

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Virus Removal and the Biosand Filter (Research Q&A)

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CAWST Webinar
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Overview

Background:
-Point-of-Use
Treatments
-Biosand
Filters
-Viruses



Previous
Experiments
and
Motivation



MS2 Removal
due to:
-Physical
Filter Factors
-Microbial
Communities



Implications
and Future
Work



Point-of-use treatment lowers diarrheal disease incidences



P&G
PURIFIER OF
WATER

Each Packet Treats
10 liters/2.5 Gallons
of Water

Calcium Hypochlorite...0.546%
2.17 ppm available chlorine

NET CONTENTS: 4g (0.14oz)

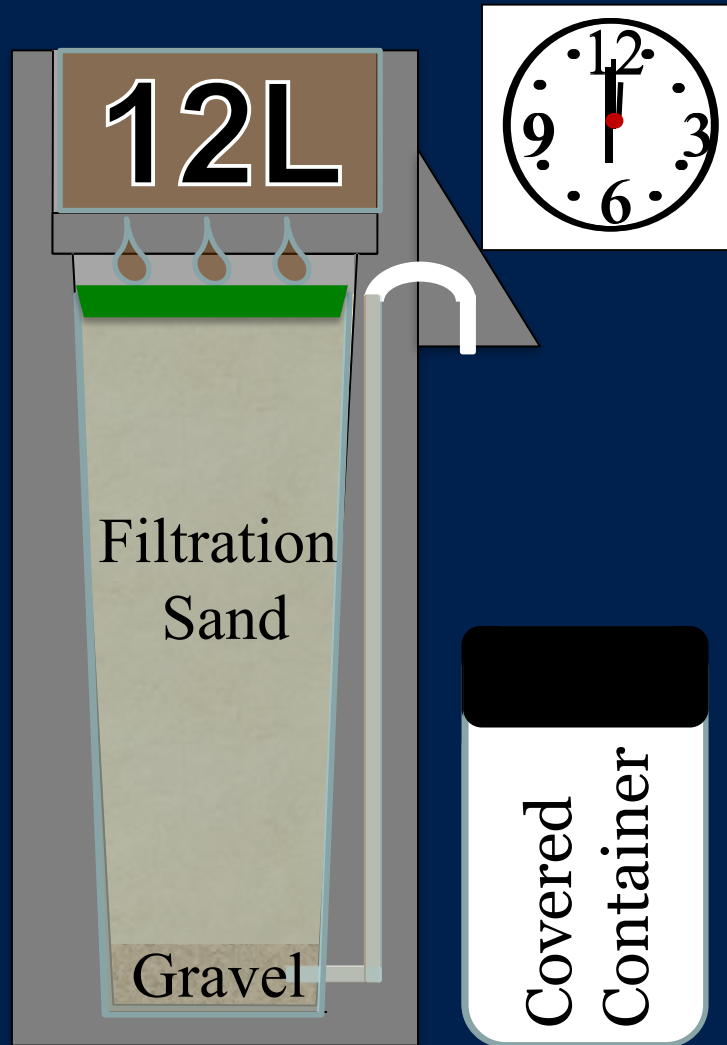


Biosand filters are most promising point-of-use technology currently available

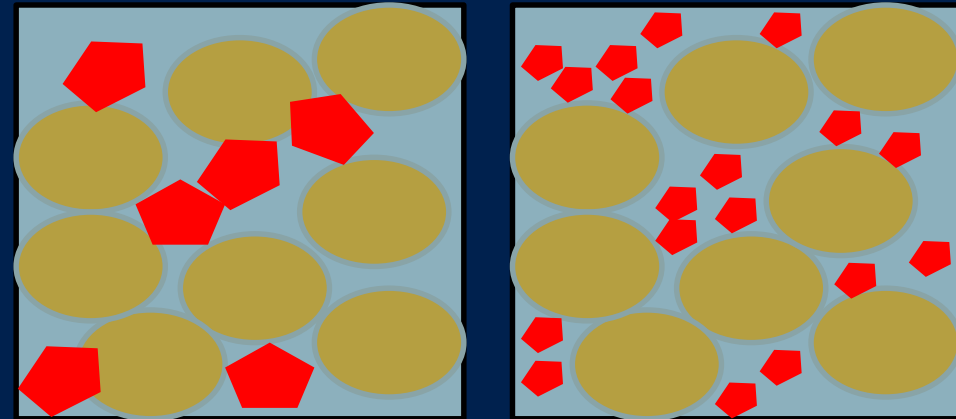
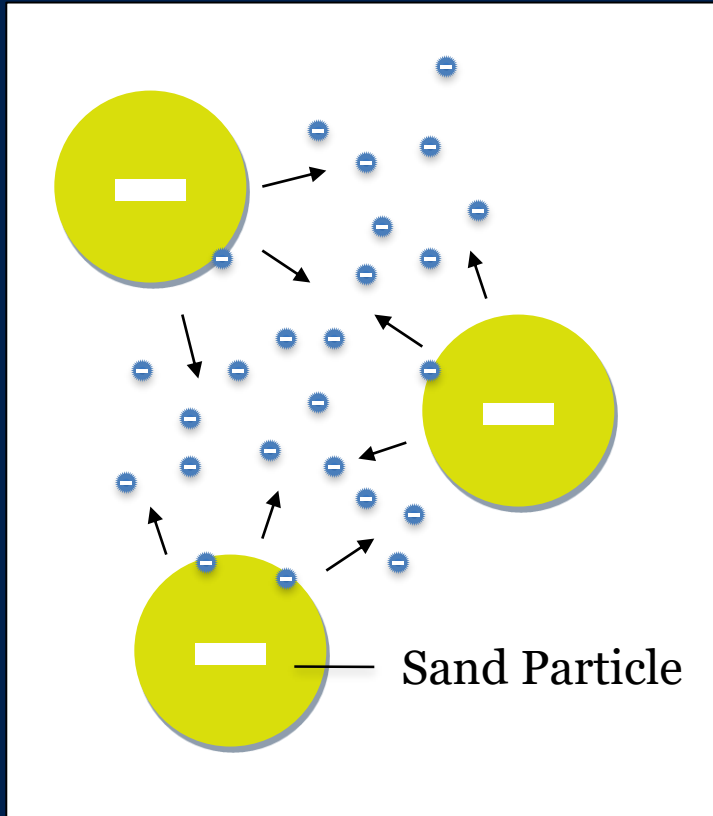


