Scientists unravel drivers of the global zinc cycle in our oceans, with implications for a changing climate

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Team South Africa getting ready to board South Africa's polar research vessle, the SA Agulhas II, for the 2019 expedition to Antarctica. Credit: Wiida Fourie-Basson

The important role of the Southern Ocean in global biological processes and the carbon cycle has been confirmed anew by a study published in *Science* that, for the first time based on field evidence, reveals the underappreciated role of inorganic zinc (Zn) particles in these cycles.

The Southern Ocean plays the greatest role in global phytoplankton productivity, which is responsible for absorbing atmospheric carbon dioxide. In these processes, Zn, present in trace quantities in seawater, is an essential micronutrient critical to many biochemical processes in marine organisms and particularly for polar phytoplankton blooms.

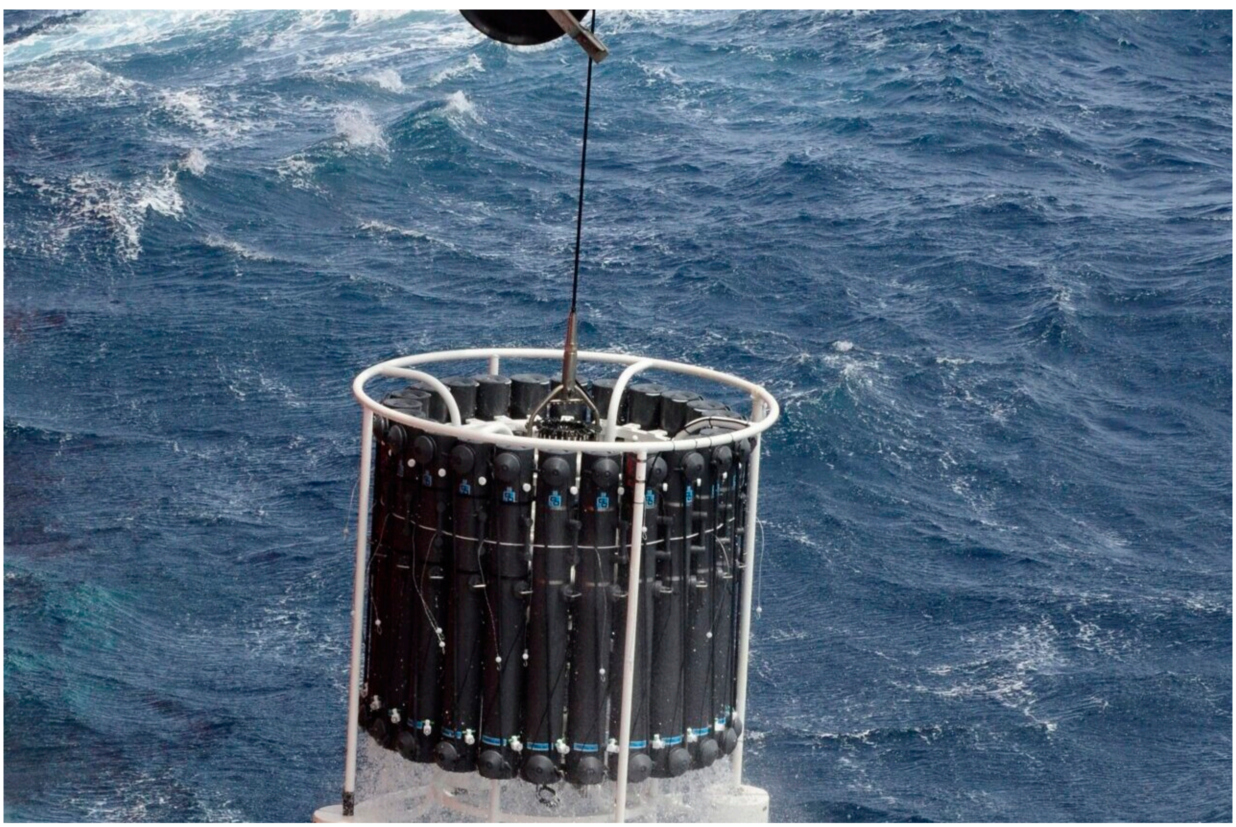
When phytoplankton blooms perish, Zn is released. But to date, scientists have been puzzled as there was an observed disjunct between Zn and phosphorus, another nutrient essential for life in the oceans, even though both nutrients are co-located in similar regions in phytoplankton. Instead, a strong (but inexplicable) coupling between Zn and dissolved Silica is often seen.

