Phosphorus Water Contamination : Win-Win for Consumers?

Project 1 - Final Presentation - 07/27/2018

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GRA: Mohini Nemade

RET Teachers: Jennifer Leigh Myka & Paul Schember

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III. Overview of Literature Review
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Abstract Summary

Problem:

Phosphorus (P) :

Wastewater Contaminant & Wasted Natural Resource

Proposed Solution:

Membrane Bioreactor :

Sequester P using microbes in biomass

Magnesium Carbonate Pellets :

Adsorb/recycle P for later commercial use

Research:

- **Plot P profile of water treatment plant.**
- **Test P adsorption by magnesium carbonate pellets.**
- **Test removal of P by biomass with membrane filtration.**

Judd, S. (2008). “The status of membrane bioreactor technology,” Trends in Biotechnology, Vol. 26, No. 2, pp.109-116.

Parsons, S.A, Smith, J.A. (2008). “Phosphorus removal and recovery from municipal wastewaters,” *Elements*, Vol. 4, pp. 109-112.

Introduction

Phosphorus as a Pollutant

Phosphorus gets into wastewater from farms, factories, and housing. When it reaches significant concentrations, this phosphorus can support algal blooms that disrupt the balanced ecosystems in rivers, lakes and oceans. How can we take out the phosphorus?

Parsons, S.A, Smith, J.A. (2008). “Phosphorus removal and recovery from municipal wastewaters,” *Elements*, Vol. 4, pp. 109-112.

Primary Settling

Primary Treatment

Grit Tanks

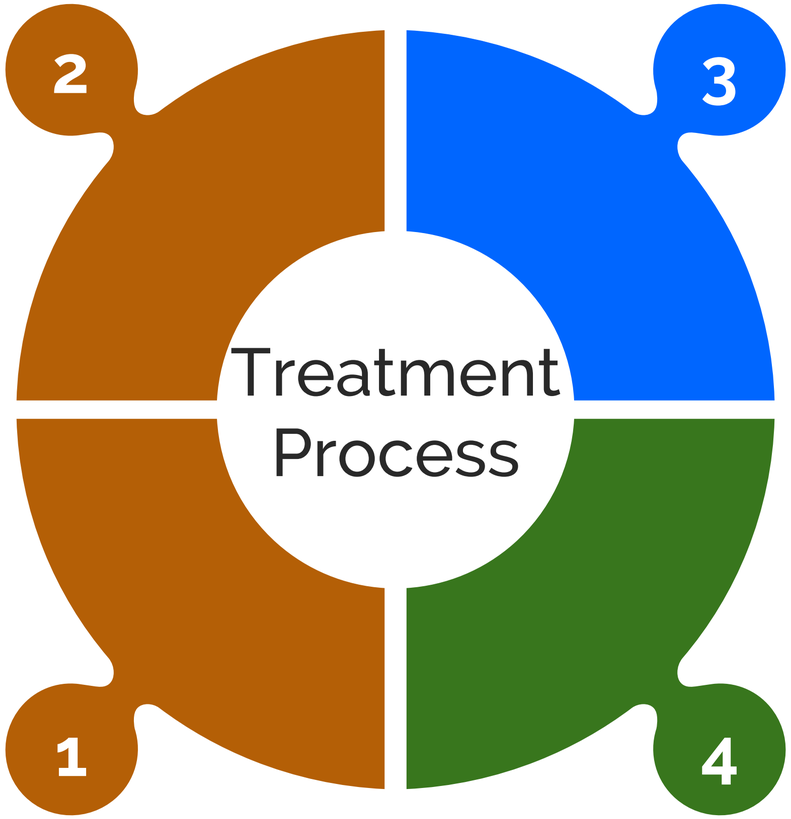
Pump

station

Bar Screens

Preliminary Treatment

Influent (wastewater) received from sewer system



Secondary Treatment

Secondary Aeration

Secondary Clarifier

Disinfection

Effluent (clean water) discharged to Ohio River

Solids Handling

Solids from Primary & Secondary Treatment

Dewatering Centrifuge

Incinerator → Landfill

Industry Partner: Mr. Achal Garg &

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

GOALS & OBJECTIVES

Research Project

Dr. Soryong Chae and Dr. Margaret J. Kupferle Laboratory Goal:

Remove & Recover Phosphorus from Wastewater

Research Objectives:

Evaluate Aspects of Membrane Bioreactor & $MgCO_3$ Pellet Technologies

Phosphorus & Existing Water Treatment

Phosphorus (P) is present in influent wastewater, but is greatly reduced after secondary aeration.

Membrane Bioreactor

Microorganisms take up P to build cellular biomolecules.

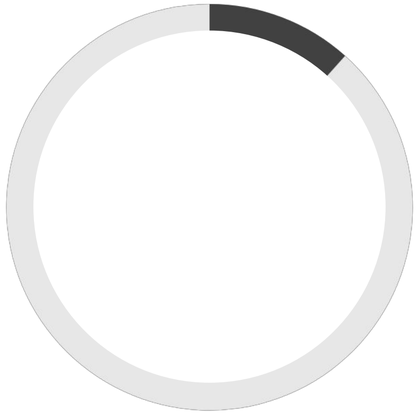
Membrane filtration removes biomass.

$MgCO_3$ Pellet Adsorption

Water is mixed with magnesium carbonate pellets.

P adsorbs to pellets and is therefore removed from water.

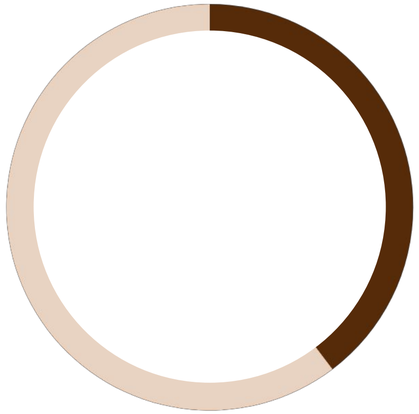
Project Background - Overview



Step #1

Instrument

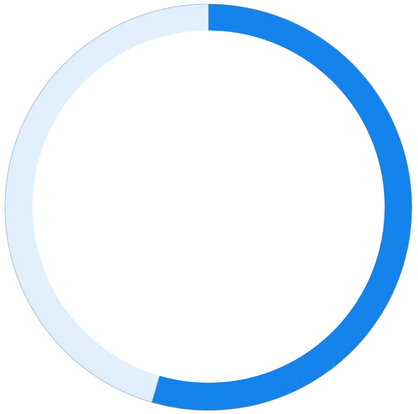
Calibration



Step #2

Plot Current Total P

Profile Change



Step #3

Membrane

Bioreactor

Step #4

MgCO3 Pellet

Adsorption

Project Timeline

Weeks 1,2,3

- Project Introduction
- Lab & MSD Tour
- Technique & Instrument Training
- Calibration & Standard Curves
- Literature Review

Week 4

- Collect & Test Water Samples
- Literature Review
- Research Paper Framework
- Plan Alternative Procedures
- Begin Poster

Week 5

- Experimental design
- Experimental Setup Training
- Begin Experiments
- Literature Review
- Research Paper
- Complete Poster

Week 6

- Experimentation
- Video Construction
- Analyze Experimental Data
- Finish Literature Review
- Finish Research Paper