\$40 per filter for labor, materials, and transportation





Viruses are Hard to Remove



Viruses are 100x
smaller than bacteria

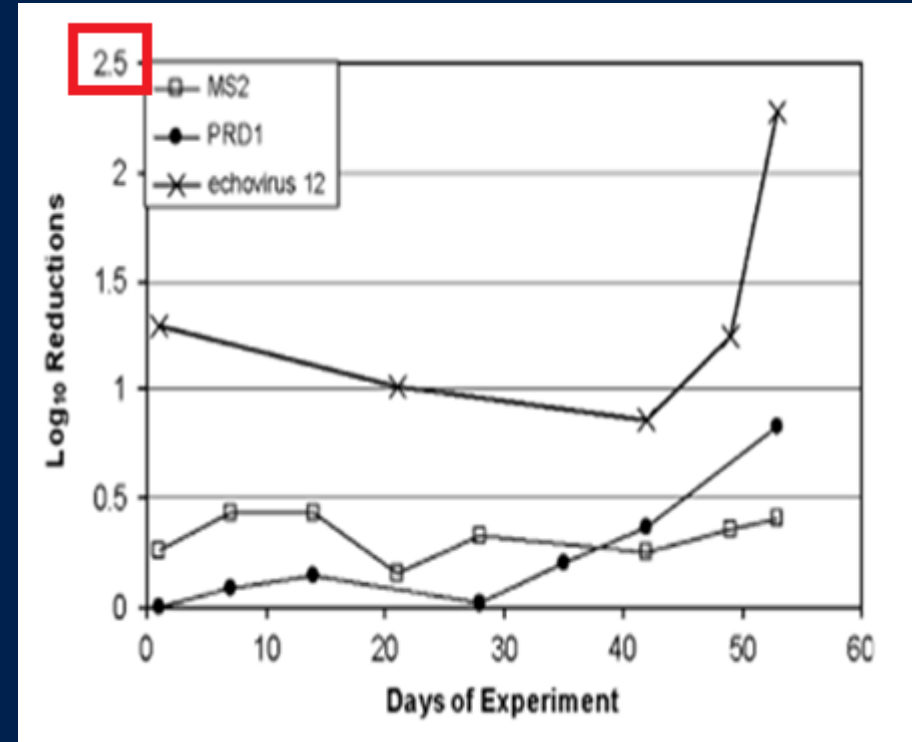
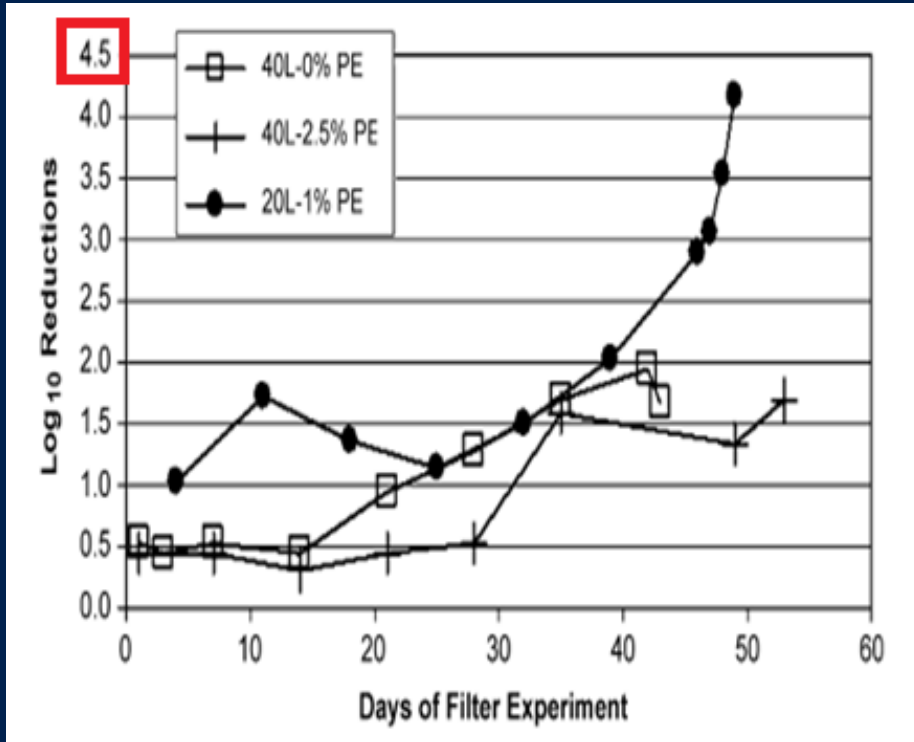
Viruses and sand are
negatively charged in
environmental conditions



