Field-Base Exploratory Study of Microbial Activity in Potable Water Storage Tanks in Barbados

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Acknowledgements

- Katelyn Long for being persistent!

- BWA and Caribbean Community Climate Change Centre for assisting with this project

- Alex Harewood for being adaptable with sampling

- Dr. Emma Smith for ALL her help in assisting USF researchers

- UWI Department of Biological and Chemical Sciences for using their laboratories

- Tamar Andrews for sampling help

- Principals and homeowners for being generous with their tanks and time

- Dr. Maya Trotz for her help and support

Barbados Water Scarcity

- Climate change is stressing freshwater resources
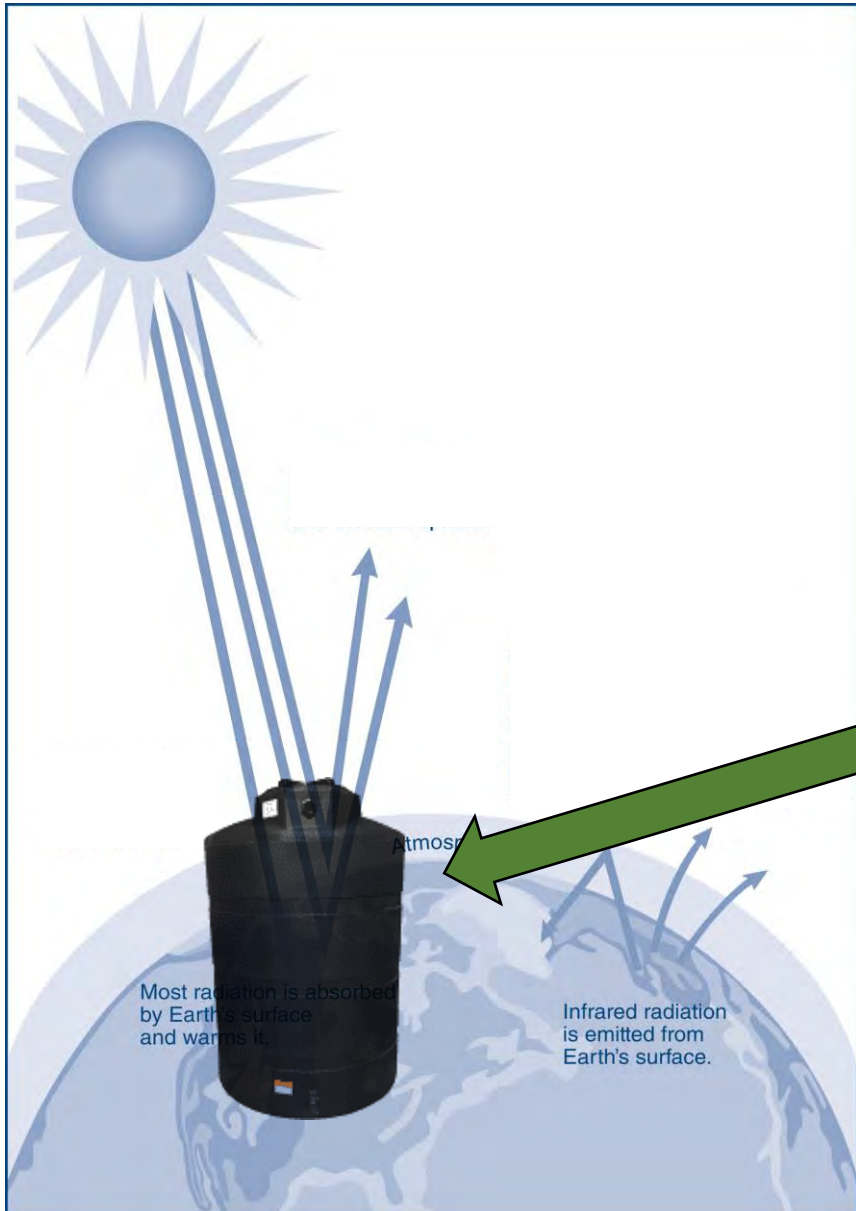- Water insecurity is a concern of the Barbados Water Authority

INSTALLATION OF POTABLE TANKS

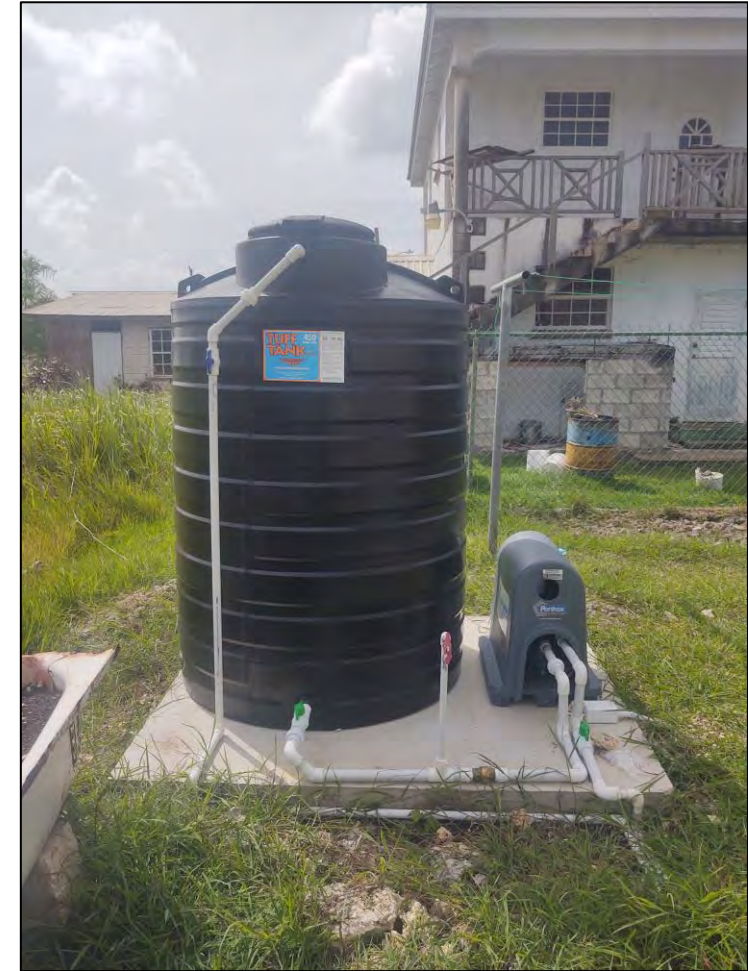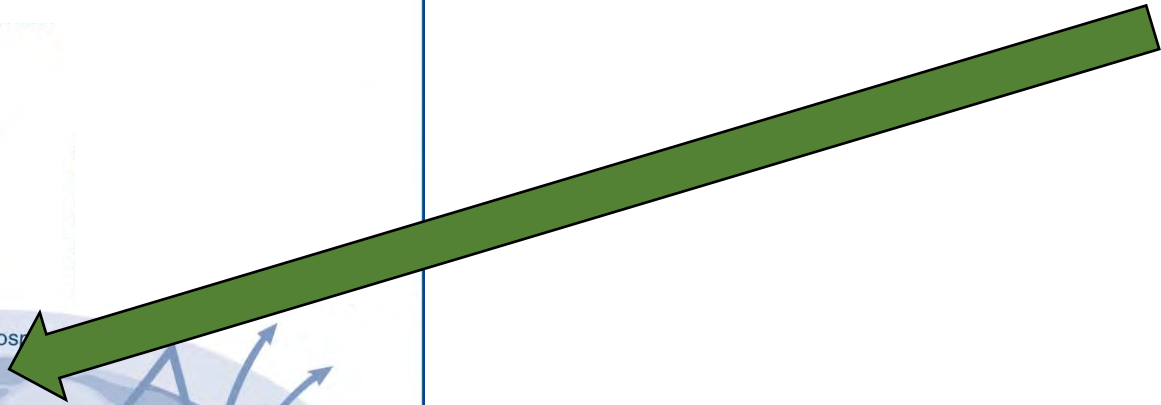- Attached pump, turns on when mains cannot supply water
- Over 1500 tanks installed

BUILD RESILIANCE OF CONSUMERS

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Barbados Water Scarcity

Chemical and Microbial Stability?