Week 7

- Submit Project Paper, Poster, Video
- Apply CBL Concepts to Units

1 Accurate & precise standards preparation

2 Sample preparation

3 UV-VIS spectrophotometry to detect total P

4 Instrument calibration & standard curves

5 Wastewater sample collection

6 Profile change plot

7 Analysis of test protocols

Sample Preparation

Sample Collection

Reagent Kits Used

Sample Preparation

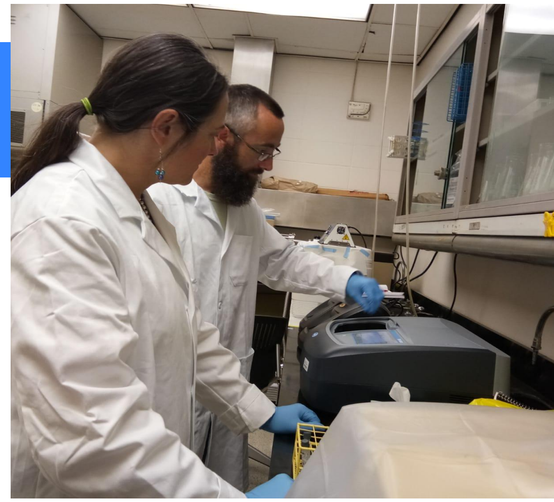
Hach Instrument Images Courtesy of www.Hach.com

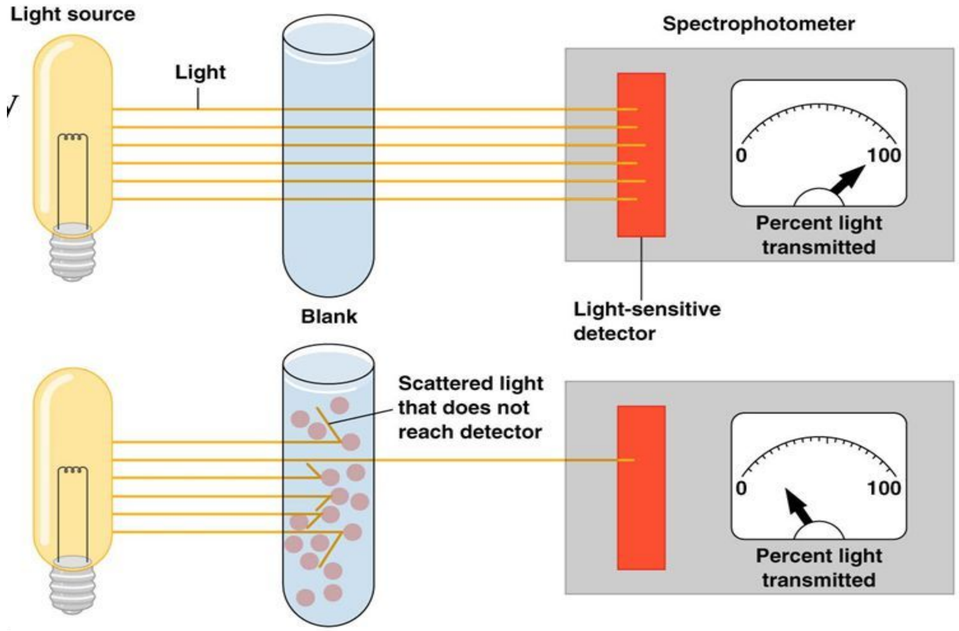
Sample Testing

TNT Plus Vial Chemistries
Phosphate - Total mg/L

Hach DRB200 Incubator

Hach DR6000 UV-VIS
Spectrophotometer





UV-VIS Spectrophotometer Principle

Hach Instrument Images Courtesy of www.Hach.com

Phosphorus Profile of Wastewater Treatment Plant

- Calibration of Spectrophotometer
- Standard Curves
- Sampled Wastewater; Analyzed Phosphorus

Membrane Bioreactor

- Planned experimental design
- Materials handling, instrumentation, safety, & experimental setup training
- Experimental data collected & analyzed

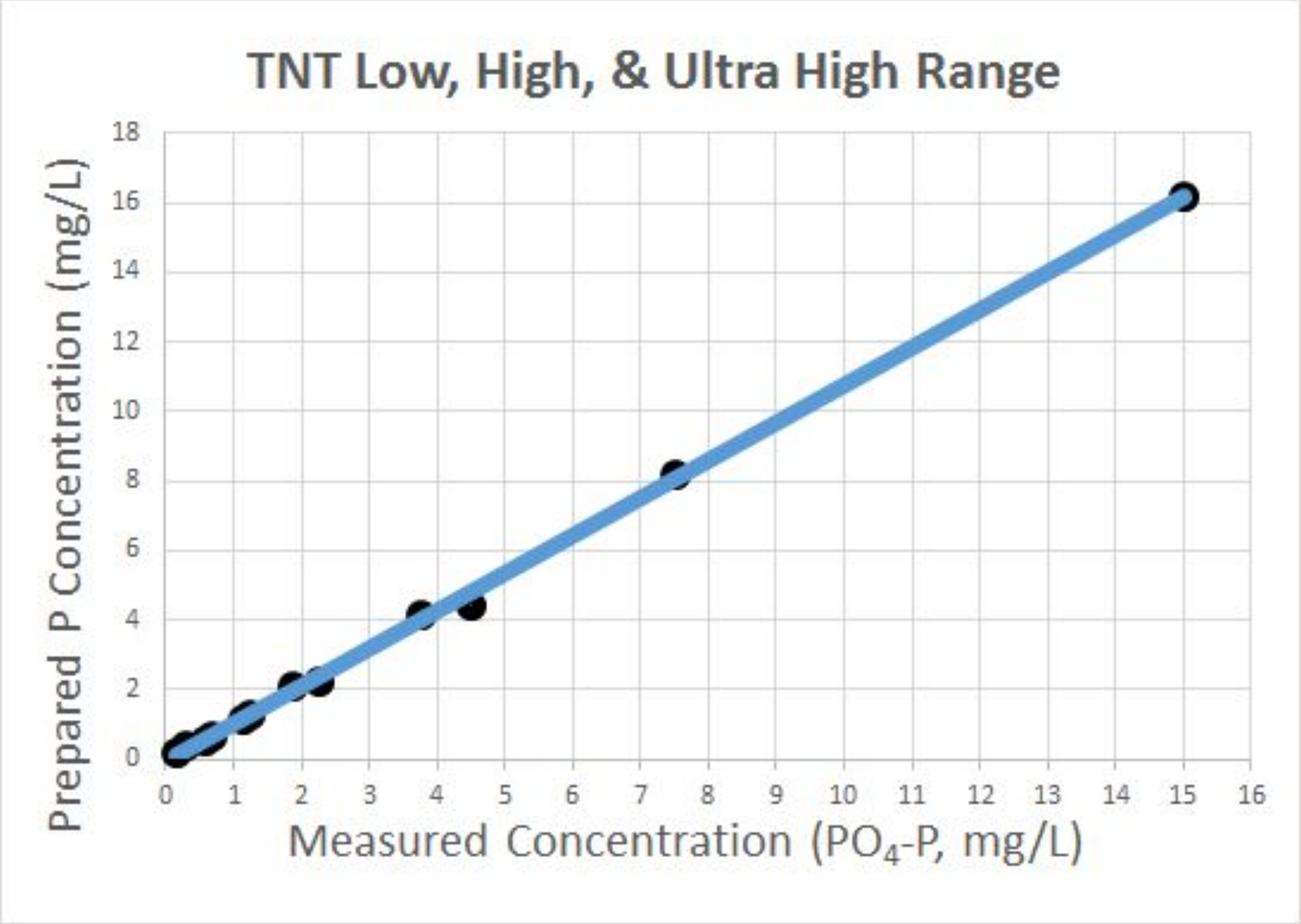
$MgCO_3$ Pellet Adsorption

- Planned experimental design
- Materials handling, instrumentation, safety, & experimental setup training
- Experimental data collected & analyzed

