OHIO UNIVERSITY

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

Sana Jamshidifard & Dr. Natalie Kruse Daniels

Master of Science in Environmental Studies

Voinovich School Ohio University

FOREVER OHIO

OHIO UNIVERSITY

Goals And Objectives

Pyrolysis

HTC

Biochar

Hydrochar

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

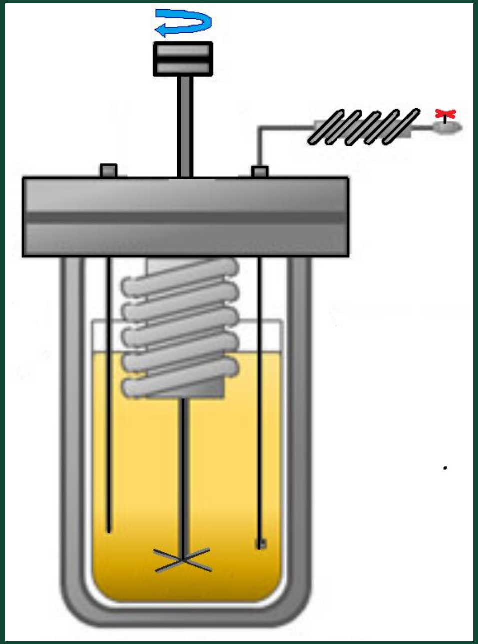
Assess the hydrochar **regeneration**

Research Methodology

Septage & food waste

Digestate

Hydrothermal Carbonization

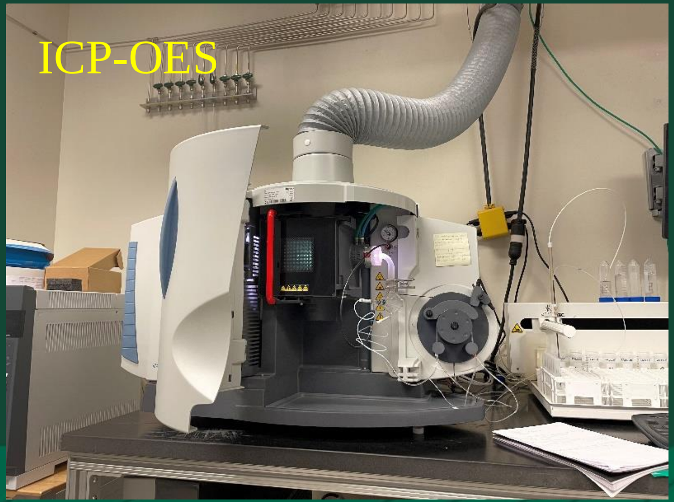


Hydrochar

Crushed hydrochar < 1mm

