C2C

From Contaminant to Commodity: Toward a Circular Economy for Arsenic in Groundwater

Abstract

Millions of people in Europe rely on groundwater containing arsenic (As) levels above the WHO provisional drinking water guideline of 10 µg/L as their primary drinking water source. Groundwater treatment via As sorption to iron (Fe) oxides minimizes health impacts from As, but generates a concentrated As-loaded sludge by-product that is universally viewed as an environmental and economic burden. At the same time, As is experiencing a renaissance. The European Union classified As as a Critical Raw Material (CRM) in 2023 due to the role of metallic As(0) in materials needed for digital infrastructure and to transition to clean energy systems, such as high-speed electronics. The simultaneous requirements to remove As from groundwater, improve As-loaded waste management and create local sources of CRMs present a compelling opportunity to redefine carcinogenic As as a commodity.

The goal of this project, Contaminant to Commodity (C2C), is to develop a circular economy for As, thus maximizing the efficiency and sustainability of delivering low As drinking water, improving As-loaded waste management and recovering and valorizing CRMs. Eliminating the need for unsustainable As-loaded waste disposal practices, i.e., landfilling, sewer discharge or open disposal, ensures that improper management of waste from drinking water production does not perpetuate As contamination. Thus, this project contributes to water security in the long term and is consistent with multiple legislative goals adopted by the European Commission, including the 2020 Circular Economy Action Plan (CEAP) and the 2024 Critical Raw Materials Act (CRMA).

In C2C, we will apply an integrated approach to transform As in groundwater from an environmental burden to a valuable resource. To this end, we aim to:

- Characterize the structure and composition of As-loaded waste from different treatment plants across Europe;
- Identify structural properties of the waste that are most favorable for As extraction and recovery;
- Optimize reaction conditions to form As(0) from extracted aqueous As;
- Develop a novel method to create high-value As-bearing semiconductors from upcycled As(0);
- Apply life cycle assessment to evaluate the human health and ecotoxicity impacts of As(0) upcycling; and
- Estimate the availability of groundwater resources with chemistry optimal for arsenic extraction and recovery based on project findings and continent-wide groundwater chemistry databases.

The knowledge and novel methods developed in this project will ensure a variety of outcomes across several sectors in Europe, namely: improved As-loaded waste handling at European waterworks, including identification of optimum sludge composition for As(0) production; the creation of sustainable sources of semiconductor raw materials, which will improve current semiconductor manufacturing practices in Europe; and more informed regulations regarding As-loaded waste disposal and management as well as new regulatory guidance to aid the Green Transition in Europe.

KEYWORDS

groundwater chemistry,
arsenic treatment,
drinking water production,
critical raw materials, metallic arsenic,
advanced functional materials, semiconductors

Project coordinator

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- EIDGENÖSSISCHE ANSTALT FÜR WASSERVERSORGUNG, ABWASSERREINIGUNG UND GEWÄSSERSCHUTZ - SWITZERLAND
- LUND UNIVERSITY MAX IV LABORATORY - SWEDEN
- BRABANT WATER - THE NETHERLANDS

Funding organisations

IFD (DENMARK) /NWO (THE NETHERLANDS) / SNSF (SWITZERLAND) / FORMAS (SWEDEN)

Duration

3 years

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