Plant Leachate Nutrient Recovery with Biological, Thermal, and Photocatalytic Pretreatments

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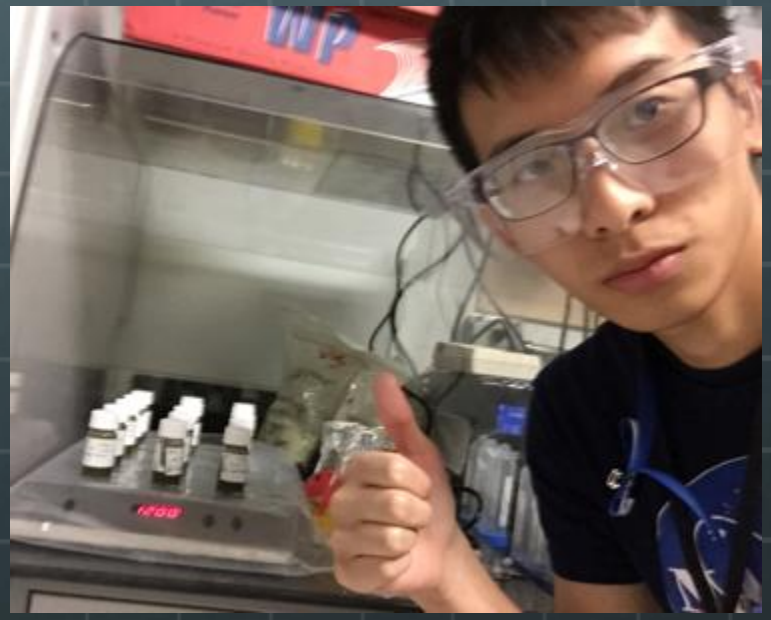
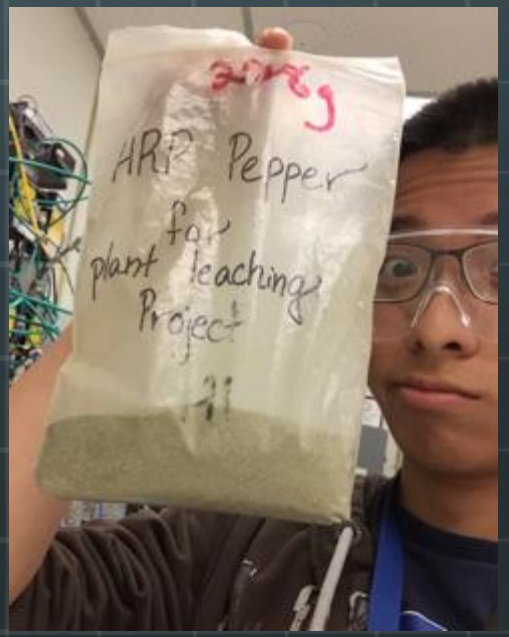
Introduction

- Plants are ideal for long term space travel
  - Provide essential resources: oxygen, water, food
- Water soaked plants expel soluble nutrients in a leachate solution
  - Toxins and wastes are also expelled and inhibit growth
- Biological, thermal, photocatalytic coupled with an acid digestion treatment will hopefully maximize recovery and remove wastes

Materials

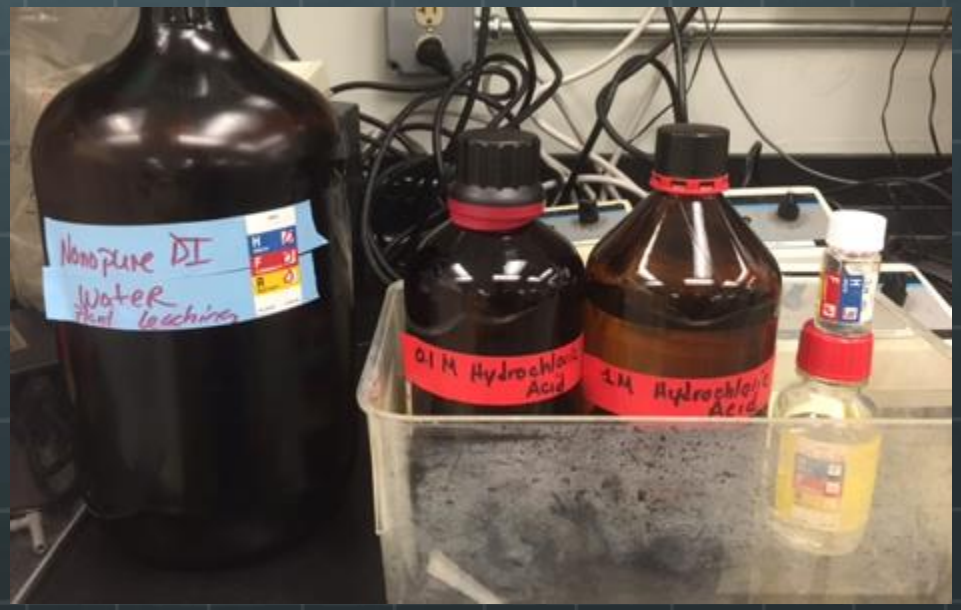
- VOA vials act as mini-bioreactors for our test cases
- Magnetic stir plate allows for sufficient mixing during the residence time
- Centrifuge and syringe filtering for separation



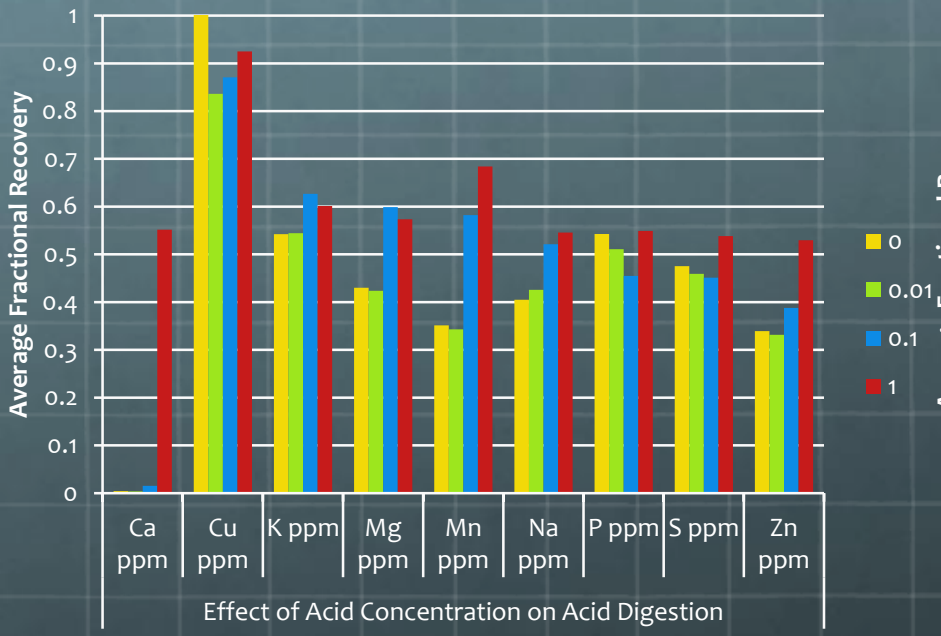


Acid Digestion

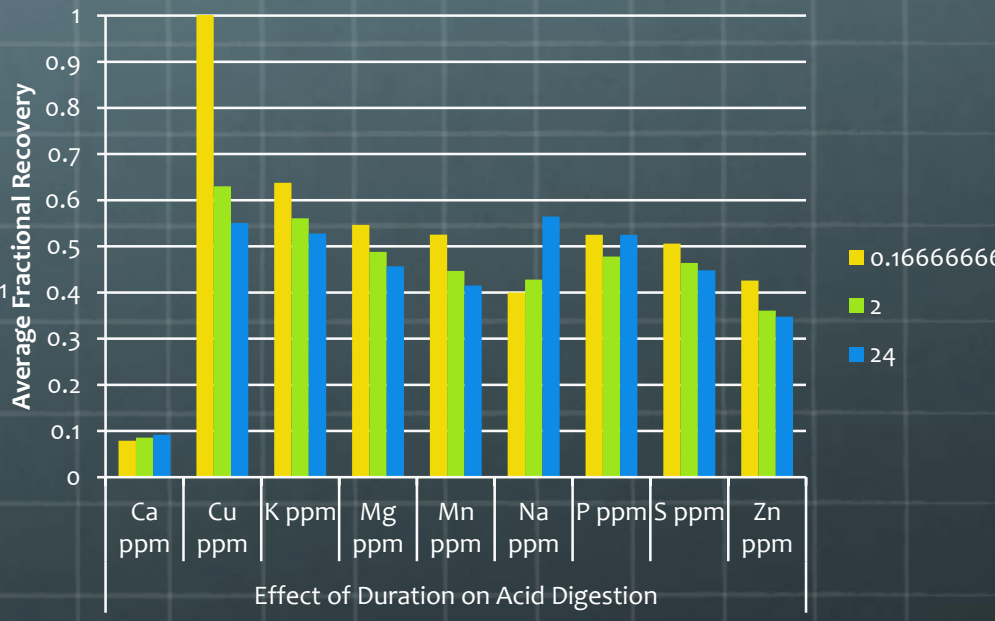
- Reduce factorial size, we did acid digestion first to narrow down the number of treatments
- 1 g of dried plant matter + 9 mL water + 1 mL desired acid concentration @ 10 mins, 2 hours, 24 hours