Research Objectives:

1) Characterize microbial presence inside potable water storage tanks of Barbados by microbial indicators like E. coli and Total Coliforms

2) Determine if conditions, including temperature and chlorine residual, are optimal for legionella pneumophila growth and to quantify presence using most probable number statistical analysis

Water Quality Parameters and Concerns

What It Is	Why It Matters
Nitrate	• Blue baby syndrome, respiratory infections, thyroid disease, certain cancers
E. Coli (fecal diseases)	• Stomach/flu-like symptoms
Legionnaire's Disease	• Legionella pneumophila grows with temperatures between 20-45ºC, low chlorine residual and stagnating water, • Harmful if vapor phase, • Causes flu-like symptoms

Water Quality Parameters and Concerns

What It Is	Why It Matters	Parameter	Indicator
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E. Coli (fecal diseases)	• Stomach/flu-like symptoms	Biological	Total Coliform & E. Coli
Legionnaire's Disease	• Legionella pneumophila grows with temperatures between 20-45ºC, low chlorine residual and stagnating water, • Harmful if vapor phase, • Causes flu-like symptoms	Biological Chemical Physical	Legionella pneumophila Total Chlorine Temperature

Sample Collection

- North of the island receives low water pressure
  - 1,000 gallon tanks function in series of two or four
  - OLD classified as 1-4 years installed prior (square)
  - NEW classified as installed this year (circle)

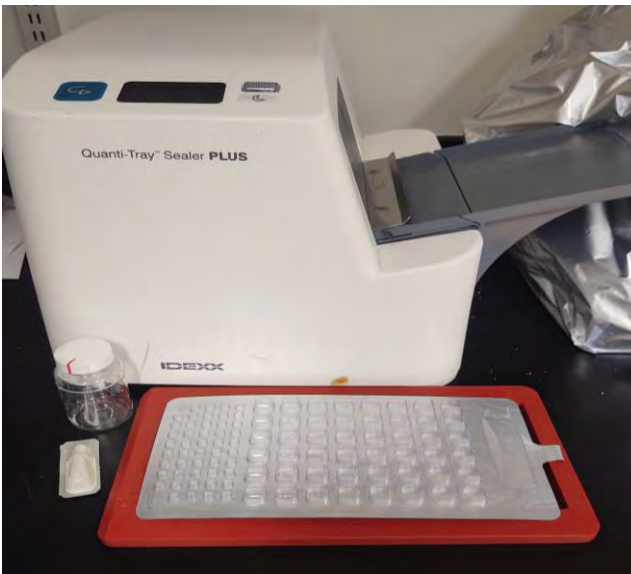| Tank Site	Size	Classification	Age
A	1,000	Public	Old
B	1,000	Public	**New**
C	450	Residential	**New**
D	450	Residential	**New**
E	1,000	Public	Old
F	1,000	Public	**New**
G	400	Residential	Old
H	450	Public	**New**
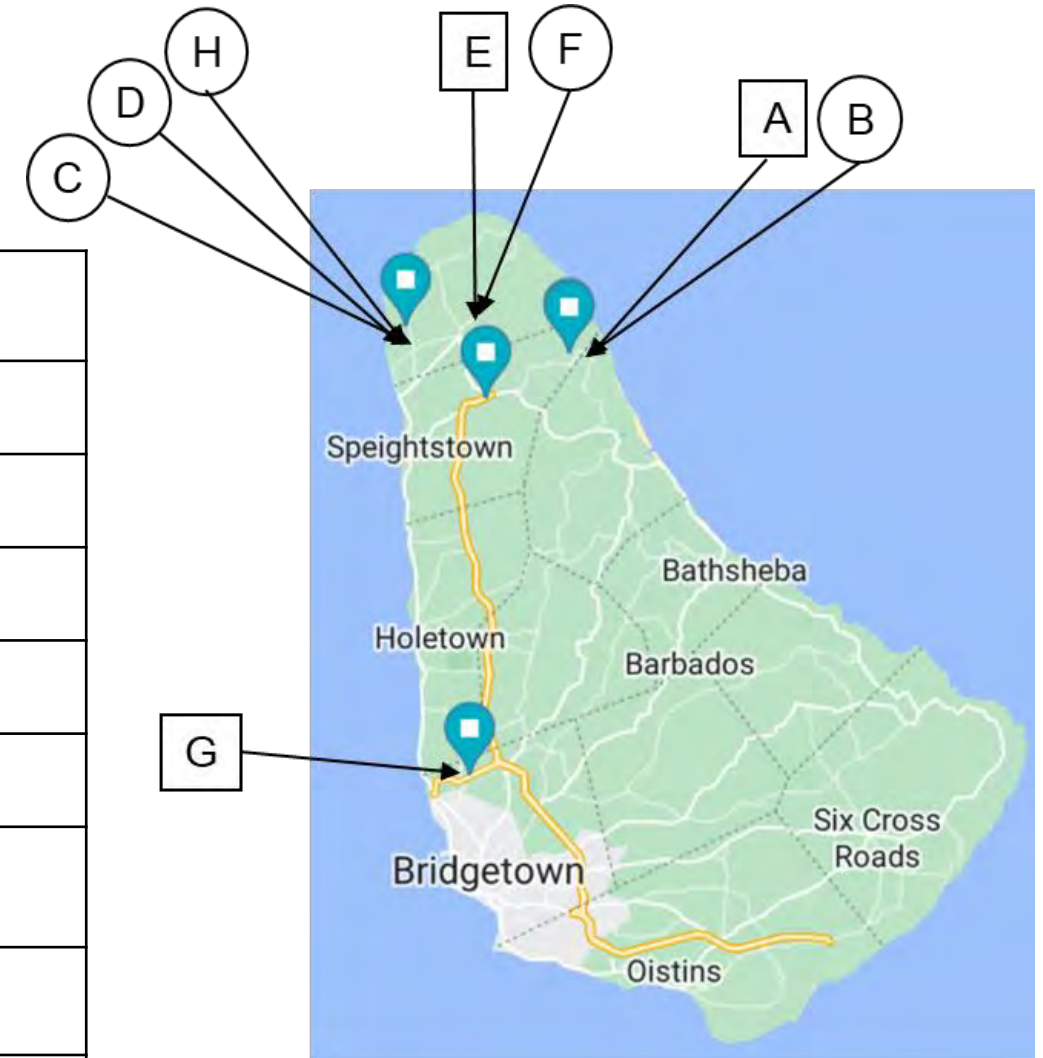
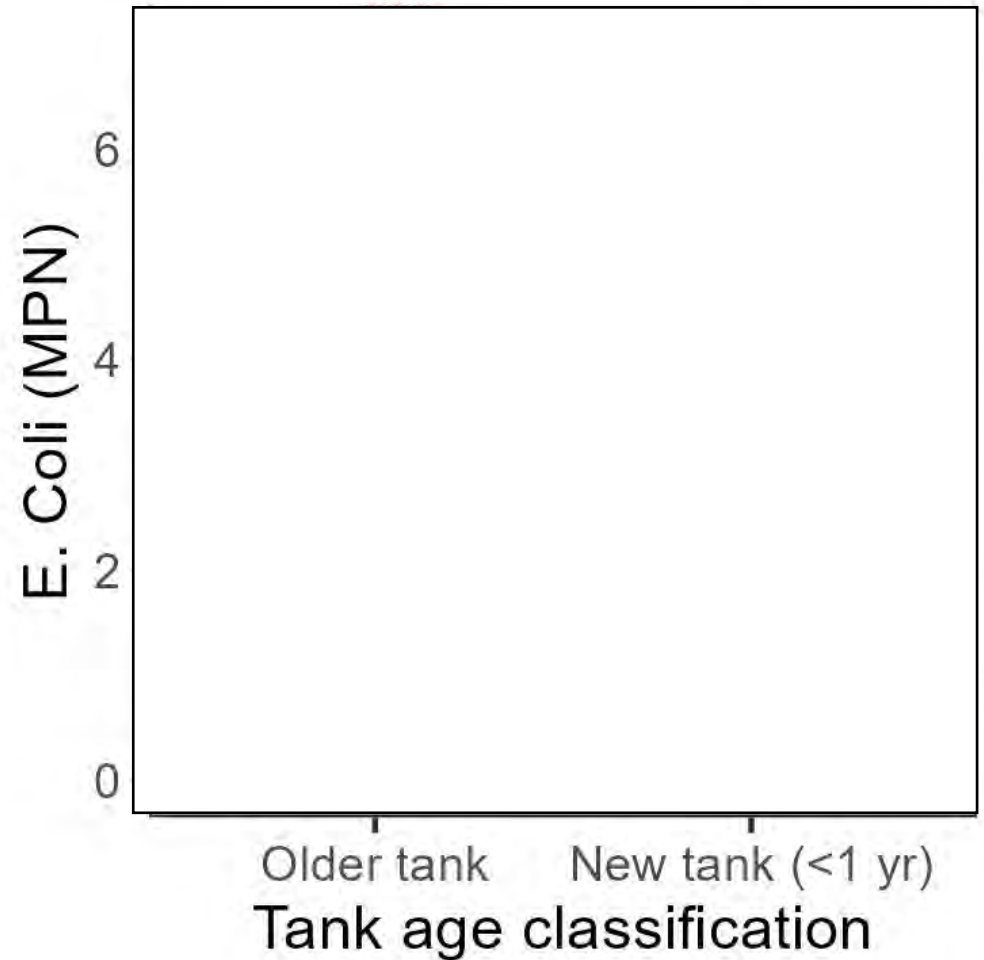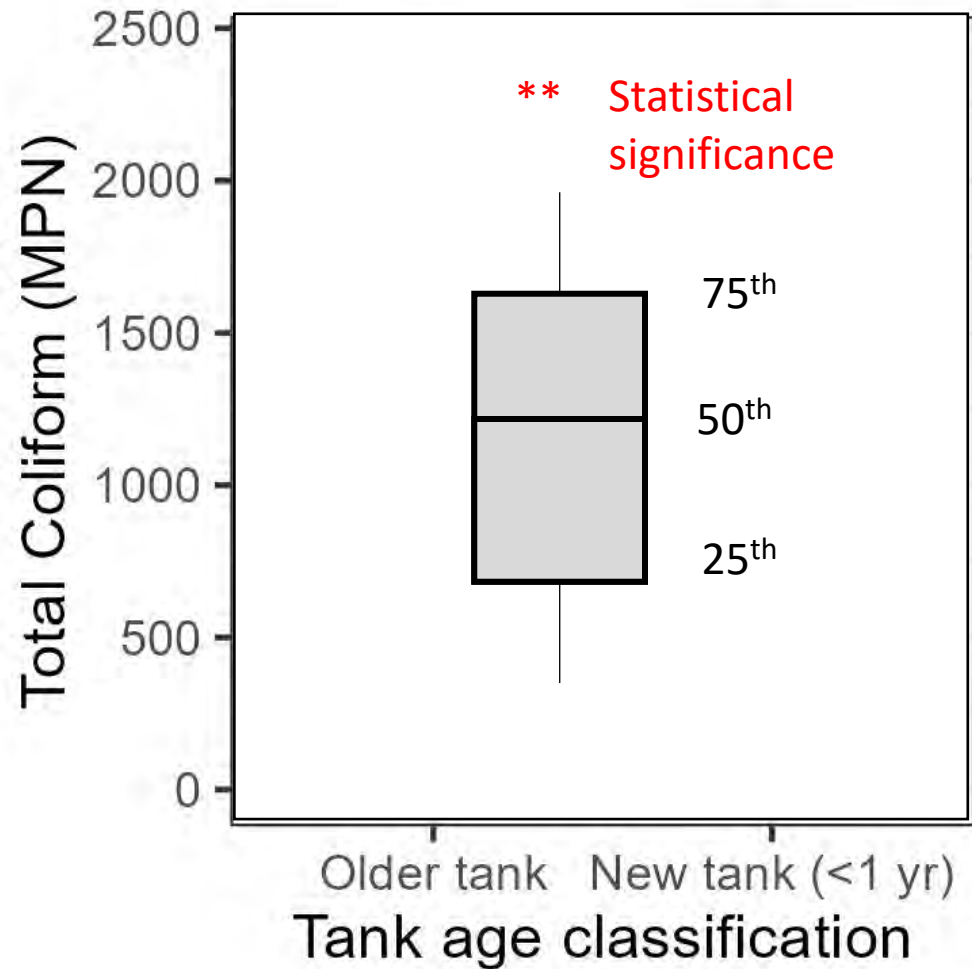Fig 1. Map of Tank Sites

