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Fluoride Adsorption Utilizing Magnetite Impregnated Bone Char

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MontanaTech

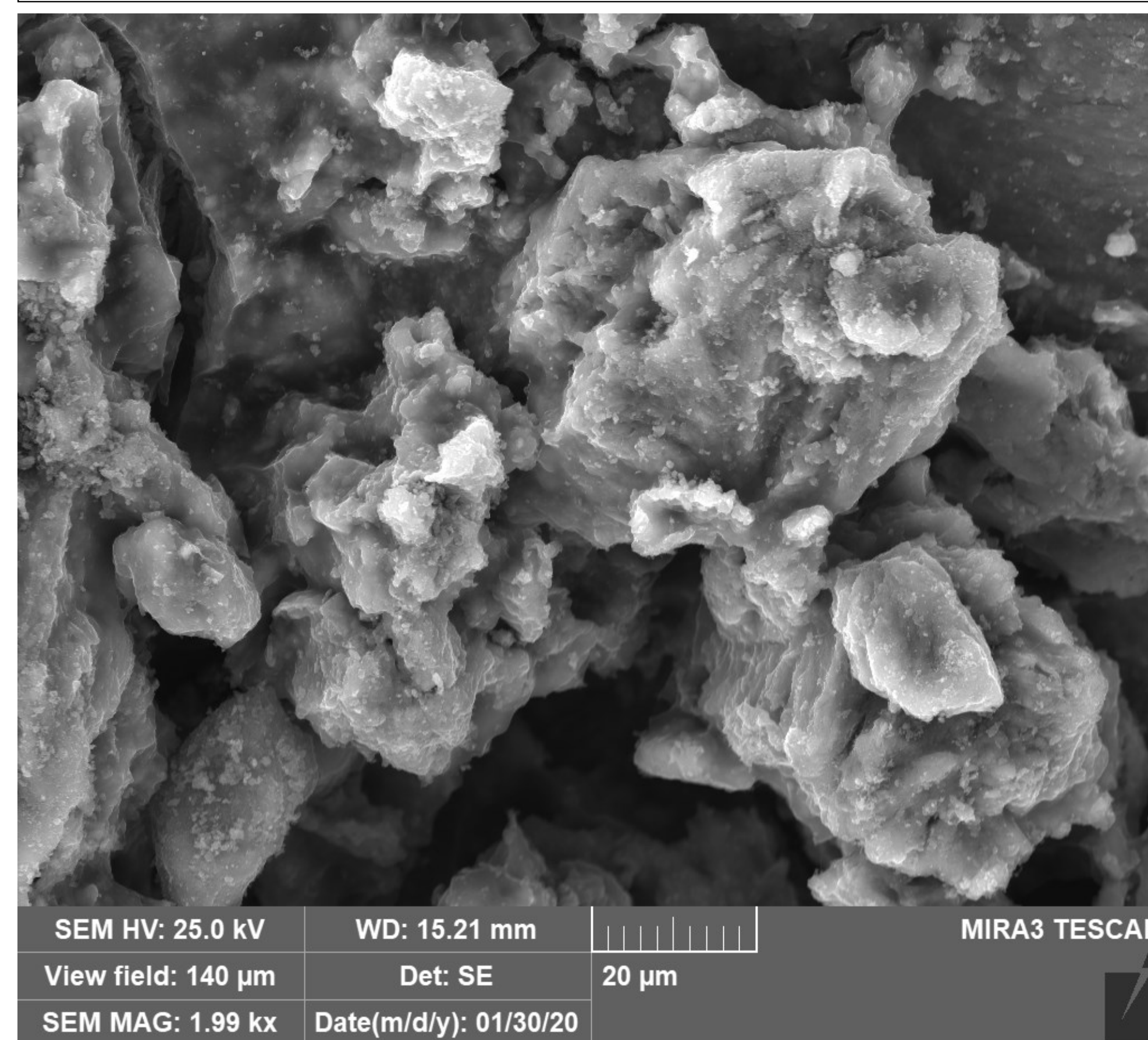# Fluoride Adsorption Utilizing Magnetite Impregnated Bone Char

