

Project Proposal

1. **Proposal Title:** Mercury Adsorption in FGD Wastewater using Waste Char
2. **Focus Category:** TOXIC SUBSTANCES, WASTEWATER TREATMENT, & WATER QUALITY
3. **Keywords:** Adsorption, Heavy Metal Removal, FGD wastewater treatment, Activated Carbon
4. **Duration:** *March 1, 2009 through February 28, 2010*
5. **Federal Funds Requested:** \$5,000
6. **Non-Federal (matching) Funds Pledged:** \$10,000

7. **Principal Investigator**

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9. **Congressional District(s) where project will occur:** 17

10. **Abstract**

Acid-gas forming emissions are becoming the target of stringent air regulations and have spurred electric utilities to compensate by installing flue gas desulfurization (FGD) systems (EPRI, 2006). These systems, which are typically wet scrubbers, emit wastewater effluent with high concentrations of fine, suspended heavy metals such as mercury (Hg) and selenium (Se) and consequently negate concurrent tightening wastewater compliance issues (EPRI, 2006). The complexities associated with soluble metal removal, combined with the challenges of utilizing waste by-products, have prompted the development of sustainable and versatile industrial wastewater treatment technology. The objective of this research is to investigate the performance of waste char produced from pyrolysis in removing mercury (Hg) from FGD wastewater. The results of this experiment will produce heavy metal adsorption isotherms for char, define breakthrough capacity, analyze relationship between char quality and adsorption, and compare two types of char for application.

11. **Statement of Critical Regional Water Problems (Rationale and Significance)**

Heavy metal pollutants have been implicated in toxicology studies (Salami et al., 2008) and are part of the National Recommended Water Quality Criteria for the Protection of Human Health of the United States Environmental Protection Agency (USEPA, 2006). As these constituents are under the Clean Water Act (CWA), which protects human consumption and provides guidance for states and tribes in adopting water quality standards (USEPA, 2006), further remediation of wet scrubber wastewater effluent is necessary prior to reclamation or final discharge into ambient waters. The proposed research is intended to devise a feasible treatment technology for point source industrial pollution prevention.

12. Nature, Scope, and Objectives of the Research

NATURE (Rationale and Significance continued)

Interest in the development of heavy metal removal technology has been triggered by anticipated USEPA regulation of industrial wastewaters. Some volatile metals in the wastewater are highly hydrophilic and cannot be easily removed through precipitation or biological treatment (EPRI, 2006) while maintaining low operating costs and environmental consciousness. Major problems with the treatment technology for heavy metals are complex and expensive production and operations, mono-functionality, and lack of re-usability.

PURPOSE

The objective of this research is to evaluate the ability of waste char, which is produced from pyrolysis, partially activated with steam, and immersed in oxide, sulfide, or hydroxide solution; to remove mercury (Hg) from flue gas desulfurization (FGD) wastewater. Pyrolysis is a thermo-chemical process that degrades organic materials in the absence of oxygen (CPEO, 2002). The process produces char, a carbon-rich, light-weight, low-moisture material that can emerge in forms such as sawdust, cotton gin, wood, and biochar (Demirbas, 2006). A series of experiments will be performed in order to achieve this objective (Figure 1). Backwashing with de-ionized water will also be performed to examine possible desorption of adsorbed metals for recovery and re-usability of the char. This research aims to address the following challenges to sustainability:

Water Quality and Availability – removal of pollutants from potentially rechargeable drinking water source

Sustainable Remediation – conversion of a waste by-product (char) to a possibly re-usable treatment technology

Economic Development – formation of fiscal value for industrial wastes

The research will be categorized into two phases to ensure timely execution and accurate data collection (Figure 1). The first phase will determine adsorption isotherms for various types of char and the top two types with the highest adsorption capacities will advance to the second phase. Phase 2 will observe the experiment as an application with real FGD wastewater being treated.

SCOPE OF WORK

The range of work for this research encompasses various aspects of engineering including design and batch experimentation, laboratory and data analysis, and data interpretation; all of which are expected to occupy a significant time period during the student's tenure in the Ph.D. program at Texas A&M University.

- Literature Review
 - Pyrolysis (rapid method, slow method, by-products, effects of feedstock)
 - Flue gas desulfurization wastewater (quality and various treatment methods)
 - Heavy metals as constituents in wastewater (health effects, regulations, etc.)
 - Mercury (properties, industrial applications, current removal technologies)
 - Char (properties, types, industrial applications, relationship to activated carbon)
 - Adsorption agent (iron oxide, iron sulfide, and hydroxide compound)
- Data Analysis and Interpretation and Report Composition
 - Evaluation of performance, serviceability, reliability, durability, and conformance to standards of the filters based on experimental results, assess feasibility of EPA compliance, and analyze possibility of mass production for industrial application
- Batch Design, Experimentation, and Column Testing (Figure 1)

- **Phase 1: Batch Experiment** – determination of optimum pH range, temperature range, sulfide/oxide/hydroxide concentrations and coating procedure, minimum media depth requirement (sulfide/oxide-dependent), adsorption breakthrough and isotherms, elimination of char types based on adsorption capacity (top two will advance to Phase 2), etc. **Phase 1 begins March 2009 and run time will be 2 months maximum.**
- **Phase 2: Column Testing** – experimental/observational comparison of two types of char adsorption (using top two char types and adsorption isotherms from Phase 1), application, incorporation of regeneration, prolonged observational experiment. Preliminary observation of re-coating adsorption agent on the char surface for re-use. **Experiment run time will be variable depending on adsorption breakthrough of each metal tested.**
- Water Quality Laboratory Analysis and Char Characterization
- Characterization of synthetic and actual wastewater using water quality analytical methods specified by the USEPA and American Public Health Association (APHA)
- External consultation with other laboratories for parameters not covered by BAEN water lab
- Char physical properties such as surface area, particle size, density and their relationship to heavy metal adsorption capacity
- Relationship between amount of adsorption agent on the char and adsorption capacity

FACILITIES AND EQUIPMENT

The researcher has access to proximately located facilities for water quality analyses and system construction on the campus. The lab and tech shop are located in the Hobgood Building on the west side of campus, adjacent to the train tracks on Olsen Boulevard.

In addition to his extensive background in municipal wastewater quality analysis, the researcher will be analyzing heavy metals with state-of-the-art equipment including:

- Ion Chromatographer – measures heavy metals and a suite of ions at the ppm level
- Atomic Absorption Spectrometer – measures heavy metals and ions at the ppb level

Char analysis will also be performed as part of media characterization procedures for this experiment. The following equipment will be used for char analysis:

- Brunauer, Emmett, Teller (BET) Surface Analyzer – measures physical properties of char such as surface area, density, ash content, carbon content, etc.

Additional equipment for basic water quality parameter analyses such as total suspended solids (TSS) and ammonia (NH₃) will also be used to aid in the characterization of the wastewater.

13. Results Expected from this Project

The results of this research are expected to determine the feasibility of waste char as an industrial wastewater treatment technology. The desired results of this experiment are the following:

- 1) Development of mercury adsorption isotherms for waste char
- 2) Validate waste char as a reasonable and versatile method of industrial wastewater treatment
- 3) Economic redemption of a waste by-product

This project is intended to provide electric utilities with an economically and environmentally sustainable FGD wastewater treatment system that can assist them with adhering to regulatory compliance issues. If the experiment produces satisfactory results, the technology may be proposed for industrial application to many facilities that use FGD systems.

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