Trace Element Sampling and Partitioning Modeling to Estimate Wastewater Composition and Treatment Performance at Coal Generators

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Regulatory Drivers and Alignment to Fossil Energy Objectives

Regulatory Drivers- Effluent Limitation Guidelines (2020)
DOE FE Objective 1.1 – Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future.
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DOE Water Security Grand Challenges - Reduce water impacts in the power sector.

Regulatory Drivers- Effluent Limitation Guidelines (2020)
Statement of purpose

• Trace elements have variable concentration in coal, and behave predictably in air pollution control devices (APCD)
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• This model improves on existing predictions for trace element partitioning at coal-fired power plants (CFPPs) by (1) accounting for plant-level variability and (2) providing validation
Project objectives

1. Develop a generalizable, open-source COntaminant behavior in Air, Liquid, and Solids (COALS) Controls Model to describe the quantity and partitioning behavior of trace elements B, As, Se, Pb, Hg, Cl and Br at US CFPPs.
Project objectives

2. Characterize removal performance for trace elements of concern within the best available technologies (BATs) under the Effluent Limitation Guidelines (ELGs) for Flue Gas Desulfurization (FGD) wastewater treatment.
Industry collaboration

- The project uses data collected at LGE-KU partner facilities and includes non-steady state plant operation
- Partner facilities include Trimble County, Ghent, and Mill Creek Generating Stations
Developed trace element partitioning model in air pollution control devices

Percent change in the mass of Selenium entering U.S. CFPPs between 1993 and 2017
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Attributional analysis of changes in the phase of trace elements exiting U.S. CFPPs

Simulated flue gas desulfurization wastewater composition

csESP = cold side electrostatic precipitator; ACI=Activated Carbon Injection; FGD=Flue Gas Desulfurization

Determined probability of treatment costs at the baseline 550 MW NETL coal fired powerplant

Costs [$M$]

Cumulative Probability

[i = 10%, n = 25 years]

CP=Chemical Precipitation; BT=Biological Treatment; TE=Brine Encapsulation; MF=Membrane Filtration
Next steps for model development

Task 4 – Calculate removal of trace elements in FGD wastewater and use linear models to predict removal efficiency

Task 5 - Continue modeling relationship between ramping and APCD/WPCD performance using the data that has been collected at Partner Facilities
Enable solid, liquid, and gas discharge management by modeling trace element behavior.
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Develop typical FGD wastewater compositions for treatment technology development

Enable solid, liquid, and gas discharge management by modeling trace element behavior

Develop typical FGD wastewater compositions for treatment technology development

Identify cost-effective FGD wastewater treatment technology options

Dissemination of results to industry

• 3 manuscripts published in Energy Policy and Environmental Science & Technology
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• Public GitHub project and Open Science Foundation project were created for the COALS Controls Graphical User Interface
Concluding remarks

• This project has successfully met objectives to predict trace element partitioning at CFPPs and identify FGD wastewater treatment costs
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• The objectives address water impacts in the power sector highlighted in DOE Water Security Grand Challenges
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