KEEPING OUR WATER SAFE

Ottawa Cleantech Breakfast Series
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Water is not abundant

- Nearly 97% of the world's water is salty or otherwise undrinkable.
- Another 2% is locked in ice caps and glaciers.
- That leaves just 1% for all of humanity's needs — all its agricultural, residential, manufacturing, community, and personal needs.

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The myth of superabundance

- "Canada is a country of unbelievable water wealth and is the most water-rich nation on the planet"
- "Canada contains as much as 25% of the global supply of fresh water"
- "Canada has lots and lots of water"
- "Canada is to water as Kuwait is to oil"

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Canada is not the Kuwait of water

- Canada appears to have lots of water, but it has a modest 6.5% of the global renewable water supply
- 60% of Canada's water flows north to arctic or subarctic regions remote from population
- The water supply in southern Canada is only about 2.6% of the world supply

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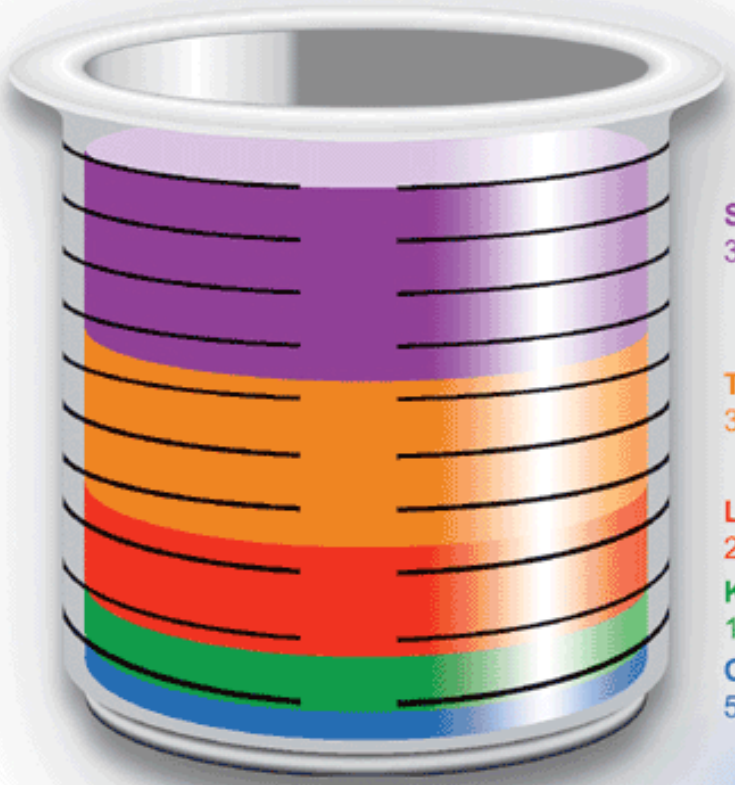
Water use in the home



