Impacts of rare earth elements on aerobic wastewater treatment microorganisms

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Rare earth elements (REE) are important components of modern communication, energy and medical technologies. Increased recovery, usage and disposal of these metals has led to increased environmental fluxes, but little is known about their potential impacts on natural or engineered ecosystems, including interactions with microorganisms involved in wastewater treatment. To investigate these interactions, we assayed growth of activated sludge microbes collected from a municipal wastewater treatment facility on agar plates doped with yttrium or gadolinium. We also monitored removal of oxygen demand and ammonia in activated sludge fed-batch bioreactors treated with either Y or Gd. In addition to the activated sludge experiments, we conducted experiments with the model ammonia oxidizer *Nitrosomonas europaea*.

Data indicate that heterotrophic members of the activated sludge community can grow on Y- or Gd-doped LB-agar plates below 3 or 2.5 mM, respectively. Nitrification was inhibited in the bioreactors treated with 560 µM Y or 320 µM Gd, as indicated by higher ammonia and lower nitrate concentrations compared to the control. 16S rRNA gene sequencing of reactor samples is underway to assess microbial community composition at timepoints before and after the observed nitrification impacts. In the experiments with *N. europaea*, ammonia oxidation was not apparently affected at nominal Gd concentrations ranging from 1 to 500 µM. It is important to note that because of the poor solubility of rare earths at circumneutral pH, most of the added REE in the experiments was precipitated. To examine the impact of increasing REE solubility, some experiments have also been conducted with Gd-diethylenetriaminepentaacetic acid (Gd-DTPA); DTPA is a common chelator used with Gd for medical imaging. At high Gd-DTPA concentrations (≥ 300 µM), ammonia oxidation by *N. europaea* appeared to be inhibited. Electron microscopy and elemental mapping are being used to assess the intracellular and. extracellular deposition of the Gd.