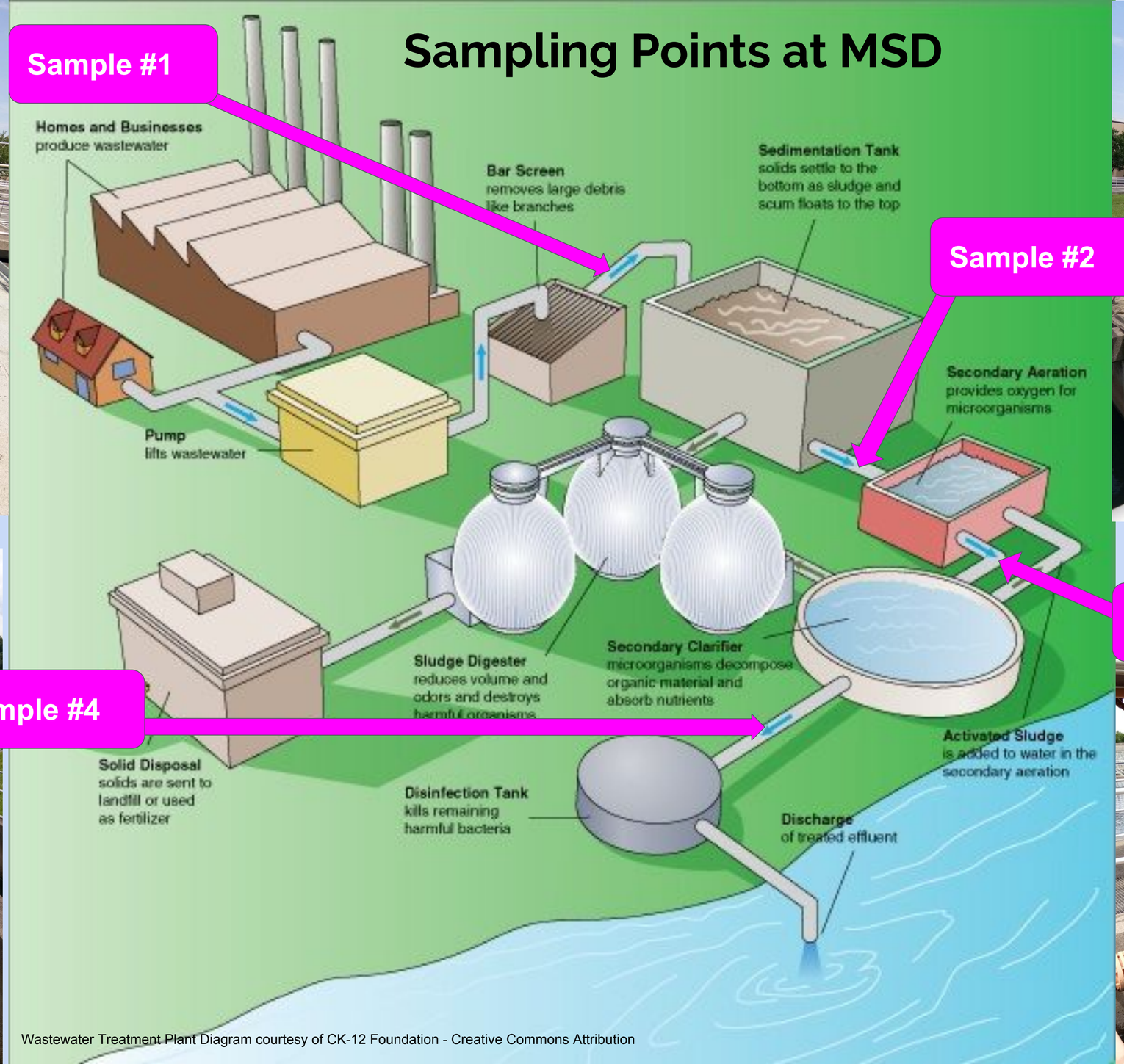
Research Completed

Calibration Curves

Hach Kit Range	P Range Detection (mg/L)	Linear Regression R^2 Value
Low	0.05-1.5	0.9974
High	0.5-5.0	0.9999
Ultra High	2.0-20.0	1.0
Combined on Graph		0.9999

