THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Knowledge that will change your world

CONTINUOUS WATER QUALITY SENSING FOR FLUE GAS DESULFURIZATION WASTEWATER

Dr. Lee Moradi

Director of UAB EITD

Project Team - Overview

UAB
EITD ENGINEERING AND INNOVATIVE TECHNICAL DEVELOPMENT GROUP

Prime
Multidisciplinary Team of University Professors, Staff Members, and Students

SR SOUTHERN RESEARCH

Subawardee
University Affiliated Research Institution

Metrohm

In-Kind Cost Share
Industry Partner

Project Team – Expertise

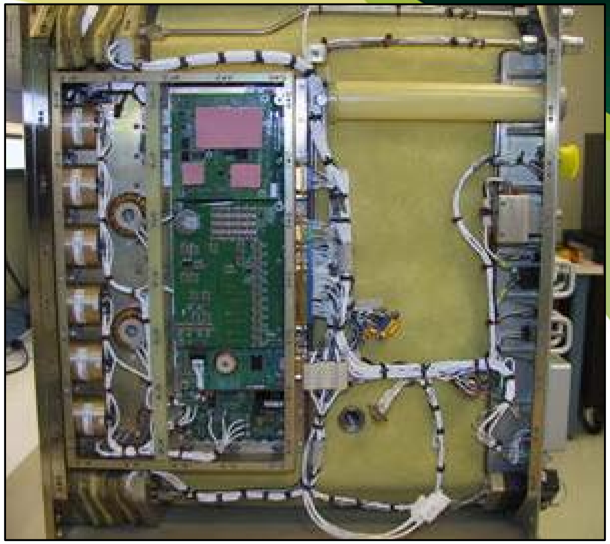
UAB EITD

Complex System Design and Integration for Extreme Environments

- Consistently delivered on well over $60M of NASA contracts over past 8-10 years
  - o Sole Supplier of Powered Cold Stowage Units for NASA ISS transport operations
    - o POLAR (+4C to -95C)
    - o GLACIER (+4C to -160C)
    - o MERLIN (+48.5C to -20C)

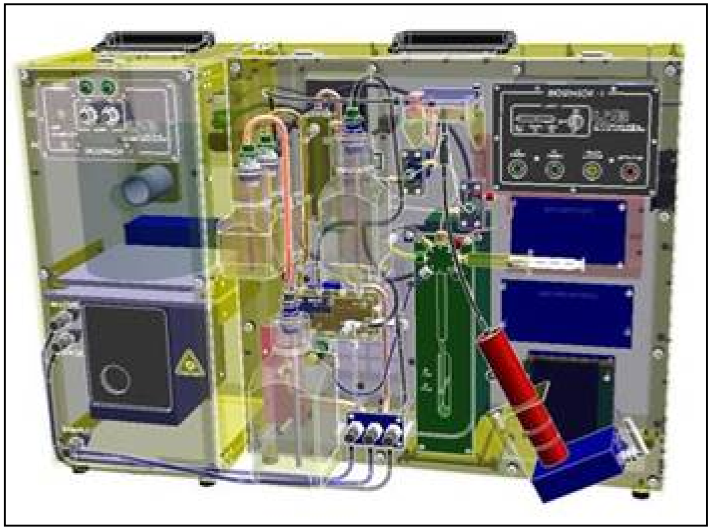
Project Team – Expertise

UAB EITD



- Diverse Array of Services Offered
  - o Rapid Prototyping
  - o Electrical, Mechanical, Software, & System Engineering

- AS9100, ISO9001 Certification
  - o 4,500 ft^2 of Production Labs
  - o 13 ESD workstations
  - o NASA electronics process standards
    - ❑ Soldering (J-STD-001ES)
    - ❑ Assembly (NASA-STD-8739.1)
    - ❑ Harness (NASA-STD-8739.4)



Biosensor for anthrax detection

Project Team – Expertise

Metrohm

Metrohm

A Leading Manufacturer of High Precision Instruments for Chemical Analysis

- Swiss based parent company
- Extensive Application Knowledgebase
  - o Application Notes
  - o Highly Educated & Experienced Support Staff
- Electrochemistry Instruments
  - o Benchtop 884 VA Voltammetry Unit
  - o On-Line ADI2045 VA Process Analyzer

