Uranium bioreduction and denitrification using two packed bed columns containing zerovalent iron and elemental sulfur

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Abstract: Uranium has been recognized as a groundwater contamination in need of treatment in many parts of the United States. In particular, historical uranium mills in Arizona have left tailings exhibiting high uranium contamination levels, and these tailings are often associated with nitrate contamination due to the use of nitric acid for the processing of uranium ores. The objective of this study was to investigate the biological reduction of uranium and denitrification by a series of reactions including a necessarily first step of biotic denitrification to dinitrogen gas and a second step of reducing the soluble uranium(VI) to its insoluble form, uranium(IV). The sulfur and limestone autotrophic denitrification (SLAD) process was used to achieve denitrification via operation of a packed bed reactor with elemental sulfur and limestone at a 50:50 ratio by volume. Uranium biomineralization was conducted in a second reactor packed with zero valent iron (ZVI) and sand at a 5:95 ratio (ZVI:sand). ZVI was the intended electron donor for the stimulation of microorganism autotrophic uranium reduction for biomineralization. The sulfur column demonstrated 99.03% efficient denitrification after a slow start-up, which has inhibited progress in the project. The ZVI column achieved 95.45% efficiency a few days after start-up. The reactors have been operating in parallel to date, but the eventual goal is to demonstrate sustainable nitrate and uranium removal from co-contaminated water by operating the columns in series. This paper describes the set-up of the columns and noteworthy issues and observations noted during operation of the columns in parallel.