Results - Initial Acid Digestion



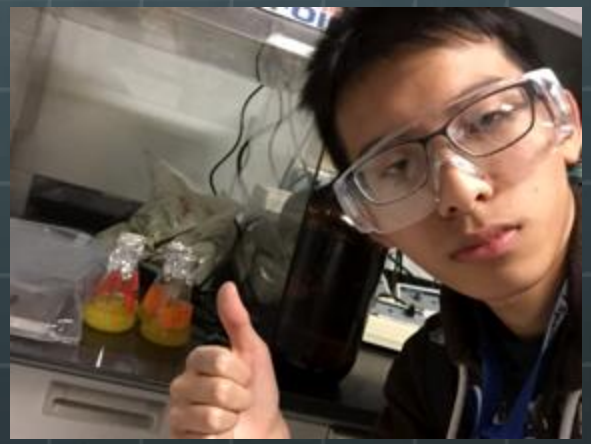
Displays average fractional recovery of the different ions for the acid digestion organized by the retention times. Legend units are in hours.



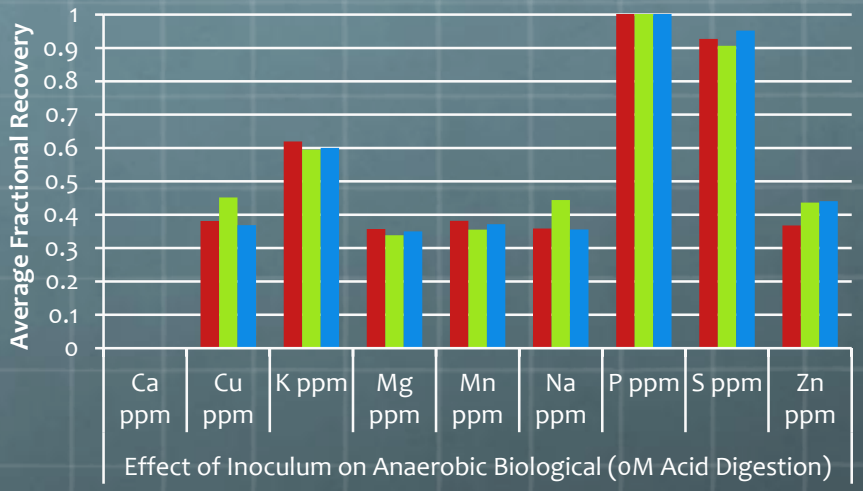
Displays the average fractional recovery of the acid digestion organized by HCl concentration. Legend units are in molarity (M).

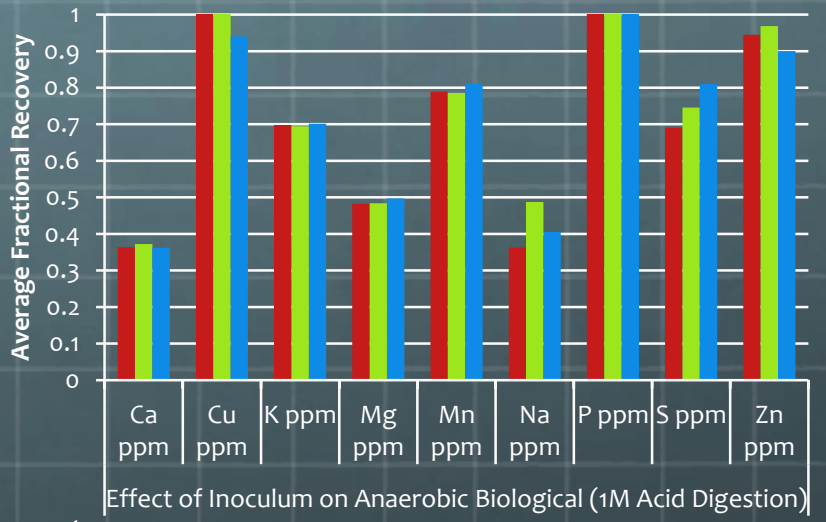
Methods-Biological Inoculum

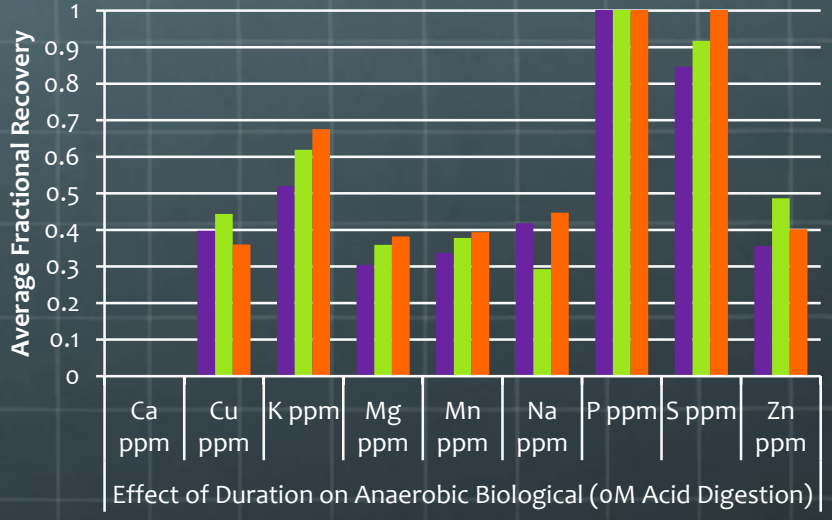
- Water (control), mixed heterotrophic/ nitrifying bioreactor effluent or *Trichoderma vessei* fungi @ 4, 24, 168 hours should help liberate nutrients
- 1 g dried plant matter + 8 mL water + 1 mL inoculum
- Final acid digestion to maximize recovery using 0M and 1M HCl

