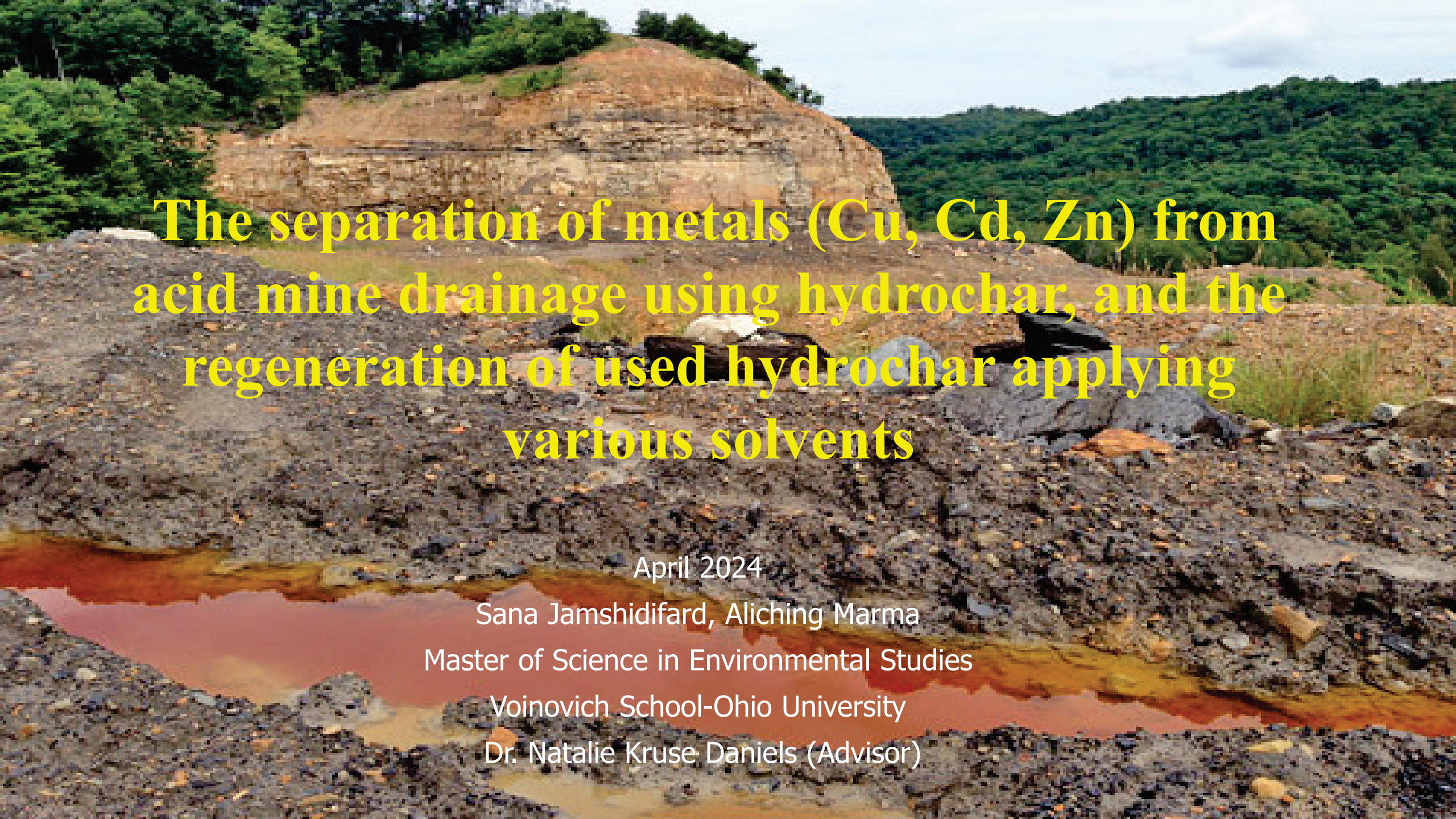

The separation of metals (Cu, Cd, Zn) from acid mine drainage using hydrochar, and the regeneration of used hydrochar applying various solvents

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Introduction

Metal	Potential Health Risks of Metals
Cd	Kidney disease, infertility, bone fracture, osteoporosis, cancer, immune system deficiency, central nervous system etc.
Cu	Wilson's disease, diarrhea, anxiety, dizziness, vomiting, irritation caused in the mouth cavity, death, etc.
Zn	Anemia, stomach cramp, Nausea and vomiting, fatigue, pancreatic complication, copper deficiency, etc.

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Goals And Objectives

Pyrolysis

Biochar

HTC

Hydrochar

To investigate the **capacity of hydrochar** as a low-cost sorbent for removing Cu, Zn, Cd in synthetic mine water

Assess the hydrochar **regeneration**

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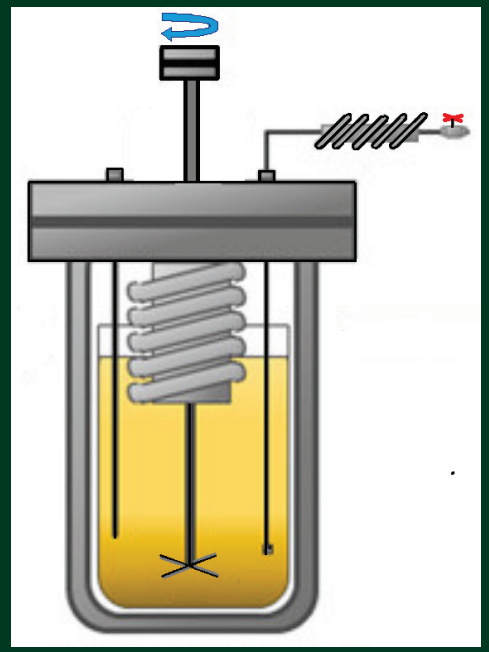
Research Methodology