Unique Resources

Water Research Center (WRC)

SOUTHERN RESEARCH

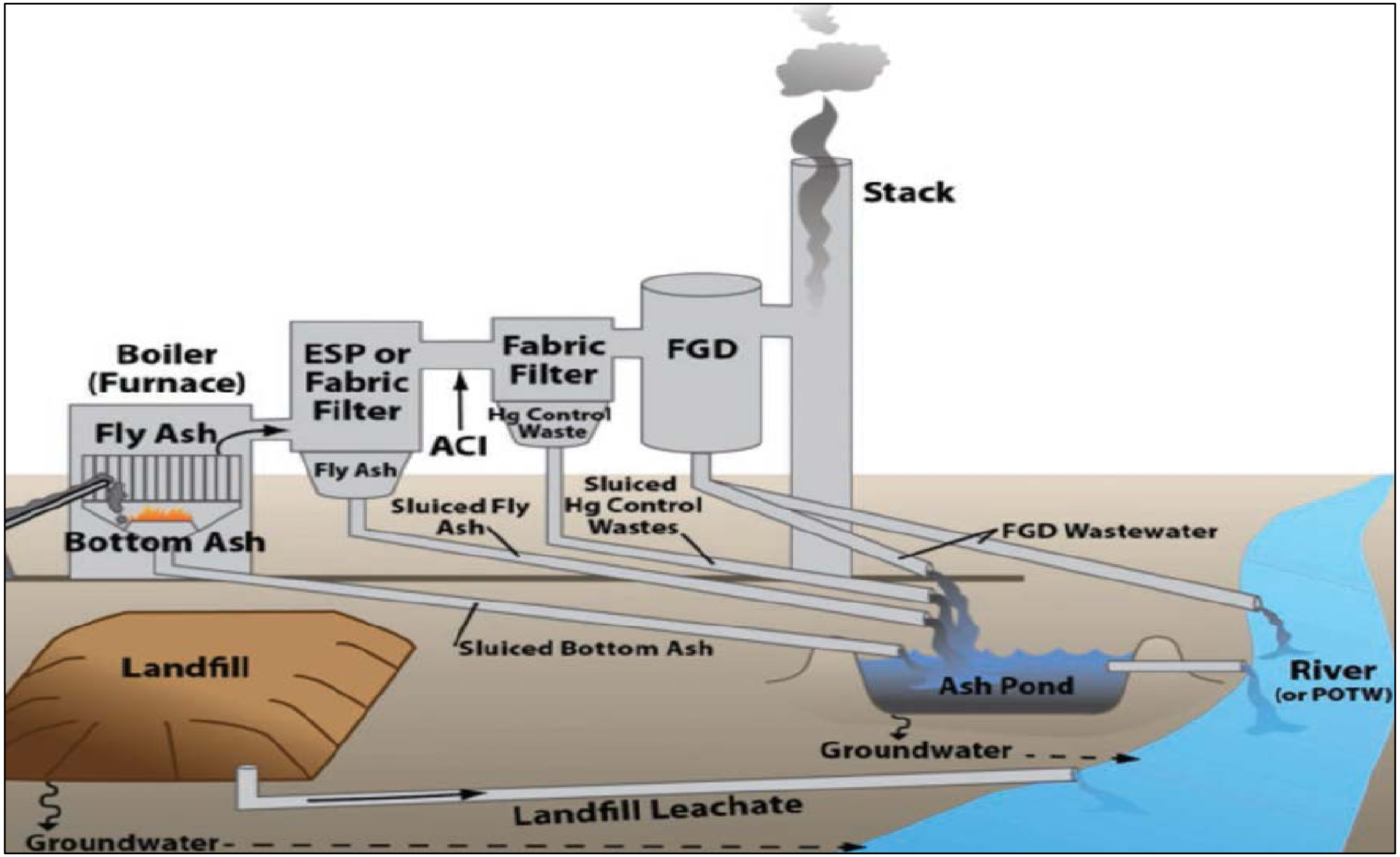
- Opened in 2012 by Georgia Power & Electric Power Research Institute (EPRI)
  - Operated by Southern Research

- Located on-site at Georgia Power's Plant Bowen
  - 9th Largest U.S. Power Plant in Net Generation (3.38 MW)

- 7 Focus Areas to include:
  - Low Volume Wastewater Treatment
  - Moisture Recovery
  - Zero Liquid Discharge
  - Water Modeling, Monitoring, & Best Management Practices

Problem Statement - *Overview*

Key waste streams from updated USEPA guidelines.



