Environmental W.W. Engineering

Feasibility of Fungi to Remove Heavy Metals from Mine Wastewater

William Bain, Sara Danielle Gallaher, Nolan Maxwell,
Yue Shen and Masad Alyahya

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Project Background

- ❖ **Objective:** Analyze fungi's ability to adsorb lead contamination from a liquid solution
- ❖ **Client:** Dr. Bridget N. Bero, Ph.D
- ❖ **Mine Waste Problem:** Harm to environment and society due to highly toxic elements in waste
- ❖ **Typical Mine Contaminants:** Lead, Chromium, Cadmium, Arsenic, Zinc and Copper

Figure 1: Gold King Mine Spill, CO

Figure 2: Gold King Mine Spill, CO

Project Purpose

Need for Alternatives

- ❖ Traditional remediation methods are..
  - ➢ Costly
  - ➢ Not sustainable
  - ➢ Difficult to implement

- ❖ Proposed method may be more cost effective and sustainable

Supporting Research

- ❖ *Aspergillus niger*
- ❖ *Agaricus bisporus*

Figure 3: *Agaricus bisporus*

Adsorption Analysis

- **Adsorption Isotherm**: the mathematical relationship of an adsorbent and a solution, at a certain concentration, at equilibrium
- Can be linear or nonlinear

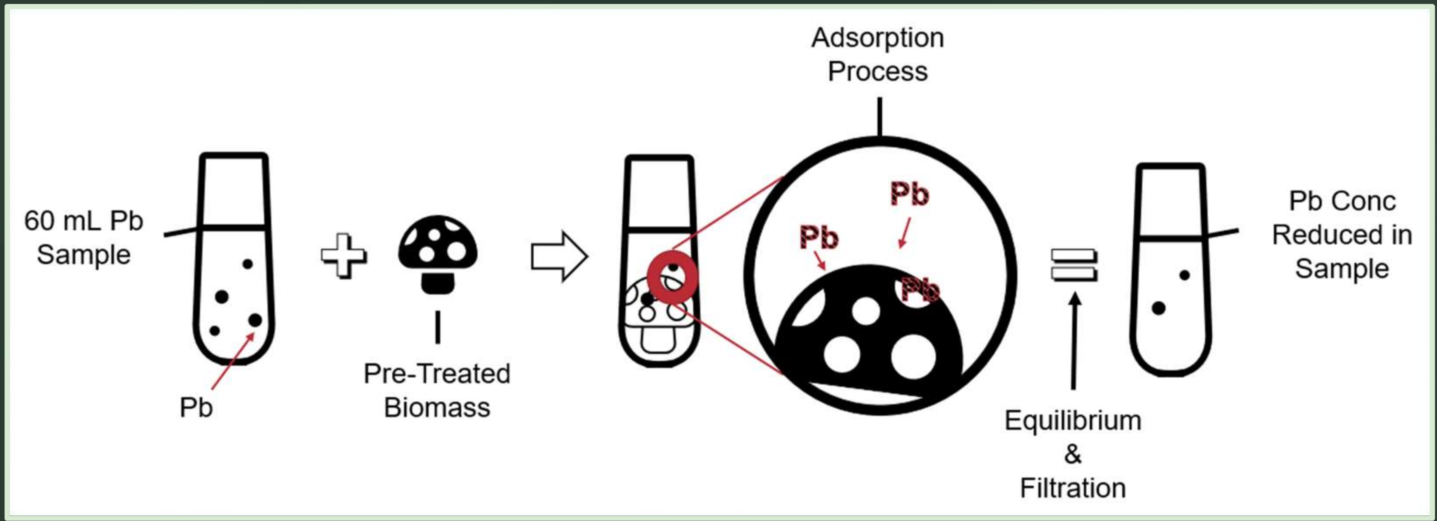


Figure 4: *Adsorption Isotherm Experiment Process*

Methodology and Procedures

Mushroom Preparation

- Chop into ~1" pieces
- Dry at 60℃ for 24 hrs in batches

Figure 6: Dried Mushrooms

Figure 7: Pretreatment Set-Up

Figure 5: Mushrooms in Drying Oven

Figure 8: Pretreated Mushrooms

Mushroom PreTreatment

- 0.5 M NaOH Solution
  - 10 g Biomass
  - 500 mL Soln
- Heat but don't burn
- Strain and Rinse
- Dry

