

# Simple process extracts valuable magnesium salt from seawater

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Researchers can isolate magnesium feedstocks from the ocean, important for renewable energy applications. Credit: Composite image by Cortland Johnson, Pacific Northwest National Laboratory

Since ancient times, humans have extracted salts, like table salt, from the ocean. While table salt is the easiest to obtain, seawater is a rich source

of different minerals, and researchers are exploring which ones they can pull from the ocean. One such mineral, magnesium, is abundant in the sea and increasingly useful on the land.

Magnesium has emerging sustainability-related applications, including in [carbon capture](#), low-carbon cement, and potential next-generation batteries. These applications are bringing renewed attention to domestic [magnesium](#) production. Currently, magnesium is obtained in the United States through an energy-intensive process from salt lake brines, some of which are in danger due to droughts. The Department of Energy included magnesium on its recently released [list of critical materials](#) for domestic production.

A paper published in *Environmental Science & Technology Letters* shows how researchers at Pacific Northwest National Laboratory (PNNL) and the University of Washington (UW) have found a simple way to isolate a pure magnesium salt, a feedstock for magnesium metal, from seawater. Their new method flows two solutions side-by-side in a long stream. Called the laminar coflow method, the process takes advantage of the fact that the flowing solutions create a constantly reacting boundary. Fresh solutions flow by, never allowing the system to reach a balance.

This method plays a new trick with an old process. In the mid-20<sup>th</sup> century, chemical companies successfully created magnesium feedstock from seawater by mixing it with sodium hydroxide, commonly known as lye. The resulting magnesium hydroxide salt, which gives the antacid milk of magnesia its name, was then processed to make magnesium metal. However, the process results in a complex mixture of magnesium and calcium salts, which are hard and costly to separate. This recent work produces pure magnesium salt, enabling more efficient processing.

"Normally, people move separations research forward by developing more complicated materials," said PNNL chemist and UW Affiliate

Professor of Materials Science and Engineering Chinmayee Subban. "This work is so exciting because we're taking a completely different approach. We found a simple process that works. When scaled, this process could help drive the renaissance of U.S. magnesium production by generating primary feedstock. We're surrounded by a huge, blue, untapped resource."



Seawater from the PNNL-Sequim campus fueled this research project. Credit: Andrea Starr, Pacific Northwest National Laboratory

### **From Sequim water to solid salt**

Subban and the team tested their new method using seawater from the

PNNL-Sequm campus, allowing the researchers to take advantage of PNNL facilities across Washington State.

"As a Coastal Sciences staff member, I just called a member of our Sequm chemistry team and requested a seawater sample," said Subban. "The next day, we had a cooler delivered to our lab in Seattle. Inside, we found cold packs and a bottle of chilled Sequm seawater." This work represents the collaboration that can happen across PNNL's Richland, Seattle, and Sequm campuses.

In the laminar coflow method, the researchers flow seawater alongside a solution with hydroxide. The magnesium-containing seawater quickly reacts to form a layer of solid magnesium hydroxide. This thin layer acts as a barrier to solution mixing.

"The flow process produces dramatically different results than simple solution mixing," said PNNL postdoctoral researcher Qingpu Wang. "The initial solid magnesium hydroxide barrier prevents calcium from interacting with the hydroxide. We can selectively produce pure solid magnesium hydroxide without needing additional purification steps."

The selectivity of this process makes it particularly powerful. Generating pure magnesium hydroxide, without any calcium contamination, allows researchers to skip energy-intensive and expensive purification steps.



The laboratory-scale flow device for extracting magnesium salt. Credit: Qingpu Wang, Pacific Northwest National Laboratory

## **Sustainability for the future**

The new and gentle process has the potential to be highly sustainable. For example, the [sodium hydroxide](#) used to extract the magnesium [salt](#) can be generated on site using seawater and marine renewable energy. Removing magnesium is a necessary pre-treatment for seawater desalination. Coupling the new process with existing technologies could make it easier and cheaper to turn [seawater](#) into freshwater.

The team is particularly excited about the future of the process. Their work is the first demonstration of the laminar coflow method for selective separations. This new approach has many additional potential applications, but more work needs to be done to understand the underlying chemistry of the process. The [knowledge gap](#) offers new possibilities and research directions for powering the blue economy.

"We want to take this work from the empirical to the predictive," said PNNL materials scientist Elias Nakouzi. "There is an exciting

opportunity to develop a fundamental understanding of how this process operates while applying it to important problems like creating new energy materials and achieving selective separation of hard-to-separate ions for water treatment and resource recovery."

**More information:** Qingpu Wang et al, Flow-Assisted Selective Mineral Extraction from Seawater, *Environmental Science & Technology Letters* (2022). [DOI: 10.1021/acs.estlett.2c00229](https://doi.org/10.1021/acs.estlett.2c00229)

Provided by Pacific Northwest National Laboratory

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