Wastewater treatment plants as dissemination hot-spots of anthropogenic rare-earth elements

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Résumé

Anthropogenic use of rare earth elements (REEs) is expanding rapidly, and the perturbations of their natural patterns associated with the release of some of them are now widely documented in the literature, notably for gadolinium. Gadolinium comes from contrast agents injected for magnetic resonance imaging and then excreted via the urine. As excretion can last up to 30 days, gadolinium is not confined to healthcare facilities, but is widely disseminated in living areas. In urban wastewater treatment plants (WWTPs), contrast agents are neither retained nor biodegraded, so gadolinium is ultimately discharged into the natural environment.
The environmental discharge of rare earth elements from two WWTPs in large conurbations, each with major hospital facilities, was studied. While one of these WWTPs discharges treated water directly into a watercourse, the other discharges it into the environment via a large surface-flow constructed wetland. Both are activated sludge WWTPs, and excess sludge from the WWTPs is conditioned for agricultural spreading.

The study covered raw and treated wastewater and sludge. Unsurprisingly, gadolinium is the most abundant REE and therefore presents a strong anthropogenic anomaly, while an anomaly has been also detected for ytterbium, although its origin has not yet been defined. Gadolinium concentrations vary on a weekly basis at both sites, with lower concentrations at weekends. On the other hand, the effect of the pandemic could be observed with a decrease in the concentration at the STEU inlet. For all REEs, fractionation occurs along the wastewater treatment chain, with a decrease of the light to heavy REEs. Total, particulate colloidal and dissolved REE fractions was investigated thanks to ultrafiltration along the wastewater treatment chain to explain REE fractionation. Gadolinium is not significantly retained in the WWTP, nor when it passes through a constructed wetland. Batch and column leaching tests on dried activated sludge showed potential gadolinium and ytterbium release.
All this information is being used to build a digital twin of an activated sludge WWTP to quantify the release of rare earth elements into the environment, depending on the site and receiving aquatic environment.

Mots-Clés: wastewater, treatment plant, fractionnation, constructed wetland, gadolinium, ytterbium

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