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Flow Diagram

Methods

How do tank characteristics and time impact results?

** Statistical significance

75th
50th
25th
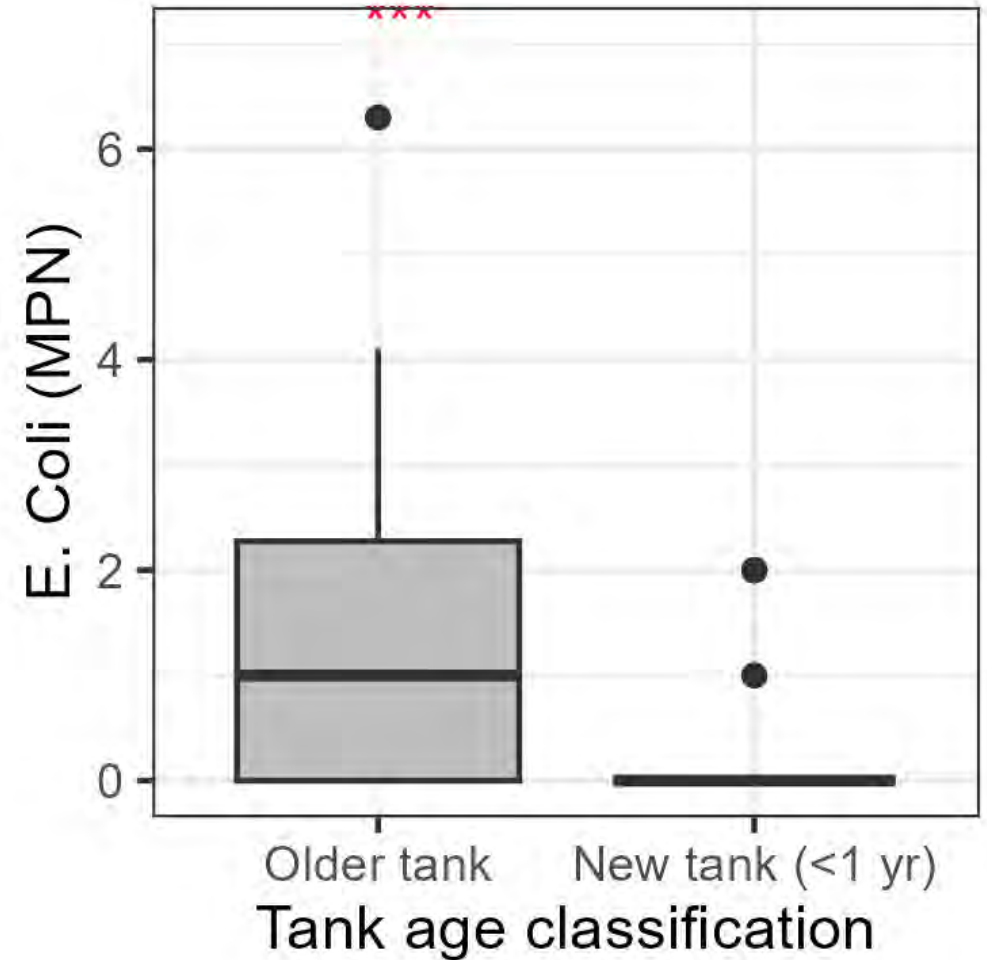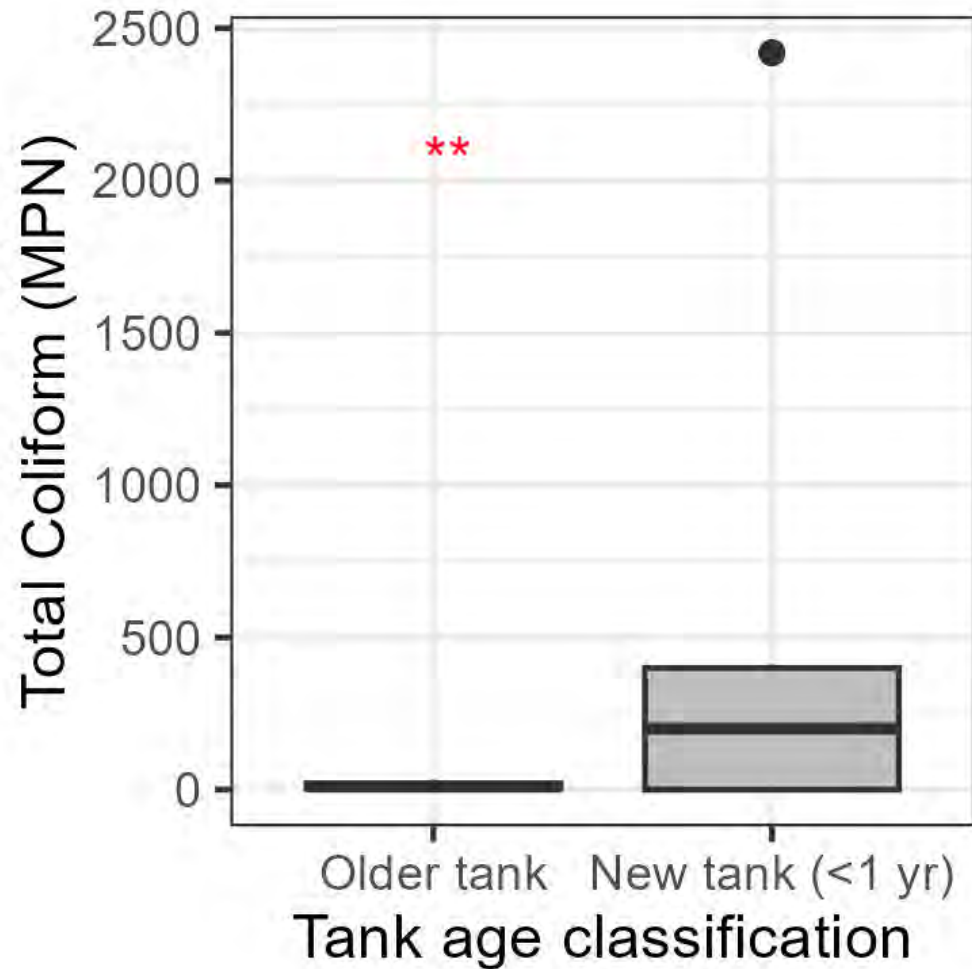
p < 0.01***, 0.05**, 0.1*

