Developing Cost Effective Biological Removal Technology for Selenium and Nitrate from Flue Gas Desulfurization (FGD) Wastewater from an Existing Power Generating Facility

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Outline

• Objective
• Background Information
• Results
• Future Works
Objectives

The overall goal of our project is to investigate and determine a technically feasible and cost-effective process for designing photosynthetic organisms capable of sequestering Se and nitrates from FGD wastewater. To realize this goal, we have chosen to focus on the following 2 objectives:

(1) Investigate changes in transcripts and metabolism in algae and plants in response to FGD wastewater.

(2) Explore biotechnological strategies to increase sequestration of Se and nitrates in biomass to improve agricultural productivity.

Academic objective: to enhance student hands-on experience and participation in STEM research and education
Freshwater consumption is projected to increase further with the implementation of carbon capture technologies
Background Information

- Flue Gas Desulfurization (FGD) treatment is incorporated in most coal burning power generation plants to remove sulfur dioxide and various oxides of nitrogen by either wet/dry scrubbing.

- Large-scale coal fired thermoelectric plants in the USA consumes significant volumes of freshwater and generate considerable amounts of FGD wastewater.

- Wet scrubber blowdown often contains heavy metals (selenium, chromium, mercury etc.), and nitrates in harmful concentrations.

- These constitute a major challenge for utilities and a major concern for environmental regulators.
Background Information

- Removing Se and nitrates to ppb level is of particular challenge as conventional methods are generally not effective.

- Over the past two decades, industry has invested substantial resources in Se and nitrate removal technology (biological and chemical), achieving significant progresses.

- However, applications of these emerging technologies are considerably constrained by high cost, process complexity and other limitations.
Green algae and plants have the natural ability to degrade inorganic Se and nitrates.
Background Information

- Green algae and plants have the natural ability to degrade inorganic Se and nitrates.
- These organisms can be used in various ways to sequester Se and nitrates.
- The best methods available for Se and nitrate reduction in FGD wastewater include sequestration in the harvestable biomass.
Overview of the movement and metabolic conversion of Se by plants and their ecological implications

Initiated collaboration with John Amos power plant through Liberty Hydro and obtained treated and untreated FGD samples
Effect of FGD wastewater on freshwater algae biomass

Growth of Algae in culture medium supplemented with FGD and T-FGD wastewater for week-1 to 3; B. Algae biomass measurement for week-1 to 3, data were derived from three replications. Data indicate that algal biomass growth rate was higher in medium supplemented with FGD and T-FGD wastewater. C: Control; FGD: Flue gas desulfurization wastewater; T-FGD: Physical/Chemical treated flue gas desulfurization wastewater.
Effect of FGD wastewater on plant biomass (*Arabidopsis thaliana*)

A. Growth of Arabidopsis in soil watered with FGD and T-FGD wastewater for week-1 to 3; B. Plant biomass measurement for week-1 to 3, data were derived from three replications. Data indicate that plant biomass growth rate was higher in plants watered with T-FGD wastewater. C: Control; FGD: Flue gas desulfurization wastewater; T-FGD: Physical/Chemical treated flue gas desulfurization wastewater.
Effect of FGD wastewater on Duckweed biomass

Control                             FGD                               T-FGD
Perform post-sequence analysis and qRT-PCR analysis

Perform functional analysis of candidate genes in model system

- Short generation time-6-8 weeks from seed-seed
- Small size
- Wider adaptability
- Self-fertilization
- Susceptibility to Agrobacterium infection
- Small genome size -125 million base pairs
- Large collection of T-DNA
Effect of Selenium on Spirodella and Lemna Growth

Control        5mg/L         10mg/L         15mg/L         20mg/L         25 mg/L       30mg/L

Control        5mg/L         10mg/L         15mg/L         20mg/L         25 mg/L       30mg/L
Effect of Selenium on Spirodella Growth

After 10 days of growth

After 20 days of growth
Effect of Selenium on Lipid Production

<table>
<thead>
<tr>
<th>Selenium Concentration (mg)</th>
<th>SPIRODELLA</th>
<th>LEMNA</th>
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<tbody>
<tr>
<td>5</td>
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TAG and DAG indicate the detection of TAG and DAG compounds respectively.
Effect of Selenium on Lipid Production in Algae
Establishment of Selenium on Setaria

- Established a hydroponics system to test effects of individual chemicals present in FGD wastewater.
- Two week old hydroponically established plants were then exposed to selenium in different concentrations from 5mg/mL up to 25mg/mL.
- Treatments ran for four weeks, rate of photosynthesis data and final biomass were calculated.
Selenium Treatment Inhibits Photosynthesis
Effect of Selenium on Aerial Biomass

Dry Weight (g)

Concentration of Selenium

Control  5mg/mL  10mg/mL  15mg/mL  20mg/mL  25mg/mL
Effect of Selenium on Arabidopsis

- Treatments ran for four weeks, photosynthesis data was collected, and biomass was harvested and weighed. Seeds were collected, weighed, and tested for germination viability.
Effect of Selenium on Seed Production

![Bar Chart: Effect of Selenium on Seed Production](chart.png)
Selenium Treatment Negatively Effects on Arabidopsis Seed Development and Germination
Schematic representation of binary vectors used for transgenic plants establishment

Current status:
T1 generation plants are growing…
Learning Water Quality in a Class Room

Oral presentation in WVSU SURE symposium, 2017
Poster presentation in 1890 ARD symposium, 2017
Oral presentation in ASPB symposium, 2017
Studying the Effect of Water on Plant Physiology
Acknowledgement

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