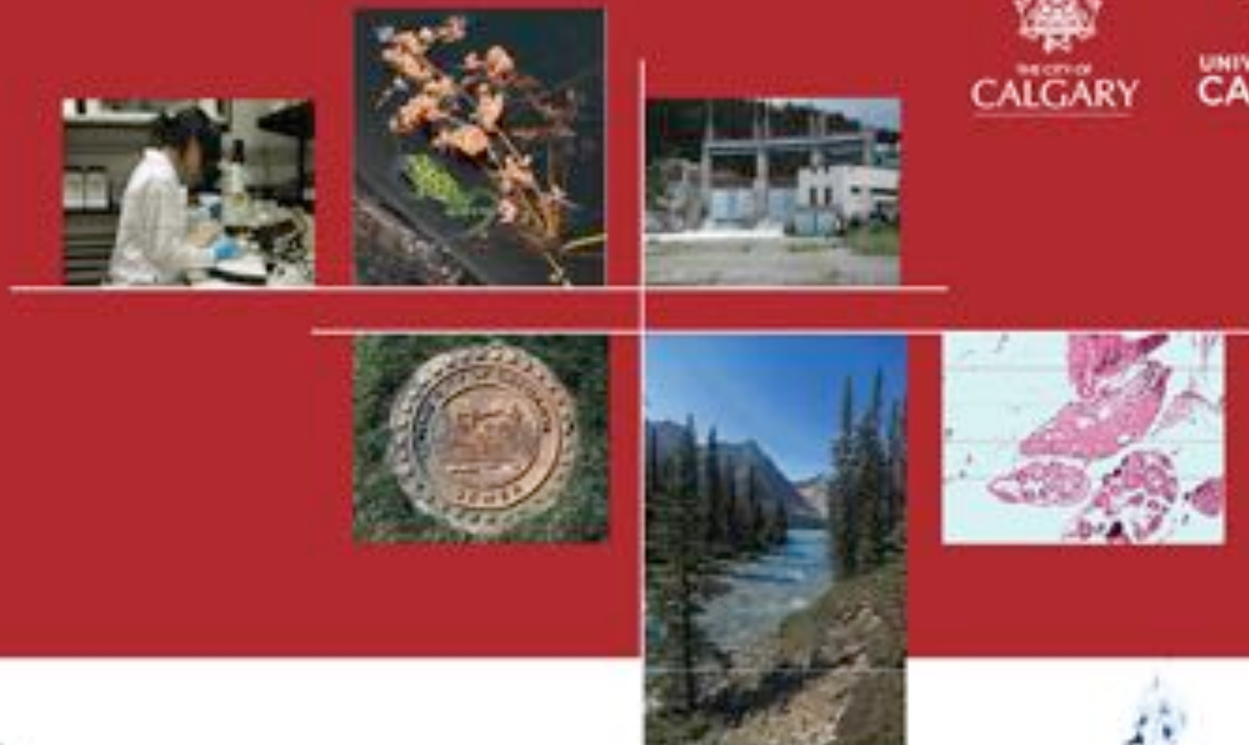


ACWA

Advancing Canadian Wastewater Assets

An Urban Alliance initiative

ACWA Provides Infrastructure to Develop Made in Alberta Water Solutions to Emerging Global Problems

Lee Jackson, PhD, Scientific Director

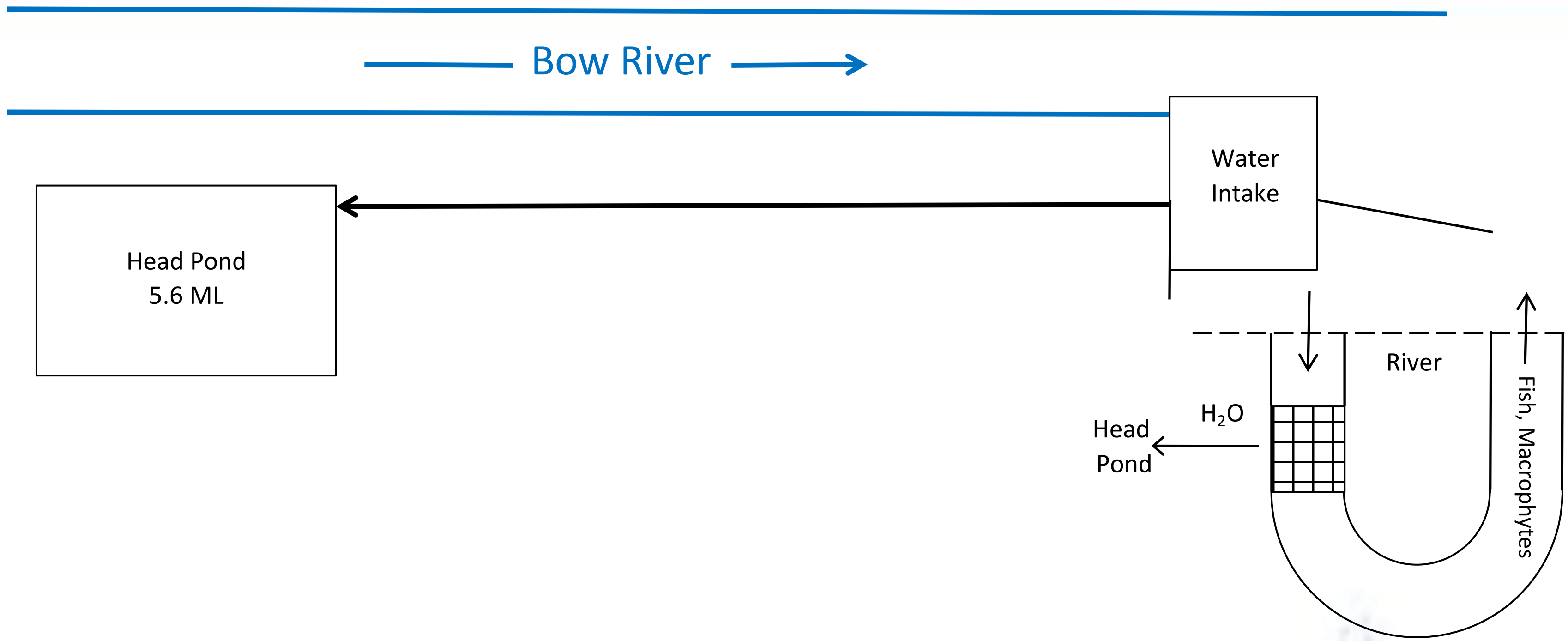
The City of Calgary | University of Calgary

