Specifically Designed Constructed Wetlands: A Novel Treatment Approach for Scrubber Wastewater

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Relatively large volumes of wastewater (0.5 – 3 MGD) are generated by coal-fired power plants during the process of flue gas desulfurization (FGD). Through wet scrubbing of sulfur from atmospheric emissions, numerous other potentially problematic elements (e.g. Se, Hg, As, etc.) are entrained in the water in both particulate and aqueous phases. After separation of gypsum ($CaSO_4$, formed in the scrubbing process), the residual wastewater or process water contains relatively high levels (mg/L) of constituents that must be treated prior to discharge of the water to receiving aquatic systems authorized by an NPDES permit issued under the Clean Water Act. Physical or chemical alternatives for treatment are not efficacious from the perspectives of capital, operating, or maintenance costs as well as sustained performance. A pilot-scale constructed wetland treatment system was specifically designed and constructed at Clemson University to evaluate removal of mercury, selenium, and other constituents from flue gas desulfurization (FGD) wastewater.

OBJECTIVES

Specific objectives of this research were: (1) to measure performance of a pilot-scale constructed wetland treatment system in terms of decreases in targeted constituents (Hg, Se and As) in the FGD wastewater; (2) to determine how the observed performance is achieved (both reactions and rates); and (3) to measure performance in terms of decreased bioavailability of these elements (i.e. toxicity of sediments in constructed wetlands and toxicity of outflow waters from the treatment system). Initial evaluations of performance contained in this progress report involved FGD wastewaters formulated based upon analyses of several actual FGD waters.

ACCOMPLISHMENTS TO DATE

Performance of the pilot constructed wetland treatment systems at this interim stage indicates that the system is decreasing aqueous concentrations of the targeted wastewater constituents (As, Hg, and Se) for the majority of the wastewaters. The removal rates of mercury ranged from 64% to 97% for the FGD waters except for a sample in which the concentration of mercury was already below the predicted NPDES permit level of 0.001 mg/L. In most weeks the removal rate for Hg was greater than 90%. Selenium removal rates were relatively stable throughout the time period covered by this report with a range

of 84 to 90% removal by the pilot-scale constructed wetland treatment systems. Arsenic removal was variable throughout the treatment weeks with higher removal rates occurring during a period of five weeks (~70%). Removal rates for arsenic in these simulated FGD wastewaters are of lesser importance than for Hg or Se, since actual FGD wastewaters analyzed to date had lower concentrations of arsenic than the required NPDES discharge limits.

Sequential extraction procedures were used as a quantitative measure to evaluate the immobilization of these elements in the sediment component of these systems. Data gathered using these procedures indicate that the majority of As, Hg, and Se is bound to residual phases within the sediment, suggesting that dissolution or re-solubility of these elements is unlikely to occur under environmental conditions within this treatment system (not thermodynamically favored).

Toxicity experiments conducted to date indicate a significant increase in survival and reproduction / growth for organisms tested in the final outflow versus inflow simulated FGD wastewaters. Chloride concentrations must be considered in the treatment process and satisfactory chloride levels (~4000mg/L) were achieved in these experiments by dilution with moderate hardness water.

FUTURE WORK

Ongoing research and data analysis are being conducted to enhance removal of these targeted constituents by manipulating minor components of these pilot-scale constructed wetland treatment systems and assessing how these changes alter transfers and transformations of As, Se, and Hg. Toxicity evaluations are also being conducted to relate these system component changes to bioavailability of these elements to the sentinel species used in NPDES toxicity tests (*Ceriodaphnia dubia, Pimephales promelas, Hyalella azteca,* and *Chironomus tentans*). Investigation of the contributions of arsenic, mercury, and selenium to the observed toxicity in the FGD wastewater and sediments is ongoing.

LIST OF PAPERS PUBLISHED, U.S. PATENT APPLICATIONS, CONFERENCE PRESENTATIONS, AWARDS RECEIVED AS A RESULT OF SUPPORTED RESEARCH, STUDENTS SUPPORTED UNDER THIS GRANT

CONFERENCE PRESENTATIONS

Eggert, D., M. Iannacone, J. C. Castle, and J.H. Rodgers, Jr. 2005. Assessment of specially designed constructed wetland treatment systems for flue gas desulfurization wastewaters. Presented at the Conference on Phytotechnology, Atlanta, GA (April 20-22, 2005) U.S. EPA sponsored

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