29

Removal of Unknown Selenium Species and other Constituents from Flue Gas Desulfurization Wastewater through Nanofiltration

Jay Renew and Kristen Jenkins, Southern Research
Chethan Acharya, Southern Company

The United States coal-fired power industry confronts increasing pressure to improve wastewater treatment and disposal practices. The United States Environmental Protection Agency (USEPA) determined that most constituent loadings associated with coal-fired power plants result from wet flue gas desulfurization (FGD) and ash handling systems. In a typical wet FGD system, Ca or Ca-Mg slurry is sprayed into flue gas in order to remove SO_2. Along with SO_2, heavy metals are also removed from the flue gas and accumulate in the FGD system. Purge brines from FGD systems are complex wastewaters that contain significant concentrations of heavy metals including As, Cd, Cr, Hg, and Se. The wastewater also contains large amounts of salt in the forms of Ca^{2+}, Mg^{2+}, Na^{+}, SO_4^{2-}, and Cl^{-}. The majority of wet FGD systems utilize $Ca(OH)_2$ or $CaCO_3$ as an alkaline sorbent. As a result, a majority of FGD wastewaters are dominated by Ca^{2+} as the major cation and Cl^{-} as the major anion due to the presence of Cl in coal and its high solubility.

One of the more difficult heavy metals to remove from FGD wastewater is Se. Se speciation in FGD wastewater can be complex. It has been assumed in the past that Se speciation included only SeO_3^{2-}/$HSeO_3^{2-}$ and SeO_4^{2-}. However, peer-reviewed scientific literature by other researchers has documented the presence of 13 Se species in FGD wastewater utilizing anion-exchange chromatography coupled with inductively coupled plasma-mass spectrometry (AEC-ICP-MS). Two of the Se species documented in previous studies included $SeSO_3^{2-}$ and $SeCN^{-}$, but most of the Se are still unknown and unconfirmed.

The presence of multiple Se species could complicate Se removal from FGD wastewater. Understanding of the efficacy of treatment techniques to remove these unknown Se species from FGD wastewater is needed. The primary project objective is to evaluate the removal of unknown Se species through nanofiltration (NF). However, removal of trace metals such as As, Cd, Cr, and Hg and macro-components such as Ca^{2+}, Mg^{2+}, Na^{+}, SO_4^{2-}, and Cl^{-} will also be evaluated.

Bench-scale experiments were conducted to evaluate treatment of real FGD wastewater with NF. Six NFs with molecular weight cut offs (MWCOs) varying from 150 to 1,000 daltons were evaluated in these experiments. Two ultrafilters (UFs) with MWCOs varying from 1,000 to 2,000 daltons were also evaluated. The feed FGD wastewater, permeate, and concentrate underwent analysis for Se speciation, metals, low level Hg, and anions.

A second set of experiments was conducted to determine the impact of oxidizing the FGD wastewater through pre-treatment prior to NF. $KMnO_4$ was utilized as the oxidant. $KMnO_4$ could possibly oxidize the unknown Se species to SeO_4^{2-}. SeO_4^{2-} has been successfully removed from wastewater by NF due to being doubly charged. Hence, it is possible that oxidation could enhance the NF process by oxidizing any singly charged unknown Se species.

Jay Renew, P.E.

Jay E. Renew, P.E. has 12 years experience in environmental engineering research, development, and design. He has led research projects on flue gas desulfurization (FGD) wastewater treatment, management of coal combustion residuals (CCRs), and encapsulation of concentrated FGD brines for safe landfill disposal. He has led efforts to characterize CCRs impacted by new air-emission controls and wastewater treatment processes.

Prior to joining Southern Research, Mr. Renew spent 8 years in water and wastewater engineering consulting. He worked on the design and construction management of wastewater collection systems, water distribution systems, and drinking water treatment plants. Mr. Renew received a Master of Science degree in Environmental Engineering from the Georgia Institute of Technology and a Bachelor of Science degree in Agricultural Engineering from the University of Georgia.