Wastewater sludge & food waste

Digestate

Hydrothermal Carbonization



Hydrochar

Crushed hydrochar < 1mm

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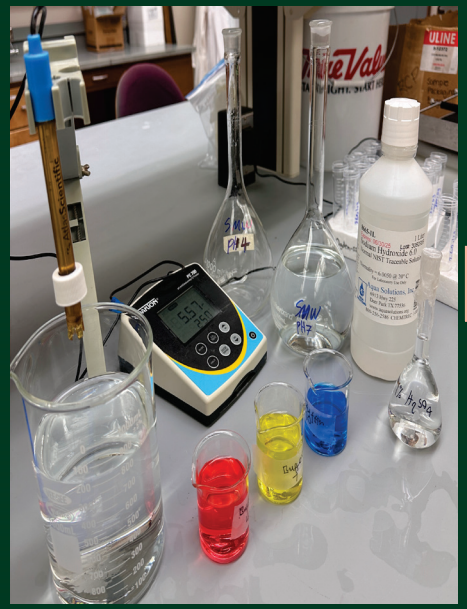
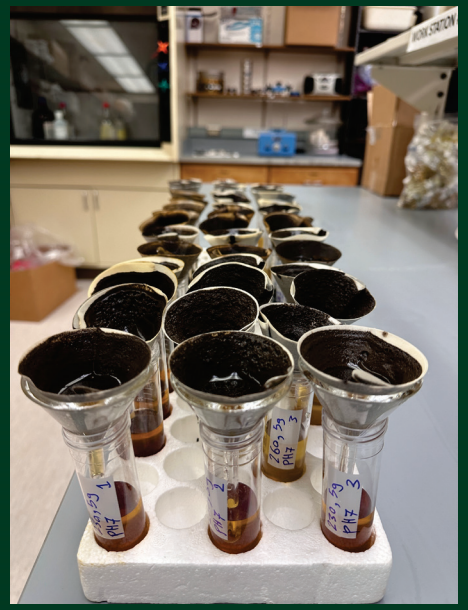
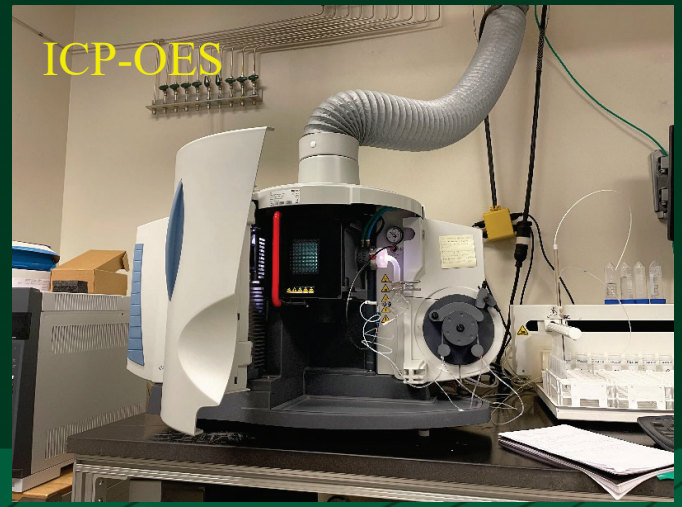
Research Methodology





$$\text{Removal percentage} = 100 \times \frac{C_0 - C_f}{C_0}$$



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Research Methodology

- Regeneration of the heavy metals from the used dried char material leached in Ethylene diamine tetra acetic acid (EDTA), HNO_3, KCl, and DI.

- For each adsorption-desorption cycle, the ratio of the solution to hydrochar was kept at 7.

$$\text{Desorption percentage } \% = 100 \times \frac{C_s \times V_s}{(C_0 - C_f) \times V}$$

EDTA, HNO_3, KCl, and DI

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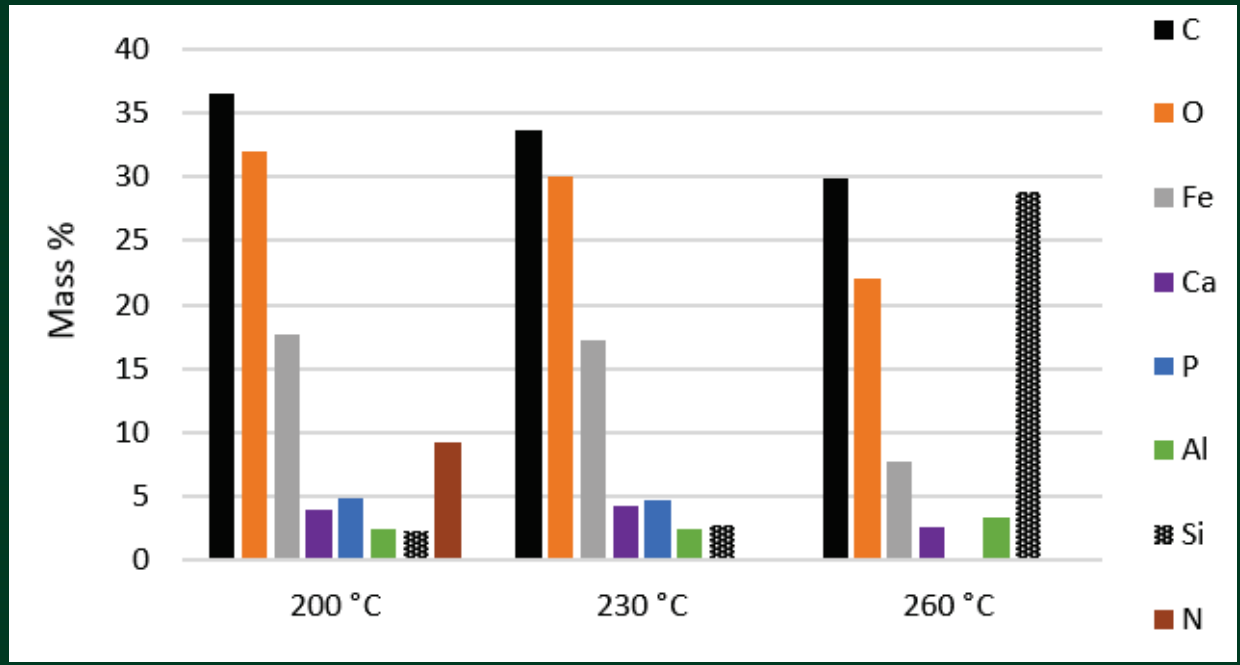
Results and Discussion:

