Research Mission of the German Marine Research Alliance (DAM)
»Marine carbon sinks in decarboniation pathways«

FACT SHEET

Synthesis

An assessment framework for marine carbon dioxide removal methods

More research is currently being conducted on marine carbon dioxide removal methods than ever before. Expertise on each approach continues to grow. At the same time, policymakers are relying on carbon dioxide removal methods to meet national climate goals. What is missing is a tool to bring together research results and evaluate methods – in a transparent way that everyone can understand. In the research mission CDRmare, an interdisciplinary team of scientists is developing an evaluation framework to make this possible. It not only asks whether a method is technically, legally or politically feasible, but also whether its use can be described as »desirable« in terms of the ethical and moral principles of our society – a fundamentally important contribution to future debates.

The big climate goal: net zero

There is a consensus in scientific climate research that humanity will only reduce global warming and its increasingly drastic consequences and risks, if it reduces the amount of its annual carbon dioxide emissions into the atmosphere to a calculated zero (net zero).

Human-induced carbon dioxide emissions result from the burning of fossil fuels such as oil, natural gas and coal, as well as changes in land use. It is unclear how mankind can avoid 100 percent of these emissions in the future in a technically, economically and socially acceptable way. Experts assume

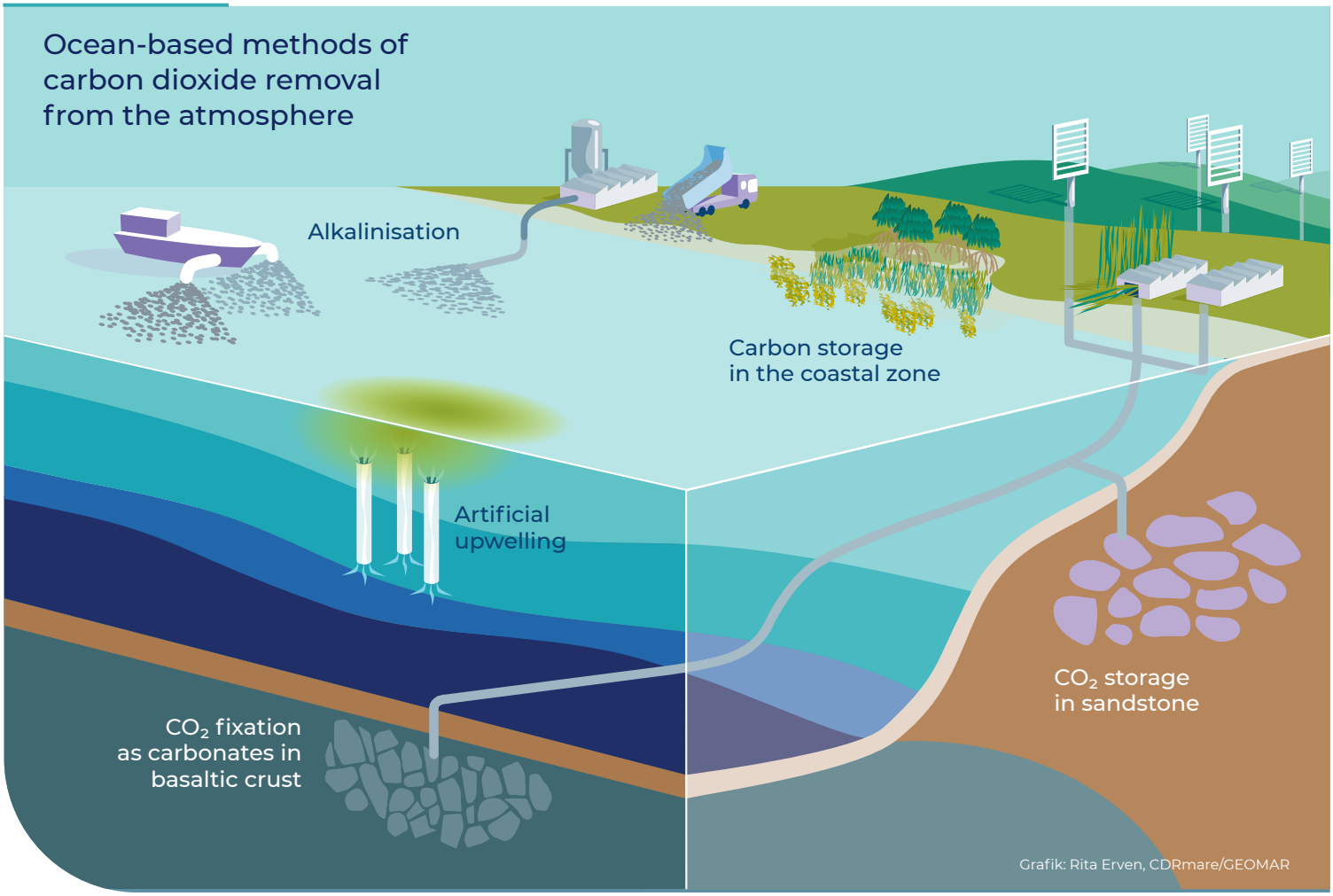
Is or would the use of marine CDR methods be desirable and worthwhile for humans and the environment in the long term?
Photo: Nattu-Adnan, unsplash.com