Experiments

Figure 9: XRF Sample Containers

Experimental Matrix - Simplified				
Initial Pb Conc mg/L	Fungi Mass Range mg	Pretreat (Yes or No)	# Mass Variations	# Replicates
1000	100-1000	Yes, Original	10	3
1000	100-1000	Yes, Updated	10	3
1000	100-1000	No	10	3
400	100-1000	Yes, Updated	7	3

Table 1: Experimental Matrix

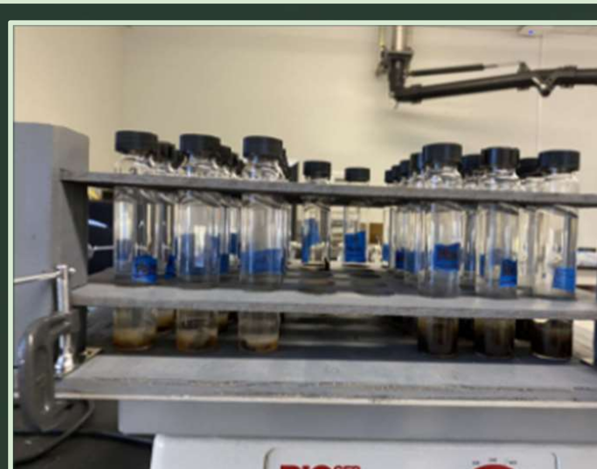


Figure 10: Sample Vials on Shaker Table