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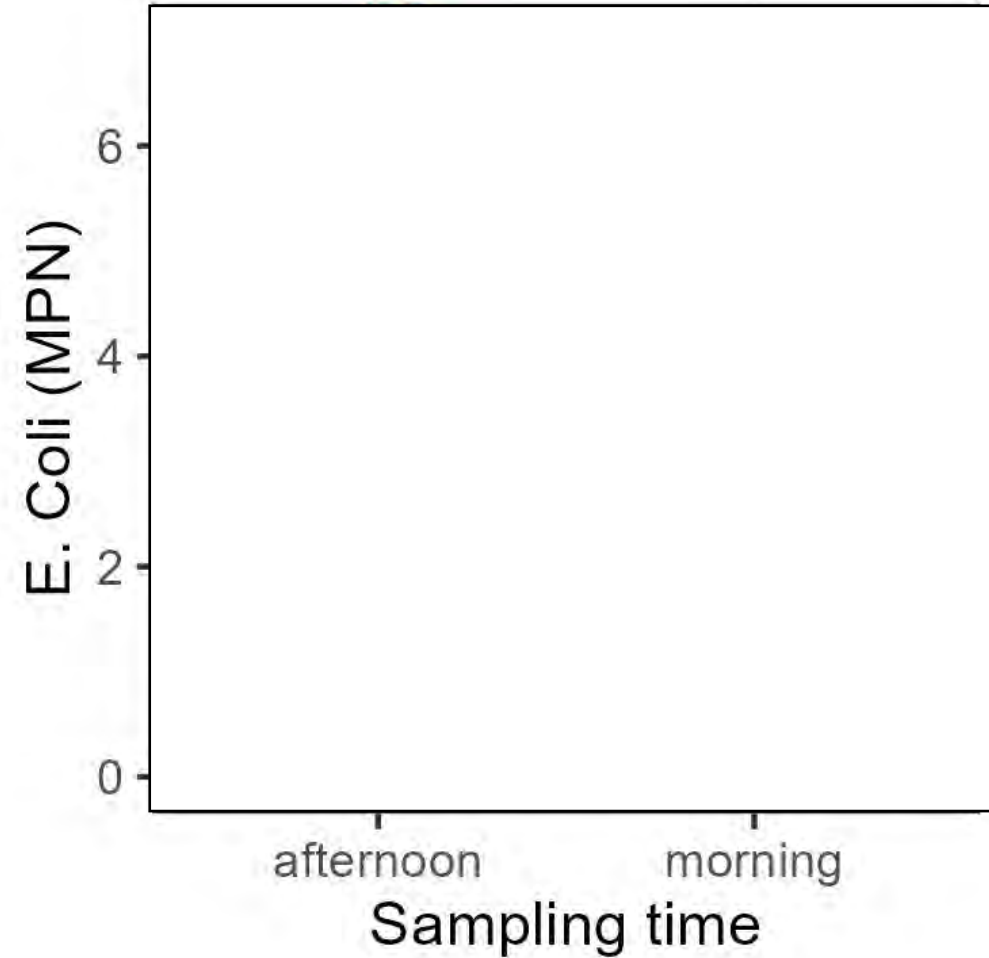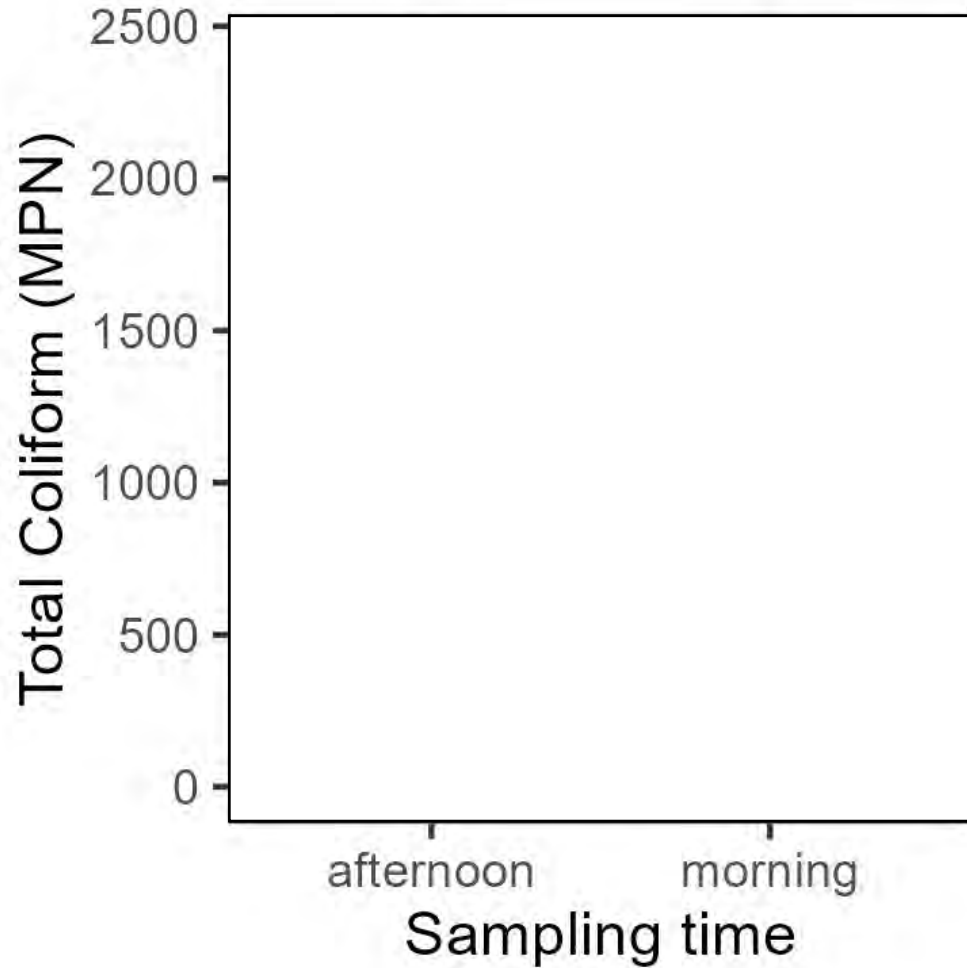# How do tank **characteristics** and time impact results?