ESSA
March 24, 2021

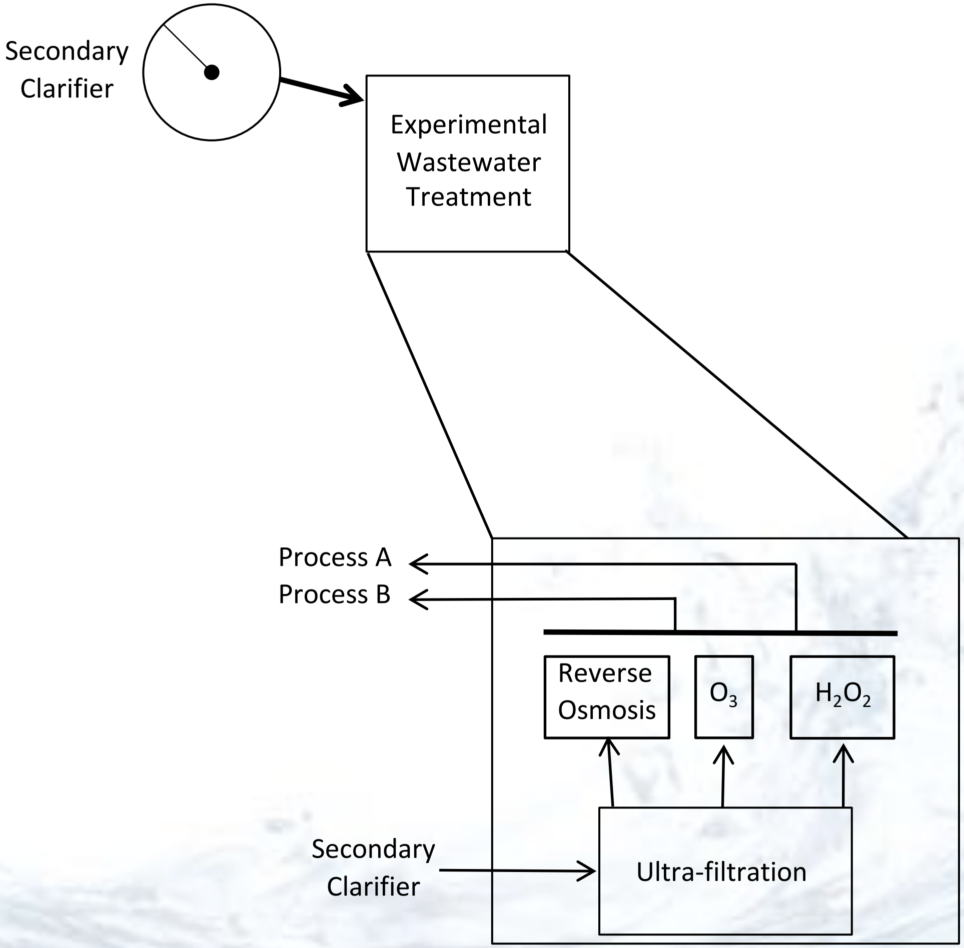
What is ACWA?