Showers and baths
35%

Toilet flushing
30%

Laundry
20%

Kitchen and drinking
10%

Cleaning
5%

Environment Canada

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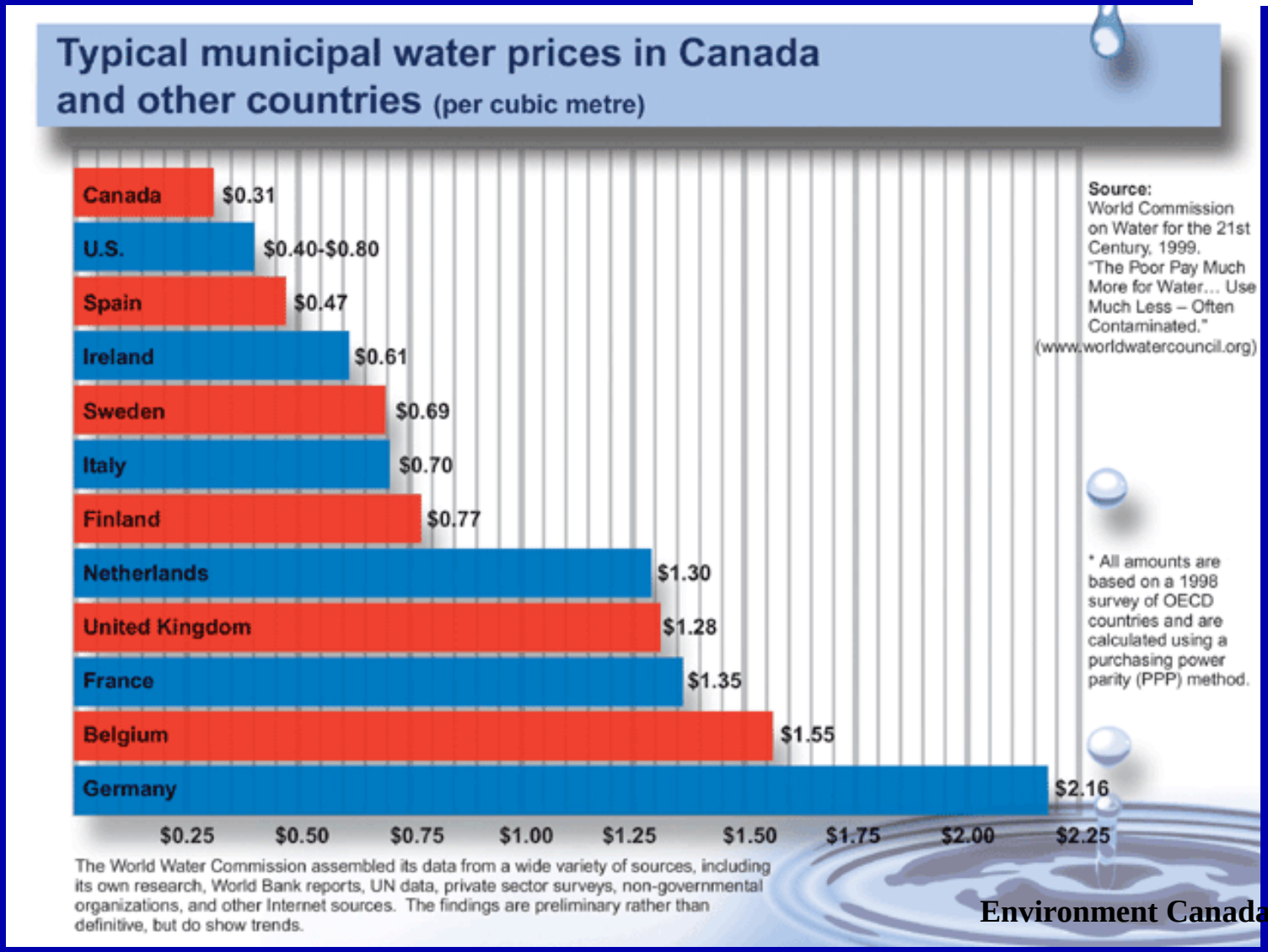