Bacteria vs Virus Removal

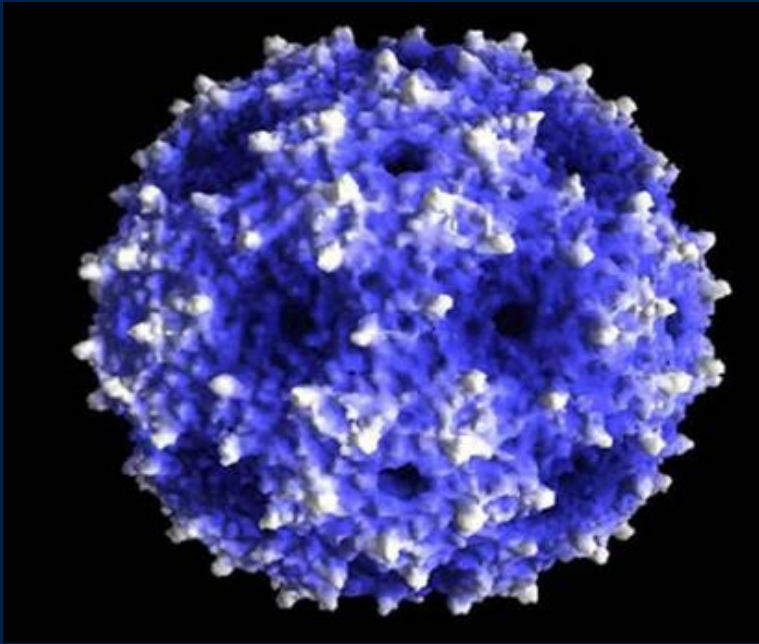
E. coli

Three different viruses



Bacteria can reach higher removal than viruses

Why Study MS2 Removal



Good surrogate for human enteric viruses

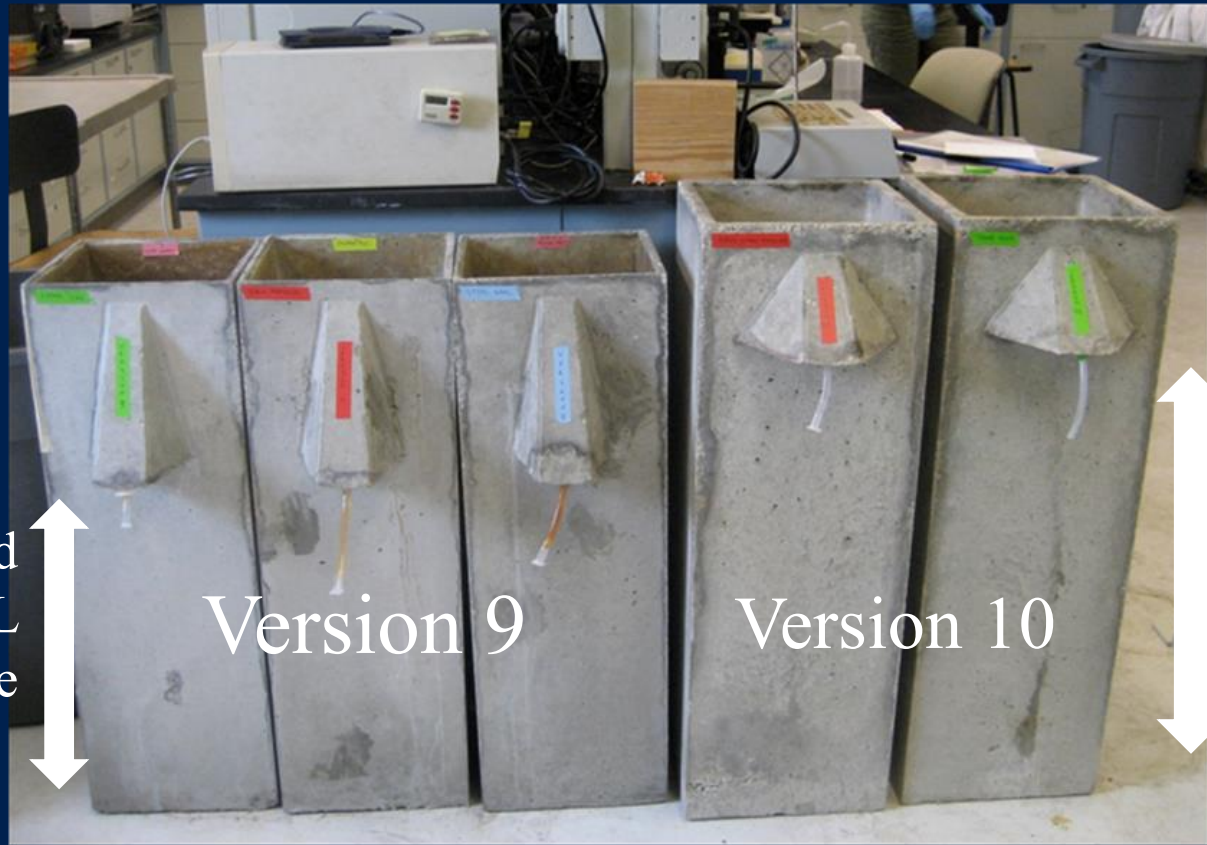
- Similar size
- Similar morphology

Easy to work with

- Propagation and quantification methods are well developed



