

The who, where, and (somewhat) why of the drinking water microbiome.

Ameet J. Pinto

@watermicrobe

Nov 4th , 2018



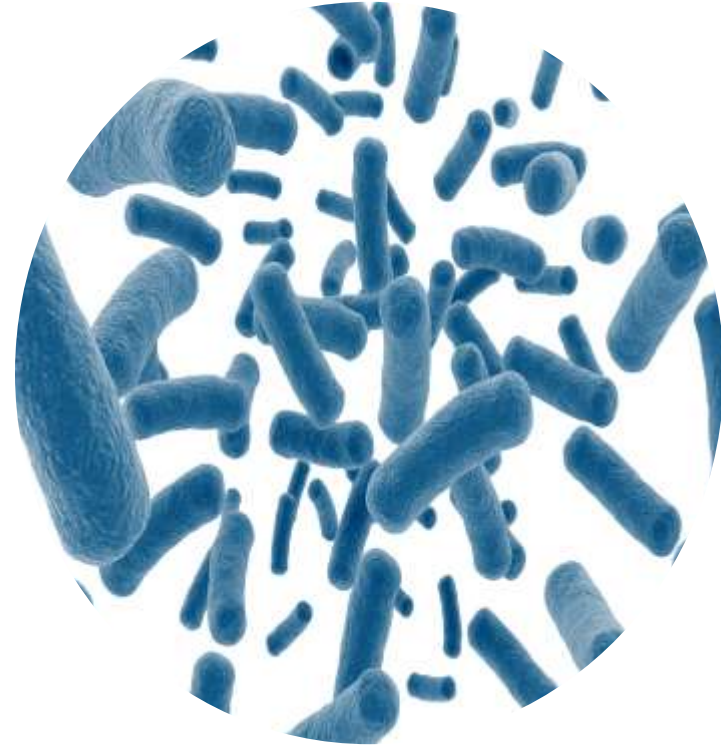
Northeastern University

What is a “microbiome”?

Microbiome may be defined as a **characteristic microbial community** occupying a reasonably **well defined habitat** which has **distinct physio-chemical properties**.

The term thus not only refers to the microorganisms involved but also **encompasses their theatre of activity**.

- JM Whipps, K Lewis, RC Cooke
(1988)

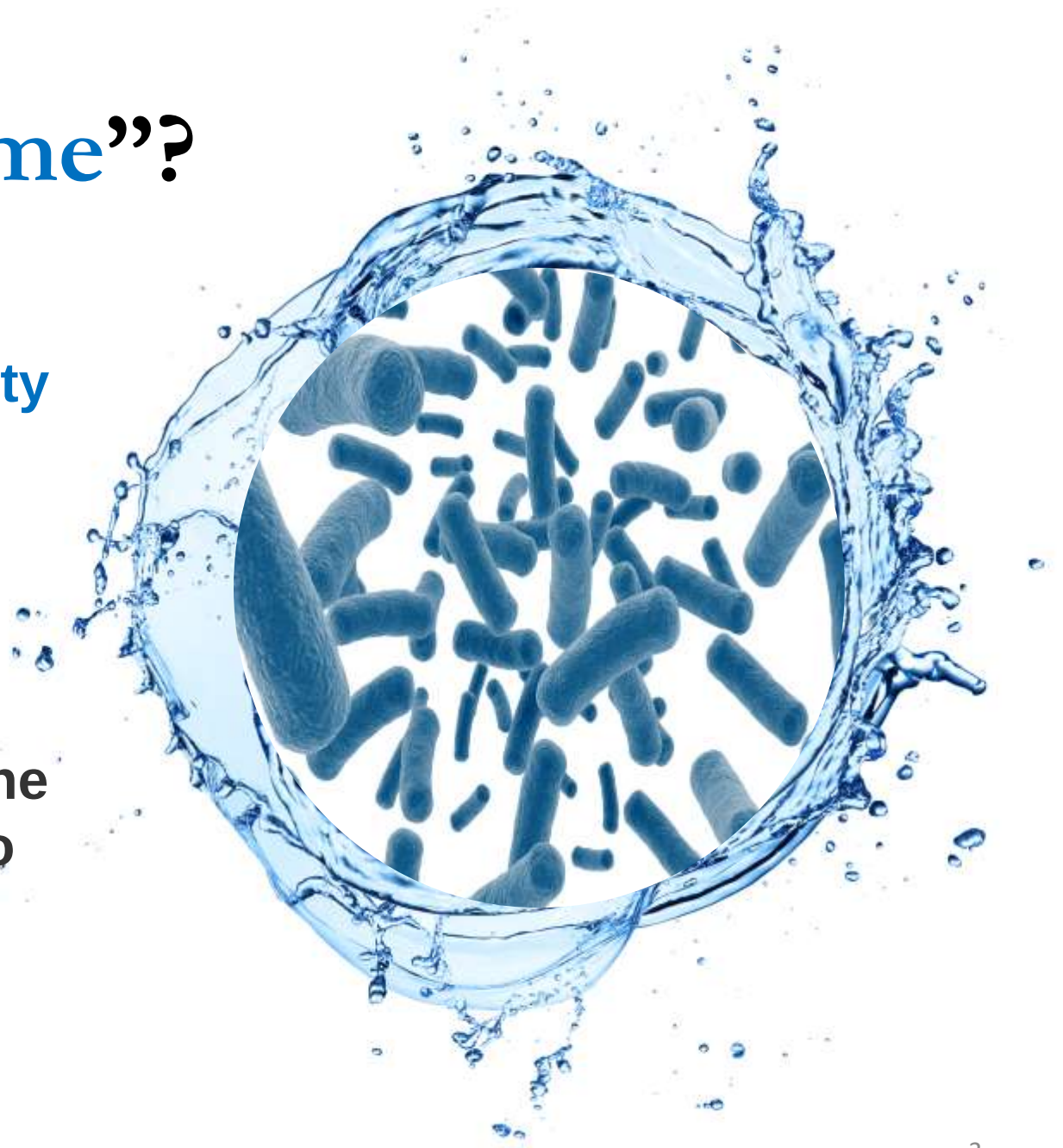


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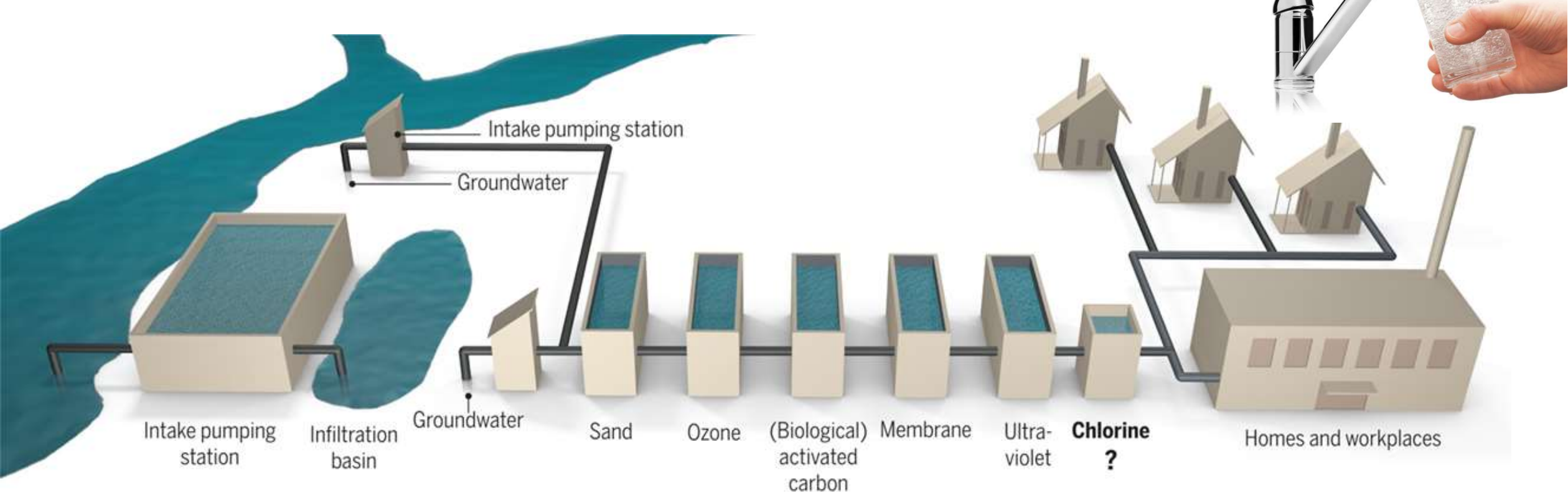
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The drinking water habitat extends
beyond the tap.



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Protection of water resources

- Active watershed management
- Riverbank filtration
- Artificial recharge
- Groundwater

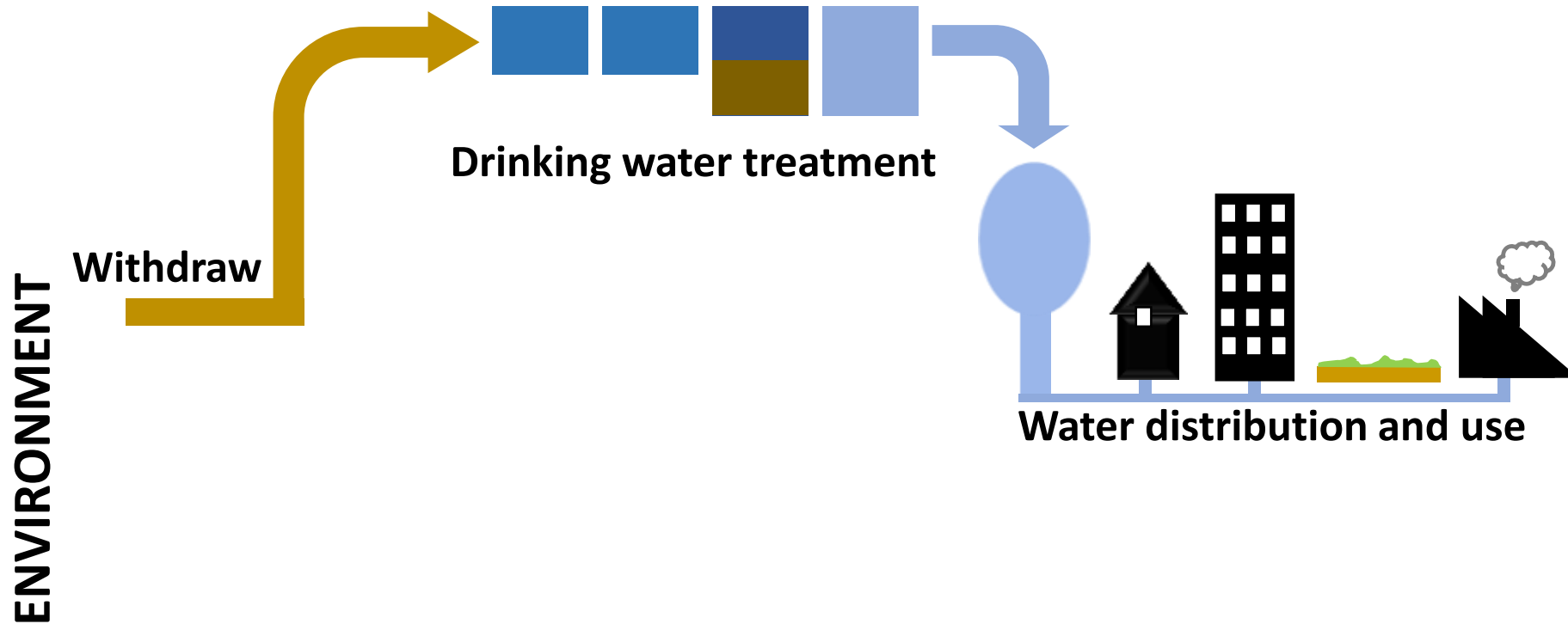
Water treatment

Multibarrier treatment (ozone, ultraviolet light, advanced oxidation processes, biological filtration, membranes, chlorine)

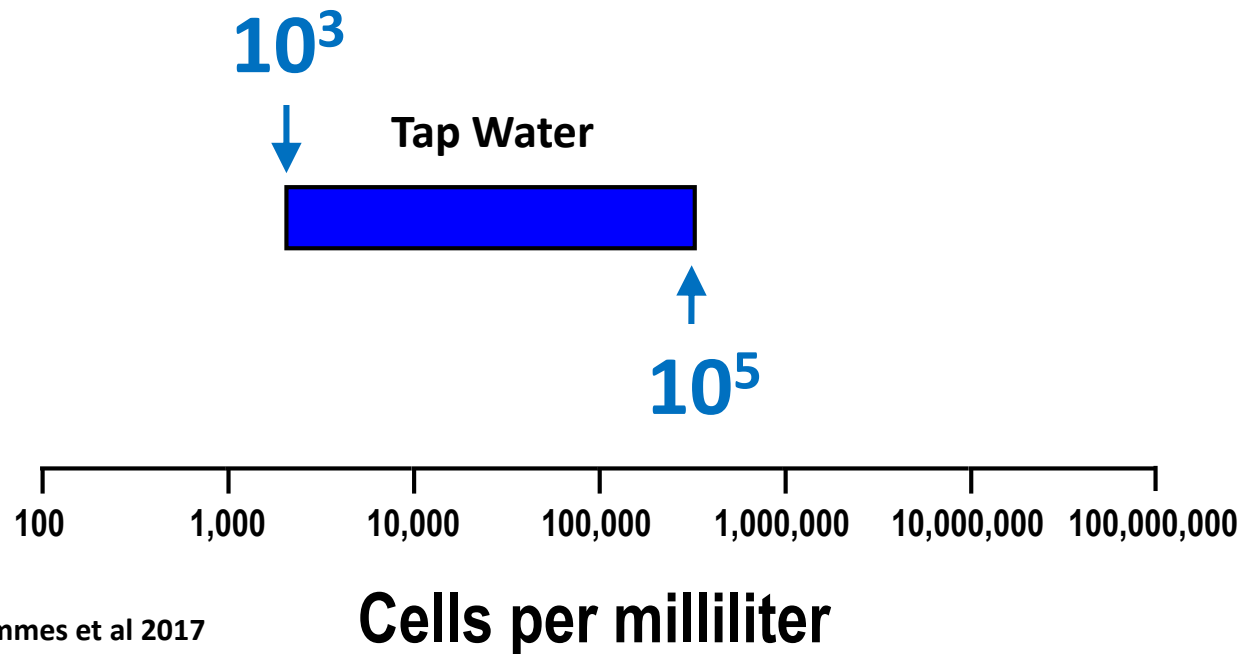
Distribution system

- Maintain and replace infrastructure
- Water-quality monitoring
- Hydraulic integrity

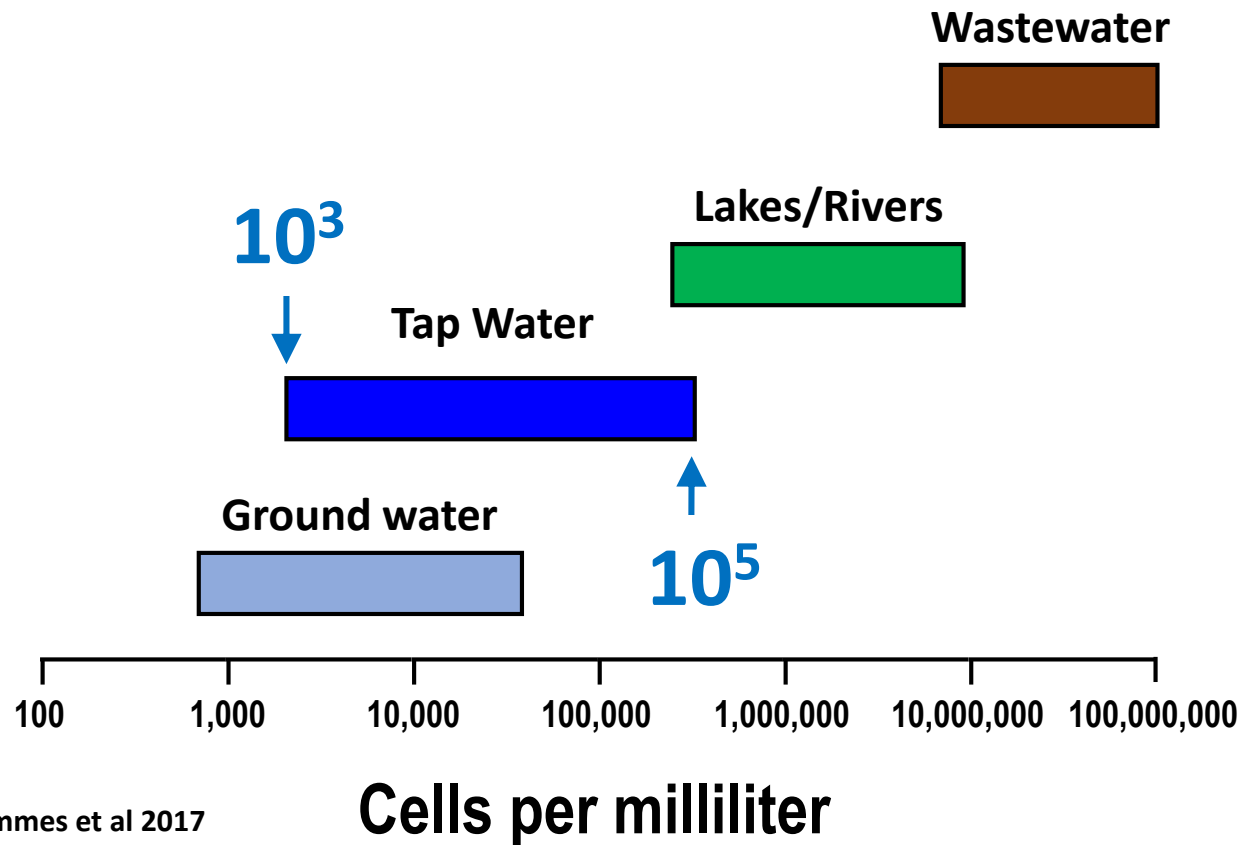
There is a **daily mass migration** from source waters through treatment plants and pipes into the built environment.



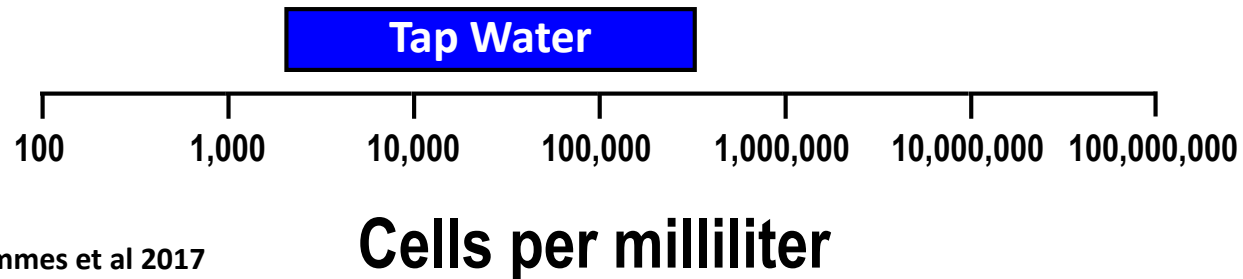
The Drinking Water Microbiome is abundant



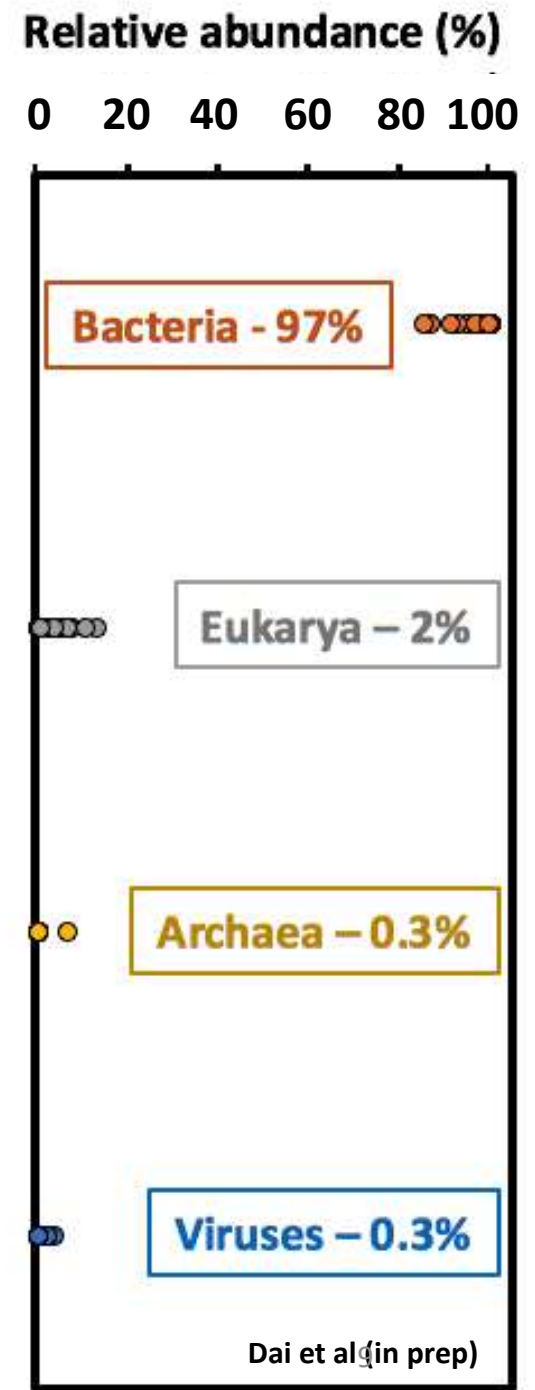
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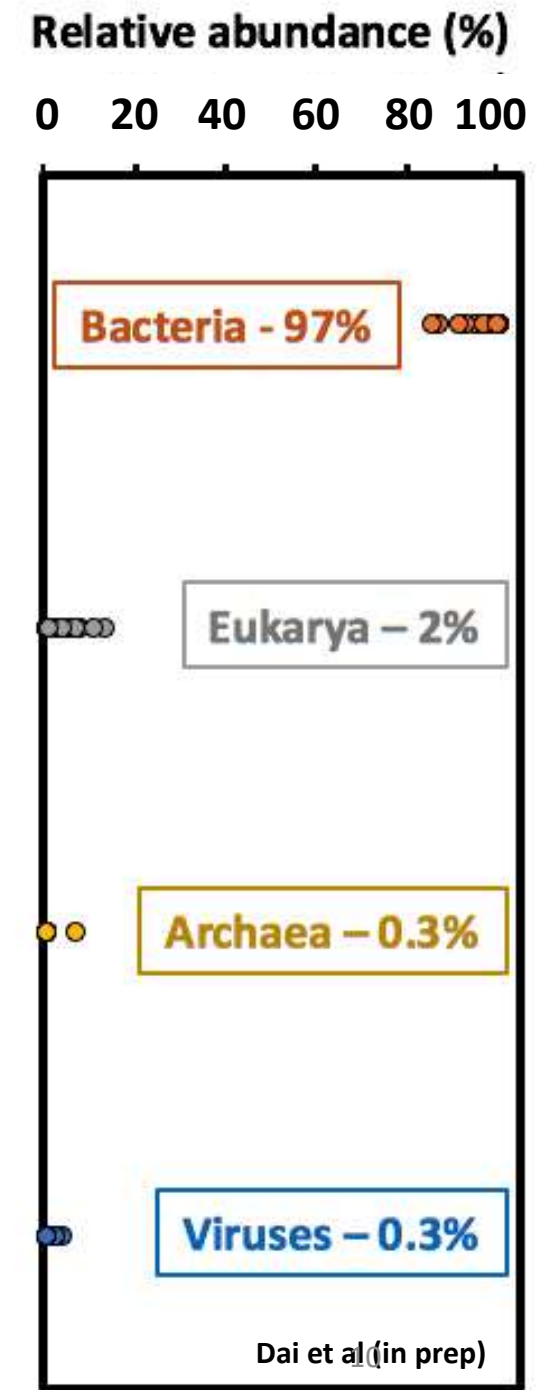
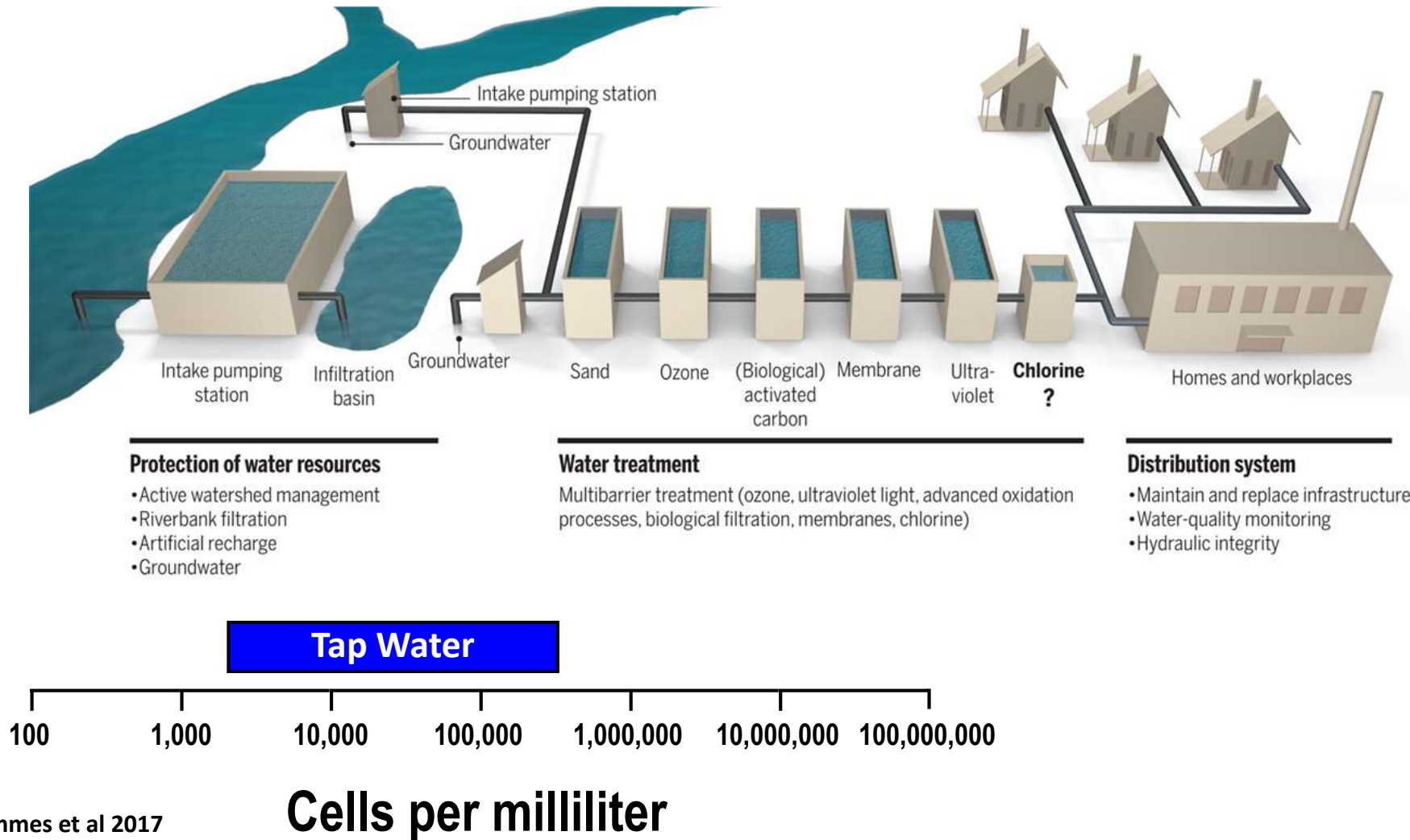
The Drinking Water Microbiome is abundant, diverse



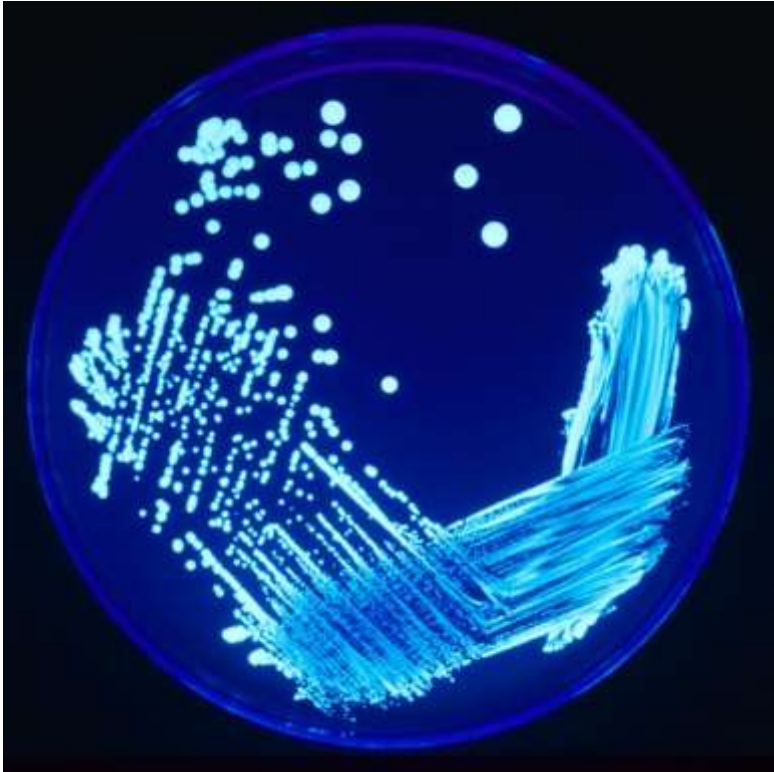
Hammes et al 2017



The Drinking Water Microbiome is abundant, diverse, and complex.



The drinking water microbiome can mediate a range of impacts – from **health to infrastructure**.



Disease



**Infrastructure
Damage**

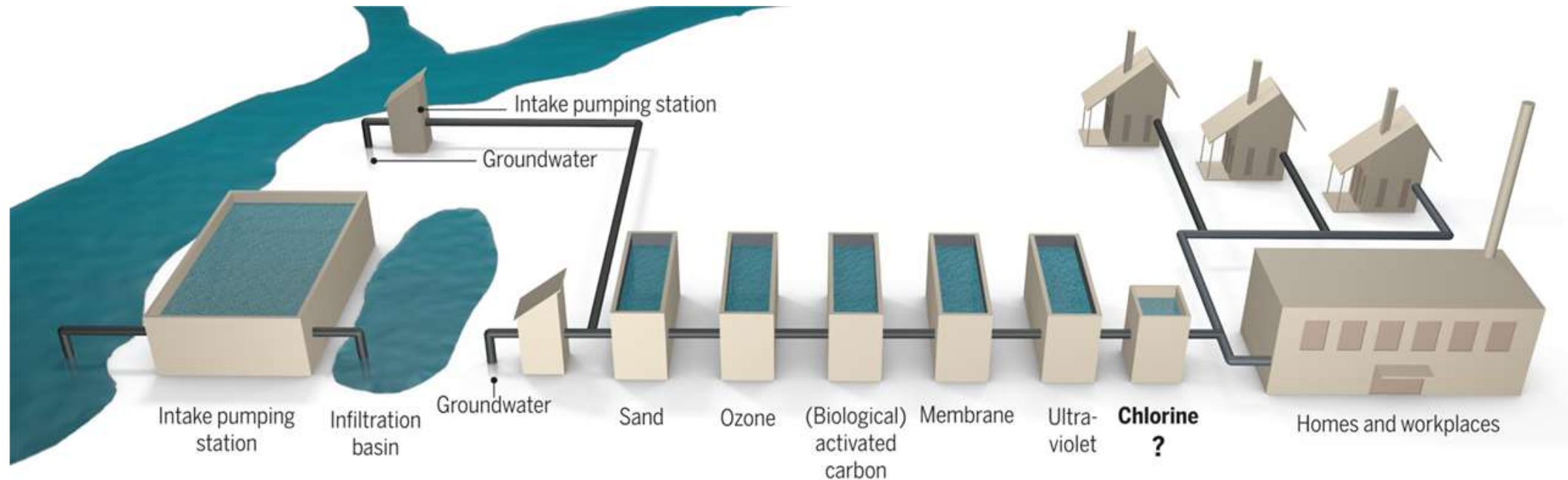


**Aesthetic
quality**

The background of the slide is a dense field of blue, rod-shaped bacteria, likely representing pathogens. The bacteria are of various sizes and orientations, some appearing as single cells and others in small clusters. They have a textured, slightly irregular surface.