Proposed Effluent Guidelines for the Steam Electric Power Generating Category. 2015; Available from: http://water.epa.gov/scitech/wastetech/guide/steam-electric/proposed.cfm.

Problem Statement – *EPA Requirements*

Steam Electric Power Generation Effluent Guidelines for Coal-fired Power Plant Wastewater

WASTE STREAM	PARAMETER	DAILY MAXIMUM	30-DAY AVERAGE
FGD WASTEWATER FOR DISCHARGE	As (µg/L)	11	8
	Se (µg/L)	23	12
	Hg (ng/L)	788	356
	NO^3/NO^2 as N (mg/L)	17	4.4
FGD WASTEWATER UNDER VOLUNTARY INCENTIVE	As (µg/L)[1]	4	
	Se (µg/L)	5	
	Hg (ng/L)[1]	39	24
	TDS (mg/L)	50	24

Proposed Effluent Guidelines for the Steam Electric Power Generating Category. 2015; Available from: http://water.epa.gov/scitech/wastetech/guide/steam-electric/proposed.cfm.

Problem Statement

Measuring Selenium Concentrations

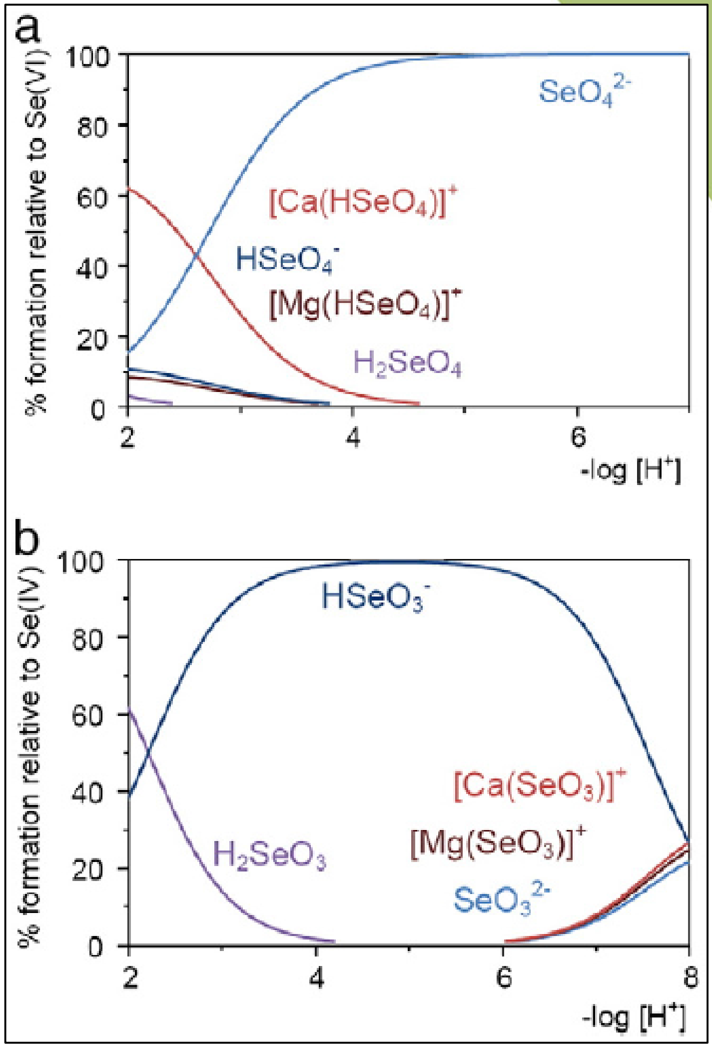
Possible formations of Selenium in FGD Wastewater

- Selenate
  - o $p\,M^{2+} + q\,H^{+} + r\,SeO_4^{2-} \rightleftharpoons [M_pH_q(SeO_4)_r]^{(2p+q-2r)+}$
- Selenite
  - o $p\,M^{2+} + q\,H^{+} + r\,SeO_3^{2-} \rightleftharpoons [M_pH_q(SeO_3)_r]^{(2p+q-2r)+}$