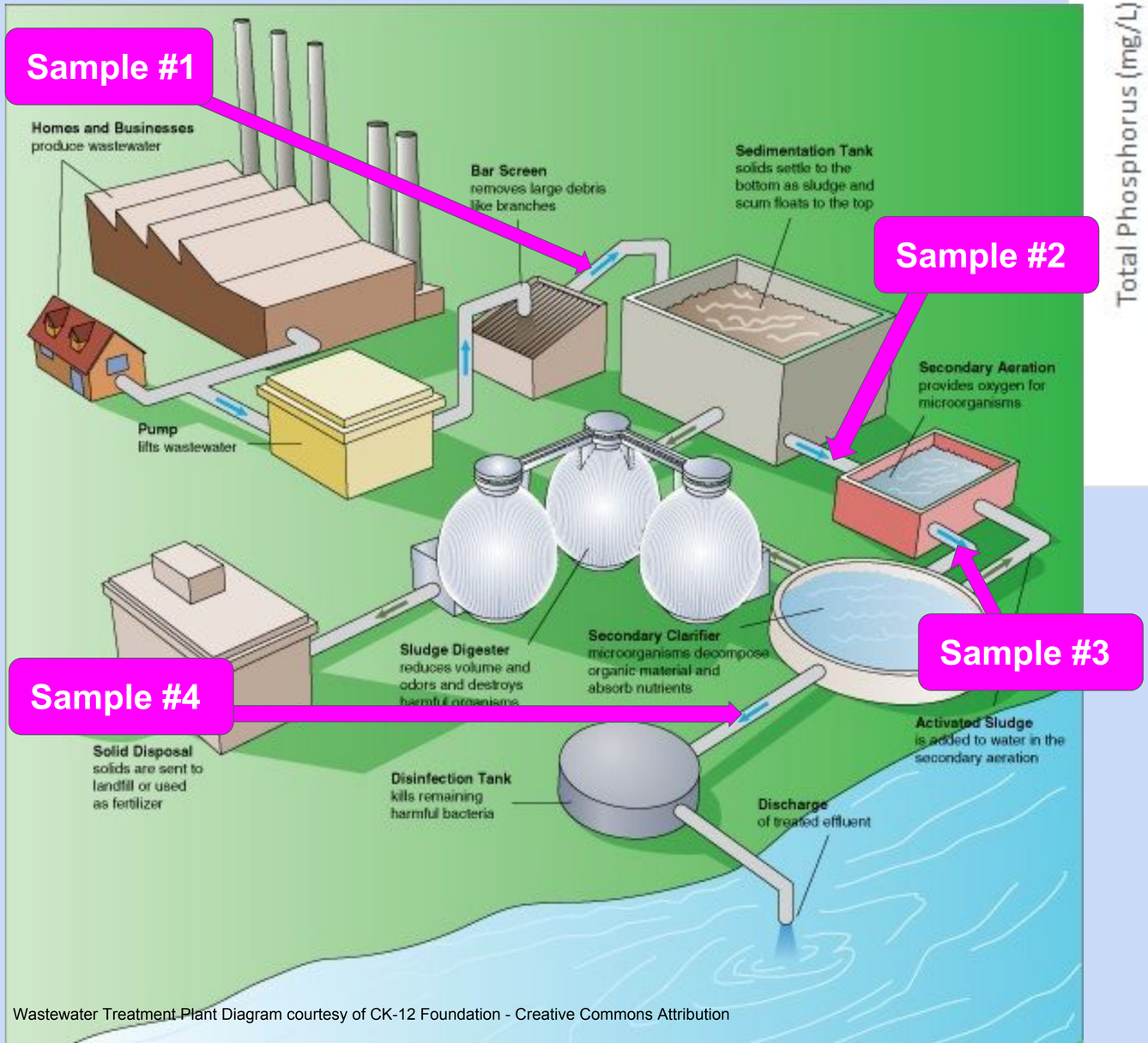


Sampling Points at MSD

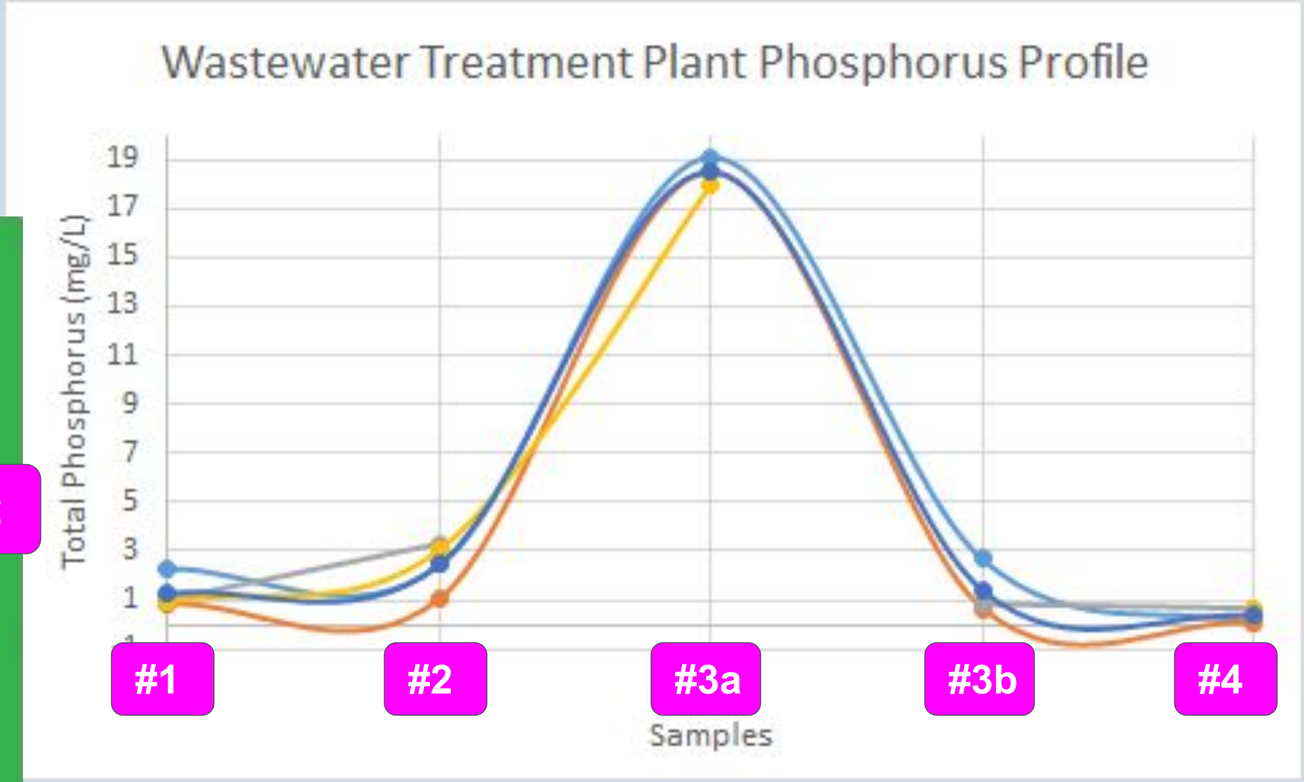


Wastewater Treatment Plant Diagram courtesy of CK-12 Foundation - Creative Commons Attribution

Plant Phosphorus Profile

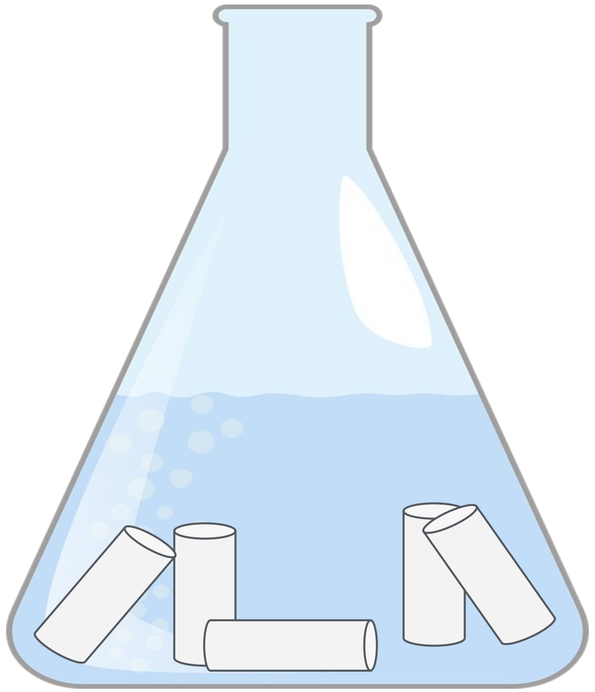


Wastewater Treatment Plant Diagram courtesy of CK-12 Foundation - Creative Commons Attribution

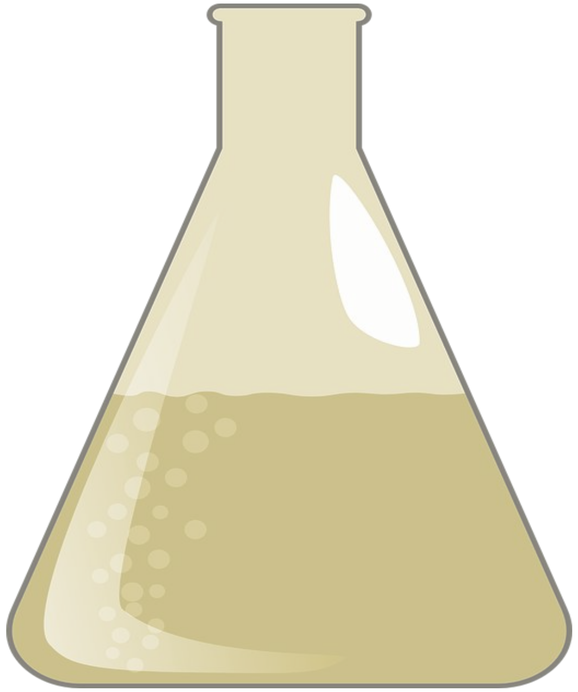


- **#1** Primary Influent
- **#2** Before Secondary Aeration
- **#3a** MLSS After Secondary Aeration
- **#3b** Supernatant after Secondary Aeration
- **#4** After Secondary Clarifier

