Dynamics and flux of bubbled oxygen in coral reef

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Coral reefs are known to have various creatures inhabiting in poor nutrient waters with high primary production. Gross organic carbon production in coral reefs is 700 - 3000 g C m^{-2} y^{-1} (Kinsey 1985), and the amount is comparable to that of tropical rainforests. In coral reef water, bubbled oxygen is observed during the day due to high photosynthesis, especially at a shallow lagoon during low tide. A part of this bubbled oxygen becomes dissolved oxygen, but it can be released directly to the atmosphere across the sea surface. In general, air-sea gas exchange is generated by molecular diffusion in the thin layer existing at the ocean surface. The air-sea oxygen flux by this thin layer model can be calculated as follows,

$$F_{air-sea} = k(O_{2\ air\ eq.} - O_{2\ sea})$$

,where k is the gas exchange coefficient, $O_{2\ air\ eq.}$ is the oxygen concentration in seawater equilibrated with air and $O_{2\ sea}$ is the oxygen concentration in seawater.

Bubbled oxygen flux cannot be considered in this equation since the model deals with only dissolved gas phase in water. It is not clear that how much O_2 is released in the bubble state despite dominating the dissolved oxygen of supersaturation generated by photosynthesis in the coral reef. A conventional technique for measuring primary production of reef community by using dissolved oxygen evolution in water can be lower estimate because of the amount of bubbled oxygen escaped to the air directly. In this graduate thesis, the aim of this study is to estimate how much bubbled oxygen are produced by reef benthic organisms and escaped from reef water to the atmosphere.

Bubbled oxygen was trapped with transparent acrylic dome covered with various bottom sediments in Sesoko beach coral reef, Okinawa, Japan. The trapped gas was collected with syringe and measured the volume, and then transferred to some vials adhered fluorescent patch for oxygen measurement on the inside. Oxygen concentration in the gas phase was measured by attaching a probe (Neo fox, Ocean Optics) outside of the vial at the patch. Bubbled oxygen flux from the bottom sediments can be calculated as follows,

$$F_{bubble} = P_{O2} \times V/(R \times T \times A \times t)$$

,where P_{O2} is the partial pressure of O_2 in gas phase, V is the volume of the gas, A is the bottom area of the dome, t is the incubation duration, R is the gas constant and T is the absolute temperature. A primary production of reef sediment was estimated by conventional method of measuring dissolved oxygen outside the dome during a low tide. Air-sea oxygen flux was also calculated with the thin layer model equation.

The partial pressures of oxygen in the trapped gas were 50.6% at sand with gravel, 43.5% at brawn algae (Amidaceae, *Padina* sp.), 53.5% at cyanobacterium and 50.5% of coralline red algae (Corallinales, Rhodophyta) bottom. Bubble content was not 100% of O_2 unexpectedly. It is suggested that this is due to the partial dissolution of oxygen from bubbled oxygen to sea water and the escape of nitrogen dissolved initially in seawater to bubbled oxygen. The ratios of dissolved phase to total oxygen flux from the bottom

sediment were 84.3% at sand with gravel, 79.7% at brawn algae, 76.1% at cyanobacterium and 88.4% of red algae bottom. The conventional primary production was 13.6 mmol m^{-2} h^{-1} in average, which was underestimated by 17.9%. The ratios of dissolved phase to total air-sea oxygen flux at the surface layer were 59.2% at sand with gravel, 51.4% at brawn algae, 46.3% at cyanobacterium and 67.3% of red algae bottom. The conventional air-sea oxygen flux was 3.68 mmol m^{-2} h^{-1} in average, which was underestimated by 44.0%.

Keywords: bubbled oxygen, dissolved oxygen, coral reef, primary production, oxygen flux