Pathogens do not exist in isolation.

Expanding from pathogens to the community as a whole to assess which factors are most influential.



Protection of water resources

- Active watershed management
- Riverbank filtration
- Artificial recharge
- Groundwater

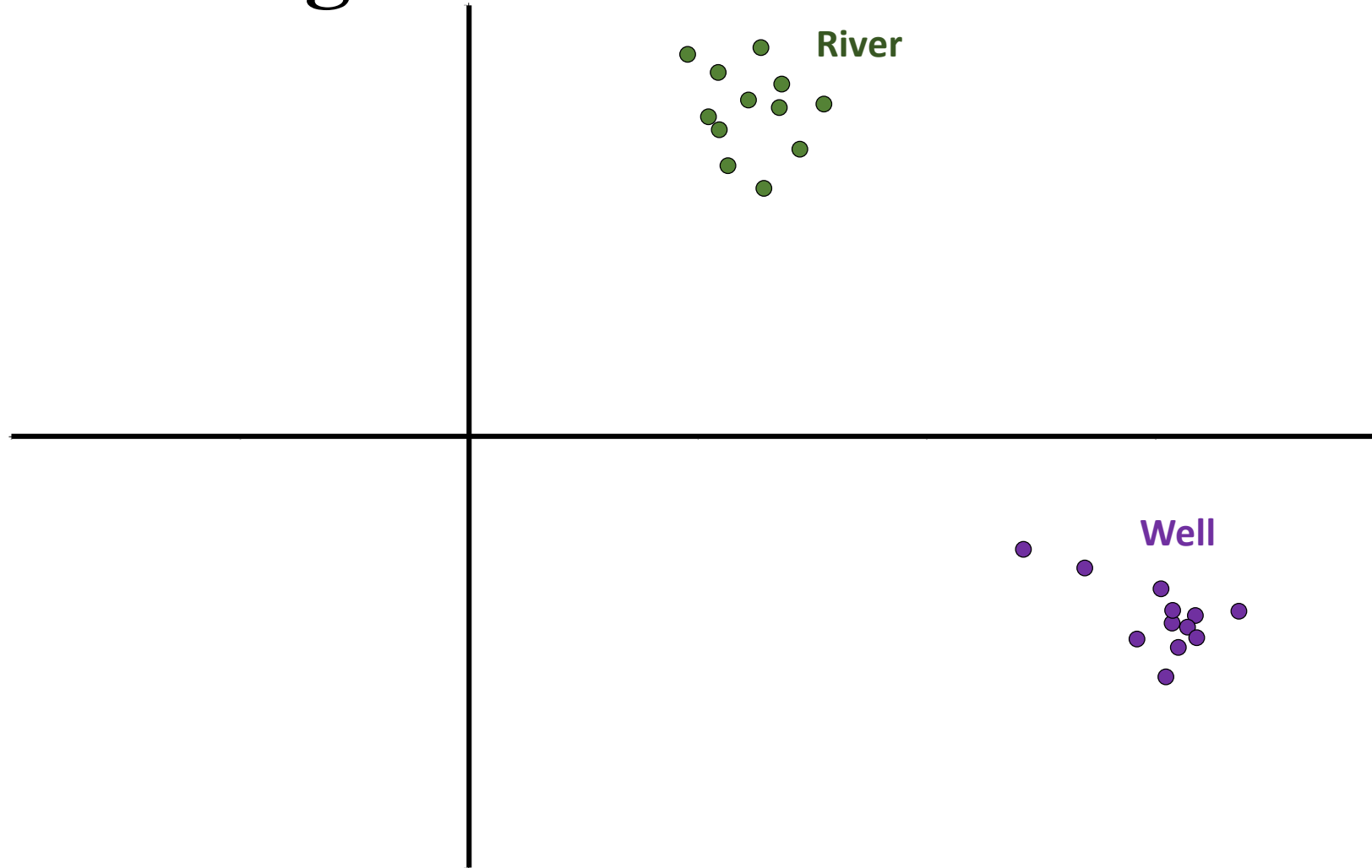
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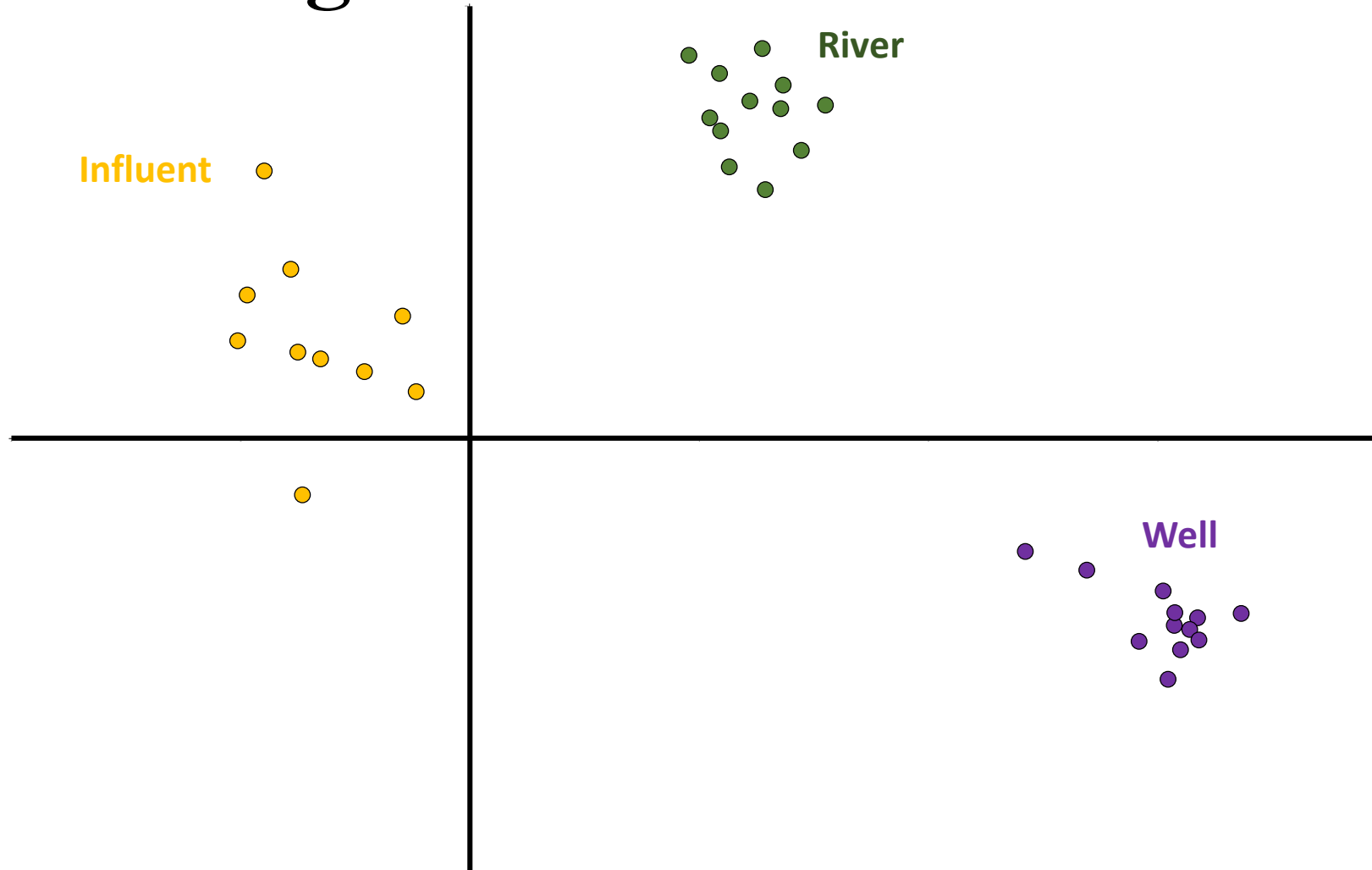
- Maintain and replace infrastructure
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- Hydraulic integrity

Treatment processes exert a selective pressure on the drinking water microbiome.

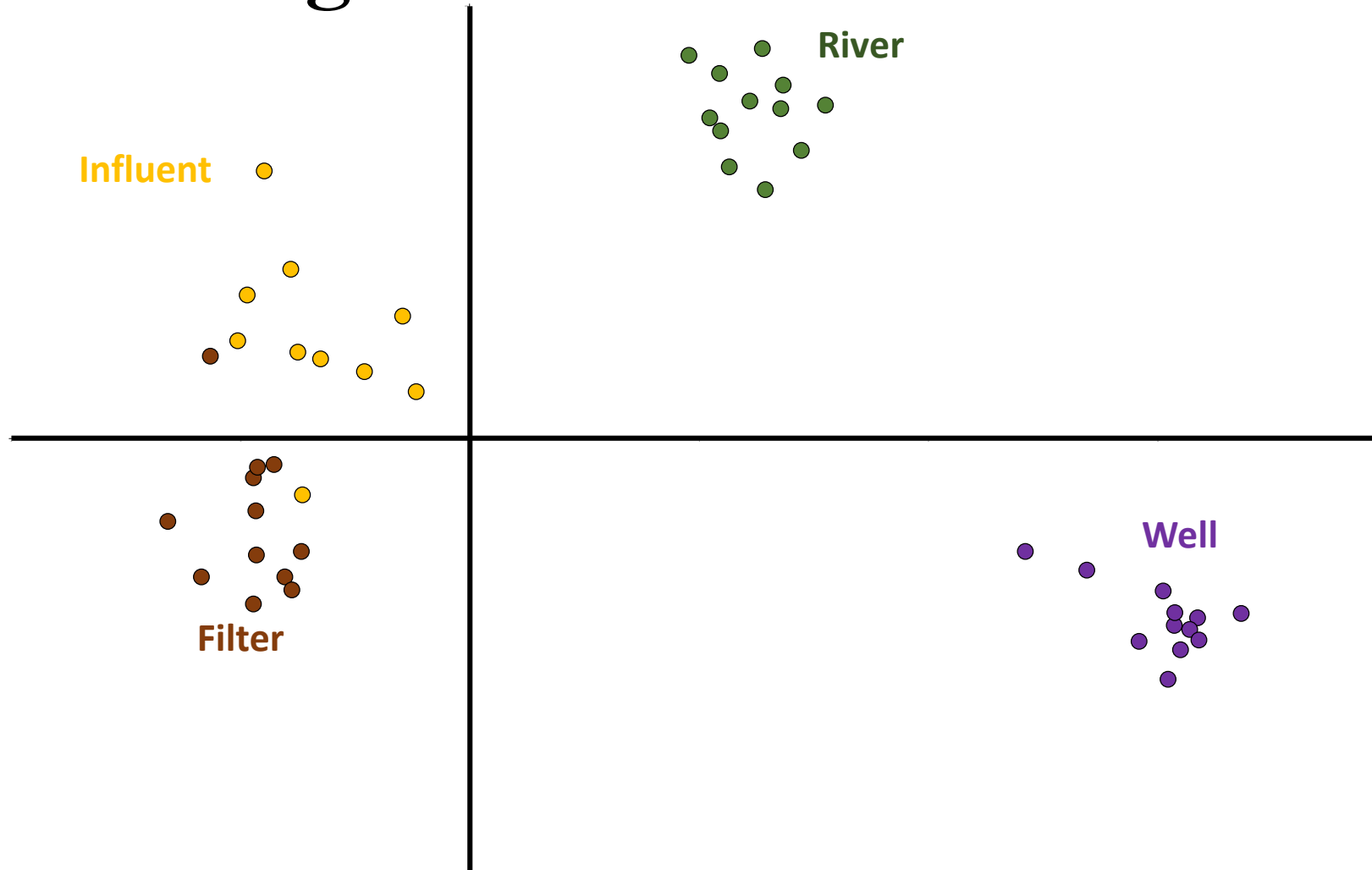


NMDS with Bray-Curtis distance metric

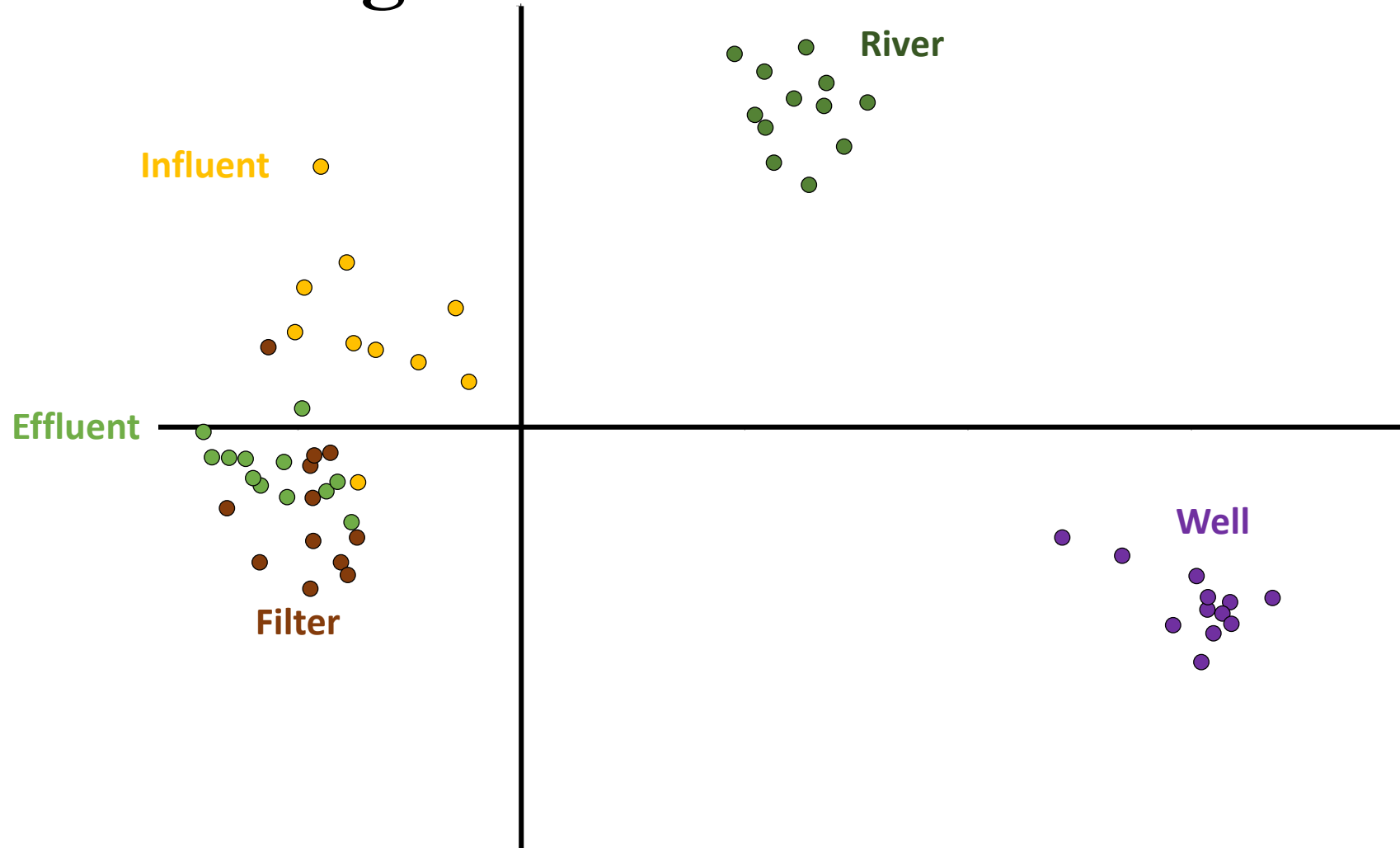
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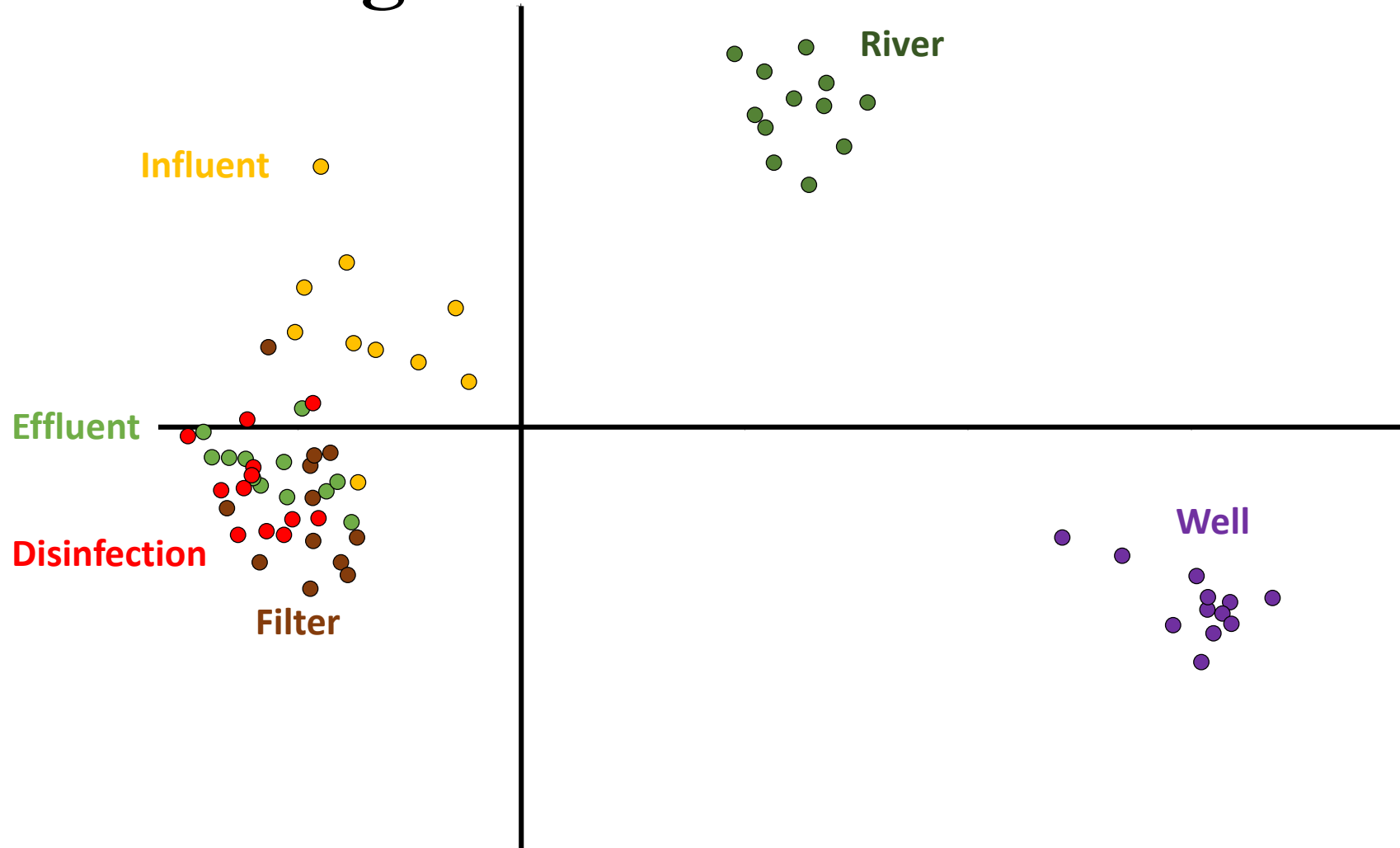
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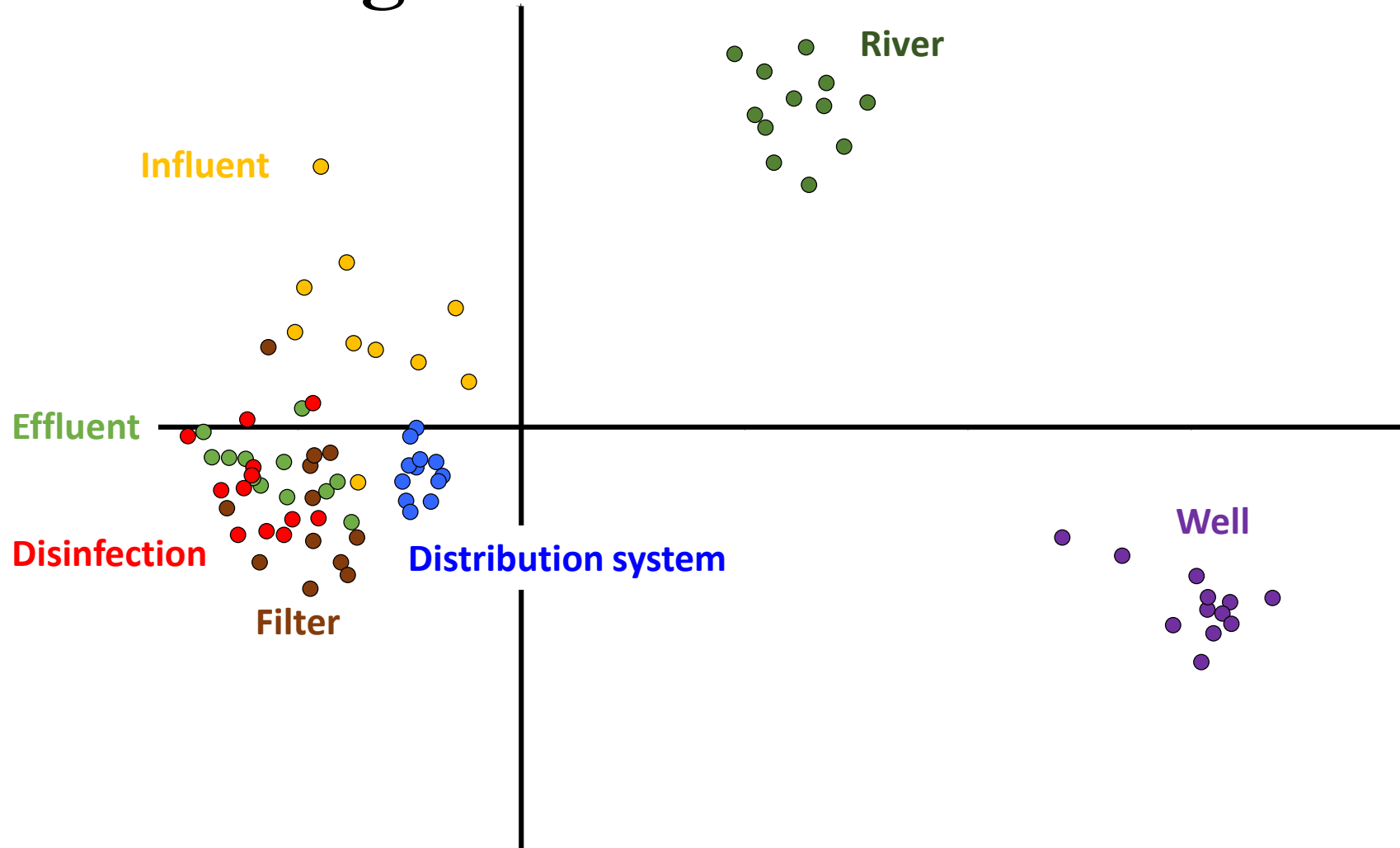


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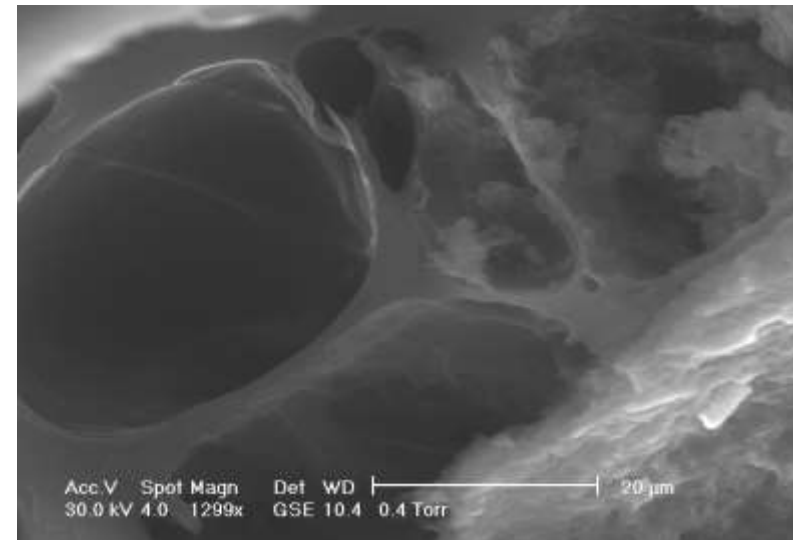
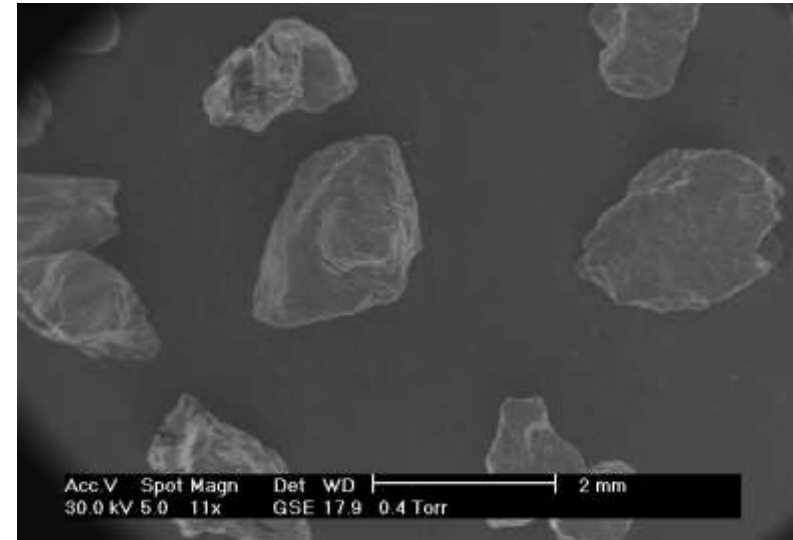
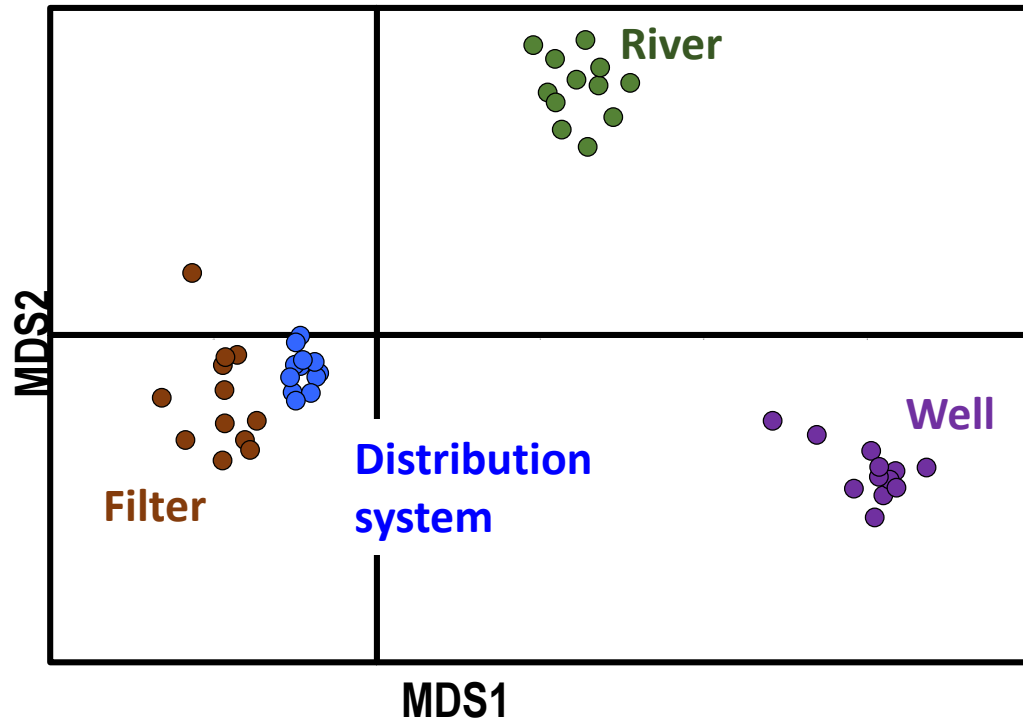