Where:

- M = Mg, Ca, Sr, Mn, Cu, Zn, Cd, etc.
- H = Protonation of selenium species

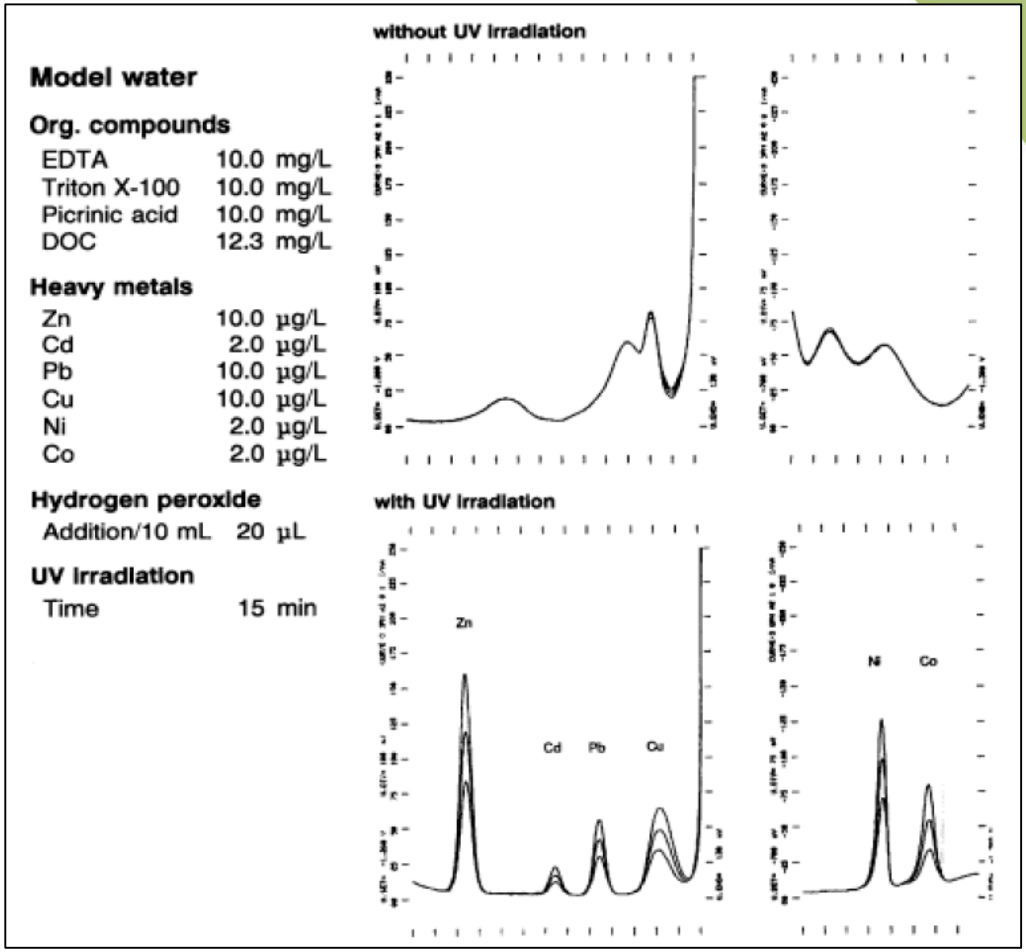
Torres et al., “Selenium Chemical Speciation in Natural Waters.”



Proposed Solution

Novel Sample Preparation Methodology

- Sample Prep to facilitate detection with COTS devices
- Methodology details are considered proprietary
- 3 Stages
    - UV-Peroxide Digester
    - Matrix Manipulation (removal & polishing)
    - Reduction



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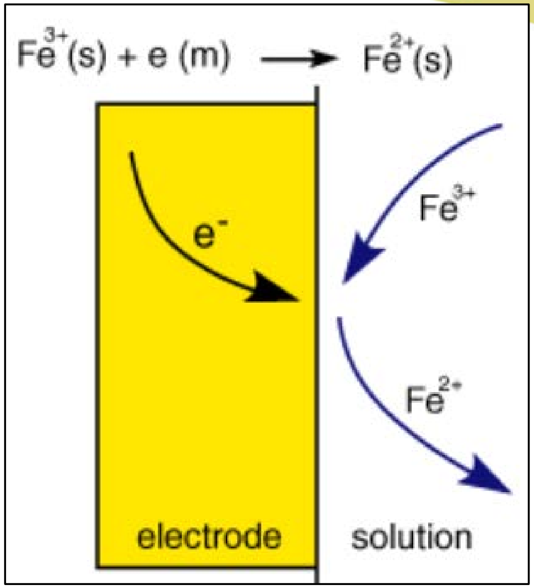
Proposed Solution