The effect of hydrochar processing temperature

- Liu et. all reported at a higher temperature range (200–250 °C), there is an initial reduction in the oxygen and carbon content of the hydrochar (F. Liu, 2017)

- As the temperature rises from 200 °C to 260 °C, there is a reduction in the atomic ratios of oxygen to carbon and hydrogen to carbon (M. Sevilla, 2009)

- This phenomenon can be the result of the thermal-induced decomposition and volatilization of organic compounds



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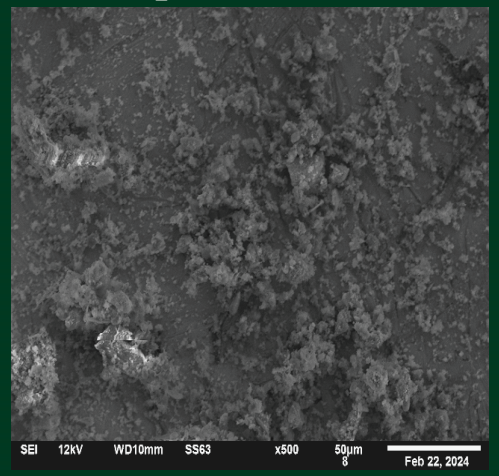
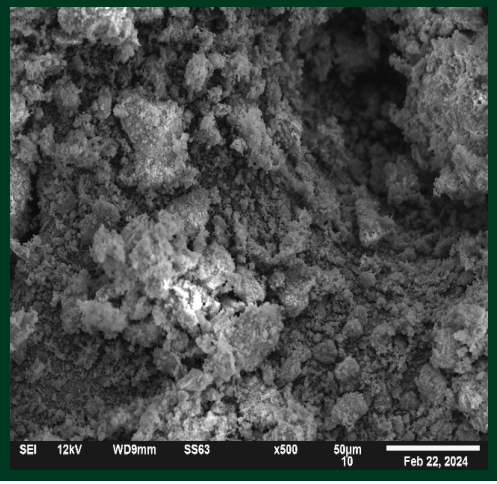
Results and Discussion:

The effect of hydrochar processing temperature

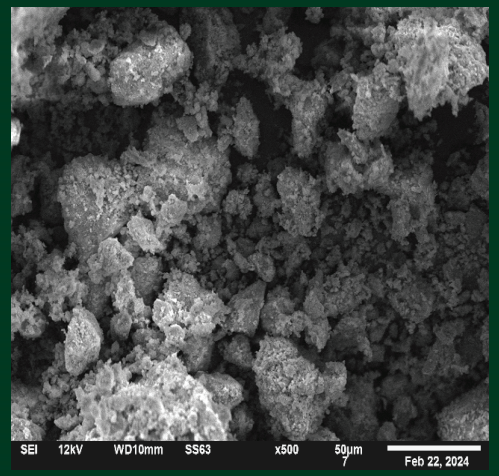
hydrochar processed at 260 °C

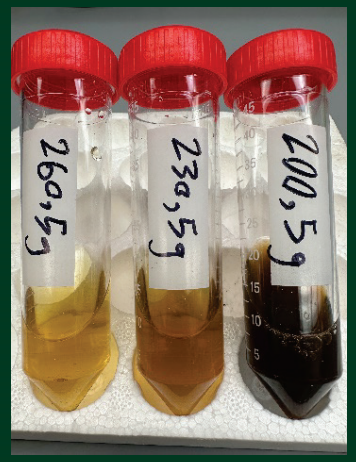


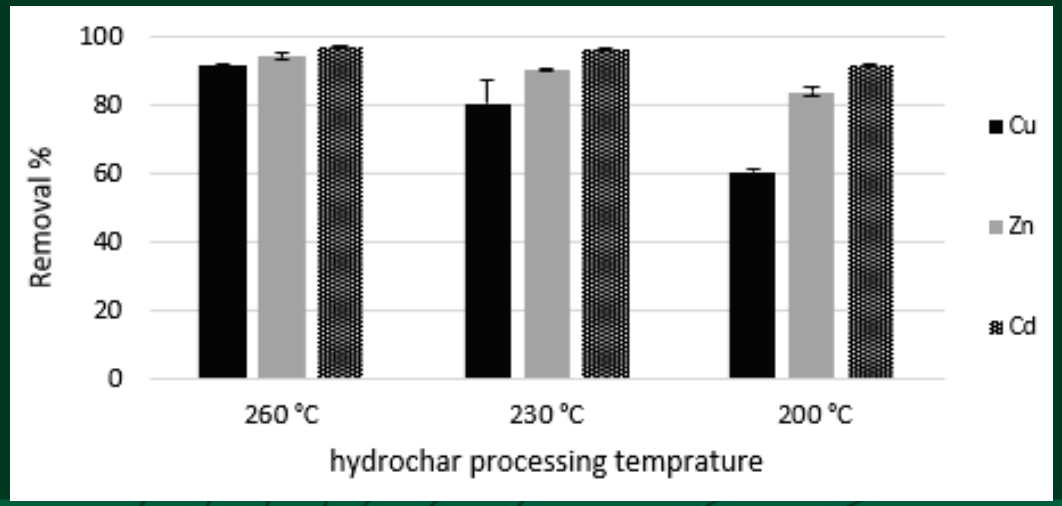
hydrochar processed at 230°C