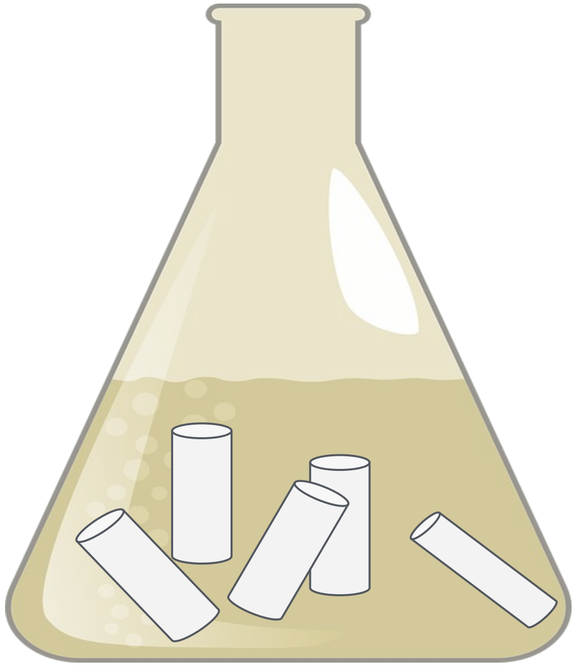
How $MgCO_3$ pellets will be tested for phosphorus adsorption in the lab.



<u>Control group #1:</u>
100 ml of deionized water with 4.65 grams of pellets

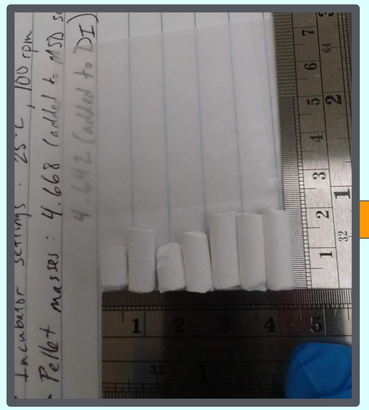


<u>Control group #2:</u>
100 ml of sewer water *without pellets*

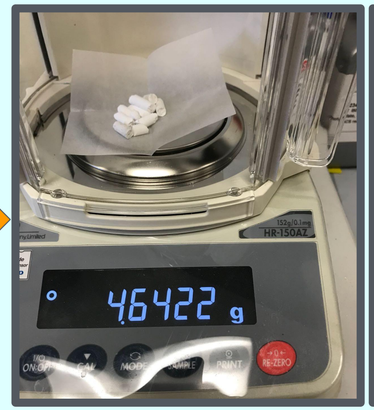


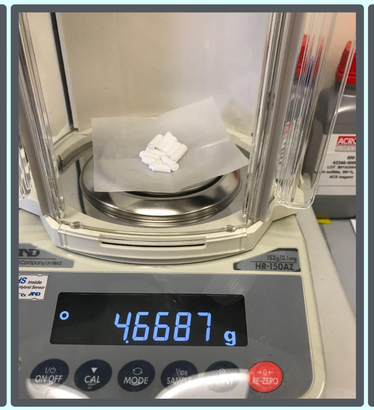
<u>Experimental group:</u>
100 ml of sewer water with 4.65 grams of pellets

Experimental Set Up for $MgCO_3$ Pellets Adsorption



Pellet size variation

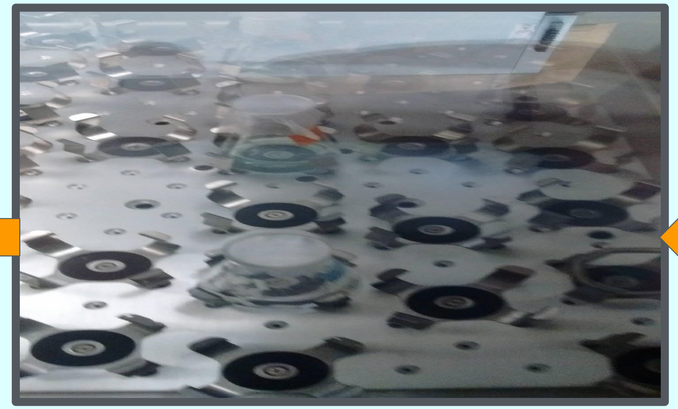




Equalizing the pellet groups

Three groups labeled and ready for testing

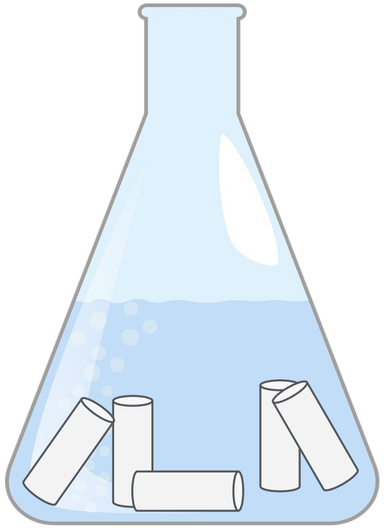
Initial levels of phosphorus are measured with HACH kits



Samples are incubated at 25 degrees C and stirred continuously for 2 hours

Final levels of phosphorus are measured, compared to initial readings, and analyzed.