Prof. Alakendra Roychoudhury, a specialist in environmental and marine biogeochemistry at Stellenbosch University (SU) and a co-author on the article, says they can now, for the first time, explain with confidence the biogeochemical processes driving the oceans' Zn cycle.

Since 2013, Roychoudhury's research group in SU's Department of Earth Sciences have joined three expeditions of South Africa's polar research vessel, the SA Agulhas II. Crossing the vast Southern Ocean on its way to Antarctica in both summer and winter, the team collected sea water samples from the surface and deep ocean, as well as sediments.

Dr. Ryan Cloete, co-first author on the paper and currently a postdoctoral fellow at the Laboratory of Environmental Marine Sciences (LEMAR) in France, participated in two of these expeditions. "Studying the Southern Ocean is so important as it acts as a central hub for global ocean circulation. Processes occurring in the Southern Ocean are imprinted on water masses which are then transported to the Atlantic, Indian and Pacific Oceans," he explains.

Working with researchers from Princeton University, the Universities of Chicago and California Santa Cruz, as well as the Max Planck Institute for Chemistry, the samples were subjected to detailed particle by particle analysis, using X-ray spectroscopic techniques at a synchrotron facility, which allowed them to study the samples at atomic and molecular level.



A Conductivity-Temperature-Depth (CTD) rosette housing 24 GO-FLO bottles about to be lowered to a depth of 4,500 meters below surface during the SA Agulhas II 2019 expedition to Antarctica. Credit: Stellenbosch University

Unraveling the drivers of the global Zn cycle in our oceans

In summer it seems that higher productivity leads to a greater abundance of Zn in the organic fraction of the surface ocean, which can readily become available for uptake by phytoplankton. But the researchers also found high concentrations of Zn associated with debris derived from rocks and earth, and from atmospheric dust, present in these samples.

In the open ocean, the interplay between Zn's association or dissociation from particles is pivotal for replenishing dissolved Zn to support marine life.

Cloete explains, "Due to poor growing conditions in winter, Zn particles are literally 'scavenged' by inorganic solids such as silica, abundantly available in the form of diatoms, as well as iron and aluminum oxides. Diatoms are microalgae—unicellular organisms with skeletons made of silica—thereby explaining the strong association between Zn and Silica in the oceans."

In other words, when Zn is bound to an organic ligand it is easy for uptake by marine life such as phytoplankton. Zn in a mineral phase, however, is not easy to dissolve and will therefore not be easily available for uptake. In this form, particulate Zn can form large aggregates and sink to the deep ocean, where it becomes unavailable for uptake by phytoplankton.

Implications for changing climate

This understanding of the global Zn cycle has important implications in the context of warming oceans, warns Roychoudhury. "A warmer climate increases erosion, leading to more dust in the atmosphere and consequently more dust being deposited into the oceans. More dust means more scavenging of Zn particles, leading to less Zn being available to sustain phytoplankton and other marine life."

Cloete says their novel approach to studying the oceanic Zn cycle now opens the door to investigating other important micronutrients. "Like Zn, the distribution of copper, cadmium, and cobalt could also experience climate-induced changes in the future," Cloete said.

For Roychoudhury, the findings reaffirm the Southern Ocean's global influence in regulating the climate and the marine food web.

"The Earth system is intricately coupled through physical, chemical and biological processes with self-correcting feedback loops to modulate variability and negate climate change. Our findings are a prime example of this coupling where biochemical processes happening at the molecular level can influence global processes like the warming of our planet," said Roychoudhury.

More information: J. Duan et al, Biogenic-to-lithogenic handoff of particulate Zn Impacts the Zn-cycle in the Southern Ocean, *Science* (2024). DOI: 10.1126/science.adh8199. www.science.org/doi/10.1126/science.adh8199

Provided by Stellenbosch University

https://phys.org/news/2024-06-scientists-unravel-drivers-global-zinc.html