A day in the life of *Trichodesmium*: Interactions between N_2 fixation, photosynthesis and iron acquisition over the diel cycle.

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N_2 fixation is a physiological challenge especially for cyanobacteria in oligotrophic oceans, since the nitrogenase enzyme is inhibited by O_2 and has a high iron requirement. As cells produce O_2 in photosynthesis and H_2 in N_2 fixation, they modify the chemical conditions in their direct vicinity. Variation in the activity of these processes over the diel cycle thus creates a dynamic chemical microenvironment which can have multiple effects on the availability of nutrients, such as iron, and feedback on cellular physiology. Here, we characterized rates of photosynthesis, respiration and N_2 fixation over the diel cycle in colonies of *Trichodesmium* collected in the Gulf of Eilat and investigated to what extent the resulting small-scale gradients in O_2, pH and H_2 affect the availability and uptake of mineral iron. Distinct patterns in N_2 fixation and photosynthesis were observed during the day, with a decrease in photosynthesis potential during the peak of N_2 fixation. In microsensor measurements, ranges of 70 to 400 μmol O_2 L^{-1} and 7.7 to 8.6 pH units were observed in the center of single colonies. Iron uptake experiments with ferrihydrite did not show systematic differences between colonies subjected to light or dark, suggesting that this range of pH and O_2 variations in single colonies is not large enough to significantly affect mineral iron bioavailability. H_2 measurements revealed strong variability between single colonies and over the diel cycle, which was linked to the diel rhythm in N_2 fixation. Remarkably, the presence of H_2 strongly stimulated uptake of mineral iron, suggesting that H_2 may play a previously unrecognized role as an electron source for mineral iron reduction. This link of N_2 fixation to iron acquisition via H_2 uptake and respiratory electron transport adds a new component to the intricate dynamic interplay of nutrient acquisition mechanisms in *Trichodesmium* over the diel cycle.