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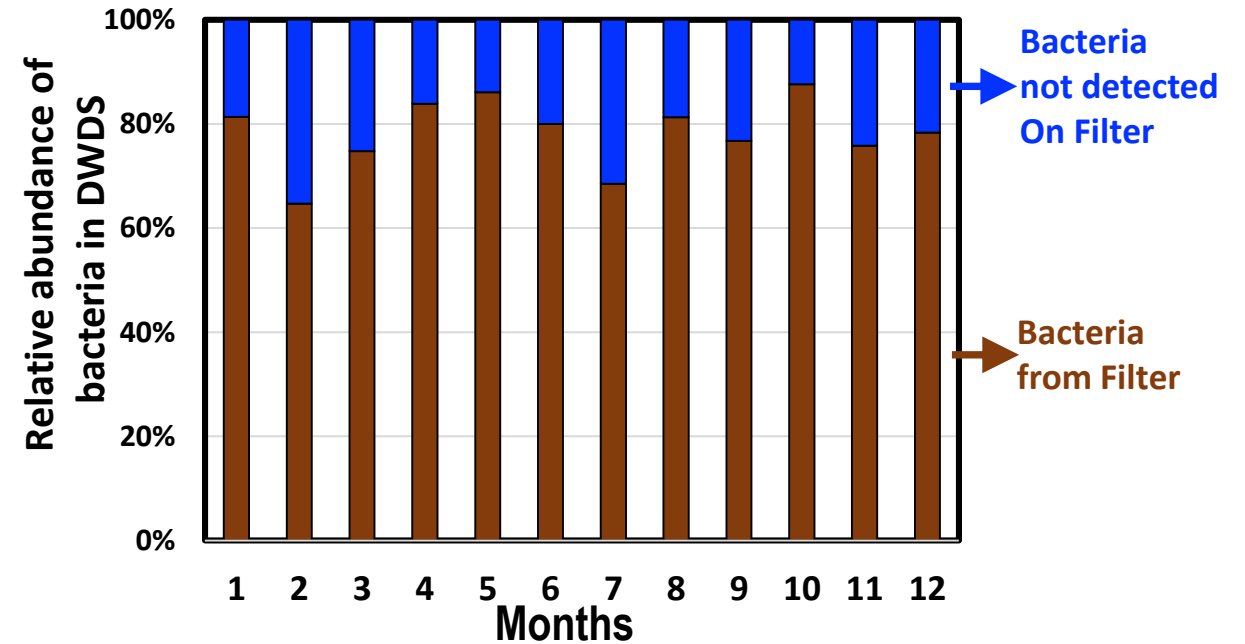
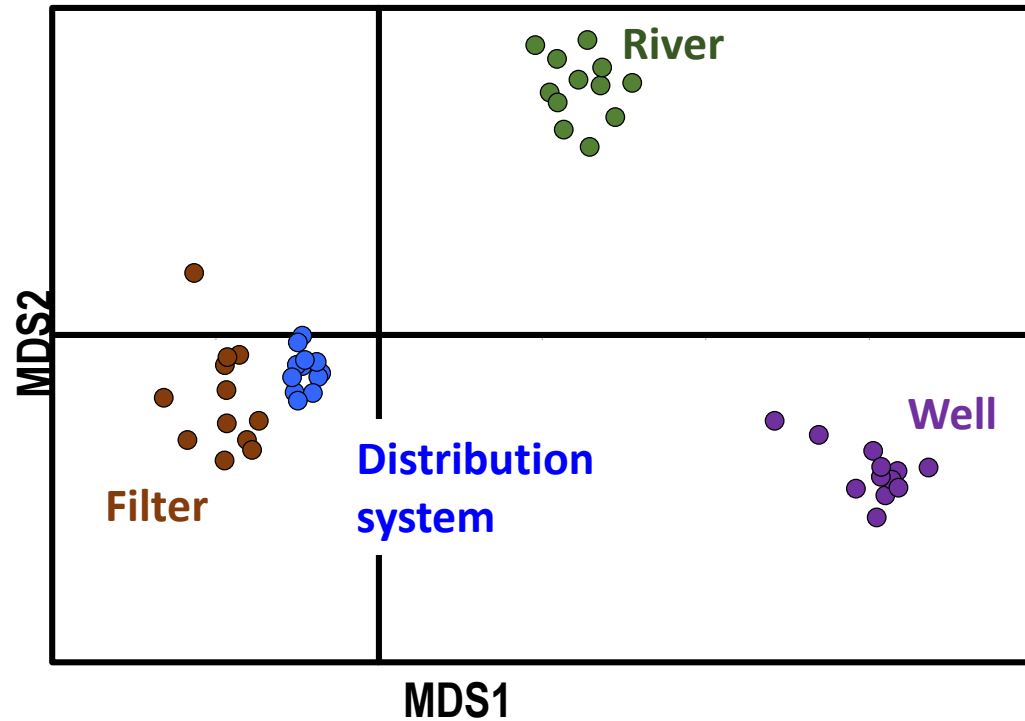
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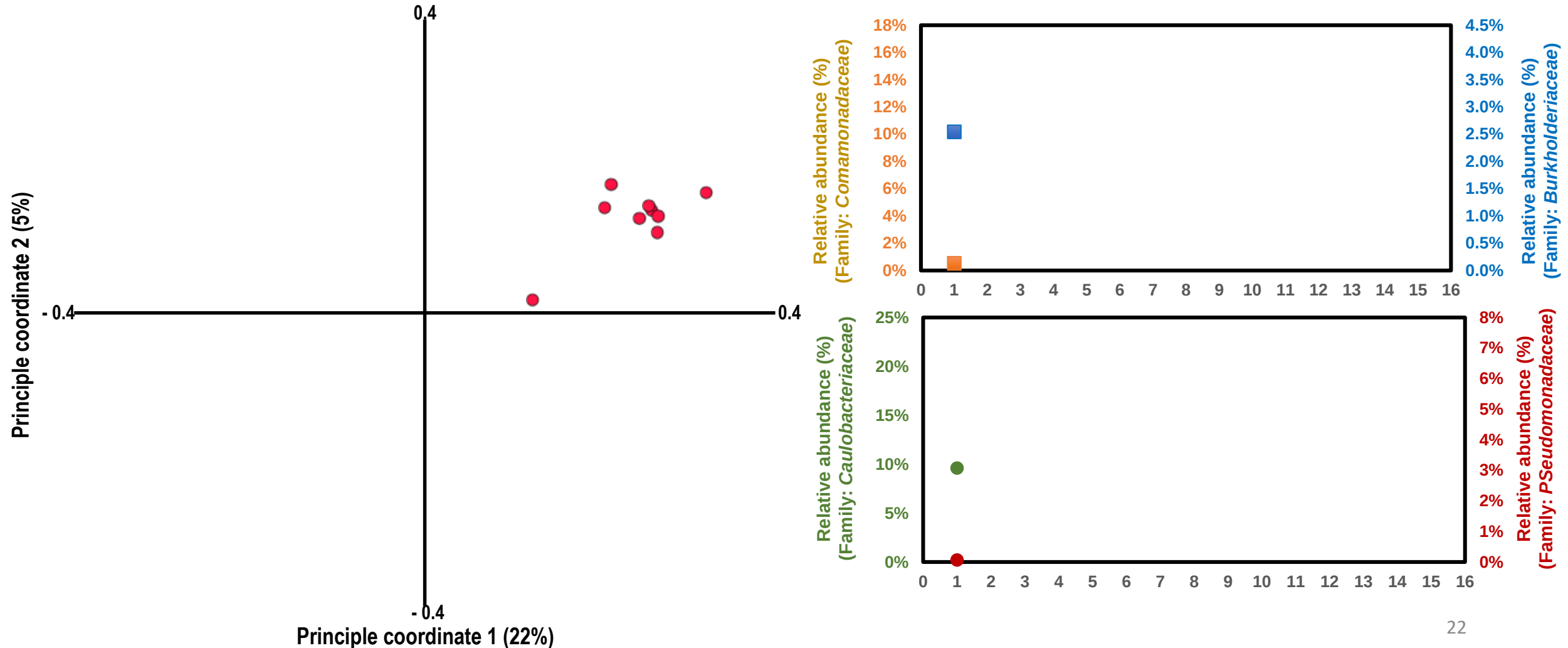
Filtration plays a key role in seeding the distribution system.



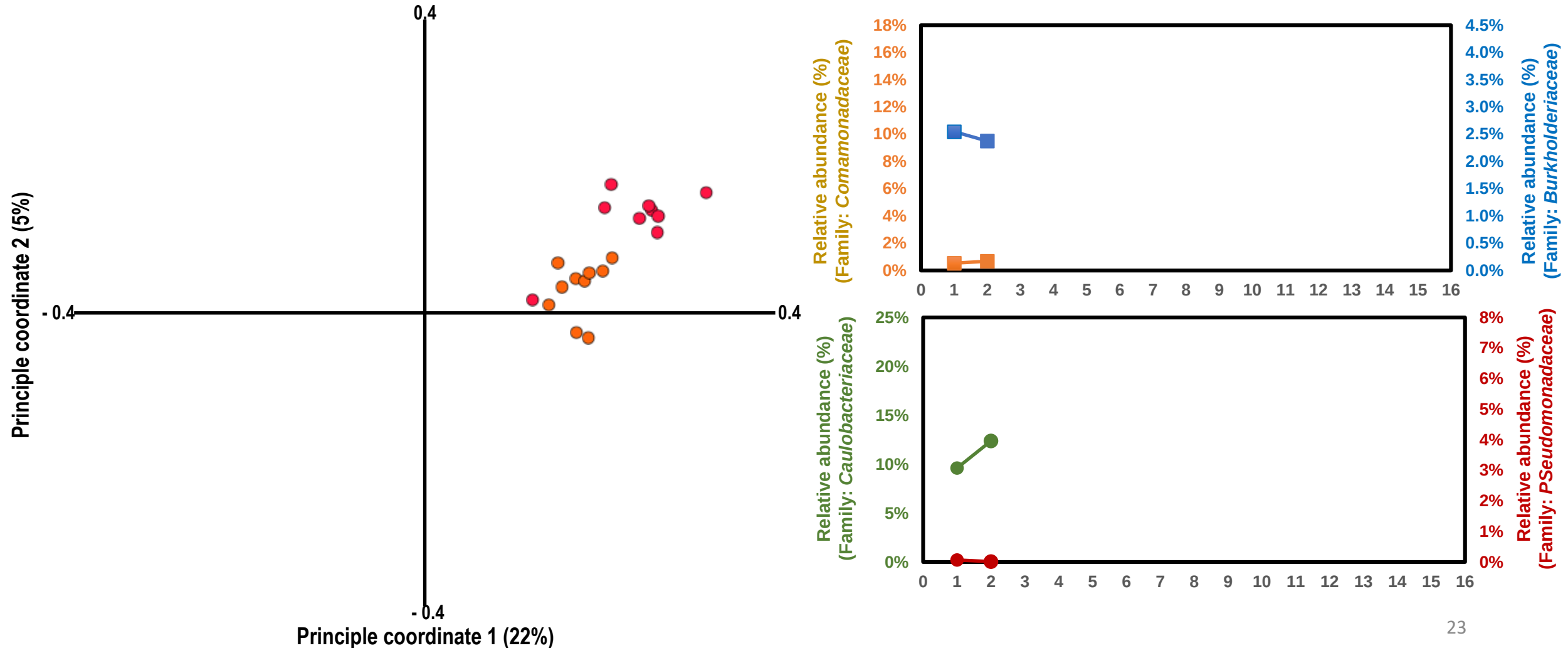
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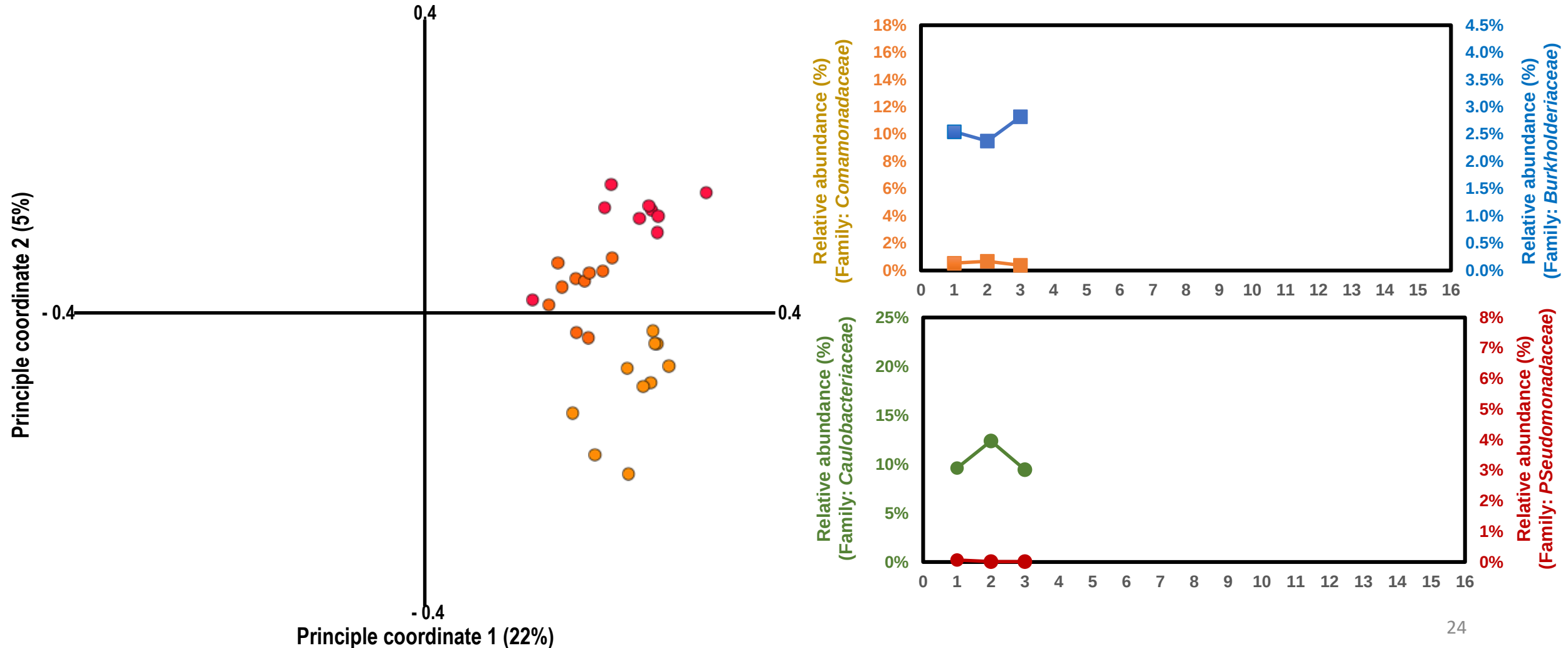
Seeding by the filter and selection by disinfection is **systematic** and **reproducible**