Research Streams
Analytical
Laboratory
Research WWTP
Bow River

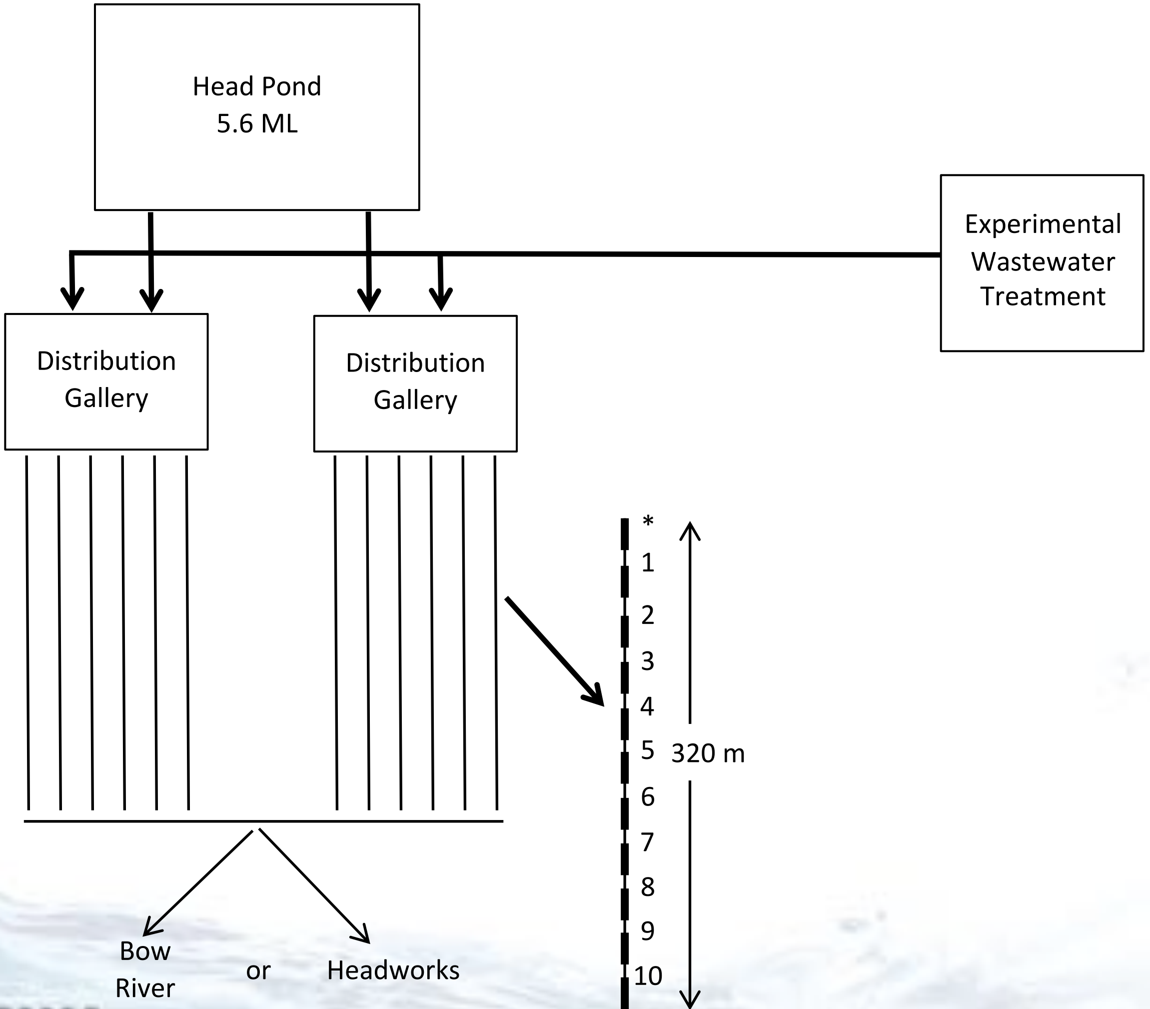
ACWA Plumbing



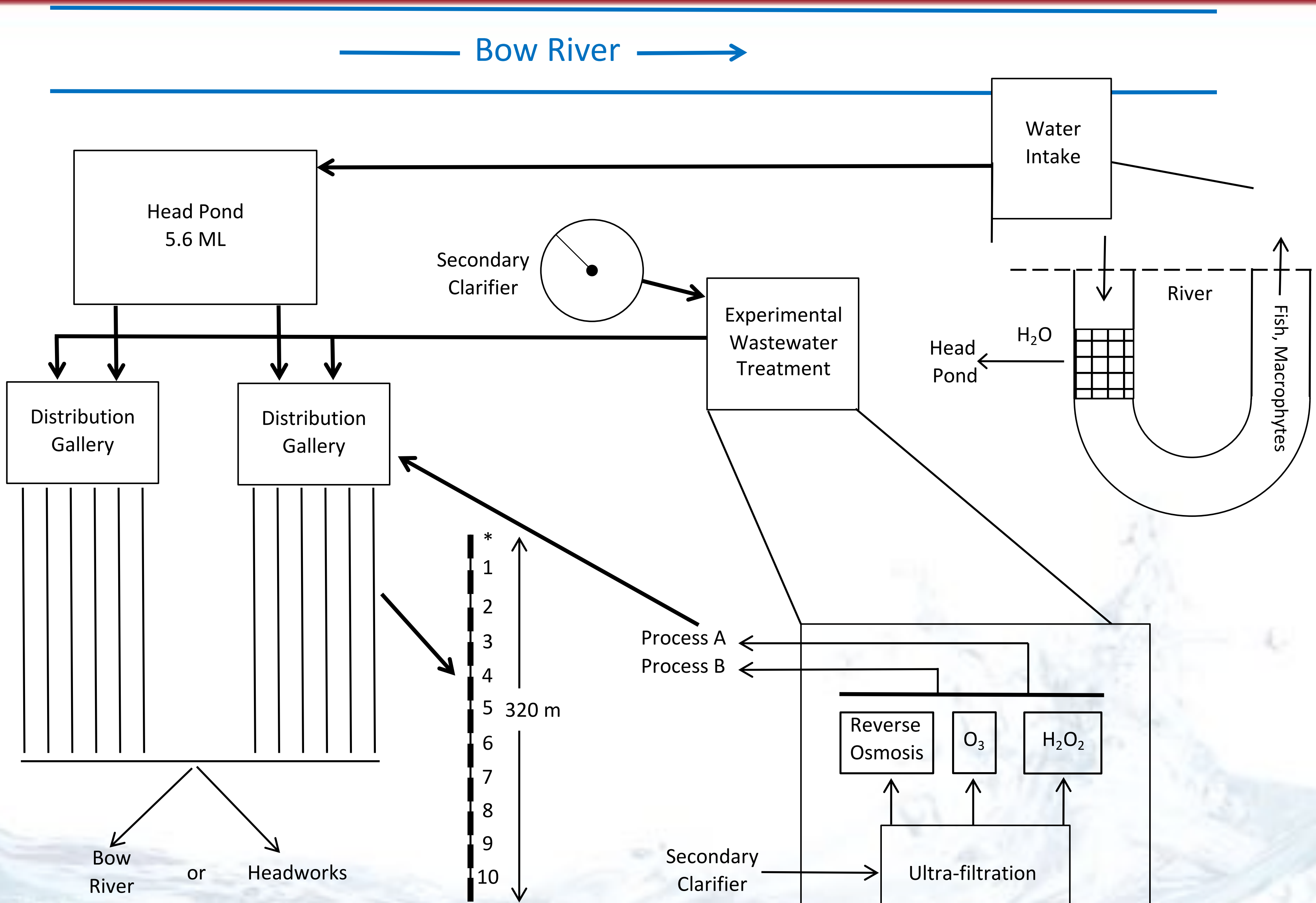
ACWA Plumbing



ACWA Plumbing

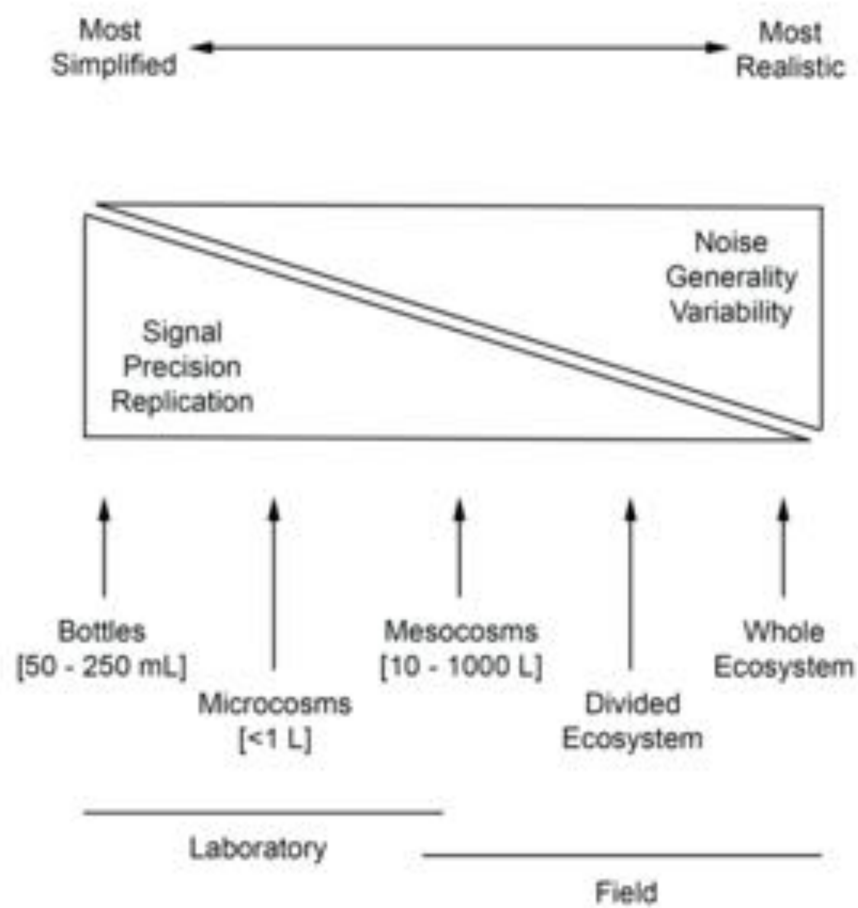


ACWA Plumbing



Jackson, LJ (2019) Advancing Canadian Wastewater Assets (ACWA) bridges laboratory-scale testing of wastewater wastewater technologies and effects on receiving environments. Can. J. Civil Eng. 47: 998-1004.

Scale of Science



ACWA
Advancing Canadian Wastewater Assets

Jackson, LJ (2019) Advancing Canadian Wastewater Assets (ACWA) bridges laboratory-scale testing of wastewater wastewater technologies and effects on receiving environments. Can. J. Civil Eng. 47: 998-1004.

Water Intake Slab

Intake Building Blocks

Intake Heat Exchanger

Intake Structure Complete – Spring 2013

Intake – flooding damage

Pump Station Heat Exchanger

Experimental Streams – clay bed

Experimental Streams – Flowing All Winter!

- 27 °C

Research Streams

- 12 streams (320 m each)
- naturalized, replicated
- 10 pools/riffles each

- measure environmental effects
- develop diagnostic tools and markers

Distribution Galleries

Analytical Lab

LC/QqQ
LC/QToF

GC/MS (P&T)
GC/FID
GC/ECD
GC/NPD

ICP/MS/QqQ

Smartchem
TOC
Freeze Dryer
HPLC

Microscopy suite

Ultra-filtration

ACWA's Research Foci

Engineered Technologies

Research & Demonstration

Environmental Impacts

Fate, Transformation, Diagnostic Tools

Public Health

Surveillance, "Pharmaprinting"

Antimicrobial Resistance

MIF, AI, X-cutting theme, WHO

Microplastics

Fate & Distribution

Industrial Partnerships

IBM/Mitacs

- Development of a water collaboration platform (SWIM – Sustainable Watershed Integrated Management)

Agilent Technologies

- Partnership on application development and analytics for untargeted analyses via LC/QToF

Blue Leg Monitor (The Netherlands)

- Evaluation of hyperspectral sensing to identify blue-green algal blooms
- Goal: couple science with sensor technology to predict microcystin (toxin) production

Trojan Technologies

- Pilot of Cl-based oxidation for reuse options

SAIT

- exploration of AI to mine data from drone imagery

Transgenic Algae (Jackson & Alcantara)

- Research that has taken genes from antibiotic resistant bacteria and inserted them into algae; genes expressed in presence of antibiotics
- Applications: feedlots to industrial waste (final product = biofuel)

Aerobic Granulation (Tay)

- Potential to allow biological nutrient removal in a very small footprint

Water Reuse (ACWA, Xylem, AHS, Village Brewery)

- Development of regulations and demonstration project of first direct potable water demonstration in Alberta (probably Canada)

Fredsense Technologies

- Development of nutrient, metals and SARS CoV-2 rapid measurement

Plastic in our Environment

https://www.nguoiduatin.vn/mumbai-dang-bi-rac-thai-nhua-xam-lan-nhu-the-nao-a379640.html

Media Portrayal

Microplastics

Microplastics can be found across waterways and on shorelines. To help simplify this macro problem, here are the 5 major types of microplastics. (Image via Lake Ontario Waterkeeper)

Microplastics = 250 μm – 5 mm size

Microplastics

Primary: enter the environment as a microplastic (eg, microbeads)

Secondary: larger pieces of plastic that have broken into smaller pieces
(eg, fragments from a plastic bag)

What Does Science Say About Microplastic Pollution?

