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UCSB-led international team evaluates anoxic marine basins as potential sites for carbon sequestration

Could taking plant biomass and burying it in the deep, anoxic parts of the ocean be a workable large-scale strategy for carbon sequestration? The concept has been intriguing scientists for years, and now a recent international workshop led by UC Santa Barbara researchers has taken the very first steps toward developing it.

“This applied challenge is much bigger than one research group can do and it affects people all over the world,” said UCSB biogeochemist Morgan Raven, whose research centers on organic matter in sulfidic environments. “And we wanted to build a research coalition and collaborative network to start a conversation about this.”

The workshop’s results are published in the European Geosciences Union journal Biogeosciences.

Leveraging the ocean's carbon storage capability

As researchers race to find ways to curb the runaway warming of the planet due to the overproduction of greenhouse gases, strategies that aim to sequester carbon away from the atmosphere long term have become just as important as strategies to

lower carbon emissions at their sources.

One potential approach that has recently begun to garner attention is the large-scale sinking of plant biomass in the ocean. Given that plants are natural carbon sequesters, the idea is to take the material and leverage the ocean's natural ability to store carbon in its depths by sinking the material where it could be stored for hundreds, perhaps even thousands of years.

"Plants fix an enormous amount of carbon from the atmosphere every year, naturally," Raven explained. However, much of that carbon is typically returned to the atmosphere as the plants decay, while some of it remains locked up in wood or buried in the soil. "And so essentially the idea is that we can stop some of that carbon from going back into the atmosphere," by sinking it to the ocean's depths, she said.

While interesting, this idea has generated concern among scientists for possible harmful effects on the ecology of the ocean floor and the chemistry of the water. There are also doubts that the carbon held at the seafloor will even stay there, and might migrate upward anyway through the water column.

The method that Raven is interested in pursuing, marine anoxic carbon storage (MACS), gets around some of those concerns by deliberately choosing anoxic, or oxygen-free basins as storage sites — sections of the seafloor where dissolved oxygen cannot reach. This could be due to restricted circulation, or drastic differences in density caused by high salt concentrations. These natural regions of the sea floor cannot support animal life and the oxygen-free chemistry of these areas lend themselves well to the preservation — essentially the pickling — of the organic matter.

But it's one thing to suggest and even find these anoxic basins around the world, which Raven and her NOISE Lab have done in previous research; it's another thing to actually consider them as real life sites for carbon storage.

"There are many countries that would need to be involved," Raven said. "If we were going to do something like this at a global scale, it would involve local economies and ports and many other things. The goal of this workshop was to bring together as many different perspectives as we could from the global community, really targeting countries that have direct interest in these low-oxygen environments, so they can be

in from the ground up in terms of talking about this as a potential project."

In previous work the Black Sea emerged as the best candidate for this large-scale carbon storage strategy, due to its size and isolation. Other locations, such as the Orca Basin in the Gulf of Mexico and other brine pools, as well as anoxic carbon sinks that develop in river deltas, are also considered potential sites for carbon dioxide removal.

The workshop, held in Bucharest, included discussions with local scientist counterparts as well as with partners from startups, policy experts, NGOs and other stakeholders. The participants analyzed risks, established current levels of understanding and contemplated the unknowns of the various factors involved in establishing a MACS project. These included discussions of the candidate sites, as well as the sources of plant biomass, which for the projects would be mainly terrestrial (from agricultural waste or excess from forestry management), and the carbon emissions involved in transport. Potential impacts to the chemistry in different areas along the water column were also addressed.

The resulting paper concludes that MACS may have the potential to operate at the enormous scale required to make a significant contribution to climate change mitigation, a goal that was defined by the US National Academies in 2022. It also presents a set of specific research questions that will be particularly important topics for the next stages of research. For example, modeling studies will be needed to understand how the Black Sea circulation may respond to changes in rainfall and stratification. Answers to these questions, according to the researchers, are needed "before we can make informed decisions about if and how to deploy MACS at scale for carbon dioxide removal."

It's still early days for the collaboration. While MACS seems to have the potential to help address greenhouse gas-driven global warming in a meaningful way, there are still many more questions and issues to resolve before moving forward. The success of the workshop was in the way it built connections among researchers and other experts with a diverse range of perspectives and specialties, Raven said.

"There's a chance, based on what we know today, that this approach could work, if we pool the expertise of all these people from all these different fields," Raven said. "It's not impossible."

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