Environment Canada

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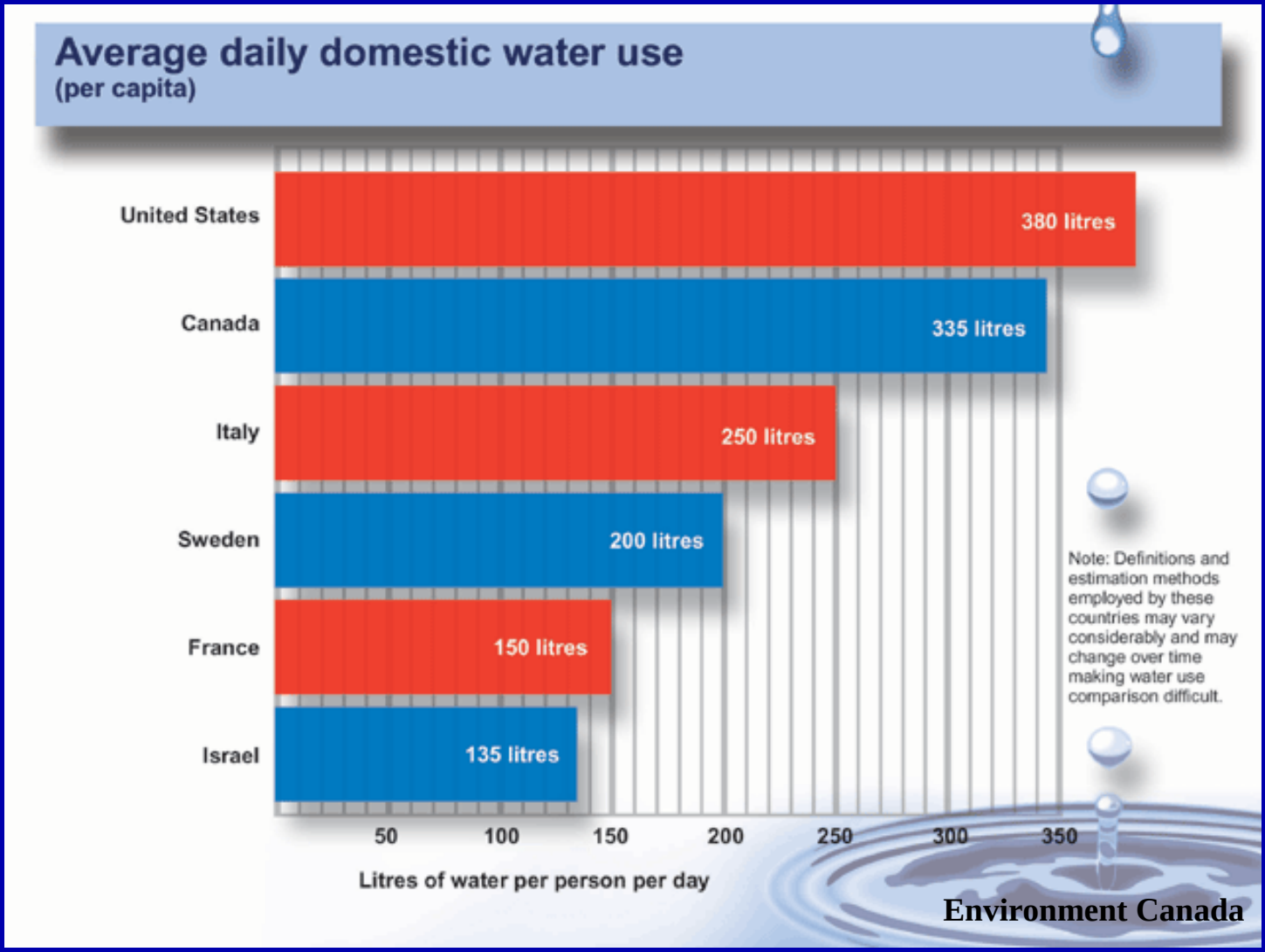

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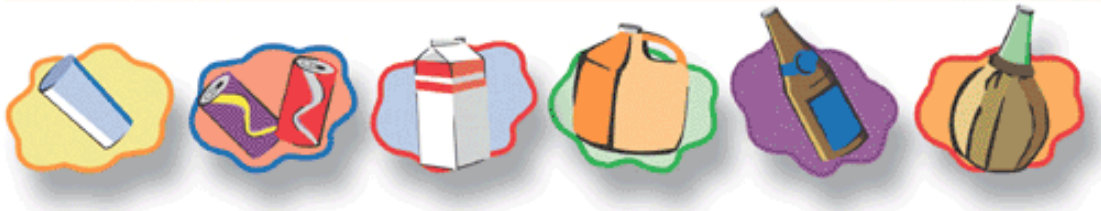
Typical prices for popular beverages
($/1000 litres)

Beverage	Cost *
Tap water **	1.14
Cola	850.00
Milk	985.00
Bottled water/Mineral water	1 500.00
Beer	2 500.00
Wine	9 000.00
Whiskey, gin…	26 700.00



Gas	**1150.00**

* All amounts are in 1999 Canadian dollars.

** Only tap water includes automatic delivery to the user. This figure also includes the cost of waste treatment.

Environment Canada

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Waterborne disease outbreaks

- Pressures of an increasing population and aging infrastructure threaten water quality
- Despite many improvements waterborne disease continues to occur at high levels
- The causative agent is not identified in about half of the waterborne disease outbreaks
- A significant portion of the waterborne disease is endemic and not reported

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Recent waterborne outbreaks in Ontario alone

- Walkerton, ON - 7 people died, 2500 people got sick, the cost to the province was $155 million (Livernois, 2001)
- Kashechewan, ON - 1,800 people were evacuated
- 30 percent of Ontario's First Nations reserves are under boil-water advisories (Health Canada)
- There are also boil-water advisories in non-native communities