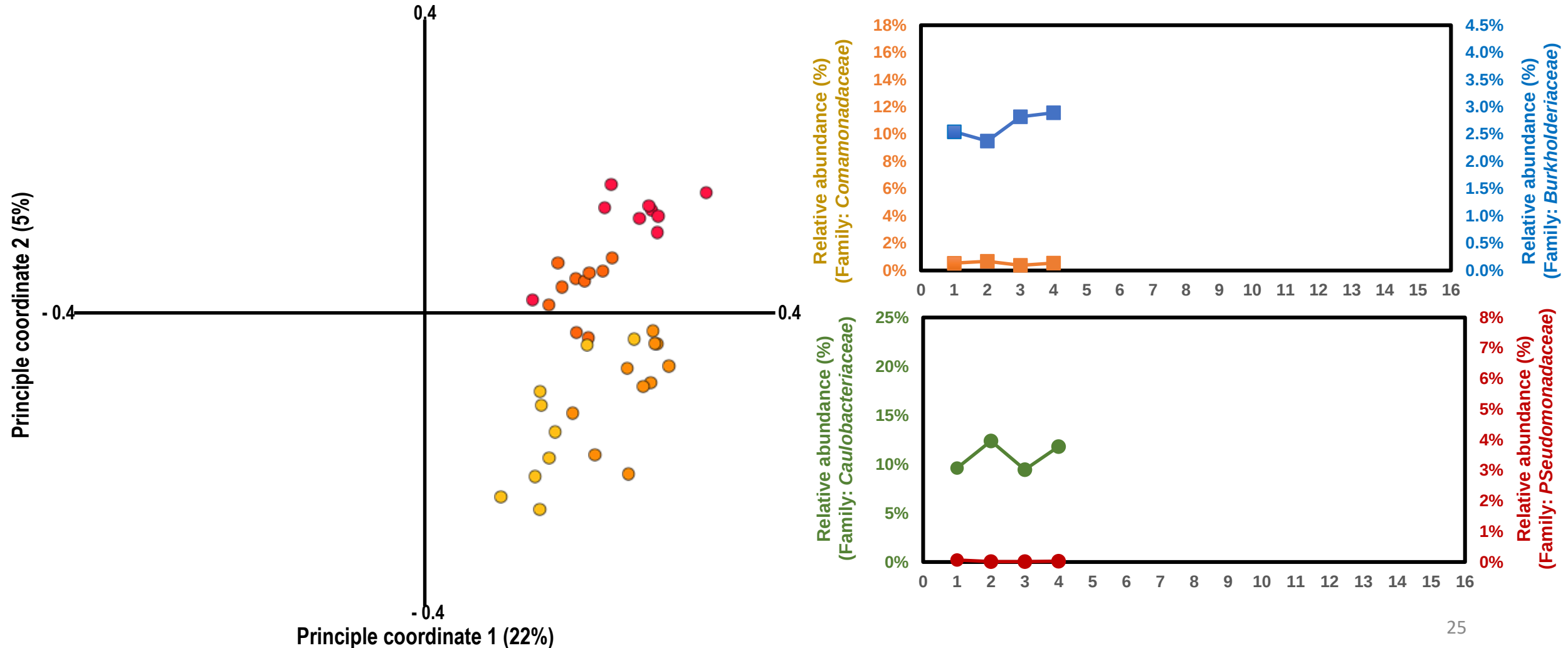
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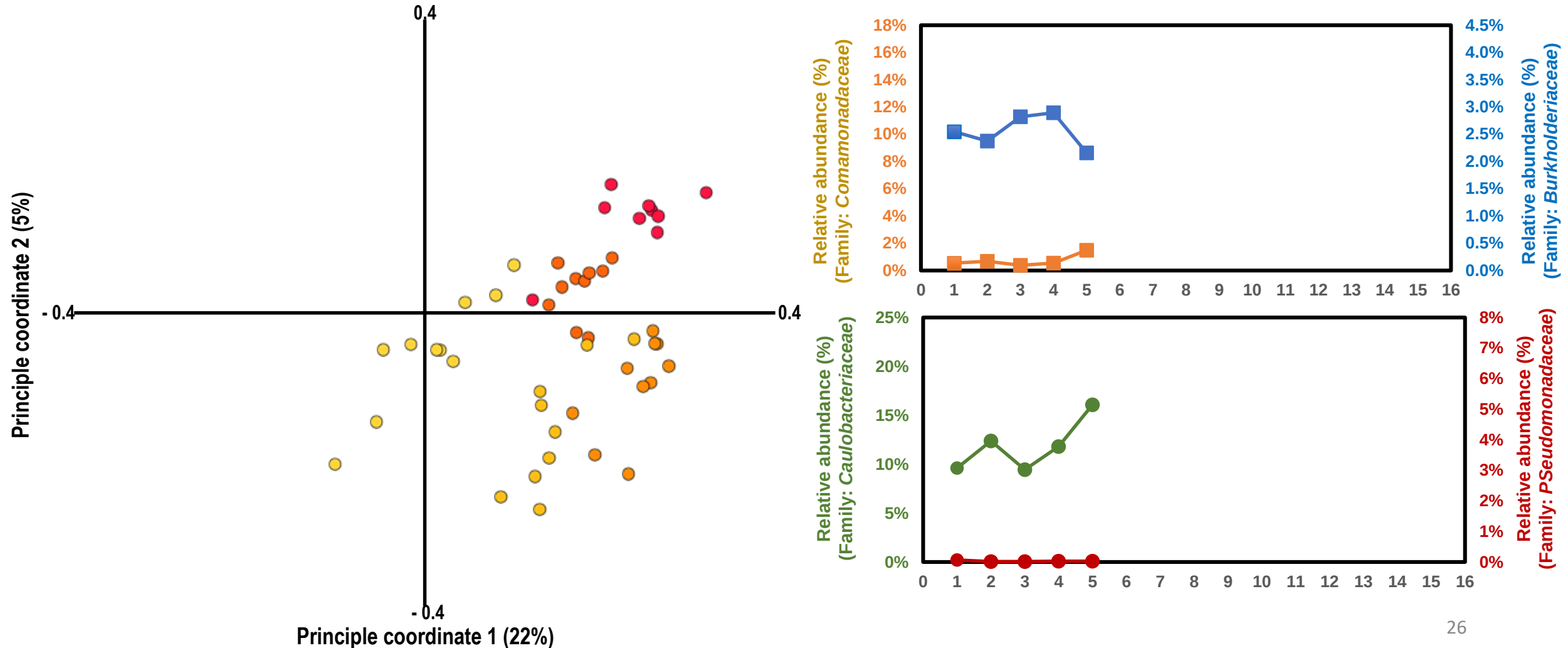
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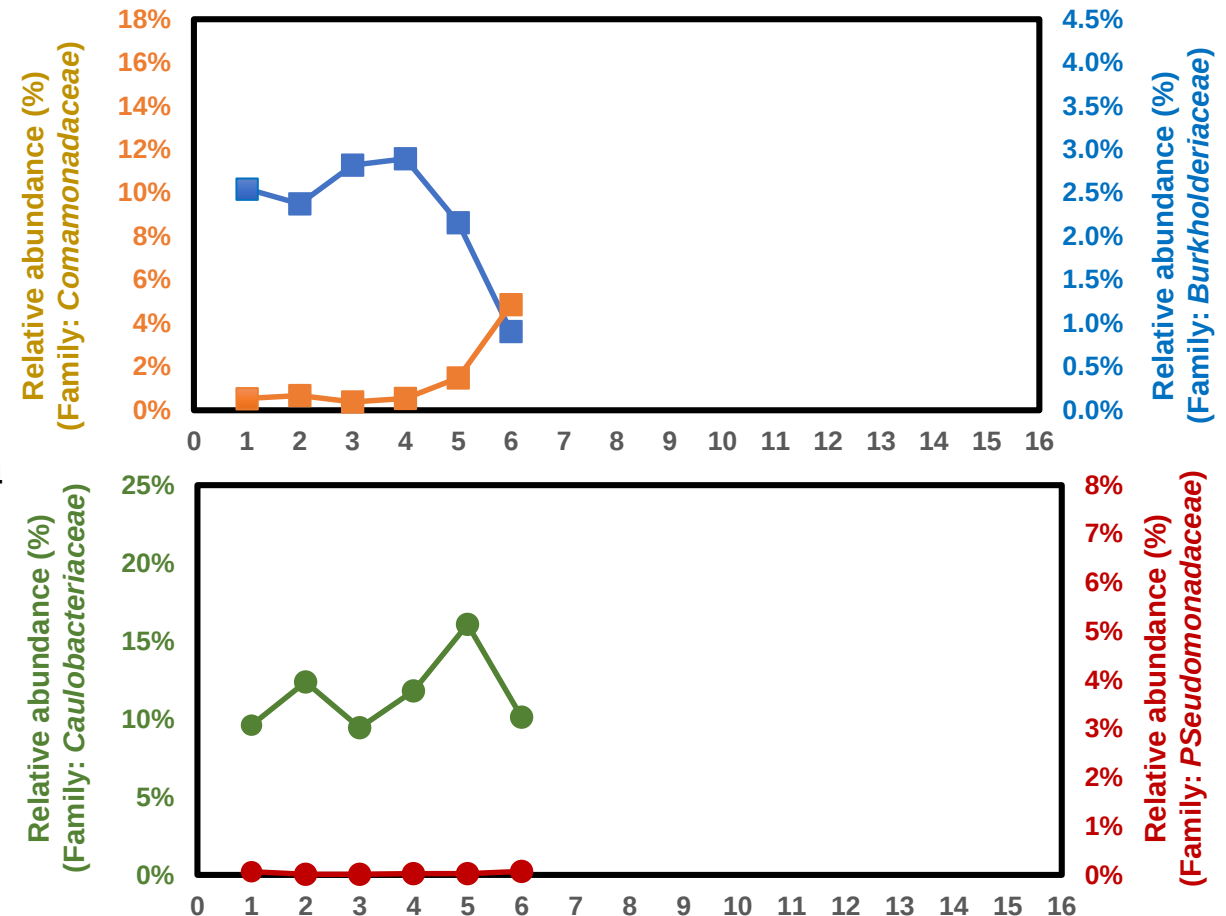
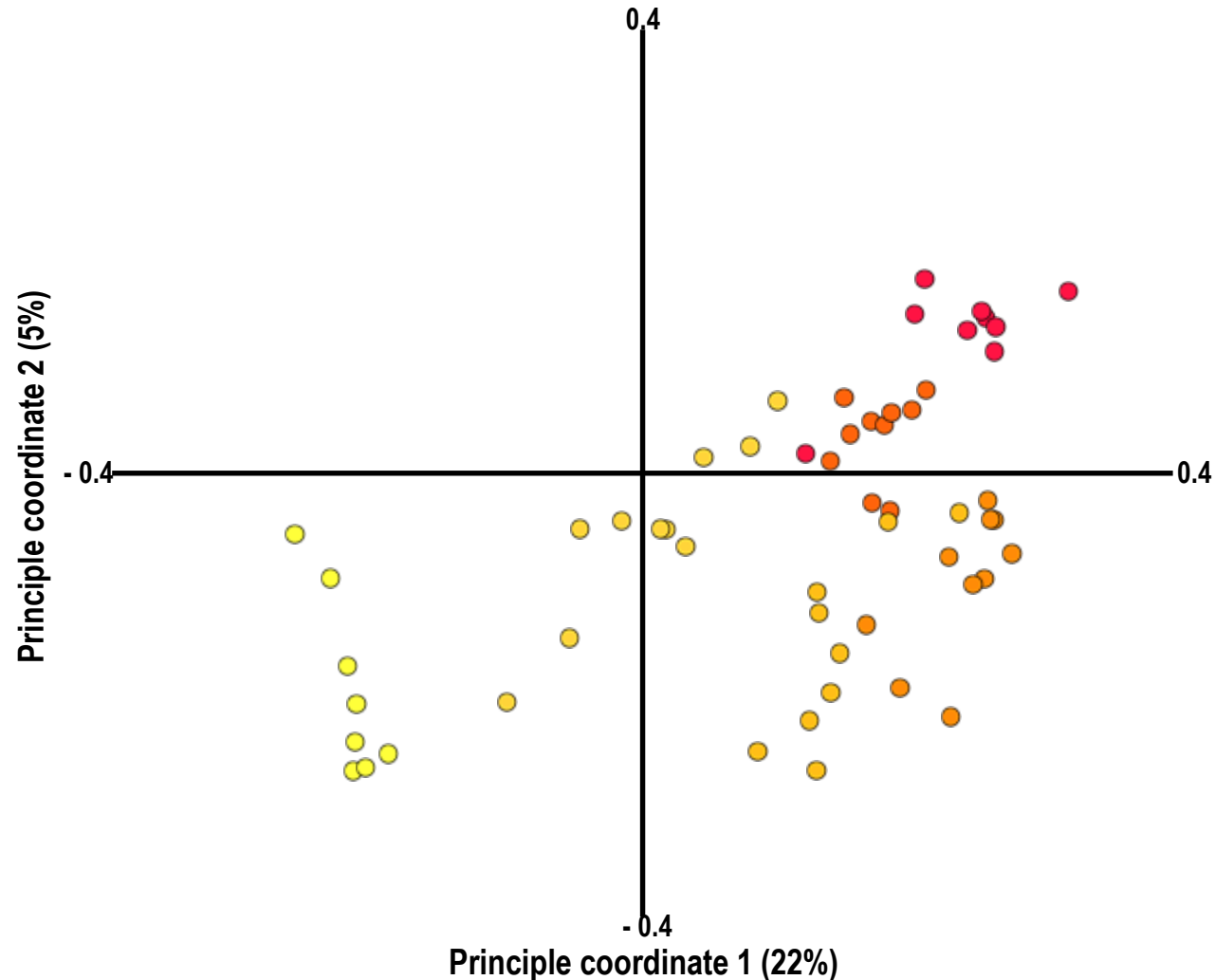
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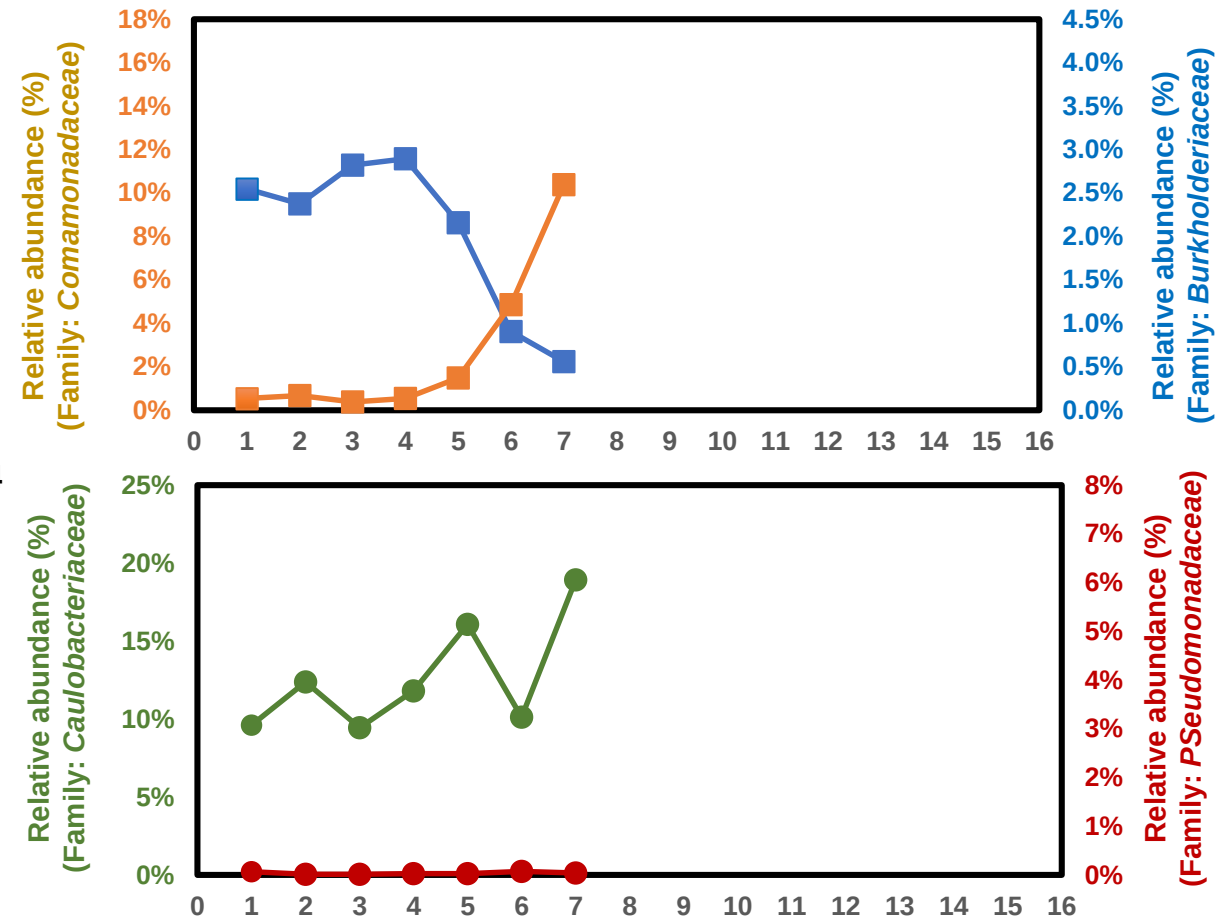
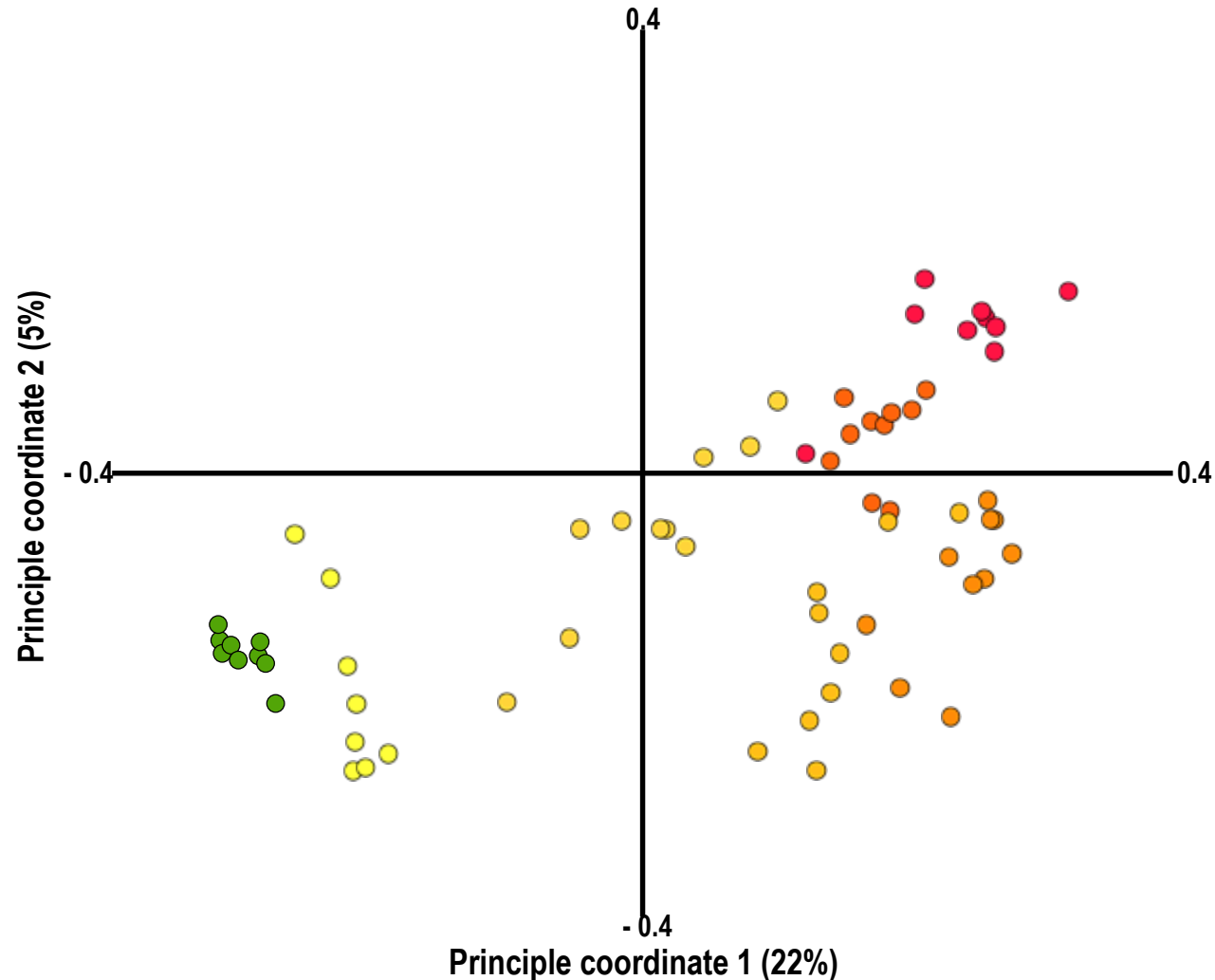
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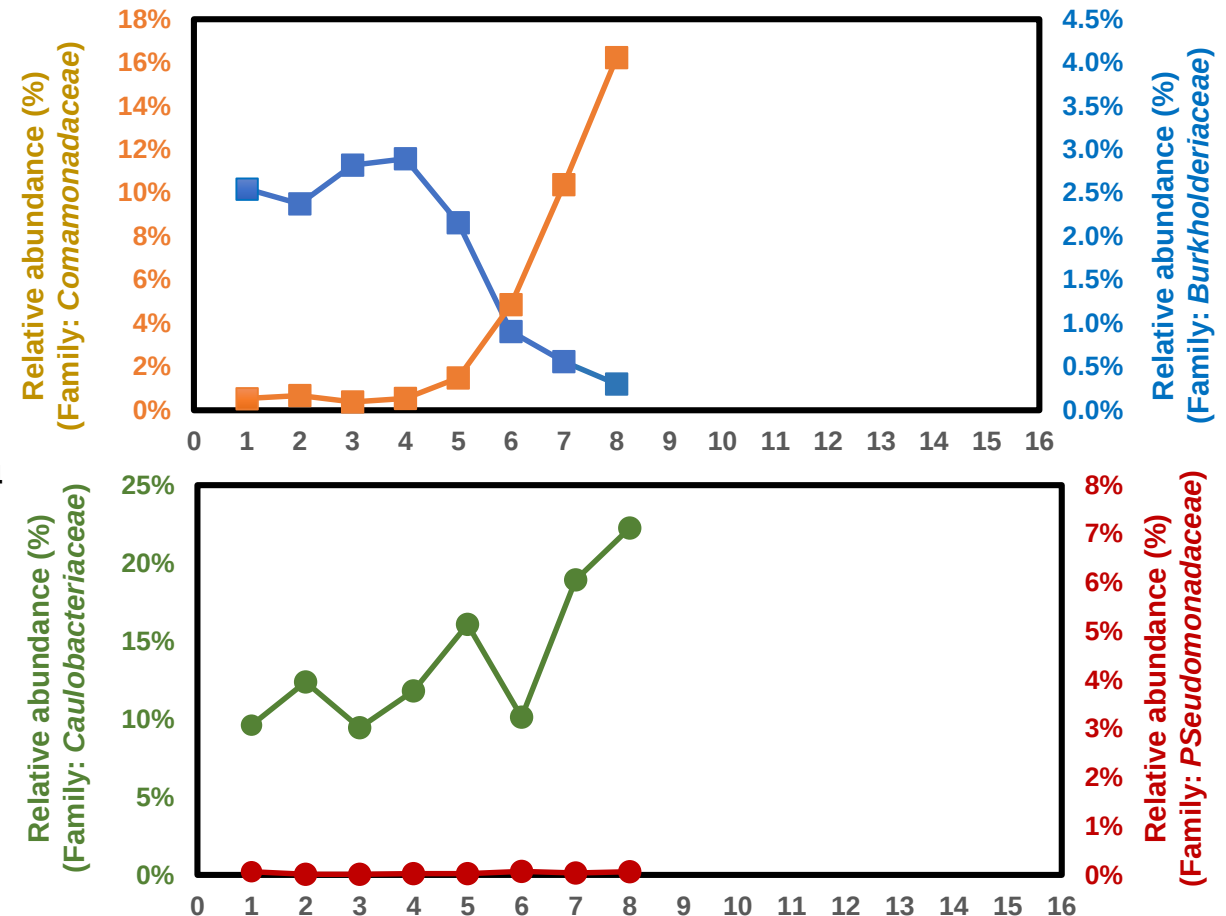
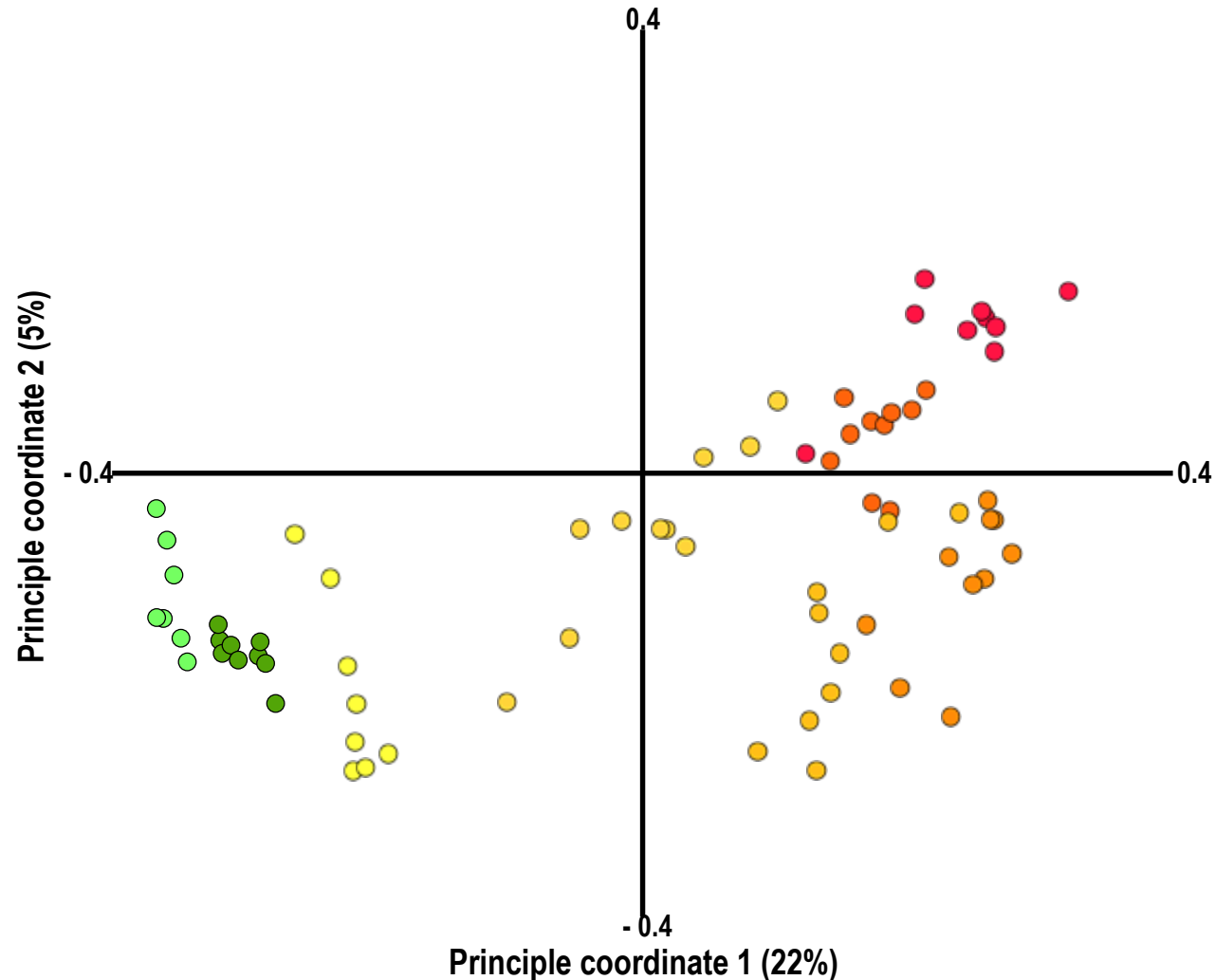
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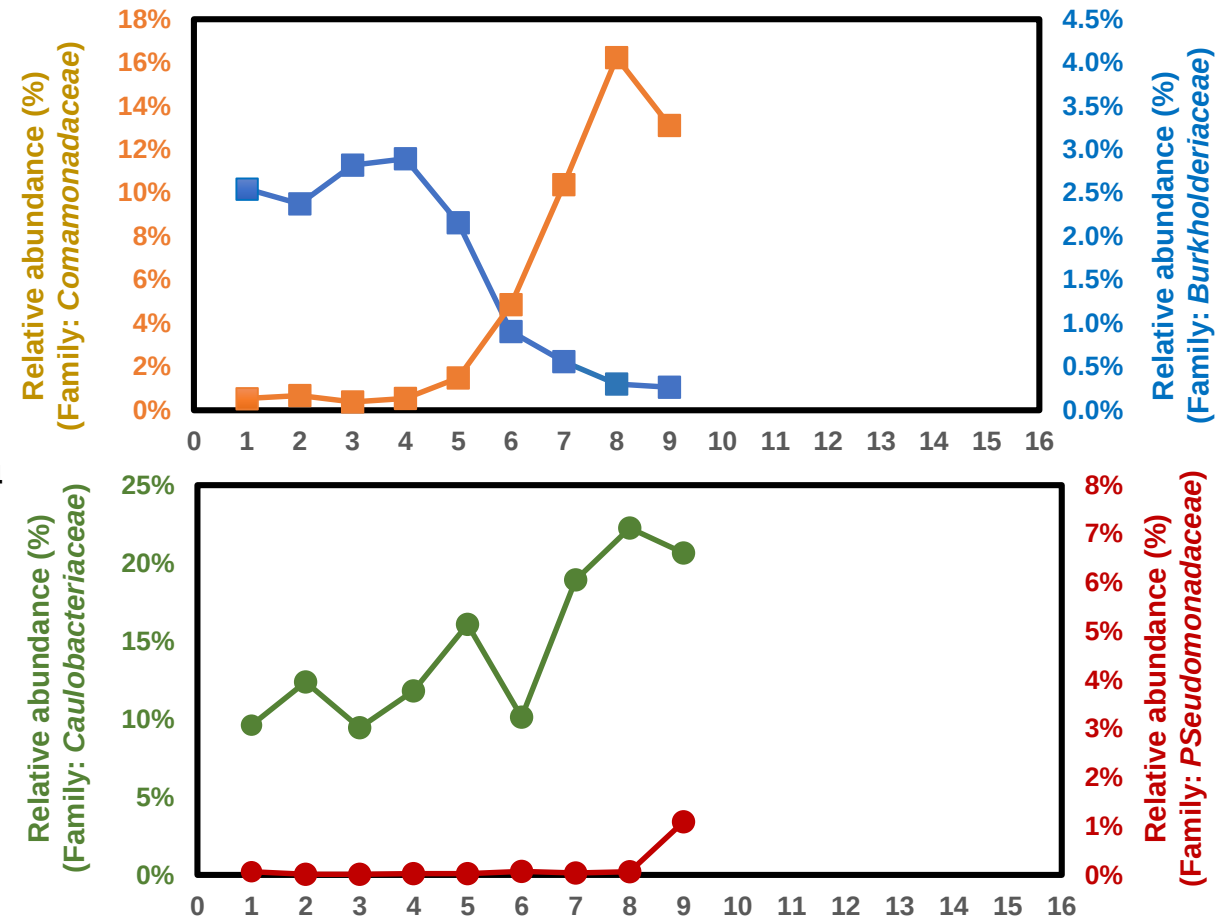
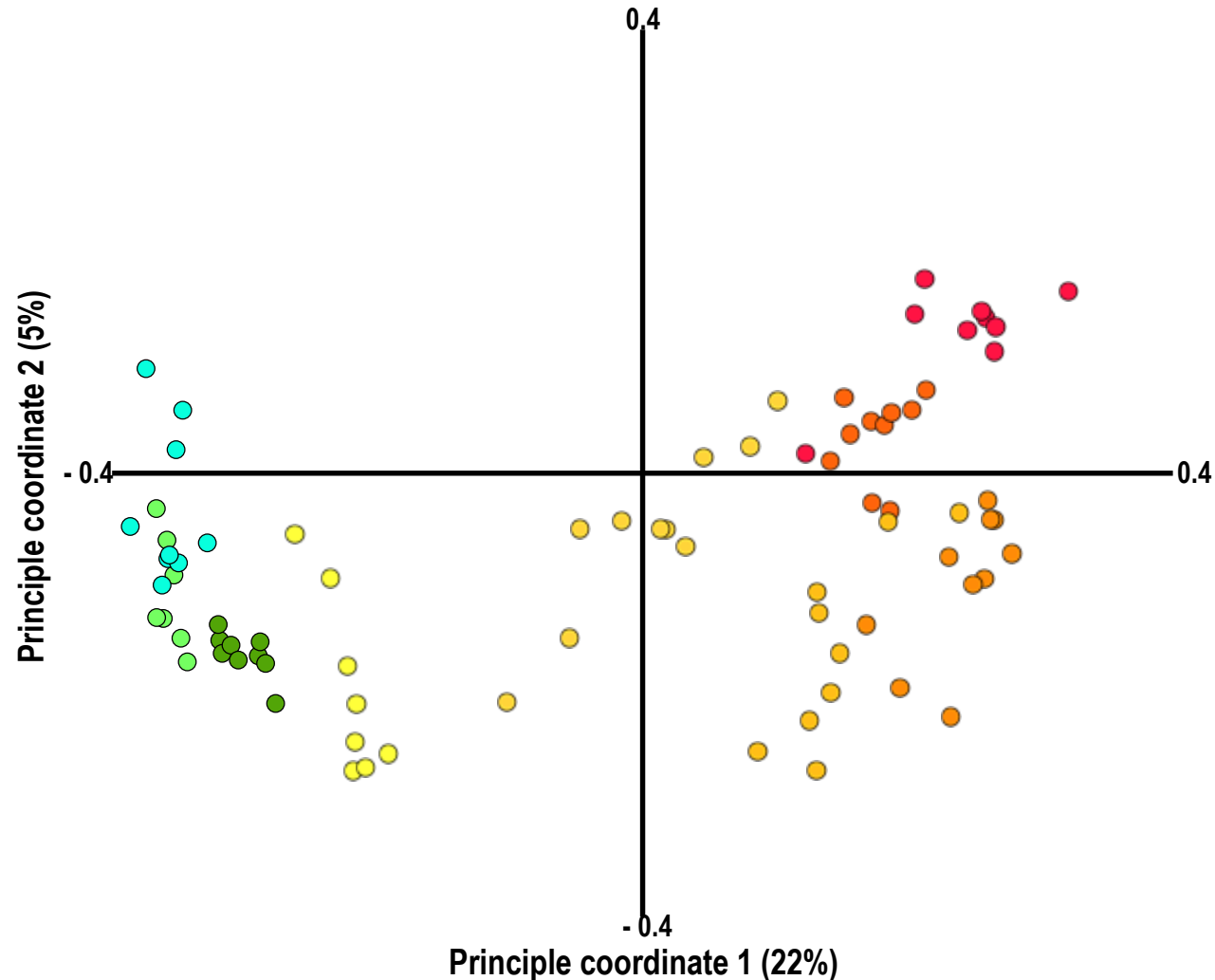
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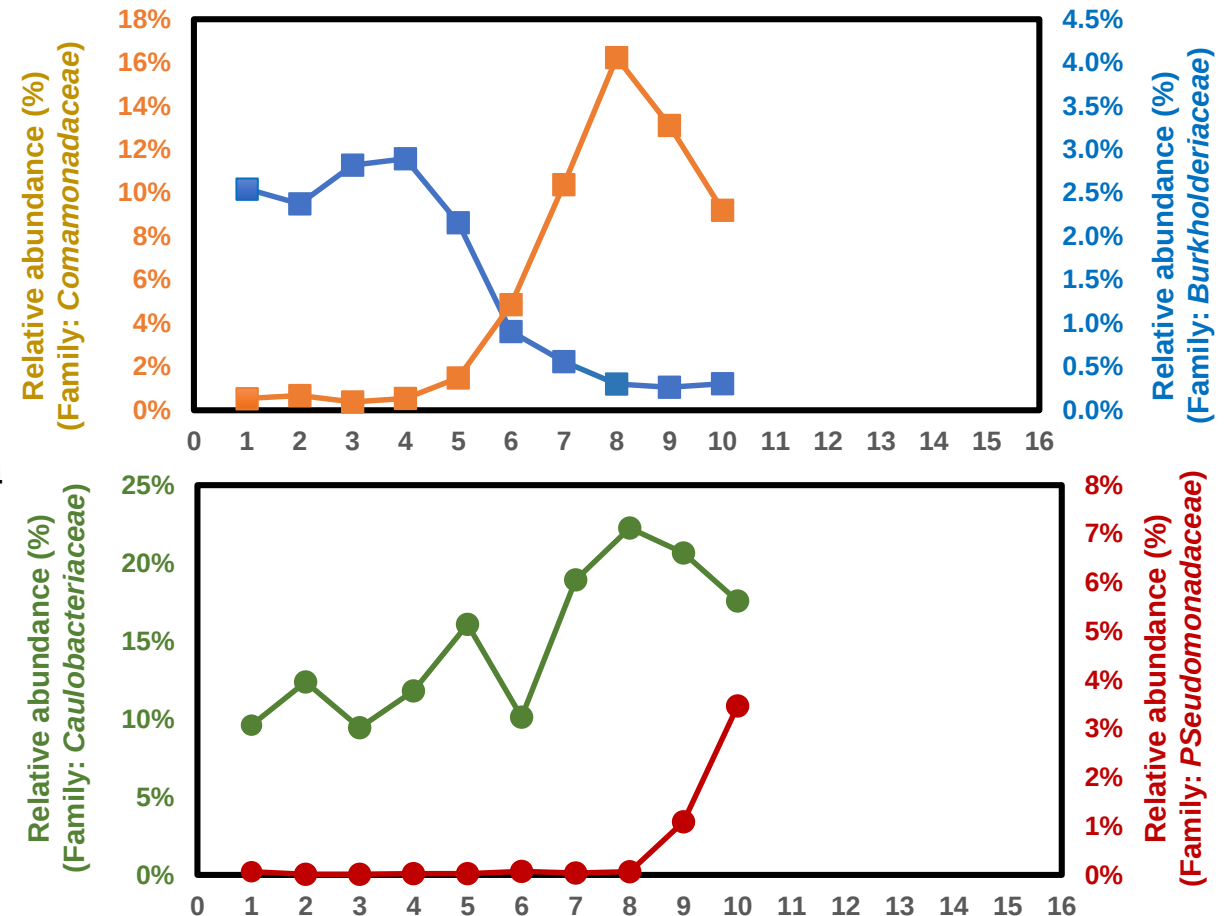
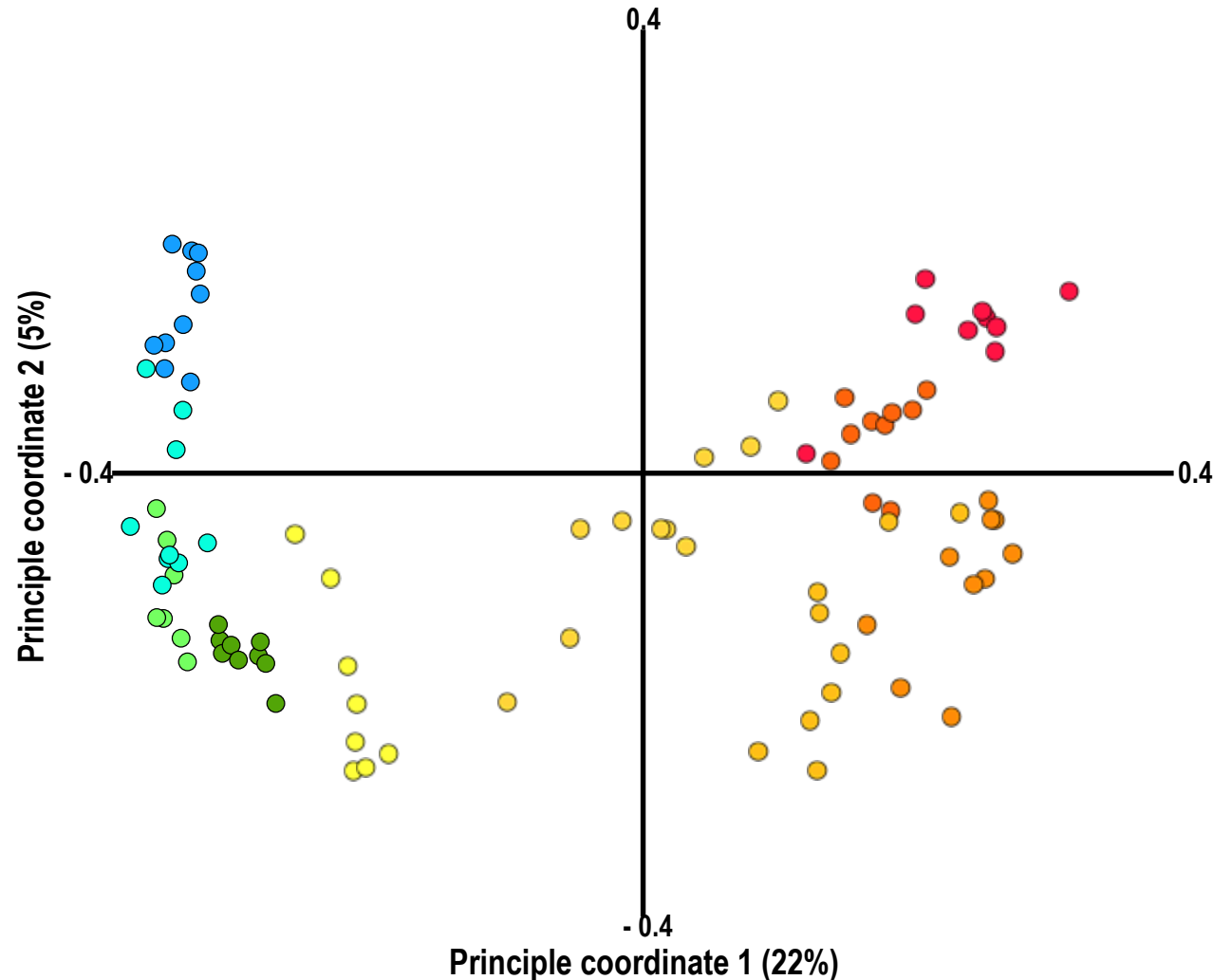
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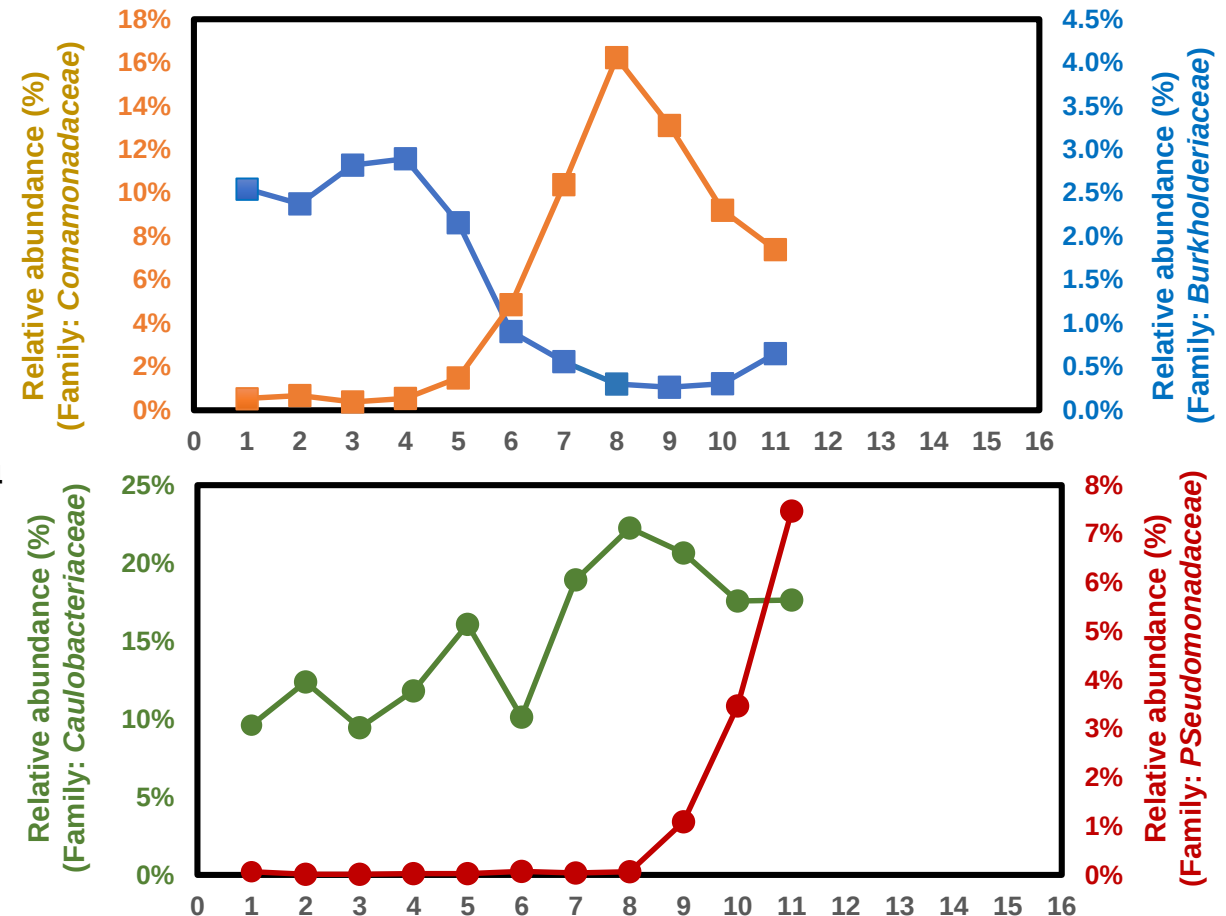