Results: based on averages from 3 runs



Initial P: 0.006 mg/L

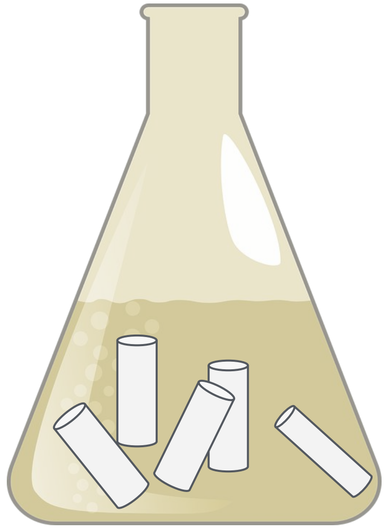
Final P: 0.002 mg/L

Change: 0.004 mg/L

Initial P: 2.240mg/L

Final P: 1.499 mg/L

Change: 0.741 mg/L



Initial P: 2.240 mg/L

Final P: 1.148 mg/L

Change: 1.092 mg/L

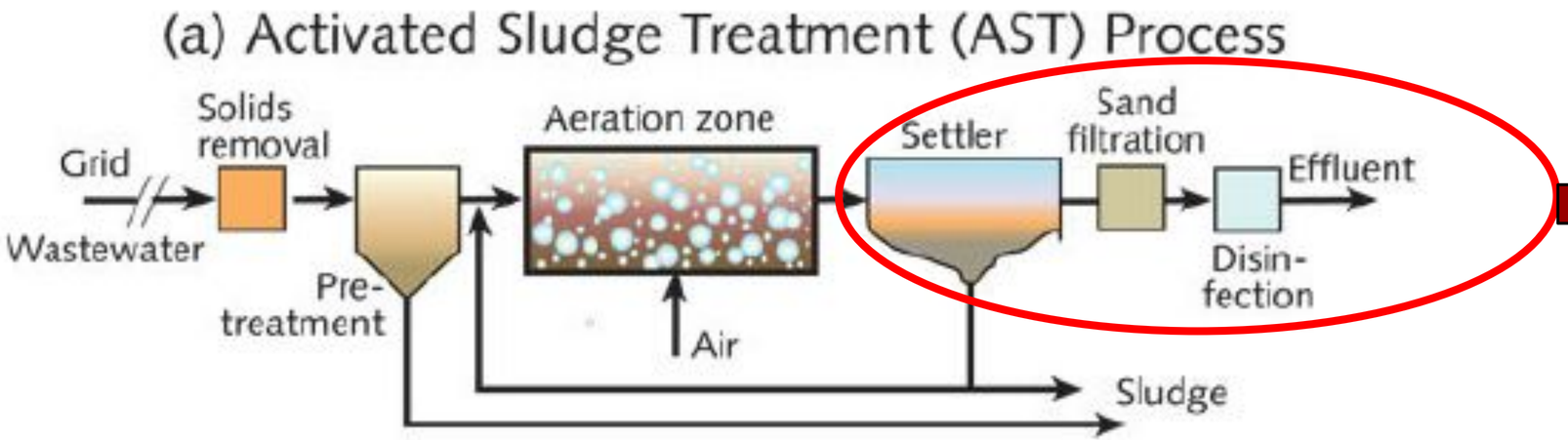
Paul's Unit: Save the Soil!

<u>Topic</u>: Earth's surface is shaped by destructive forces.

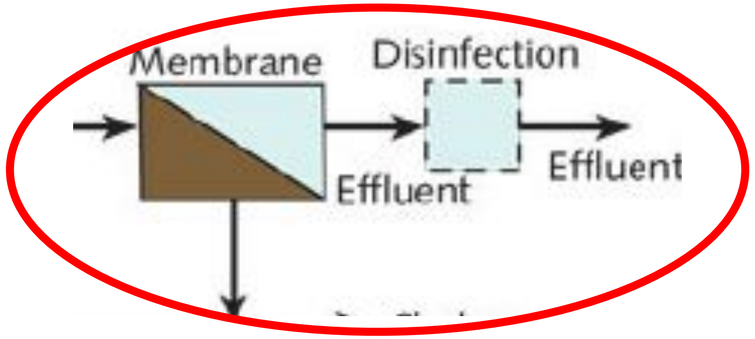
<u>Essential Question</u>: What materials and methods can be used to prevent erosion?

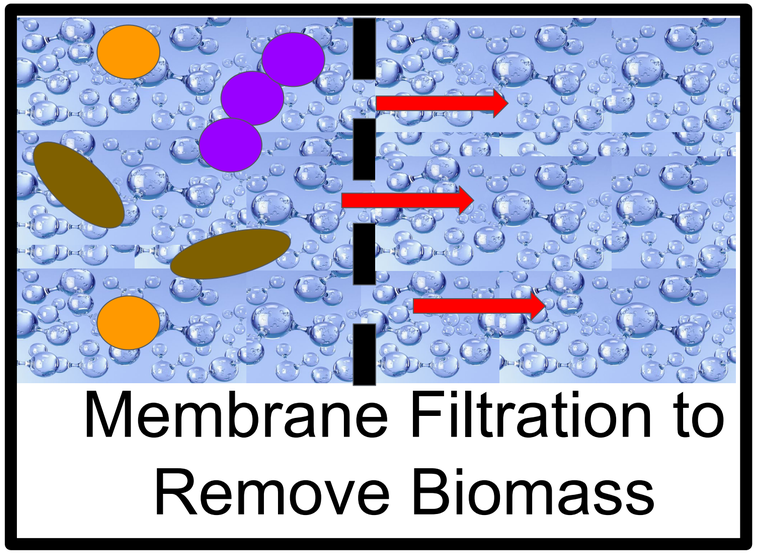
<u>Challenge</u>: Build a scale model of a sloped farm field and design a way to prevent its soil from eroding.

