diameter were about 15 cm and 11 cm, respectively. Two core samples were used for the experiments of SOC. The other one was used for the measurement of organic matters included the sediment. The core samples were kept cool in a ice chest and were carried to the laboratory. Seawater samples used for the SOC experiments were also obtained at each sapling site.

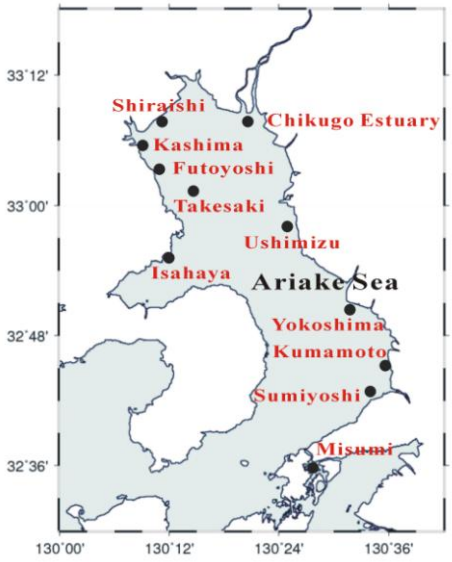

Fig. 1 Sampling sites of sediment cores.

Fig. 2 shows the SOC experimental set-up. To measure the values of SOC, the seawater samples were first pretread by filtering with Whatman GF/C and aerating for more than 1h in a dark room. The pretreated water was superposed slowly on the sediment core in order to undisturb the bed surface and for the water depth to be 25 cm. The 25 cm column of the pretreated seawater without containing sediment was used as a control to measur bacterial respiration in the water column. The water surface was sealed with thin Liquid Paraffin to avoid the oxygen transfer at the air-water interface, and the water column was strirred slowly to suppress the stratification. The concentration of dissolved oxygen (DO) was measured by using a pre-calibrated DO electrode and obtained at 5-min intervals for 12 h. The experiments were carried out under dark condition to suppress the primary production and the water temperature was kept at a fixed temperature of 20℃.

To obtain the vertical profiles of orgnic matter in sediment, the sediment was sectioned horizontally at 0.5 cm thickness to 3 cm. Then the concentration of chlorophyll a (Chl.a) and pheophytin (Pheo.) in each section were measured by Acetone extraction method and Lorenzen method.

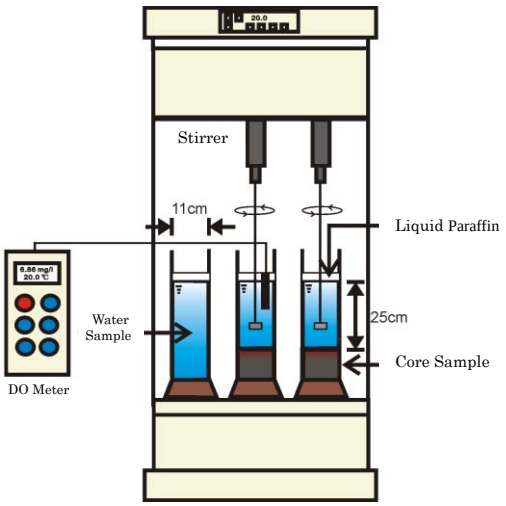

Fig. 2 Experimental set-up.

3. Experimental Results

3.1 Sediment oxygen consumption

The DO depletion profiles are graphically presented in Fig. 3. The DO concentrations are made dimensionless by

dividing by the initial DO concentrations (DO_0). The values of DO decrease exponentially though the profiles are diverse in the consumption rate. The DO concentration at the site of Yokoshima decreases most rapidly. At the sites of Sumiyoshi, Chikugo Estuary (2) and Misumi, on the other hand, the DO concentrations decrease very slowly. From this figure, it is seen that the sediment of Yokoshima was most deteriorated.

