Water Management At Power Systems

Technical Portfolio Lead: Nicholas Siefert

PIs: Eric Grol, McMahan Gray, Erik Shuster, Djuna Gulliver, Dustin McIntyre, Tim Skone

Technology Manager: Briggs White

September 17, 2020

NATIONAL ENERGY TECHNOLOGY LABORATORY

Water Management for Power Systems: Overview

Program Goal

The Water Management for Power Systems FWP seeks to reduce water consumption at both new and existing fossil power plants, as well as to decrease the cost of treating power plant effluent streams by converting them into valuable resources

Tasks include:

• Task#2: Guiding R&D for Treatment of Coal Power Plant Effluent Streams	Eric Grol
• Task#3: Selective Removal of Heavy Metals for Effluent Streams	McMahon Gray
• Task#4: Concentrating Wastewater Effluent Streams	Nicholas Siefert
• Task#5: Impact of Water Use of Power Systems	Erik Shuster
• Task#6: Biological Treatment of FGD Effluent Streams	Djuna Gulliver
• Task#7: Characterization of FGD Effluent Streams	Dustin McIntyre
• Task#8: Water Management for Fossil-Based Hydrogen Production	Timothy Skone

EPA Limits on Effluent compared against FGD Compositions

2020 New Final Ruling

Pollutant	Unit	Avg	Monthly Avg Lim
Arsenic, total	(ug/L)	5	9
Mercury, total	(ng/L)	13	34
Selenium, total	(ug/L)	16	29
Nitrate/nitrite as N	(mg/L)	2	3

Link to Aug 31, 2020 Ruling

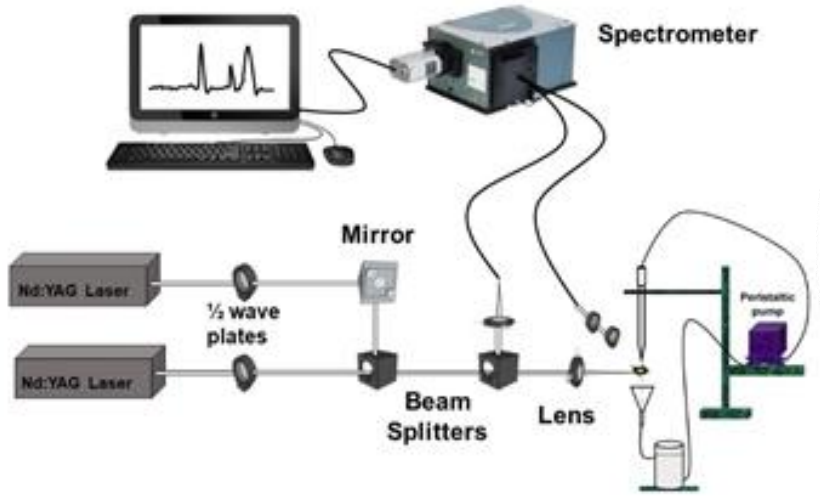
EPA Data Collected during Initial Rule Making

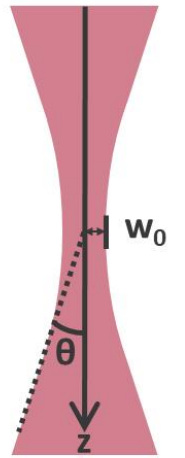
Pollutant	Unit	PP June 22 2010	MF July 12 2010	A Aug 2 2010	BC June 2010
Arsenic, total	(ug/L)	160	937	120	240
Mercury, total	(ng/L)	2,080,000	166,000	50,300	291,000
Selenium, total	(ug/L)	15,000	3,400	1,500	6,600
Nitrate/nitrite as N	(mg/L)	160	72	14	16

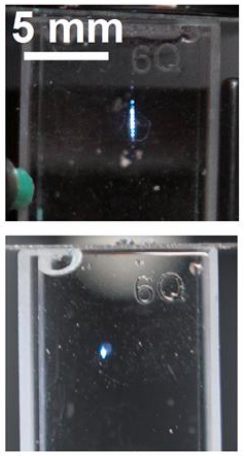
- Hg is mostly in solid phase
- Se and Nitrate/Nitrite are almost entirely dissolved