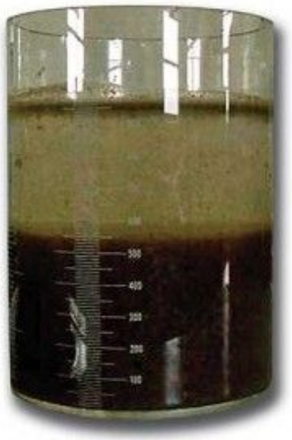
Membrane Bioreactor Concept



Membrane Bioreactor Process





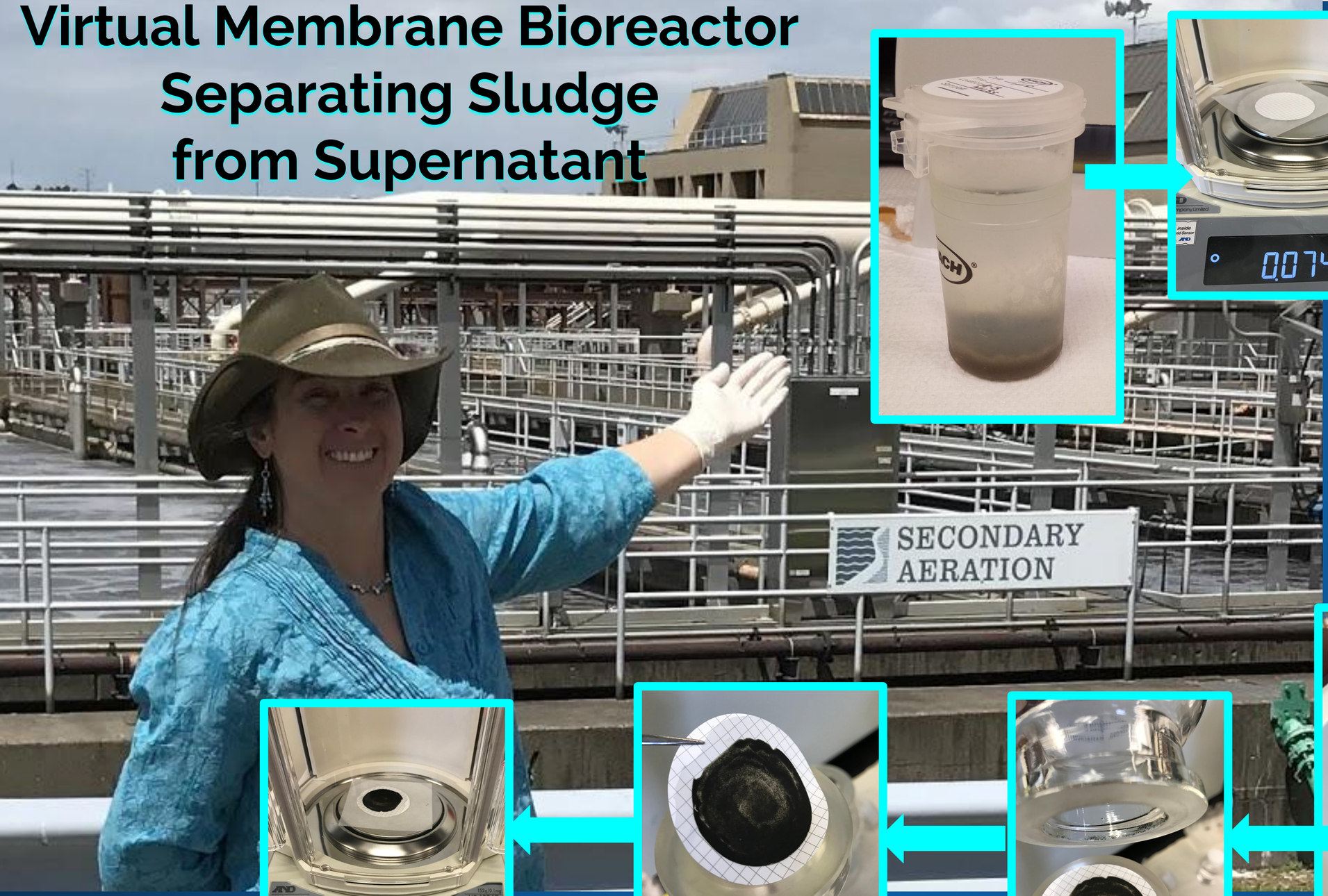


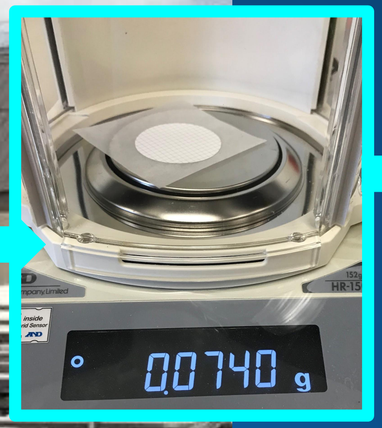
Mixed Liquor Suspended Solids (MLSS)

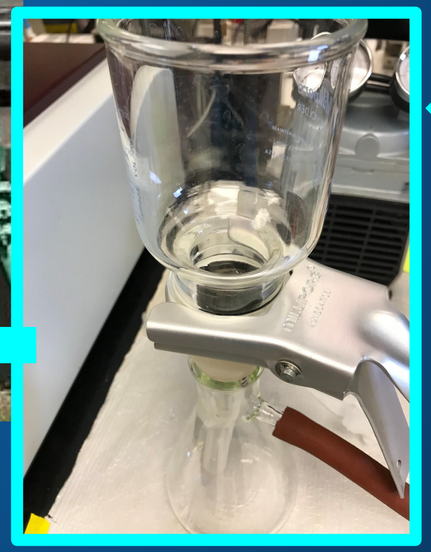
→ Proposed Biomass Digestion to Recover P

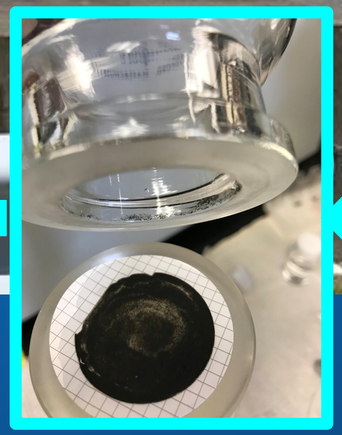
MLSS Image courtesy of: https://www.ebsbiowizard.com/mixed-liquor-volatile-suspended-solids-mlvss-mlss-1056/
Process Images courtesy of: https://www.researchgate.net/figure/Basic-principle-of-membrane-filtration-A-pressure-difference-draws-raw-wastewater-through_fig2_261958205
Water molecule background image courtesy of: https://www.mnn.com/earth-matters/wilderness-resources/stories/how-long-does-water-molecule-stay-oceans-lakes-rivers

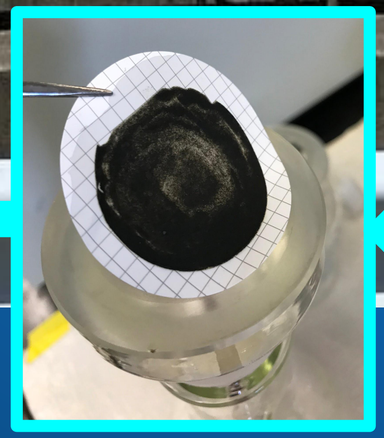
Virtual Membrane Bioreactor Separating Sludge from Supernatant





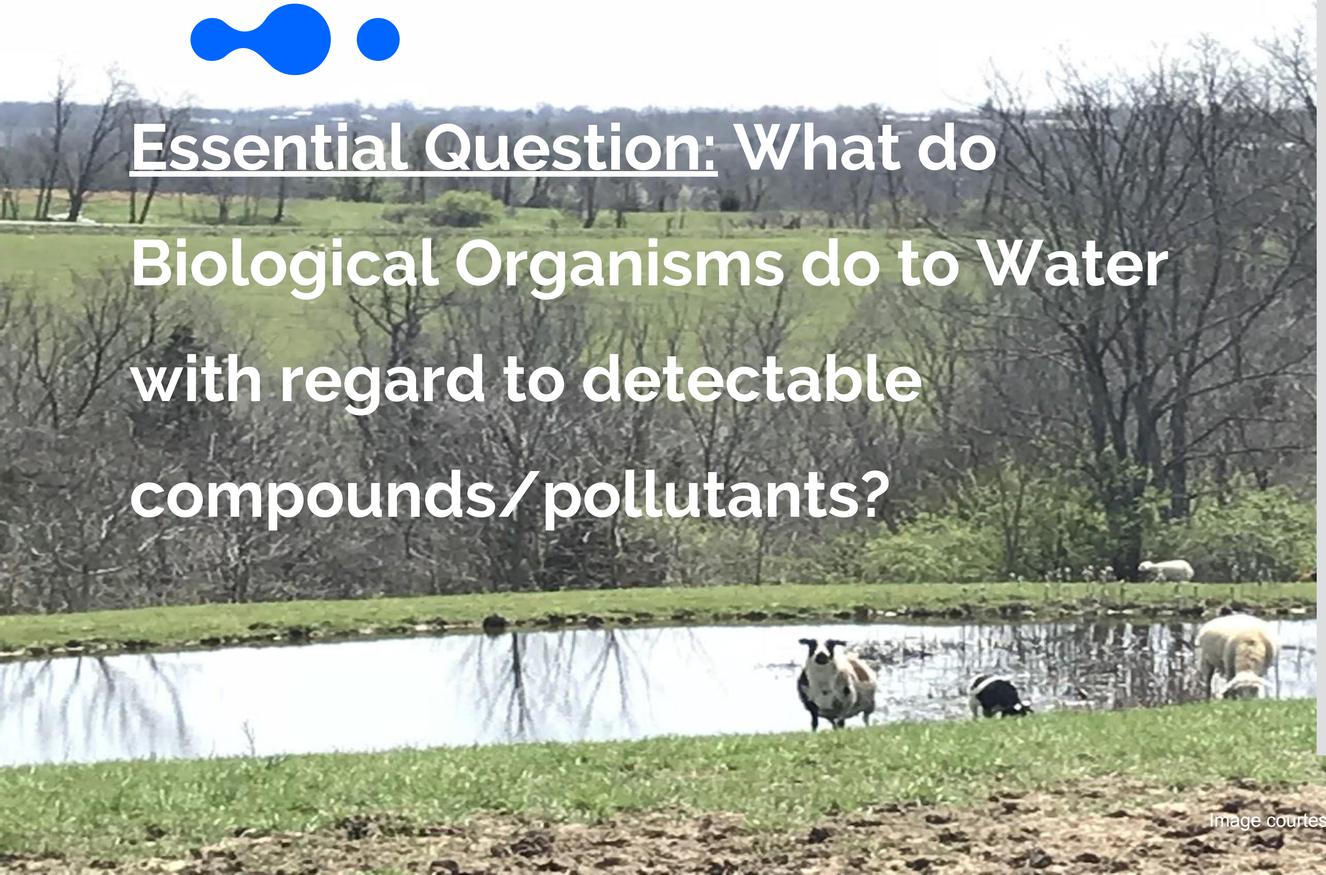






Jennifer's Unit: Membrane Bioreactors

What Can Biological Organisms Do To and For Your Water?
Design & Implement a Biological System to Modify Water Samples



<u>Essential Question:</u> What do Biological Organisms do to Water with regard to detectable compounds/pollutants?

