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Sorption of Metals from Low -Iron Acid Mine Drainage (AMD) Using Agricultural Waste Materials

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Circular Economy

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Introduction

- Problem?
- Small-scale gold mining in Ghana
- No wastewater treatment systems
- Low regulations (Affian et al., 2009).
- Contaminates river bodies in Ghana such Pra, Offin, Ayensu, etc. (Duncan et al., 2018)
- Water bodies are public and primary resource for villages

ISmall-scale mining by CERSGIS2024

Introduction

- Challenges!
- Discharge contain mercury and other metals
- Metals in elevated concentration are dangerous
  - High toxicity
  - Accumulation in food chain
  - Persistence in nature
- Polluted water treatment is of global concern

Figure shows the contamination of the Amoya Stream by Edward

Introduction

- Making water system support life again!
- Environmentally and sustainable treatment approach?
- Low-cost treatment?

- Biosorption: agricultural byproduct to remove metals from low-iron AMD
  - Proven to be effective
  - Inexpensive
  - Easy to operate

24% food waste in 146.1 million tons MSW (USEPA, 2018)

Introduction

- Biosorption technique
  - Mechanism explained by adsorption
  - Occurs at interface between solids and fluid
  - Solid-liquid equilibrium and mass transfer rate

- Species between fluid and sorbed phase
  - Isotherms-mass sorbed and equilibrium concentration
  - Physical or chemical interactions-intermolecular force

Objectives and Hypothesis

- Objectives
  - Evaluate the capacity of agricultural and waste
  - Determine the most effective biosorbent
  - Estimate pH point-of-zero charge of the biosorbents
  - Conduct experiment with “minimal” sorbent treatment

- Hypothesis
  - Small-scale gold mining leads low-iron AMD and agricultural waste is effective for removing mercury-Hg, cadmium-Cd, lead-Pb, copper-Cu, and zinc-Zn.

Literature

- Banana peel removes copper and lead at pH 5.2-5.4 (Vilardi *et al.*, 2018)
- Activated bamboo stem removes lead at pH 5 (Asrat *et al.*, 2021)
- Modified plantain peel sorbs copper at pH 4.36 (Garba *et al.*, 2016)
- Activated coconut coir has high sorption capacity Cu and Cd (Chauhuri *et al.*, 2010)

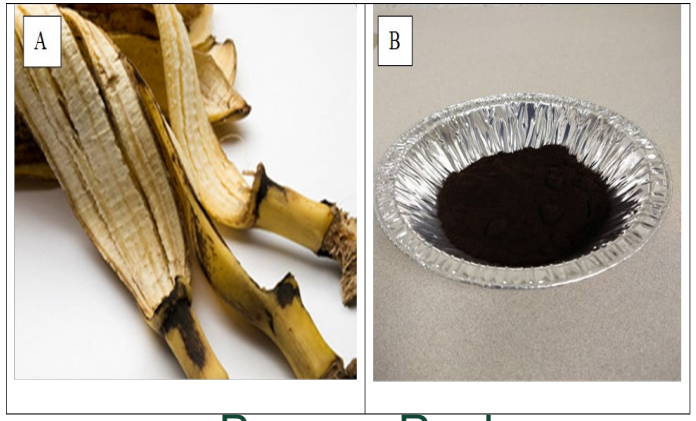
Methods

- Sheep and goat dung from local farmers in Athens, Ohio, US
- Plantain and banana bought from Walmart
- Bamboo stems from Ohio University's student farm
- Coconut coir bought from Amazon
- Waste ground and sieved through 0.098 mm sieve

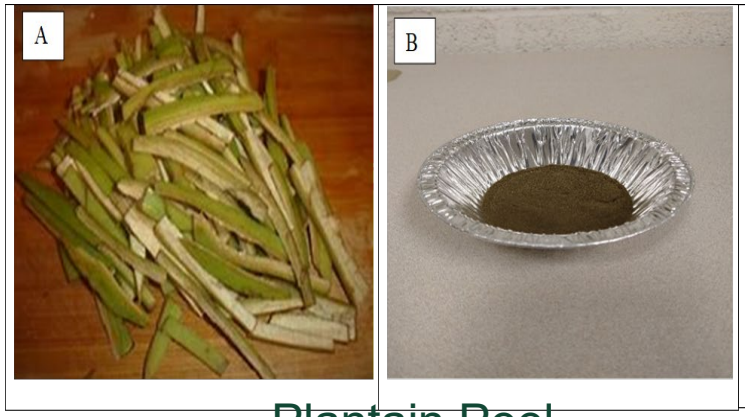
- Artificial Mine Water (AMW): Hg, Pb, Cu, Zn, and Cd from fisher scientific
- Conc. 20.42, 1.33, 1.03, 7.48, and 0.33 were prepared for the respective metals

