How costly is active CO2 drawdown in marine systems? A socio-economic analysis of Coastal Enhanced Silicate Weathering

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The Paris climate agreement aims to reduce global warming by 1.5°C by the end of the century. This goal is only achieved through a collective and ambitious effort that requires not only "traditional mitigation" (avoidance of fossil CO_2 emissions) but also active CO_2 drawdown from the atmosphere (negative emissions). The latter is realized using "negative emissions technologies" (NETs), most of which are in an early stage of development. A number of technologies focus on CO_2 drawdown in the marine realm, which covers 71% of the earth's surface. One promising approach for achieving marine negative emissions is through coastal enhanced silicate weathering (C-ESW).

The geological rock record shows that the natural process of silicate weathering is able to take up large amounts of CO_2 from the atmosphere, thus stabilizing the climate. However, natural rock weathering is very slow, so the idea behind enhanced weathering is to stimulate this process by: [1] selectively mining fast weathering rocks such as olivine, [2] finely grinding these rocks so that more surface area is exposed to weathering, and [3] spreading these rocks in favorable locations with high dissolution rates. The coastal zone is potentially such a favorable environment, where wave and current action will naturally grind silicate particles, and biological activity stimulates silicate dissolution. A major advantage of coastal-ESW is that deployment can be done with current infrastructure, making it rapidly deployable and readily scalable.

Yet, to fully assess the potential of coastal-ESW as a NET technique, the following aspects need to be assessed: (1) the CO_2 sequestration efficiency, (2) the ecosystem impact, and (3) the economic feasibility. The first two aspects are currently investigated in a large-scale mesocosm facility operated by UAntwerpen and VLIZ at the Marine Station Oostende. The goal of the current study was to investigate the economic feasibility of C-ESW. For this purpose, we first created a weathering model that predicts the speed at which silicate particles weather and sequester CO_2 in coastal waters. This weathering model was subsequently integrated into an economic cost model that compares the investment costs from C-ESW with the future profits made from CO_2 credits (i.e. the price the market pays for a ton of CO_2 sequestration). The investment cost is determined by the mining, grinding, transport, and spreading costs as well as the external CO_2 emissions associated with these activities. The future profits depend on the temporal evolution of CO_2 sequestration and the future CO_2 price. The latter is a crucial but uncertain parameter, as it highly depends on our ambition to tackle climate change as a society. To encompass this uncertainty we modeled 3 separate socio-economic pathways: [1] a high generational inequality pathway, where we bet on future generations to solve the climate crisis, [2] a low generational inequality pathway, where society places greater weight on the well-being of future generations and hence acts more responsibly, and finally [3] the whatever-it-takes pathway, where society does everything needed to limit global warming to 1.5 °C by the end of the century.

Overall our analysis shows that coastal ESW can act as a cost-effective pathway for marine carbon dioxide removal, where the overall financial return on investment is positive. In my presentation, I will discuss the economic feasibility of C-ESW in more detail, highlighting the economic trade-offs present. These results can serve as a guideline for its implementation in future trial experiments. Furthermore, our analysis sheds light on the role C-ESW can play as a future technology for active CO_2 removal from the atmosphere.

Keywords: Coastal enhanced silicate weathering; Cost analysis; Negative emission technologies; CO_2-removal; Carbon dioxide removal, Climate change