<u>Challenge:</u> Design and test a water treatment protocol involving biological organisms to remove some quantity of an identified pollutant from the water

Image courtesy of Jennifer Leigh Myka, M.S., Ph.D., Free Radical Ranch

Questions?

RET is funded by the
National Science Foundation
Grant # EEC-1710826

A. **Title Page**

B. **Table of contents**

C. **Abstract (Perhaps bullets go here.)**

D. **Introduction**: A paragraph that provided general overview of the research topic being pursued and its importance.

E. **Background Literature Review - overview**

F. **Goals and Objectives** of the research project, **Research Tasks** to be undertaken, and **Timeline** to complete the research tasks and produce the project deliverables (Technical Paper, PowerPoint Presentation, Display Poster, and NSF Project Summary).

G. **Research Training Received**

H. **Unit Topic, Essential Question and Challenge –** Report each teacher's progress on Unit plan including Topic, Essential Question and Challenge

I. **Progress made** on any of the research tasks undertaken until now. This could have subsections

Suggestions by Mohini

Background - Industry partner - MSD https://youtu.be/Ta38Vx13sYE
Outline the Millcreek Water Treatment Plant process in flow chart format

$MgCO_3$ - How does it adsorb P? Why can it be washed off in rain? Recycled?

Membrane Bioreactor - What is the biological reactor process? What happens to P? Why use the membrane? Can we get P out of sludge with a digestion process?

Detection - highlight instrumentation - spec and incubator
Mention three ranges of Hach tubes

Calibrated the instrument by preparing serial dilutions of P in water and testing samples using Hach
Plotted results in standard curve - R2 values - means that instrument is detecting linearly within range and accurately
Note - unknown levels from samples so tested all ranges available

Plan - collect samples → Identify areas to test on flow chart - discuss P expected

Future research - collect samples, plot P, etc.

Unit Plans - Each outline their own - include mention of industry partner impact!

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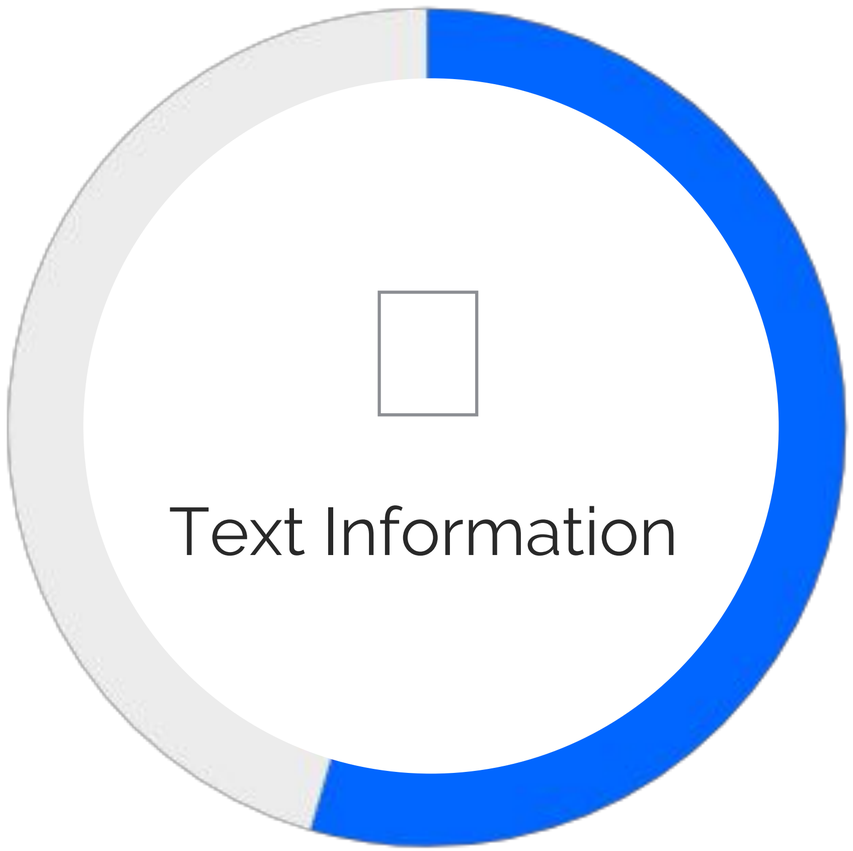

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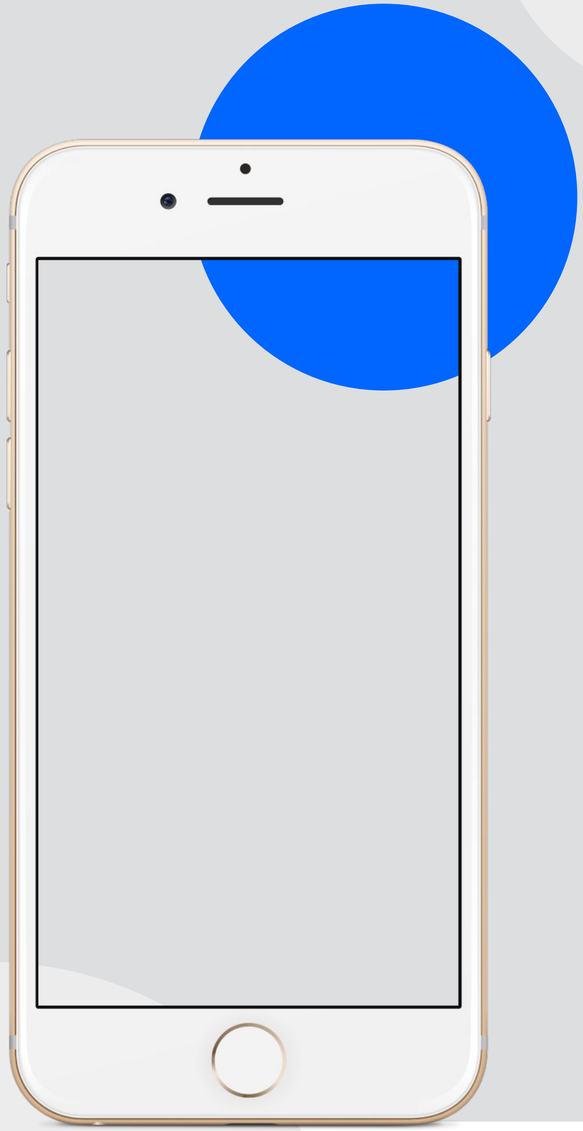

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