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How sulphur affects the carbon cycle of subtropical seagrass meadows: New findings from Florida Bay

Seagrass meadows have an important climate protection function due to their long-term carbon storage potential. An international research team led by the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) has now been able to show that seagrass beds have a stronger influence on the carbon and sulphur cycling in subtropical coastal areas than previously thought. Of particular interest is the important role of sulphur, which stabilises organic carbon, regardless of whether it is sequestered in the calcareous sediments of subtropical seagrass meadows or remains in dissolved form. The results of the study were recently published in "Communications Earth & Environment".

Seagrass ecosystems are particularly worthy of protection as they provide shelter and food for a wide diversity of marine species and act as natural wave breakers that reduce coastal erosion. They also store so-called "blue carbon" – carbon that stays trapped in the ocean and in coastal ecosystems for a long time and therefore cannot have a climate-damaging effect as carbon dioxide (CO_2). Seagrass not only stores carbon via photosynthesis in its plant components, but also buries the organic material of other organisms that accumulates in the dense plant cover in its root sediments.

How do subtropical seagrass meadows 'tick'?

"It has been known for some time that not all seagrass meadows 'tick' in the same way when it comes to carbon storage. Tropical and subtropical seagrass meadows in particular can sometimes release more carbon than they store," says Mary Zeller. The marine chemist is an expert in biogeochemical seabed processes and lead author of the new *Communications Earth & Environment* study on the seagrass carbon cycle. "However, as seagrass meadows are particularly widespread in warm ocean regions, we wanted to take a close look at the processes that ultimately determine their carbon balance. This is the only way to correctly estimate their climate protection potential," says the scientist, who now works at MARUM – Centre for Marine Environmental Sciences at the University of Bremen, but was a researcher in IOW's Geochemistry & Isotope Biogeochemistry working group during the seagrass study.

Mary Zeller and her German-American research team focussed on subtropical seagrass beds located in Florida Bay in the south of the United States. In order to understand whether and how organic matter – and therefore carbon – is released from the sediments into the water column, they combined state-of-the-art geochemical and molecular methods to analyse sediments, pore water and the surrounding water. The focus of the involved IOW researchers Mary Zeller and Michael Böttcher was to analyse various stable isotopes as biogeochemical markers to understand the complex matter transformation processes, as well as to employ a special method of high-resolution mass spectrometry, which allows the determination of the molecular formula of individual molecule types in complex mixtures of organic molecules.

Surprisingly close coupling of the sulphur and carbon cycles

The researchers found that almost 10 % of all organic matter of the investigated seagrass meadows is bound to their calcareous sediments. This type of sediment is a characteristic of tropical and subtropical seagrass ecosystems, because in the warm environment the metabolic processes of the seagrass plants cause carbonate, which is dissolved in the seawater, to be converted into lime that accumulates in the root area. If these sediments disintegrate, the bound organic substances can dissolve and enter the water column, making them potentially available again to the marine carbon cycle. "We were able to provide direct prove for the first time that seagrass sediments actually release organic carbon. Especially our molecular analyses have shown that the dissolved organic molecules in the surrounding water correspond to 97% in structure and composition with the lime-associated organic material in the sediments," Zeller explains.

A crucial role in the mobilisation of organic substances from the sediments is played by the sulphur chemistry in the seabed, which the seagrass meadows stimulate like a kind of biocatalyst: Their roots actively transport oxygen into the sediment, which facilitates the oxidation of sulphur compounds by microorganisms. This produces acid, which causes the calcareous sediments at the seagrass roots to partially disintegrate, releasing previously bound organic matter. Additionally, these microbial processes produce highly stable organic sulphur compounds that are largely resistant to biological decomposition and degradation by the UV radiation of sunlight.

Improved modelling of the climate protection potential of seagrass & co.
"The fact that the sedimentary and dissolved carbon pools in seagrass meadows are so closely coupled was previously unknown and was therefore not adequately taken into account in climate modelling," comments Mary Zeller on the results of the study. "In this context, it is also important that although the organic sulphur generated in seagrass beds mostly exists in dissolved rather than particulate form, it is apparently still a very long-lived carbon reservoir that cannot be easily metabolised into climate-active CO_2," Zeller continues. According to the marine chemist, the study could help to improve modelling of the "blue carbon" storage potential of the widespread tropical and subtropical seagrass meadows. "However, further research is needed to clarify, whether the mechanisms found here are universal – i. e. whether they also apply to other ecosystems with similar rhizosphere processes, such as mangroves. It also needs to be clarified whether and what kind of impact environmental changes such as climate change have on these processes," concludes Zeller.

Original Publication:

Zeller, M.A., Van Dam, B.R., Lopes, C., McKenna, A.M., Osburn, C.L., Fourqurean, J.W., Kominoski, J.S., Böttcher, M.E. (2024): *The unique biogeochemical role of carbonate-associated organic matter in a subtropical seagrass meadow.* Communications Earth & Environment 5, 681.
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