Team members: Tavi Wise, Alexis Icenogle, Jeremy Miller, Scott Swedberg, Barry Mitchell
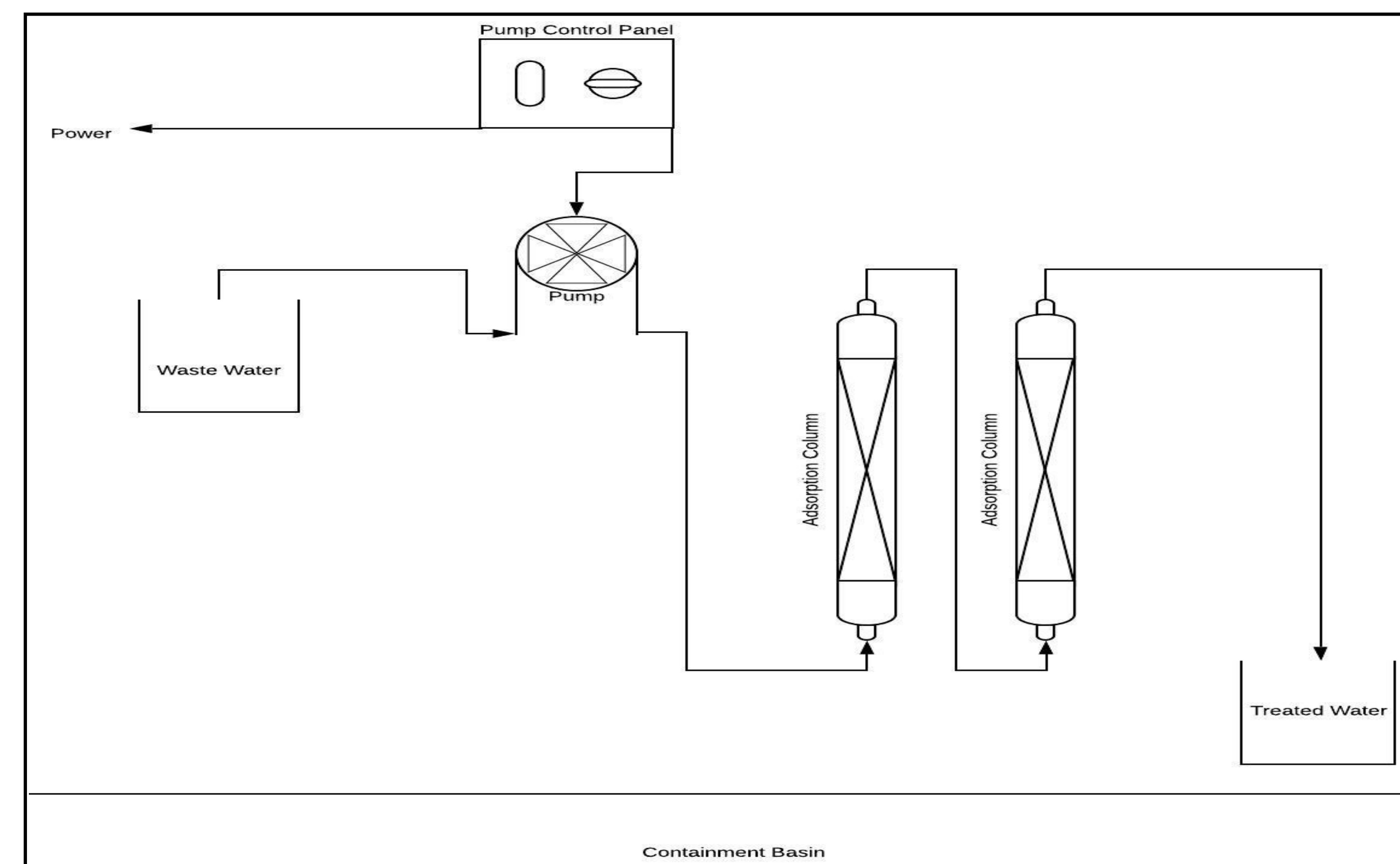
Advisors: Kumar Ganesan, David Hutchins

Sized bone char before pyrolysis

Bone char after pyrolysis

- **WERC Task (#4):** Reduce fluoride concentrations in contaminated mine water from **10** mg/L to below **2** mg/L.
- Design an energy efficient and sustainable system with a minimal carbon footprint.
- Recover Fluoride as a saleable product