Copper Standard

Methods

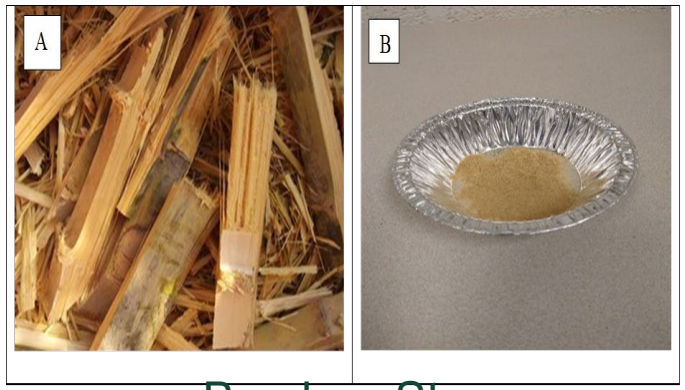


Banana Peel

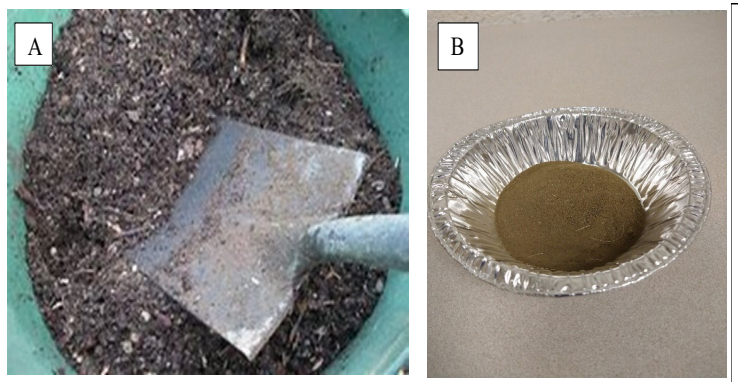


Plantain Peel

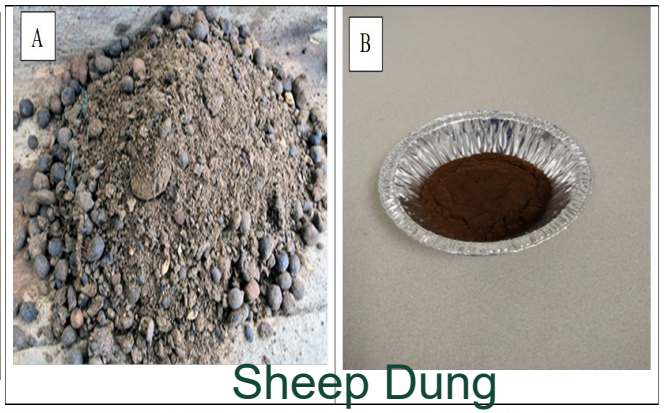
Coconut Coir



Bamboo Stem



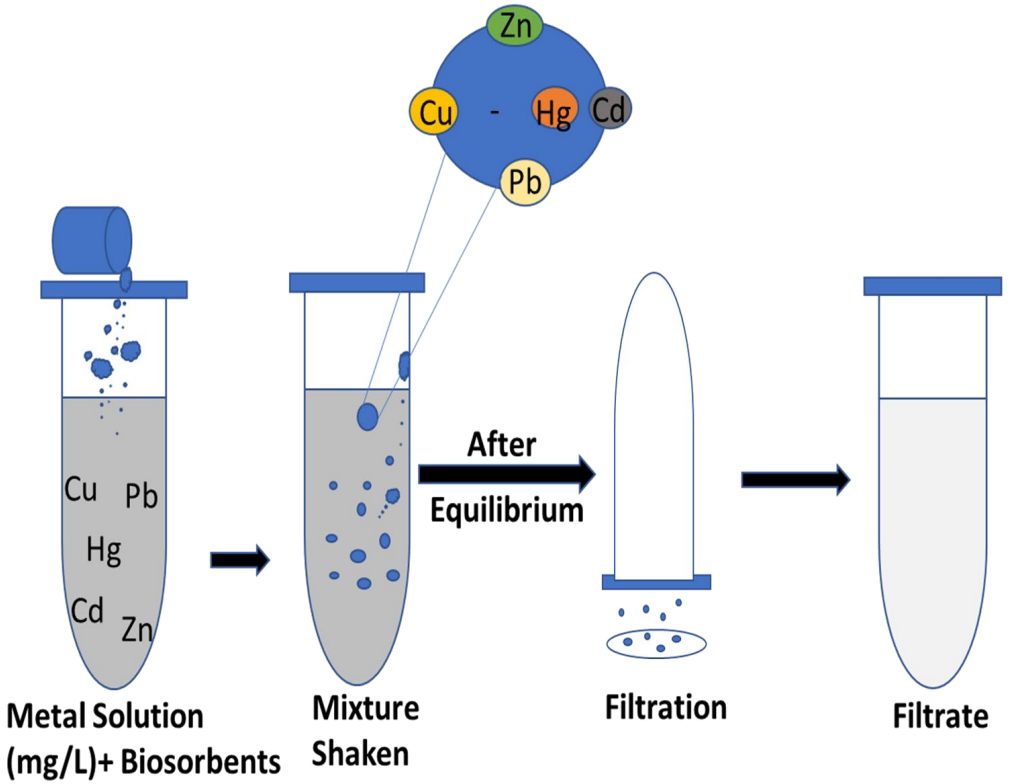
Goat Dung



Sheep Dung

Methods

- Batch sorption at laboratory scale
- Optimized parameters: sorbent mass, concentration, and pH
- Trial 1: dry masses, 0.1, 0.5, 1, and 2 g of waste were and added to 35 mL AMW
- Mixture shaken at 120 rpm for 24hrs
- Trial 2: 0.1 and 0.5 g of coconut coir, banana, peel, and sheep dung in 5 mg/L AMW were tested at pH 4 and 8