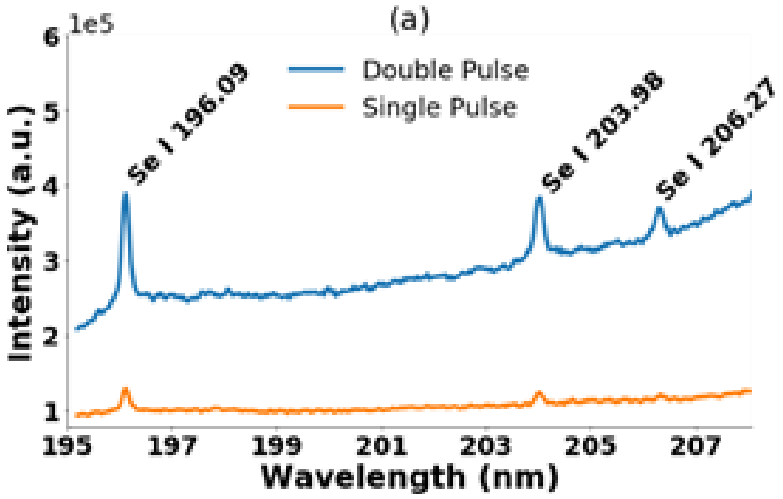
Task 7: LIBS calibration and measurement of FGD water elements

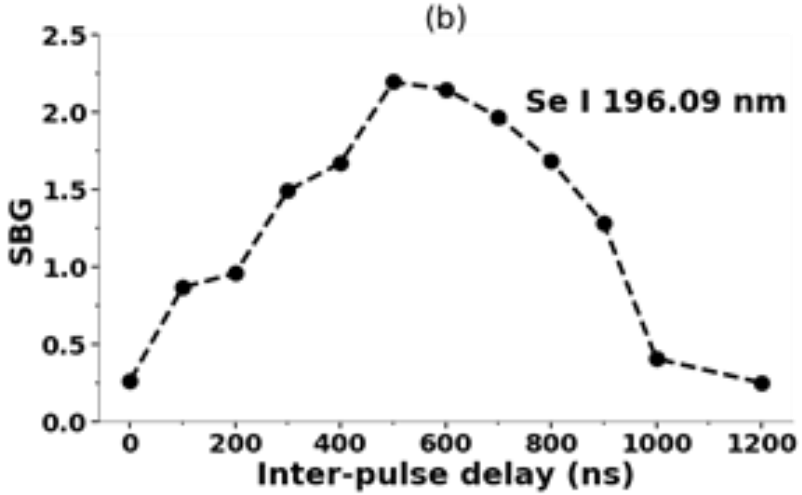
- Jet of water improves detection
- Single and double laser pulses were used to enhance atomic emission data
- Timing of laser pulses was optimized
- Limits of Detection (LOD) determined for <u>As, Hg, S and Se</u>