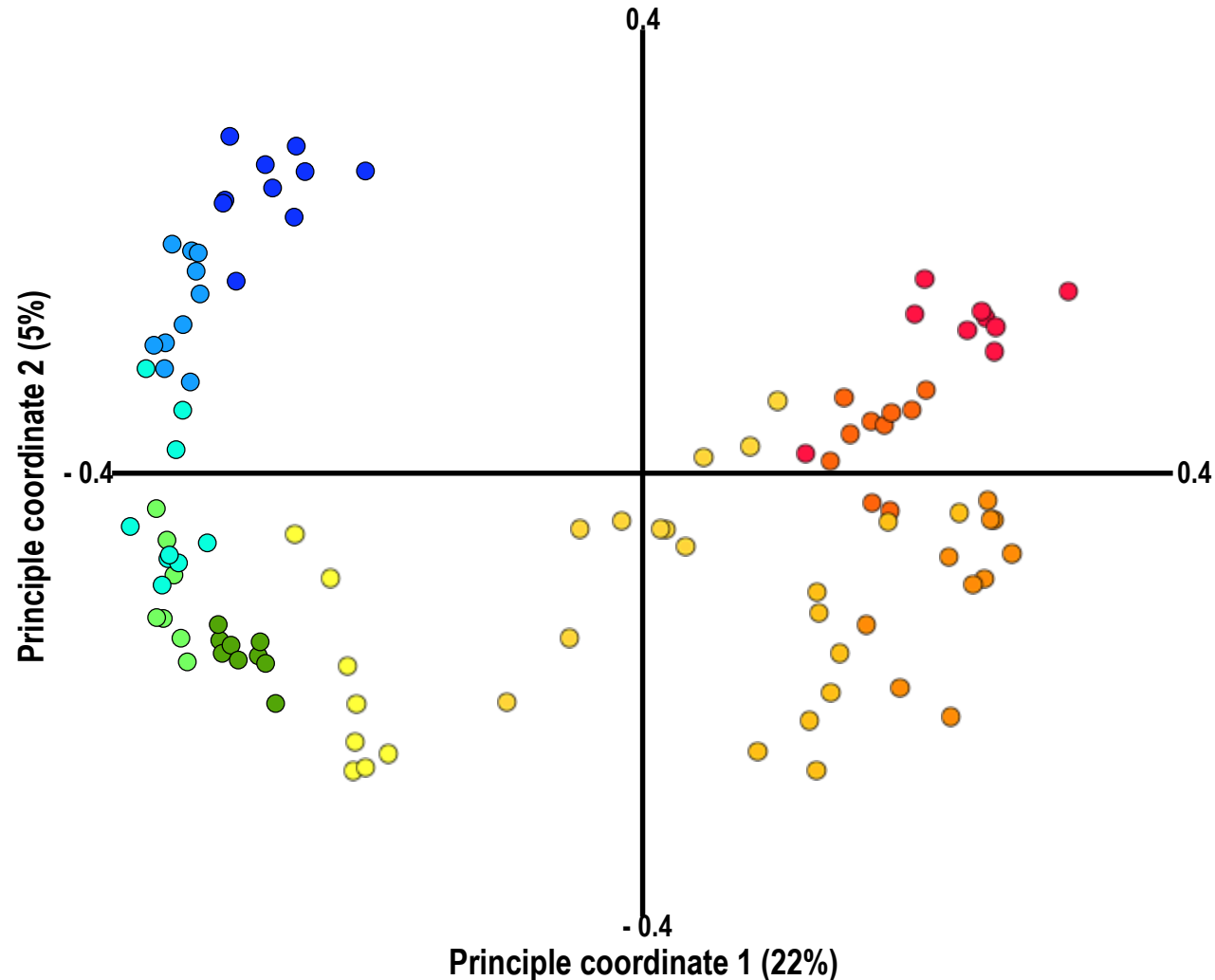
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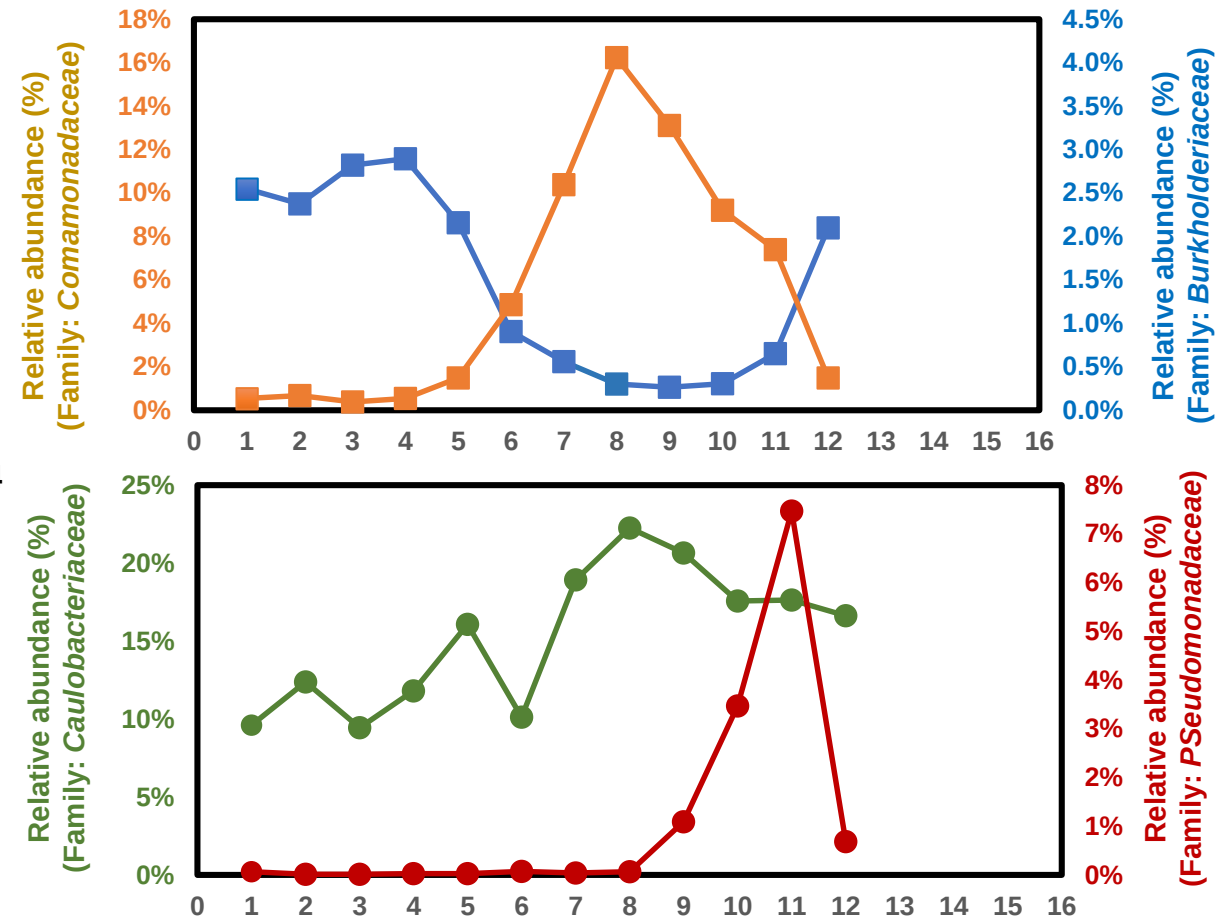
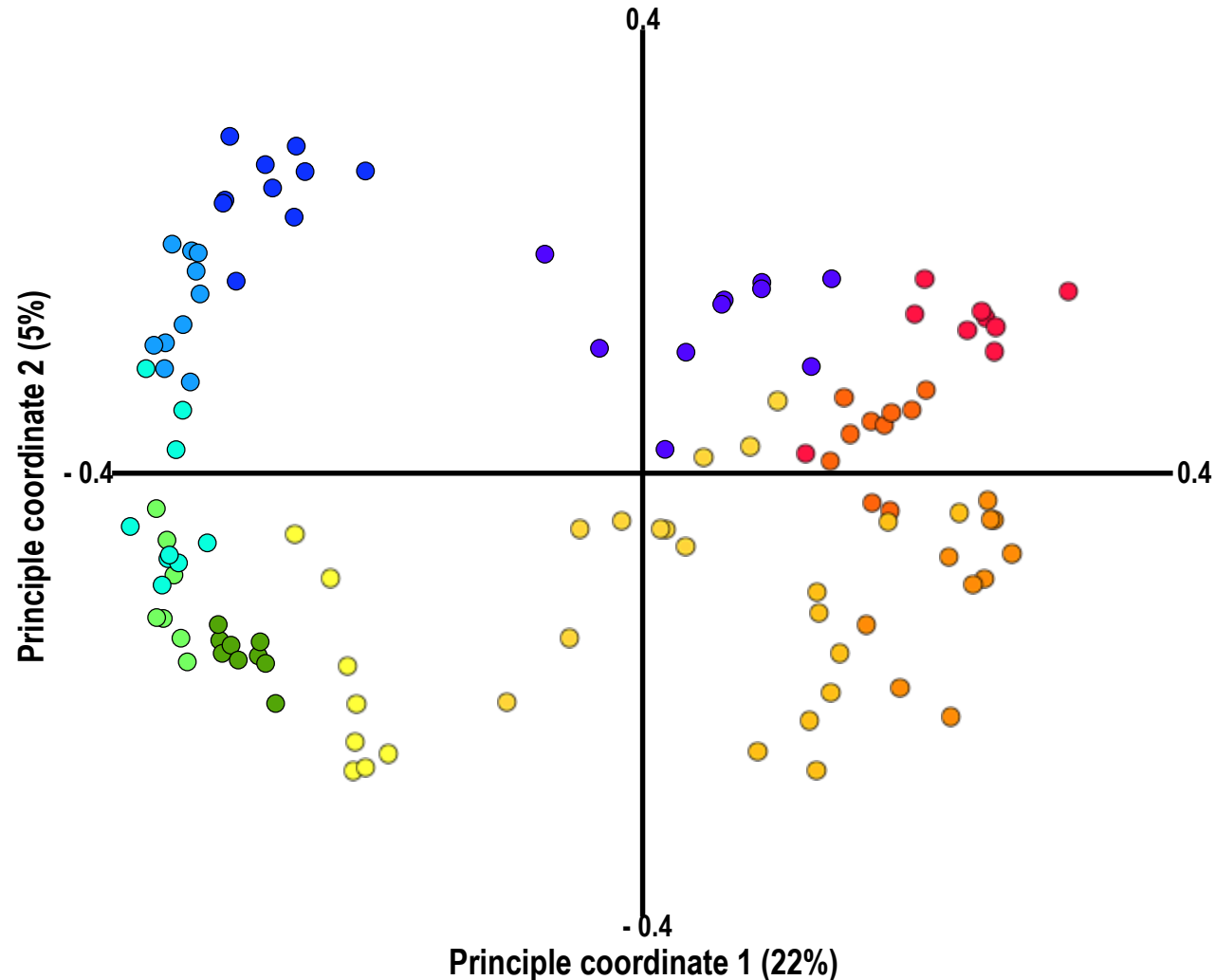
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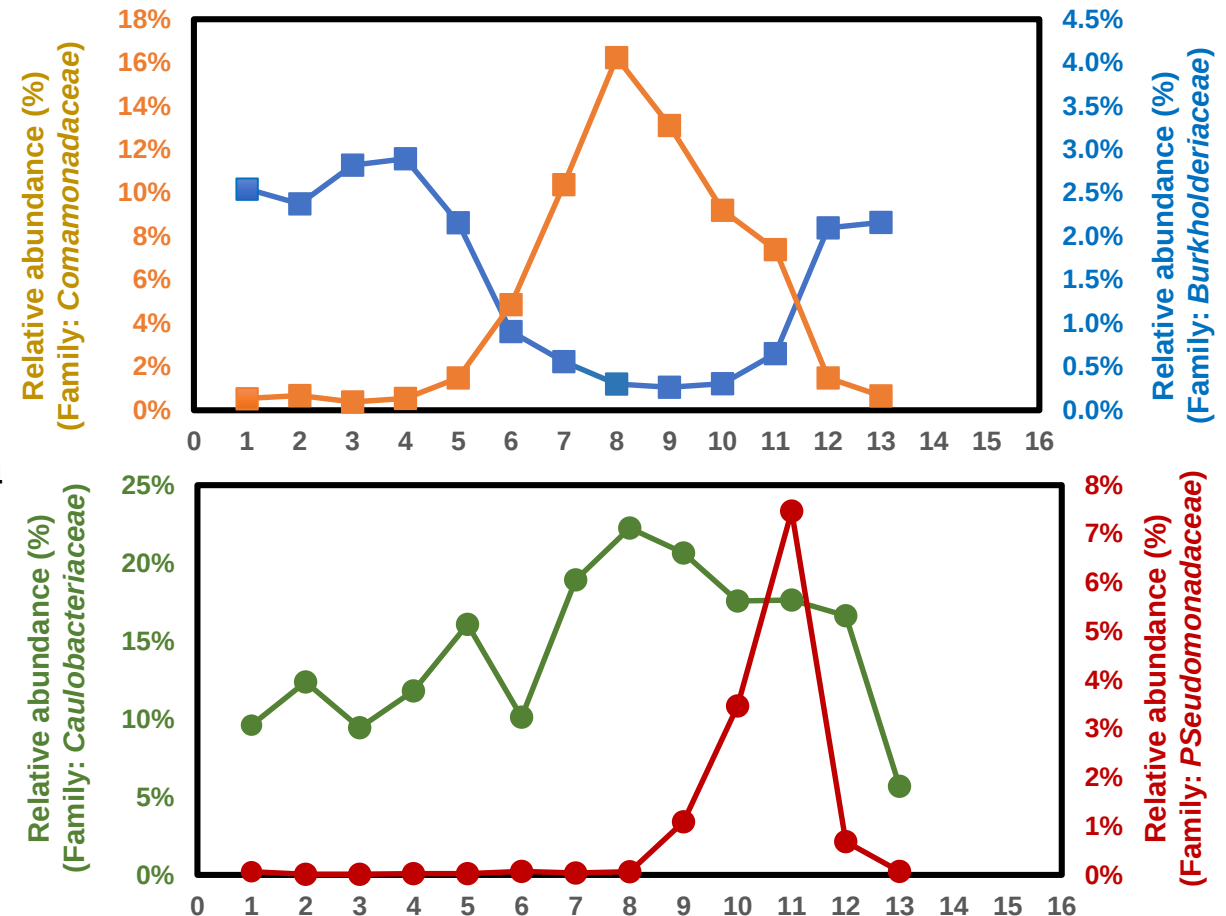
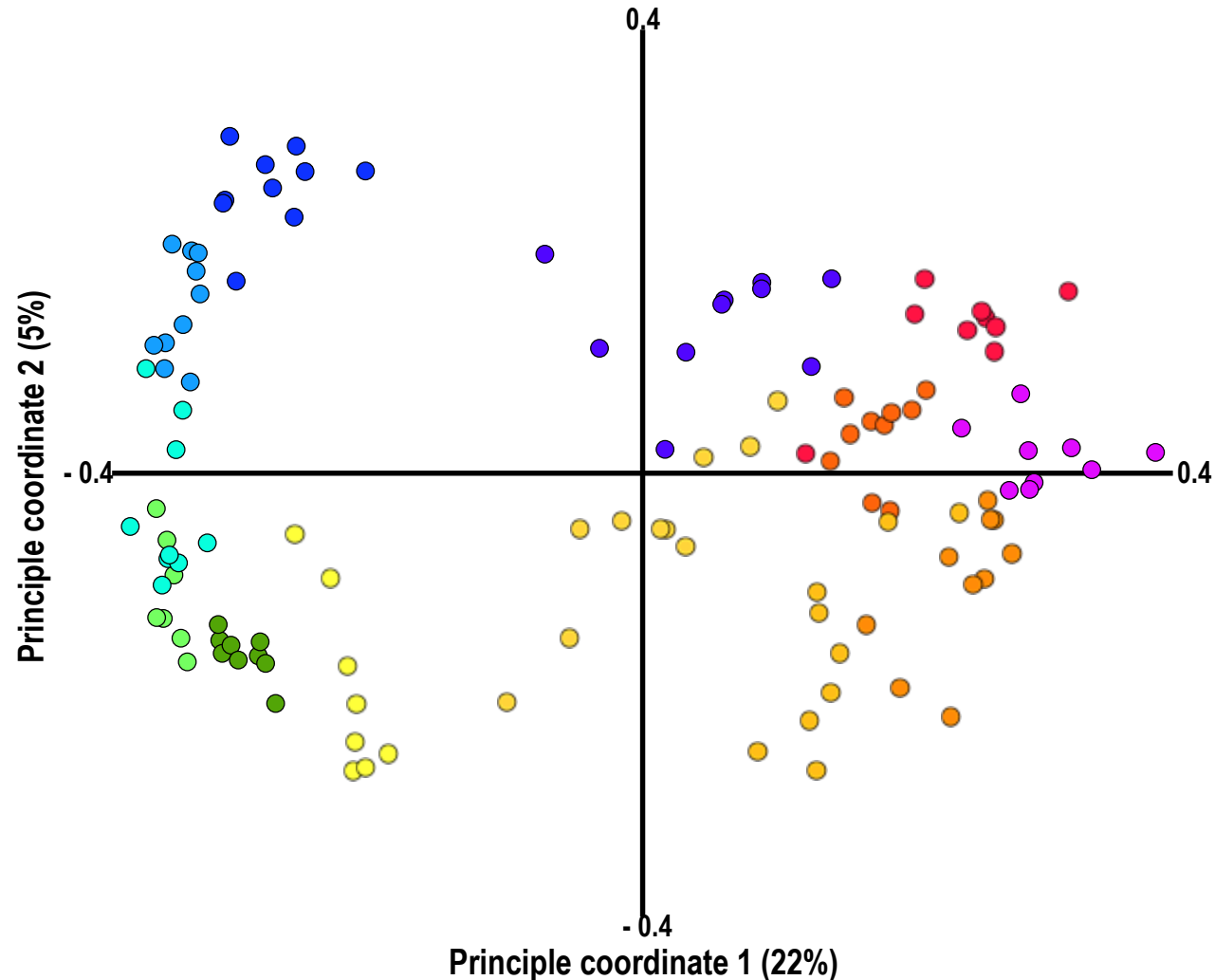
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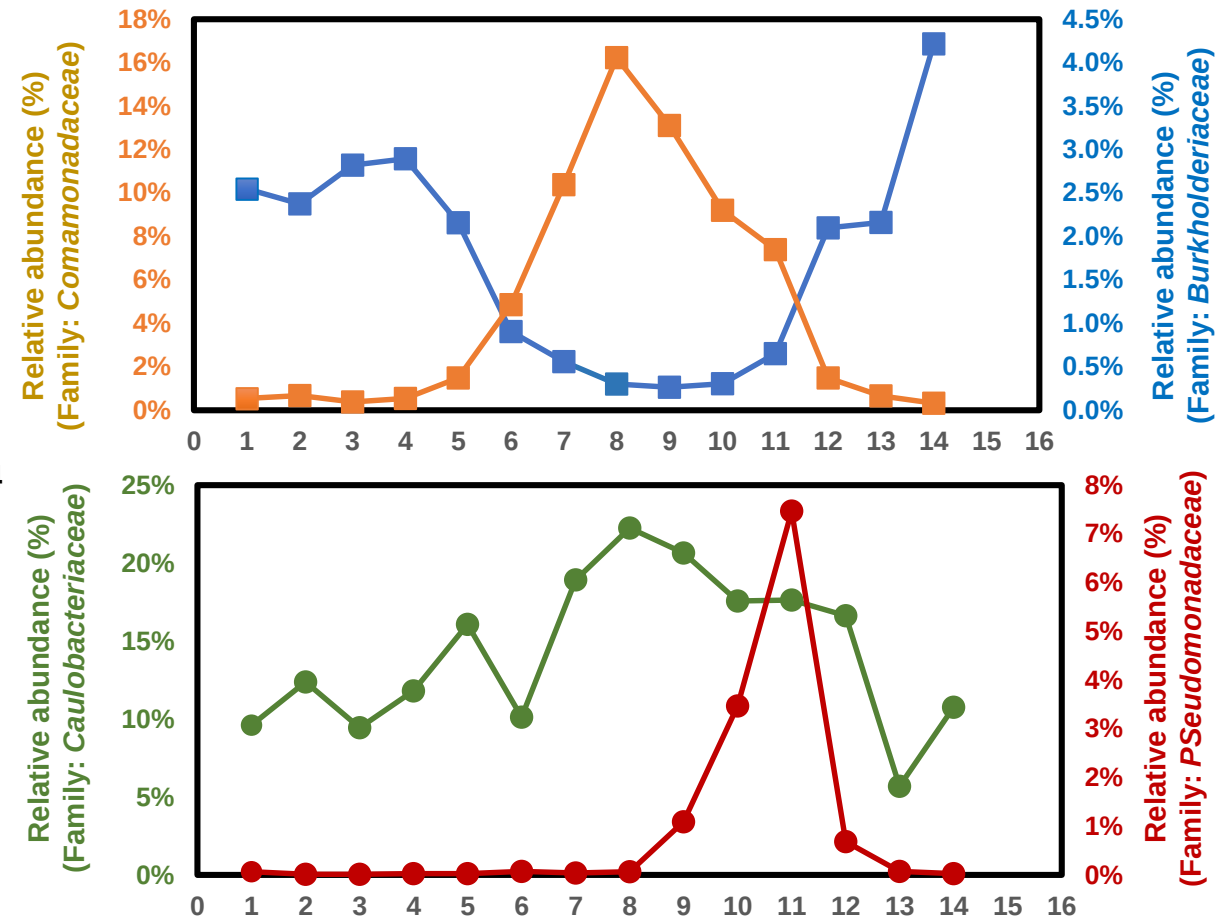
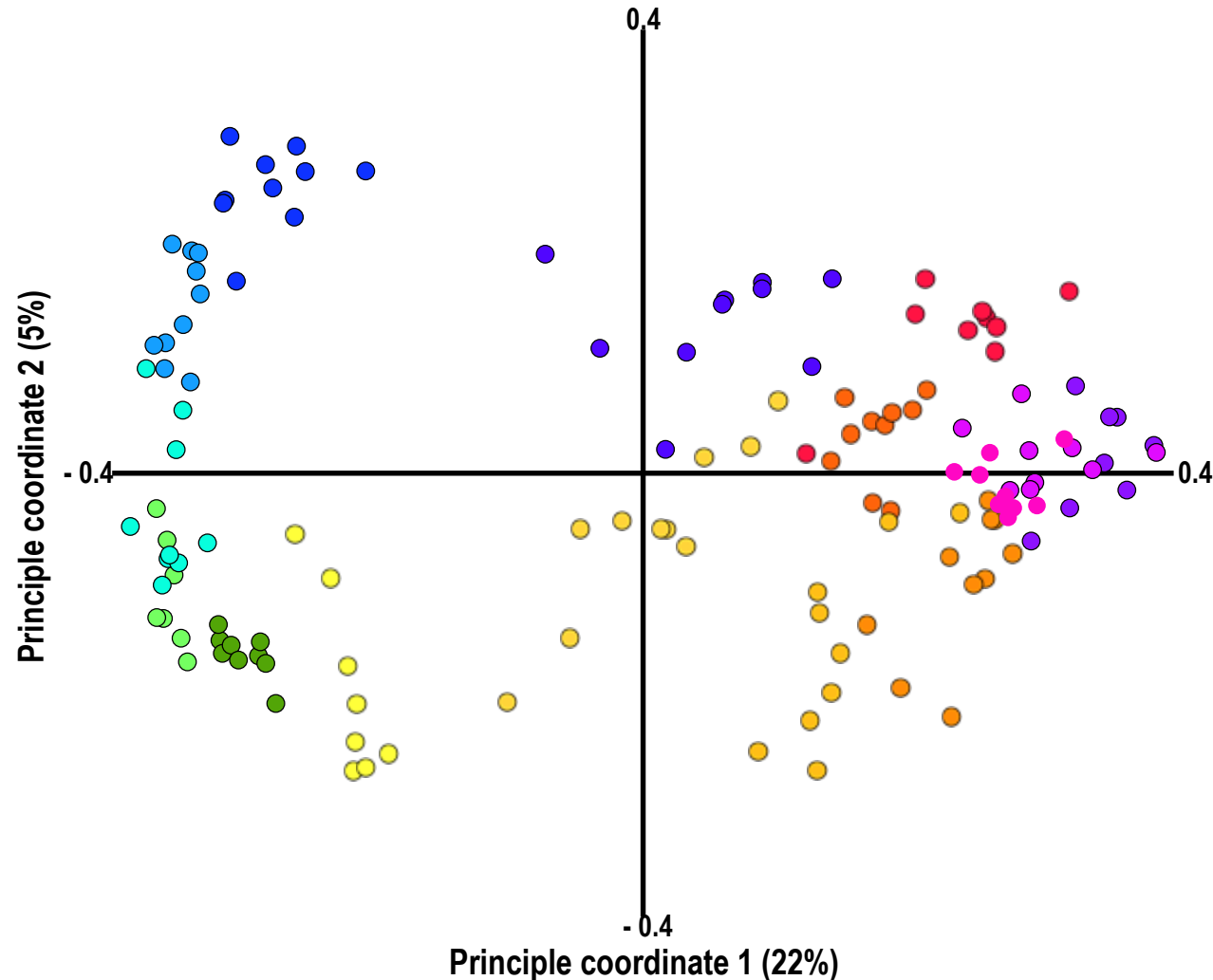
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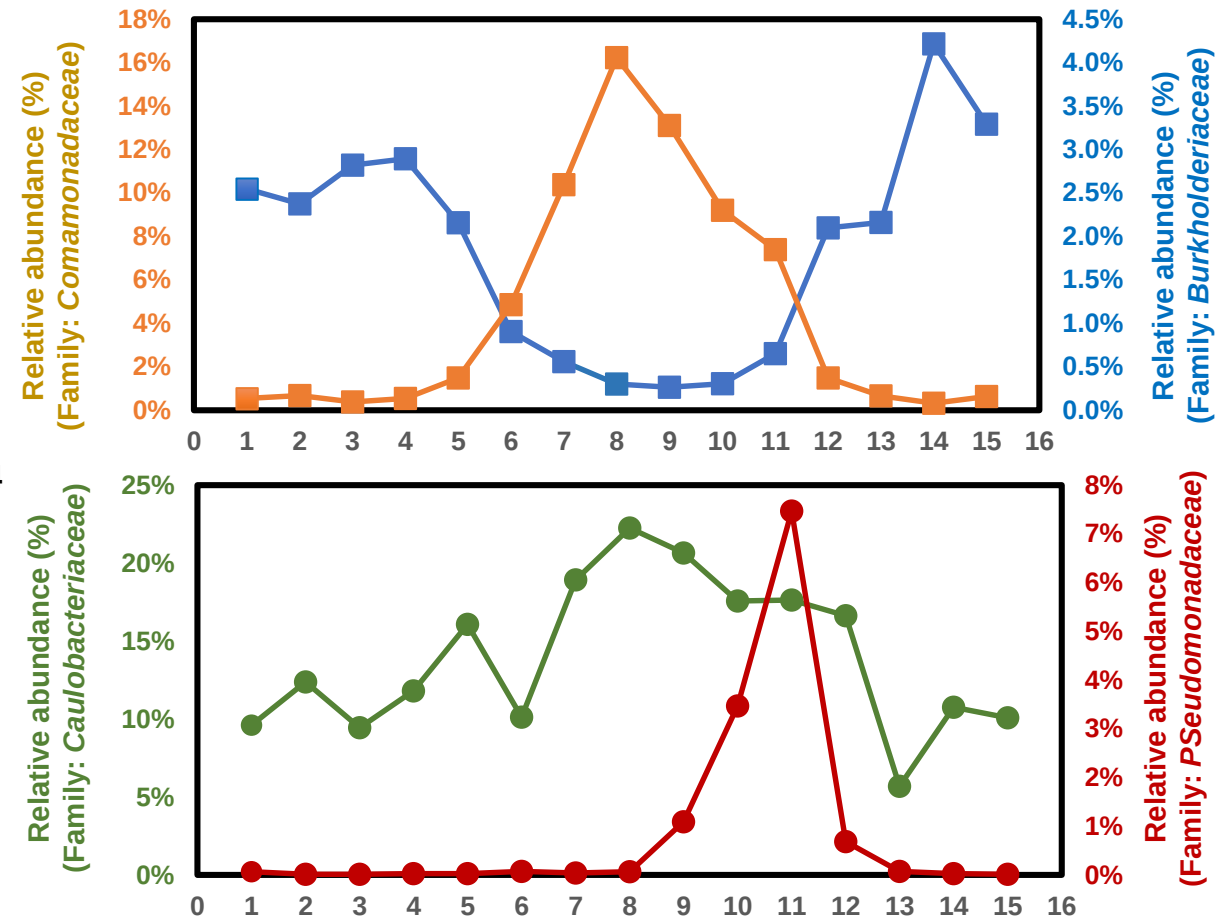
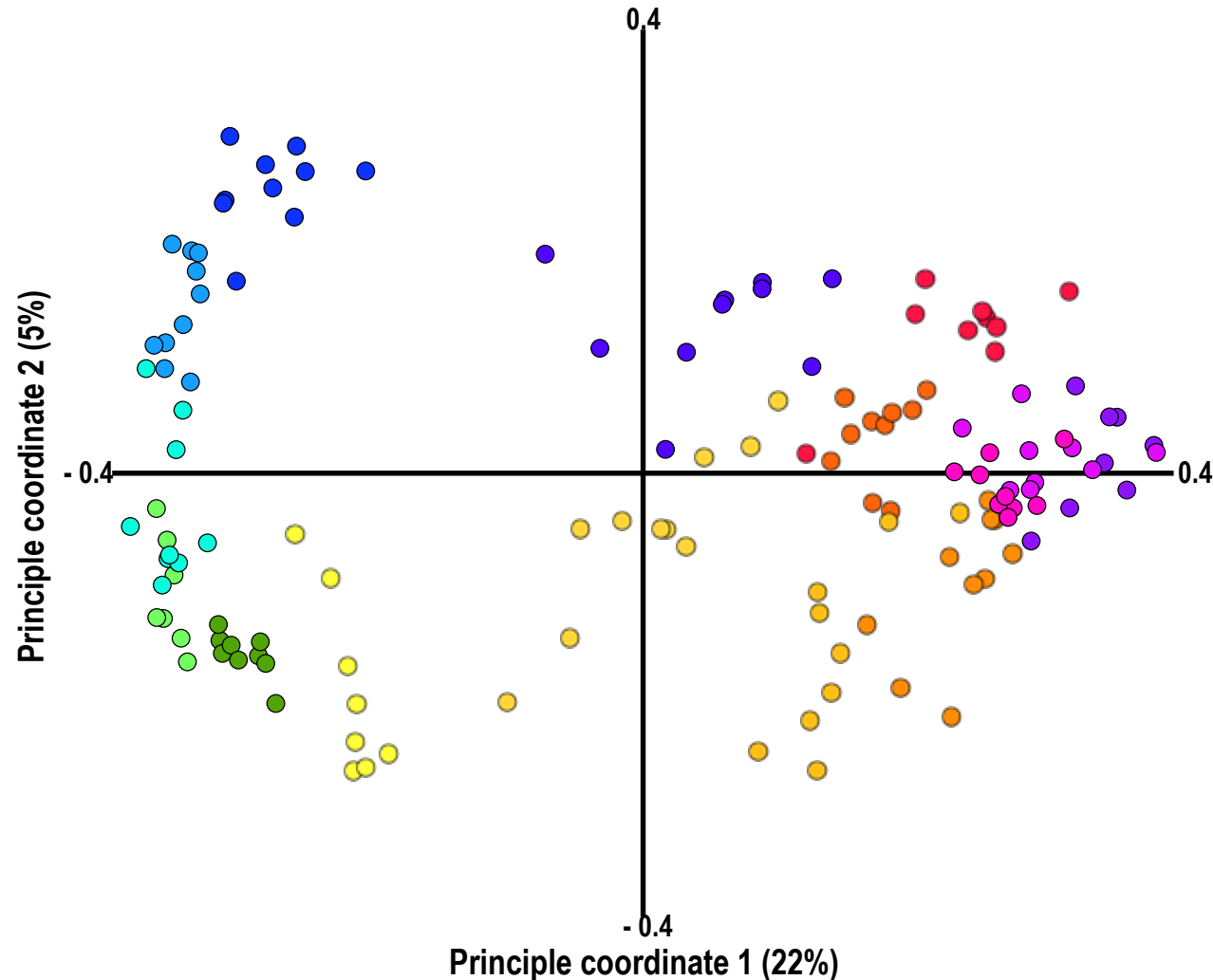
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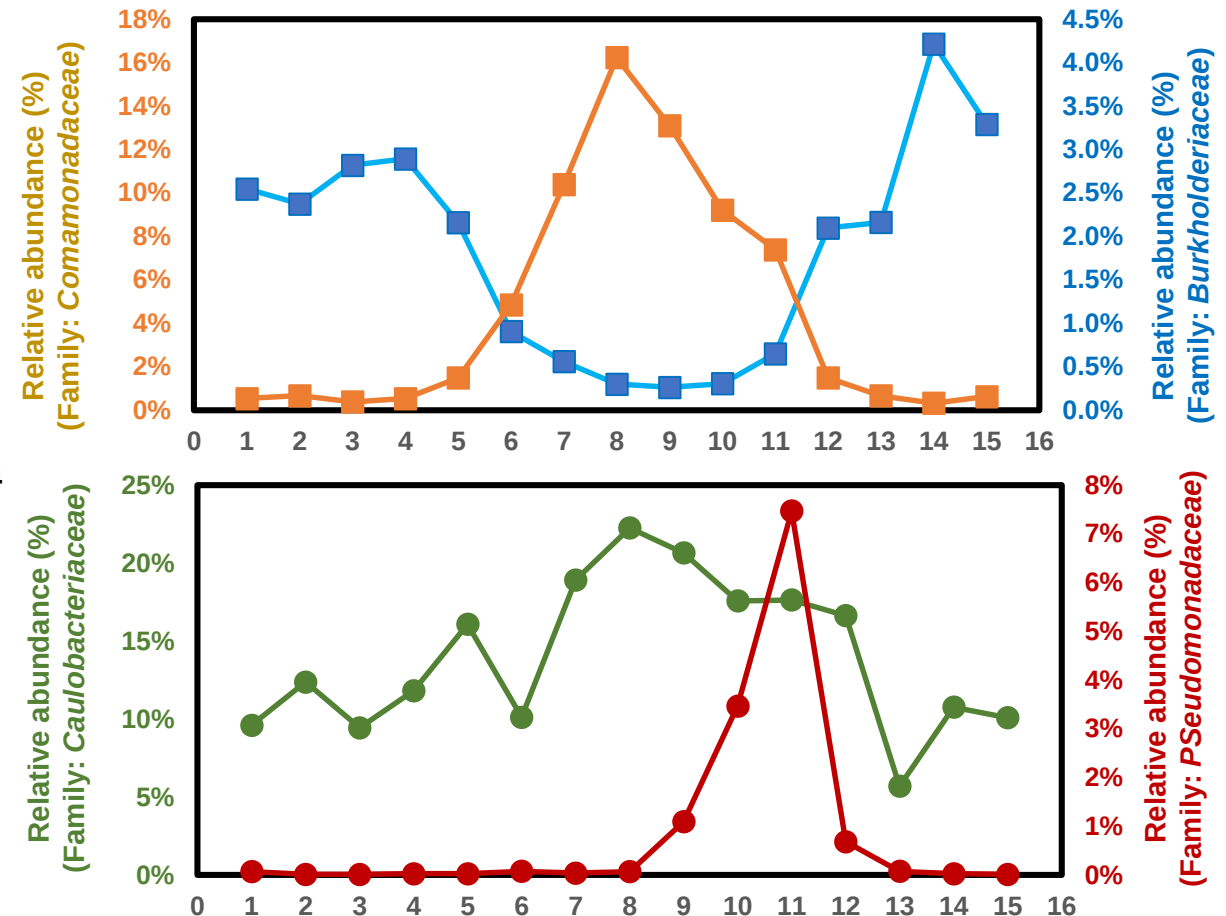
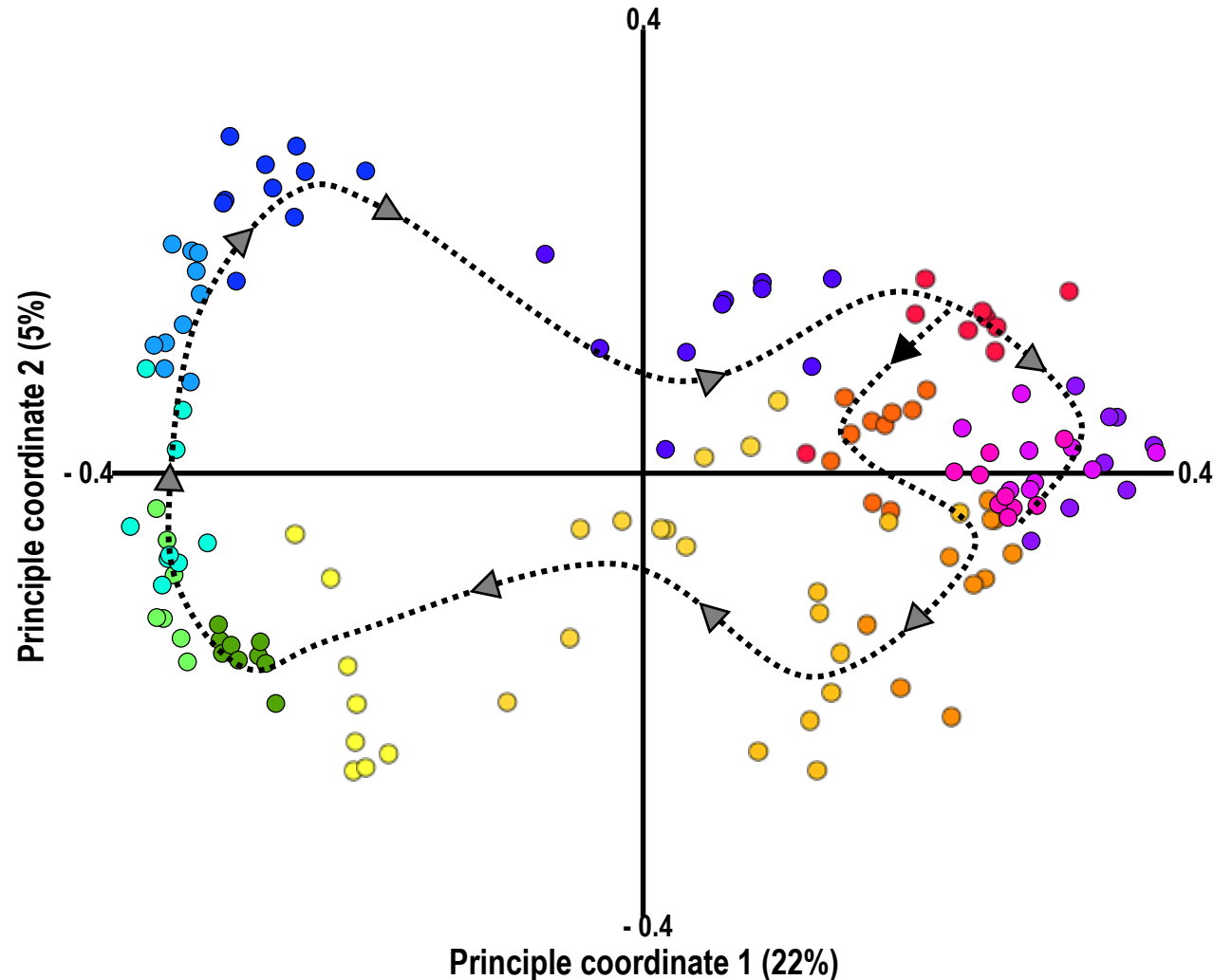
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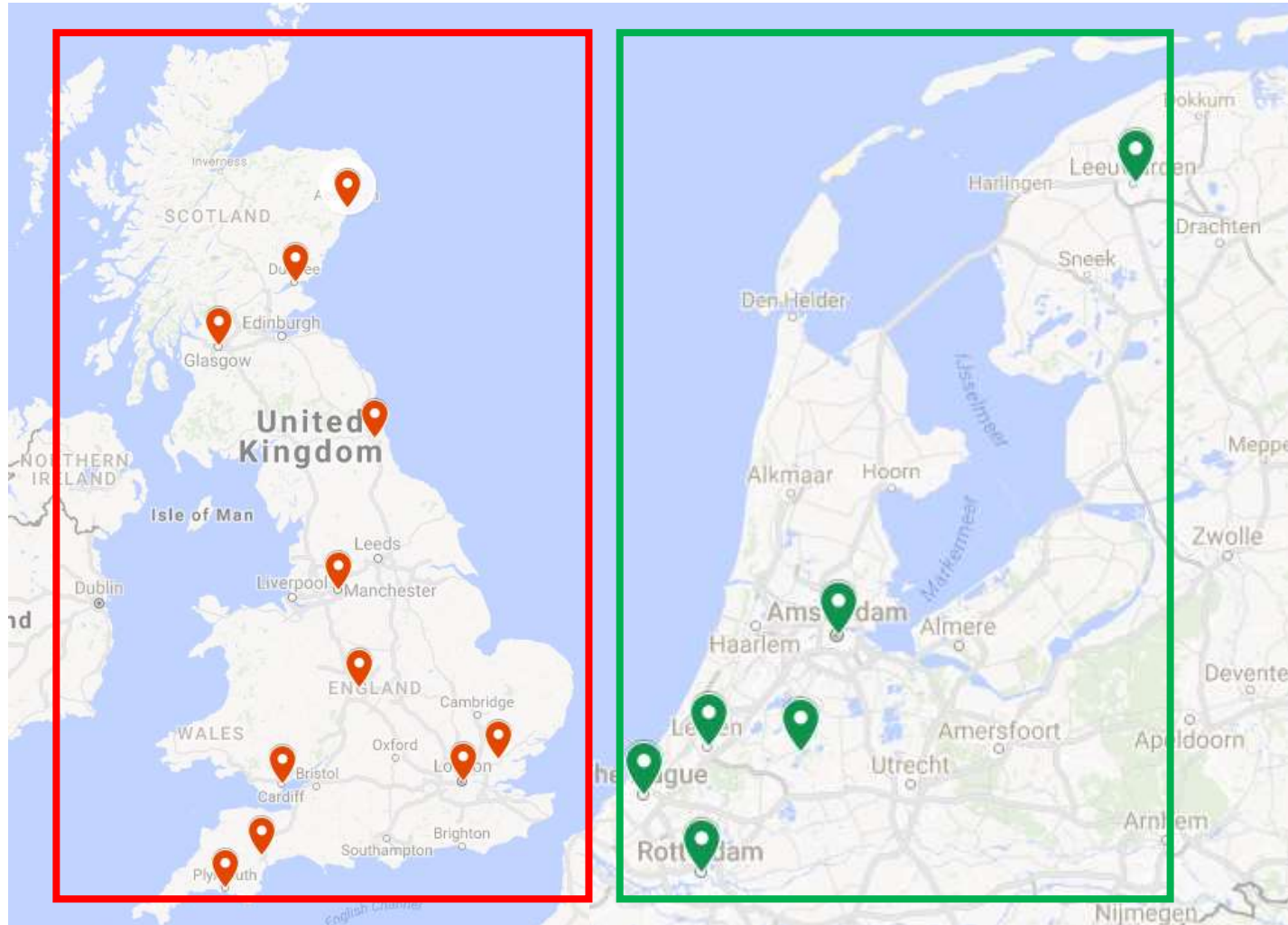
Assessing impact of disinfection by sampling full-scale drinking water systems.