Concentration Measurements



<u>884 VA Voltammetry Unit</u>

- Low Limit of Detection:
  - Se: 300ppt
  - As, Hg: 100ppt
- Replaceable Measuring Head:
  - Multi-Mode Electrode Pro
    - ❑ Hanging Mercury Drop (Se)
  - scTRACE Gold Electrode
    - ❑ Solid State (As, Hg)
- Relatively portable, with low maintenance and operating costs (vs. ICP-MS)

Significance of Results

- Enable closed loop control of contaminant concentrations in effluent discharge

- Provide superior data for 30-day averaging compliance
  - Easier to prove compliance
  - Better for the environment

- Significantly reduce operating costs of coal fired power plants with wet FGD systems
  - Replace periodic grab sample analysis by off-site laboratories
  - Minimize required FGD wastewater treatment reagents and equipment

Relevance to Fossil Energy

- No longer blindly discharging contaminants into the environment!
- Global Impact
  - ~1/3rd of US Coal Fired Power Plants have wet FGD systems
  - By comparison, China exceeds this number by 3-5 times
- Adoption of continuous monitoring has many attractive benefits

Statement of Project Objectives

Key Features

<u>Continuous Water Quality Monitor for FGD Wastewater</u>

- Concentrations of Trace Metals
  - 1st Priority: Se
  - 2nd Priority: As, Hg

- Reliable, Automated In-Field Operation
  - Goal for Prototype: 1 week of intervention-free operation

- High Measurement Frequency (<1hr latency)

Statement of Project Objectives

Multi-Phase Approach

I. Development of Batch Process for Sample Preparation

II. Design and Development of Continuous Sample Preparation Prototype

III. Demonstration Unit Integration and Field Testing

Project Milestones & Schedule

- Period of Performance: 18 mths (Aug ’16 – Jan ‘18)
  - o ≈ 6mths / Phase

- Milestone Distribution Basis (10 total):
  - o Validation of Critical Sample Preparation Steps including:
    - ❑ UV-Peroxide Digester
    - ❑ Matrix Manipulation (removal & polishing)
    - ❑ Reduction
  - o Validation of Critical “” Steps throughout:
    - ❑ Batch Process Development
    - ❑ Continuous Prototype Development
    - ❑ Demonstration Unit Integration

Budget

Total Budget: $439, 986

- Labor: 24.4%
- Equipment & Supplies: 12.7%
- Contractual: 44.2%
  - In-Kind Cost Share from Metrohm: 9%
  - Sub-Award to Southern Research: 35.2%
    - Labor: 40.3% (of sub-award)
    - Supplies: 2.7% (of sub-award)
- Indirect: 17.1%

Risk Management

(Probability, Impact)

- Technical Risk: (Moderate, High) Failure of primary sample preparation methodology to produce desired results.
- Mitigation: Two contingency methodologies identified before proposal submission.

- Organizational Risk: (Moderate, Moderate) Labor overruns due to difficulty in identifying sample preparation process.
- Mitigation: Minimize labor costs by leveraging team expertise:
    - UAB to leverage Metrohm expertise in hardware design
    - SR WRC to leverage in-house experience evaluating other attempts to monitor and treat FGD wastewater

Project Status

- Phase I development is underway
  - UV-Peroxide Digester design ongoing
    - Custom design to allow for re-use of key components for continuous prototype.
  - UV-Peroxide Digester Procedure Document Complete

- Less than 1mth behind schedule
  - Slow award acceptance and sub-award distribution timeline
    - Work around: At-risk accounts at UAB & SR
  - Personnel time conflicts
    - Mitigation: Completion of other projects imminent
  - UV-Peroxide Digester Component Re-usability requirement
    - Awaiting Metrohm Design Input based on Process Analyzer design

Questions?