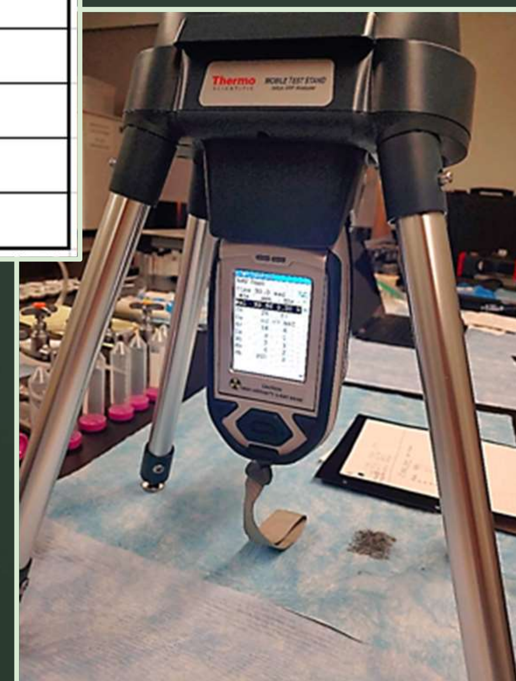


Figure 11: XRF

Calibration Curve

Lead (Pb) Detection by XRF Device vs Known Concentrations

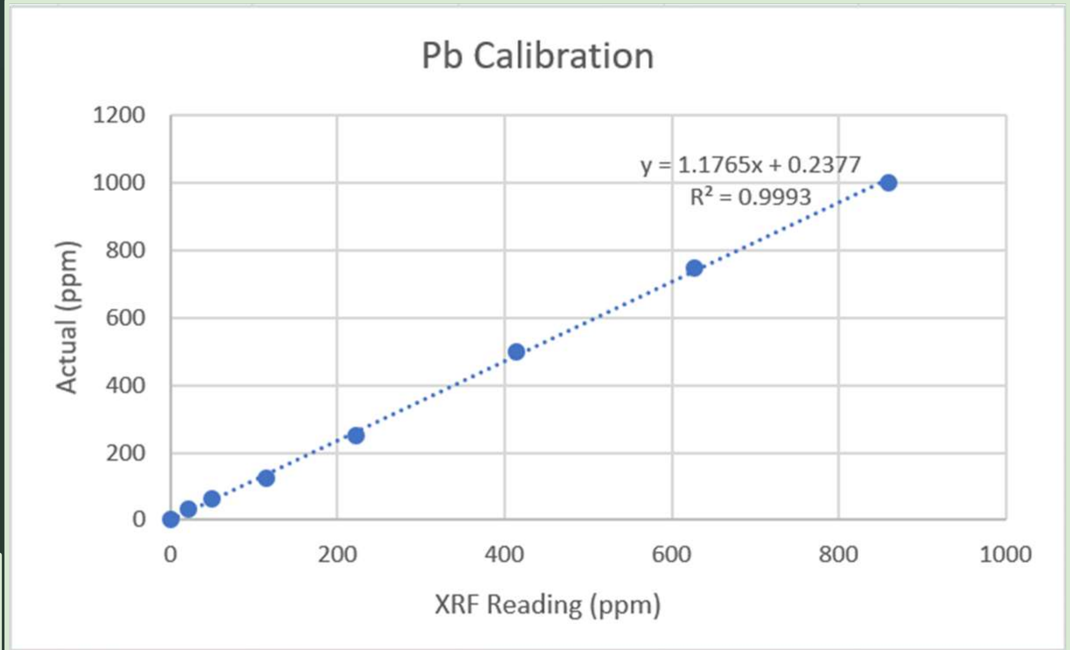


Figure 12: XRF Calibration Curve for Lead

Dilution	Known Conc Pb (ppm)	XRF Pb (ppm)	SD (%)
None	1000	867	14
1	500	416	10
1	500	426	10
1	500	419	10
2	250	204	7
2	250	212	7
2	250	206	7
3	125	75	4
3	125	74	4
3	125	81	5
4	62.5	26	3
4	62.5	25	3
4	62.5	25	3