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Kashechewan

(CP Photo/Jonathan Hayward)

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Residents get off a plane at the Sudbury airport after being evacuated from Kashechewan, Wednesday, Oct. 26, 2005. (CP Photo/Jonathan Hayward)

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Mary-Joe Kataquapit shows the sores on her hands that have been caused by the water on the Kashechewan reserve, Thursday, Oct. 27. (CP Photo/Jonathan Hayward)

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A child suffering from impetigo, a bacterial infection, is seen in this handout photo. (CP Photo)

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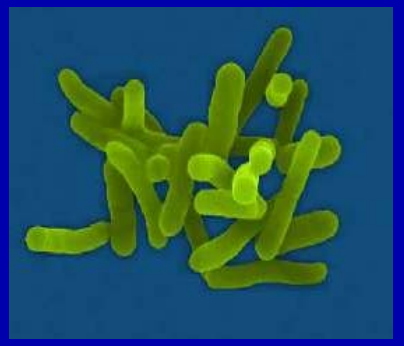
Pathogenic organisms

- Bacteria (e.g., *Salmonella, Shigella, Vibrio cholerae, E. coli*)
- Viruses (e.g., *Poliovirus, Rotavirus, Norwalk virus, Hepatitis A*)
- Protozoa (e.g., *Giardia, C. parvum*)

E. coli

Salmonella



Shigella

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My research interests

- Water and wastewater disinfection
- Advanced ultraviolet (UV) processes
- Fate and persistence of pathogens and chemicals through treatment processes
- Sludge treatment and disposal
- Coagulation/flocculation/dewatering

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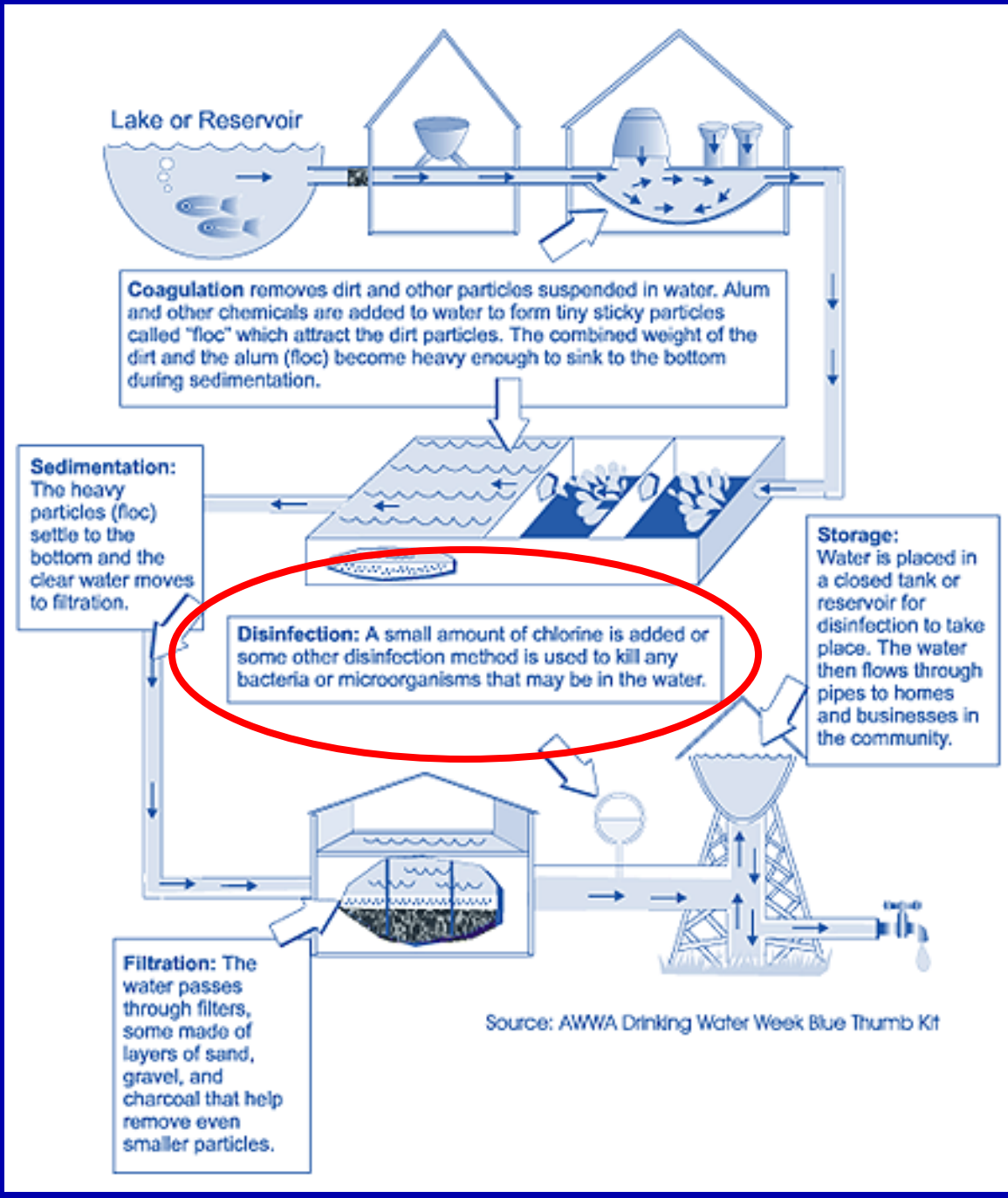