p < 0.01***, 0.05**, 0.1*

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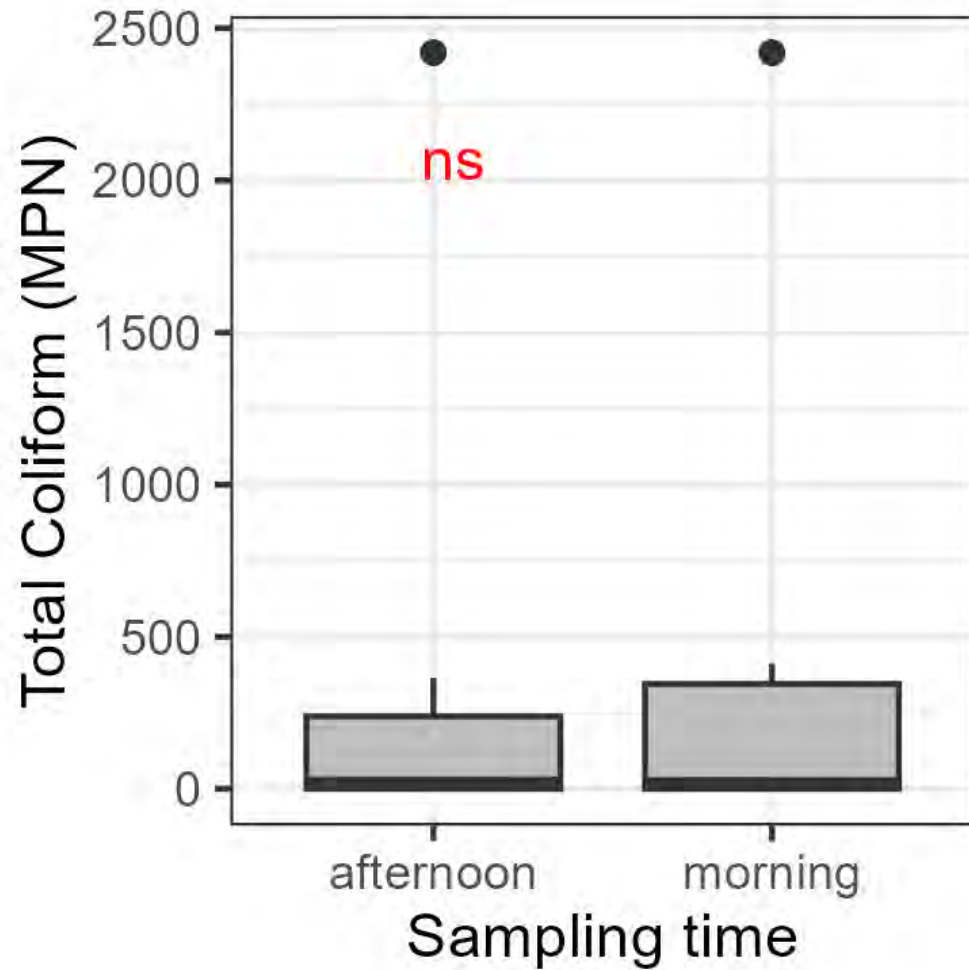
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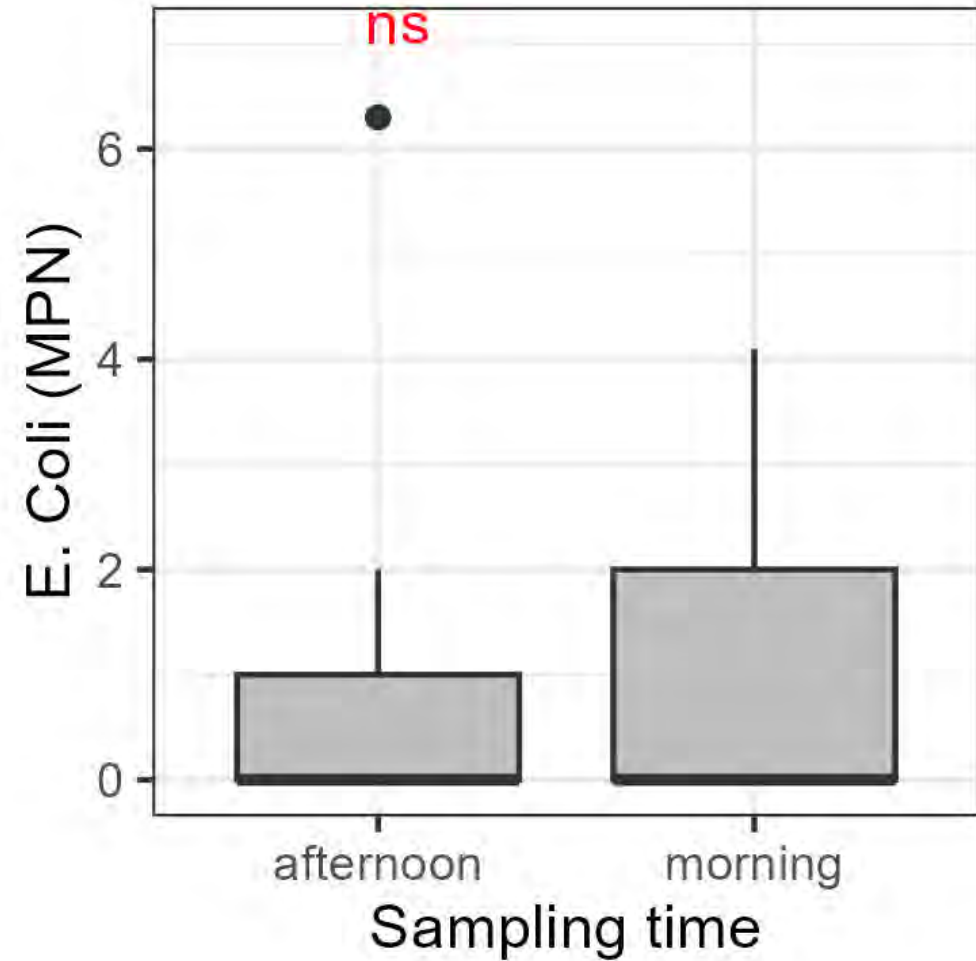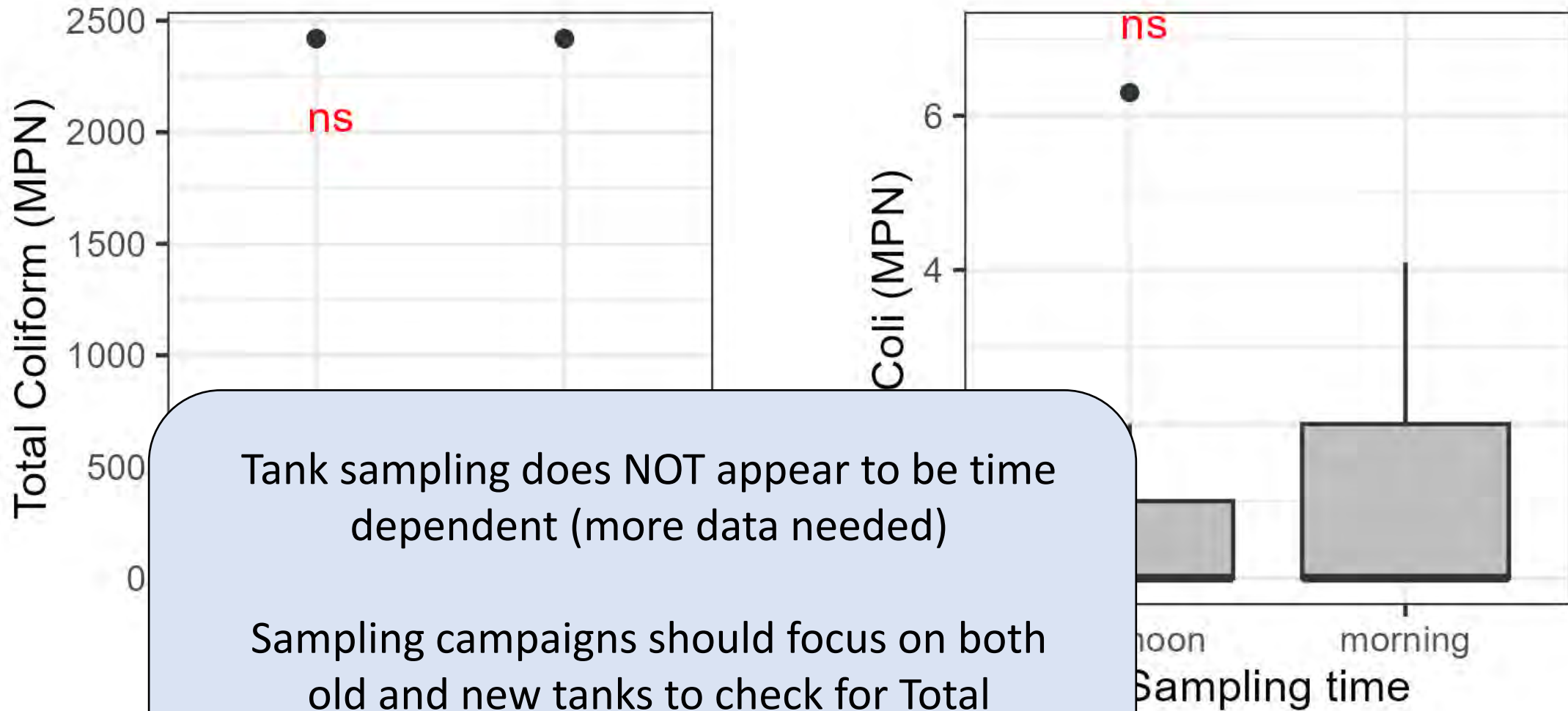

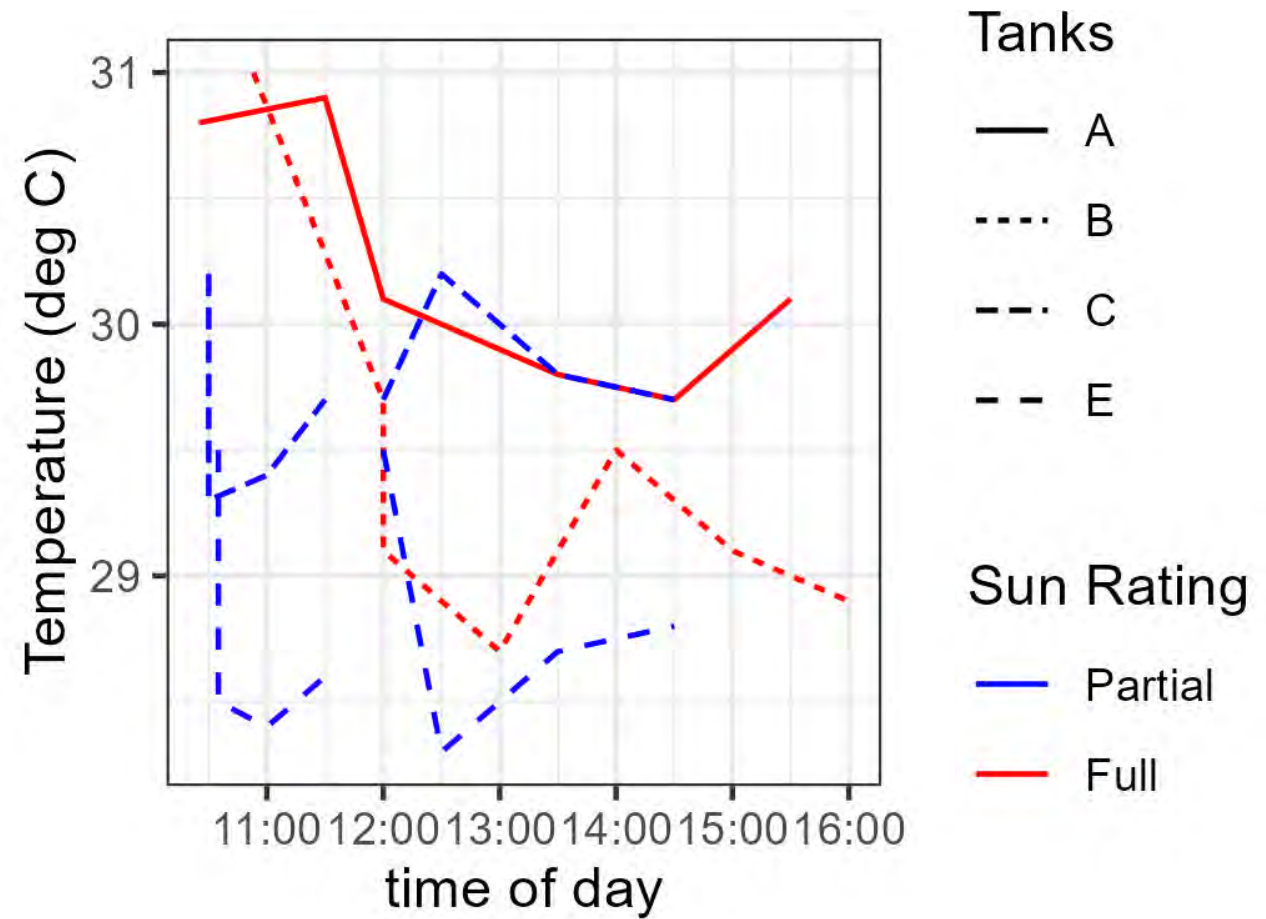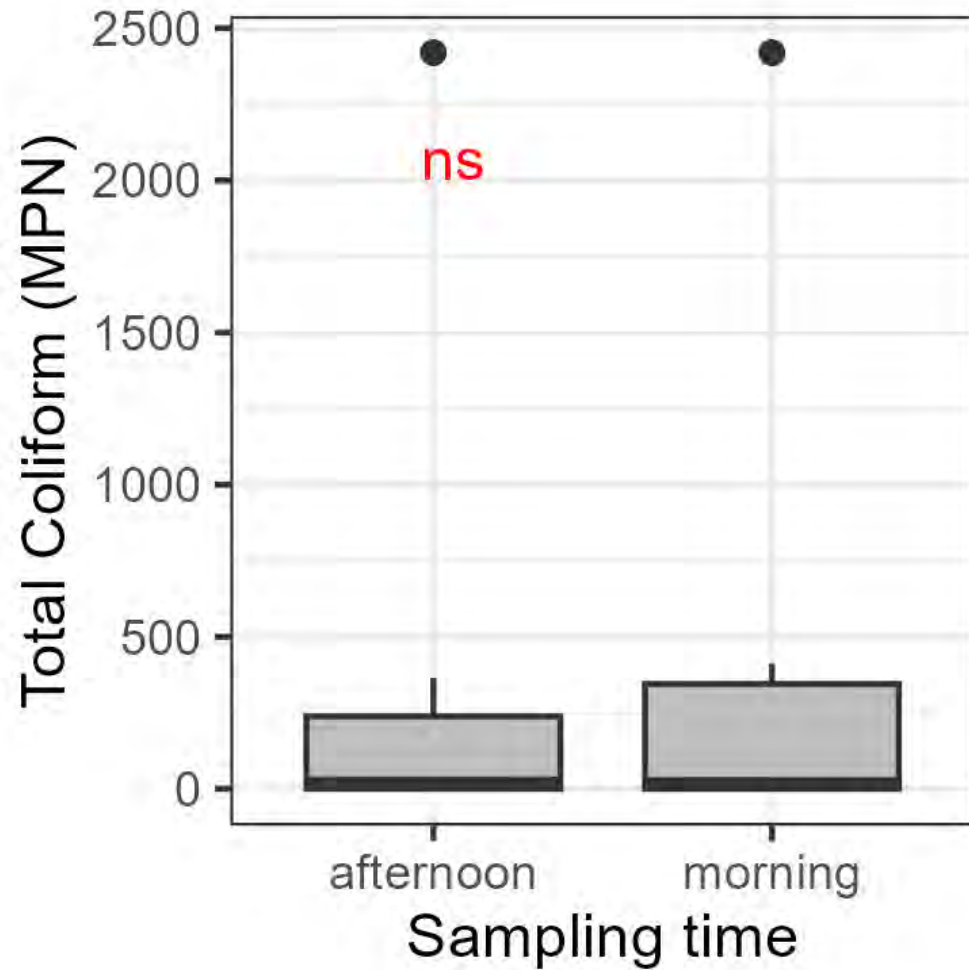Tank sampling does NOT appear to be time dependent (more data needed)