Table 2: Detection Limit Testing Results

Detection Limit

Lead (Pb) detection limit for liquid samples in XRF Device

Results: Pre-Treatment Use

Pretreatment resulted in better adsorption than no pretreatment

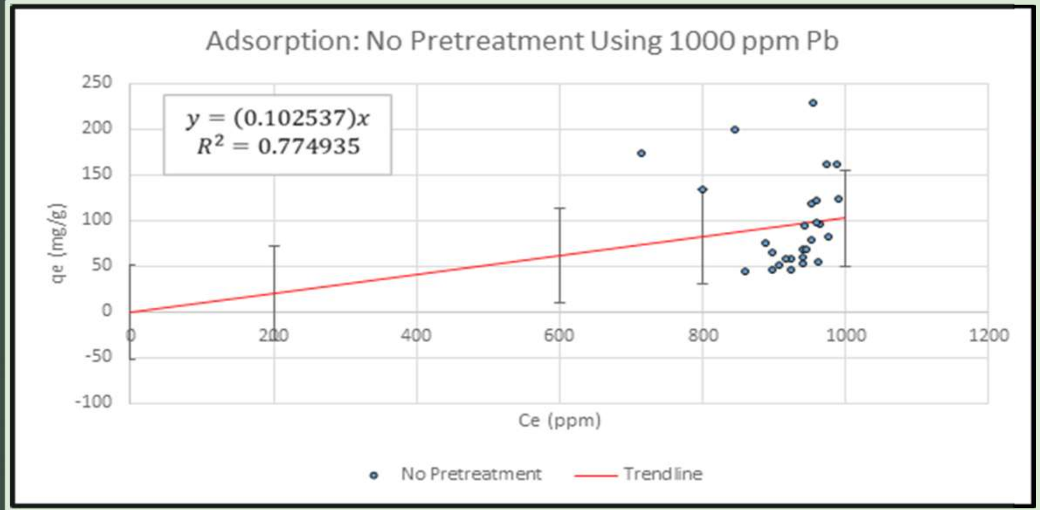


Figure 13: *No Pretreatment*

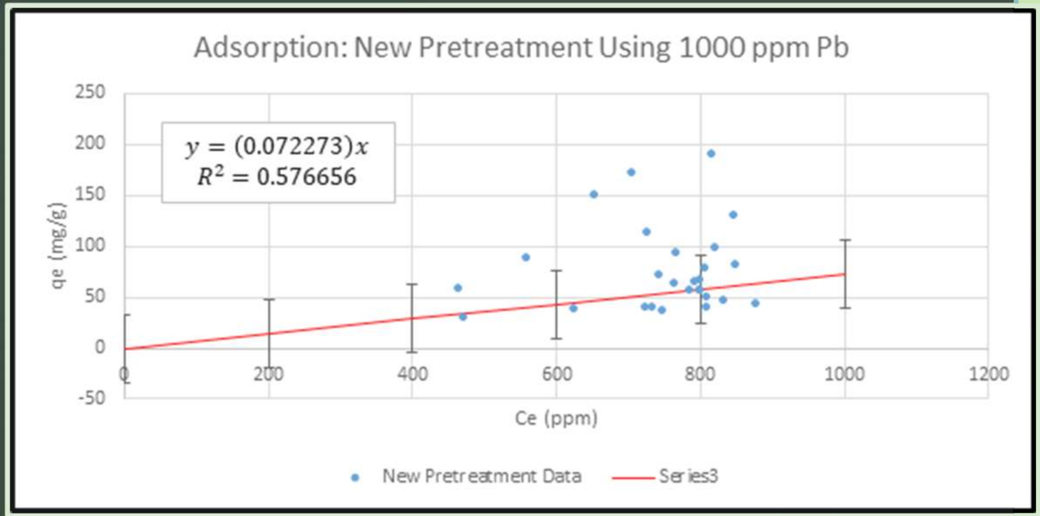


Figure 14: *Updated Pretreatment*

Results: Adsorption Isotherm Experiment

Variables:

qe (mass Pb per mass fungi)

Ce (conc of Pb in the water)