- **Pyrolysis:** Requires an oxygen-free environment to avoid burning the bone.
- Final bone char size: 20 x 60 mesh. (0.85mm)
- Argon gas was used to expel oxygen from the atmosphere inside of the furnace.
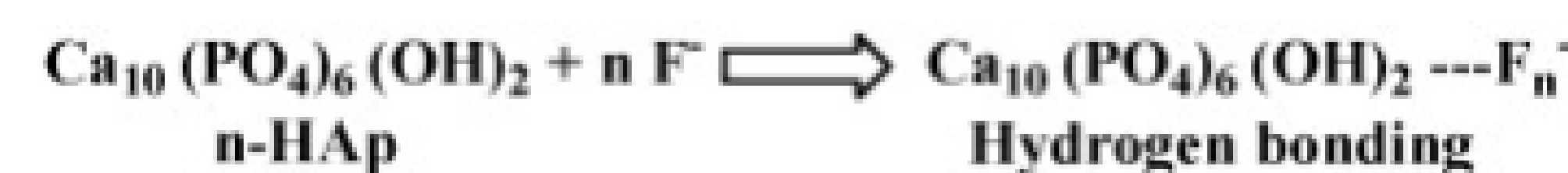- **Temp:** 550 °C   **Time:** 2 hours

$$Ca_{10}(PO_4)_6(OH)_2 + n\ F^- \Rightarrow Ca_{10}(PO_4)_6(OH)_2 \text{---} F_n^-$$
$$\text{n-HAp} \qquad\qquad\qquad \text{Hydrogen bonding}$$

Figure 1 Fluoride Removal by Adsorption

$$Ca_{10}(PO_4)_6(OH)_2 + 2\ F^- \Rightarrow Ca_{10}(PO_4)_6 F_2 + 2\ OH^-$$
$$\text{n-HAp} \qquad\qquad\qquad \text{Fluoroapatite}$$
$$Ca_{10}(PO_4)_6(OH)_2 + F^- \Rightarrow Ca_{10}(PO_4)_6 FOH + OH^-$$
$$\text{n-HAp} \qquad\qquad\qquad \text{Hydroxyfluoroapatite}$$