Main concerns are due to ingestion:

1. microplastics perceived as food by fish, amphibians, reptiles, birds

2. may cause abrasion to digestive tract once ingested

3. may have toxins absorbed to their surface (eg flame retardants)

4. release chemicals (recall bisphenyl-A (BPA) and MEC pulling polycarbonate bottles from their shelves in 2007) such as phthalates, that are biologically active.

   DEHP: Di-2-ethylhexyl Phthalate

   Makes plastic flexible, yet leaches out of plastics with repeated use, washing and heating. Is contained in medical devices, furniture products, personal care products and cosmetics. It is an endocrine disruptor that affects the ovaries, uterus, testes, kidneys, nervous system and thyroid*.

Municipal wastewater treatment plants are a large point source of microplastics because plants accept waste from our homes, hospitals, industries and microplastics are generally too small to be effectively removed.

*Rowdhwahl and Chen (2018) Toxic Effects of Di-2-ethylhexyl Phthalate: An Overview. Biomed Research International doi: https://doi.org/10.1155/2018/1750368

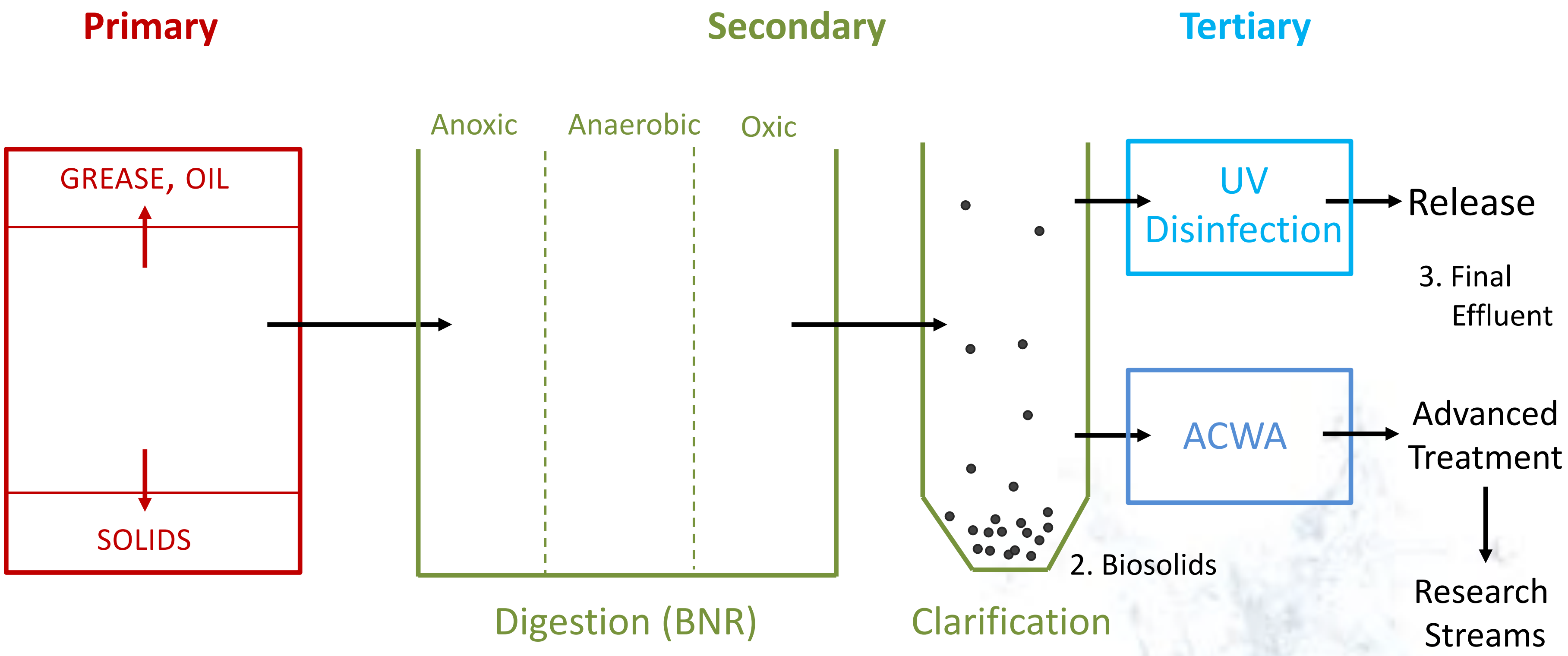
Raw Sewage →

→ Further Treatment

1. Influent

Coarse Screening

Generalized Wastewater Treatment



Fate of Microplastics in WWTP

BSc Honours Thesis Project of Paige Jackson (Co-Supervised by Dr. Sean Rogers)

Sampling Final Effluent

Sampling UF Effluent

Sampling Design

- Samples Taken Of:
  Influent
  Final Effluent
  Biosolids

- 1 x / week for 8 weeks, then frozen

- Determination of digestion protocol
  (practice sludge)

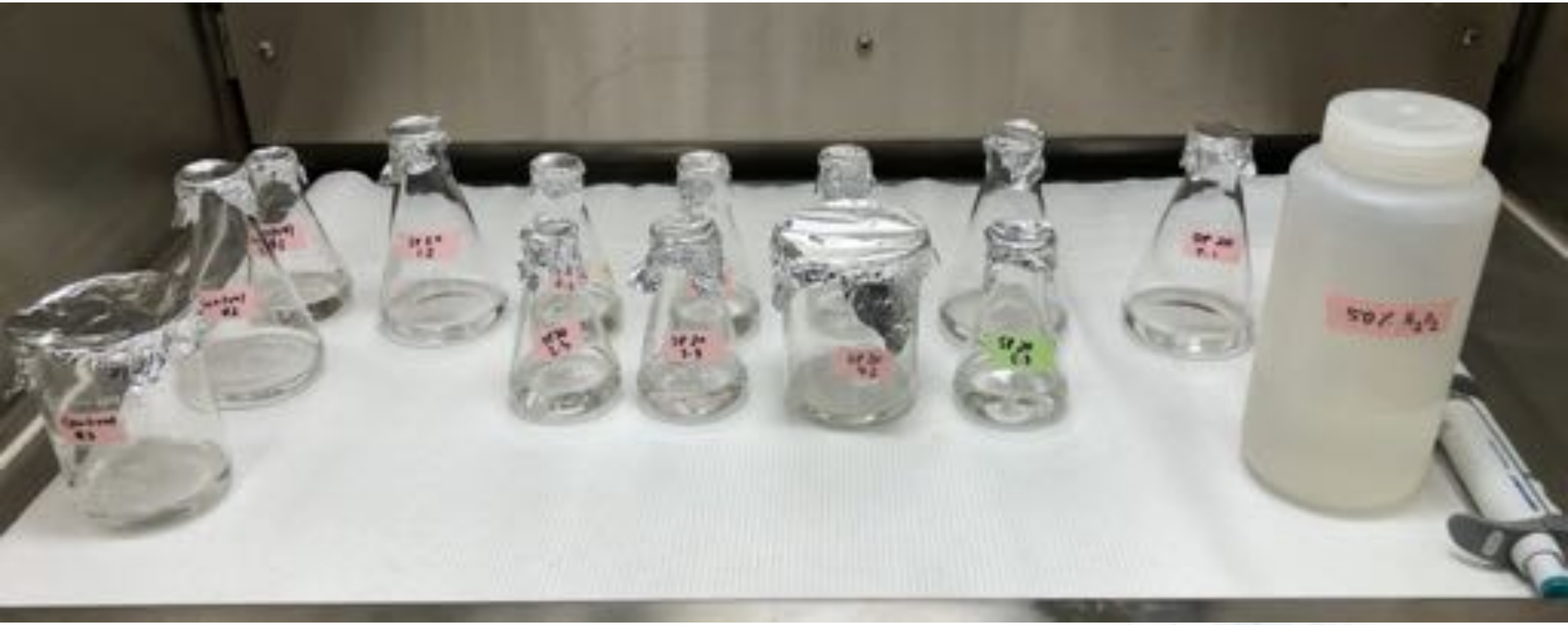
- Digestion (50% H_2O_2), filtration (47 mm, 1.2 μm, glass fibre filters), microscopy, FTIR-ATR