Previous Experiments and Motivation



45 cm sand height and 20 L charge volume



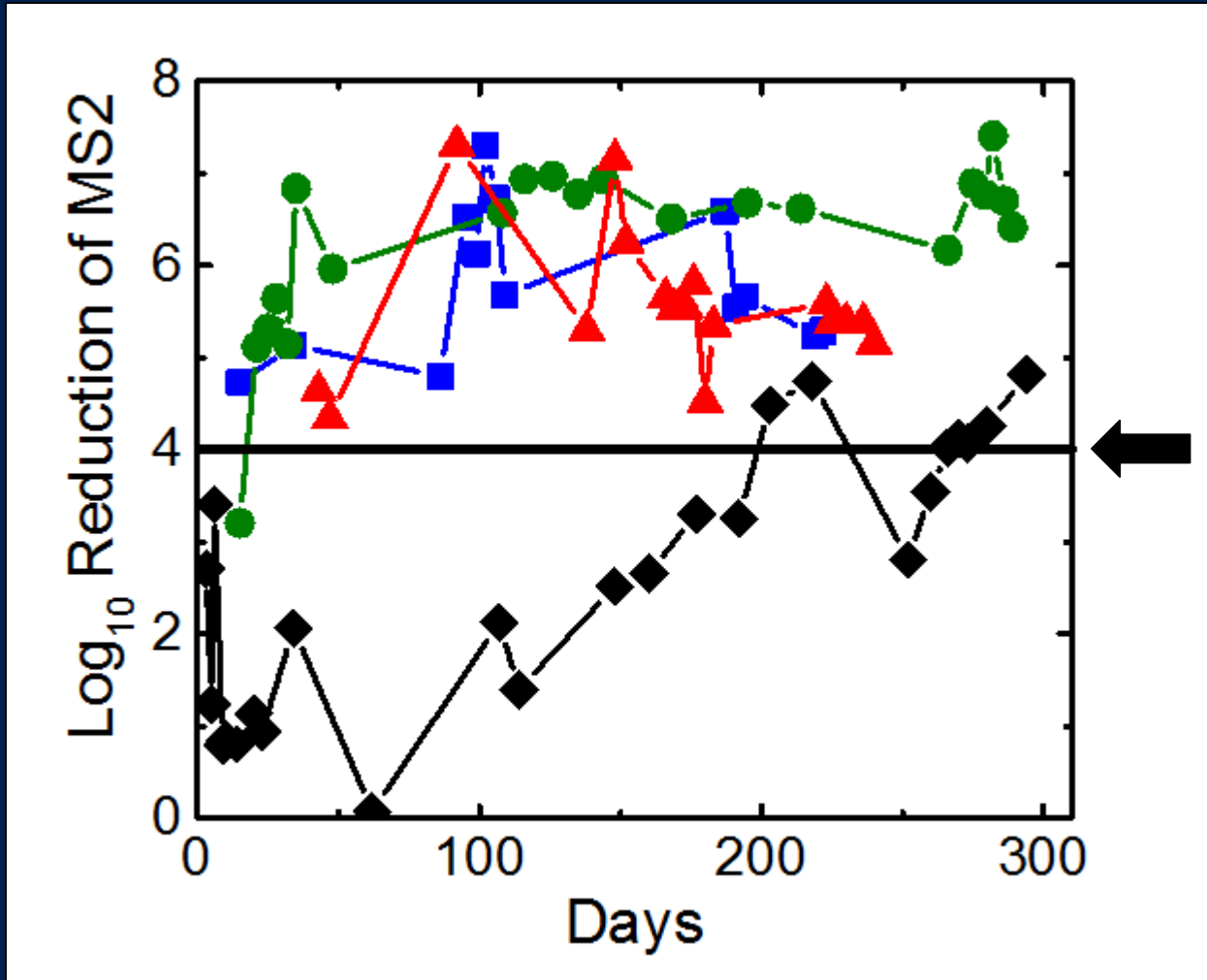
Version 9

Version 10

55 cm sand height and 12 L charge volume



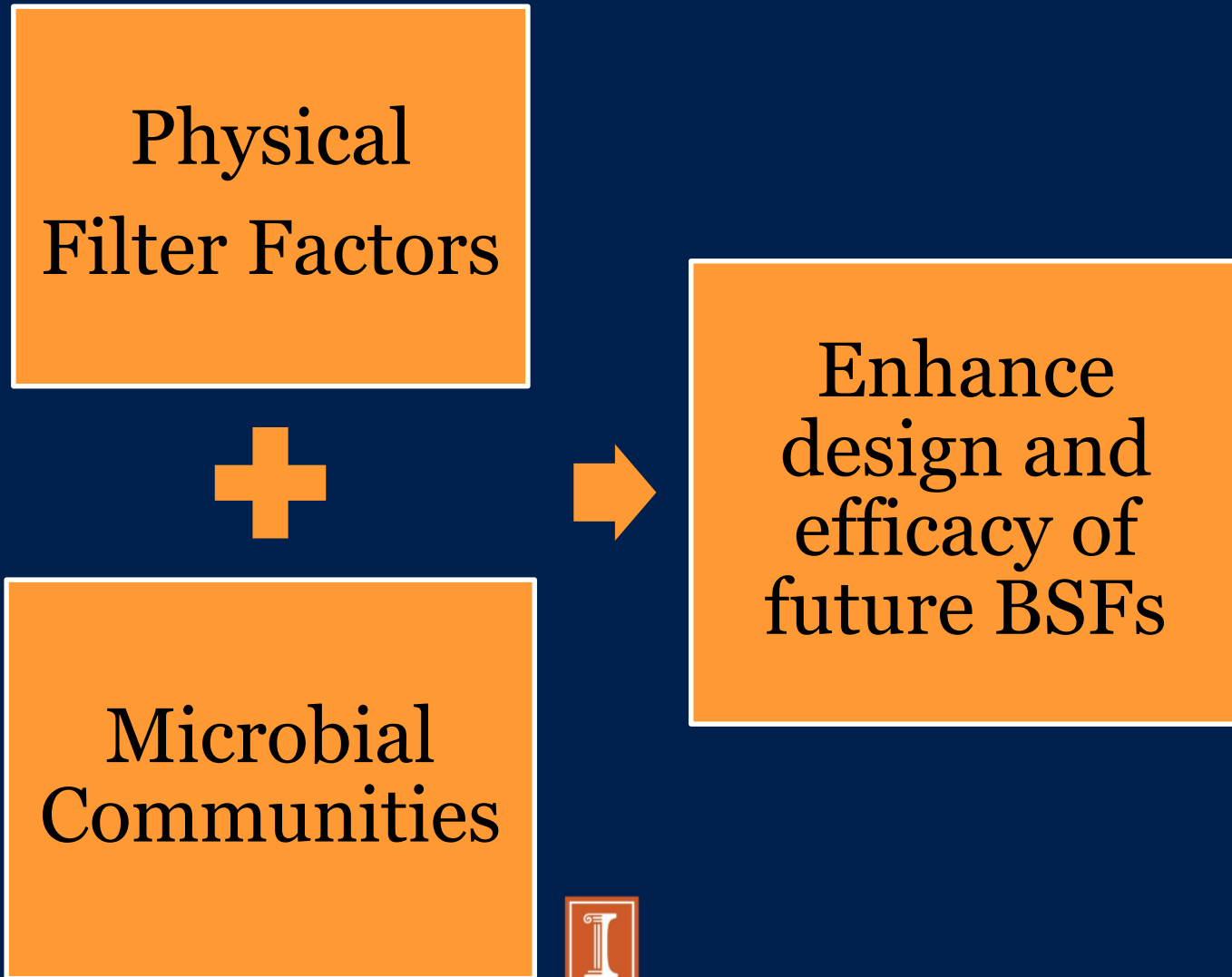
Previous Experiments and Motivation



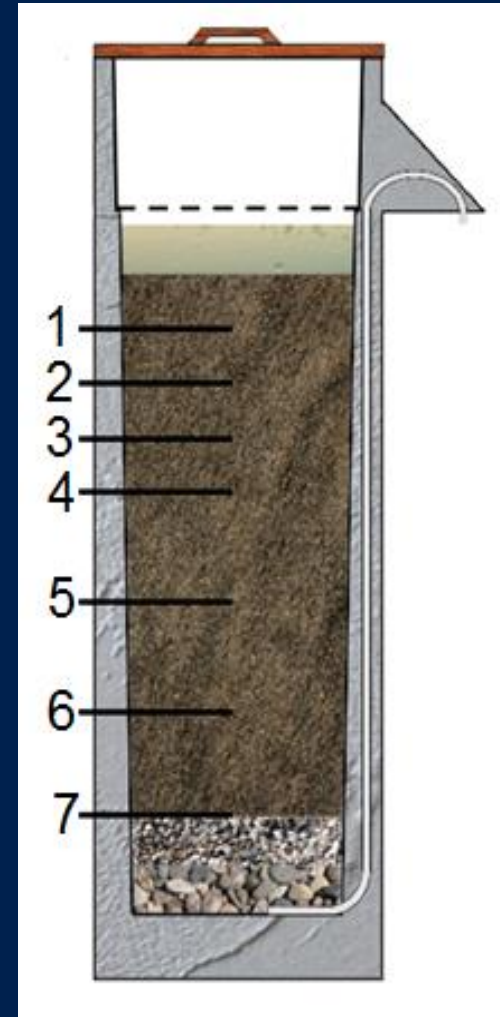
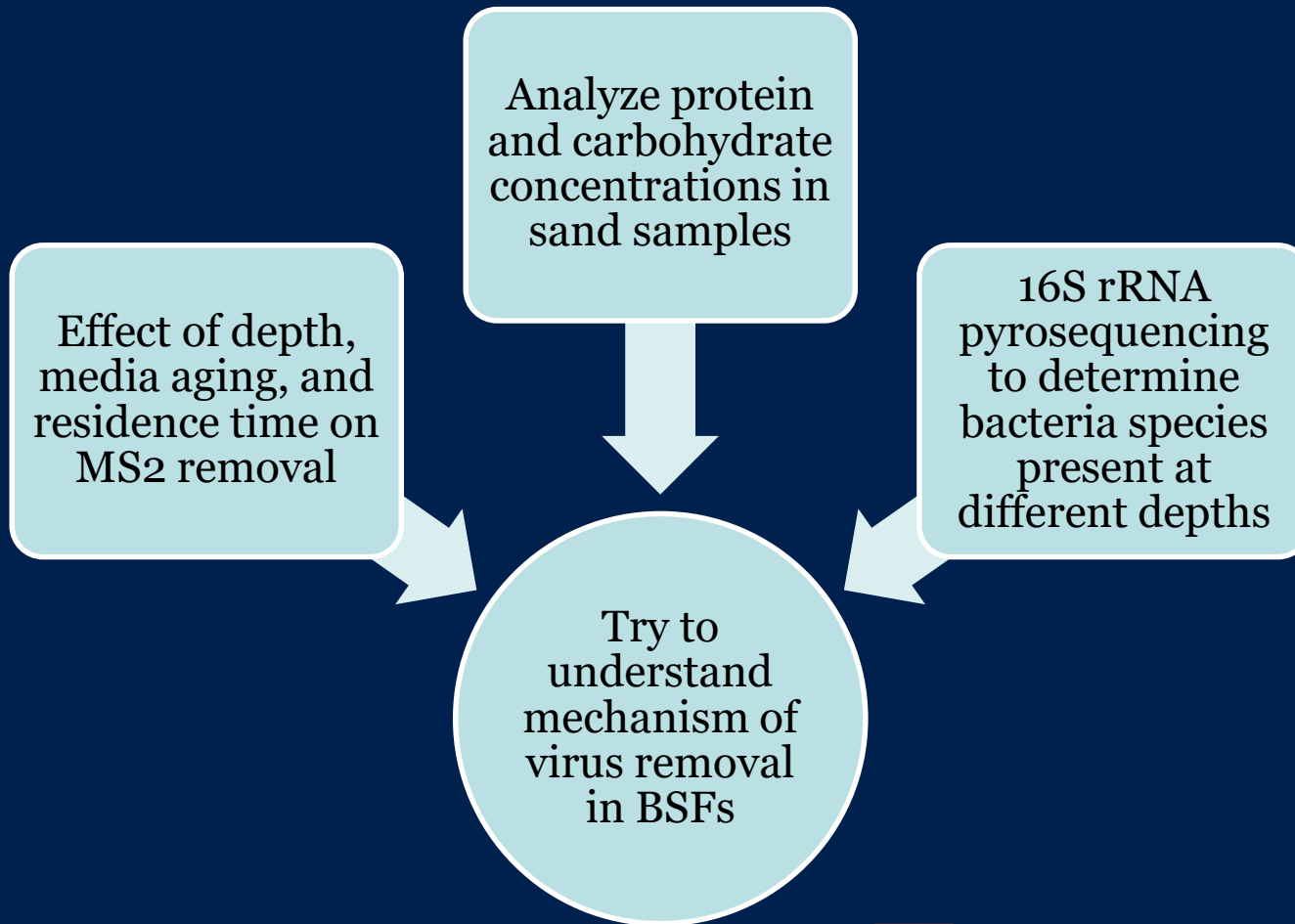
EPA Standard for
Virus Reduction:
99.99%



