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Special issue overview

Overview: Environmental impacts of ocean alkalinity enhancement

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There is consensus in the scientific community that even under the most optimistic emissions scenarios, the target of a maximum of 2 °C of warming as stated in the Paris Agreement will no longer be achievable by reducing CO_2 emissions alone. Measures to actively remove CO_2 from the atmosphere will have to be used. To date, research in this area has focused on land-based measures for carbon dioxide removal (CDR). However, many of the land-based measures are in conflict with other interests and requirements, such as food security, urbanization, water supply and the preservation of biodiversity. The capacity of land-based CDR is also considered to be rather low. In contrast, ocean-based measures under consideration generally have few conflicts of interest and a comparatively high capacity. Of the various marine CDR (mCDR) technologies proposed to date, ocean alkalinity enhancement (OAE) has, arguably, the largest carbon removal potential. OAE has several advantages over other approaches: it does not compete for nutrient use, it is applicable to large regions of the coastal and open ocean, it mitigates ocean acidification, and it has a high potential for permanence. Consequently, more and more players in the private sector endeavour to pursue OAE, leading to the potential risk that independent, non-profit-oriented research could fall behind in providing a balanced assessment of OAE, in terms of its efficiency, long-term storage of CO_2 and environmental safety.

OAE mimics the natural process of rock weathering, which has helped to stabilize the Earth's climate over the past billions of years. Now, however, the carbon dioxide input caused by humans is about 100 times too fast to be balanced by natural weathering. The direct addition of alkaline minerals to the sea has the same effect as rock weathering: the pH value rises and the CO_2 concentration in the surface ocean decreases as a result. As the ocean and atmosphere strive to equilibrate, more CO_2 is transported from the atmosphere into the ocean.

An essential prerequisite for the implementation of OAE approaches is their environmental safety, keeping in mind that climate change has already had detrimental effects and that future harm to ecosystems may be greater than with OAE. The paramount metrics for environmental safety of OAE measures are the preservation of structural and functional biodiversity; ecosystem functioning; and associated ecosystem services, including fisheries, climate regulation and coastal protection. With this in mind, it is of critical importance to determine the regionally allowable scale of manipulation against the environmental baseline at the location considered for OAE. Research is essential to better understand how diverse OAE approaches can be effectively and safely implemented while minimizing ecological disruption. That kind of knowledge will be required by the authorities and the general public to judge whether or not OAE implementation is benign. However, the governance structures have yet to be established.

In this special issue, over a dozen papers examine the environmental impacts of several OAE approaches (different minerals, equilibrated and non-equilibrated) across a range of organisms, regions and experimental systems. In view of the predominantly moderate responses to OAE reported in these studies, it is of utmost importance that all parties involved with OAE research and development act with a sense of proportion. It is essential for the licensing authorities to apply sound judgement in the sense that the risks of inaction are recognized. On the implementation side, work is needed to provide knowledge to the public that helps them weigh the benefits of OAE versus its risks to help shape the process. And on the jurisdictional side, work is needed to create governance structures that facilitate mCDR activities. Given the urgency of the climate crisis, there is no time to lose.

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