- Statistical Analyses
  (X^2 and ANOVA)

Initial Screening

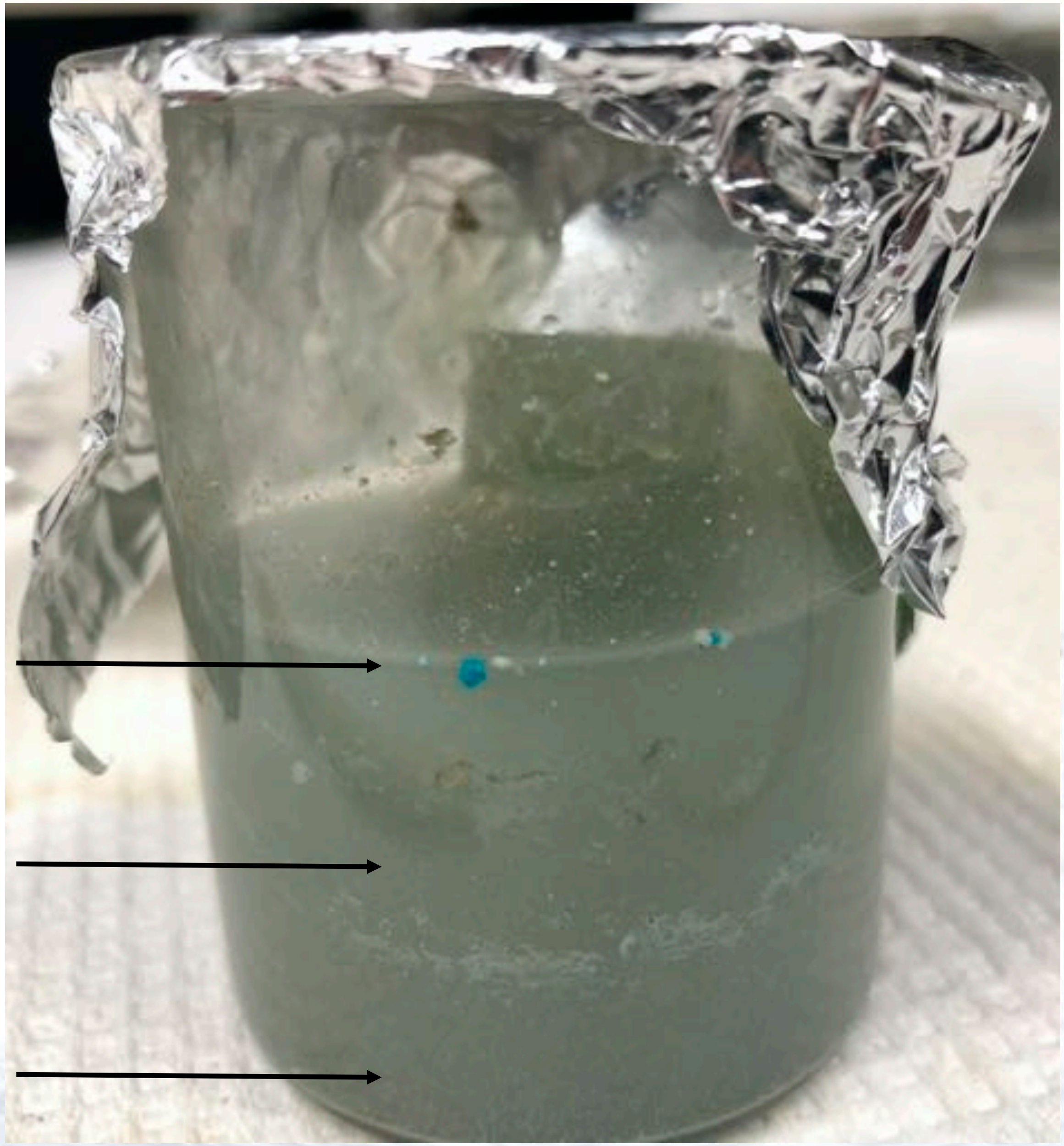
Initial Screening (250 μm) and collection