hydrochar processed at 200 °C







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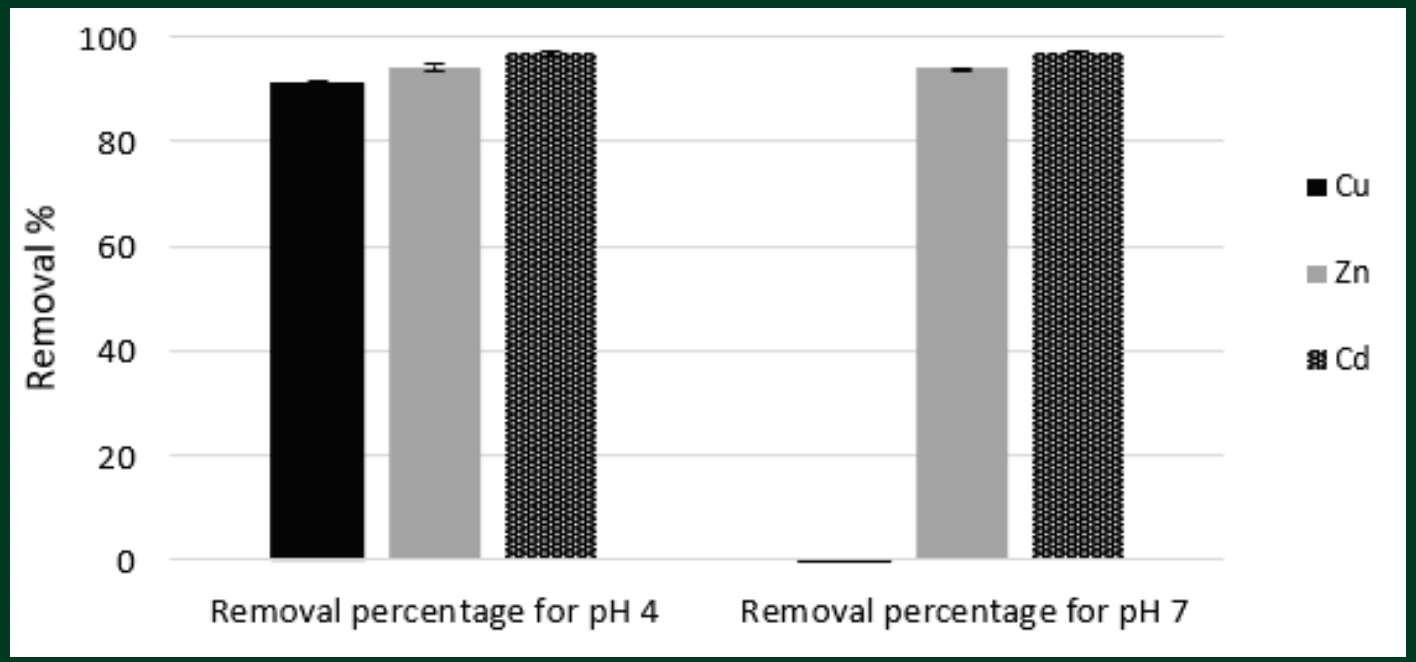
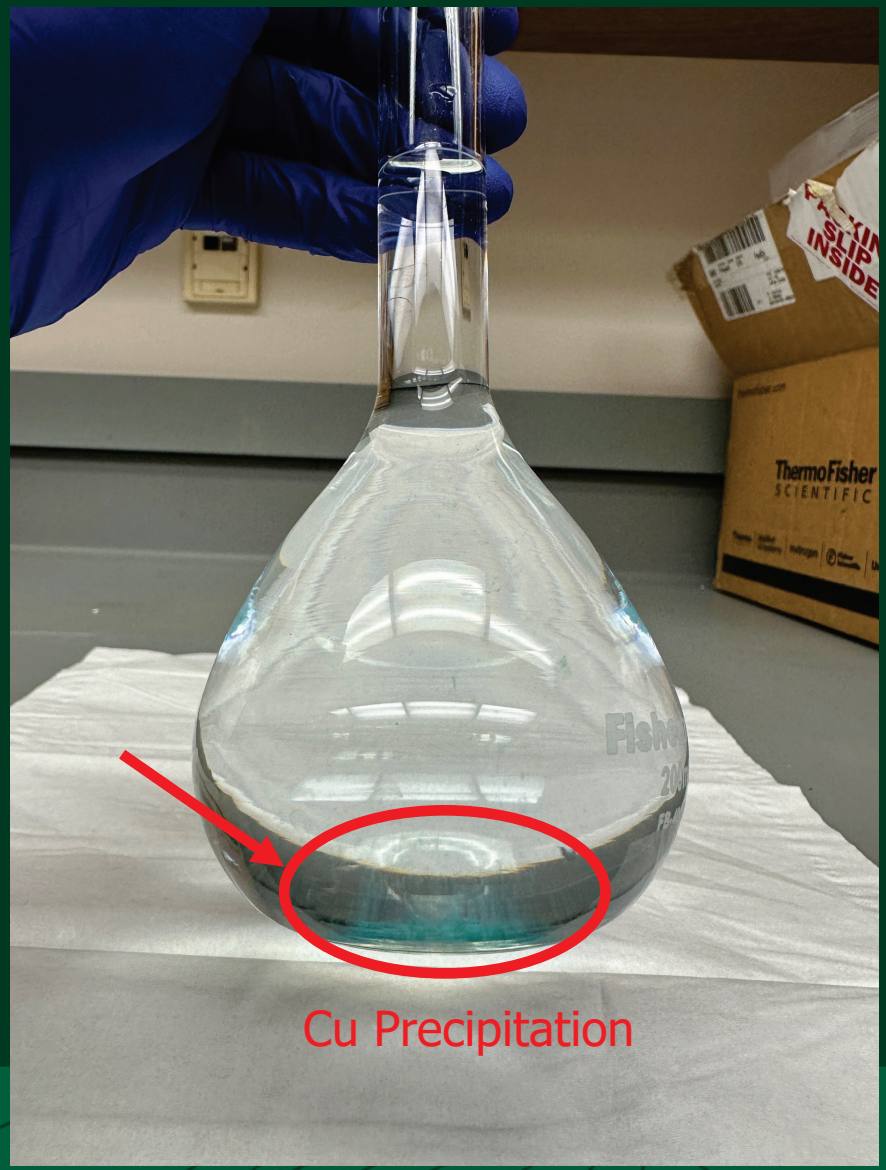
Results and Discussion: The effect of the pH of SMW

