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Impacts of Rare Earth Elements on the Microbiology of Conventional Biological Wastewater Treatment

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Modern technologies containing magnets and/or phosphors rely on rare earth elements (REE) to function. Their increasing importance for national security, consumer electronics, modern energy technologies, and health care requires new and innovative mining, ore processing, and recycling technologies to offset REE supply constraints. With each new technology aimed at increasing REE supply comes the potential for new and increased waste production, either containing REE or REE processing agents that are potentially harmful to our environment. To evaluate the potential impacts of REE on conventional domestic wastewater treatment performance, bench-scale sequencing batch bioreactors containing activated sludge and synthetic wastewater were exposed to increasing concentrations of gadolinium or yttrium salts. Nitrification inhibition was observed when soluble REE concentrations approached ~1 μM; under our reactor conditions, this corresponded to nominal Gd additions of 320 μM and nominal Y additions of 280 μM. These findings suggest that under typical domestic wastewater treatment conditions, the low solubility of REE would require high concentrations of total Gd or Y to result in large-scale wastewater treatment performance degradation. Microbiome analyses indicated changes in microbial communities as a function of REE exposure, including decreases in the relative abundance of putative nitrifying bacteria. Nitrifying populations recovered after discontinuation of Gd or Y addition. Follow-up experiments using the model wastewater nitrifier *Nitrosomonas europaea* confirmed previous nitrification inhibition results, and analysis of the *N. europaea* transcriptome identified 282 differentially expressed genes due to Y treatment, including genes that encode metalloproteins, proteins involved in nitrogen cycling and transporter-related genes. The current study provides water professionals with information to evaluate the potential negative impacts of Gd or Y during wastewater treatment, and if necessary implement preventive and remedial strategies.