Final Effluent Digestion



Biosolids Digestion

Membrane Backflush, Post-digestion

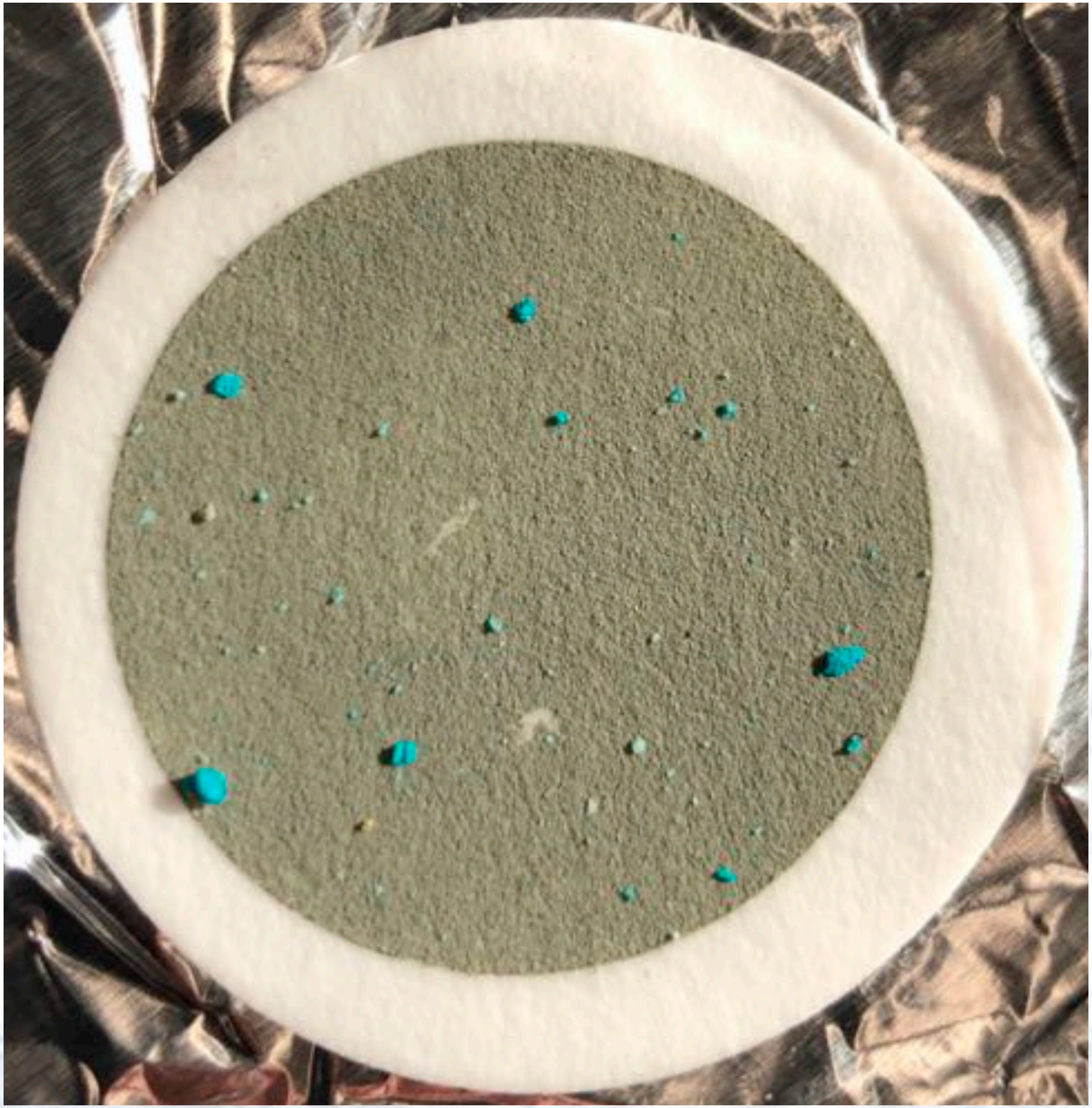


Floating

Neutral Density

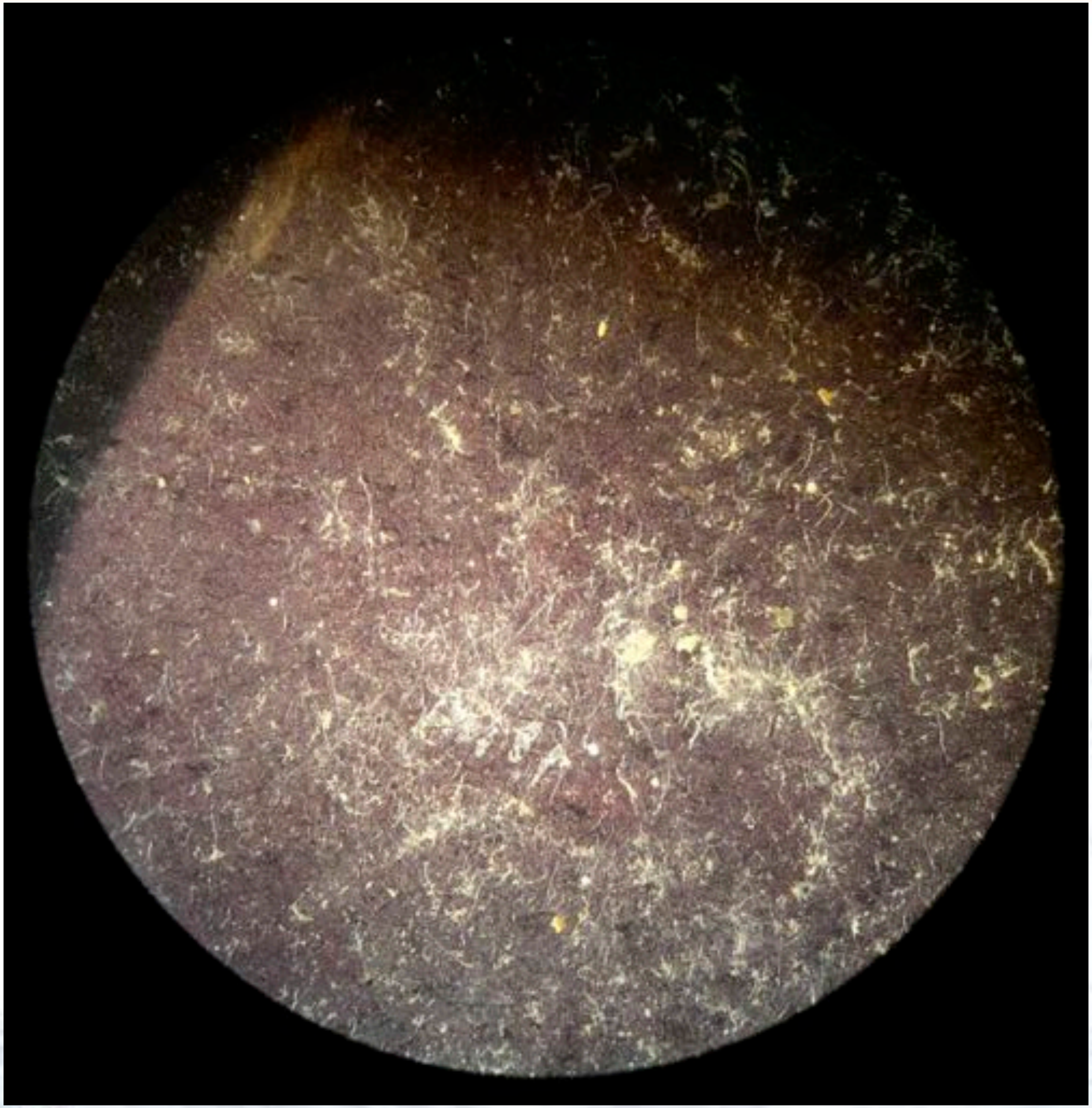
Sinking

Membrane Backflush, Post-digestion, Filtered



47 mm, Glass Fibre filter, 1.2 μm

Raw Influent, Post-digestion



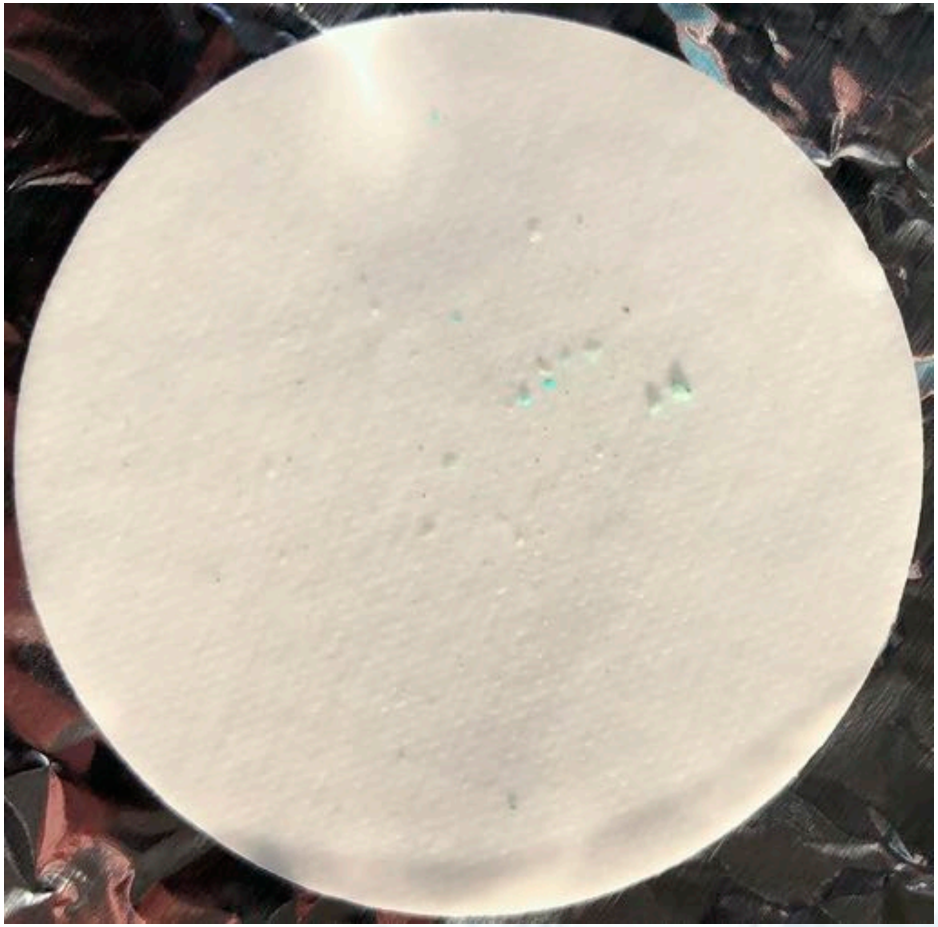
Microscopy

Example Filters & Plastics

Biosolids

Fibres (zoomed in)

Final Effluent



Nurdles and Foam

47 mm, Glass Fibre filter, 1.2 μm

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Questions

Influent → Biosolids

Influent → Final Effluent

1. Does the proportion of different microplastic categories change throughout the treatment process?

2. Do microplastics partition differently between biosolids and final effluent?

3. Does the amount of microplastics in influent (by category) balance with what is measured in biosolids and final effluent?

The South Saskatchewan River Basin (Red Deer, Bow & Oldman Rivers) is closed to new water licences (effective 2006).

Growth requires water. If you need water, you must purchase from an existing licence.

Growth will require that we do more with the same, or less (think changing climate)

Water Reuse, where water is used, treated and used again for the same or another purpose is part of the solution

Once treated, water is fit for a purpose. *Water Safety Plans* (developed by AHS) determine the level of treatment required to treat water to be reused.

Wastewater to Beer!

Last year, ACWA partnered with Xylem, Village Brewery and AHS to treat raw sewage and make beer with the treated water.

AHS worked with ACWA to develop the water safety plan for this project.

Treatment processes were constantly monitored while the water was treated. A third party lab confirmed that treated water met all Canadian drinking water guidelines.

The beer was launched on August 22, 2020 (Earth Overshoot Day 2020).

Requirements of the Water Safety Plan

- System design and LRVs

Process	Log_{10} reduction values Viruses	Log_{10} reduction for *Cryptosporidium*	Log_{10} reduction for *Giardia*
1° and 2° treatment	**2.2**	**0.7**	**2.3**
Ultrafiltration	**2**	**4**	**4**
Ozone	**6.5**	**3**	**3**
UV	**4**	**3**	**3**
RO (at brewery)*	6	6	6
Processing (at brewery)*	4	4	4
TOTAL	14.7 (24.7)	10.7 (20.7)	12.3 (22.3)

The real win was the development of the Water Safety Plan that allowed treatment of the worse water (raw sewage) to the best water (potable).

The plan is the first in Alberta, and very likely Canada.

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* These are theoretical log_{10} reduction credits based on Sharvelle et al., 2017

Media Attention

H2OPINION

Want to share your H2Opinion? Email andrew@actualmedia.ca

One of the advanced tertiary treatment technologies used to transform wastewater into potable water was ACWA's Reverse Osmosis membrane system.

Turning Waste(water) into Gold

BY LEE JACKSON

WATER IS ESSENTIAL TO LIFE. Growing populations are currently expected to decrease their per capita volume of clean water, unless they find ways to do more with the same or less. Technologies currently exist that can turn wastewater directly into safe, drinkable water. Yet barriers exist to making this commonplace in Canada.

Recently, a partnership between Advancing Canadian Wastewater Assets, Village Brewery, Xylem Technologies, and Alberta Health Services turned wastewater to potable water and then into beer. The project was announced publicly on Earth Overshoot Day—August 22, 2020—a poignant context when the global population consumed nature's budget for 2020. Brewing beer created a direct potable reuse example that certainly grabbed peoples' attention—good and bad. Comments on social media ranged from "disgusting—I'll never drink your beer again" to "fantastic idea."