Objectives of Study

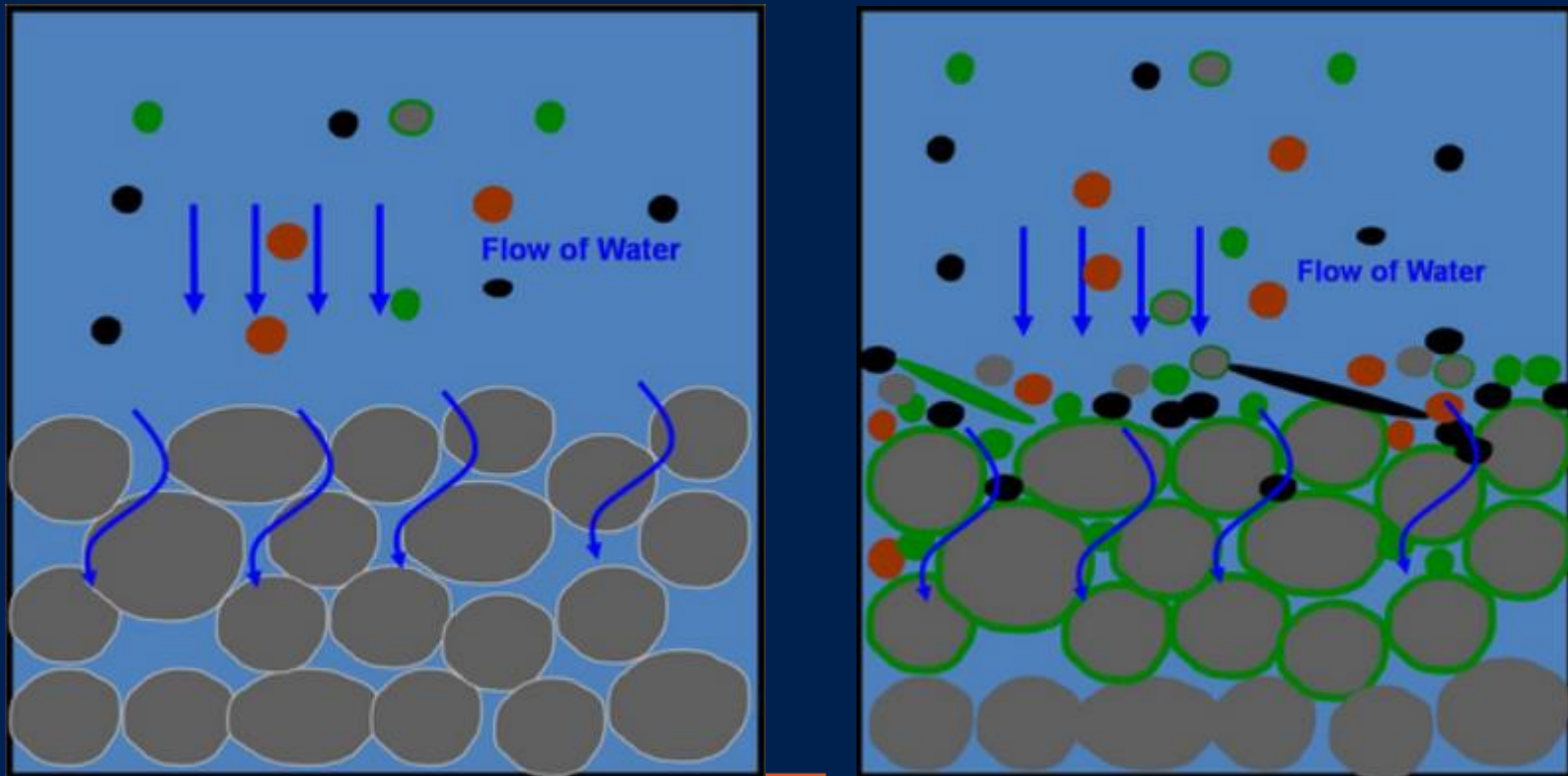


Port Filter Experiments



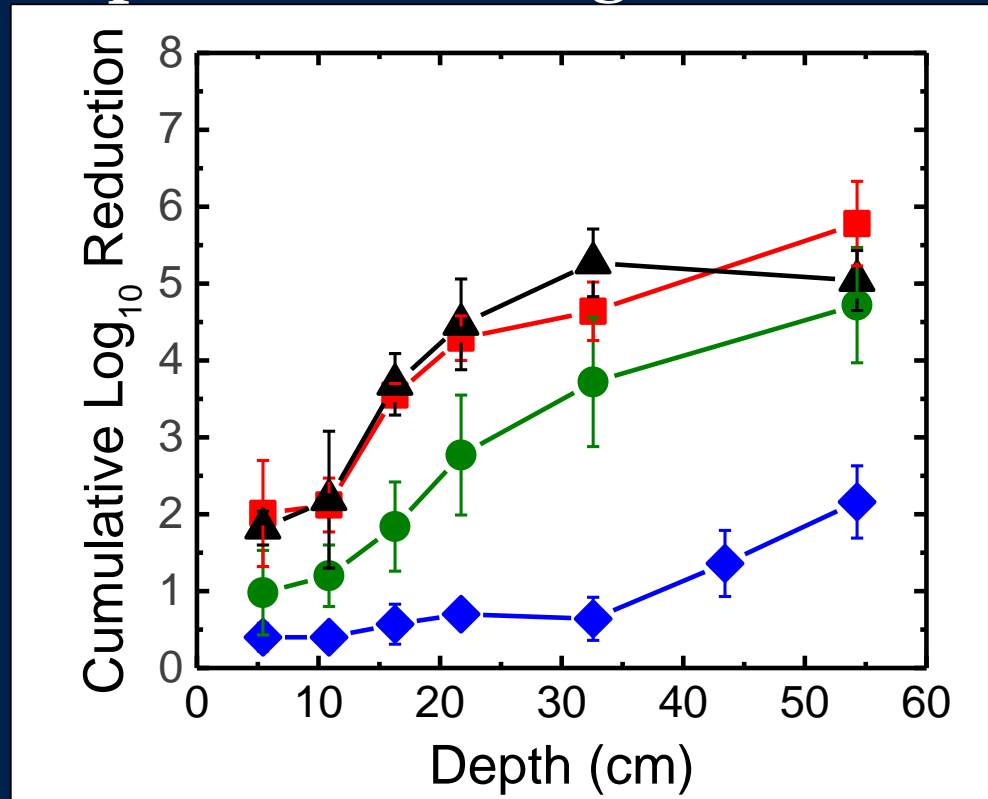
Two Types of Ripening

1. Biofilms can develop around individual sand particles throughout the filter

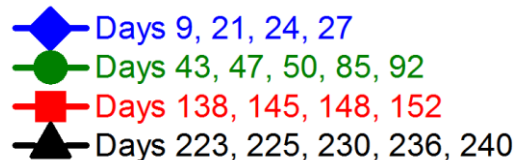


Two Types of Ripening

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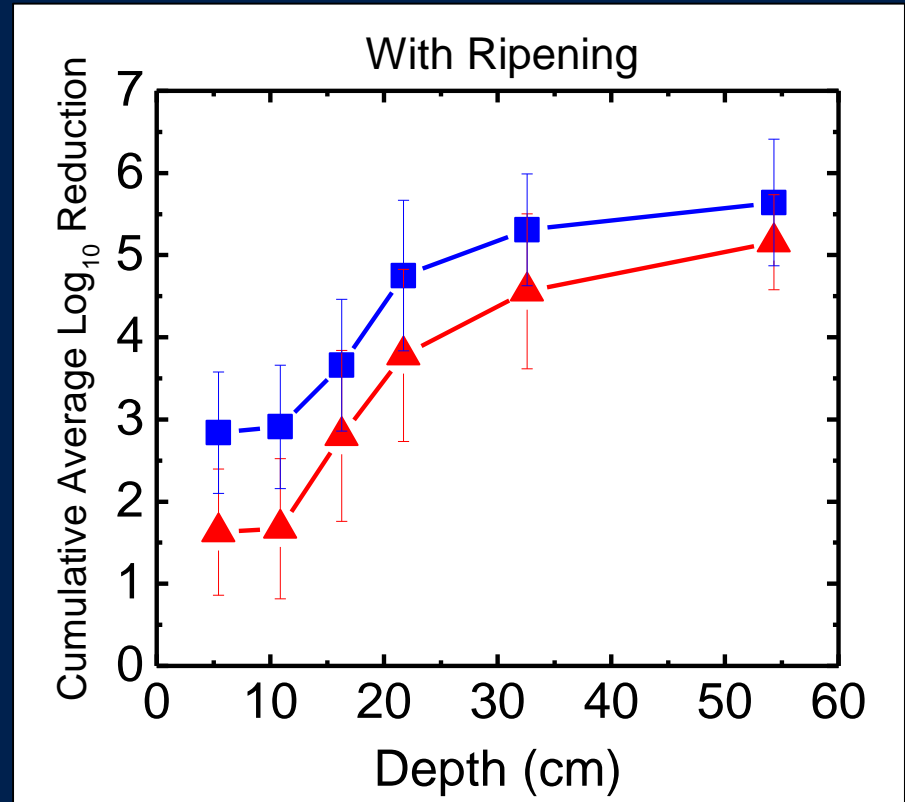
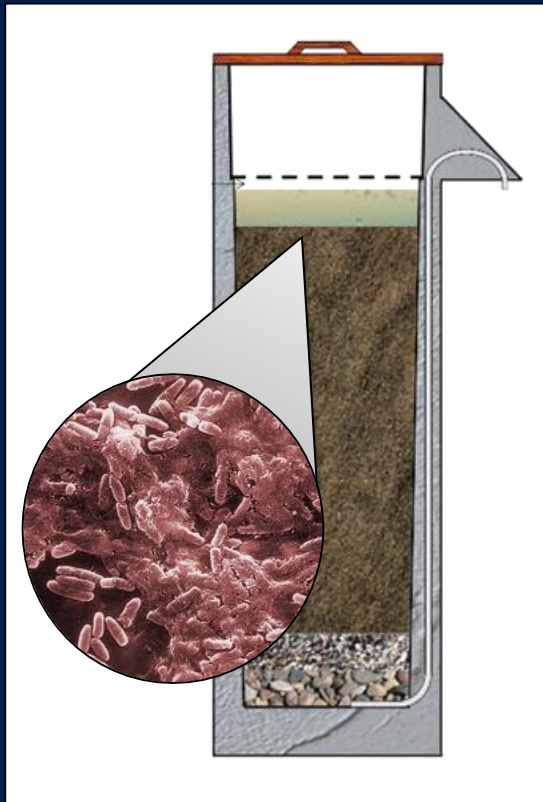