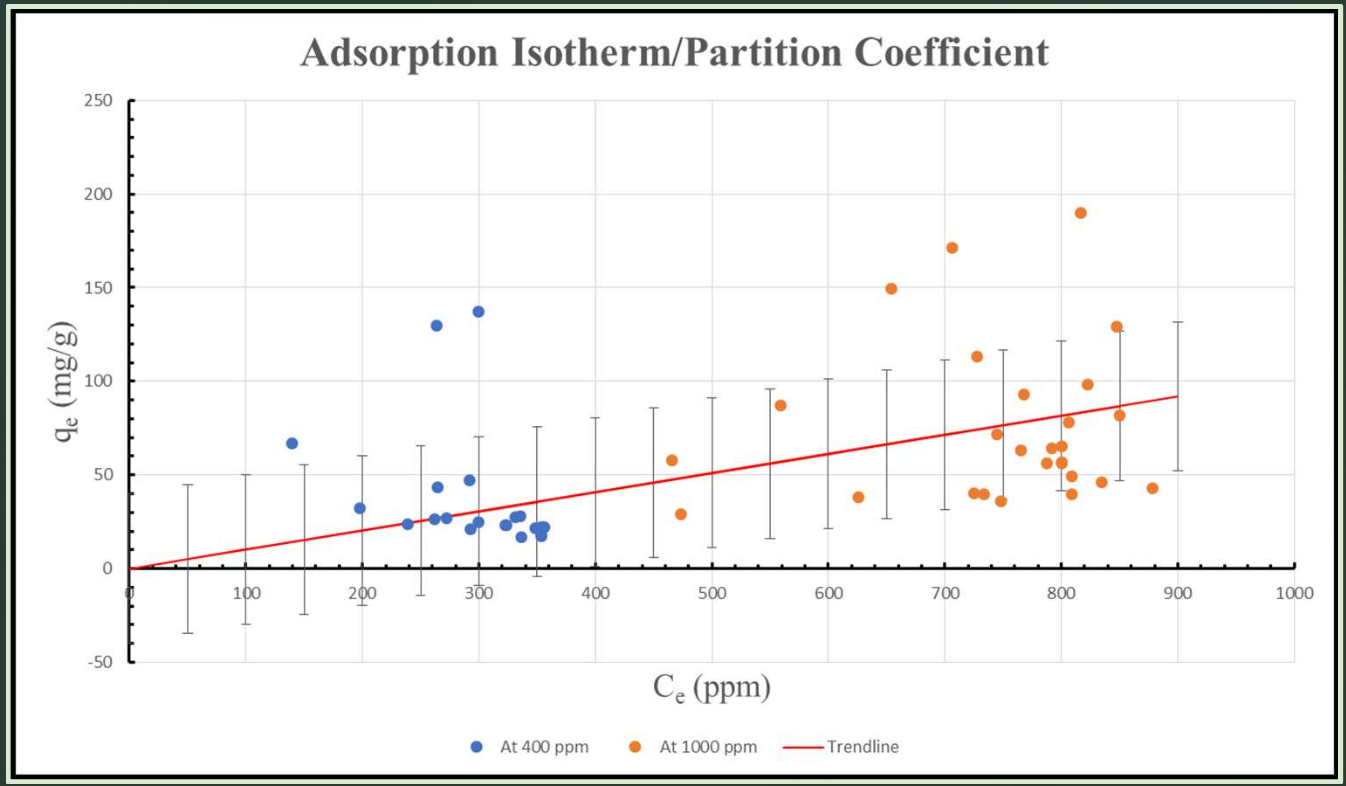


Figure 15: Final Results

Treatment System Scale-Up

- ❖ Sequencing Batch Reactor
  - ➢ Filling
  - ➢ Reaction
  - ➢ Settling
  - ➢ Decating or Drawing
  - ➢ Idling
- ❖ Continuous Stirred Tank Reactor
  - ➢ Steady Rate operation
  - ➢ Well Mixed Process
  - ➢ Continuous Influent Flow
- ❖ Fixed-Bed Column
  - ➢ Unsteady Rate Operation
  - ➢ Upper and Lower Support
  - ➢ Upper and Lower Cotton Wool