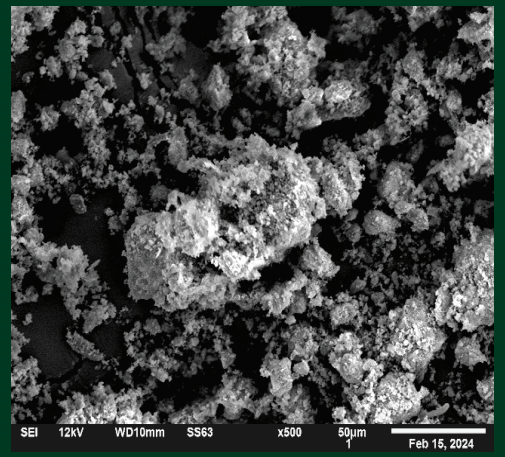
$$M^{2+}(aq.) + nH_2O \leftrightharpoons M(OH)^{2-n} + nH^+$$



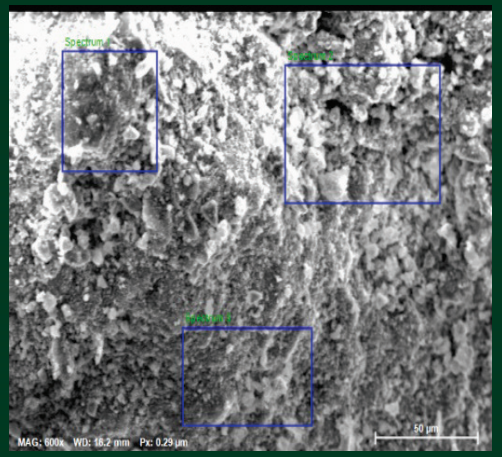


Results and Discussion: The effect of first-cycle

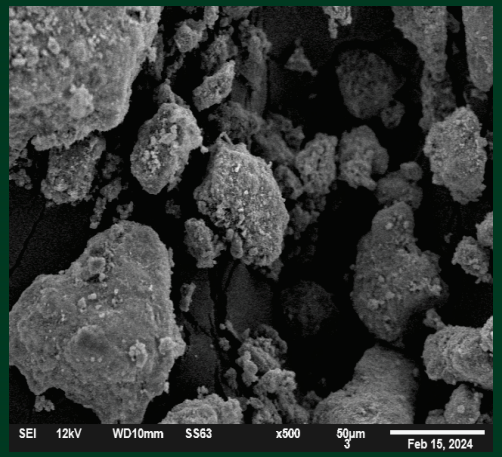
Raw hydrochar



After the first adsorption



After the first desorption by EDTA

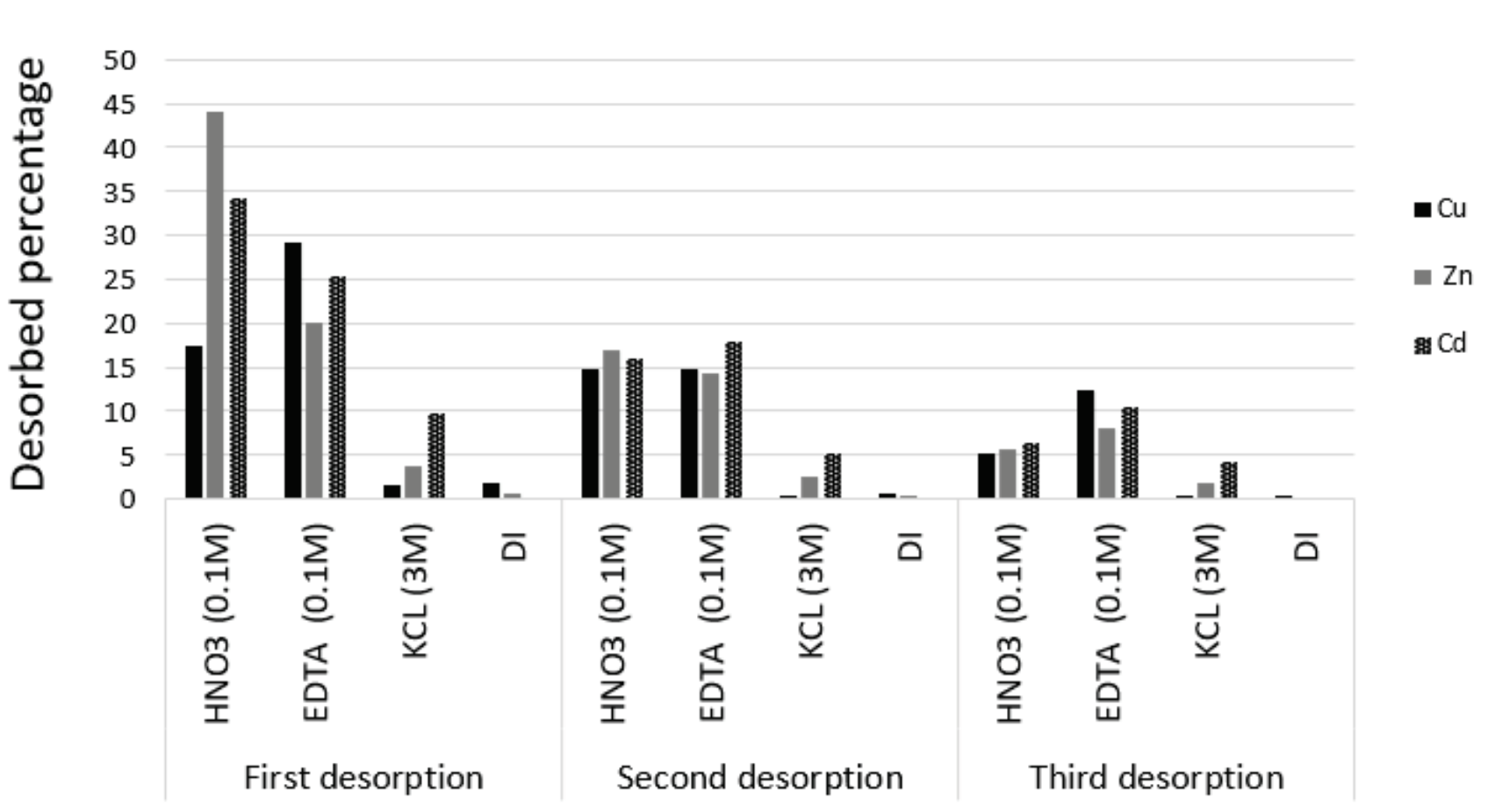


Element	At. No.	Mass [%]	Mass Norm. [%]	Atom [%]	abs. error [%] (3 sigma)
C	6	4.98	9.00	25.00	0.63
Fe	26	18.53	33.47	20.00	2.31
P	15	6.49	11.73	12.64	0.70
Al	13	3.83	6.91	8.55	0.53
O	8	2.25	4.07	8.48	0.24
Si	14	3.40	6.15	7.31	0.41
Ca	20	4.70	8.49	7.07	0.47
S	16	1.65	2.99	3.11	0.17
Pd	46	5.33	9.62	3.02	0.51
Mg	12	0.98	1.77	2.44	0.16
Cd	48	2.23	4.03	1.20	0.21
Zn	30	0.64	1.16	0.59	0.11
Na	11	0.17	0.30	0.43	0.03
Cu	29	0.18	0.32	0.17	0.03
		55.38	**100.00**	**100.00**	

Results and Discussion:

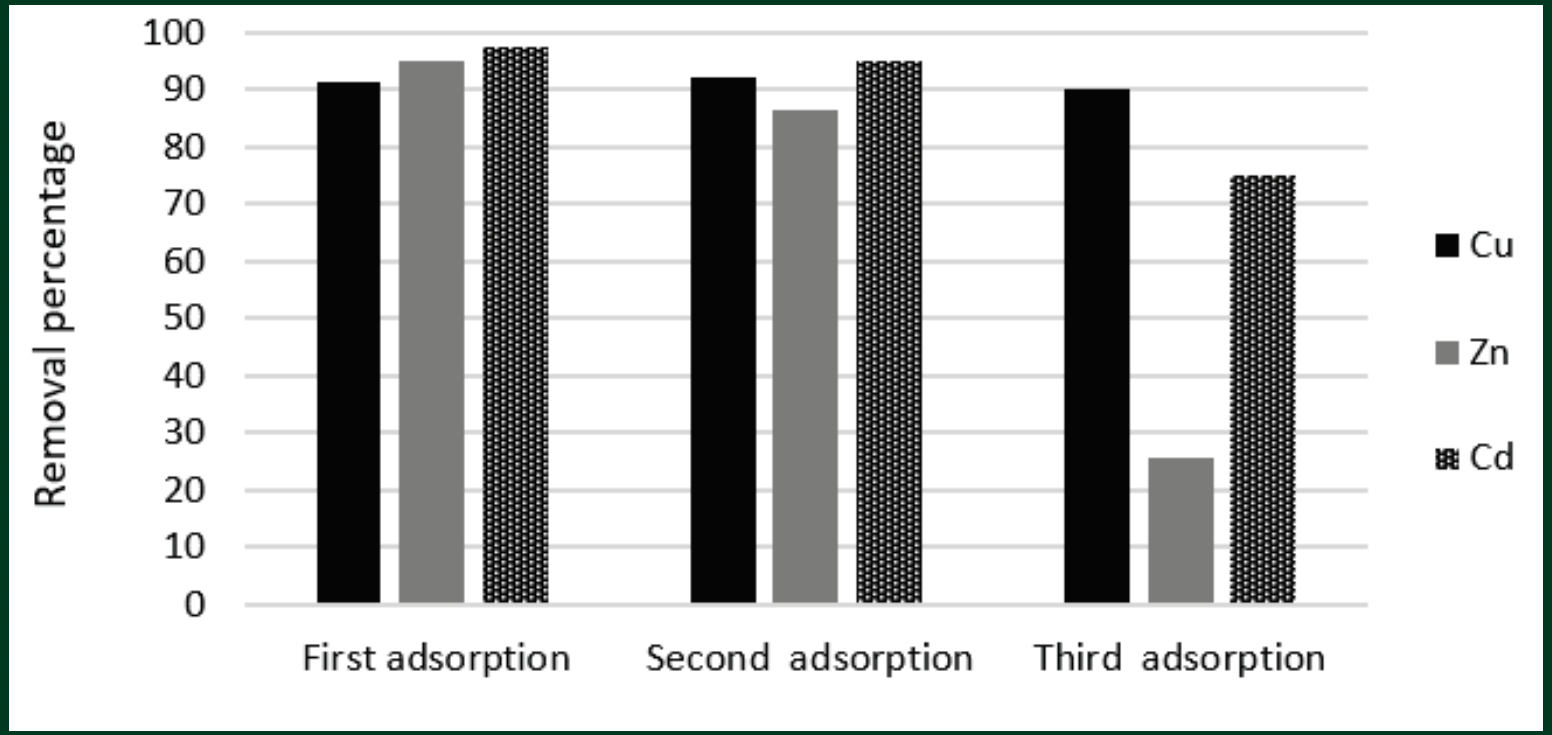
Reduction in desorption through the second and third desorption cycles

- The reduction in desorption percentage observed in subsequent cycles can be attributed to several factors such as **surface saturation, sorbent degradation, metal redistribution, ion exchange dynamics, and kinetic effects.**



Results and Discussion:

Comparison of metal removal percentage observed in subsequent cycles



- Due to **the different properties of the metals**, they were removed with different amounts.

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Conclusions:

1. The highest metal removal was obtained at pH 4 for the hydrochar processed at 260 °C.
2. 5g hydrochar resulted in higher removal percentage for Cu, and Cd ions.
3. As processing temperature increased, there was a notable decrease in O/C and H/C ratios. A smoother surface, and higher solubility were also observed.
4. Precipitation observed at pH 7.
5. EDTA and HNO_3 were the most effective solvents for desorption.
6. KCl solvent was not applicable as EDTA and HNO_3.
7. The hydrochar lost its functionality to remove metals after the second desorption cycle.

Next Steps: Hydrochar as an additive to bioreactors Research Question

- How efficient is the use of hydrochar in bioreactors to remediate acid mine drainage?
- Can locally accessible, biodegradable and by product sources support the growth of sulfate-reducing bacteria in the bioreactor to efficiently remove sulfate and heavy metals?
- How successful is the use of metagenomics in the DNA analysis of bacteria cultured in bioreactors?