Sampling campaigns should focus on both old and new tanks to check for Total Coliforms and E. Coli

p < 0.01***, 0.05*

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How do tank characteristics and time impact results?

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Temperature and Chlorine

KEY RANGE FOR
LEGIONELLA
GROWTH IS 25-45°C
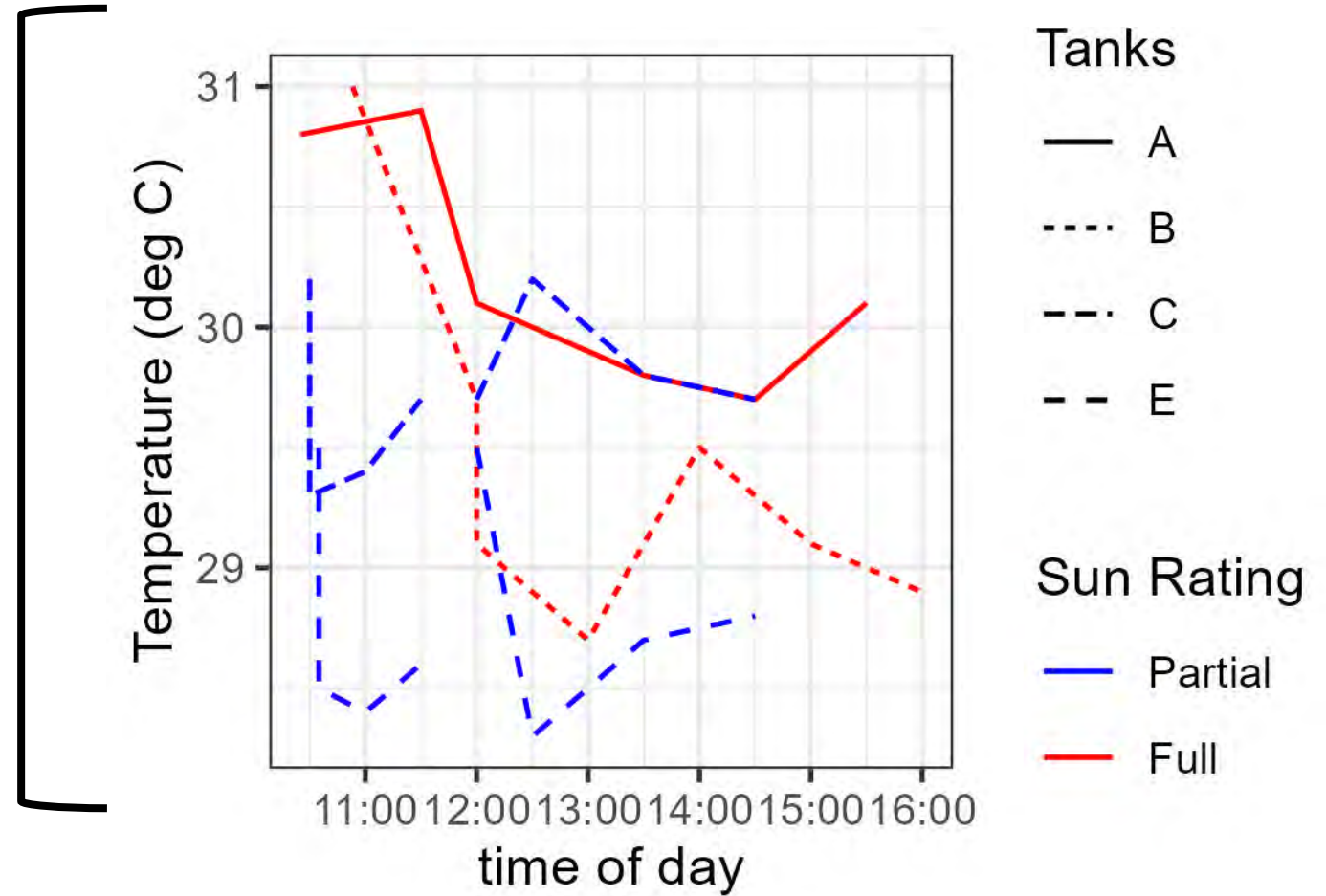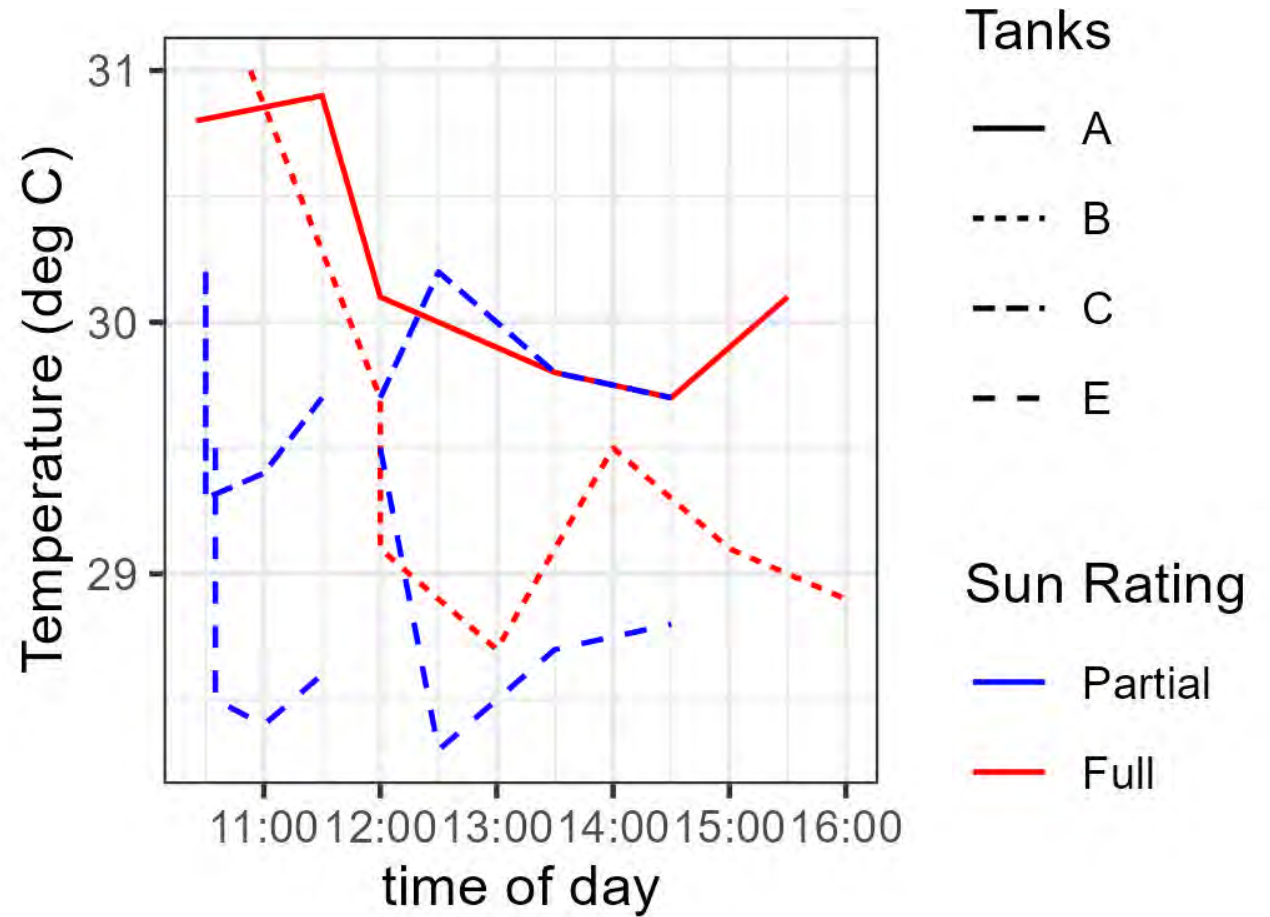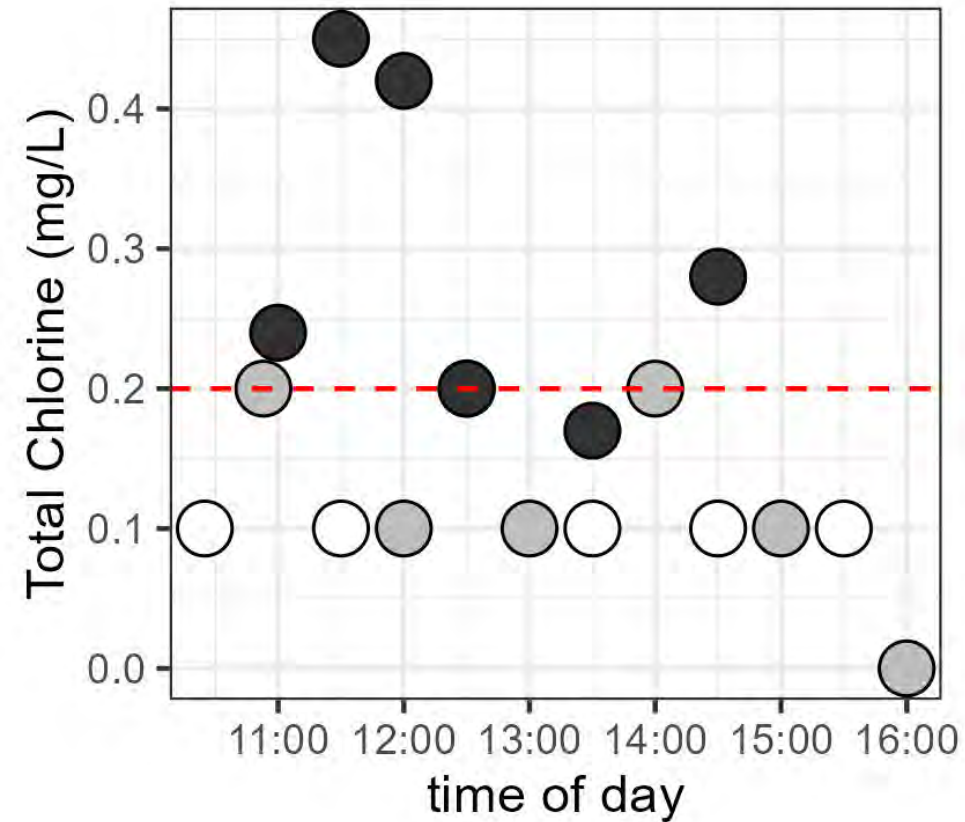
Temperature and Chlorine