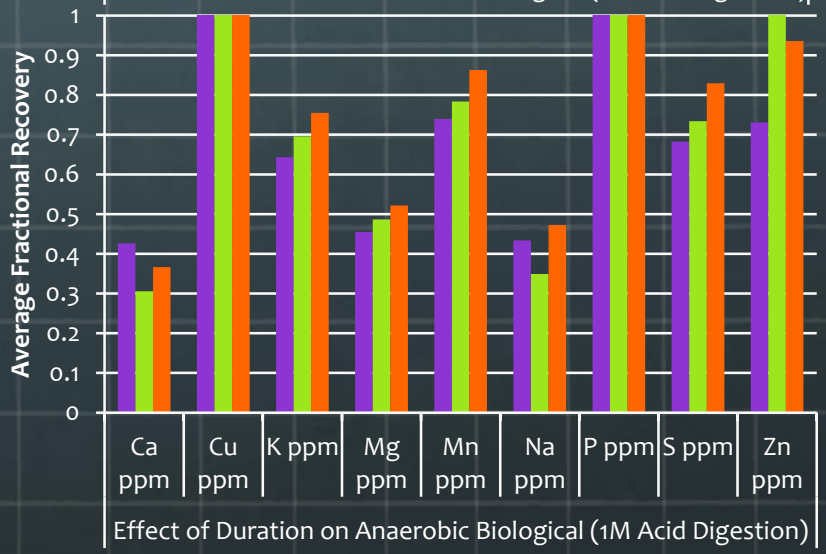


Results - Anaerobic Biological

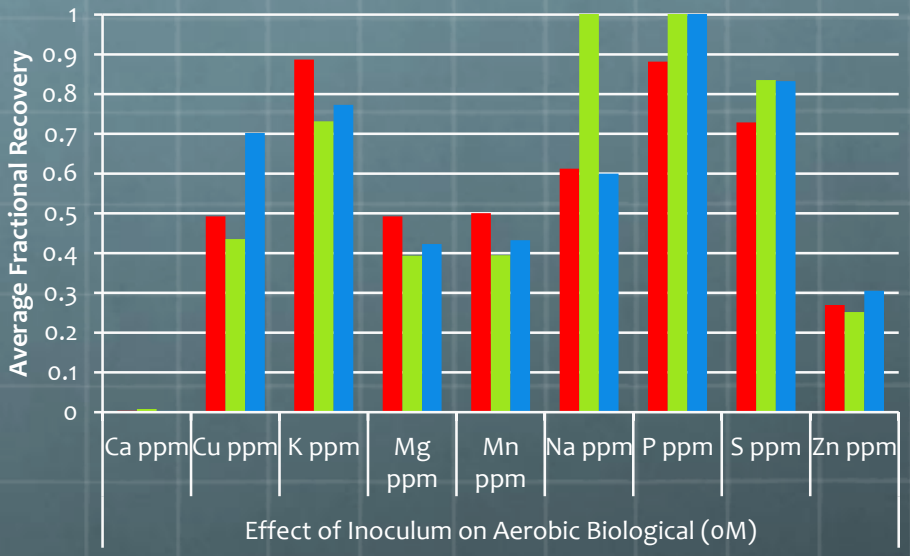


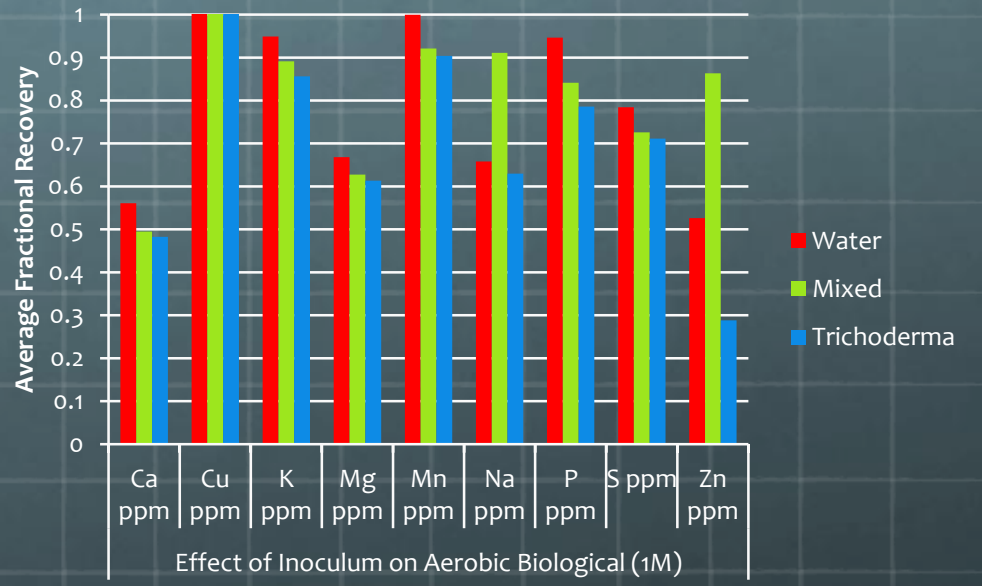


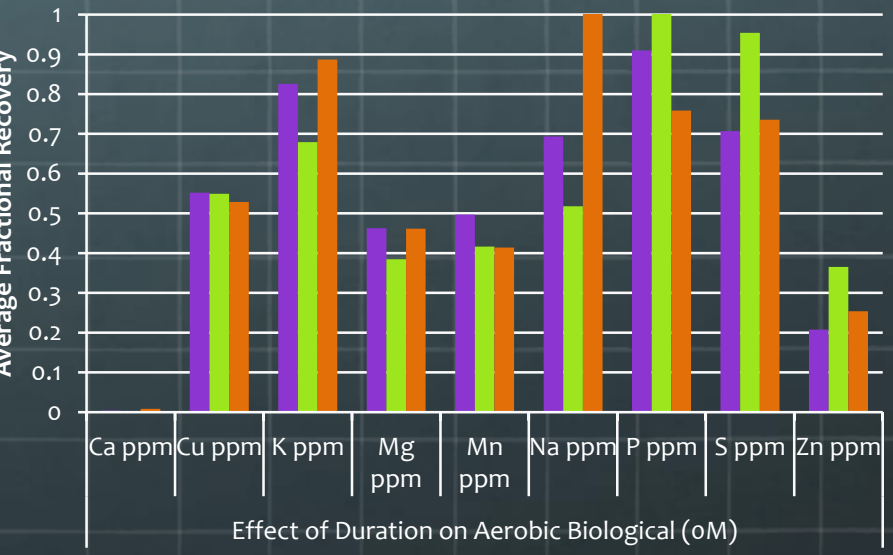


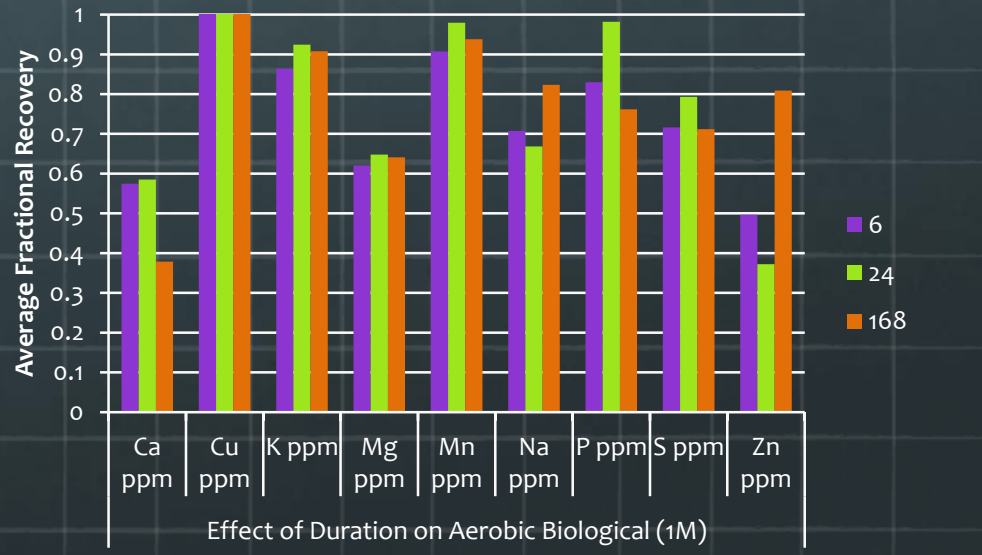


Results – Aerobic Biological



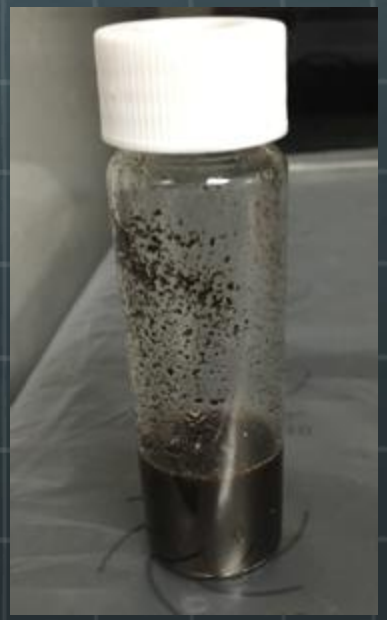




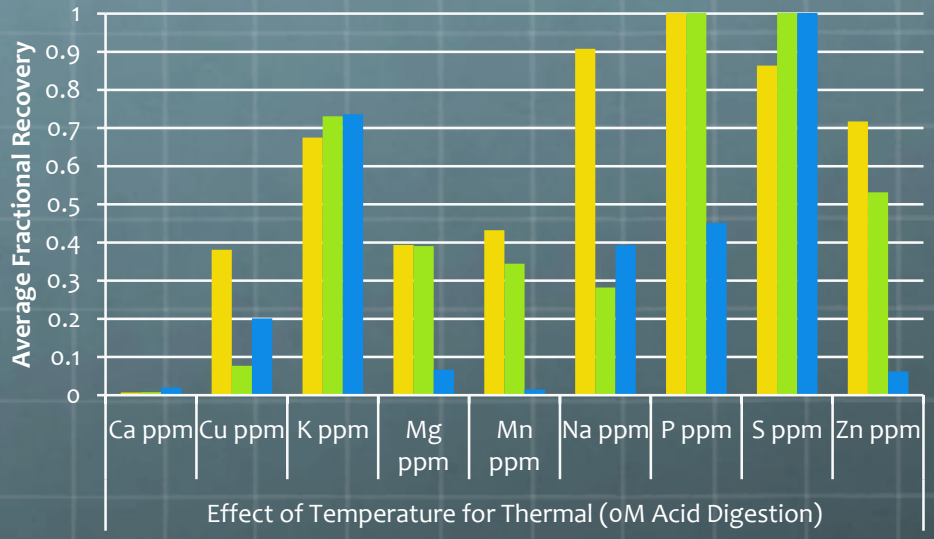


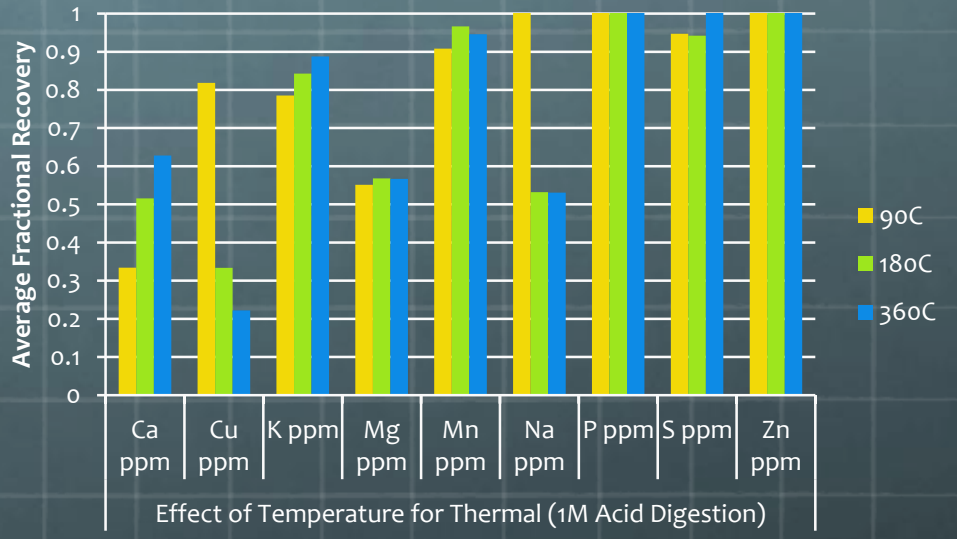
Methods-Thermal Heating

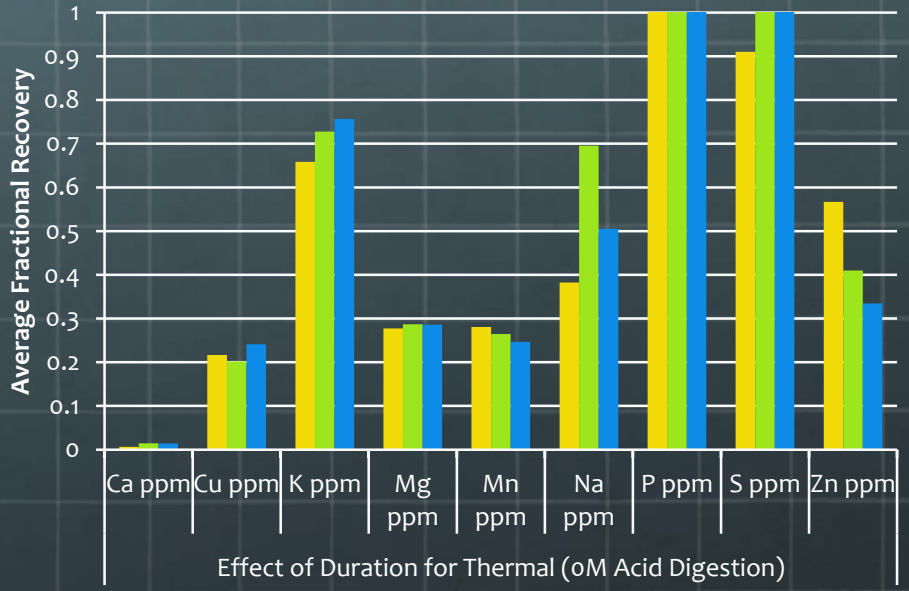
- Dried plant matter (1 g) subjected to 90C, 180C, 360C @ 1, 4, 24 hours aids in nutrient gain
- Final acid digestion: add 9 mL water, 1 mL 0M and 1M HCl