Maria



Zihan



Post-filtration disinfection has a **selective impact**.

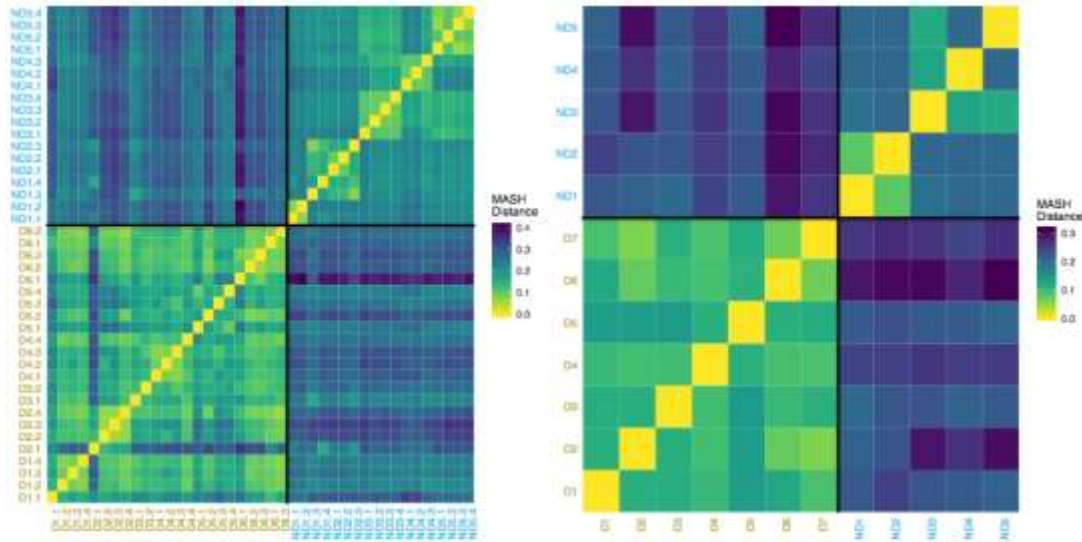


Maria

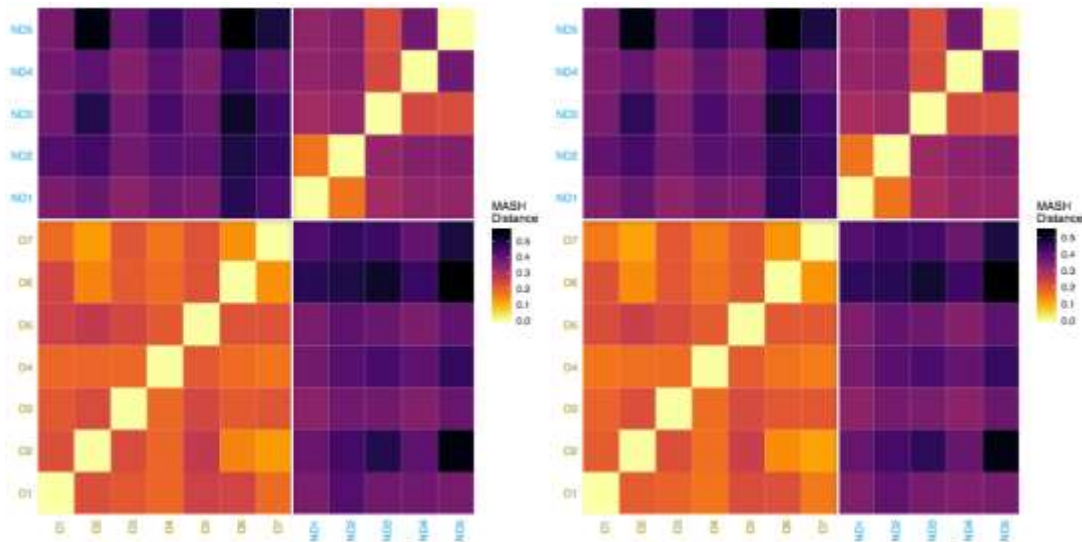


Zihan

Structure

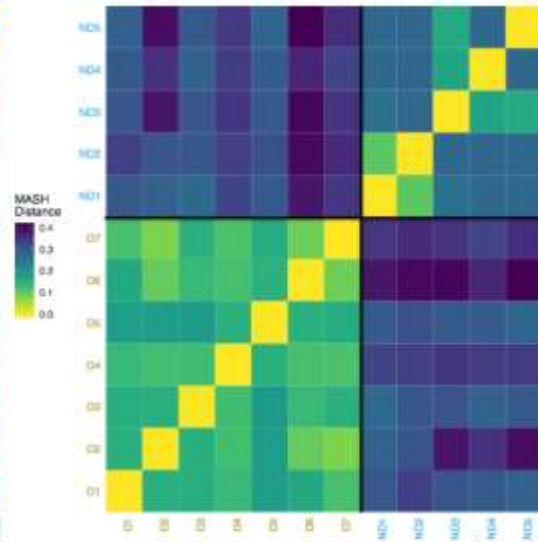
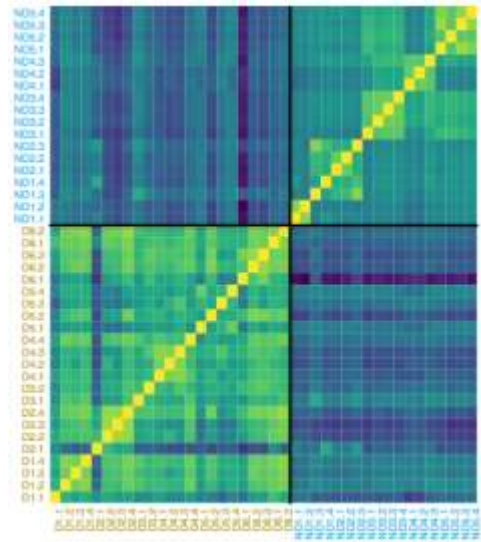


Function

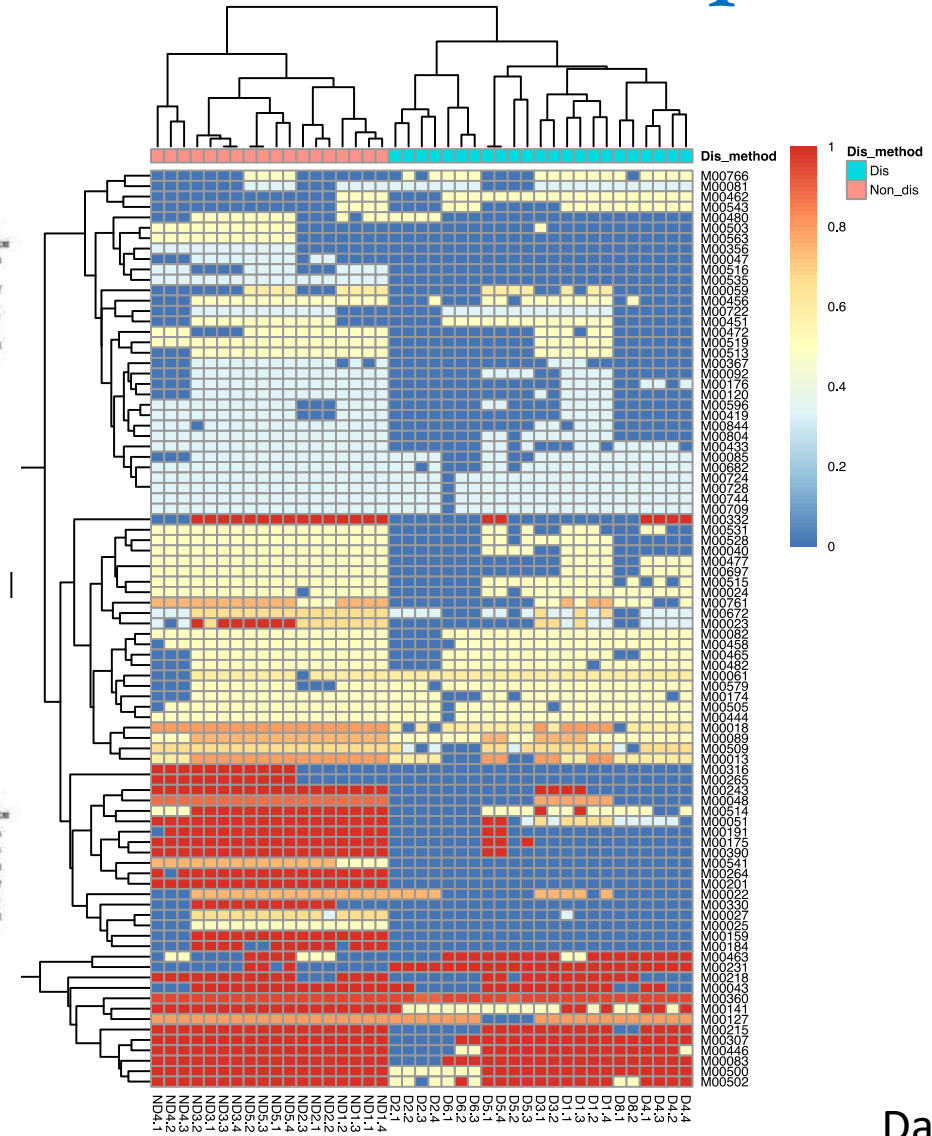
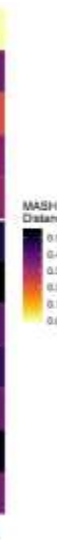
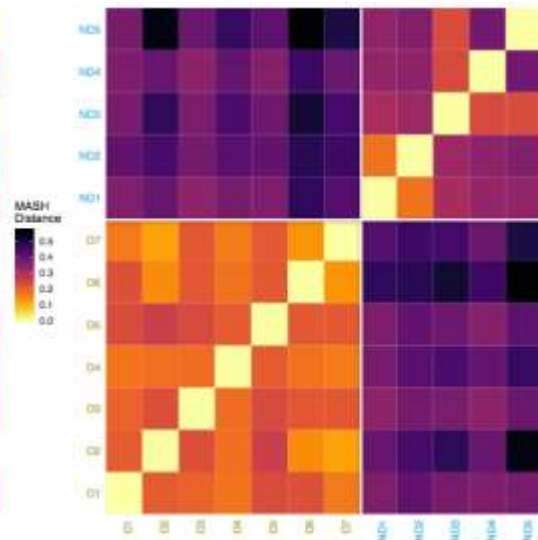
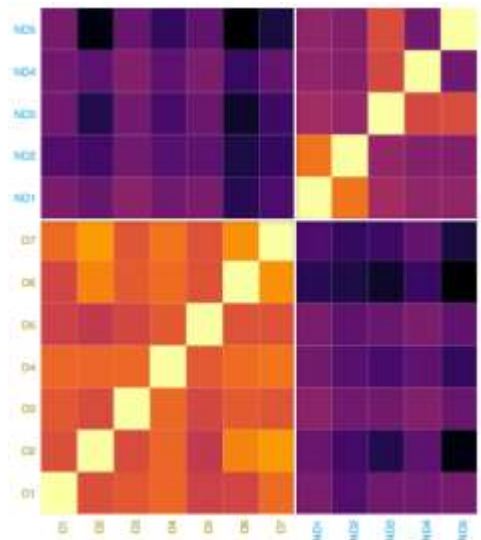


Post-filtration disinfection has a selective impact.

Structure



Function



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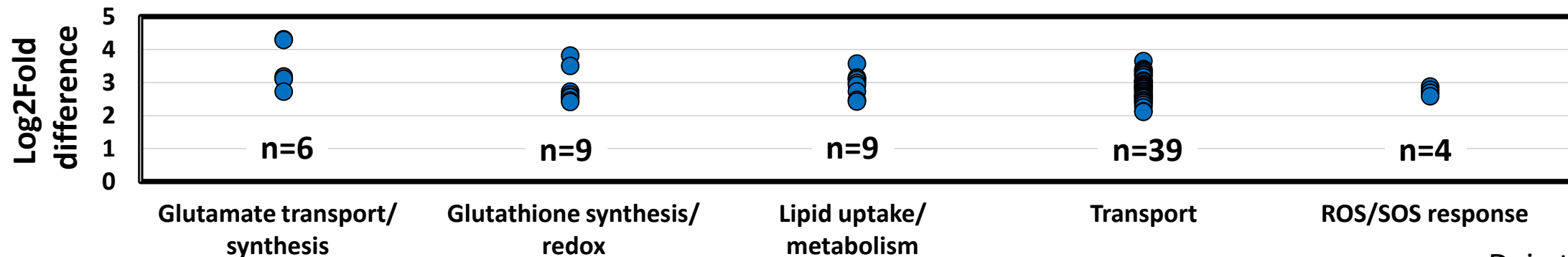
Traits to **scavenge macromolecules for cellular repair and oxidative stress** were enriched in genomes of microbes in disinfected systems.



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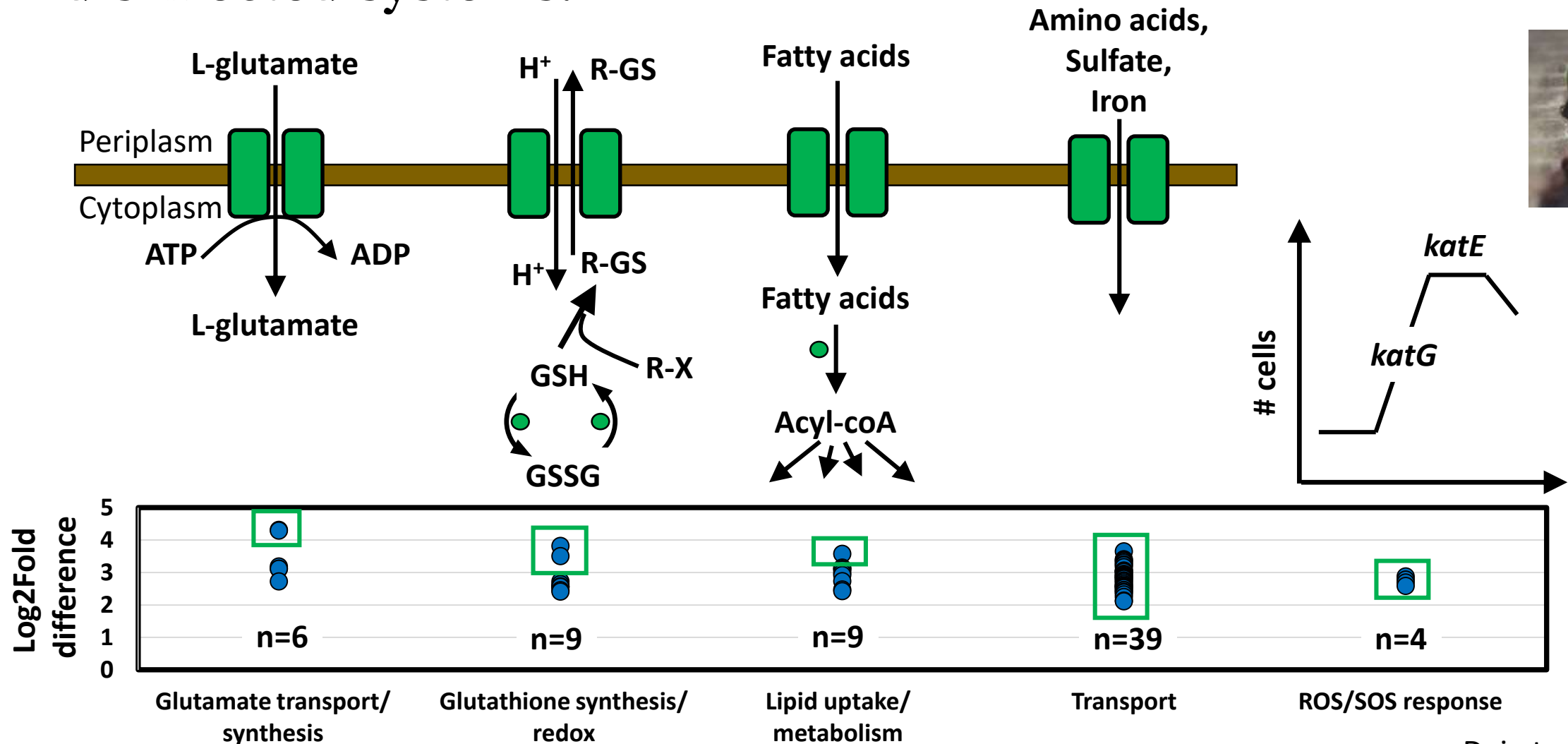
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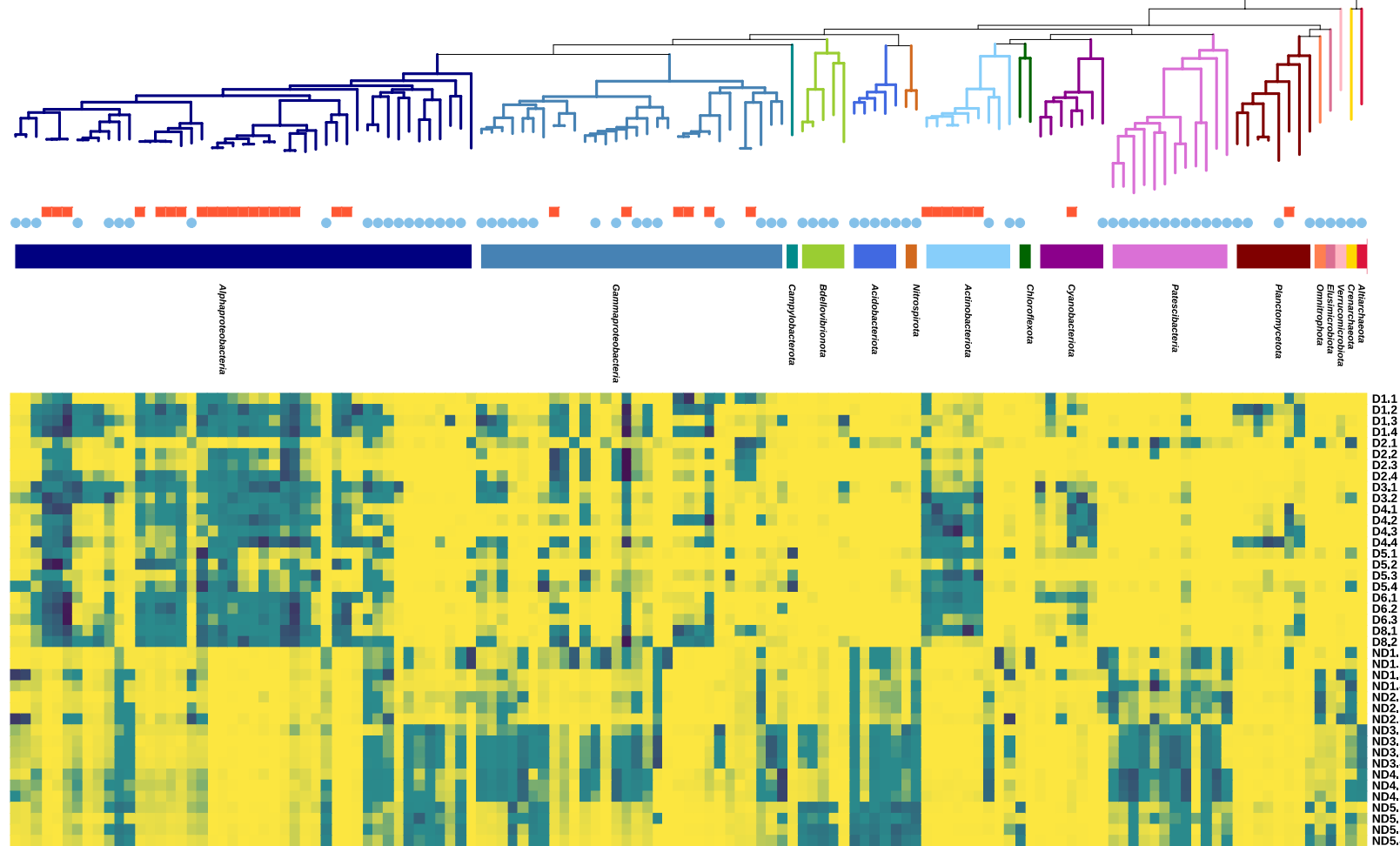
Zihan



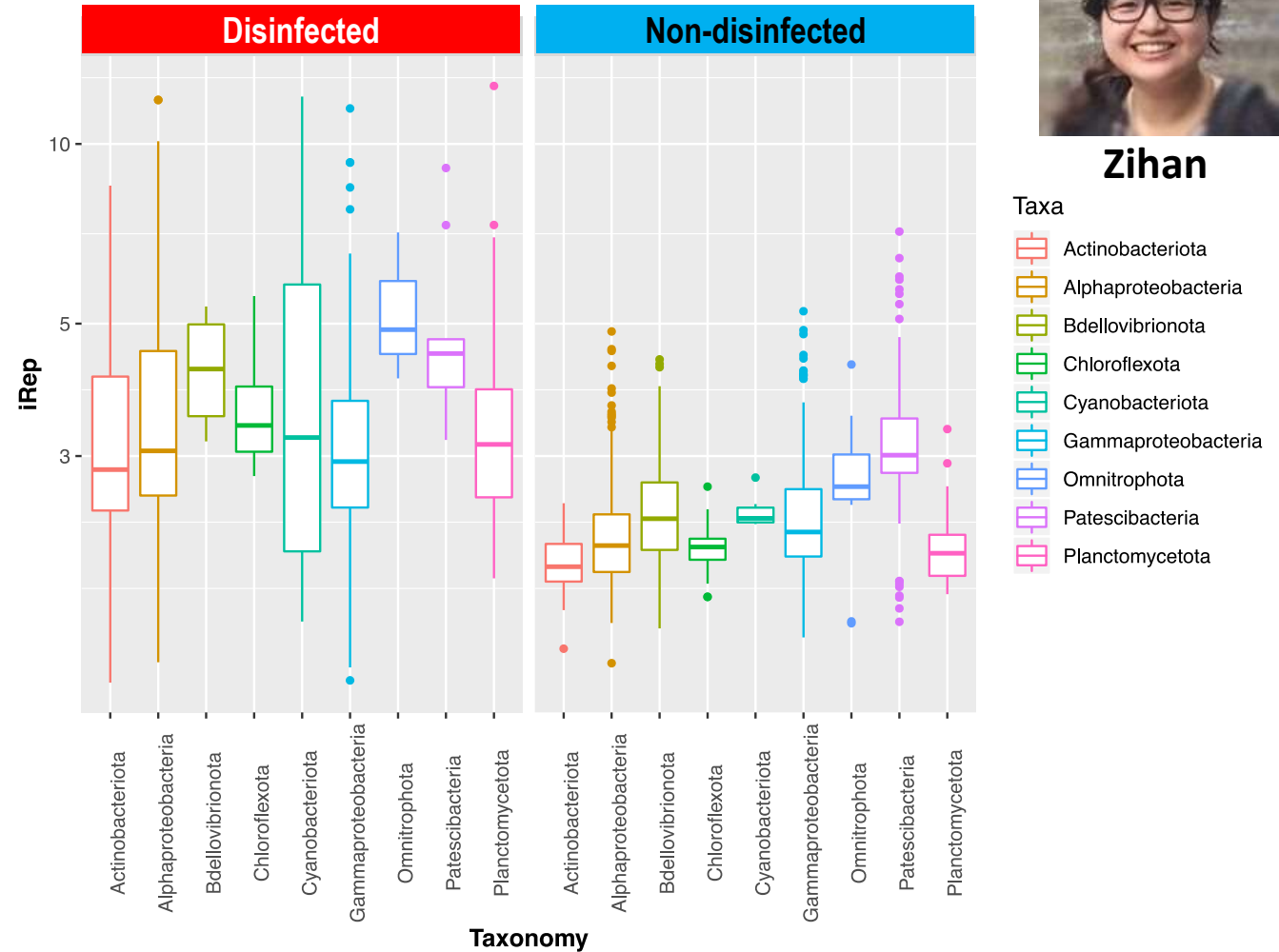
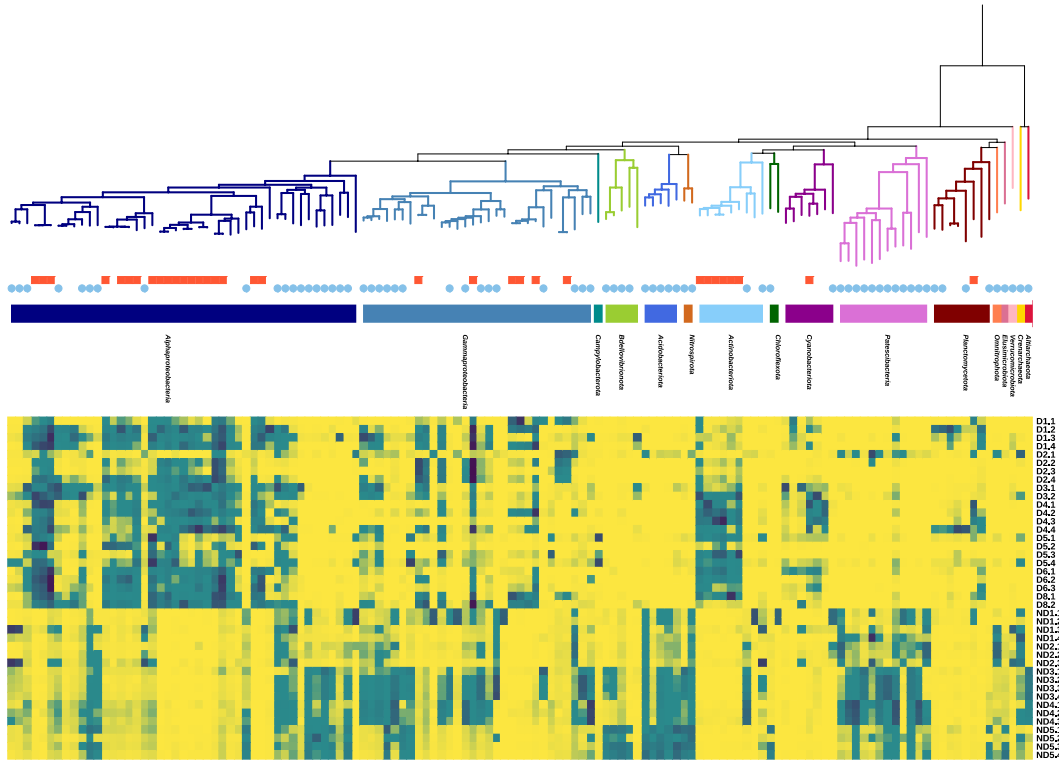
Genome coverage analyses suggests that microbes in disinfected systems have higher replication rates.