Short Residence Time:
 ~10 minutes for Days 9-27
 ~45 minutes for Days 43-240

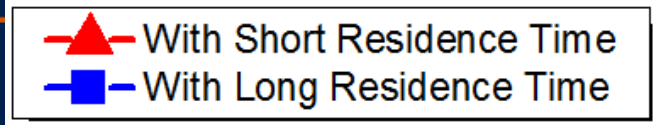


Two Types of Ripening

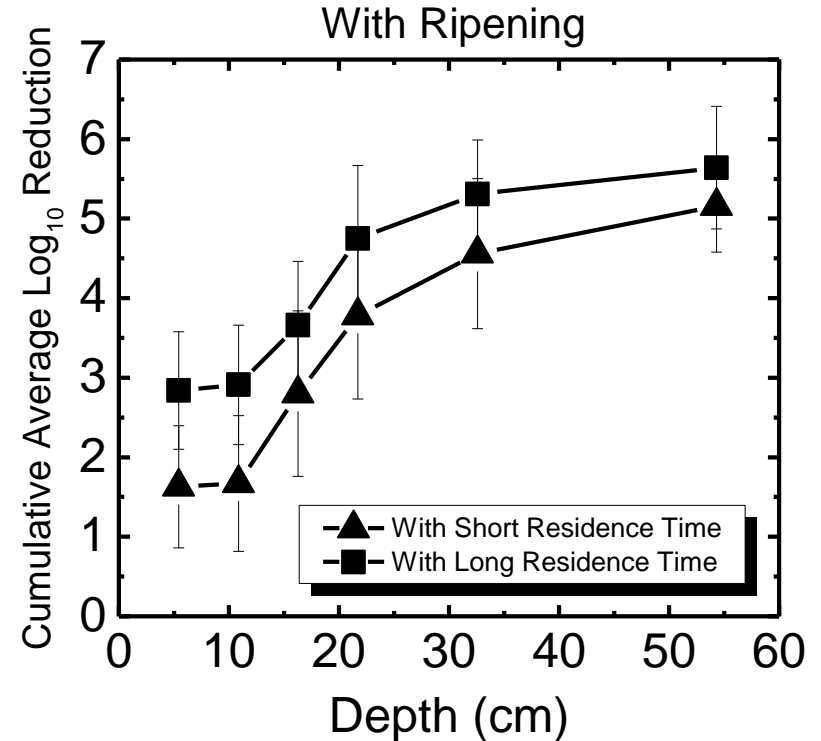
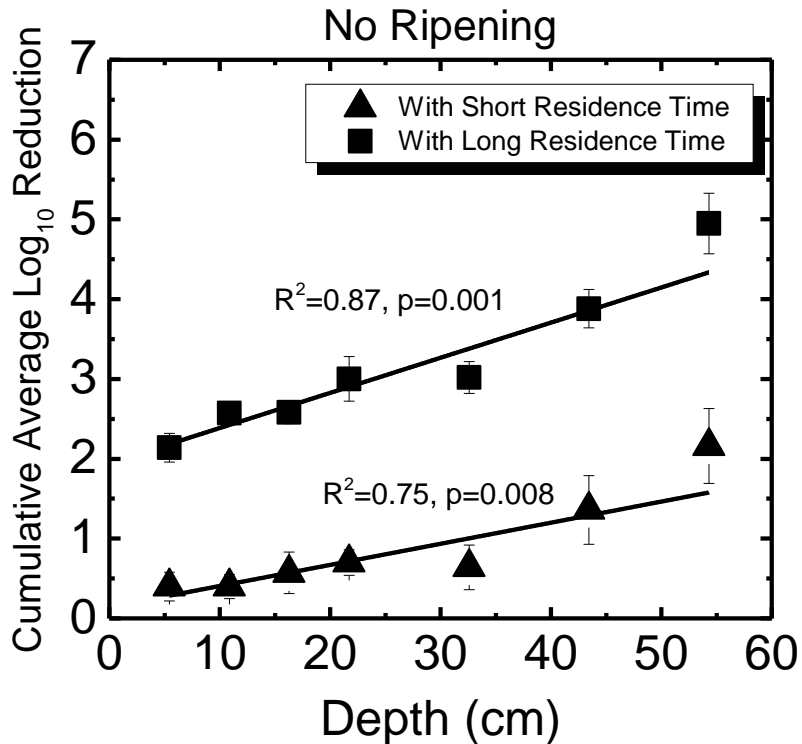
2. Biomass accumulate densely in the biolayer due to extensive biofilm growth and the lack of backwash



Short Residence Time: ~45 minutes
 Long Residence Time: 24 ± 8.5 hours



Physical characteristics (depth and residence time) are critical factors for unripened filters



Short Residence Time:
 ~10 minutes for No Ripening
 ~45 minutes for With Ripening



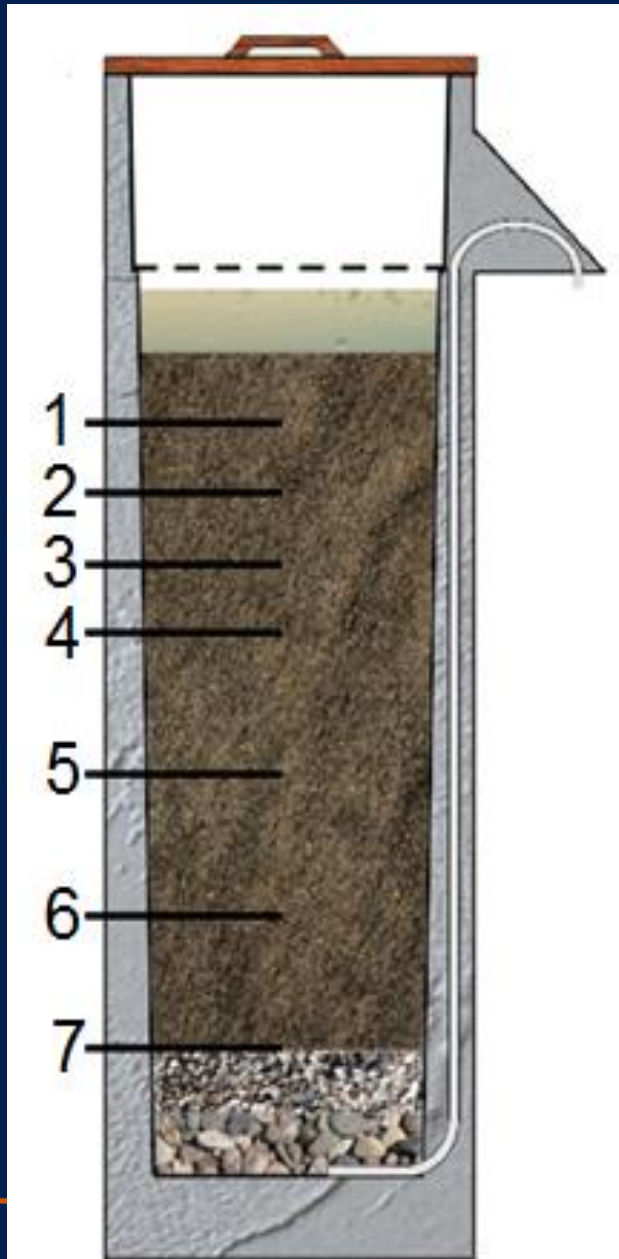
No Ripening: Days 9-27
 Ripening: Days 9-240

Average
[Protein]
(mg/L)