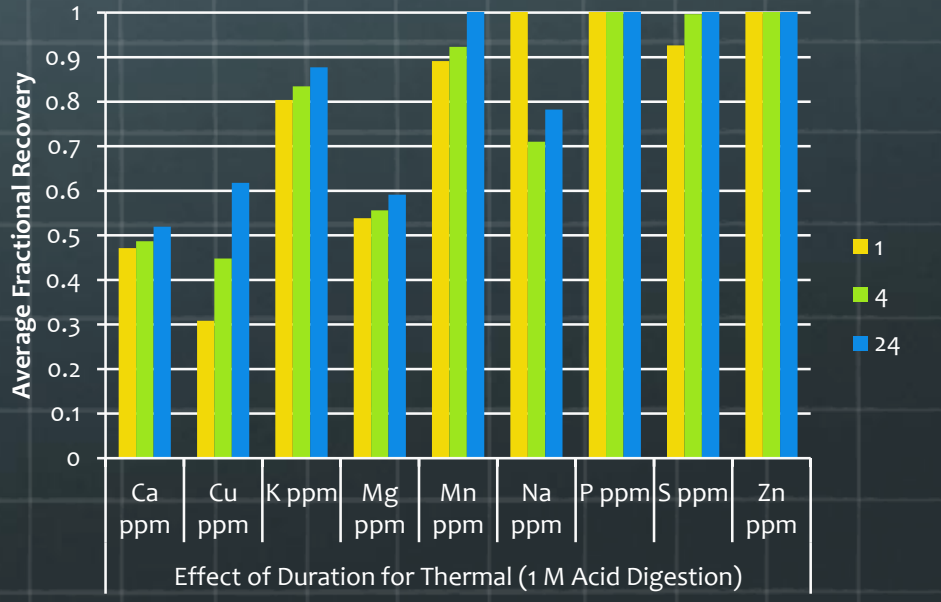


Results - Thermal





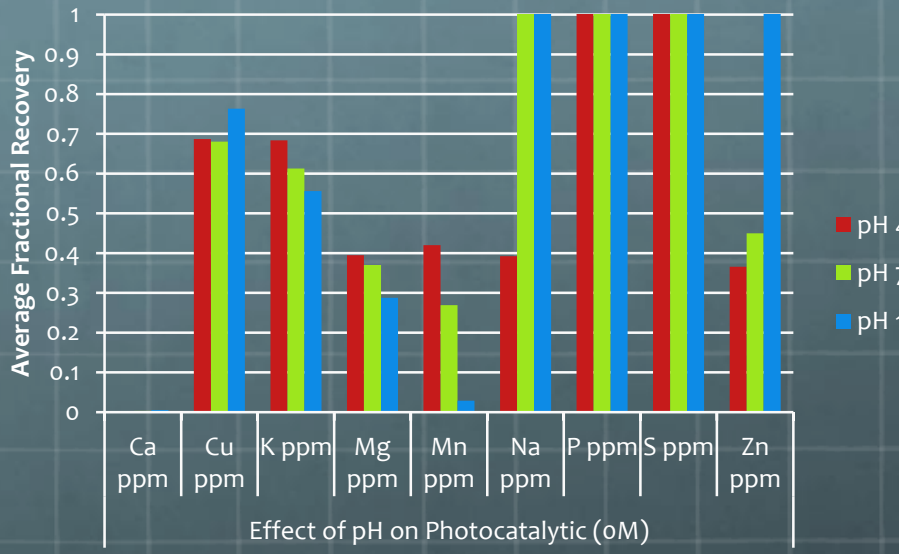


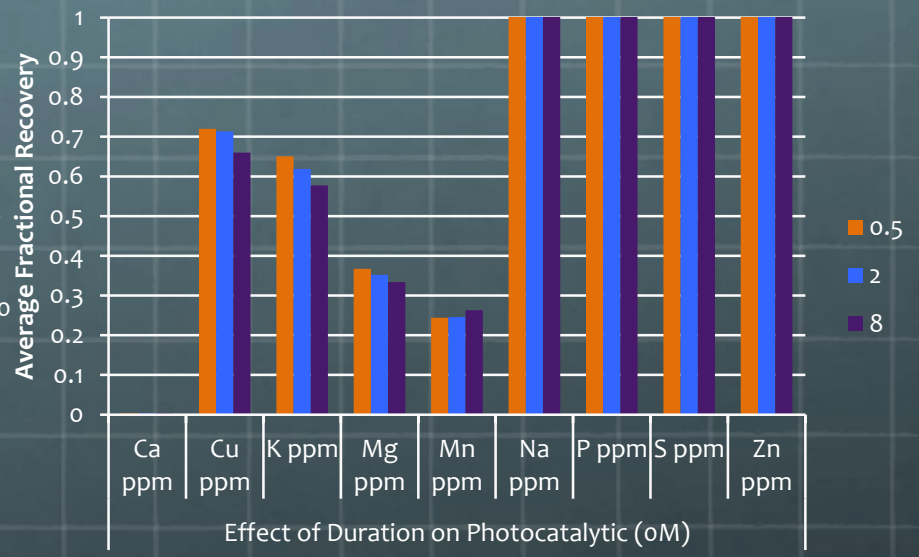


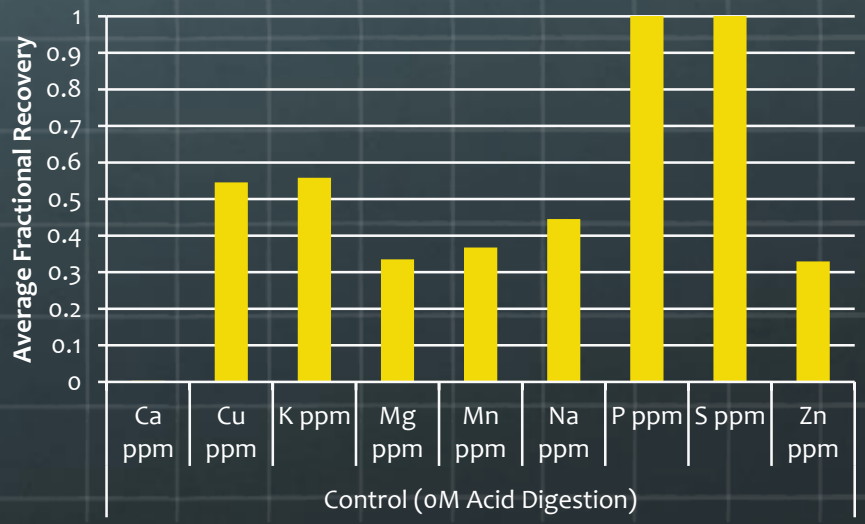
Methods-Photocatalytic Oxidation

- Photocatalytic TiO_2 allows water to photolyze and create a highly oxidative hydroxyl radical
- Dried plant matter subjected to TiO_2 slurry with pH 4, 7, 10 @ 1, 8, 24 hours
- Final acid digestion: 0M HCl and 1M HCl to maximize recovery

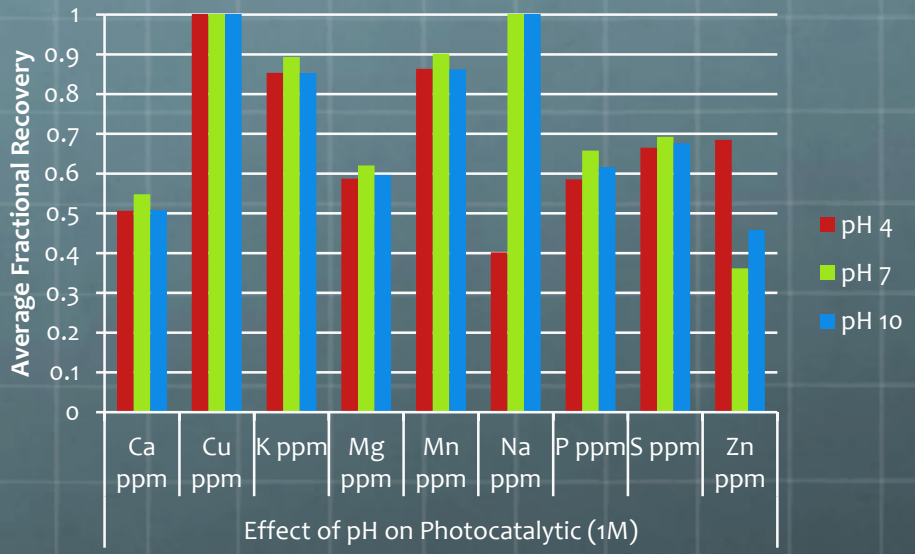
Results – Photocatalytic (0M)

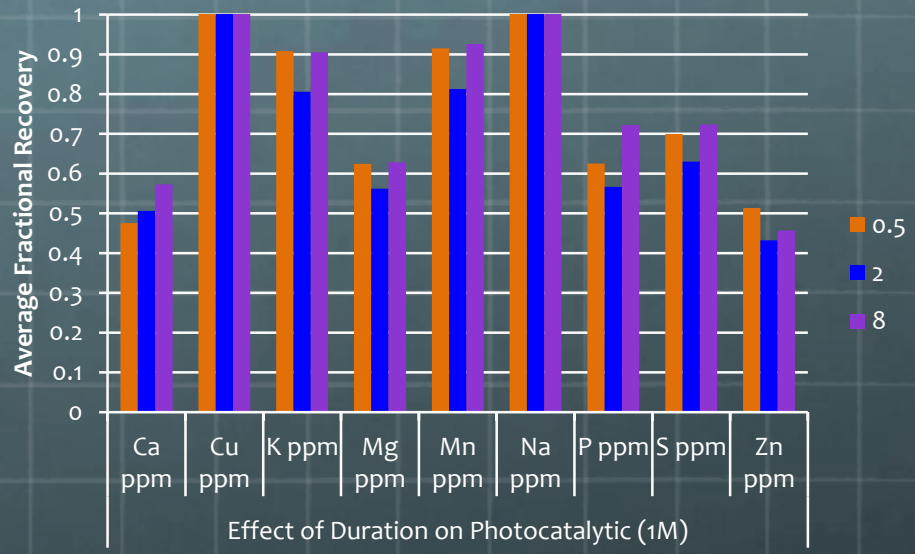


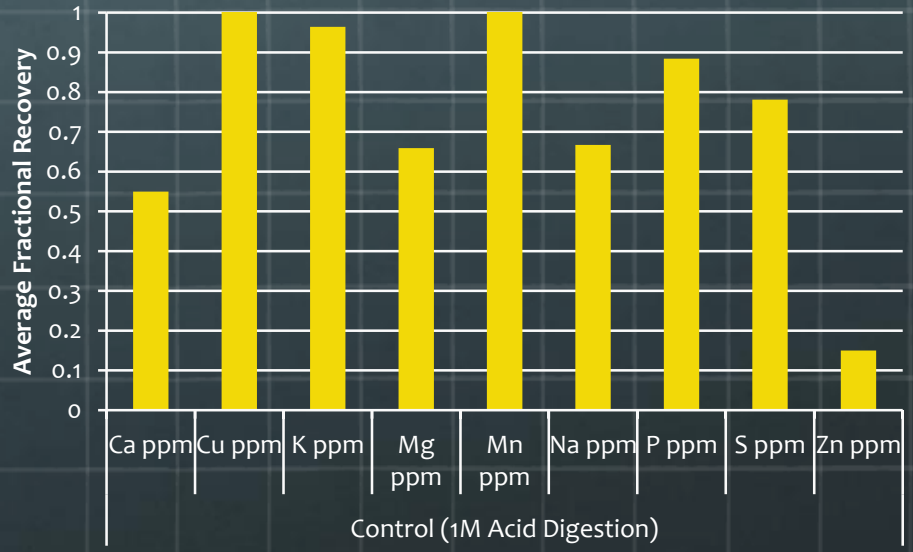




Results – Photocatalytic (1M)

