Aluminum may affect climate change by increasing ocean's carbon sink capacity

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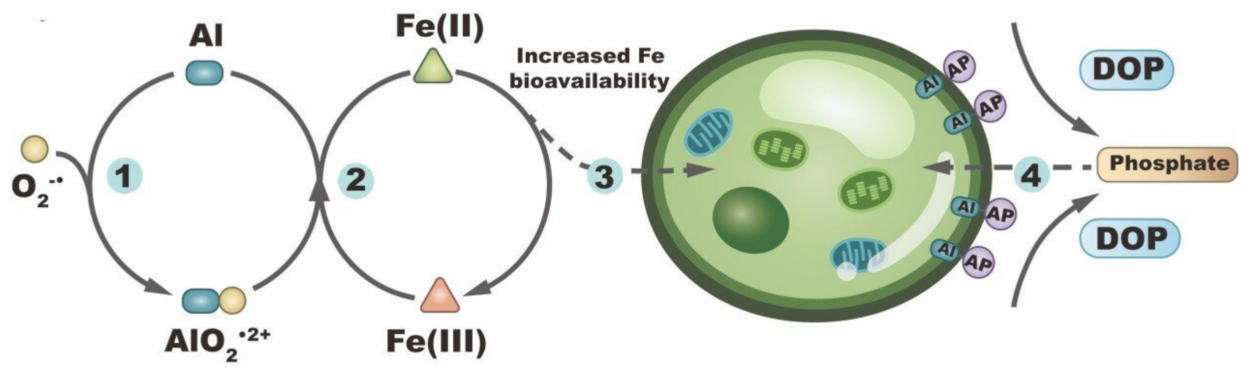


Diagram of how aluminum may facilitate the uptake of iron and the utilization of dissolved organic phosphorus by marine phytoplankton. Credit: ZHOU Linbin

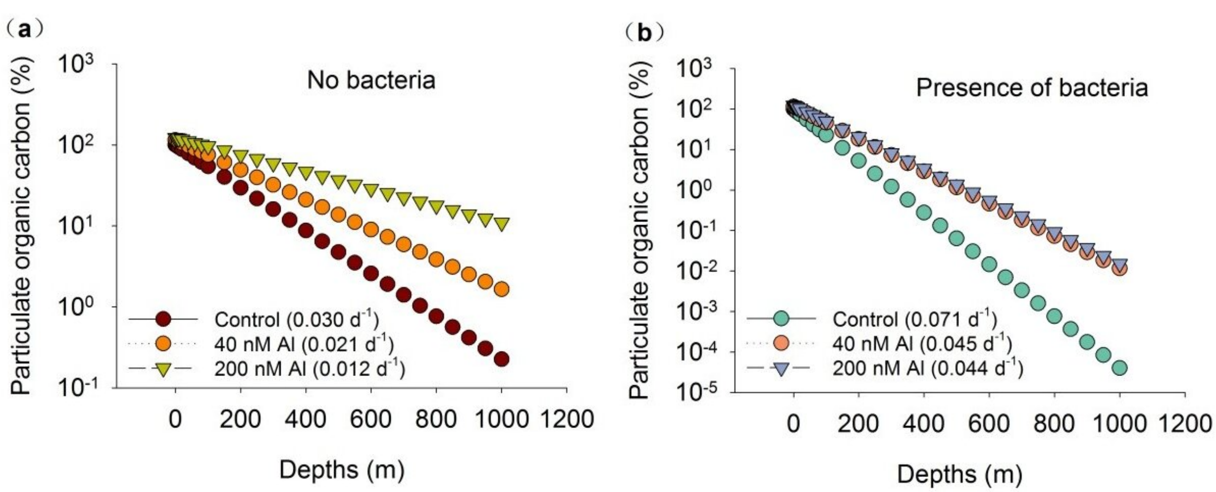
Reducing net greenhouse gas emissions to zero as soon as possible and achieving "carbon neutrality" is the key to addressing global warming and climate change. The ocean is the largest active carbon pool on the planet, with huge potential to help achieve negative emissions by serving as a carbon sink.

Recently, researchers found that adding a small amount of aluminum to achieve concentrations in the 10x nanomolar (nM) range can increase the net fixation of CO_2 by marine diatoms and decrease their decomposition, thus improving the ocean's ability to absorb CO_2 and sequester carbon at deep ocean depths.

The study, published in *Limnology and Oceanography* on May 3, was conducted by a joint team led by Prof. Tan Yehui from the South China Sea Institute of Oceanology (SCSIO) of the Chinese Academy of Sciences and Prof. Peter G.C. Campbell from the Eau Terre Environnement Research Centre of the National Institute of Scientific Research, Canada.

According to the earlier 'iron hypothesis,' adding a small amount of iron to the iron-limited but nutrient-rich oceans could significantly promote the growth of marine phytoplankton (microalgae) and their absorption of CO_2, and the consequent burial of organic matter in the ocean. However, the results of artificial iron fertilization experiments did not fully support the iron hypothesis and later studies suggested that ignoring the effects of aluminum and other elements may be the reason.

"In fact, natural iron fertilization, as caused by dust deposition, upwelling and hydrothermal venting, provides the ocean not only iron, but also aluminum and other elements. Aluminum concentrations in the upper ocean are usually one order of magnitude higher than those of iron," said Prof. Tan.



Estimated effects of aluminum on the export of particulate organic carbon to ocean depths. Credit: ZHOU Linbin

Prof. Tan's team and their collaborators found that aluminum may not only improve the utilization efficiency of iron and dissolved organic phosphorus by marine phytoplankton, thus enhancing carbon fixation in the upper ocean, but may also reduce the decomposition rate of biogenic organic carbon and enhance the export and sequestration of carbon in deep ocean depths.

They also found a significant negative correlation between aluminum input to the Southern Ocean and atmospheric CO_2 concentration over the past 160,000 years.

Based on their findings about aluminum, they improved the original "iron hypothesis" by proposing the "iron-aluminum hypothesis" to better explain the roles of the two elements in climate change.

In this study, the researchers used radiocarbon (^{14}C) as a tracer to show that adding aluminum to seawater to achieve trace concentrations (e.g., 40 nM) increased net carbon fixation of marine diatoms 10% to 30%.

More importantly, this study proved that environmentally relevant low concentrations of aluminum can reduce the daily decomposition rate of marine diatom-produced particulate organic carbon by 50% or more.

Calculations based on the new data suggest that adding aluminum at a concentration of 40 nM or lower to the ocean may increase the amount of particulate organic carbon exported to depths of 1,000 m and deeper by 1-3 orders of magnitude. This will significantly increase the ocean's carbon sink capacity and sequester carbon in the ocean for a long time, thus ameliorating climate change.

More information: Linbin Zhou et al, Aluminum increases net carbon fixation by marine diatoms and decreases their decomposition: Evidence for the iron–aluminum hypothesis, *Limnology and Oceanography* (2021). DOI: 10.1002/lno.11784

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