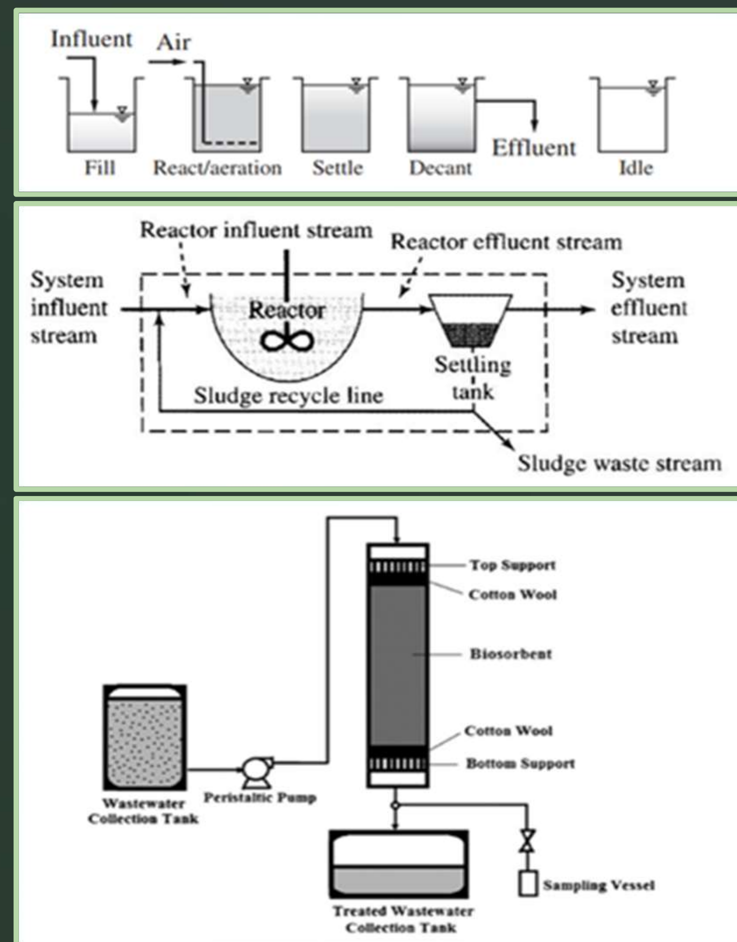


Figure 16: Treatment System Options

Treatment System Selection

Table 3: Treatment System Decision Matrix

Criteria	Weight (%)	Batch Reactor	CSTR	Fixed-Bed Column
Operation Cost	25	60	40	80
Simplicity	20	80	60	40
Biomass Injection	15	70	70	40
Sludge Control	15	60	80	40
Applicability	25	80	80	60
Overall	100	70.5	64.5	55

Selected System

Design of a Treatment System

Hypothetical Design

Table 4: Treatment System Design Variables

K	Ce	qe	C0	V	m	NaOH	Rinsing DI Water
Unitless	(mg/L)	(mg/g)	(mg/L)	(m3/d)	(kg/d)	(L/d)	(L/d)
0.102109	0.6	0.061265	60	3.79	3674.6	13123.5	13123.5
0.102109	0.6	0.061265	50	3.79	3055.9	10914.2	10914.2
0.102109	0.6	0.061265	40	3.79	2437.3	8704.8	8704.8
0.102109	0.6	0.061265	30	3.79	1818.7	6495.5	6495.5
0.102109	0.6	0.061265	20	3.79	1200.1	4286.1	4286.1
0.102109	0.6	0.061265	10	3.79	581.5	2076.7	2076.7

Equations and Calculations

Equation 1: Solute Adsorbed Per Mass of Adsorbent

$$q_e = K\,C_e$$

Equation 2: The Required Mass Rate of Adsorbent

$$\dot{m} = \frac{\dot{V}(C_0 - C_e)}{q_e}$$

$$q_e = 0.102109(0.6)\frac{mg}{L} = 0.061265\frac{mg}{kg}$$

$$m = \frac{\left(\frac{3.79\,m^3}{d}\right)\left(1000\frac{L}{m^3}\right)\left(60\frac{mg}{L} - 0.6\frac{mg}{L}\right)}{0.061265\frac{mg}{kg}} = 3674.602631\frac{kg}{d}$$

$$NaOH\ Required = \frac{50\ mL}{14\ g}\left(\frac{1000\ g}{kg}\right)\left(\frac{1\text{L}}{1000\ \text{mL}}\right)\left(3674.6\frac{\text{kg}}{\text{d}}\right) = 13123.5\ \text{L/d}$$

$$DI\ Water\ Required = \frac{50\ mL}{14\ g}\left(\frac{1000\ g}{kg}\right)\left(\frac{1\text{L}}{1000\ \text{mL}}\right)\left(3674.6\frac{\text{kg}}{\text{d}}\right) = 13123.5\ \text{L/d}$$

Note: 50 mL of NaOH is the required to pre-treat 14 g of mushroom and 50 mL of DI water is the required to rinse 14 g of mushroom