OHIO UNIVERSITY

Research Methodology

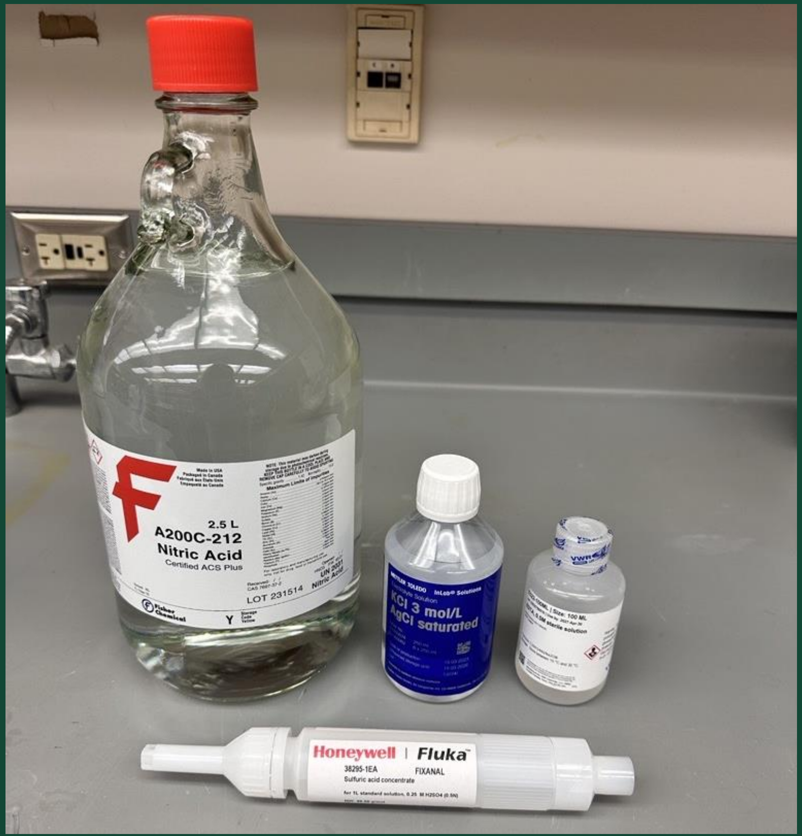


$$\text{Removal percentage} = 100 \times \frac{C_0 - C_f}{C_0}$$

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.
- Dried char mixed with solvent, centrifuged & filtered; eluent analyzed and char saved for analysis and further use.
- For each adsorption-desorption cycle, the ratio of the solution to hydrochar was kept at 7.

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

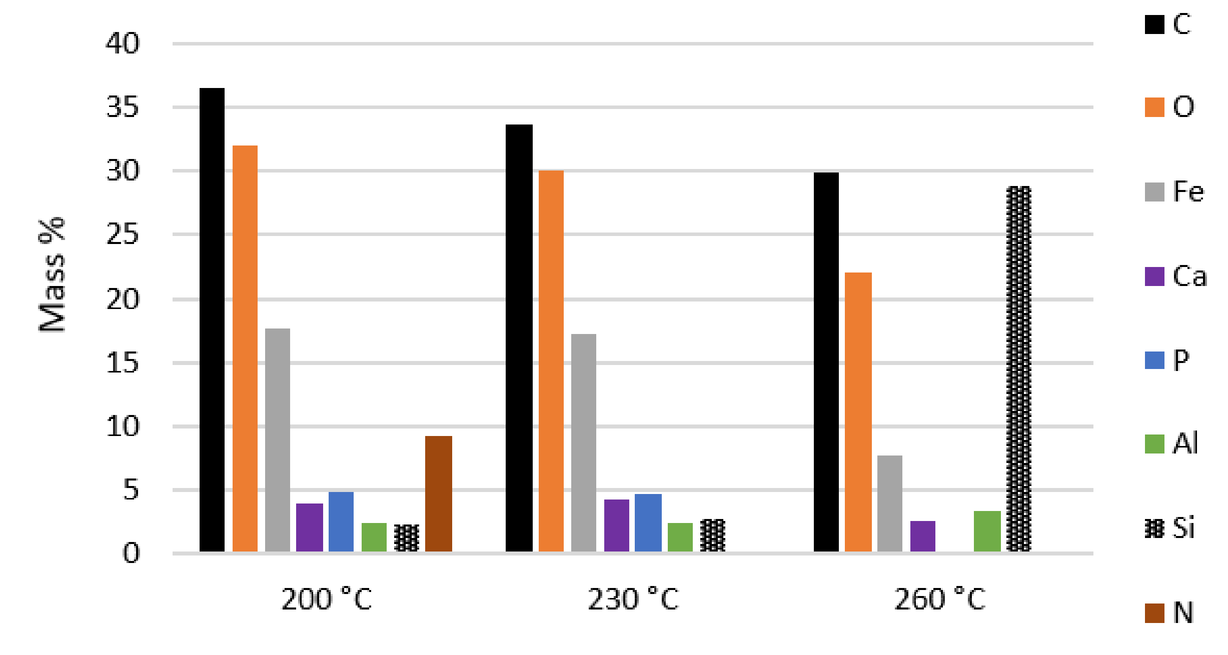


EDTA, HNO_3, KCl, and DI

Results and Discussion:

The effect of hydrochar processing temperature

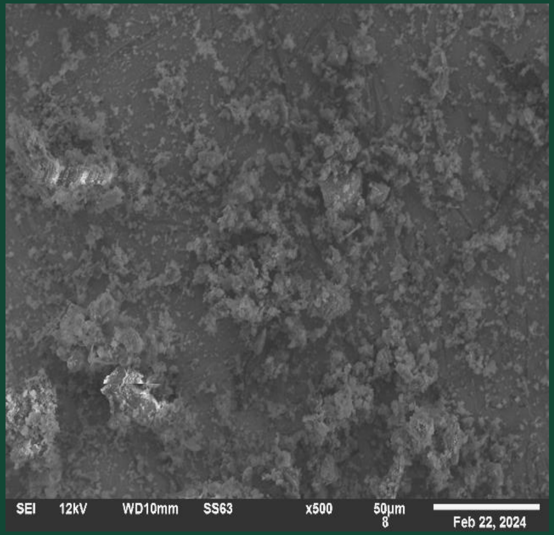
- Liu et. all reported at a higher temperature range (200–250 °C), there is an initial reduction in the oxygen and carbon content of the hydrochar (F. Liu, 2017)
- As the temperature rises from 200 °C to 260 °C, there is a reduction in the atomic ratios of oxygen to carbon and hydrogen to carbon (M. Sevilla, 2009)
- This phenomenon can be the result of the thermal-induced decomposition and volatilization of organic compounds



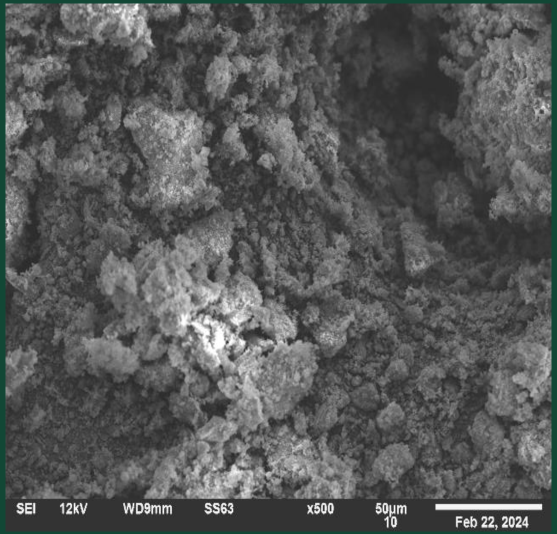
Results and Discussion:

The effect of hydrochar processing temperature

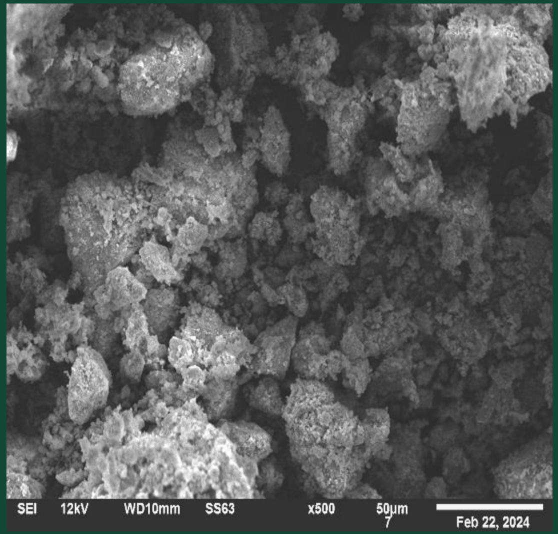
hydrochar processed at 260 °C



hydrochar processed at 230°C

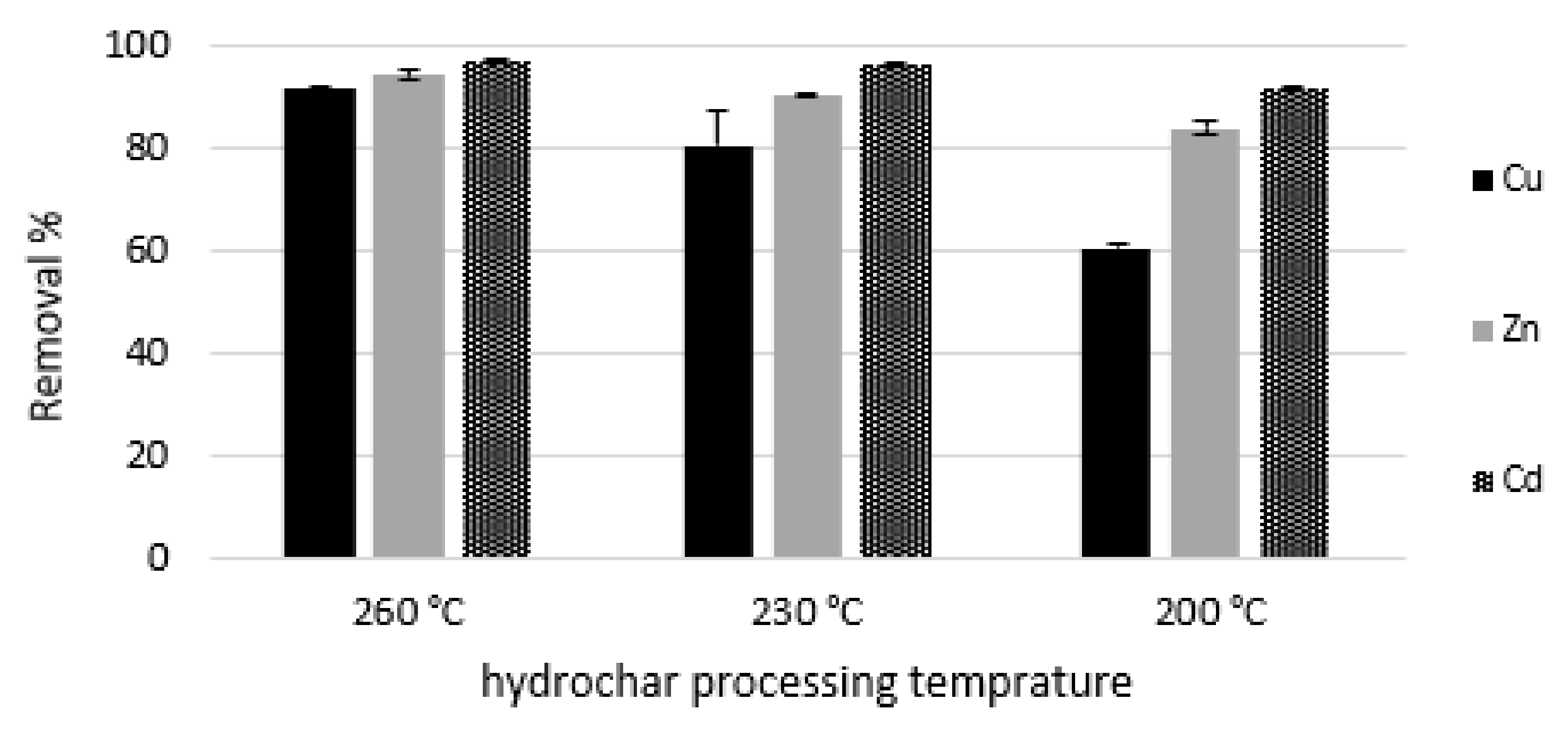


hydrochar processed at 200 °C



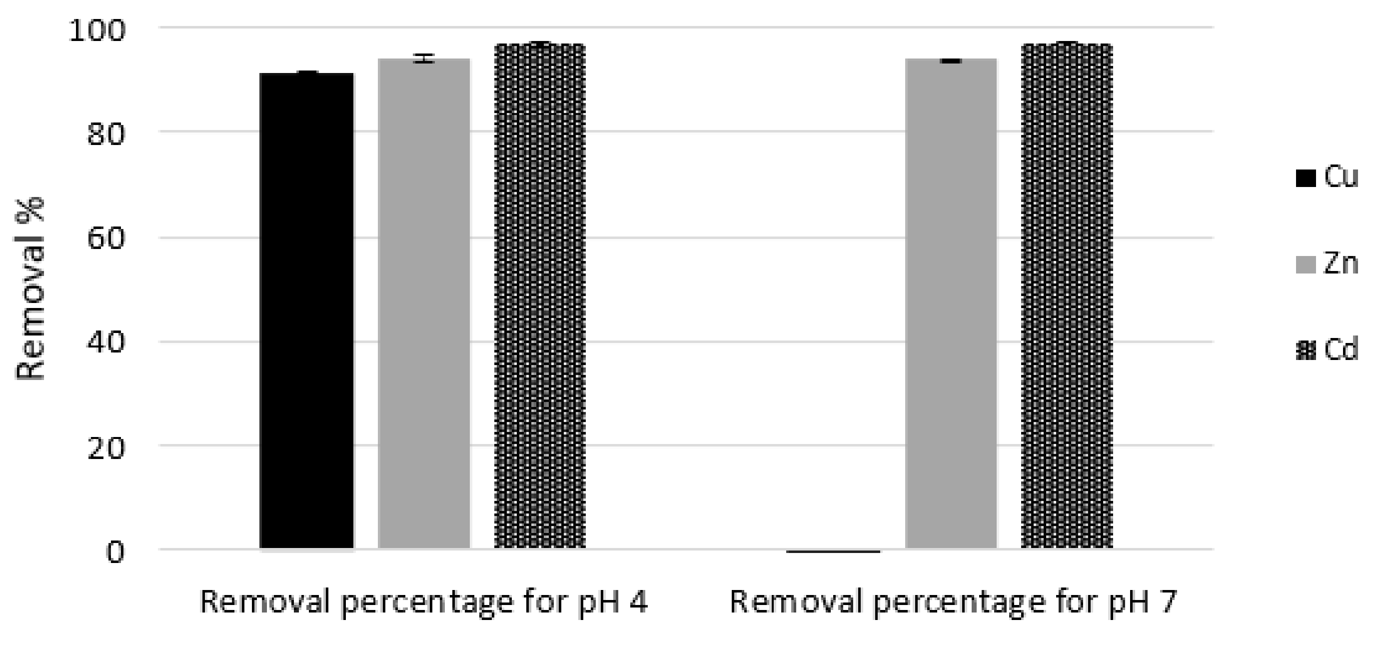
Results and Discussion:

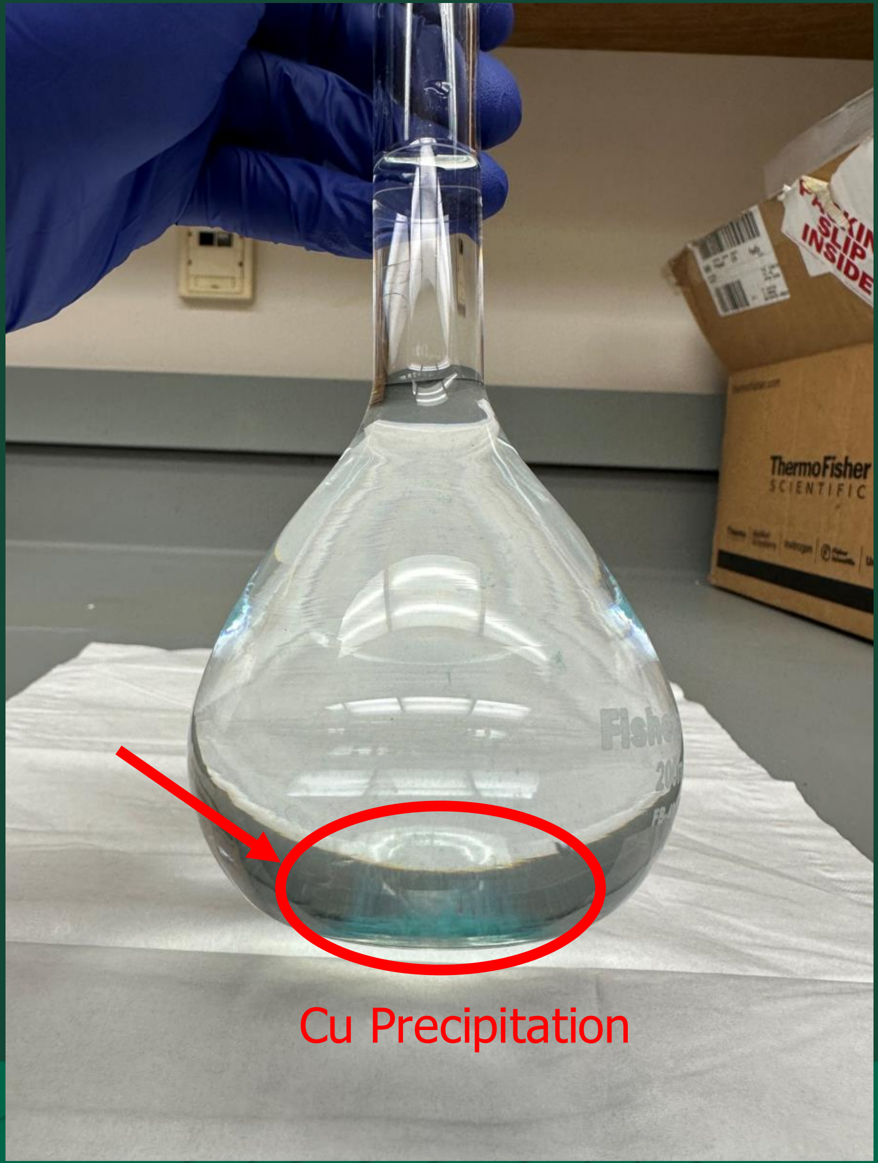
The effect of hydrochar processing temperature