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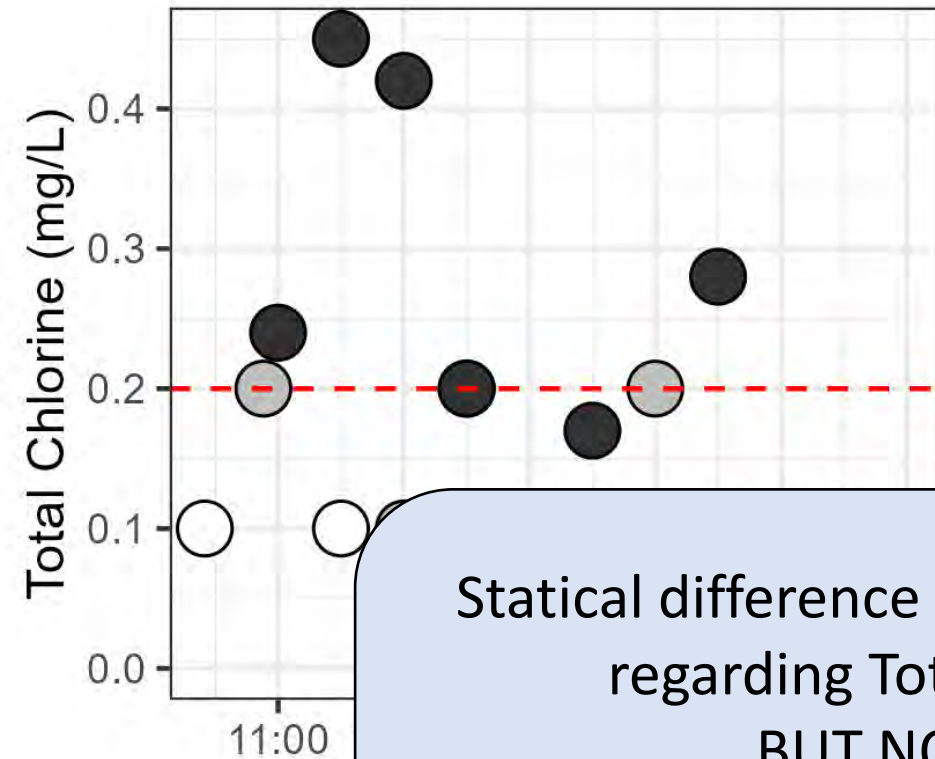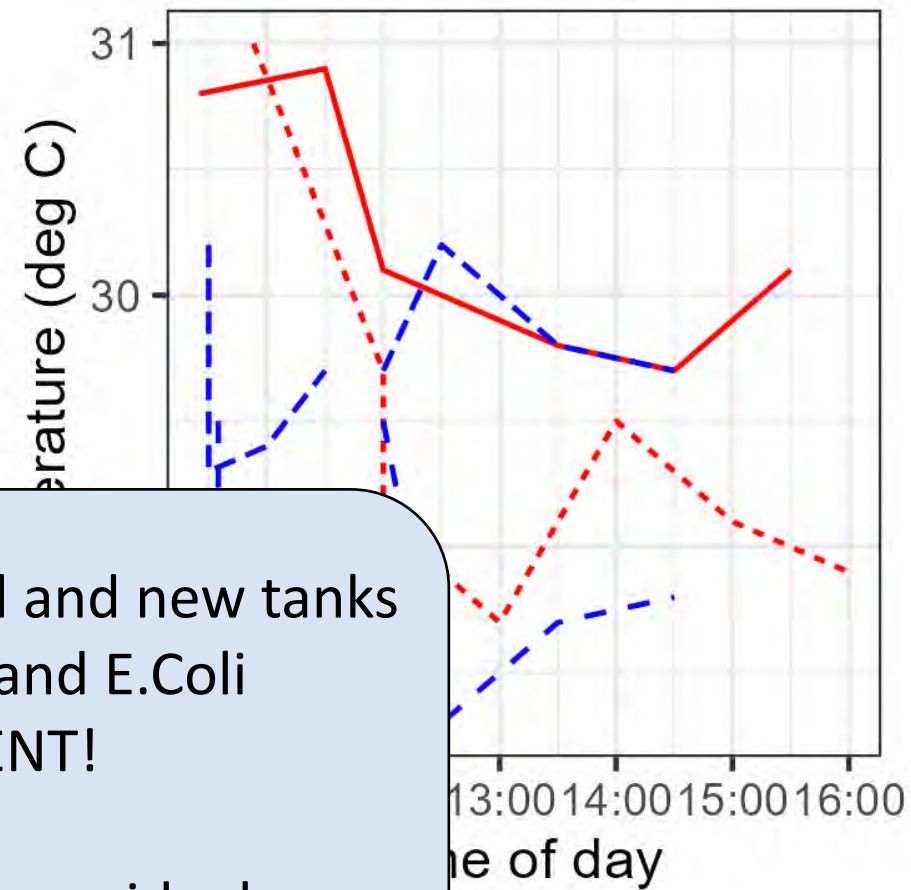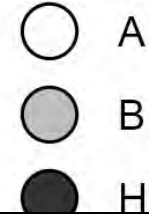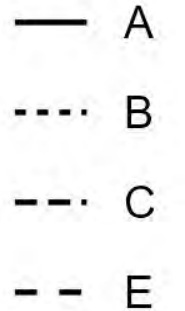
Statical difference between old and new tanks regarding Total Coliform and E.Coli
BUT NOT CONSISTENT!