Treatment System Block Diagram

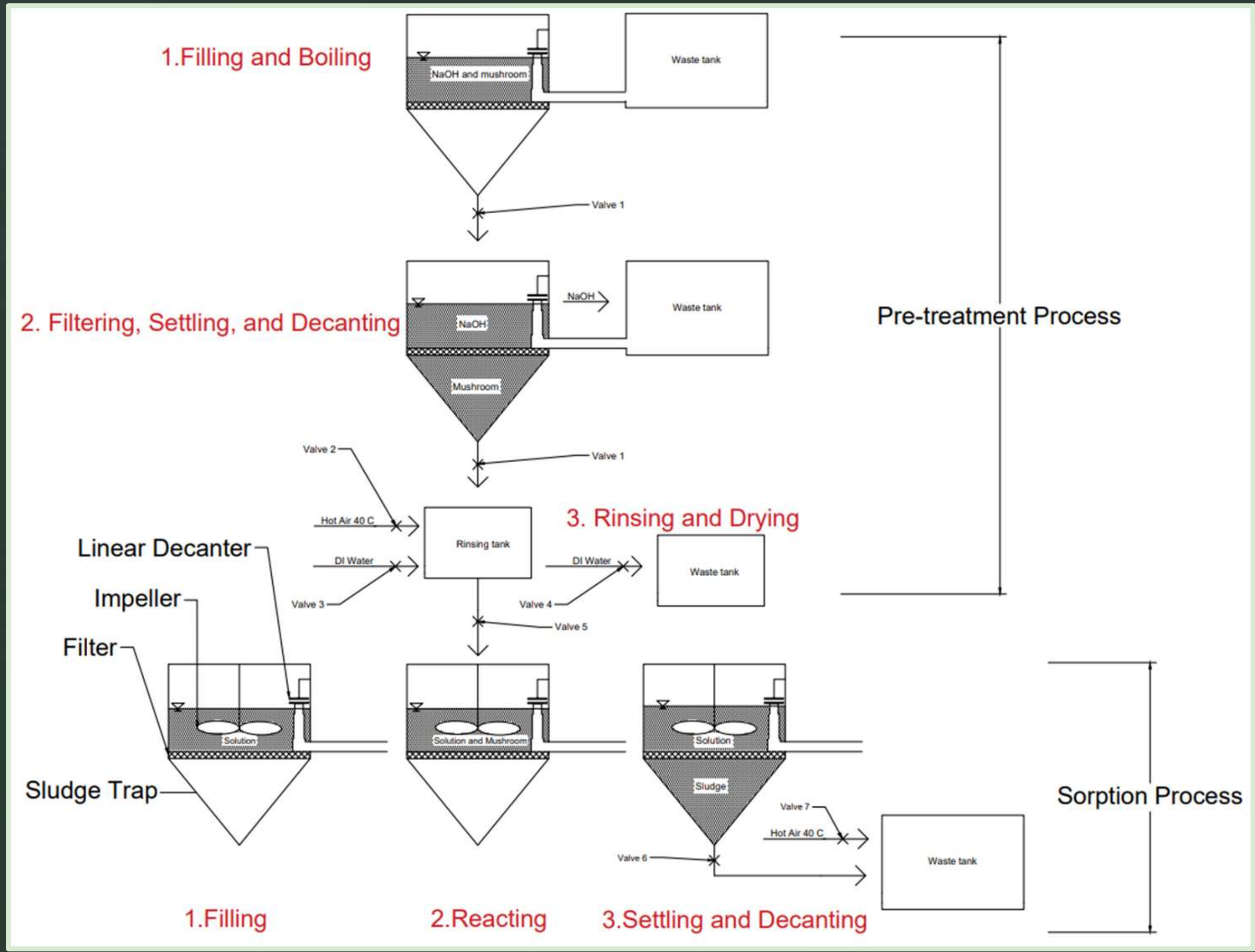