that mankind will still be emitting carbon dioxide and other greenhouse gases in the middle of the 21st century.

According to optimistic forecasts, the level of these residual emissions for Germany is estimated at 10 to 20 percent of our current greenhouse gas emissions. This share corresponds to emissions of around 60 to 130 million metric tons of greenhouse gases per year, including to a large extent methane and nitrous oxide. However, there is still no societal consensus on how high potential residual emissions may be and which sectors may cause them. At present, residual emissions are difficult to avoid, for example, in cement production, air and heavy-duty transport, agriculture and waste incineration.

Experts agree that residual emissions must be compensated if warming is to be halted. There are various approaches to this. Methods that remove carbon dioxide from the atmosphere are known as carbon dioxide removal (CDR). In addition, methods are being discussed in which the release of residual emissions is prevented – for example, by capturing the carbon dioxide from fossil sources at the emission source and subsequently storing it geologically, i.e., in the deep underground. Processes of this type are known as carbon capture and storage (CCS) and are not counted as removal processes.

Many known methods of carbon dioxide removal are land-based. However, because land area is a scarce resource, ocean-based methods are now coming into greater focus. In the inter-disciplinary research mission CDRmare, researchers investigate a wide range of marine approaches, including methods and measures that appear promising.



Difficult decisions for society and politics

Human intervention in marine space with the aim of increasing the ocean's carbon dioxide uptake is associated with a change in marine chemistry or ecosystems and thus in the living conditions for many marine organisms. The ocean is also an intensively and diversely used space by humanity, and our demands on ocean services continue to increase. An entire branch of industry – the ocean economy or blue economy – relies on the ocean to provide a growing world population with the food, energy and raw materials (also for the energy transition) that can no longer be produced on land in sufficient quantities. Any use of and intervention in the sensitive ocean system must therefore be carefully considered and it must be ensured that the biotic

communities of the oceans are preserved and used sustainably. According to current estimates, mankind will have to remove 420 to 1100 billion tons of carbon dioxide from the atmosphere over the next 80 years if it wants to limit global warming to 1.5 degrees Celsius by 2100. If this removal were to be done increasingly by ocean-based methods, it would require large-scale interventions over long periods of time – that much is already clear – even if only the most efficient methods were used. That is, international industries and their associated regulatory frameworks would have to emerge, the primary purpose of which would be to increase carbon dioxide uptake by the oceans.

This complex situation poses an enormous challenge to society and its decision-makers. It is necessary to effectively limit climate change and at the same time ensure sustainable development and thus a future worth living for all people on earth. This is how the international community has defined it in the 17 goals for sustainable development, which must also be taken into account when considering marine carbon dioxide removal methods. In these goals, the international community has committed itself, among other things, to the protection of life under water, the protection of biological diversity, climate protection and the right of people to peace, health, education and fair treatment.

How can marine carbon dioxide removal methods be evaluated?

To meet this challenge, political and societal decision-makers need answers to the questions of whether marine carbon dioxide removal methods actually work to the extent hoped for, whether they would be politically, legally, socially and financially feasible, what additional benefits and risks they pose to humans and the environment, and whether the impacts associated with their use are actually desirable in the long term. Based on this knowledge, a fact-based decision can then be made as to whether or not marine CDR methods might be implemented on a large scale.

An urgently needed guide for evaluating the various CDR methods is being developed by scientists from the natural sciences, social sciences, humanities, law and economics in the research mission CDRmare. It is intended to cover the many dimensions of the multi-faceted topic of carbon dioxide uptake and storage in the ocean, and to enable a fact-based and comprehensible judgement to be made on individual methods or future individual projects and applications.