The change of DO is given by

$$V\frac{d[DO]}{dt} + Sv[DO] = 0 \qquad (1)$$

Where V is the volume of water, S the surface area of the sediment core sample and v is the oxygen consumption velocity. By dividing the both sides by

$$\frac{d[DO]}{dt} + \frac{v}{h}[DO] = 0 \qquad (2)$$

V, is obtained. Here, h is the sample water depth i.e., 0.25 m. The solution of Eq. (2) is given by

$$[DO^*] = \exp(-t^*) \qquad (3)$$

where

$$DO^* = \frac{[DO]}{[DO_0]} \quad \text{and} \quad t^* = \frac{vt}{h}$$

By superposing Eq. (3) to the data shown in Fig. 3, the values of v can be evaluated. The data in Fig. 4 are normalized by using the values of *v*. The various profiles in Fig. 3 are expressed universally by the exponential curve of Eq. (3).

3.2 Quantification of the velocity of SOC

Fig. 5 shows the relationship between the velocity of oxygen consumption and the concentration of organic matter. The concentration of organic matter is the sum of Chl. a and Pheo., which was averaged over 3 cm thickness. The relationship is approximated by the solid line and the oxygen consumption velocity seems to increase gradually with the increase of the amounts of organic matter.

4. Conclutions

The relationship between the organic matter and sediment oxygen consumption velocity was investigated for the tidal flats in the Ariake Sea. A universal expression was obtained for the DO depletion profiles and was given by an exponential curve. The oxygen consumption velocity depends strongly on the concentration of organic matter in sediment.

References

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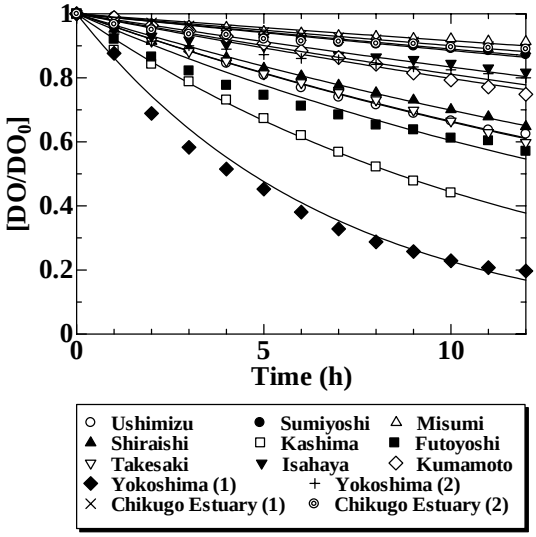

Fig. 3 DO depletion profiles.

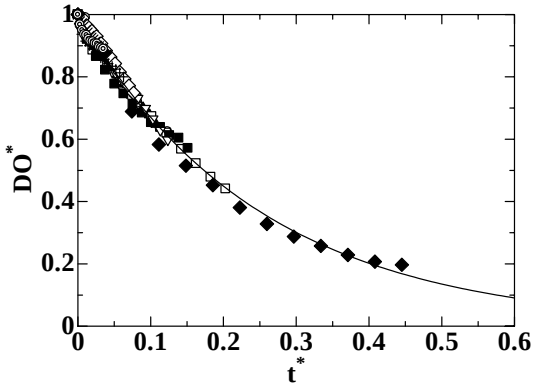

Fig. 4 Universal expression of SOC. (See the legend in Fig. 3)

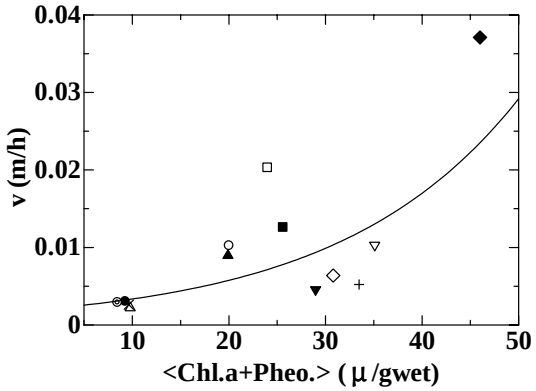

Fig. 5 Relationship between oxygen consumption velocity and organic matter in sediment. (See the legend in Fig. 3)