Regulation of biogeochemical fluxes through microbial networks

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Microbiological research on biogeochemical processes, such as hydrocarbon degradation, is greatly stimulated by the application of the new meta-omics techniques (metagenomics, metatranscriptomics, metaproteomics). The integration of the resulting data and their interpretation in relation to biogeochemical processes requires new modelling tools. We recently developed ecological regulation analysis (ERA) [1]. ERA quantifies how changes in biogeochemical fluxes are actually regulated by the microorganisms performing the process. ERA was applied to data sets obtained from scientific literature. In general, changes in flux were found to be related to changes in cellular activity and not to changes in cell numbers. ERA has now been extended to enable dissecting how these changes in cellular activity are achieved, by metabolic regulation (changes in the interaction of enzymes with their substrates, products and co-factors) or hierarchical regulation (changes in enzyme concentrations due changes in translation, transcription, post-translational modification and degradation of mRNA and protein). The extended ERA allows for the integration of data on fluxes through specific functional groups, their cell numbers, and mRNA and protein levels of specific genes.

Mathematical modelling approaches can also provide insight into how the trophic structure of microbial networks, in relation to environmental conditions, affects biogeochemical processes. The combined influence of predation of bacteria by protozoa and nutrient limitation on biogeochemical fluxes was assessed and subsequently followed up by experiments. Paradoxically, the presence of protozoa can stimulate bacteria-catalyzed processes under nitrogen or phosphorous limitation, via protozoa-mediated nutrient recycling. The effect of predation on biogeochemical flux depends on the type of nutrient limitation, predation had a slight negative effect under carbon limitation.

Systems biology approaches integrating microbial ecology and biogeochemistry, like the two examples presented here, will enhance understanding on ecosystem functioning.

[1] Röling (2007) *FEMS Microb. Ecol.* **62**, 202-210.

Impact of environmental conditions and skeletal ultrastructure on the Li isotopic composition of scleractinian corals

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An important challenge towards reaching a better understanding of the global CO_2 cycle is to better quantify the weathering rate of continental silicates. The isotopic composition of Li that gets incorporated into marine carbonates has the potential to be a proxy for the seawater composition and the amount of Li weathered out of continental rocks and transported into the oceans.

The lithium isotope compositions ($^7Li/^6Li$) of shallow-water (*Porites lutea* and *Cladocora caespitosa)* and deep-sea corals (*Lophelia pertusa* and *Desmophyllum cristagalli*) were measured using a Caméca ims 1270 ion microprobe. The two *C. caespitosa* samples were grown in laboratory under controlled conditions at CO_2 partial pressures (pCO_2) of 416 ± 29 µatm and 729 ± 30 µatm, respectively. *In situ* analyses show that all samples are isotopically homogeneous and display significantly lower δ^7Li values relative to seawater, indicating a significant isotope fractionation during aragonite formation. In contrast to essentially all other elements analysed so far, there is no relationship between the Li isotopic compositions and the skeletal ultrastructure. This implies that the biomineralization mechanisms, which are supposed to be different for the different skeletal components COC and fibers), do not influence the Li isotopic composition in corals. We also show that changes in pCO_2 (pH) did not significantly affect the Li isotope signature. Nevertheless, a small but significant and systematic difference between deep-sea azooxanthellate and shallow-water zooxanthellate species is highlighted. The lack of dependence on pH on skeletal ultrastructure indicates that Li isotopic signature of corals could be used as a proxy for reconstructing the paleo-δ^7Li of seawater and, potentially, for deconvolving past continental weathering rates.