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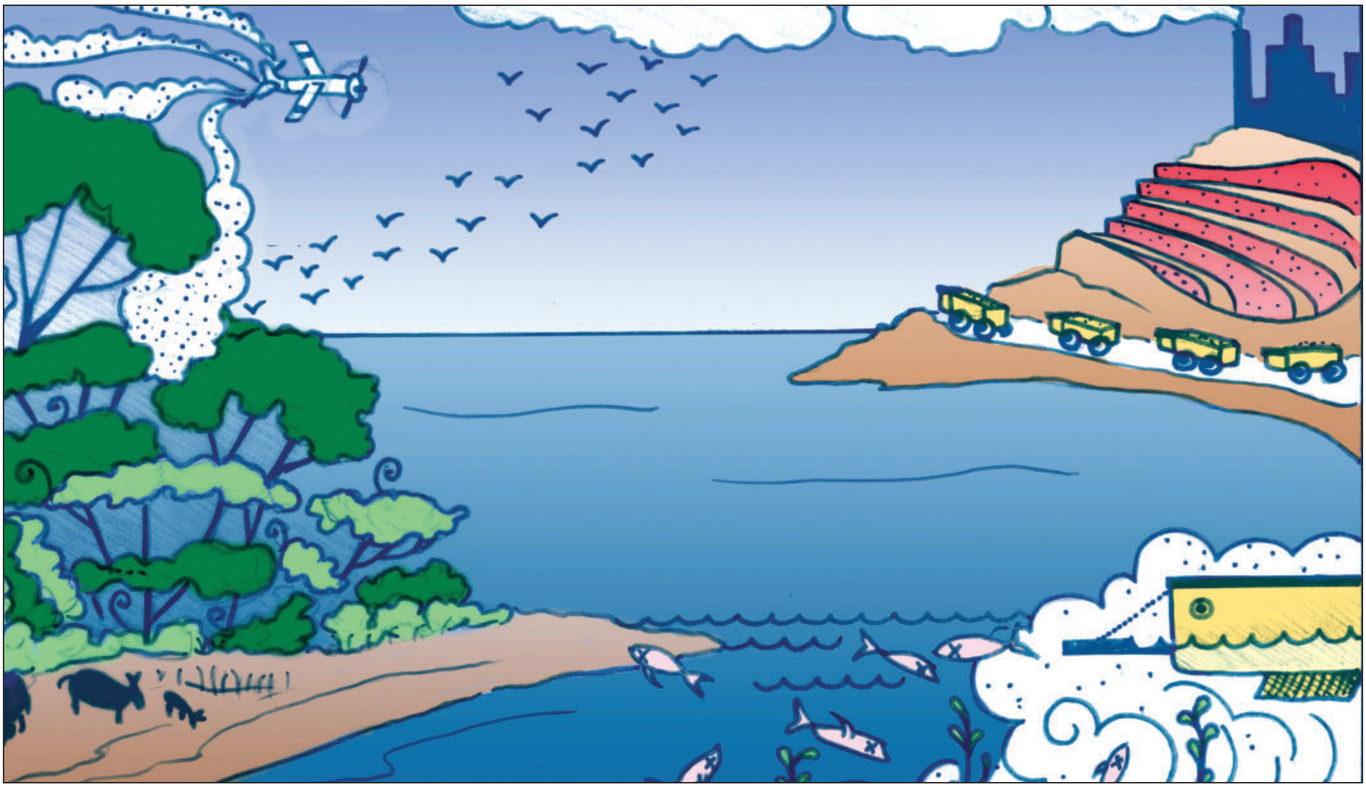
Enhanced weathering (marine & terrestrial)



Enhanced weathering is a theoretical process of sequestering carbon by scattering mined minerals over vast areas.

Description and purpose of the technology

Enhanced weathering (EW) is a set of theoretical proposals to remove CO_2 by spreading large quantities of selected and finely ground rock material onto extensive land areas, beaches or the sea surface. The hypothetical carbon dioxide removal (CDR) technology aims to mimic and accelerate the natural weathering processes of silicate and carbonate rocks, a slow carbonation process that is estimated to consume and absorb about one billion tonnes of CO_2 from the atmosphere every year.

Point of Intervention:

Reality Check:

The acceleration of the weathering process would theoretically be achieved by mining and crushing large amounts of suitable rocks to increase the amount of weathering rocks as well as their reactive surface.[1] Accelerating the CO_2-consuming weathering process is associated with great expenses, and also with impacts on poor communities, environmental damages, and high water and energy consumption comparable to coal mining. Suitable rocks, particularly silicate and carbonate minerals rich in Calcium and Magnesium such as olivine-rich ultramafic and mafic rocks or basaltic rocks, need to be mined, crushed, transported and dispersed.

Other proposals suggest the use of waste materials, such as mine tailings or industrial by-products from iron and steel production, for example steel slag or cement kiln dust, which may release pollutants with harmful effects.[2]

The dispersion of minerals and waste materials able to absorb CO_2, is proposed for terrestrial, coastal and marine environments. On land, the application is usually proposed for agricultural fields, based on the argument that addition of stone meals may increase soil fertility and therefore crop yields.[3] Although stone meals are regularly used as fertilisers or soil conditioners to correct deficiencies in soil nutrients or soil structure, it is unlikely that the amount required for an optimum supply of nutrients would have substantial effects on the global concentration of atmospheric CO_2: the average amount of finely ground rock needed to absorb 1 tonne of CO2 is 2 tonnes.[4]

Enhanced weathering in marine environments is also referred to as ocean alkalinity enhancement (OAE) and involves adding ground minerals directly to the ocean or dumping them on beaches where wave action disperses them into water to theoretically increase alkalinity and therefore CO_2 uptake. The effects of OAE on biochemical processes or the marine food chain are unknown.[5]

Actors involved

Although some companies attempt to commercialise EW approaches, most activities take place within the scope of research projects originating from academic research institutions in the UK, the Netherlands and North America.