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Disinfection

- Disinfection is the process that partially kills pathogenic microorganisms
- Chlorine is the most commonly used disinfectant throughout the world
- Chlorine reacts with the organic constituents in water to produce disinfection byproducts (THMs, HAAs) which are suspected carcinogens
- Chlorine is not effective on certain microorganisms such as *C. parvum* and *Giardia*

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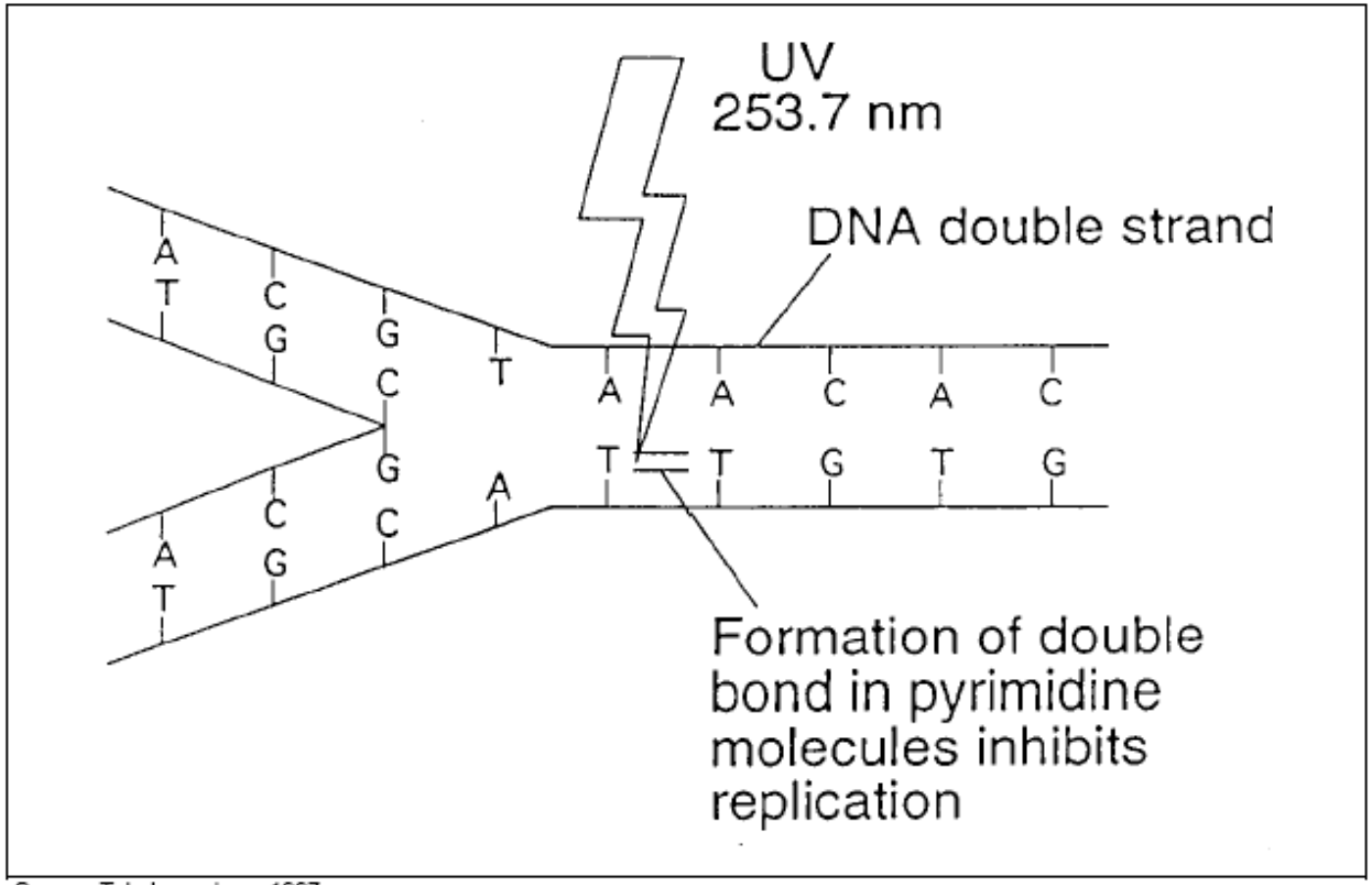
Ultraviolet disinfection