However, before the researchers can test the first version of such an assessment framework for its suitability for use, the scientists must answer fundamental questions.

Which categories should be used to evaluate marine carbon dioxide removal methods?

In the debate on marine carbon dioxide removal methods, the main focus so far has been on technological, economic, political and legal feasibility and thus on the question: Which methods work and can actually be implemented?

However, a second question plays an equally important role, but is often not explicitly asked: Is or would the use of marine CDR methods also be desirable for society? This involves weighing the advantages and disadvantages and whether they are compatible with other community goals.

The importance of this question is demonstrated, among other things, by the fact that almost all scientific studies dealing with the feasibility of marine CDR methods also consider possible positive and negative impacts for humans and the environment. Researchers want to find out whether marine methods of carbon dioxide removal can contribute to our goal of greenhouse gas neutrality without compromising other internationally recognised goals and norms – such as the right to food and health.

Another increasingly important claim is that of equitable and fair burden-sharing of climate change. This is being debated politically under the heading of »climate justice«. Against the background of the debate on marine carbon dioxide removal methods, this aspect includes in particular questions such as: Should the major greenhouse gas emitters primarily pay for potential CDR measures? How will potential risks and benefits of CDR deployment be distributed? And should states be allowed to export captured carbon dioxide to other countries for underground storage?

In the research mission CDRmare, researchers therefore pursue the goal of developing, for the first time, an evaluation framework for marine carbon dioxide removal methods that clearly distinguishes between the evaluation categories of what is technologically, economically, legally and politically feasible and what is community desirable, and assigns the same priority to both categories. This is to ensure that, in the course of a process or project evaluation, all information relevant to the decision is compiled transparently and that, on this basis, a comprehensive judgment can be made about the suitability of the process or project – both from a technical, financial, legal and political perspective and measured against recognised social and environmental standards. In this context, the findings of all consortia working on the individual extraction and storage methods within the research mission CDRmare are incorporated into the assessment – for example, on blue carbon, on the alkalinity increase of seawater, on artificial upwelling, and on carbon dioxide deposits in the upper ocean basalt crust or in the sandstone formations under the German North Sea.

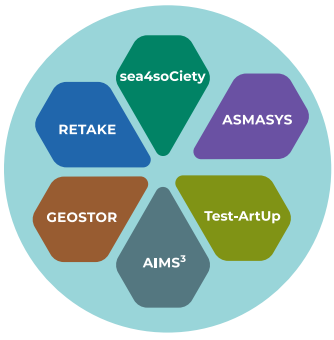
The clear systematic distinction of the assessment of feasibility and desirability is enormously important for a societal debate. Because ultimately, we need a debate not only about which forms of CDR we can implement, but also about which forms of CDR we want to implement. Science cannot decide the latter for society, but it can provide important foundations for the debate. The evaluation guide to be developed is intended to contribute to this.

What challenges arise from the task of developing the assessment guide as a tool for German climate protection policy?

Researchers in CDRmare investigate the extent to which marine methods for carbon dioxide removal within German territorial waters or as part of an internationally oriented German climate strategy are feasible and socially desirable.

As part of this process, the researchers will enter into dialogue with stakeholders from politics, industry and civil society in order to obtain or jointly develop their views on the envisaged assessment categories and criteria. The development of plausible deployment scenarios for marine carbon dioxide removal methods provides a platform for discussion. It is also planned to synchronise the assessment guideline developed in CDRmare in such a way that it enables comparison with land-based carbon dioxide removal methods.

In the end, according to the CDRmare team's objective, the developed assessment framework for marine carbon dioxide removal methods should enable the German government and other decision-makers to form a comprehensive opinion on the different ocean-based carbon dioxide removal methods and to adapt their climate protection strategies and measures accordingly.



All research activities described here are carried out within the CDRmare consortium »ASMASYS – Assessment framework for marine CO_2 removal and synthesis of current knowledge«.

Within the research mission CDRmare of the German Marine Research Alliance (DAM), which involves about 200 researchers in 6 consortia, different methods of marine CO_2 removal and storage (alkalinisation, blue carbon, artificial upwelling, CCS) are investigated with respect to their potential, risks and trade-offs and brought together in a transdisciplinary assessment framework. CDRmare has been funded by the German Federal Ministry of Education and Research with 26 million euros since August 2021 and will run for three years.

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