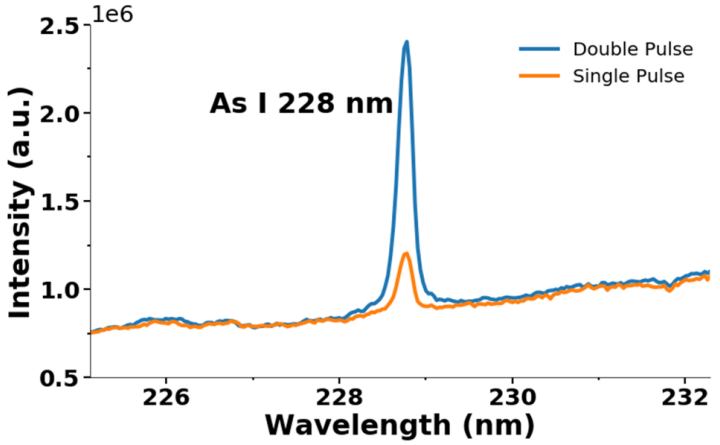






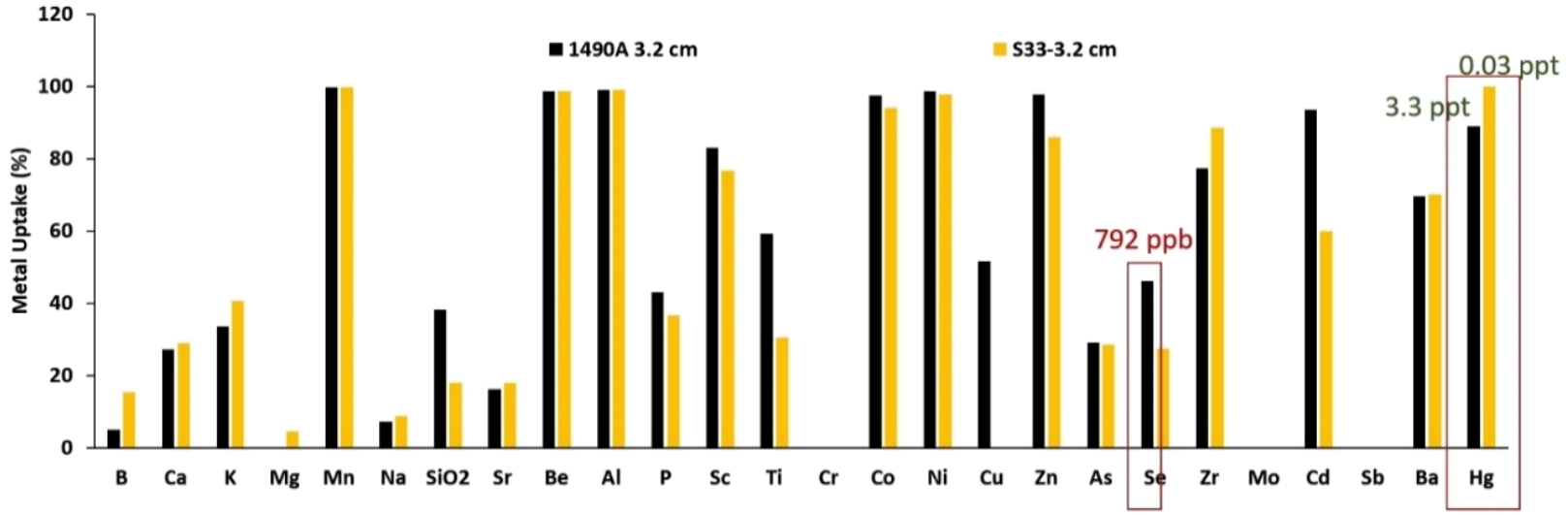






Task 3: Selective Removal of Heavy Metals for Effluent Streams

Percentage uptake of elements into NETL sorbents from Longview FGD water



Publication:

- W. C. Wilfong, B. W. Kail, Q. Wang, F. Shi, G. Shipley, T. J. Tarka, and M. L. Gray. Stable Immobilized Amine Sorbents for Heavy Metal and REE Removal from Industrial Wastewaters. Environmental Science: Water Research & Technology. Mar. 2020. 6,5, 1286-1299.

Patent Applications:

- M. L. Gray, B. W. Kail, W. C. Wilfong, Q. Wang, Stable Immobilized Amine Sorbents for REE and Heavy Metal Recovery from Liquid Sources. Published April 2018, WO2018071730A1 (**Licensed to PQ cooperation**)
- M. L. Gray, B. W. Kail, W. C. Wilfong, Q. Wang, F. Shi, Metal-loaded Basic Immobilized Amine Sorbents for the Removal of Metal Contaminants from Wastewater. Filed Jul. 17, 2019, US 62875364 (**Licensing in process and projected 2-ton test proposed by Somerset Environmental Solutions, Inc**.)
- M. L. Gray, B. W. Kail, W. C. Wilfong, Q. Wang, F. Shi. Multi-Functionalized Basic Immobilized Amine Sorbents for Removal of Metal Contaminants from Wastewater. Filed Jul. 18, 2019, US 62875829 (**Licensing in process and projected 2-ton test proposed by Somerset Environmental Solutions, Inc**.)

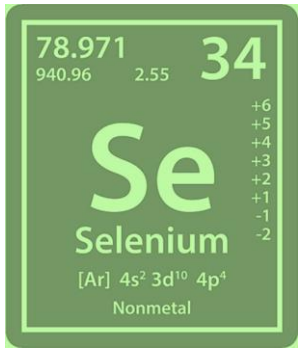
Goals

- Develop sorbent materials to improve the selective removal of heavy metals and regulated species from FGD effluent

Approaches

- Three NETL sorbents selectively reduced Se and Hg levels to below EPA discharge limit from Somerset FGD water.
- Two NETL sorbents selectively reduced Hg concentrations below EPA discharge limit from Longview FGD water.

Water Management for Power Systems – Task 6.0



Why should we care about selenium?

Chemical element selenium is a non-metal found in coal and is then released into the environment via coal fired powerplants. Small amounts of this element can cause detrimental ecological consequences. The EPA 2015 ELG rule seeks to revise the regulations currently in place for discharge of this contaminant. **Currently, it is known that biological treatment can remove dissolved selenium species, but not much is known about the organisms with this capability.**

Objective

This project seeks to **enrich**, **identify**, and **characterize** some of the **anaerobic** microorganisms present in FGD systems with the capability of reducing selenium oxyanions (Selenate [SeO_4^{2-}] and selenite [SeO_3^{2-}] to elemental selenium [Se^0]. In addition, this project seeks **to characterize the selenium nanospheres created by these organisms**. Enrichment of these biocatalysts will help form a detailed characterization of the microorganisms. Knowing more about these organisms and their capabilities **can lead to a seamless implementation of these organisms for selenium contaminant recovery during FGD wastewater treatment.**