Zihan



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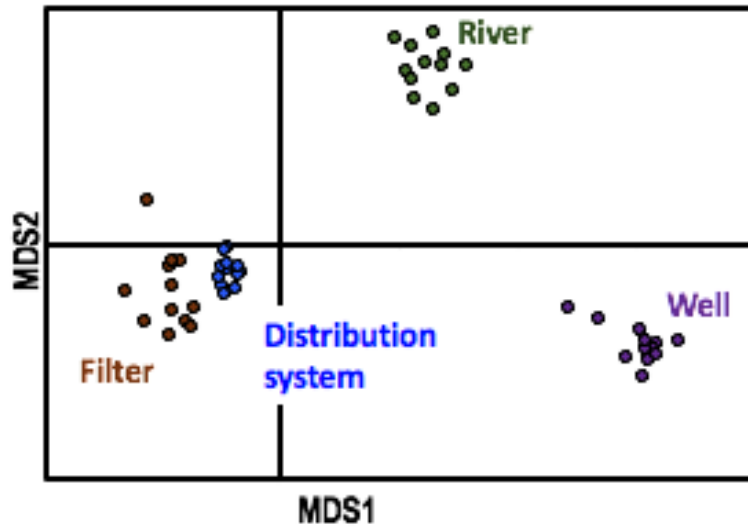


Zihan

- Taxa
- Actinobacteriota
 - Alphaproteobacteria
 - Bdellovibrionota
 - Chloroflexota
 - Cyanobacteriota
 - Gammaproteobacteria
 - Omnitrophota
 - Patescibacteria
 - Planctomycetota

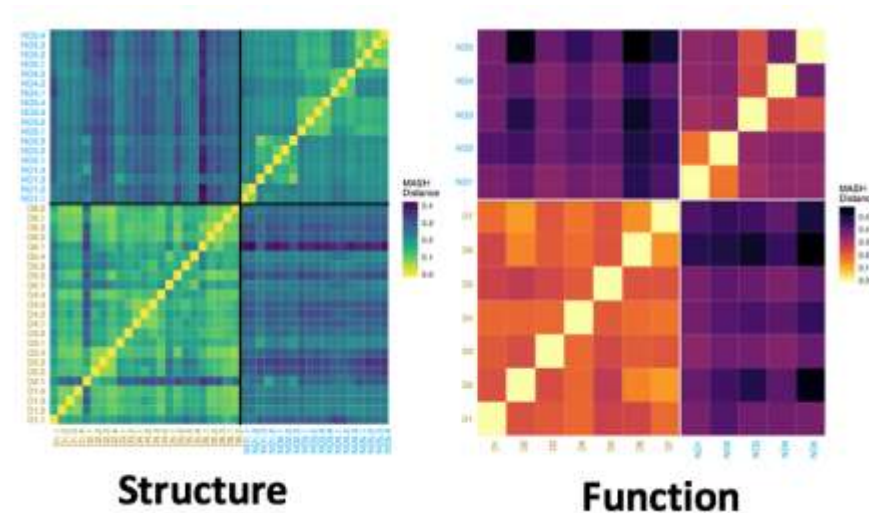
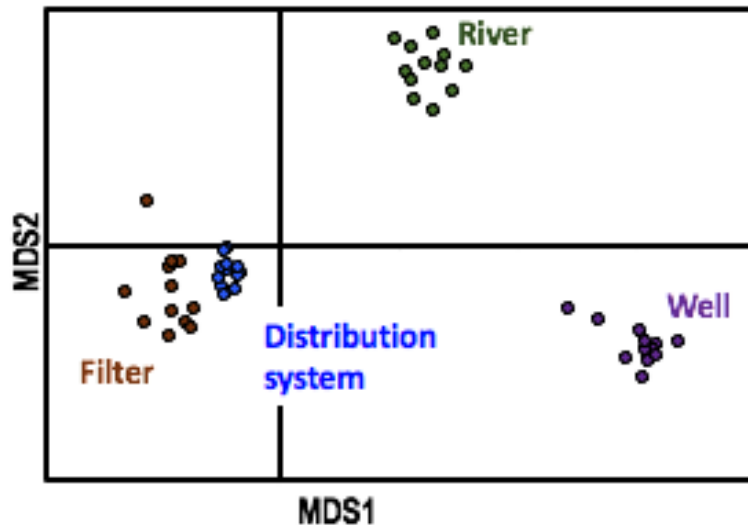
In Drinking water systems

Filter seeds

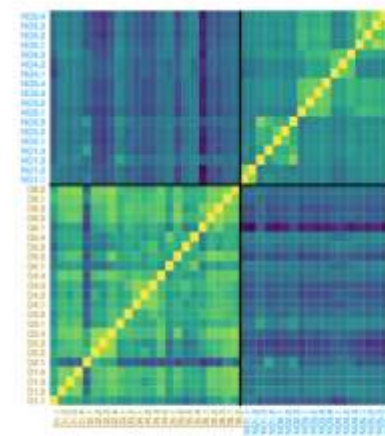
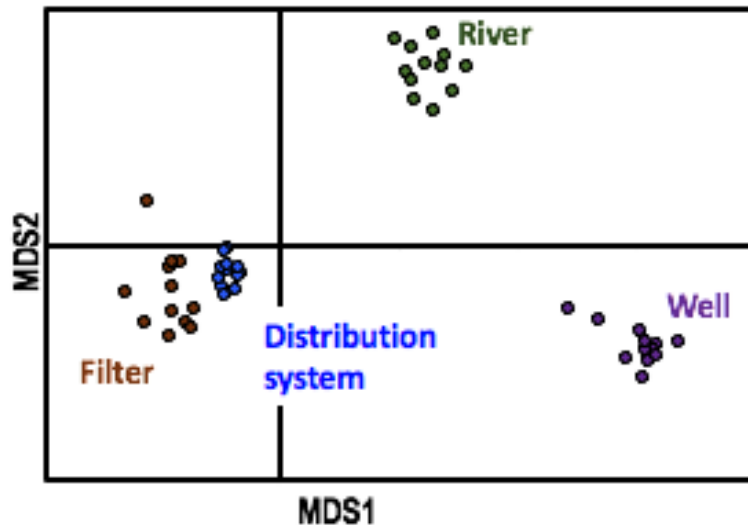


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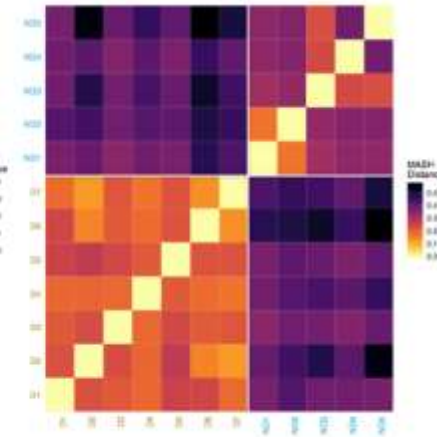
Filter seeds and disinfection
selects



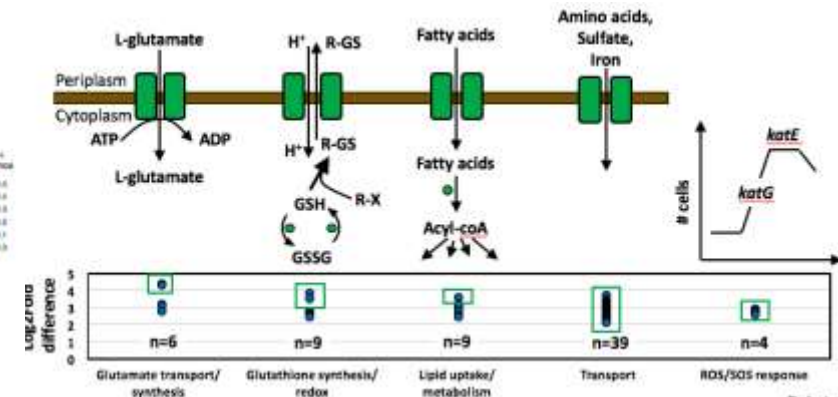
In Drinking water systems
Filter seeds and disinfection
selects for rapid growing
scavengers & ROS/RCS resistant
microbes



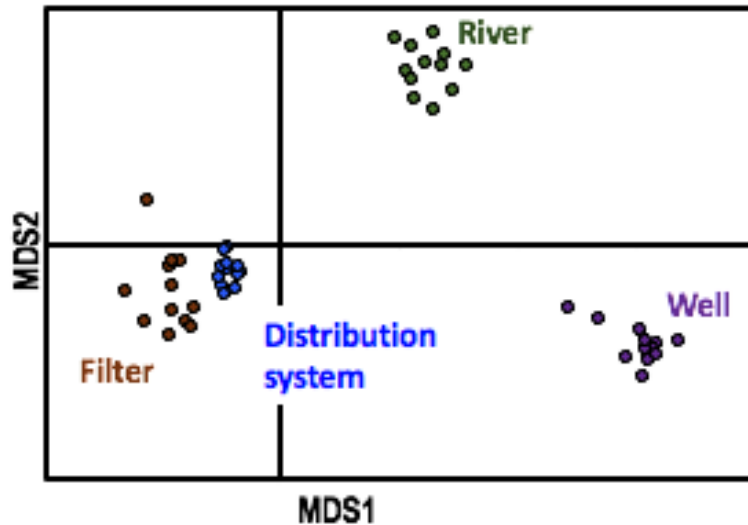
Structure



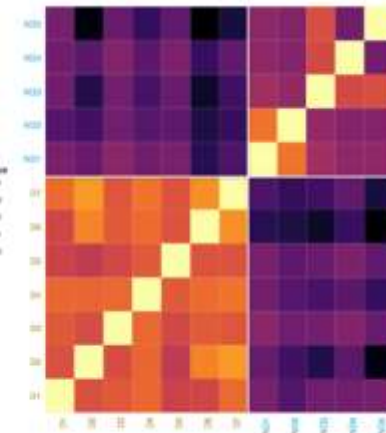
Function



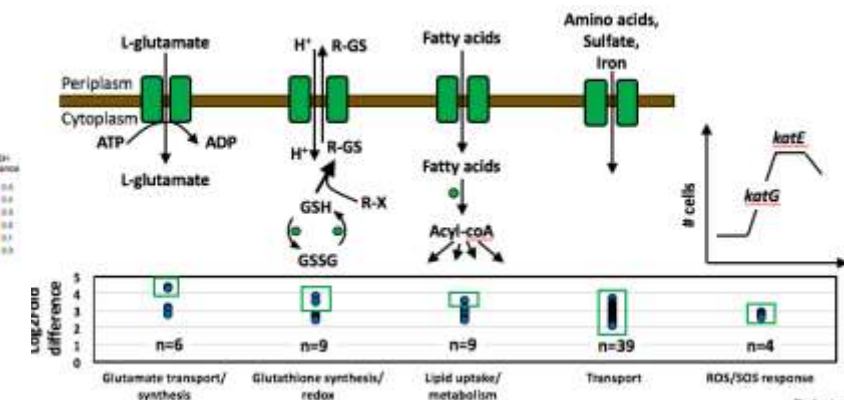
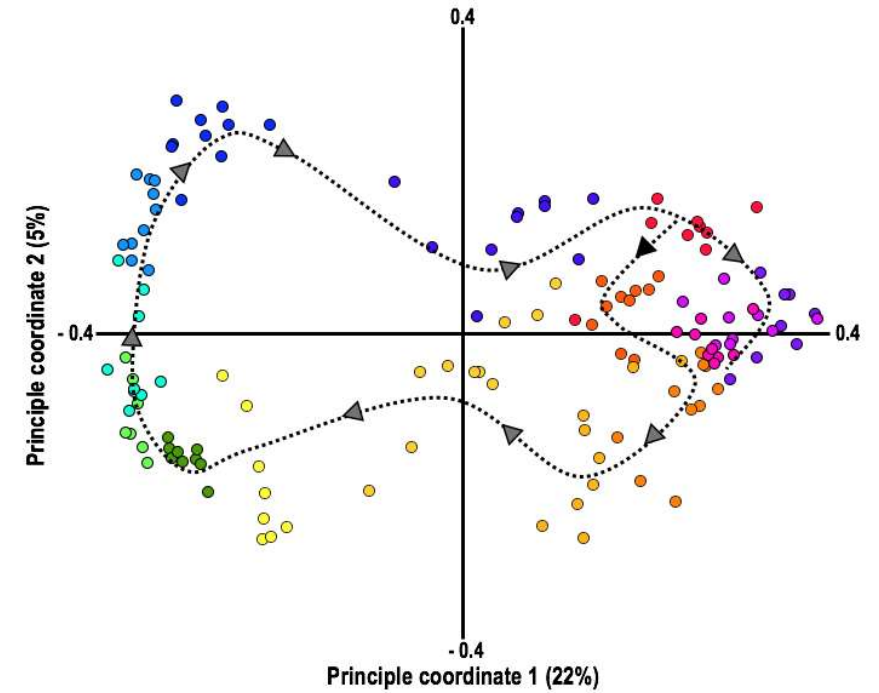
In Drinking water systems
Filter seeds and disinfection
selects for rapid growing
scavengers & ROS/RCS resistant
microbes in a systematic and
reproducible way.



Structure

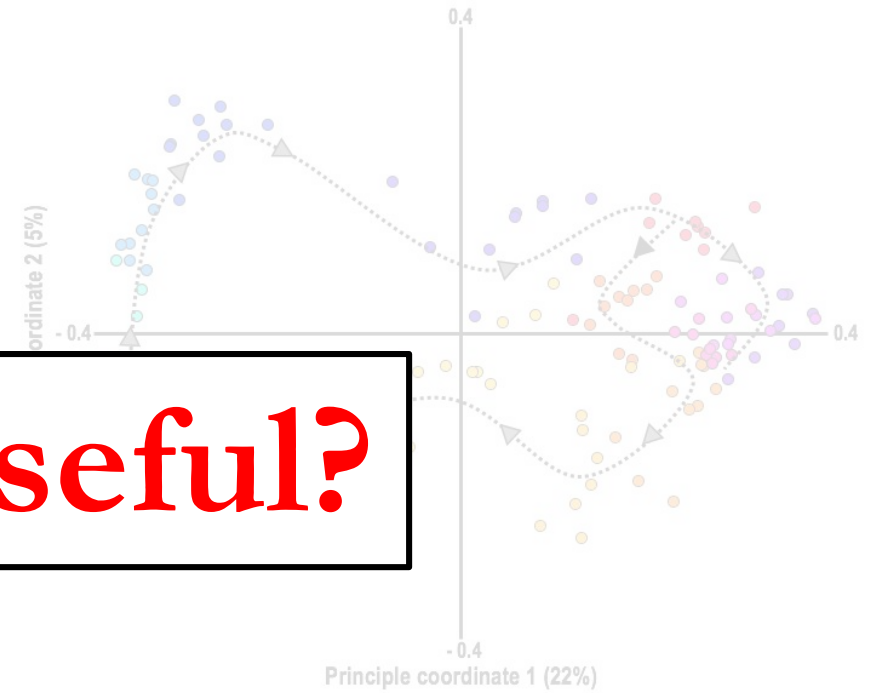


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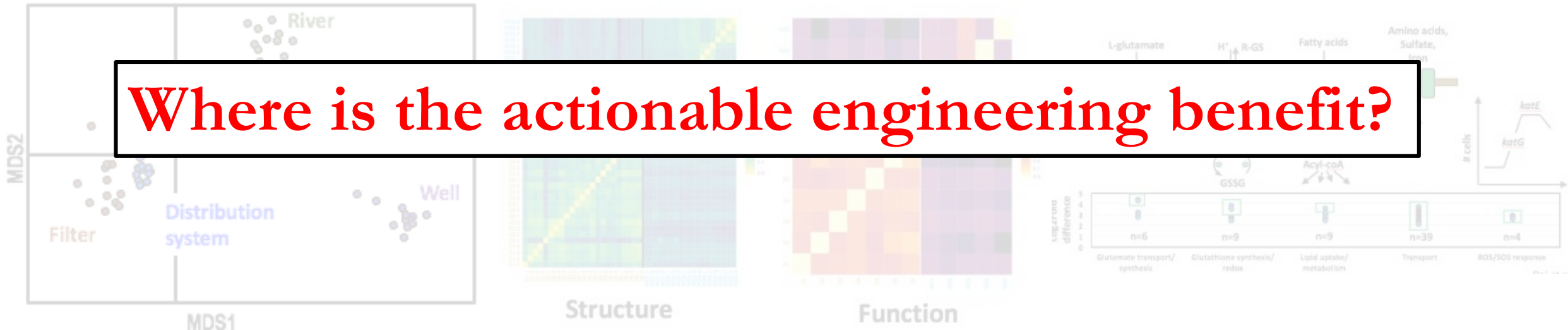


In Drinking water systems
Filter seeds and disinfection
selects for scavengers & ROS/RCS
resistant n
and repro

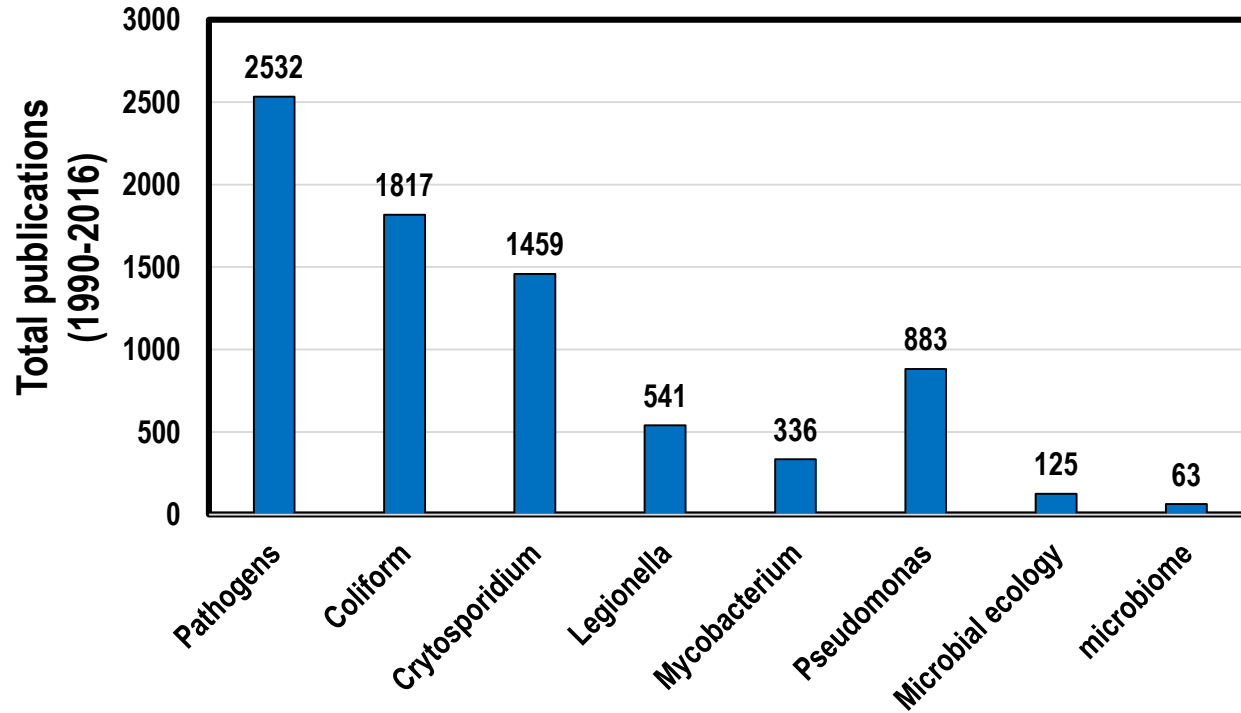
But why is this useful?



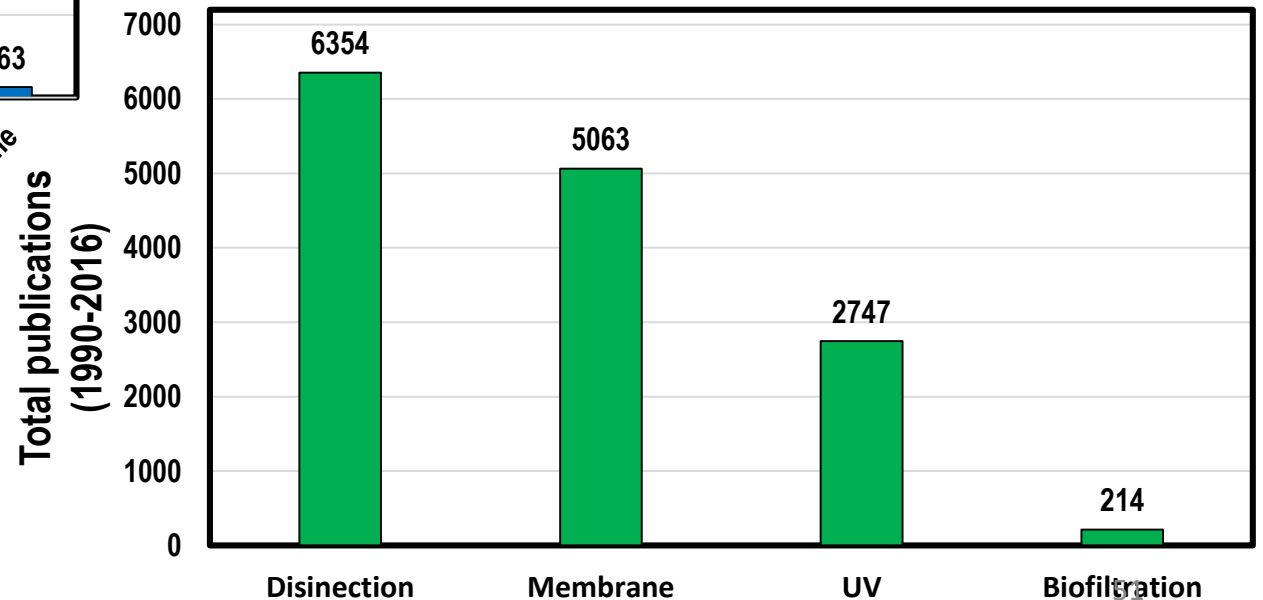
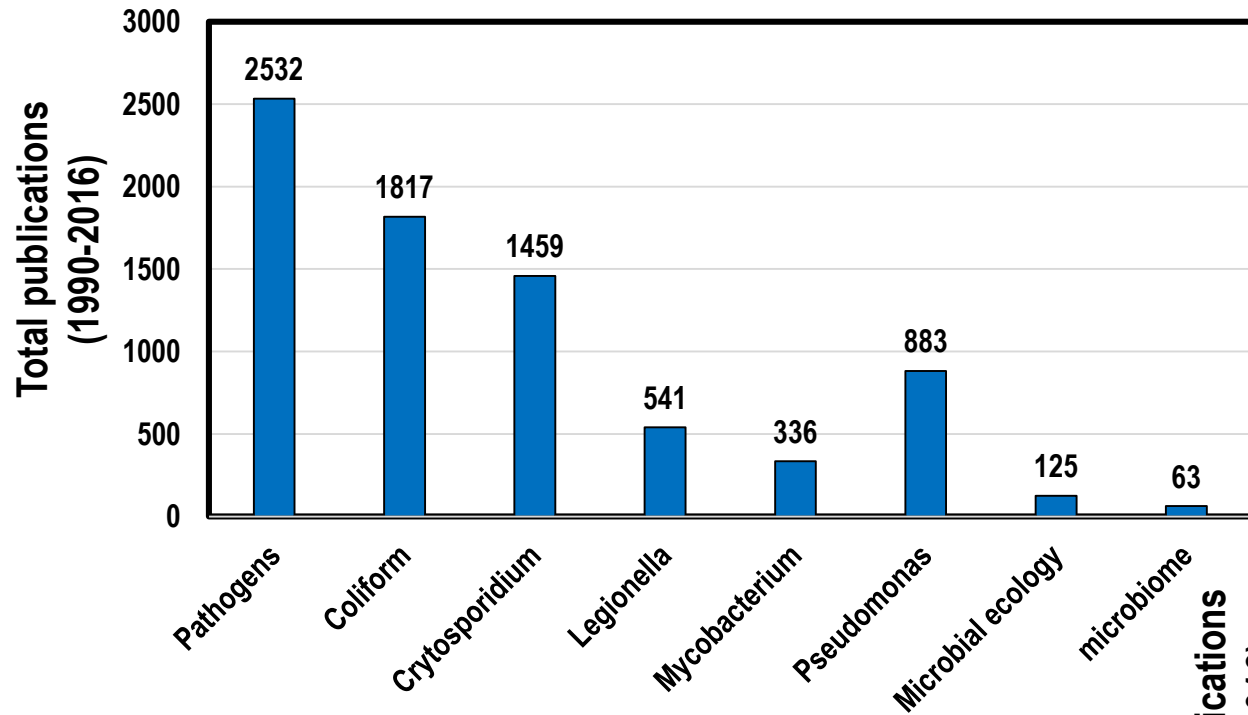
Where is the actionable engineering benefit?



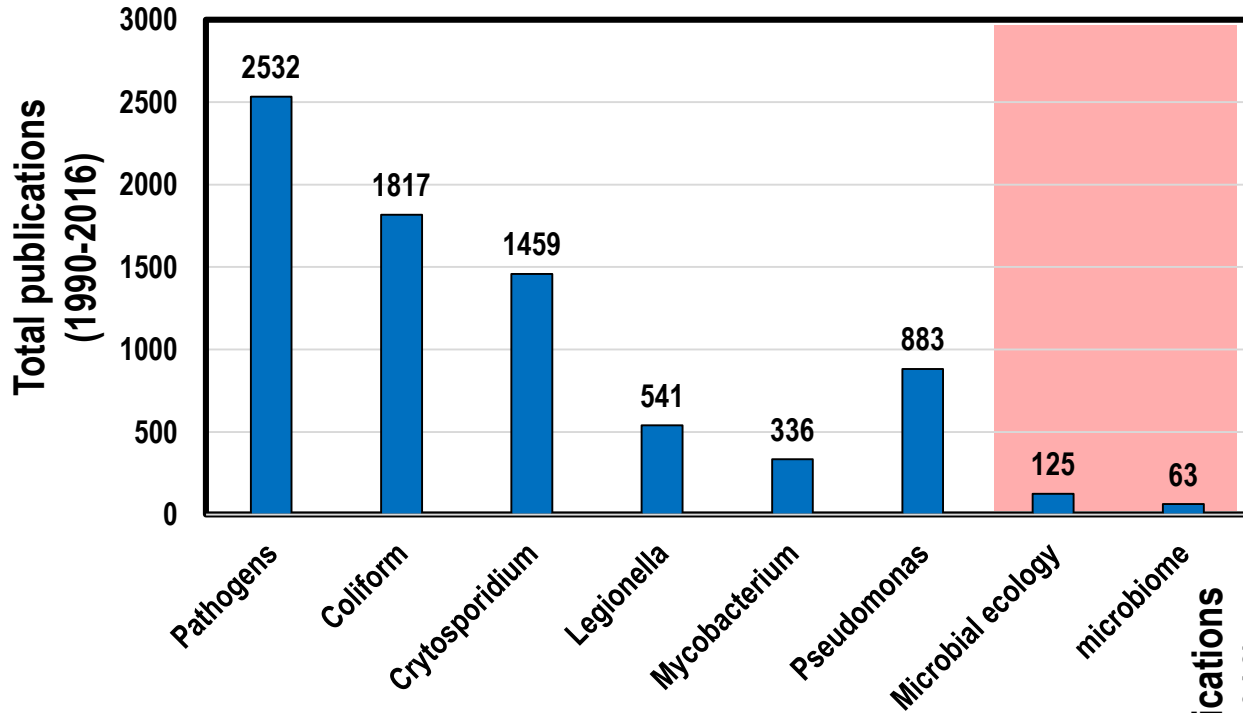
“Who” we manage has been largely constrained to pathogens.



