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A new way to remove troublesome ions from water

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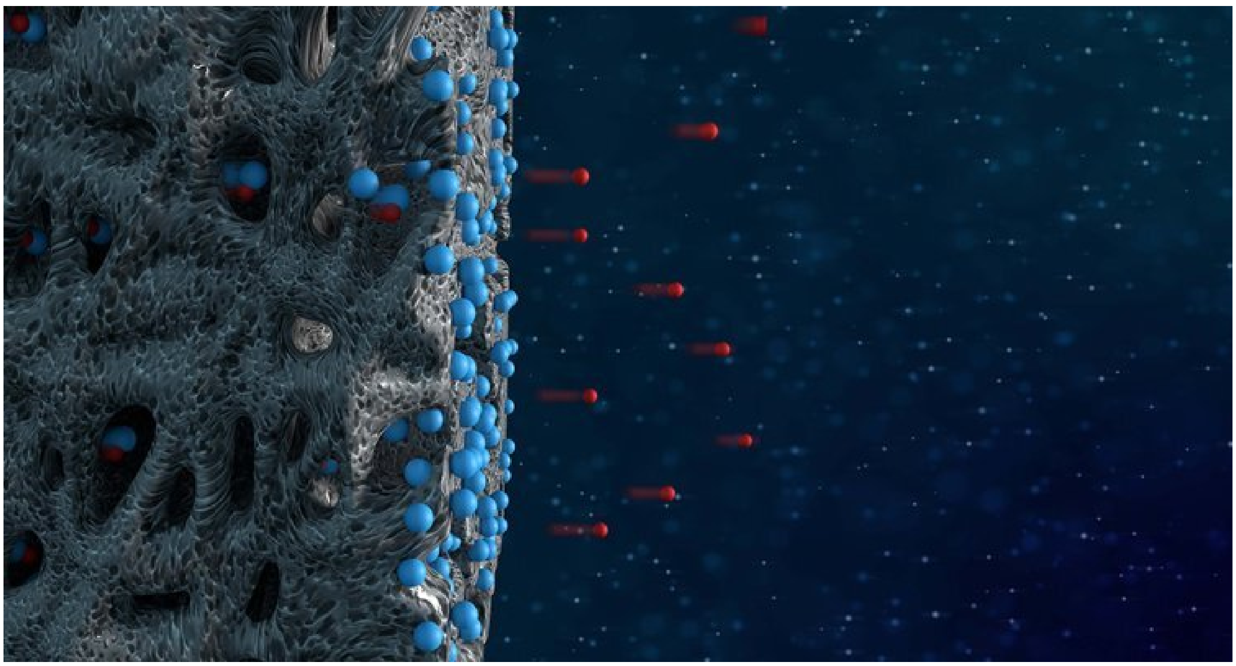

Credit: Wageningen University

Converting seawater into fresh water is important in water-scarce countries. For that process, certain charged particles—known as ions—have to be removed from the water. However, some ions are difficult to remove from water due to their chemical properties. Recent research by scientists from Israel and the Netherlands is helping to improve this ion-removal process.

The researchers were able to predict the behavior of boron ions during water processing and thus simplify their removal. The study is available on-line at the *Proceedings of the National Academy of Sciences* (*PNAS*). Many harmful or valuable ions in seawater, brackish water or freshwater are amphoteric: their properties vary with the pH. "It is difficult to remove these particles from the water with standard membrane technologies," says Jouke Dykstra, Assistant Professor at the Department of Environmental Technology at Wageningen University & Research. "You then have to add certain chemicals to control the pH. But we want to avoid that as much as possible: there is a strong trend to use fewer chemicals."

Seawater desalination

As an example of this ion removal process, Dykstra refers to the desalination of seawater. This is happening worldwide at locations with a shortage of fresh water. For example, many countries around the Mediterranean use desalinated seawater for irrigation. "But seawater also contains boron, which is toxic in high concentrations and it inhibits plant growth. Obviously, this is a problem for irrigation, and that is why we are looking for new ways to remove boron and other ions from sea water." Desalination is becoming increasingly important due to drought in many regions. Dykstra says that "new technologies are needed to continue to meet the demand for fresh water, not only in the Mediterranean and the Middle East, but also in the Netherlands."

Wageningen researchers are working on this challenge together with colleagues from Technion—the Israel Institute of Technology, and from Wetsus—the European Centre of Excellence for Sustainable Water Technology in Leeuwarden. Together they have developed a new theoretical model of the behavior of boron during a process known as capacitive deionisation. This is an emerging, membraneless technique for water treatment and desalination using microporous, flow-through electrodes When an electric current is applied, ions are adsorbed to the electrodes and hence removed from the water. Dykstra: "We are the first to develop a theoretical model that enables us to predict this behavior and use it to our advantage."

Entirely new design

The Israeli and Dutch researchers discovered that such systems require a completely new design. For example, they demonstrated both theoretically and experimentally that the water has to flow from the positive to the negative electrode, and not the other way around, as is now customary. "Our research has shown that a good theoretical model is essential to effectively control such complex chemical processes," concludes Dykstra. "This approach offers many interesting possibilities. You could also use this model for other challenges in waste water treatment, including removing arsenic or small organic molecules, such as drug residues or herbicides."

More information: Amit N. Shocron et al, Electrochemical removal of amphoteric ions, *Proceedings of the National Academy of Sciences* (2021). DOI: 10.1073/pnas.2108240118

Provided by Wageningen University