Temperature and total chlorine residuals are conducive to *Legionella* growth
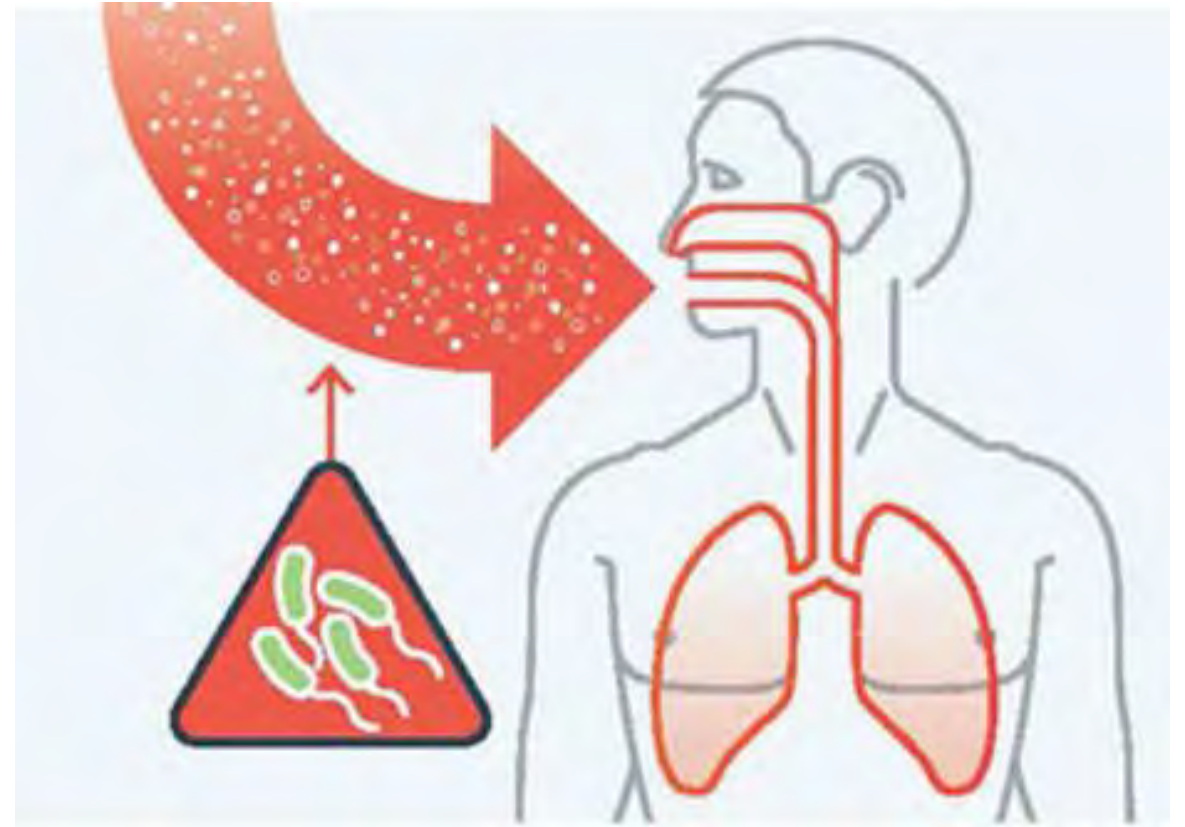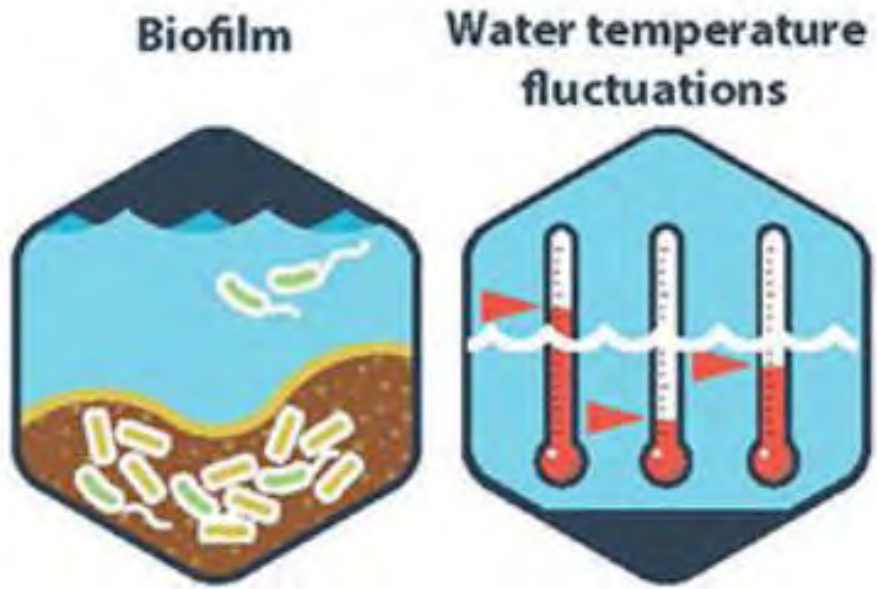
Tanks C, D, E,

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Legionella

Biofilm
Water temperature fluctuations

How do all the data align?

Tank	TC Positive	EC Positive	Old or New	Full or Partial Sun	Legionella Positive
A	**Yes**	**Yes**	Old	Full	
B	**Yes**	No	New	Full	
C	**Yes**	**Yes**	New	Partial	
D	**Yes**	No	New	Full	
E	**Yes**	**Yes**	Old	Partial	
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F	No	No	New	Full	No
G	No	No	Old	Partial	No
H	No	No	New	Full	No

LORIDA

Legionella

- Regression analysis

$$Y_i = \mathrm{C}_i \sum_{i=1}^{N} Z_i + \beta_i \sum_{i=1}^{N} X_i + error$$

Outcome Variable
Legionella counts

Control variables

i1-5: all the variables and coefficients
Z—things of interest
Main effect or interaction effect
Individual (i) level

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Legionella

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Parameter	Model 1	Model 2	Model 3
Temperature (C)	**386***	**454***	339
Total Chlorine (mg/L)	**-5149***	-3878	-4792
Nitrate (mg/L N)		-786	
New or Old			122

p<.1 * , p<.05 ** , p<.001***

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Regression analysis suggests that temperature is the most important factor---but not consistently significant.

More information on tank characteristics and operational modes are needed (and more data!)

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SIMPLE CORRELATIONS ALONE MIGHT NOT BE ENOUGH TO IDENTIFY DRIVERS FOR LEGIONELLA CONTAMINATION

*p<.1 * , p<.05 ** , p<.001****
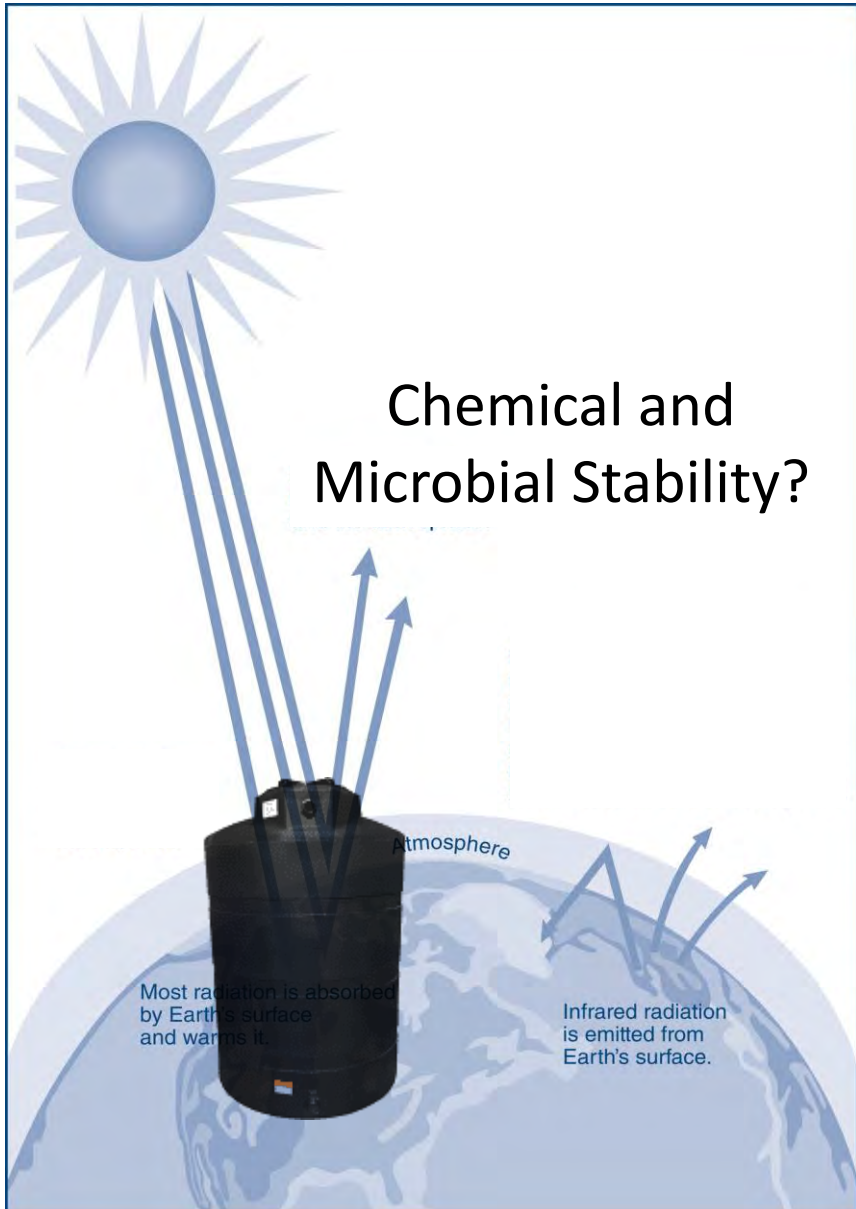
Future Work

More data is needed (N~100)

- Multiple parishes
- Different times of year
- Operational information

Test mitigation strategies

- Water circulation/flush before use
- Sanitize tanks more often
- Shock chlorination disinfection
- Solar panel pump installation and use

Thank You!

Dr. Katherine Alfredo, Assistant Professor, University of South Florida

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Chemical and Microbial Stability?

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