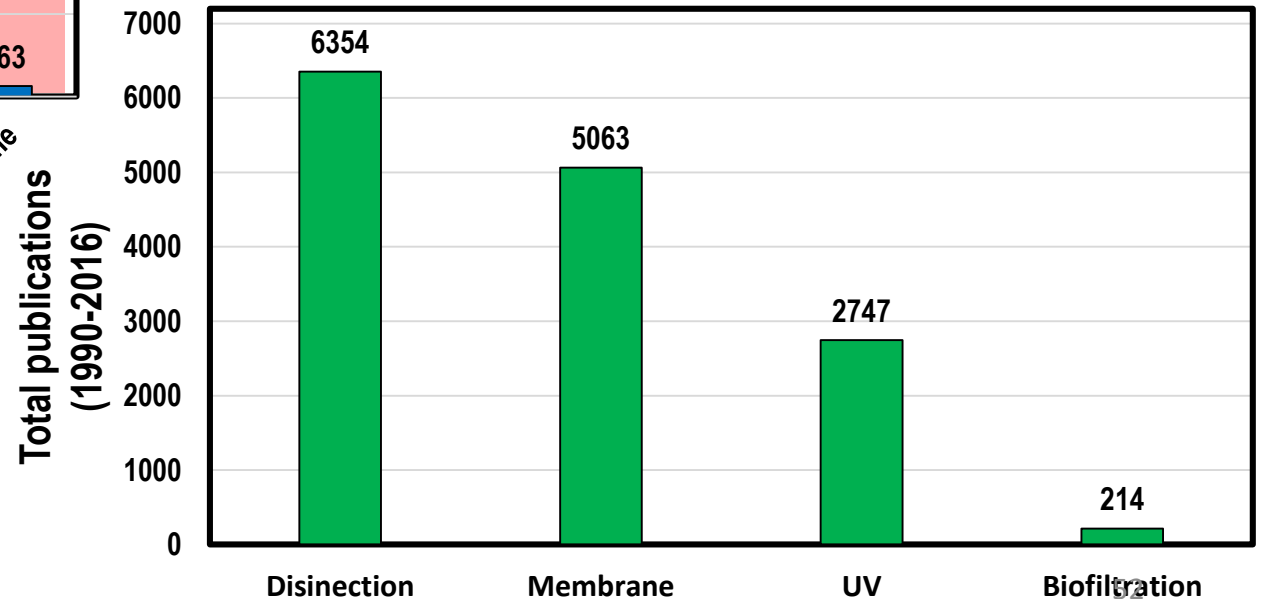
“Who” and “how” we manage has been largely constrained to pathogens.

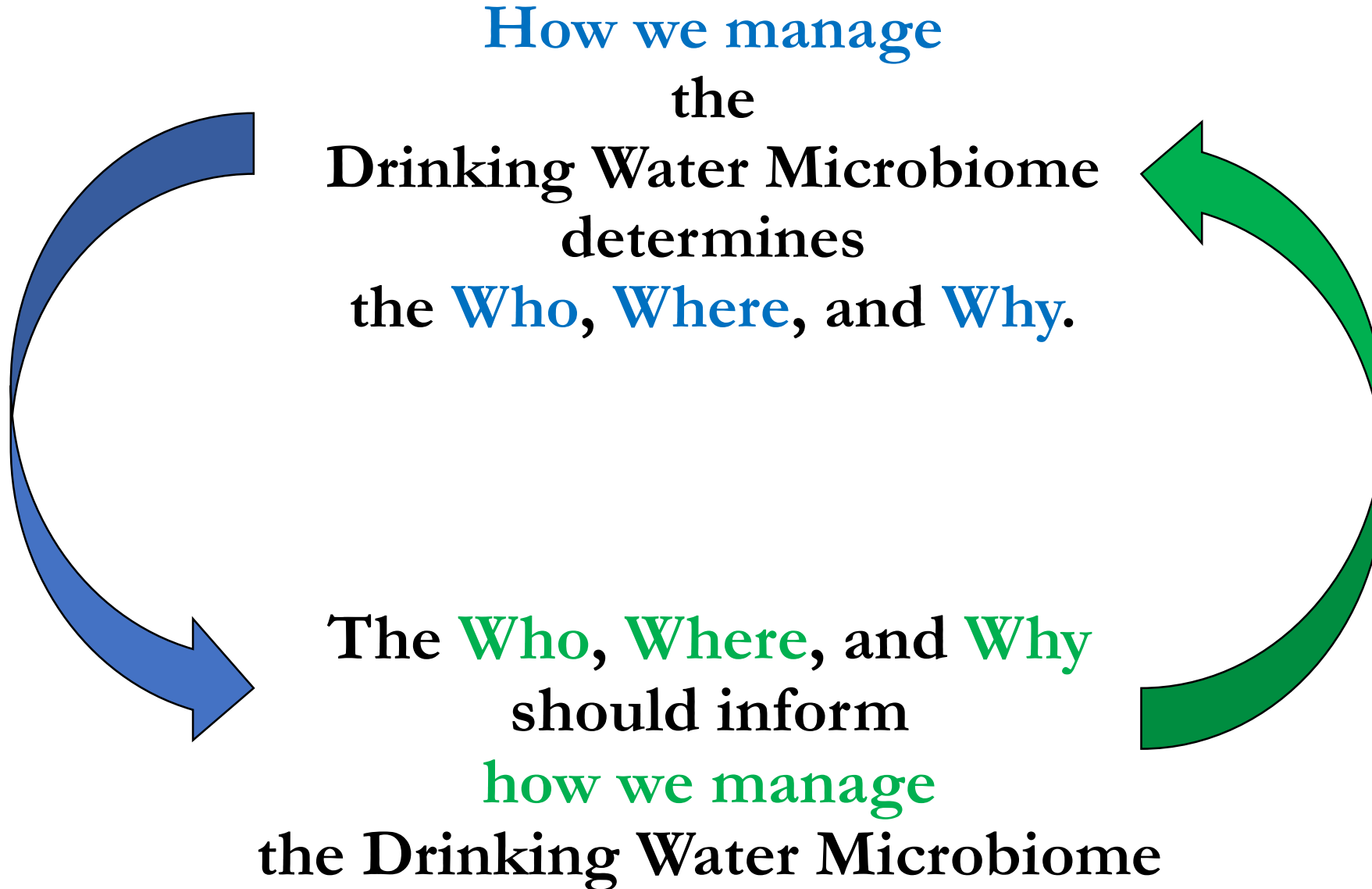


Transitioning from **pathogen-centric** to **microbiome-inclusive** is the future

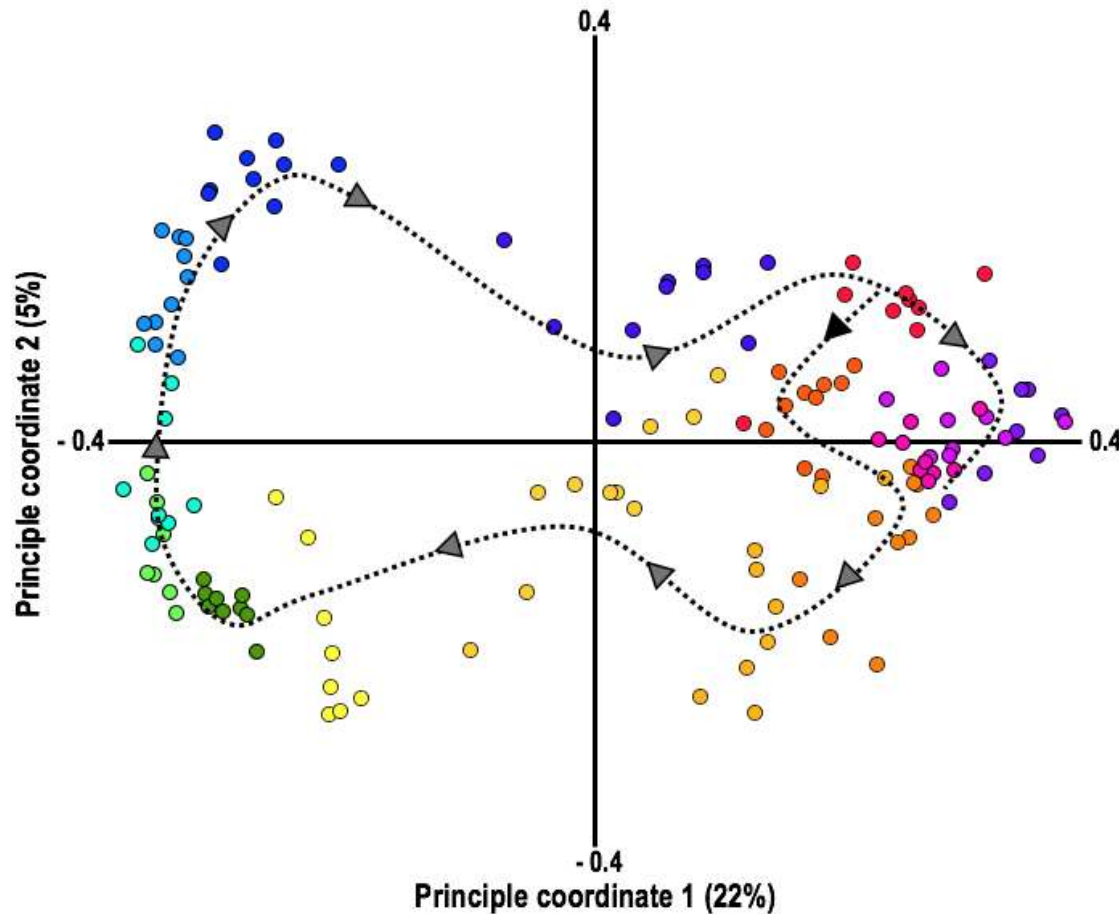


Opportunity in ecology

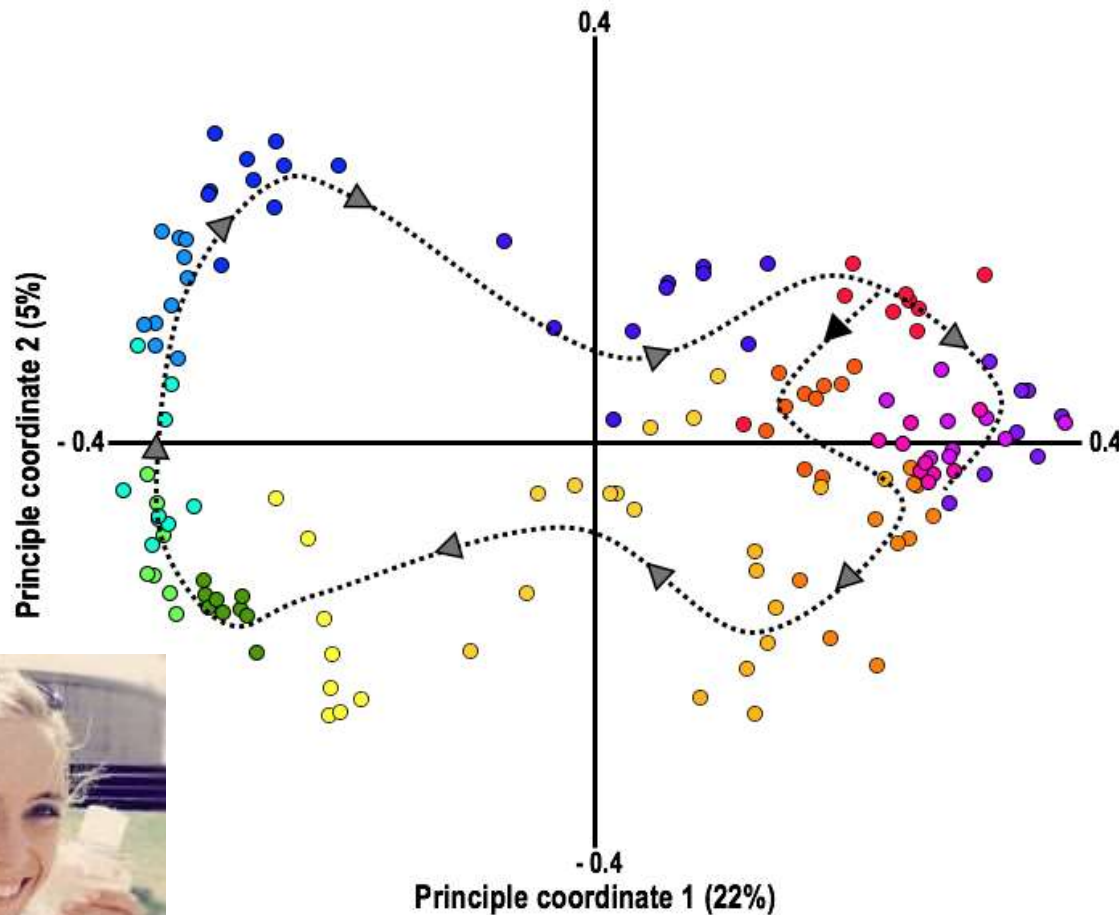




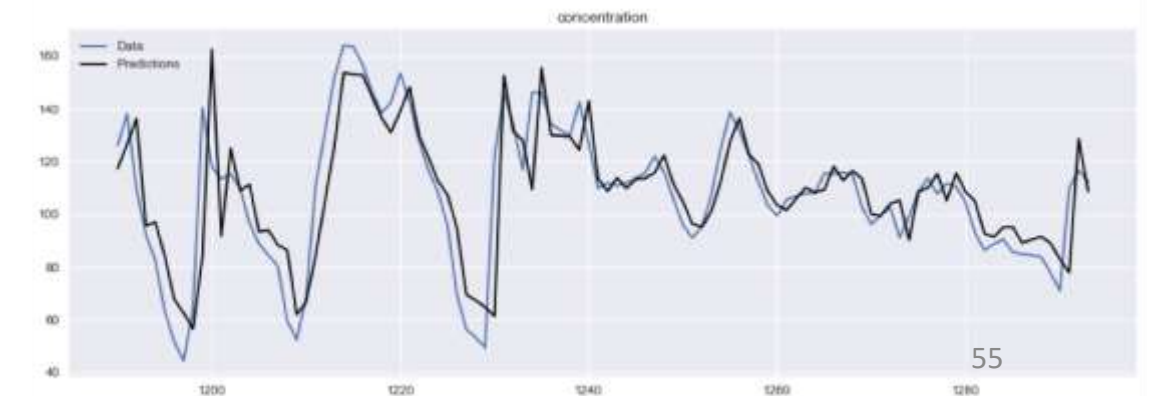
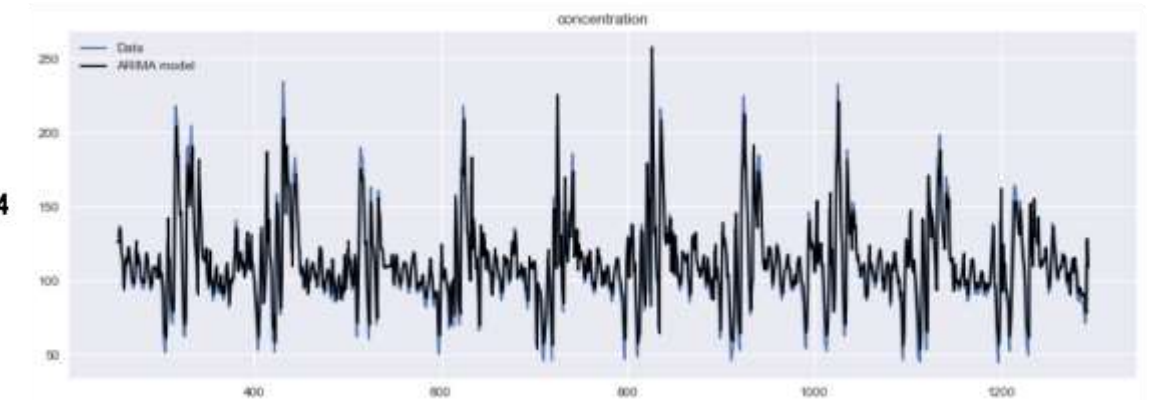
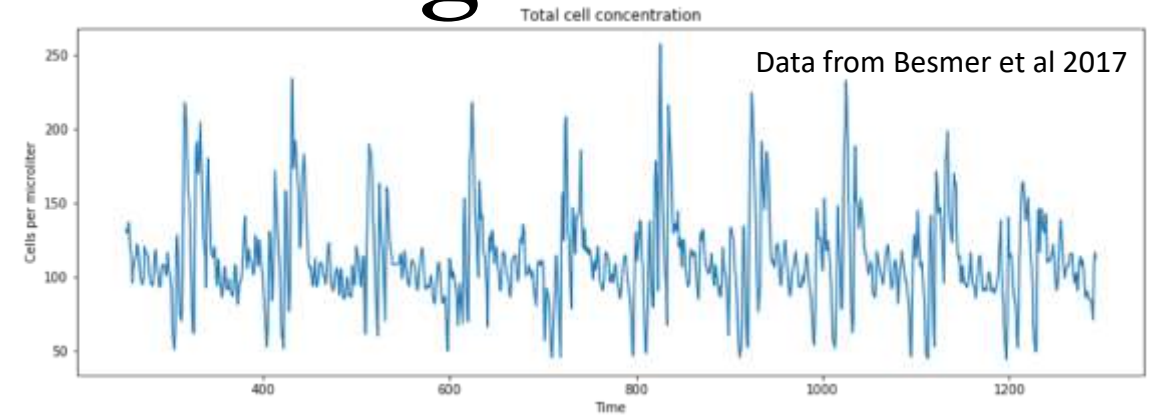
High-resolution datasets coupled with spatial-temporal modeling can enable **prediction**.



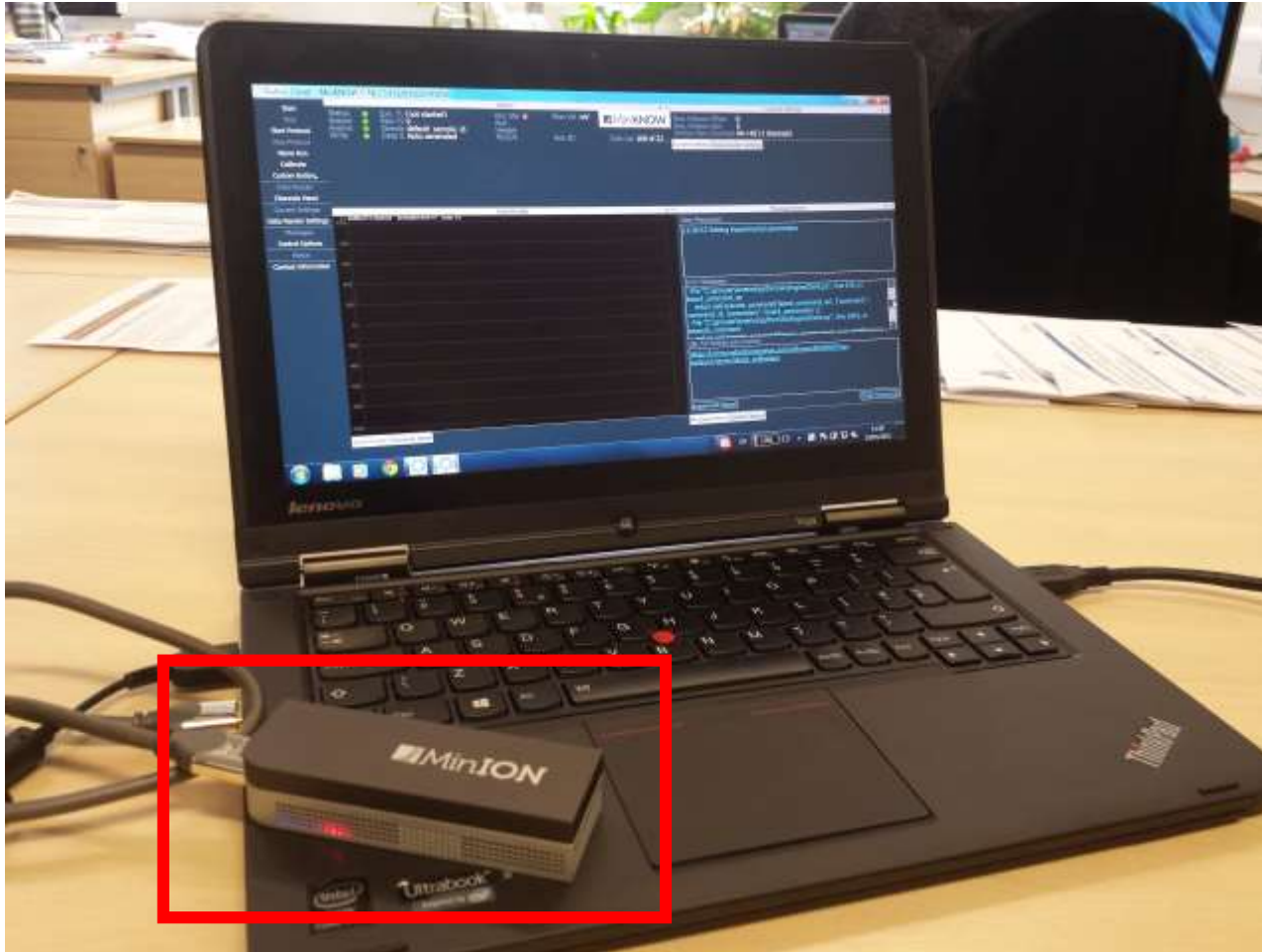
Monitor and Predict the drinking water microbiome.



Solize Vosloo



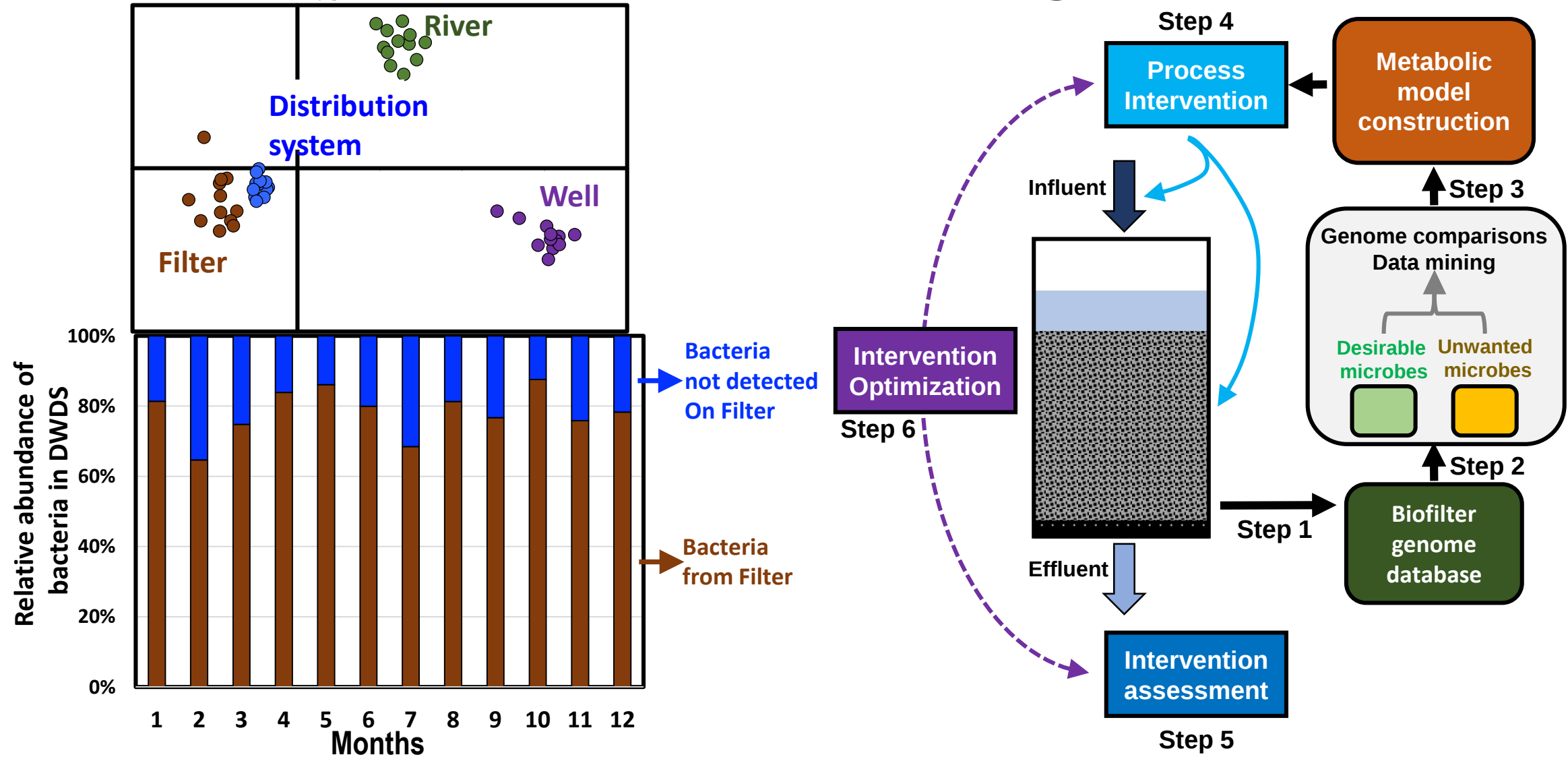
Remote, real-time, and autonomous monitoring of microbes in drinking water.



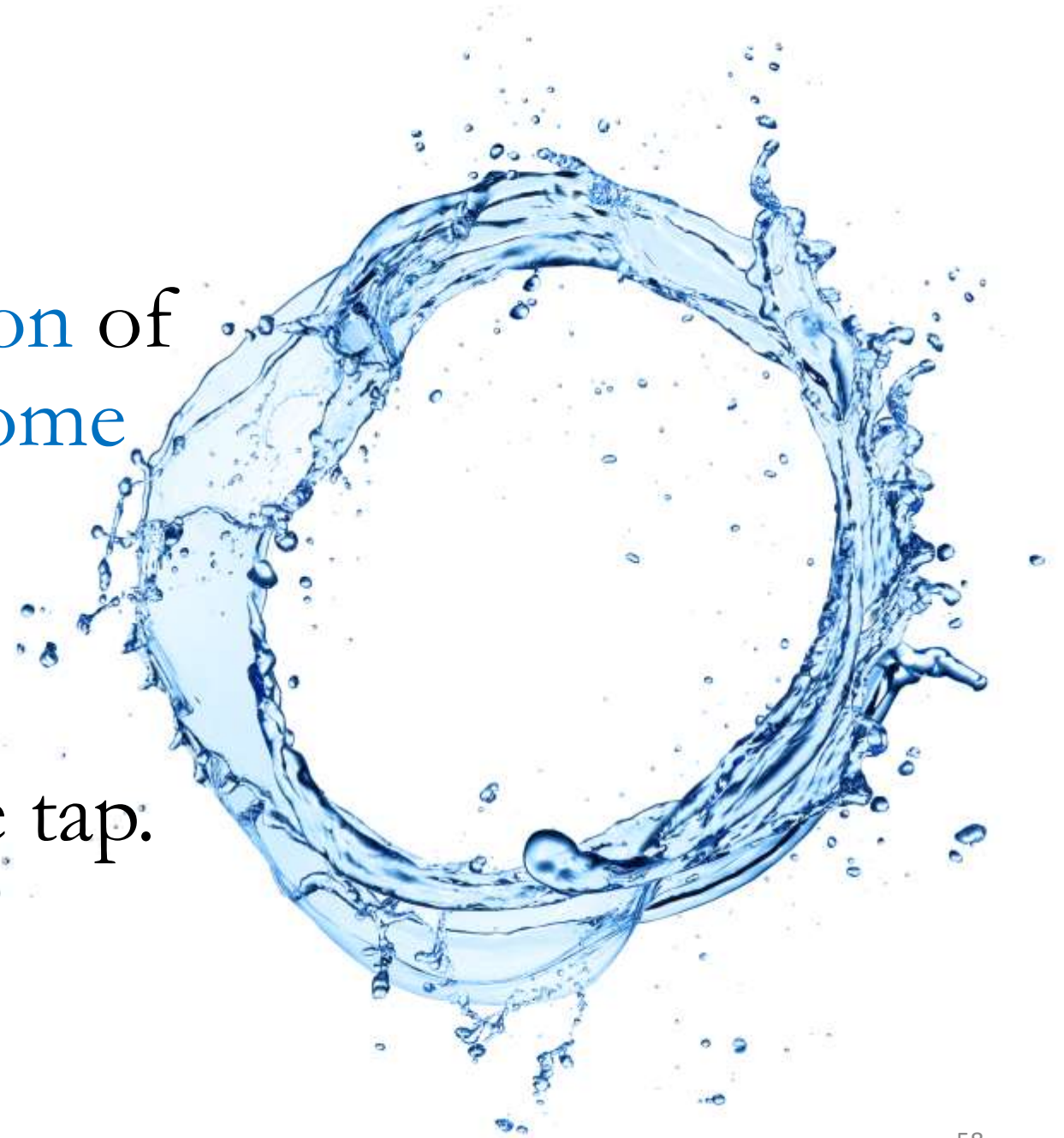
Szymon

\$1000 device for real-time
DNA sequencing.

Building metabolic profiles of biofilter microbes to devise process intervention strategies.



A comprehensive exploration of the drinking water microbiome will allow for real-time monitoring, predictive framework, and a tailored microbial community at the tap.





Northeastern University

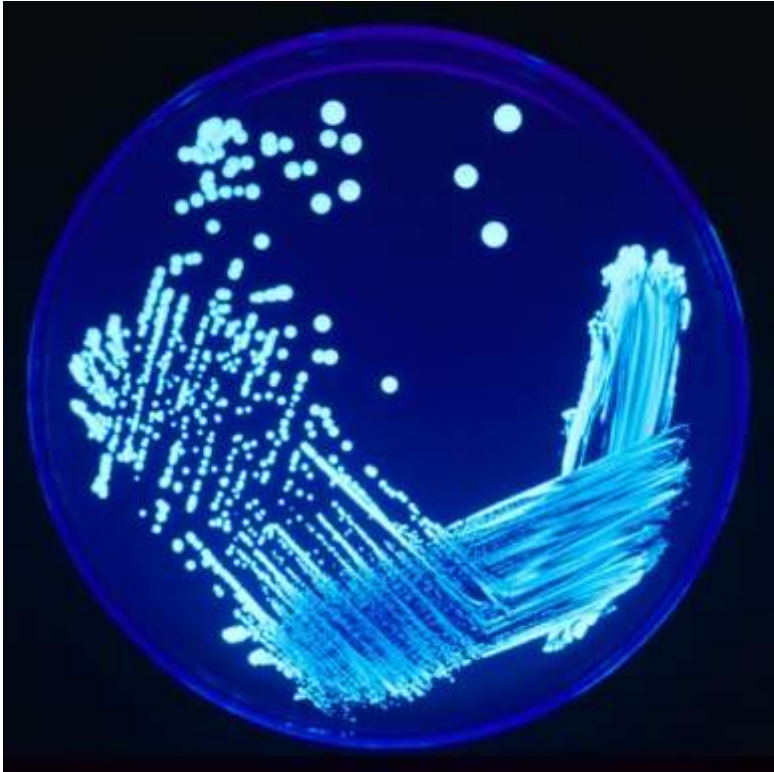


Collaborators



pintolab.com

We are **laser focused** on managing (**some of**) these detrimental impacts.



Disease



**Infrastructure
Damage**



**Aesthetic
quality**