Use of sediment CO₂ by submersed rooted plants

Submersed plants other than isoetids can utilize sediment CO₂

A Winkel¹, J Borum¹ & O Pedersen¹

Radial sediment CO₂ uptake may play an important role in carbon acquisition for many small and medium-sized submersed plant species especially in low alkaline lakes with low CO₂ concentrations in the water column.

Radial CO₂ uptake of submersed rooted plants can account for a considerable proportion of the plant’s carbon uptake. Following the opposite gradient of radial O₂ loss, CO₂ diffuses from the surrounding pore water (high concentrations) into the roots (low concentrations). Here, it diffuses via the aerenchyma to the shoot where it is fixed in photosynthesis.

Underwater photosynthesis of submersed plants are often limited by Dissolved Inorganic Carbon (DIC). CO₂ concentrations in the sediment may reach values above 5 mM and is therefore a huge potential source of DIC. Hence, by tapping into the pool of sediment CO₂ submersed plants may alleviate the DIC limitation.

The graph above illustrates the maximum underwater photosynthesis with sediment CO₂ stations for the five species tested.

The ability to take up CO₂ from the roots and use it in underwater photosynthesis depends on the specific plant species and their morphology. Well developed aerenchyma, gas permeable roots and a short distance from roots to shoot enhances radial CO₂ uptake significantly.

In general, small rosette species with leaves and roots of high tissue porosity should be able to tap into the sediment CO₂ pool to enhance their inorganic carbon availability.

The flux of CO₂ from roots to shoot depends on tissue porosity, the distance and the concentration gradient from the pore water to the shoot. The flux of CO₂ inside a lacuna with the area of 0.93 mm² at different concentration gradients is shown in the graph above.

The distance is the most important factor determining the flux; even at very high concentration gradients, the flux is low once the distance exceeds 15-20 cm.

Aquatic rosette plants with short (< 10 cm) and highly porous leaves follow an ideal model that enables them to tap into the rich sediment CO₂ pool.

Recent research on sediment CO₂ uptake has led to the hypothesis that more species than previously believed are relying on this rich pool of DIC. The hypothesis is based on field observation that many plants grow with the basal part of the shoot buried inside the sediment. This white part of the shoot may provide a low resistance pathway for radial CO₂ uptake and, in addition, it bypasses the roots and thereby shortens the diffusional distance from CO₂ source to sink in underwater photosynthesis.

Literature


¹Freshwater Biological Laboratory, University of Copenhagen