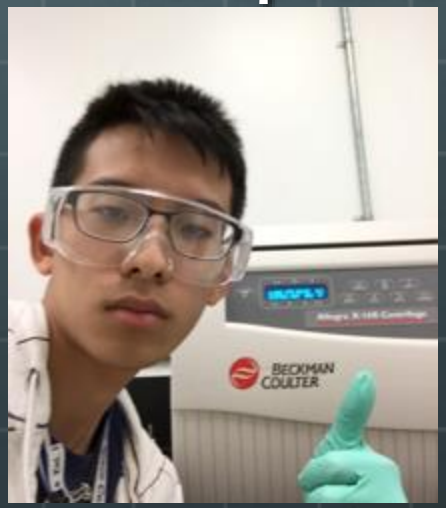


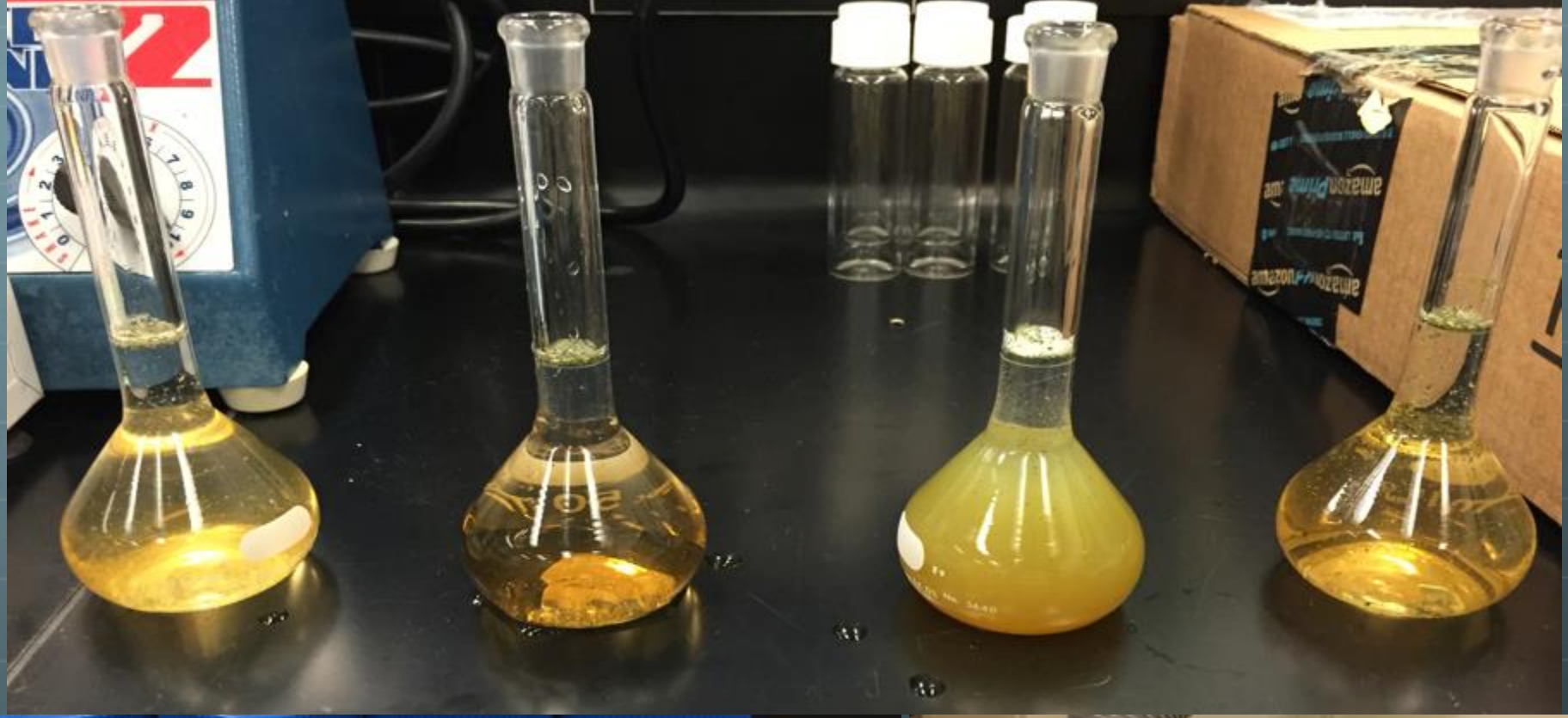


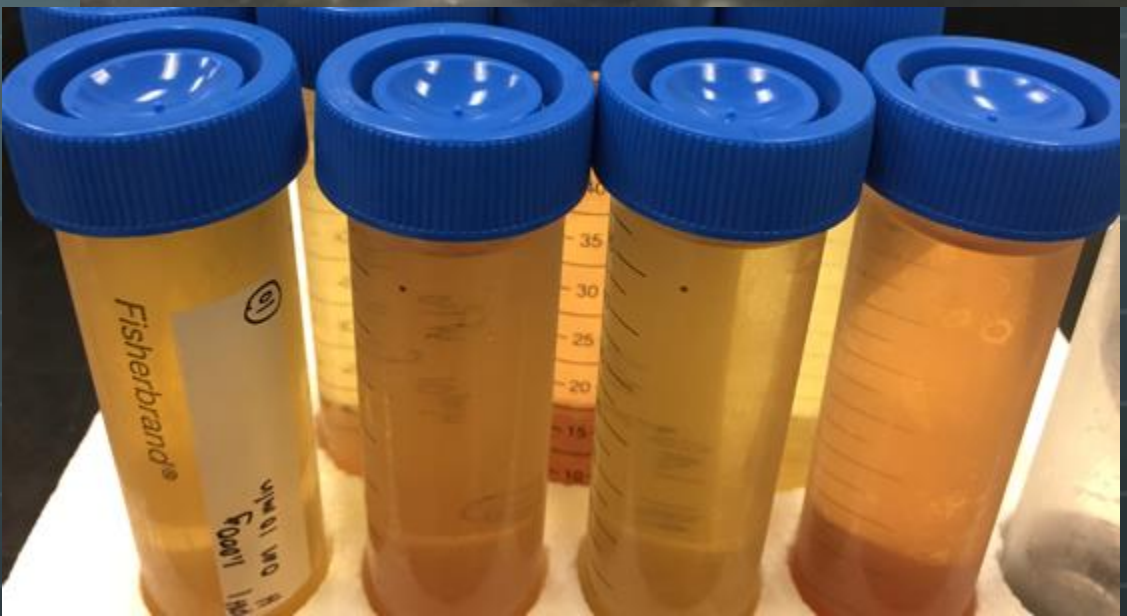


Methods-Quenching

- Resulting solution is centrifuged and supernatant is decanted
- Supernatant is diluted to 50 mL and syringe filtered
- ICP (inductively coupled plasma) is used to analyze for specific ion recovery

