

Feasibility study on seepage water treatment at a uranium TMF site by ion exchange and ferric hydroxide adsorption

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Extended Abstract

Uranium and arsenic retention by ion exchange and ferric hydroxide adsorption, respectively, was investigated as seepage water treatment option for the WISMUT TMF - site Helmsdorf. The conducted feasibility study involved geochemical modeling, laboratory tests and pilot scale field tests.

Helmsdorf TMF seepage water is alkaline ($\text{pH} \sim 9$) and contains up to 10 mg / l uranium, ~ 1 mg / l arsenic and 1 - 2 g / l hydrogen carbonate, sulfate and sodium, respectively. Seepage water pollutant speciation was calculated by PhreeqC using an extended Wateq4f database. Calcium uranyl carbonate and hydrogen arsenate species dominate dissolved uranium and arsenic, respectively. While hydrogen arsenate adsorbs to ferric hydroxide preferentially, alkaline earth carbonate complexation is known to hinder uranyl sorption [1]. Prior to laboratory tests, optimal geochemical conditions for uranium and arsenic retention by ion exchange and ferric hydroxides were modeled. Both pollutant speciation and surface properties of ferric hydroxide adsorbent depend on pH. A drop in treatment pH from $\text{pH} \sim 9$ to $\text{pH} \leq 6$ facilitates uranium and arsenic retention by suppression of alkaline earth uranyl carbonates complex formation and increase in the number of positively charged ferric hydroxide surface sites, respectively.

Laboratory experiments were conducted to test uranium and arsenic retention from original seepage water at different ion exchange resins and ferric hydroxide adsorption materials. Different pH values were adjusted using hydrochloric acid. Uranium retention of all tested ion exchange resins improved from insignificant at original seepage water pH to technically feasible levels at adjusted seepage water pH of $\text{pH} = 5.5 - 6$. Arsenic retention was tested with GEH, FerroSorp and Bayoxide as adsorbent. Despite differences in pzc and total loading capacities, the different ferric hydroxides showed comparable arsenic sorption at $\text{pH} = 6 - 6.5$. Next to pH, contact time was found to be of capital importance for ferric hydroxide adsorption.

Pilot testing was performed using a multi-stage ion exchange and a single-stage ferric hydroxide adsorption unit subsequent to pH controlled hydrochloric acid dosage and sand filtration. The treatment tests were performed on-site at seepage water pH adjusted to $\text{pH} = 5.5$, $\text{pH} = 6$ and $\text{pH} = 6.5$. For prevention of CO_2 degassing, the pilot installation was operated at a pressure of 3 bar. At a flux of 500 l / h, seepage water treatment was demonstrated successfully over a period of one year. Uranium and arsenic effluent concentrations were reduced to < 0.2 mg / l. The identified operational parameters met or even slightly exceeded the range of typical ion exchange and ferric hydroxide adsorption applications in water treatment.

Key words: Uranium mining, seepage water treatment, geochemical modeling, ion exchange, ferric hydroxide adsorption, laboratory test, pilot plant test

References

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