Market demand creates 'pull' for an undeveloped good or service. Undoubtedly, the largest barrier for many people—the lack of pull—derives from the "yuck" factor, something the launch promotion materials addressed head on. The yuck factor is the root of an educational challenge to change the notion that direct potable reused water is not safe.

Regulators have legal authority and thus provide 'push,' which motivates technology developers to innovate and create new solutions in accordance with regulations. In Canada, the siloing of water management and lack of direct potable reuse regulations means there is little incentive to develop direct potable reuse solutions.

Why is this example the first direct potable reuse in Alberta, and possibly Canada? How was the lack of a framework overcome? In the case of turning waste(water) into gold (Village Blonde was brewed), the push barrier was overcome by a shared vision and collaboration among the four parties. It also came from the fact that Alberta Health Services was already two years into developing a provincial framework for water reuse. Successful approvals had previously been granted for reuse, such as car washes, that was expanded to include direct potable reuse through development of a Water Safety Plan.

To many Canadians, the idea that our water is, or ever could become, in short supply is nonsense. After all, many of us live on or near the Great Lakes. Despite the water prosperity currently enjoyed by many Canadians who live in large cities with centralized infrastructure, far too many Canadians in remote communities today are on boil water advisories, in some cases exceeding a decade, or even do not consume advisories.

UNICEF and the World Health Organization suggest that globally, 33 per cent (2.2 billion) of global citizens currently lack access to safe drinking water. The UN also predicts that water demand will increase by 70 per cent by 2050 when we are ~9.5 billion people. As the global population grows and the effects of changing climate alter water cycles, direct potable reuse options could help many communities.

As a homebrewer for nearly 30 years, I understand how important my water is to making good beer. Just as clean water is to sustaining life. Now that there is an Alberta example of turning the worse water (raw sewage) into the best water (drinking water), I argue that we need a collective sense of urgency, among regulators, researchers, technology developers, and the public to accelerate the development of reuse solutions, including direct potable reuse. We need to devise solutions for water scarcity today while there still options. We need to increase peoples' awareness and literacy for water challenges and possible solutions. Success will require collective action. WC

Lee Jackson is a professor in the Department of Biological Sciences at the University of Calgary. He is also the scientific director of Advancing Canadian Wastewater Assets.

WATERCANADA NOVEMBER/DECEMBER 2020

WATERCANADA.NET

Future Human

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It's Time to Get Used to Drinking Recycled Wastewater

North American cities are preparing to source water from toilets and sinks

In August 2020, a group of 50 beer lovers in Calgary—along with drinkers videoconferenced in from Edmonton and Ottawa — had a communal sip of a limited-edition brew of Village Brewery's Blonde. This one-off was made from purified water that had only recently been wastewater flowing from the city's toilets and sinks.

