Treatment of Wastewater Using Apatite II

Background

In the winter of 2001, a fire sprinkler system froze and accidentally discharged approximately 100,000 gallons of mixed wastewater into the basements of two former process buildings at the Department of Energy (DOE) Paducah site. The facility manager had the wastewater sampled and discovered that it contained soluble radionuclides (U, Np, TcO_4^-), RCRA-regulated toxic metals (Cd, Zn, Cu) and detectable amounts of polychlorinated biphenyls (PCBs). Because of the elevated amounts of Cd present, the water was designated RCRA waste and, thus, could not be taken to the site's normal process water treatment system. A DOE subcontractor was assigned the task of treating the contaminated wastewater and discharging it at a permitted outfall subject to strict DOE and state discharge criteria. The negotiated compliance goals required very high removal efficiencies for the metal species, especially cadmium. Based upon the levels of RCRA metals and uranium present, DOE was interested in evaluating the use of phosphate-induced metals stabilization (PIMS) technology for the remediation of the wastewater. A particularly effective material for this purpose is Apatite II, a calcium-phosphate substance derived from processed fish bones.

Technical Approach

Treatability tests were performed with authentic and simulated site water. Media investigated included activated carbon (several forms with significantly different performance), zero-valent iron (ZVI), iron co-precipitation, synthetic ion exchange media, mineral zeolite, activated alumnina, and Apatite II. Only a combination of acid-washed coal (AWC) and Apatite II met the overall performance requirements for the water composition. Both ZVI and iron co-precipitation produced colloidal particulate that was difficult to flocculate and filter. Mineral zeolite and synthetic cation exchange medium were not effective for any of the contaminants of concern in the raw water; anion exchange medium removed pertechnetate, but inexpensive AWC was also effective for this purpose. Of the media evaluated, only the Apatite II was capable of reducing cadmium to the compliance requirements.

A mobile wastewater treatment system was designed by the Materials and Chemistry Laboratory, Inc. (MCLinc) in Oak Ridge for deployment at the DOE site that would remove the contaminants of concern to the DOE-mandated discharge levels (that is, 10% of applicable discharge limits mandated by the state). The treatment system consisted of three Apatite II columns and pre- and post- AWC columns along with the required pumping and flow control mechanisms to maintain a prescribed flow rate and contact time within the columns and the appropriate filtration systems (Figure 1).

Results

The overall performance of the treatment train is given in Table 1 for the treated 100,000 gallons, and the average relative performance of sequenced media (unit operations) is presented in Figure 2. The combination of media was effective and relatively economical. All of the treated water met DOE-prescribed discharge limits and proved considerably more cost-effective and efficient than competing technologies, such as ion exchange, reverse osmosis, or ultra-filtration. Average removal efficiencies obtained using Apatite II were ≥99.7% for U, ≥99.5% for Cd, and ≥99.7% for Zn. A secondary benefit of using Apatite I has been significantly less secondary waste generation.

Figure 1. Apatite II Treatment System for U and RCRA Metal Contaminated Wastewater

Table 1. Overall Removal of Select Contaminants from Paducah Wastewater

Contaminant	Ave. Feed (mg/L)	Ave. Effluent (mg/L)	Treatment Goal (mg/L)	Ave. % Removed
U	**18.1**	**0.045**	**0.378**	**>99.7**
Cd	**1.67**	**0.0087**	**0.0099**	**>99.5**
Zn	**4.6**	**0.015**	**0.216**	**>99.7**

Figure 2. Performance of Treatment Train Used for Paducah Wastewater