60 ± 10

58 ± 8

$p=0.59$



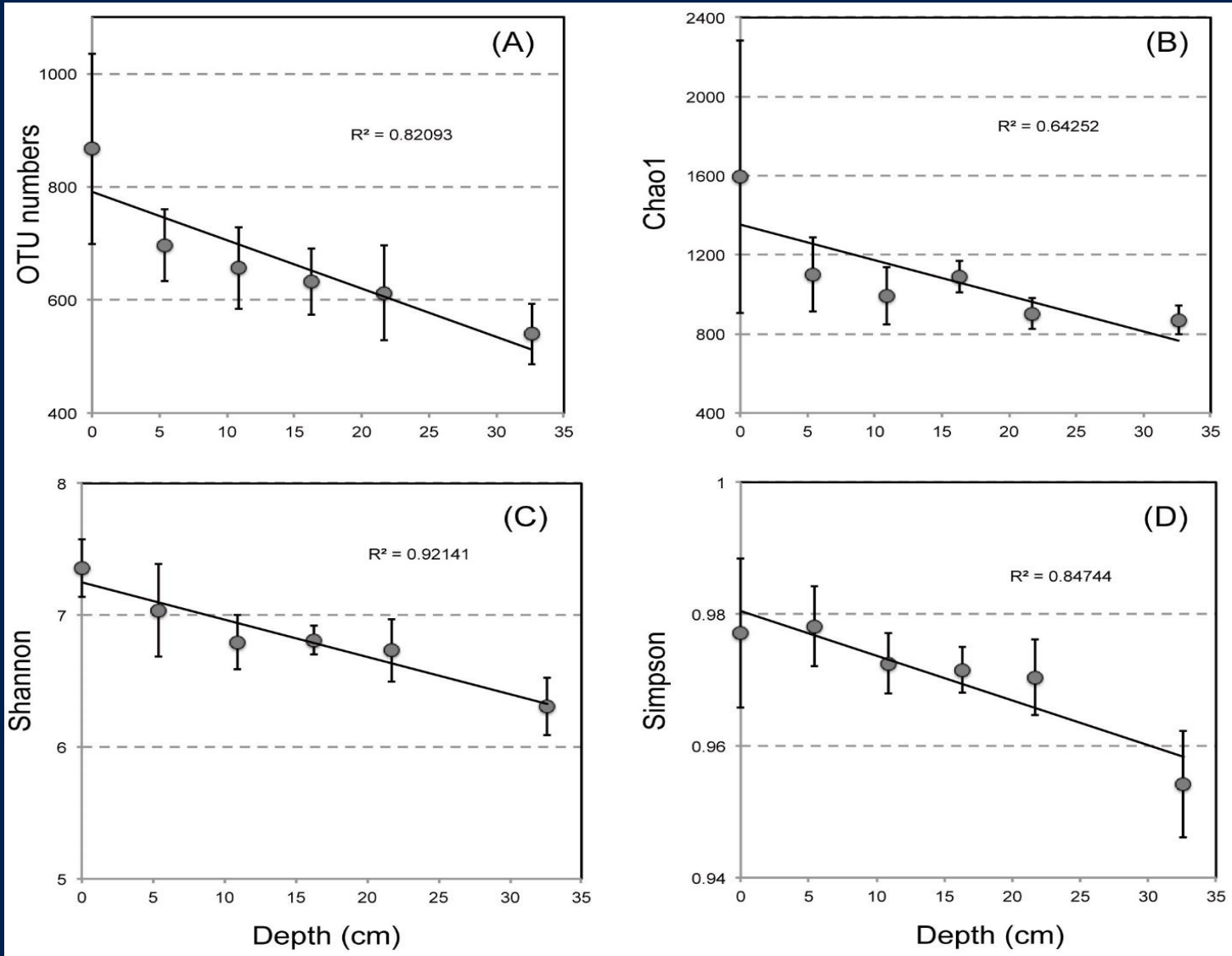
Average
[Carbohydrate]
(mg/L)