In the UK, the Oxford Geoengineering Programme, an initiative led by Tim Kruger at Oxford University, leads and conducts research activities on EW. The project Greenhouse Gas Removal by Enhanced Weathering (GGREW) aims to explore the feasibility of EW in oceans, assess different ways to accelerate the weathering process artificially and plans to conduct open-ocean trials in the Great Barrier Reef, Australia and in the Gulf of Aqaba, off the coast of Israel. Since 2008, Tim Kruger has been trying to market an OAE approach based on lime. His company Cquestrate received early-stage funding from Shell.

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The Leverhulme Centre for Climate Change Mitigation (LC3M), based at and led by the University of Sheffield, UK, was founded in 2016 to conduct research on EW on croplands as a potential strategy for increasing field yields while removing CO_2 from the atmosphere. The research activities also include field trials at farming sites, applying 50 tonnes of mined and crushed basalt per hectare per year, to test EW in different agricultural environments. The trials are conducted on farms in Australia, Malaysia and the USA with various crops, among them oil palm, sugar cane and soy. The LC3M also studied EW in coastal environments and carried out laboratory tests with sea water in cooperation with the University of Brussels, in Belgium.

In the Netherlands, Olaf Schuiling conducted lab-based research on EW with olivine-rich rocks at Utrecht University. He founded the Smart Stones Foundation (formerly The Olivine Foundation) in 2009 to promote and commercialize olivine applications for CO_2 removal and conducted small-scale trials. Larger outdoor trials were proposed but not put into practice. Schuiling's research contributed to the founding of the Dutch companies greenSand and Green Minerals, both trying to commercialise EW with olivine-rich rocks. Green Minerals also participates in the German research project CO_2MIN, which explores the absorption of CO_2 with olivine-rich and basalt rocks from flue gas.

A limestone quarry   Photo by Thomas Bjørkan via Flickr

Furthermore, EW requires these big quantities of rocks to be milled, transported and dispersed, which further increases the CO_2 and environmental footprint of EW.[8]

Although rock products may supply nutrients to agricultural land, they may also change soil properties and release substances with harmful effects even in small doses, such as nickel, chromium or cadmium. EW may also provoke hydrological changes and pollution in water bodies by leaching or erosion.[9]

In Northern America, researchers at the University of Guelph, Ontario, proposed and test EW with the calcium silicate rock wollastonite in pot trials with beans and corn. The suitability of mine tailings from nickel, diamond or platinum mining for EW is tested in a research project financed by Natural Resources Canada and conducted by the University of British Columbia. UBC partnered with the FPX Nickel Corporation, an owner of several nickel mines, to conduct field trials at a mine in the Decar Nickel District in British Columbia, Canada. The California-based Project Vesta, founded by "biohacker" and brain drug entrepreneur Eric Matzner, aims to set up a project for testing EW with olivine-rich rocks on beaches. Oceankind, a philanthropic funding organisation, plans to form a knowledge hub on OAE with stakeholders from science, policy and the private sector and organised a kick-off event in California, in September 2019.[6]

Impacts of the technology

In the event EW is employed with the goal to significantly reduce atmospheric CO_2-concentration on a global scale, huge amounts of rocks would need to be mined, comparable to present day global coal mining, because it takes approximatively 2 tonnes of rock material to absorb 1 tonne of CO_2. Obviously, such massive mining operations would increase exponentially the devastating effects of mining on poor communities around the world, as well as increase the significant adverse environmental impacts and cause large amounts of greenhouse gas emissions.[7]

EW is often recommended for tropical regions with soils poor in nutrients such as oxisols and ultisols. This is in contradiction to the findings, which suggest that weathering is highly sensitive to temperature with optimum results at temperatures from 10°C to 15°C, and both low and high temperatures limit weathering.[10]

If milled rock material is applied directly to the ocean and on a larger scale, harmful substances, changes in the silicon concentration, or unintended biogeochemical processes may affect marine biota. OAE could lead to changes in the composition of marine species and changes in the marine food web. Its effects on deep-sea life are unknown.[11]

If products from mines and industry are considered for EW or OAE, they are likely to contain substances such as heavy metals, which would affect marine life and the ocean's biogeochemistry.[12]

Enhanced weathering and ocean acidification enhancement are cost- and energy-intensive proposals for terrestrial, coastal and marine environments. They are associated with unforeseeable risks for ecosystems, large social impacts for communities in mining areas, and a very doubtful overall emission balance. In addition, EW and OAE are impracticable due to the massive amounts of rock required and their potential to actually remove CO_2 on a larger scale is not proven.

Reality check

EW and OAE are mainly based on modelling exercises and theoretical models, but a few field-scale trials are being conducted and further trials are anticipated or in preparation, among them experiments in reef environments in Israel and Australia (GGREW), on beaches in the Caribbean (Project Vesta), and in nickel mines in Canada (FPX Nickel Corporation and research partners).

Further reading

ETC Group and Heinrich Böll Foundation, "***Geoengineering Map***."
https://map.geoengineeringmonitor.org/

Endnotes

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