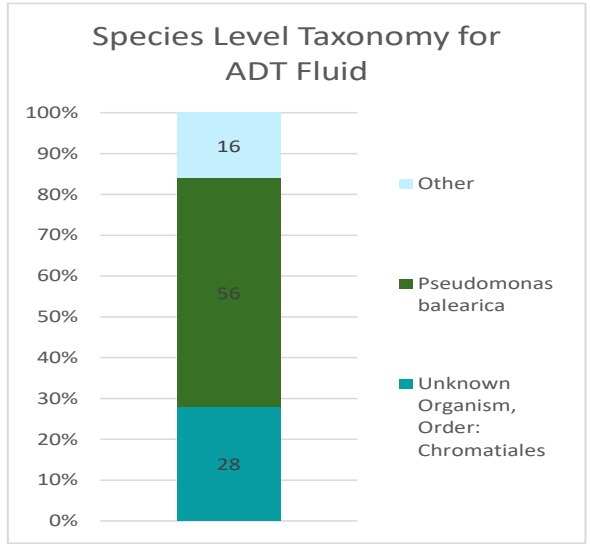
Progress

Qualitatively able to show that organisms able to reduce selenate and selenite exist in FGD wastewater. Finished enrichments for selenium oxyanion reducers. Biological analysis will be taking place soon.

Initial Inoculation with Alternative Discharge Tank Fluid from FGD system

After Initial 7 Day Incubation

Enrichment after Last 7 Day Incubation Period

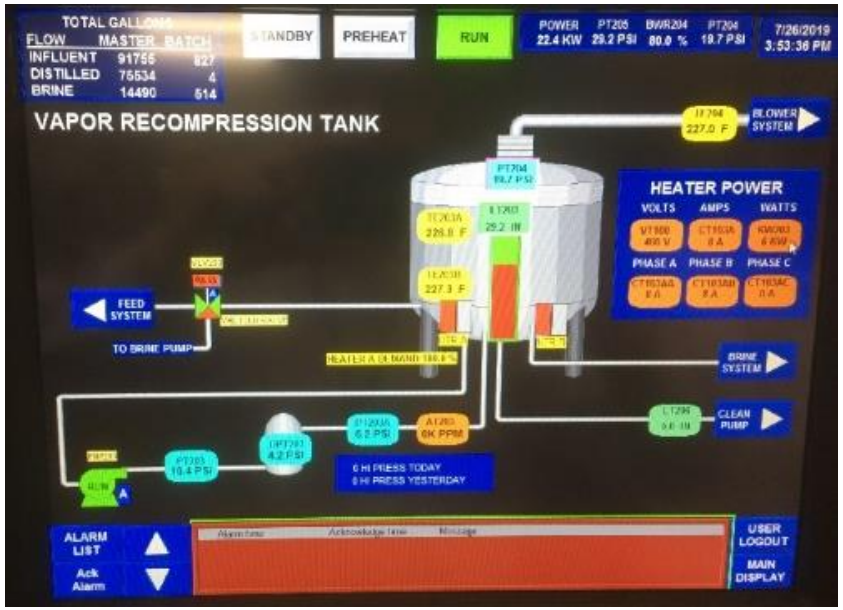


Taxonomy of starting microbial community before enrichment with selenium oxyanions demonstrates a unique and diverse ecosystem that is being optimized to produce competitive and symbiotic relationships that generate elemental selenium.