Figure 2 Fluoride Removal by Ion-exchange

S.E.M. image: char & magnetite

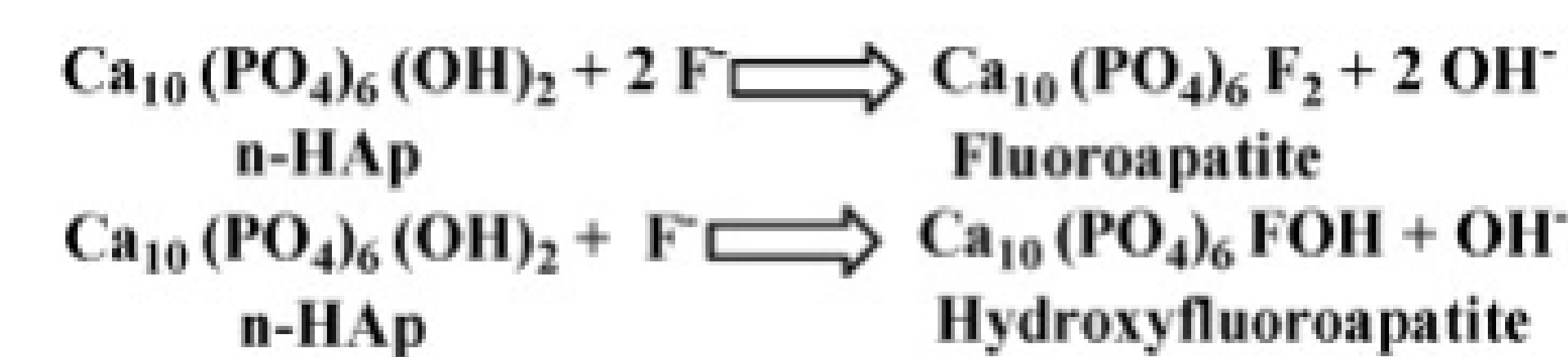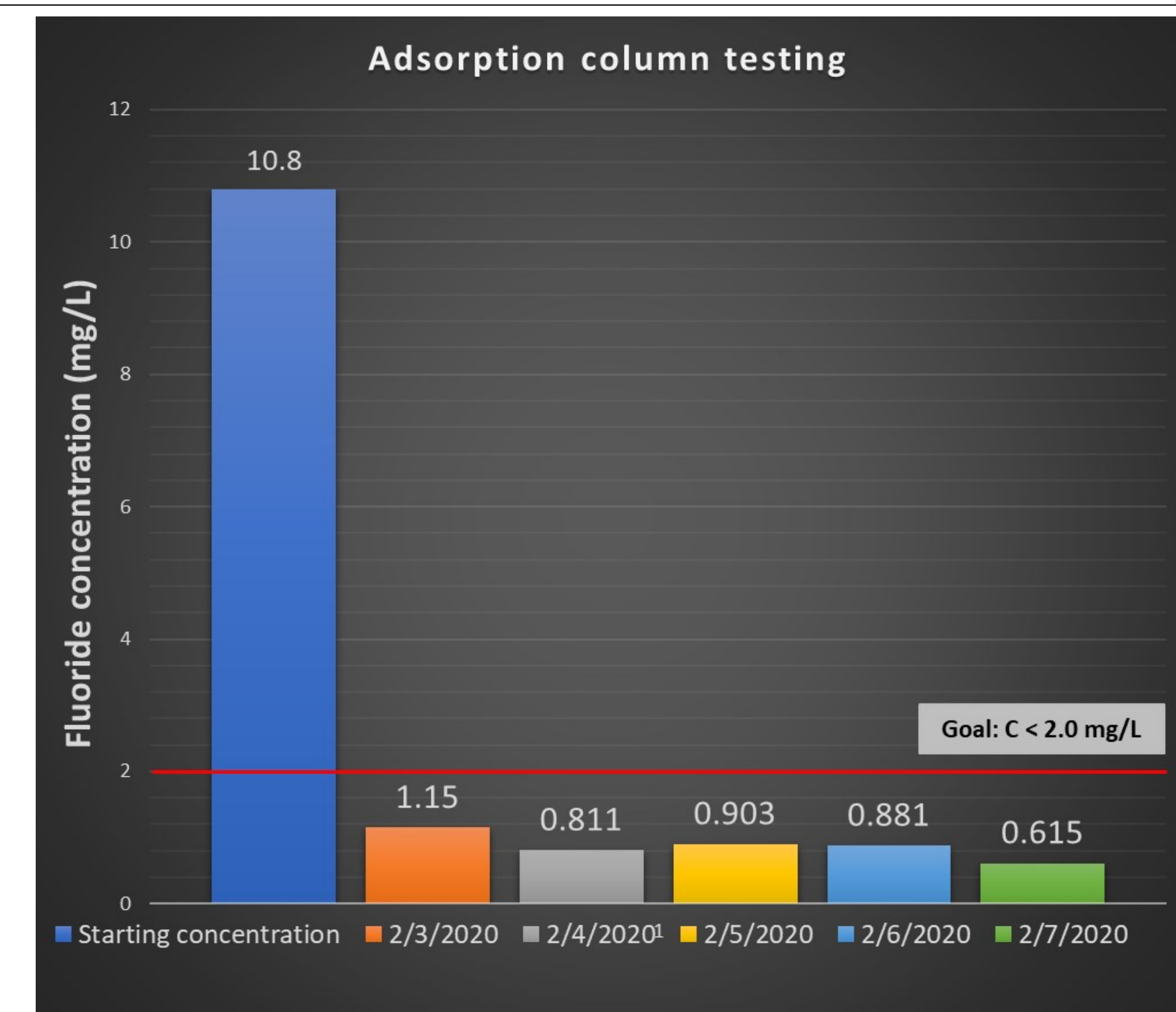Using a scanning electron microscope allowed us to visually and analytically identify the magnetite bound to bone char.

Sustainability

- Redirects bone waste from landfill
- Low cost
- Waste bone is readily available, especially in developing nations
- Regeneration of bed material
- Recovery of NaF provides a salable product

Cost analysis

- Capital Cost: $ 313,000
- Operating cost: $ 27,000 per month
- Resale of NaF: $ 47,000 per month
- Profit: $ 20,000 per month

Adsorption column testing

Starting concentration: 10.8
2/3/2020: 1.15
2/4/2020: 0.811
2/5/2020: 0.903
2/6/2020: 0.881
2/7/2020: 0.615
Goal: C < 2.0 mg/L

Adsorption column testing

Average reduction: 92%

Flowrate: 30 mL/min

Adsorption Kinetics: 3 minutes

Met WERC task

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