$6.7 \times 10^3 \pm 1.2 \times 10^3$

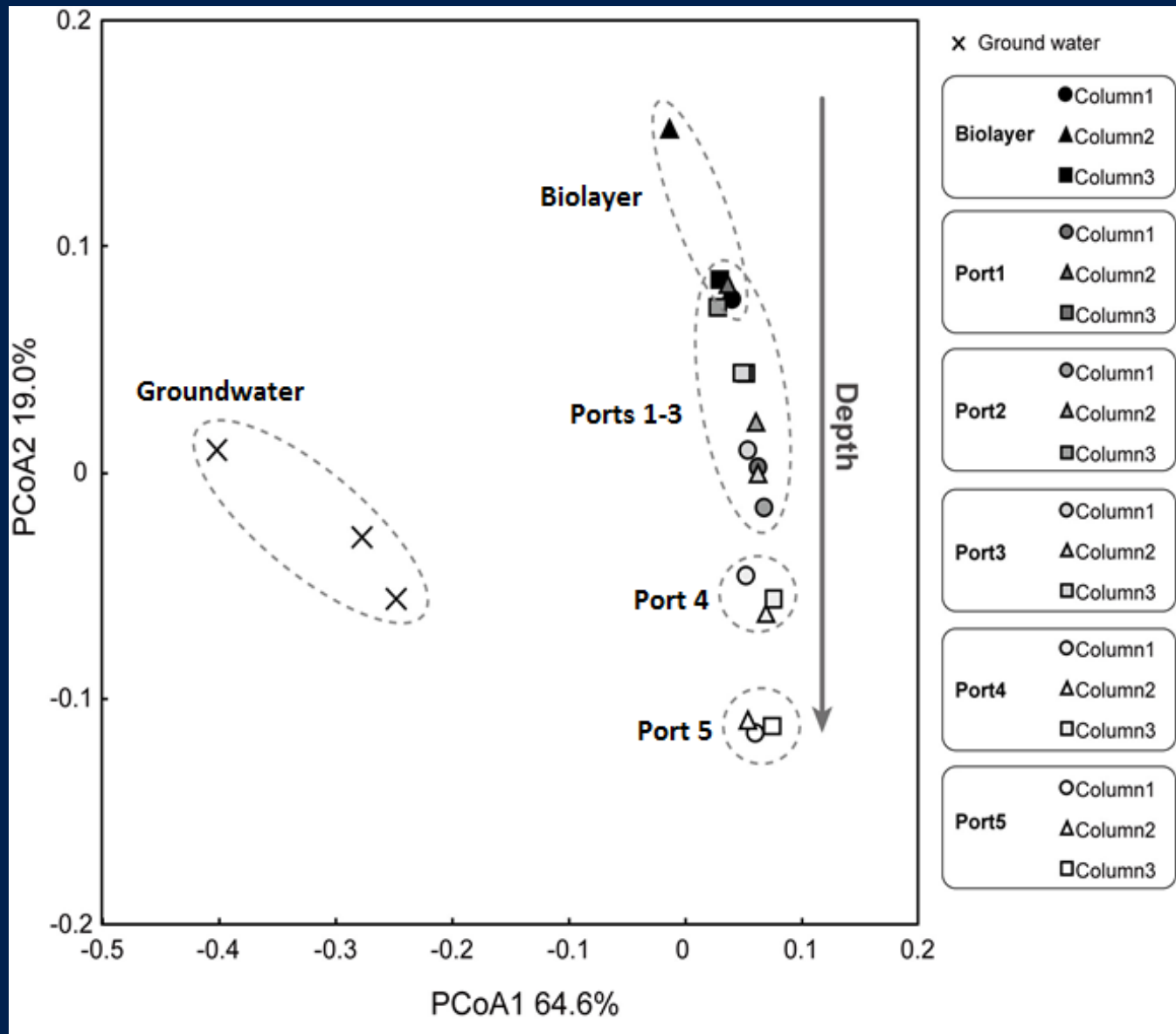
$5.2 \times 10^3 \pm 1.9 \times 10^3$

$p=0.01$



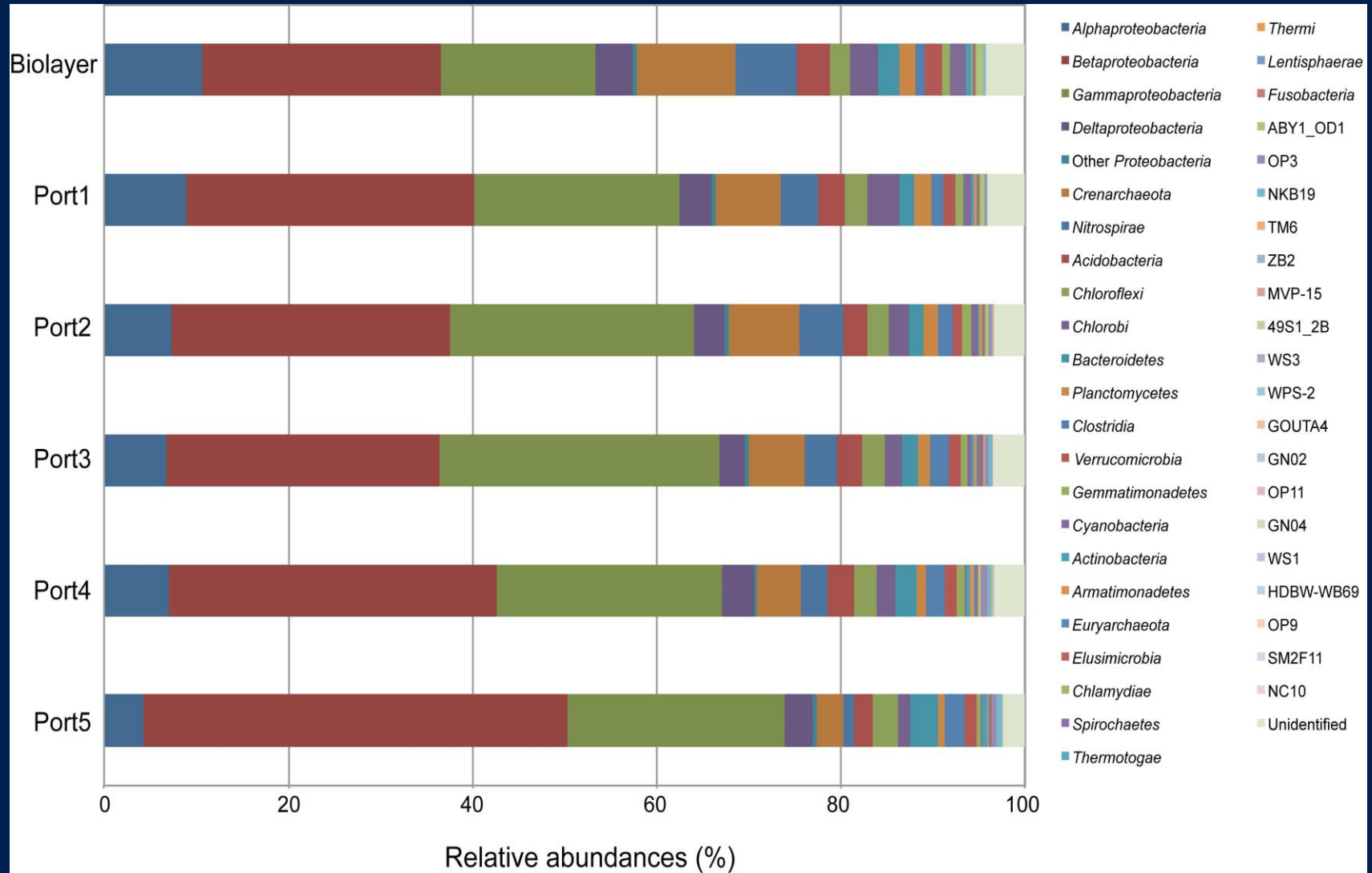


Microbial Diversity Decreases with Depth



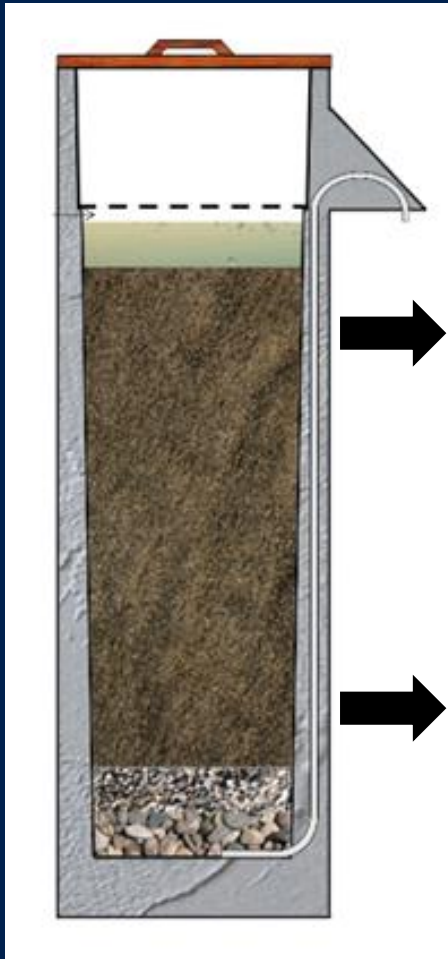
Microbial Community Structures Shift with Depth

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Classes *Betaproteobacteria* and *Gammaproteobacteria* dominated BSF

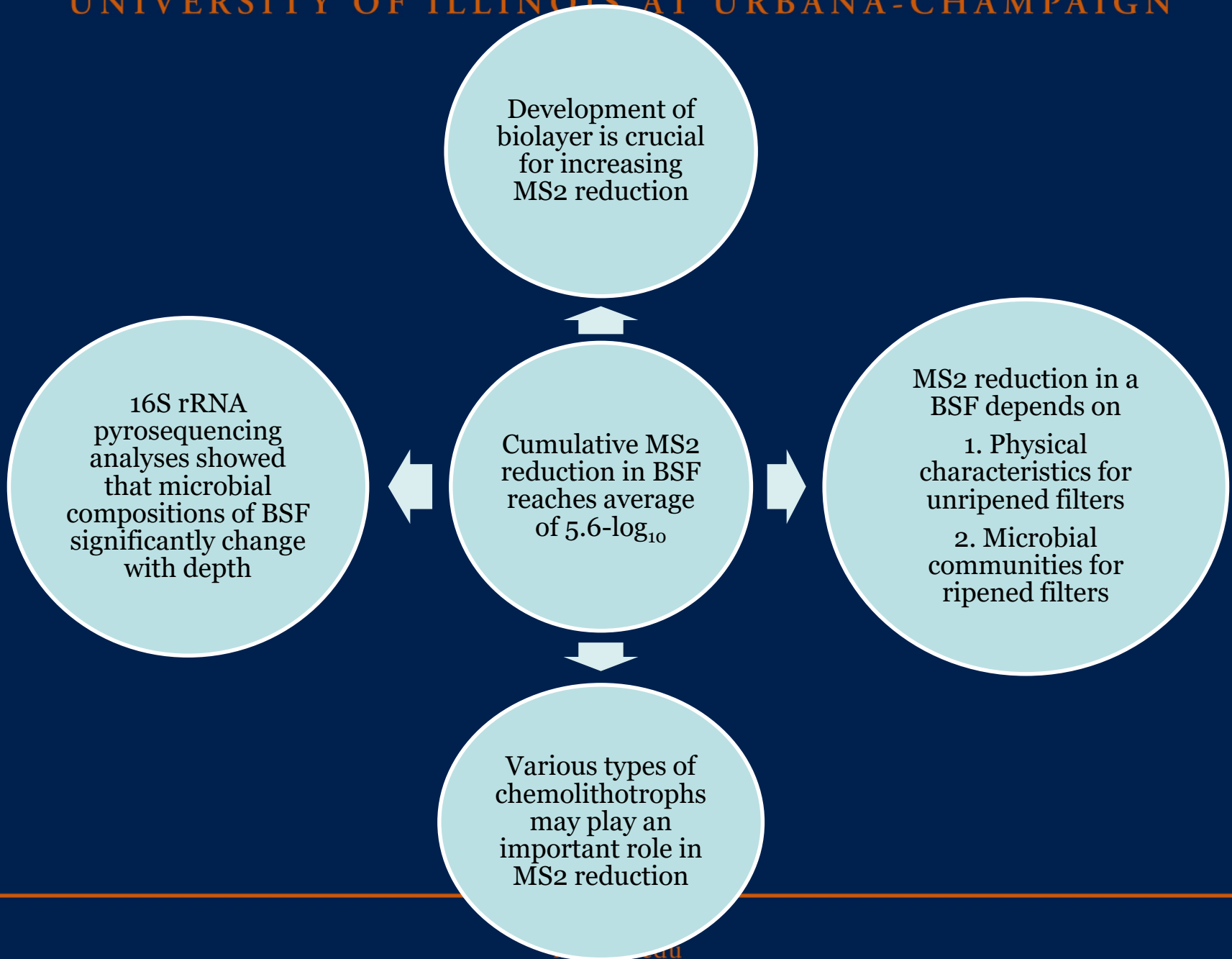
Microbial Compositions throughout Depth



“*Ca. Nitrosopumilus*” (AOA) and *Nitrospira* (NOB): nitrogen-cycling microbes

Genus *Thiobacillus*: sulfur-cycling microbes

Chemolithotrophs found throughout filter but function on MS2 reduction still unclear





Swirl and dump
method used for
maintenance

Disrupts biolayer

Enhance biofilm
development
throughout the filter

When maintenance is
needed, removal
efficacy is not
compromised

Acknowledgements

- USEPA P3 Phase I Grant (835515)
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- Centre for Affordable Water and Sanitation Technology (CAWST)



Questions?

- Thank you for your attention!
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