MEASUREMENT OF DO PROFILES NEAR THE SEDIMENT -WATER INTERFACE USING MICROELECTRODES

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Introduction

Dissolved oxygen depletion is an old issue that scientists have payed attention almost one century ago. Recently this problem has received a great deal of importance as it damages the fisheries and ecosystem due to the increase of pollution in body waters. There are four well-known general techniques used nowadays to measure solutes uptake in shallow water: (1) non-aerated chamber ; (2) continuous chamber flow; (3) sediment incubation techniques ; (4) micro-electrodes. The common of these four techniques is measurement of solute concentration based on the changeability of concentration with time or depth. This paper describes and gives some conclusions to the experiment that we did in two brackish lakes, Lake Nakaumi and Lake Shinji, in order to measure the DO profiles using microelectrodes as a device. As well the major aim was to compare the experimental results of DO profiles as a function of flow velocity, with theoretical one given by Nakamura and Stefan (1994).

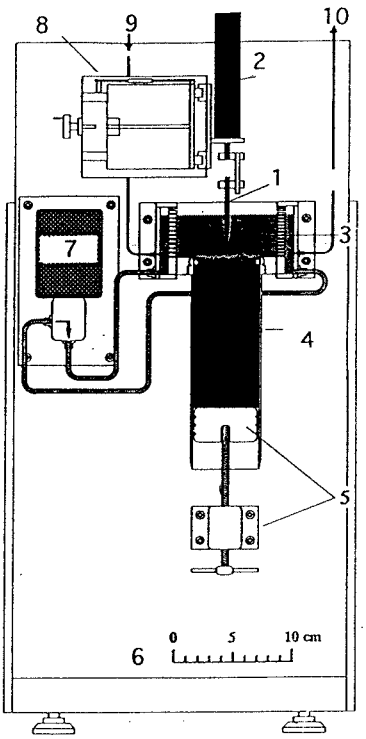

Fig 1. Experimental equipments: 1-microelectrode; 2-micromanipulator; 3-main flume; 4-sediment eore 5-piston; 6-stand frame; 7-variable pump; 8-micromoving system; 9-feeding tank ;10- DO meter

Materials and methods

Lake shinji is a lake with surface area of 80 km^2 and mean depth of 4.5 m. This lake is indirectly connected to the sea and nowadays suffer from eutrophication. Lake Nakaumi, whose surface area is 88 km^2 and mean depth 5.4 m, is connected to the sea through a narrow strait. To accomplish our purpose we used oxygen microelectrodes which determinate the concentration of dissolved oxygen. The voltages generated output is proportional to the dissolved oxygen in the electrode, which is proportional to the concentration to the surrounding water. The glass coated electrodes has a platinum tip of 2-8 μ m diameter. Microelectrode was attached to a micromanipulator ,which make feasible performance of vertical measurements with steps as small as 20 μm with a precision < 1 μm and can very accurately produce a high resolution profile with depth. The microelectrode current was measured by a picoammeter in connection with a strip chart recorder .

The sediment samples were taken at the mid-point of the lakes into plexiglass cores ,using a special sampler operated from a boat. The samples were covered with bottom water and transported to the laboratory. Samples had an unregulated surface topography and a structure purely sorted green clay covered with a dark silt stratum. Oxidized layer thickness was 6 mm for sediments of Lake Shinji and 3 mm for Lake Nakaumi. No high developed activity of the fauna was observed.

In Fig 1 is given schematically the establishing of experimental equipments. The vertical position of microelectrodes were determined by observing the tip of the electrodes using a dissecting microscope, illuminated by a light. The sediment core was flush with the bottom of the main flume. Water in the flume was recirculated, whose velocity was controlled using a variable centrifugal pump. Filtered bottom water almost saturated with oxygen was continuously supplied from a feeding tank. DO in outlet

water and inlet were measured using two DO meters connected with strip chart recorder. The water level at the main flume was kept constant, and water surface was covered with paraffin so as to inhibit gas transfer .

Results and discussions

We performed 72 consecutive measurements of DO profiles ,45 of which belong to Lake Nakaumi and 27 to Lake Shinji. The flow velocity was controlled using a controlled pump with varying frequency ranged of 30, 34, 38, and 42 Hz. During the experiment we have checked a response time of DO profile to step change in velocity. (Fig. 2 illustrates the example.) Run 19 started immediately after we changed the pump frequency from 42 to 34 Hz. Steady state profile (run 20) was obtained 35 minutes after the change of velocity. Thus the response time was found to be less than 35 minutes.

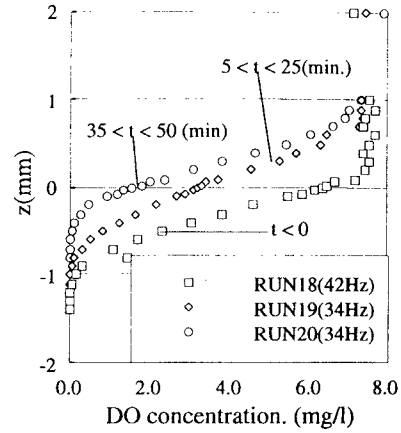

Fig 2. Response of DO concentration profile to change in flow velocity

Fig 3 shows examples of DO profiles under different velocity conditions. Each measurement was made more than 30 minutes after change of velocity. As flow velocity increased the point where the concentration start to decrease shifted down close to the sediment interface and the oxygen penetration depth into sediment increased. Profiles show that thickness of concentration boundary layer decreases as velocity increases. Boundary layer thickness measured directly during the experiment are in accordance with theoretical conclusions given by Nakamura and Stefan (1994).

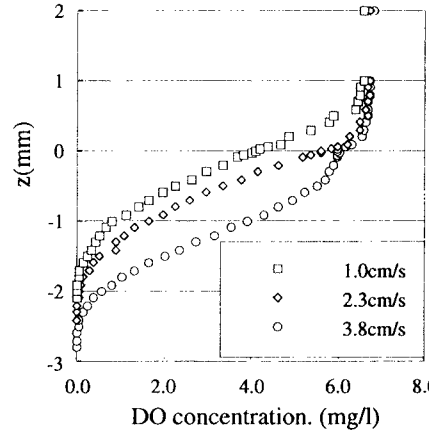

Fig 3. Effect of flow velocity on DO concentration profile

Gradient of DO concentration at the sediment -water interface gives diffusive flux of oxygen (diffusive SOD). Diffusive SOD is also found to be a function of flow velocity. From DO concentration difference between input and output fluid in continuous flow system, total SOD was also obtained for both lake Nakaumi and Lake Shinji. For sediment of Lake Shinji, total and diffusive flux were 1.6 and 0.8 g/m^{2}day, respectively. The difference was caused due to three reasons: (1) true surface area was much larger than vertically projected area; (2) the microelectrodes measurements were made at a few points and not representative; (3) effect of bioturbation was appreciable.

Conclusions

Repeated measurements of DO concentration profile with microelectrode enabled us to find a relationship between the flow velocity and DO concentration profiles. The response time to achieve a steady state due to change in velocity was 30 minutes. Diffusive flux of oxygen (diffusive SOD) was ,typically, as half as total SOD for sediments taken from Lake Shinji.

References

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