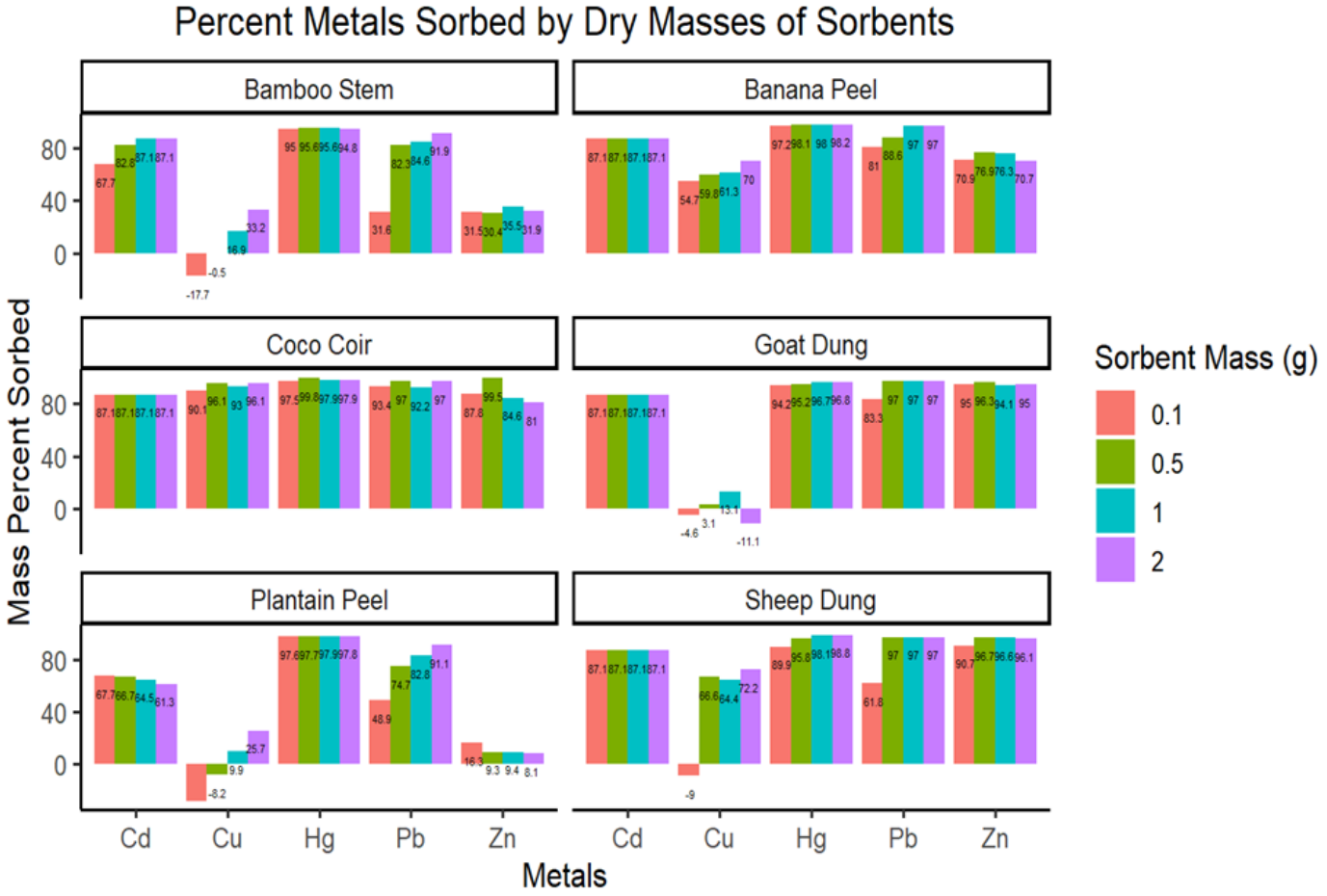
Experimental Design

pH-Point Of Zero Charge

- 40 mL 0.1 M $NaNO_3$ in ten different 50-mL and labeled, pH 2 to pH 11
- Initial pH recorded in MS excel document as pHi
- Dry mass of sorbent were added to each solution
- Mixture was shaken on a rotary agitator at 150 rpm for 24hrs
- Mixture was filtered and filtrate was analyzed for final pH
- Final pH (pHfi) was recorded
- pH pzc was obtained from $(\Delta pH) = (pHf - pHi)$ against pHi
- Graphs were plotted for each sorbent