We brewed beer from recycled wastewater – and it tasted great

Safe to consume

Antimicrobial Resistance (AMR)

Clearly, water reuse strategies focus on public health safety and risk reduction from exposure to pathogens.

”Superbugs” are microbes that have developed or acquired resistance to antimicrobial agents, including metals and antibiotics (many people associate superbugs with hospitals eg, MRSA - Methicillin-resistant *Staphylococcus aureus*).

Evidence is emerging that bacteria in wastewater treatment plants have acquired resistance to a growing list of antimicrobials (metals, UV radiation, antibiotics).

Why is this Important?

The Bramaputra River, Bangladesh. Some river locations in Bangladesh carry antibiotic levels 300 times higher than is considered safe for the environment.

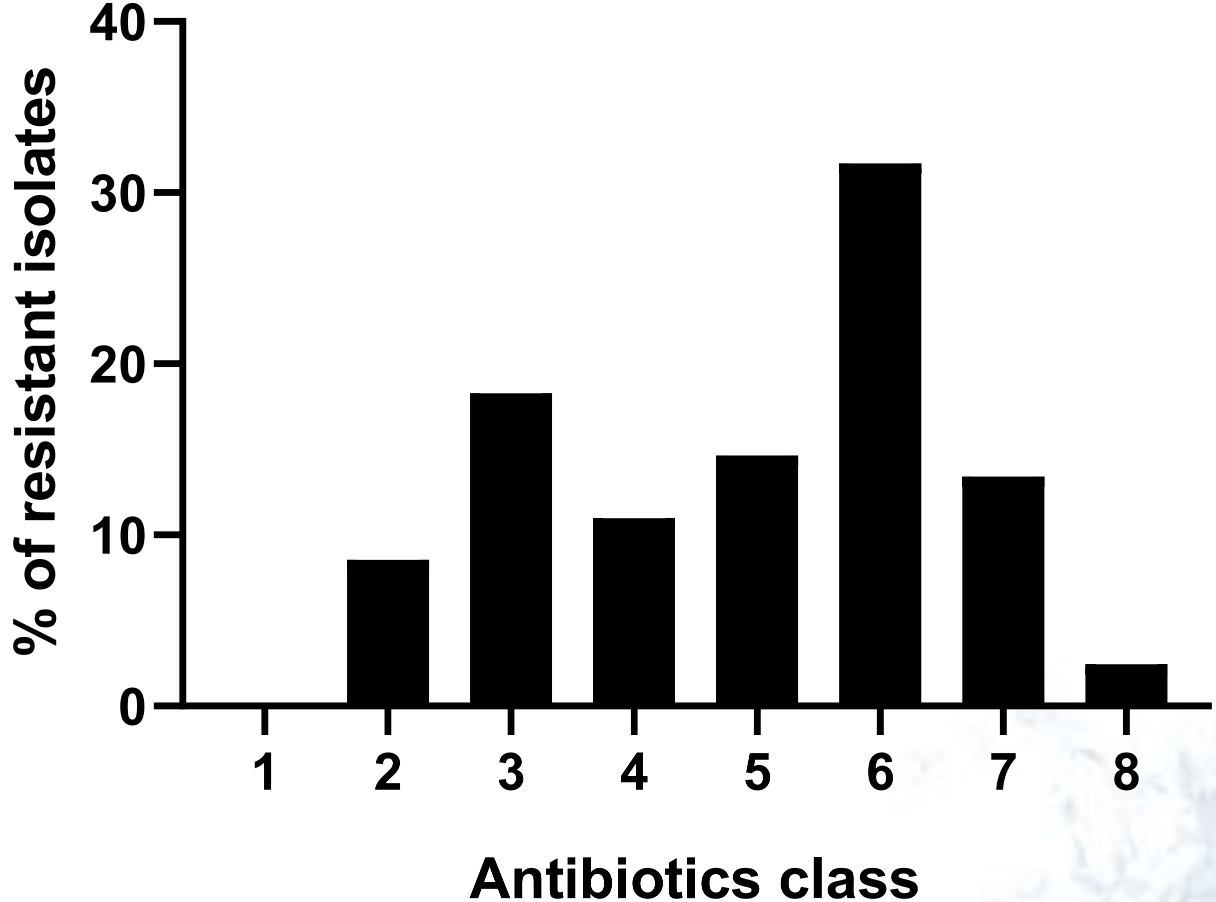
PHOTOGRAPH BY JONAS BENDIKSEN, NAT GEO IMAGE COLLECTION

ENVIRONMENT

First global look finds most rivers awash with antibiotics

Almost two-thirds of the rivers studied contained enough antibiotics to contribute to the growing problem of antibiotic-resistant bacteria.

National Geographic



Half of wastewater treatment plant isolates that display antibiotic resistance are resistant to > 6 antibiotic classes

Tao Dong, unpublished data

Urinary Pathogenic *Escherichia coli* (UPECs)

- There are 150 million Urinary Tract Infections (UTI) globally each year[1]
- 40 % of females will have 1 UTI in their lifetime
- 11 % of females over 18 will have 1 UTI/year
- UPEC accounts for 80-90 % of community acquired UTIs
- In the USA alone – 11 million annual cases of UTIs; $5 Billion in health care costs[2]
- Resistance is developing to[3]:
  - trimethoprim-sulfamethoxazole (14.6 – 60 %) [European countries]
  - fluoroquinolones (55.5 – 85.5 %) [developing countries]
  - amoxicillin-clavulanic acid (5.3 – 37.6 %) [Germany, France]

1. Terlizzi ME, Gribaudo G & ME Maffe (2017) UroPathogenic *Escherichia coli* (UPEC) Infections: Virulence Factors, Bladder Responses, Antibiotic, and Non-antibiotic Antimicrobial Strategies Front. Microbiol. 8: 1566. doi: 10.3389/fmicb.2017.01566

2. Foxman B. (2014). Urinary tract infection syndromes occurrence, recurrence, bacteriology, risk factors, and disease burden. Infect. Dis. Clin. North Am. 28, 1–13. doi: 10.1016/j.idc.2013.09.003

3. Kot B (2019) Antibiotic Resistance Among Uropathogenic *Escherichia coli.* Pol J Microbiol. 68(4): 403–415.

Research Questions

1. What ozone (O_3) dose and contact times lead to complete wastewater disinfection?

2. What bacteria survive current O_3 dosing regimes?

3. What variation in antimicrobial elements are present in municipal wastewater treatment plants, dairy and beef operations and their receiving environments?

4. What are the rates of horizontal gene transmission in environmental reservoirs?

Research Approach

1, 2. Our approach is to manipulate O_3 dose and contact times, followed by measurement of wastewater disinfection endpoints and identify treatment survivors (species or functional groups).

3. We will survey wastewater treatment plant and agricultural (dairy and beef) operations wastewater isolates for antimicrobial resistance.

4. We will grow periphyton communities on unglazed tiles in ACWA's replicated, naturalized research streams that receive different
treated effluents to evaluate the changes in antimicrobial elements over time.

One Health @ UC

University of Calgary has created a new research focus under the One Health paradigm

- Antimicrobial Resistance
- Healthy Aquatic Ecosystems
- Infectious Diseases and the Microbiome
- Healthy Communities

A One Health approach explicitly recognizes that infectious disease arises from the interactions of hosts, pathogens and our environment. We need to understand key drivers and develop a range of solutions (behavioural and technological).

Contact Information

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