Results and Discussion: **The effect of the pH of SMW**

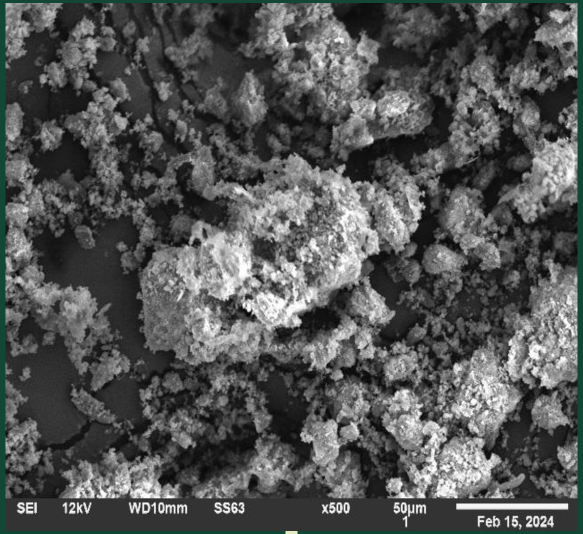
$$M^{2+}(aq.) + nH_2O \leftrightharpoons M(OH)^{2-n} + nH^+$$



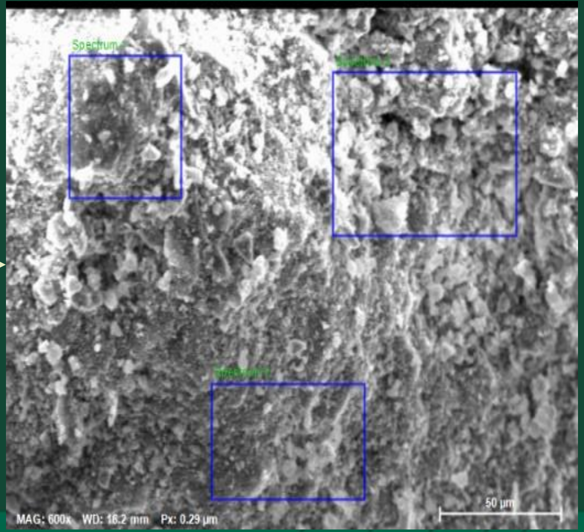


Results and Discussion: The effect of first-cycle

Raw hydrochar

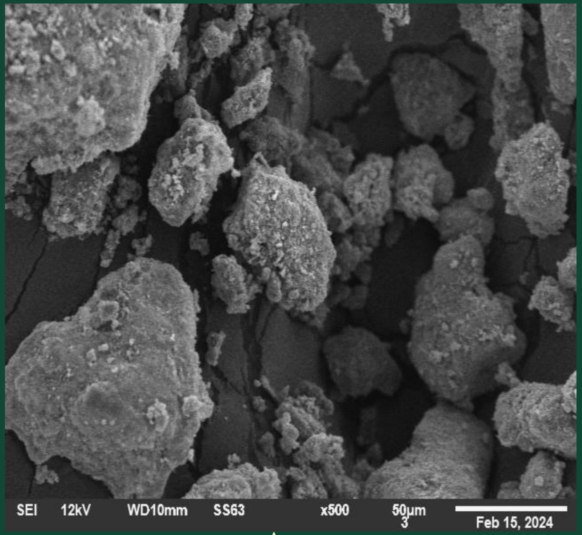


After the first adsorption



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	

After the first desorption by EDTA

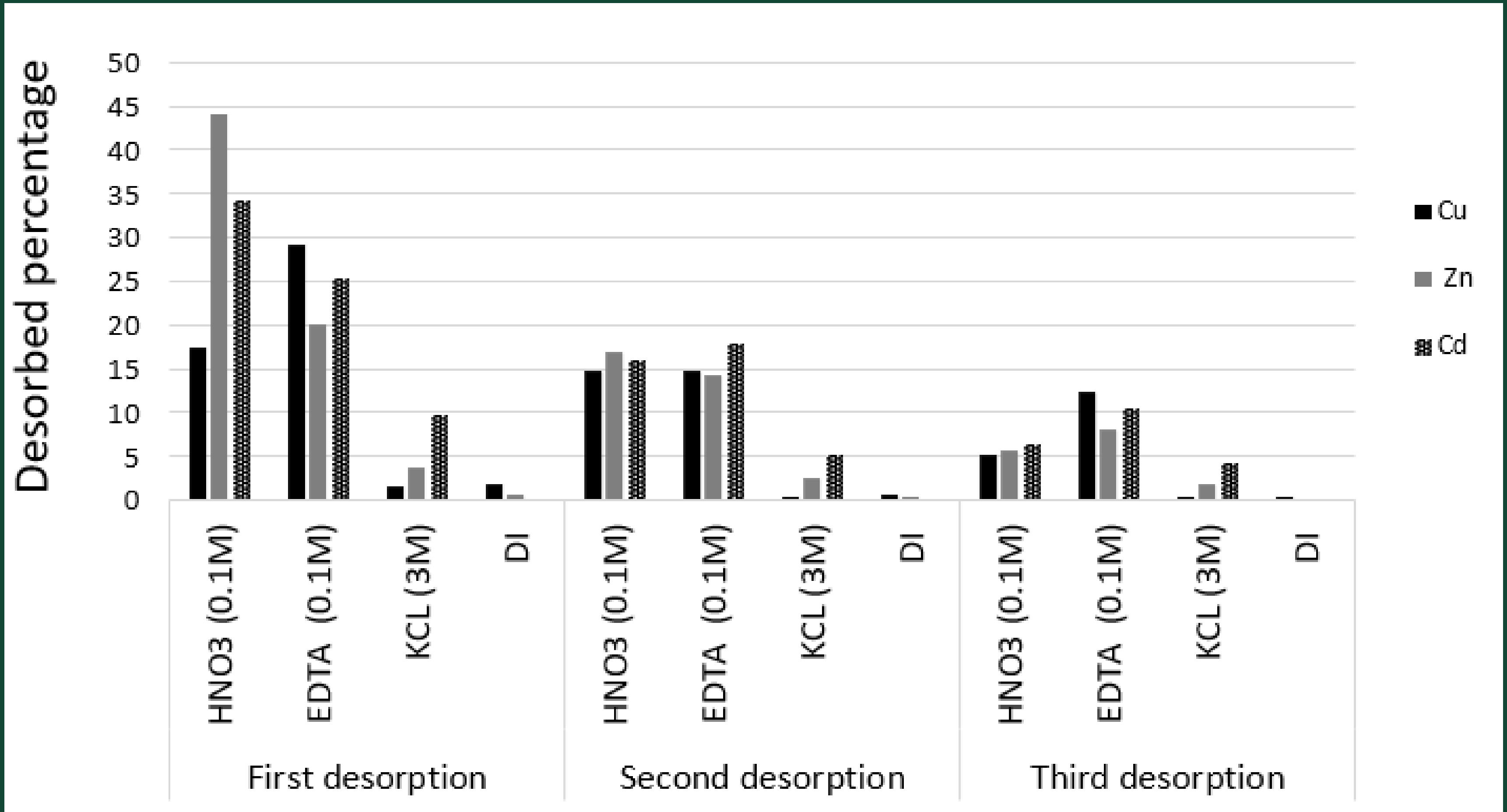


OHIO UNIVERSITY

Results and Discussion:

Reduction in desorption through the second and third desorption cycles

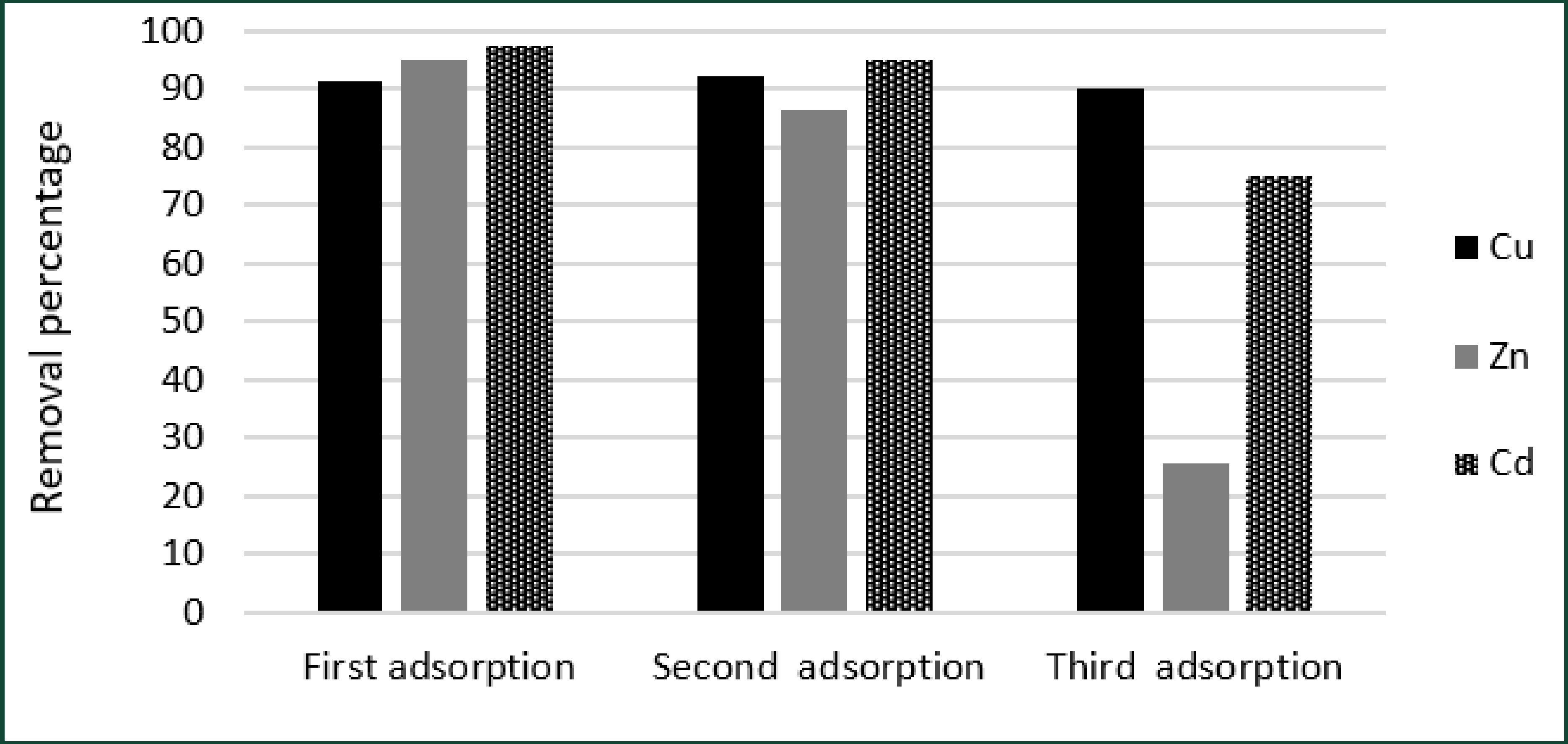
- The reduction in desorption percentage observed in subsequent cycles can be attributed to several factors such as **surface saturation, sorbent degradation, metal redistribution, ion exchange dynamics, and kinetic effects.**



FOREVER OHIO

Results and Discussion:

Comparison of metal removal percentage observed in subsequent cycles



Conclusions:

- The highest metal removal was obtained at pH 4 for the hydrochar processed at 260 °C.
- 5g hydrochar resulted in consistent removal percentage for Cu and Cd ions.
- 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.
- Zn precipitation observed at pH 7.
- EDTA and HNO_3 were the most effective solvents for desorption.
- KCl solvent was a less effective solvent.
- Metal removal dropped after the second desorption cycle and the material became “sludgy”.

OHIO UNIVERSITY

Acknowledgments:

This material is based upon work supported by the National Science Foundation under Grant No. 2123495

Thank you to:
Edward Abbiw
Blake Madden
Benjamin Quardey
Dr. Toufiq Reza
Dr. Sarah Davis

OHIO UNIVERSITY

Thank you !

FOREVER OHIO