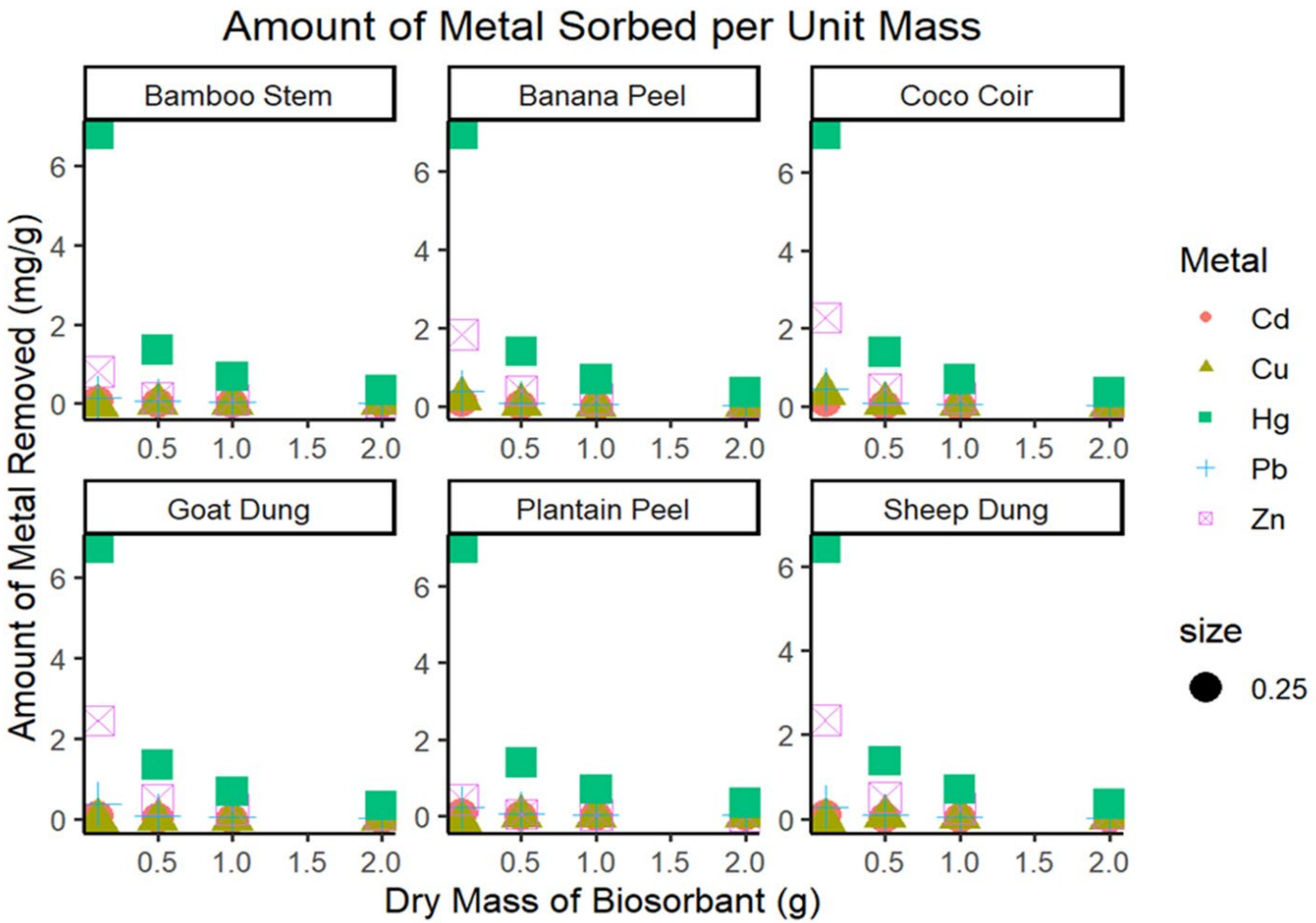
Results

- Sorption was successful at pH 7
- Removal efficiency of Hg is relatively high > 95%
- Bamboo, goat dung, and plantain peel added Cu in some case
- Sorption efficiency of Zn by bamboo and plantain was relatively low
- Coconut coir, sheep dung, and banana peel were most efficient