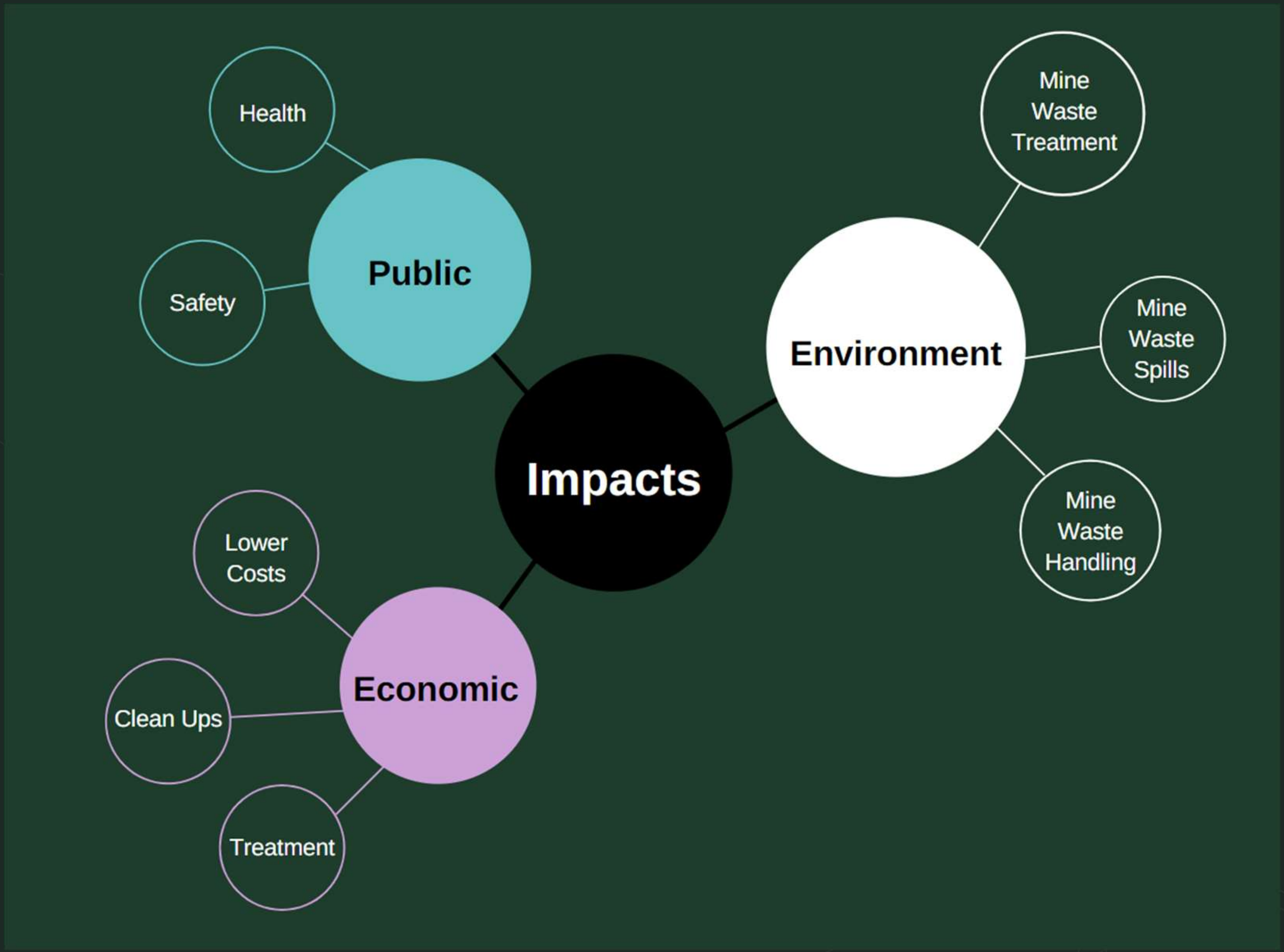


Figure 17: Batch Reactor Steps

Impact Analysis



Questions?