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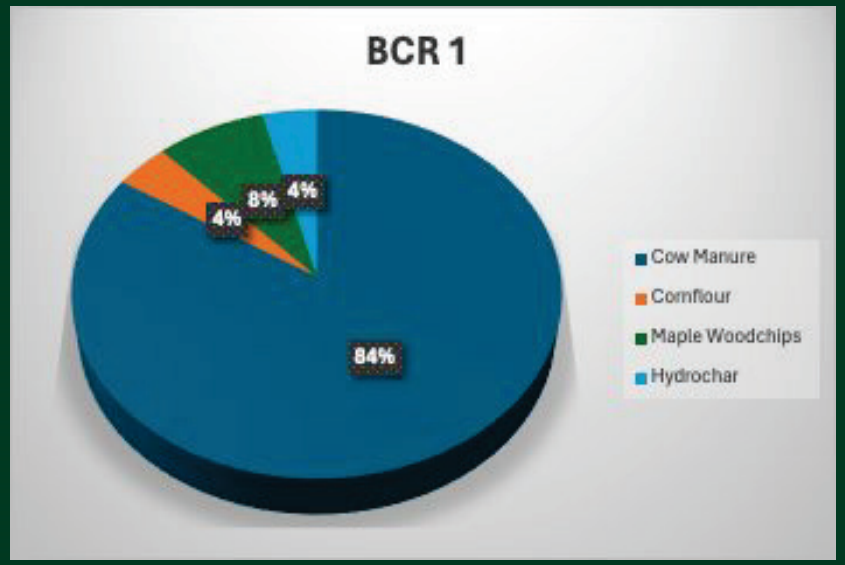
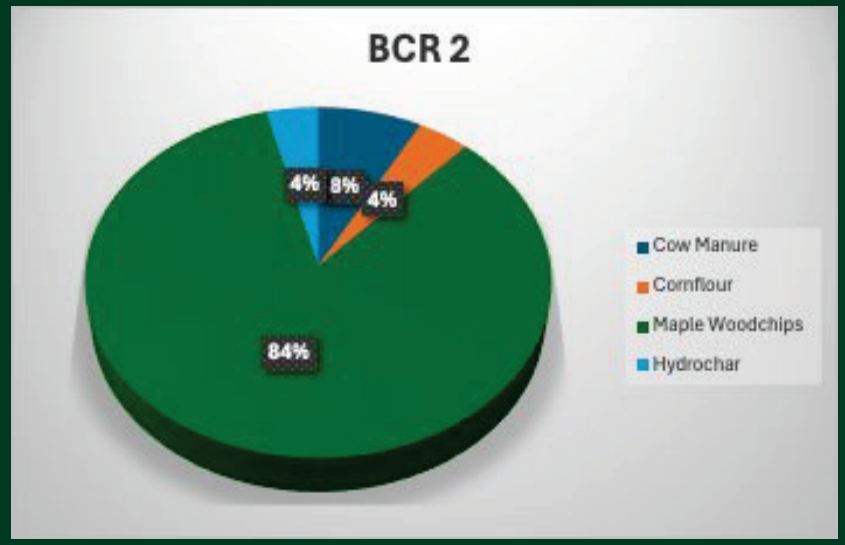
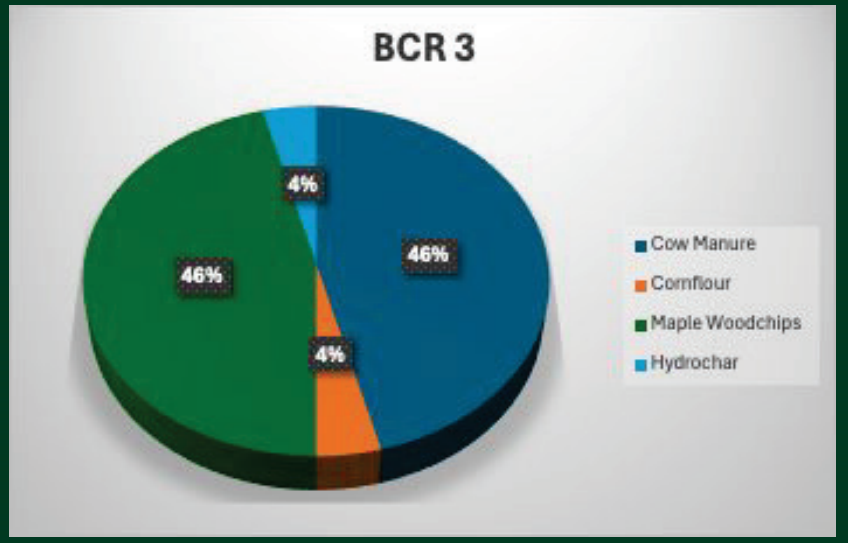
Composition of Organic Substrates







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Batch Bioreactor Set Up

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Analysis of Samples

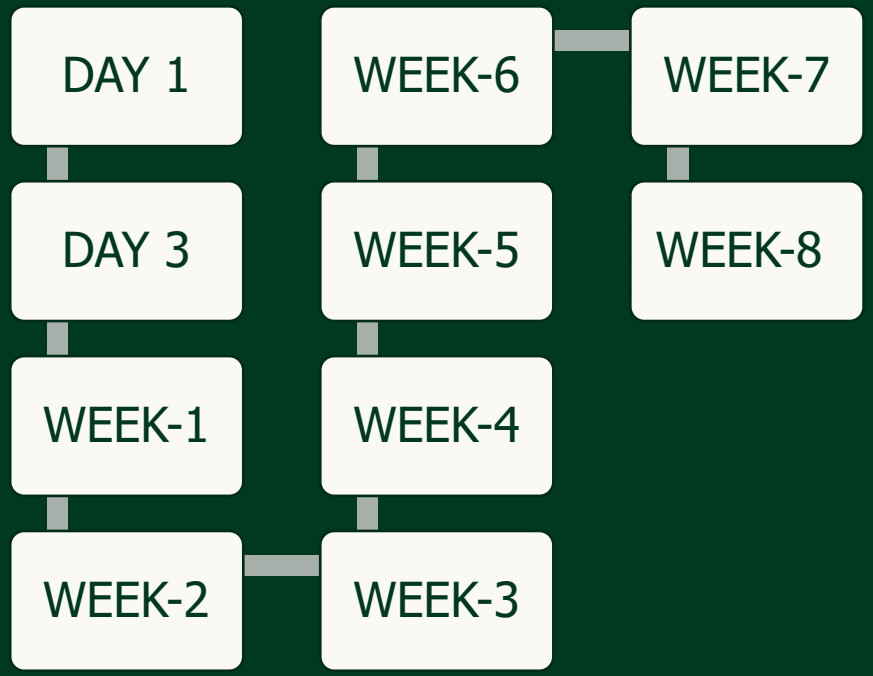
Characterization of organic substrates

- Total Carbon and Nitrogen of the organic substrates analysis by dry combustion method
- Dissolved Organic Carbon and Total organic carbon analysis

Analysis of wastewater sample

- pH and Conductivity measurement of the sample
- Eh Measurement
- COD Analysis using Hach method
- Sulfate Concentration using HACH Method
- Determination of heavy metal concentration of synthetic mine water samples by ICP-OES

Effluent Sampling Schedule



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