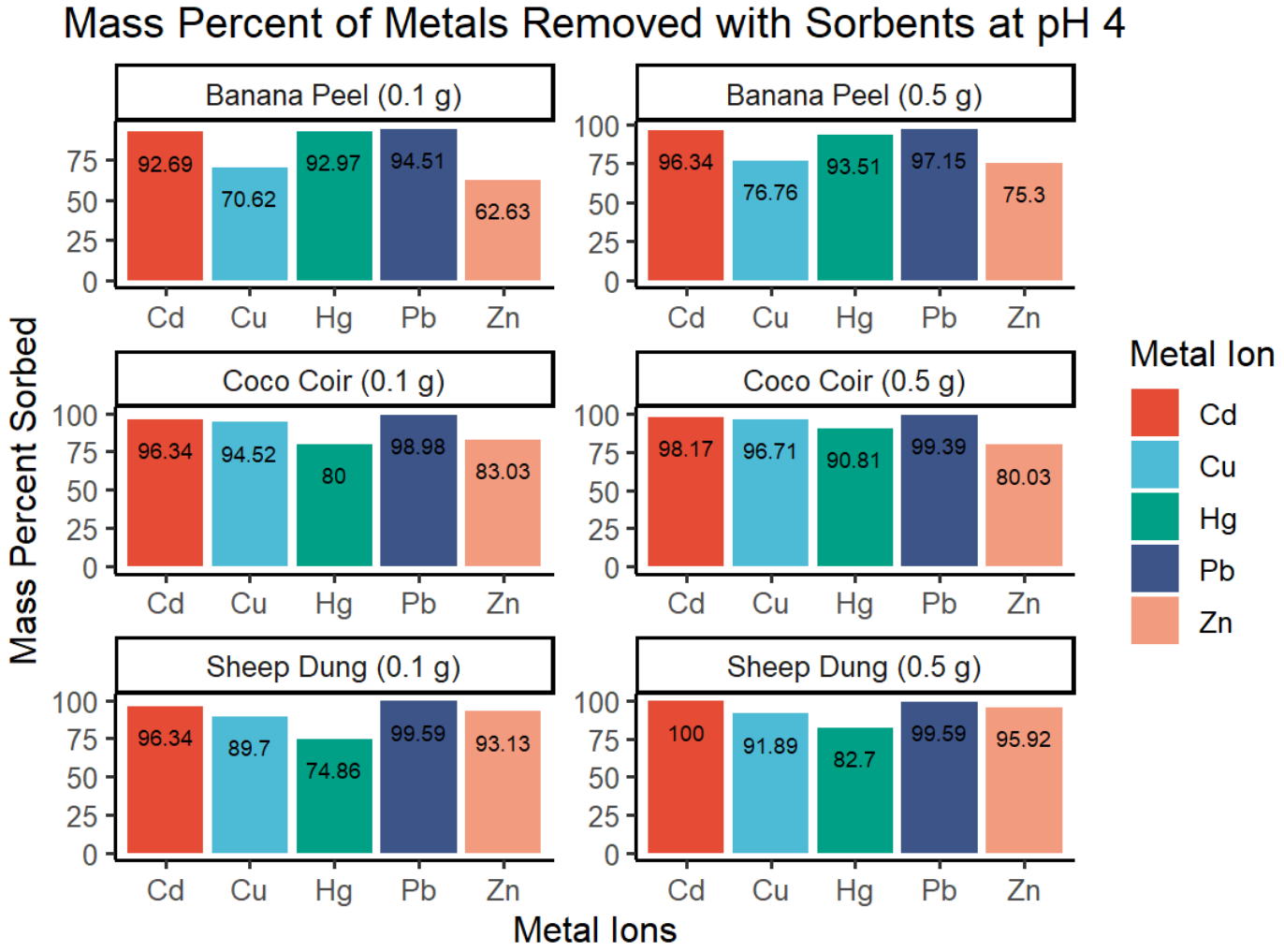
Results

- Amount of metal sorbed per unit mass of biosorbent at pH 7
- Removal decrease asunit mass of biosorbent increases
- Maximum adsorption capacity
  - 6.43, 2.34, 0.29, 0.048, and 0.01mg/L for Hg, Zn, Pb, Cu and Cd respectively