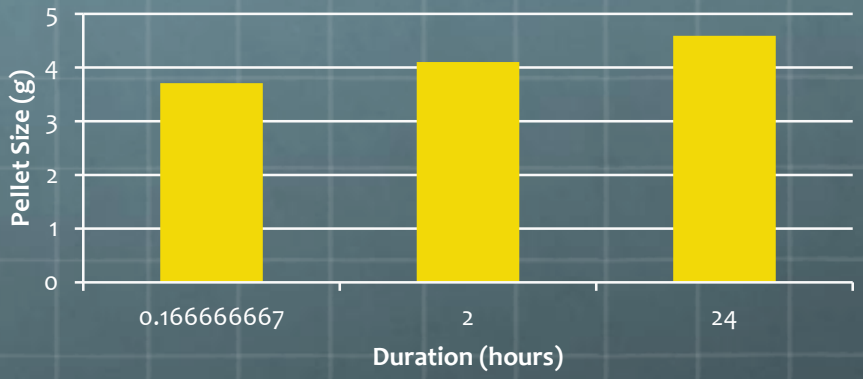




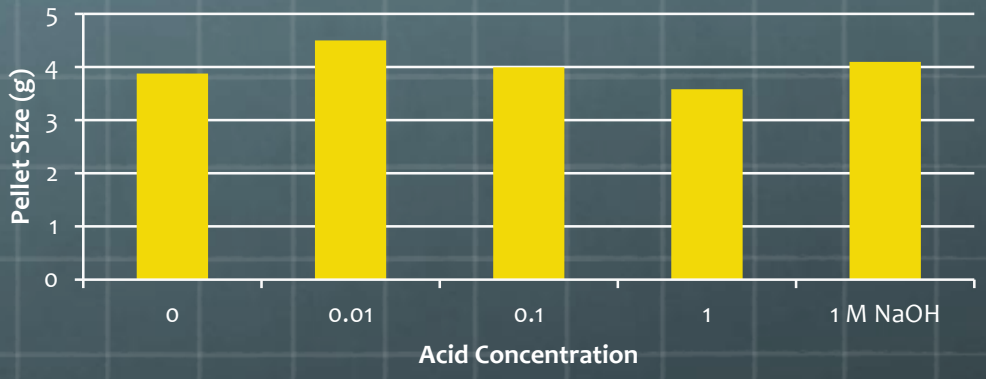

Fisherbrand

Pellet Data

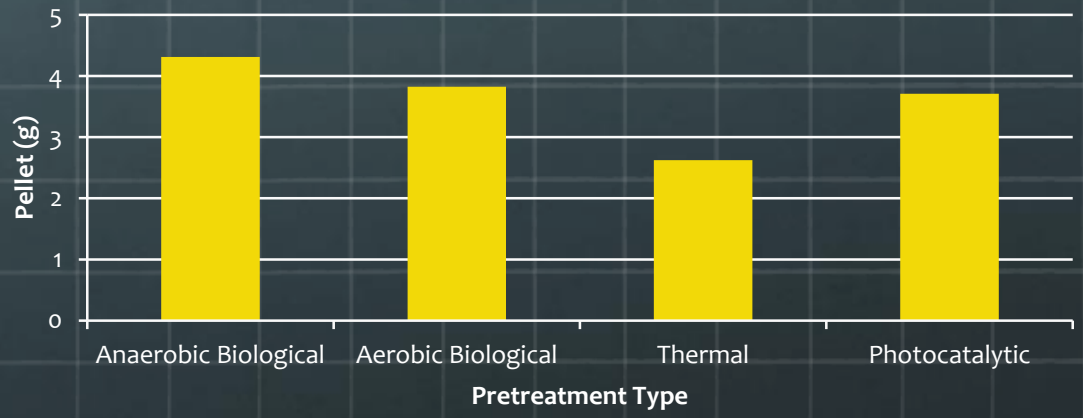
Effect of Duration (Acid Treatment) on Pellet Size