Task 4: Concentrating Wastewater Effluent Streams

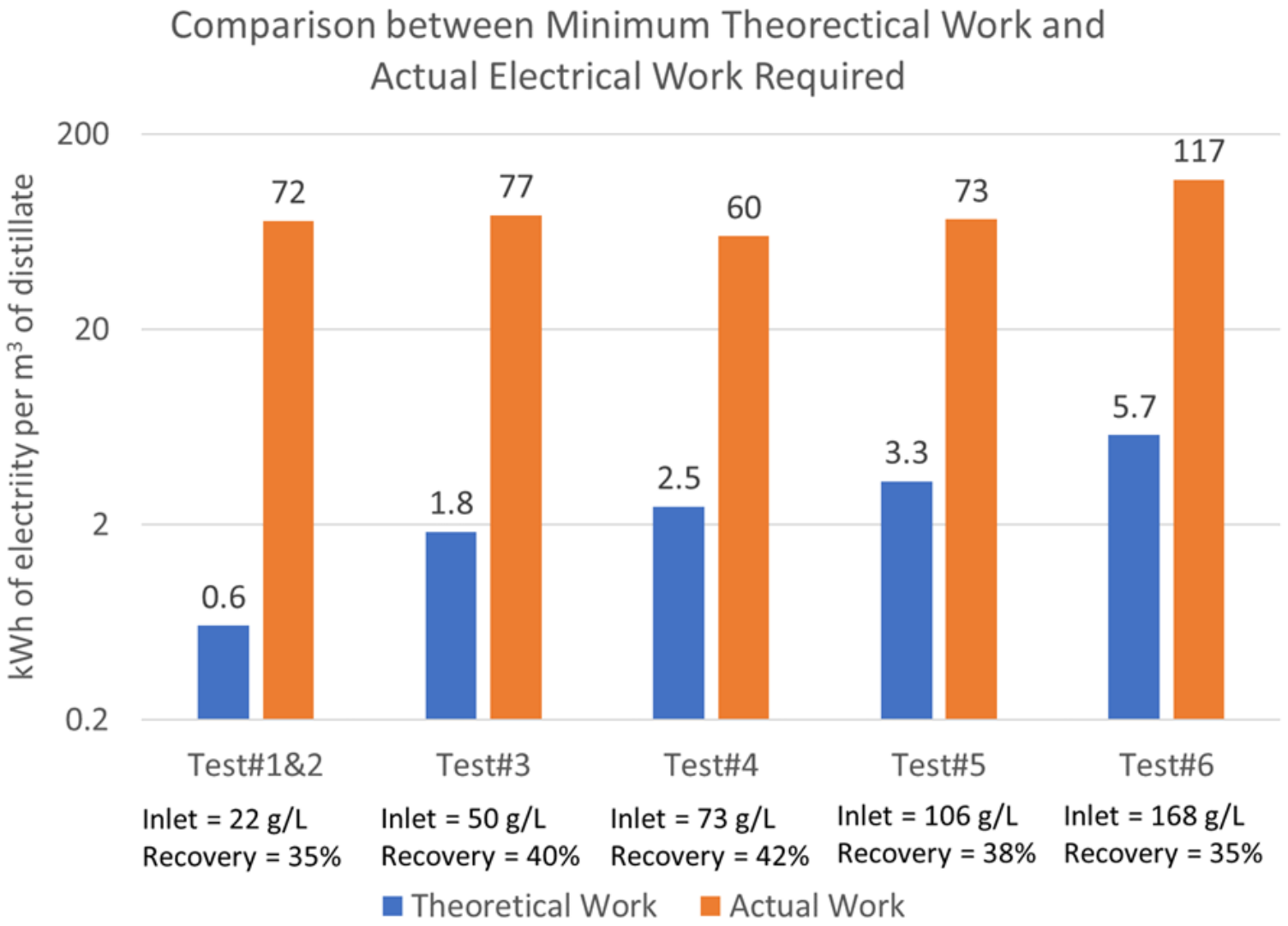
U.S. Army Brine Concentrator Baseline Tested at UND EERC

- Testing Dates: Aug 12th through 23rd
- Total Electrical Energy Consumption calculated at a range of inlet salinities



MVR Brine Concentrator is a baseline to compare more advanced treatment technologies that will be tested at the UND EERC BEST site. https://www.netl.doe.gov/node/9024

Task 4: Concentrating Wastewater Effluent Streams



- Flow rates, compositions and the kWh/m³ for all 6 cases
- Theoretical minimum work was estimated using OLI Flowsheet: Difference of Gibbs free energy of inlets and outlets (per m³ distillate)
- <u>Higher salinities had higher electrical efficiencies</u>
  - <1% efficient at low salinity
  - Approaching 5% efficient at highest salinities

Water Management for Power Systems

NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE/HQ Program Lead: Regis Conrad
Technology Manager: Briggs White
TD&IC Project Managers: Jessica Mullen & Barbara Carney

RIC Technical Portfolio Lead: Nicholas Siefert
RIC Principal Investigators:

• Task#2: Guiding R&D for Treatment of Coal Power Plant Effluent Streams	Eric Grol
• Task#3: Selective Removal of Heavy Metals for Effluent Streams	McMahon Gray
• Task#4: Concentrating Wastewater Effluent Streams	Nicholas Siefert
• Task#5: Impact of Water Use of Power Systems	Erik Shuster
• Task#6: Biological Treatment of FGD Effluent Streams	Djuna Gulliver
• Task#7: Characterization of FGD Effluent Streams	Dustin McIntyre
• Task#8: Water Management for Fossil-Based Hydrogen Production	Timothy Skone