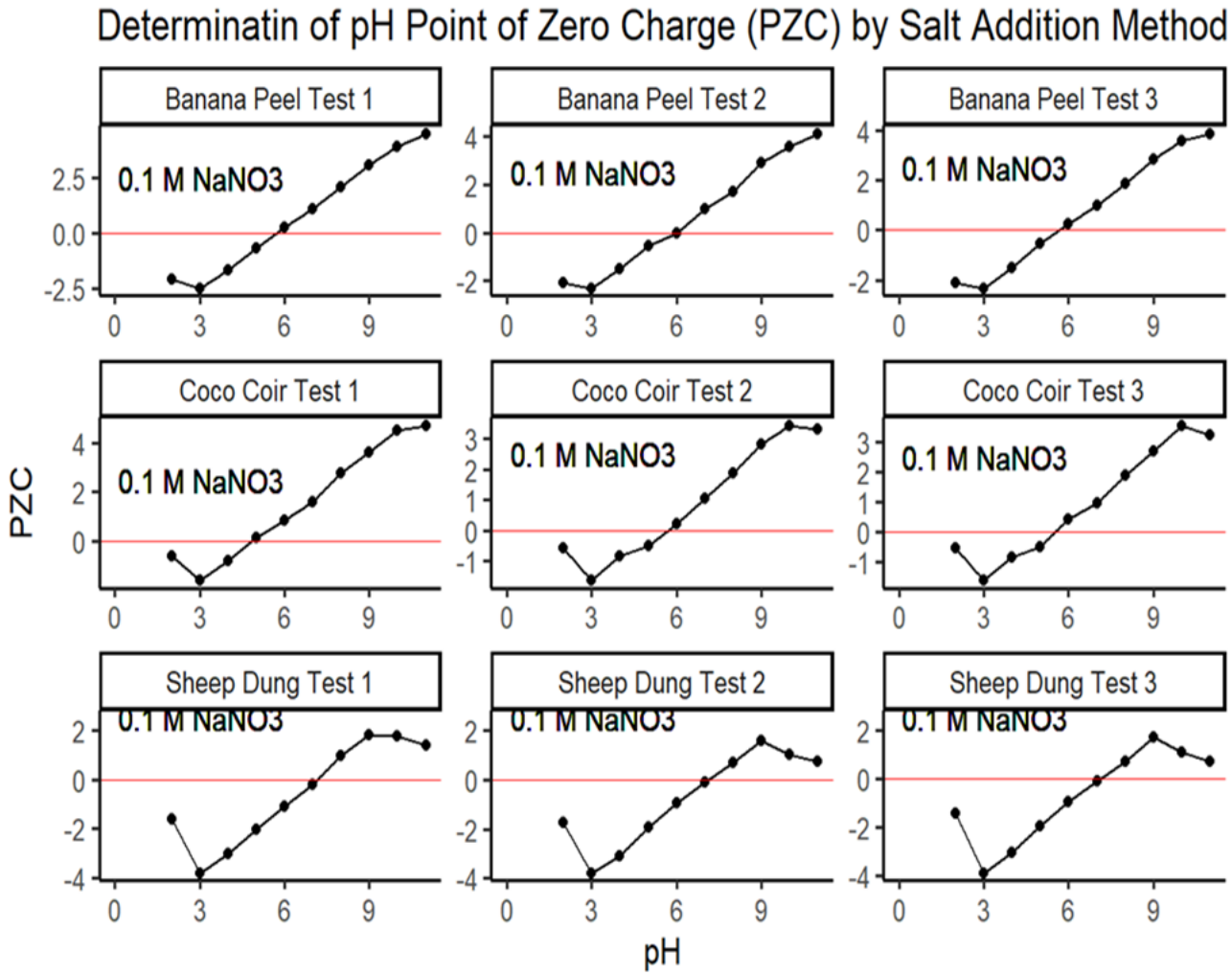
Results

- Treatment of 0.1 and 0.5 g sorbent in 5 mg/L AMW
- 0.5 g had relatively higher removal efficiency
- 0.1 g coconut coir and 0.5 g sheep dung removed all the Cd
- All sorbent were efficient in removing Pb
- Achieved removal efficiency between 60 and 100 %



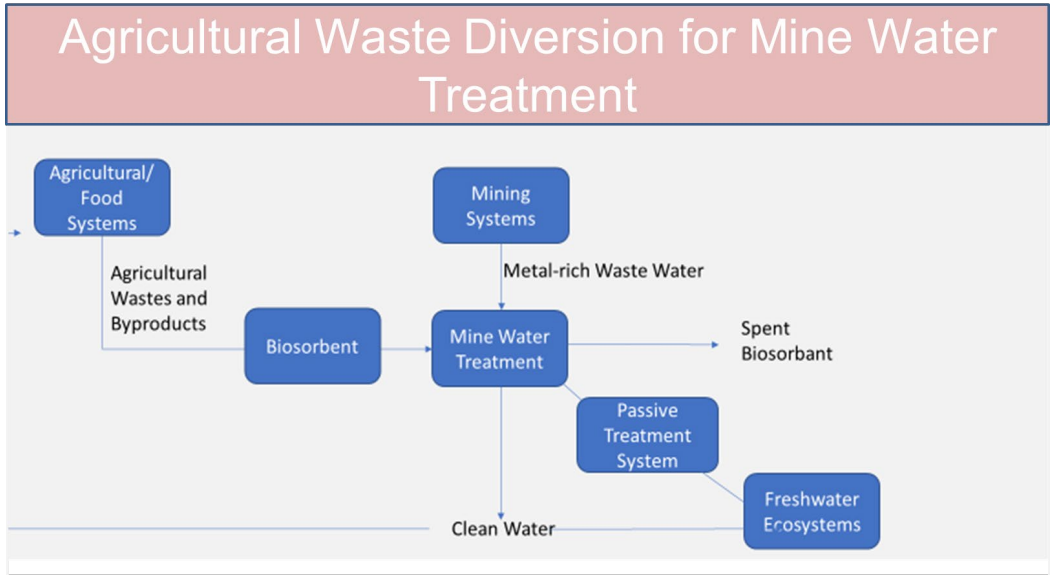
Results-pH pzc

- The pH-pzc of the sheep dung ranged between 7.18 and 7.21
- pH-pzc of coconut coir was between 4.8-5.7
- pH-pzc of sheep dung was ranged between 5.71-6.9
- Net surface charge of coconut coir and sheep dung could be negative to attract metals



Summary and Application

- Sorption successful at pH 4 and pH 7
-
- Sorption was not successful at pH 8
- Coconut coir, sheep dung and banana peel: most efficient
- On average pH-pzc of coconut coir, sheep dung, and banana peel were respectively 5.25, 7.15, and 5.8
- pilot scale application in the future



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Thank you!

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