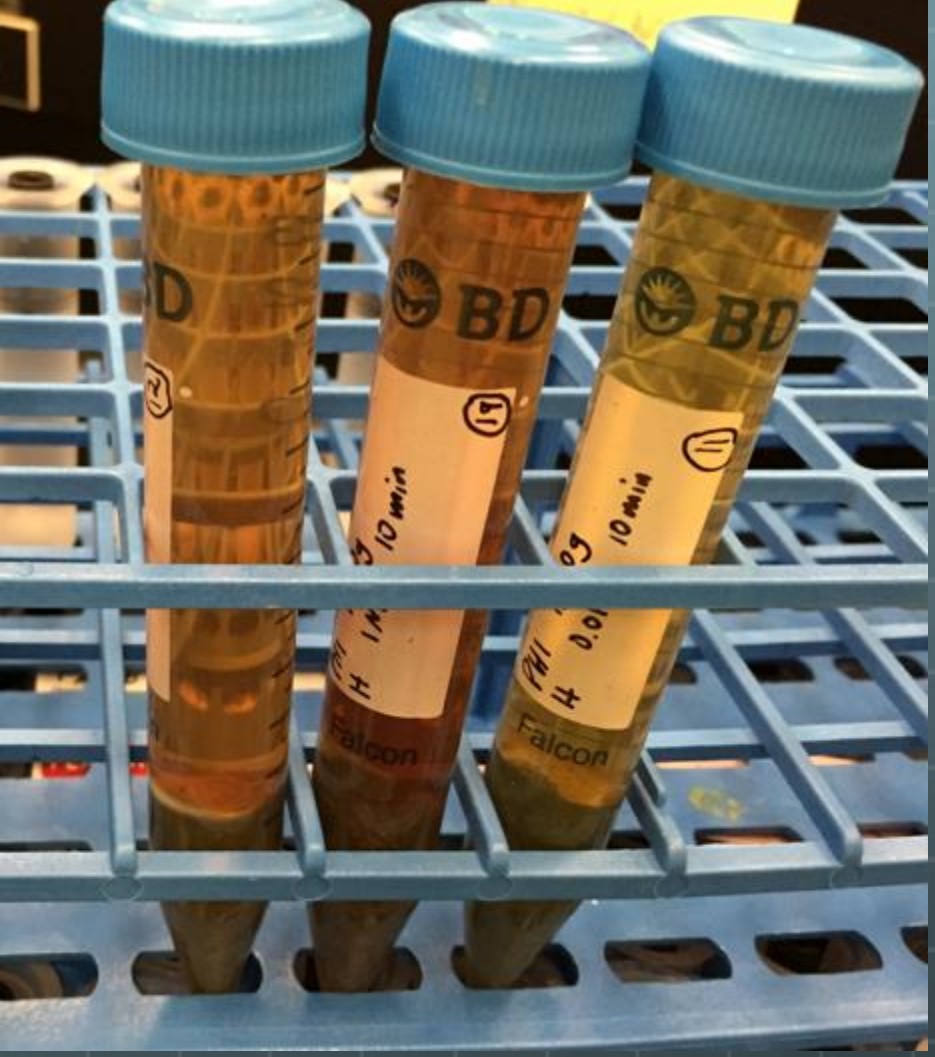


Effect of Acid Concentration on Pellet Size



Effect of Pretreatment on Pellet Size Pellet Mass

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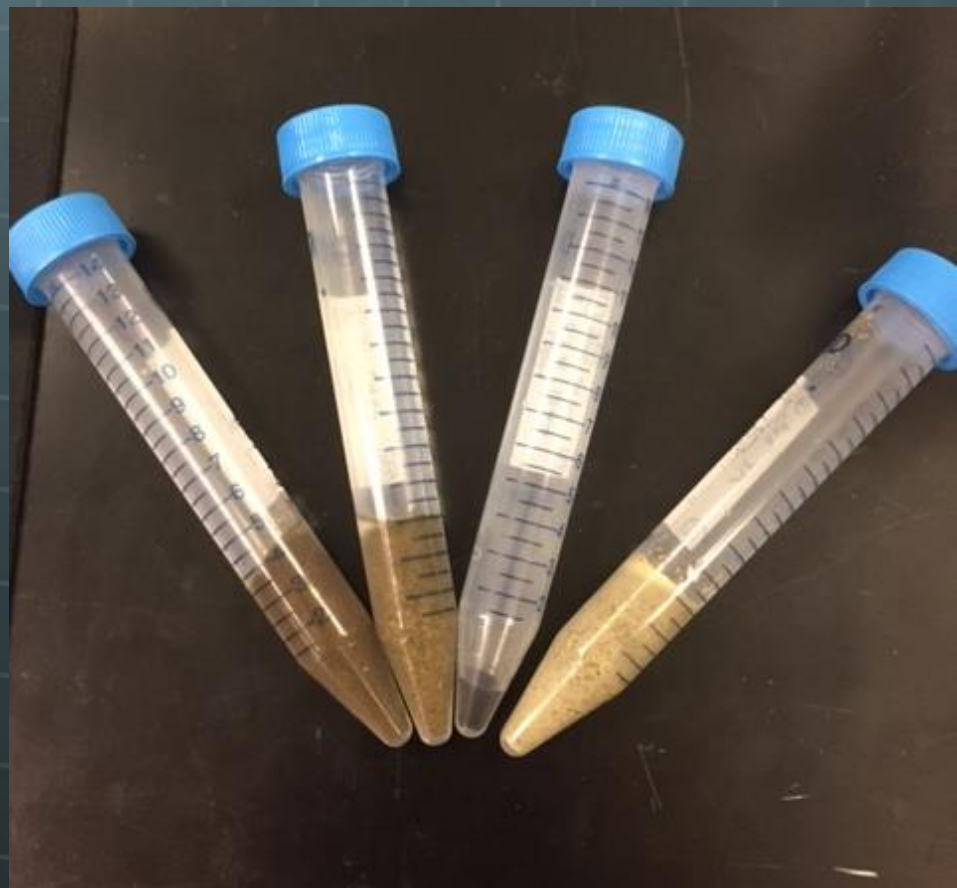
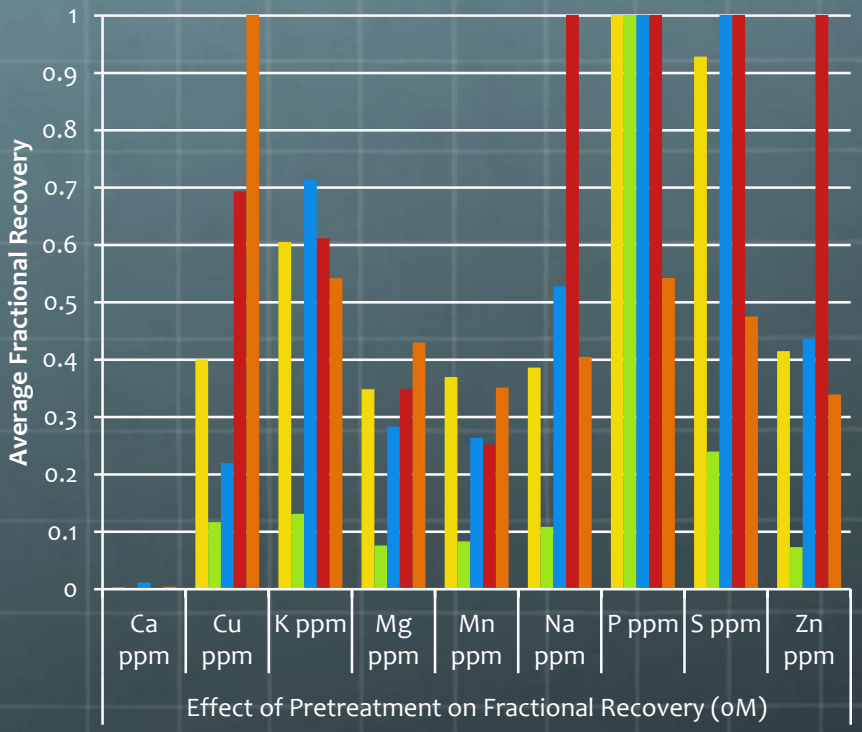
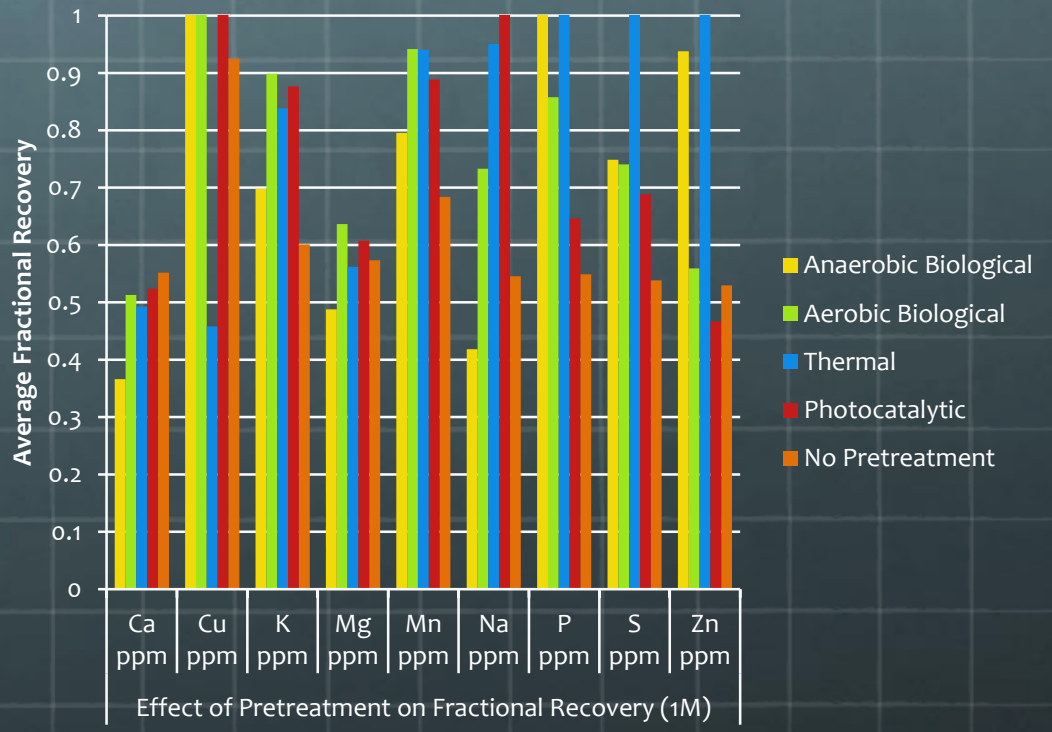


Pretreatment Data



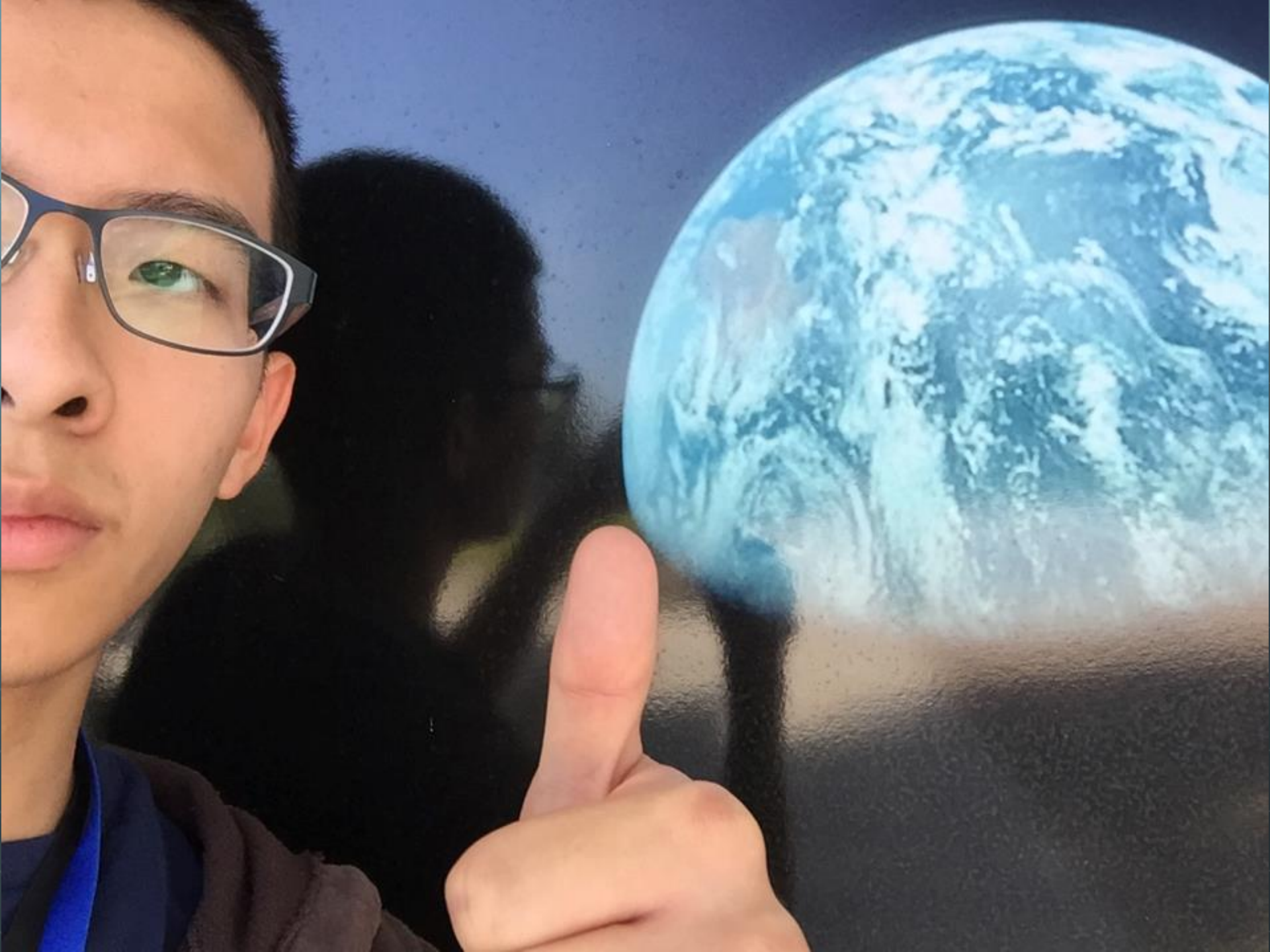


Conclusion

- Thermal, aerobic, and photocatalytic pretreatments look to be relatively effective, anaerobic biological not too effective
- Acid digestion gives a significant boost in nutrient recovery, especially calcium
- Recovery “ceilings” were seen at 70% in many ions
- More testing or a procedural change may be necessary to maximize ion recovery

Conclusion Cont'd

- Multiple leaches may be needed to overcome solubility issues
- Series leaches with different pretreatments
- Oxygen feeds for photocatalytic and biological
- More powerful UV lamp for photocatalytic
- Cover crucibles for the thermal pretreatment
- Need to completely digest remaining pellets with nitric acid to determine how much more ions are trapped



Special Thanks to

- Griffin Lunn, Raymond Wheeler, Gary Stutte for the mentorship and assistance
- LaShelle Spencer for lab assistance and data collection
- Janelle Coutts for photocatalyst assistance and handling