- UV disinfection is a *physical* disinfection process
- No chemicals are added to water
- UV light inactivates microorganisms by damaging their nucleic acid, thereby preventing the microorganisms from replicating
- A microorganism that cannot replicate cannot infect a host



Source: Tchobanoglous, 1997.

Germicidal inactivation by UV radiation

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Why UV disinfection? Why now?

- Chlorine is not effective against protozoa
- Generation of disinfection by-products
  - Cl_2 – THM's, HAA's
  - O_3 – Bromate

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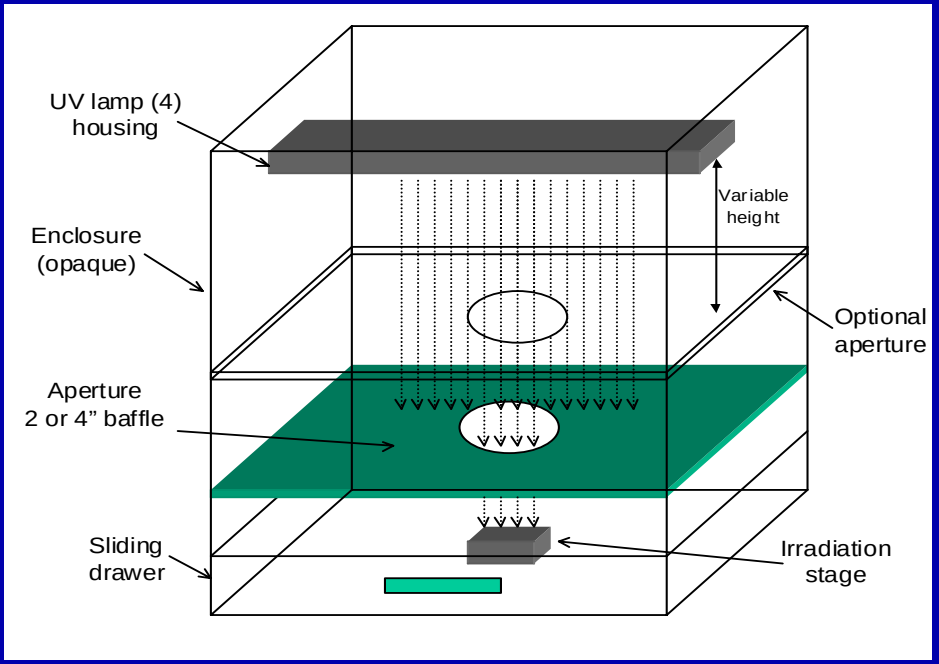
UV Collimated Beam Apparatus



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Problem

- Water characteristics and environmental factors impact the disinfection performance
- Particles present in water and wastewater may protect pathogens from lethal doses of disinfection
- Microorganisms associated with particles may survive the disinfection processes in a treatment plant

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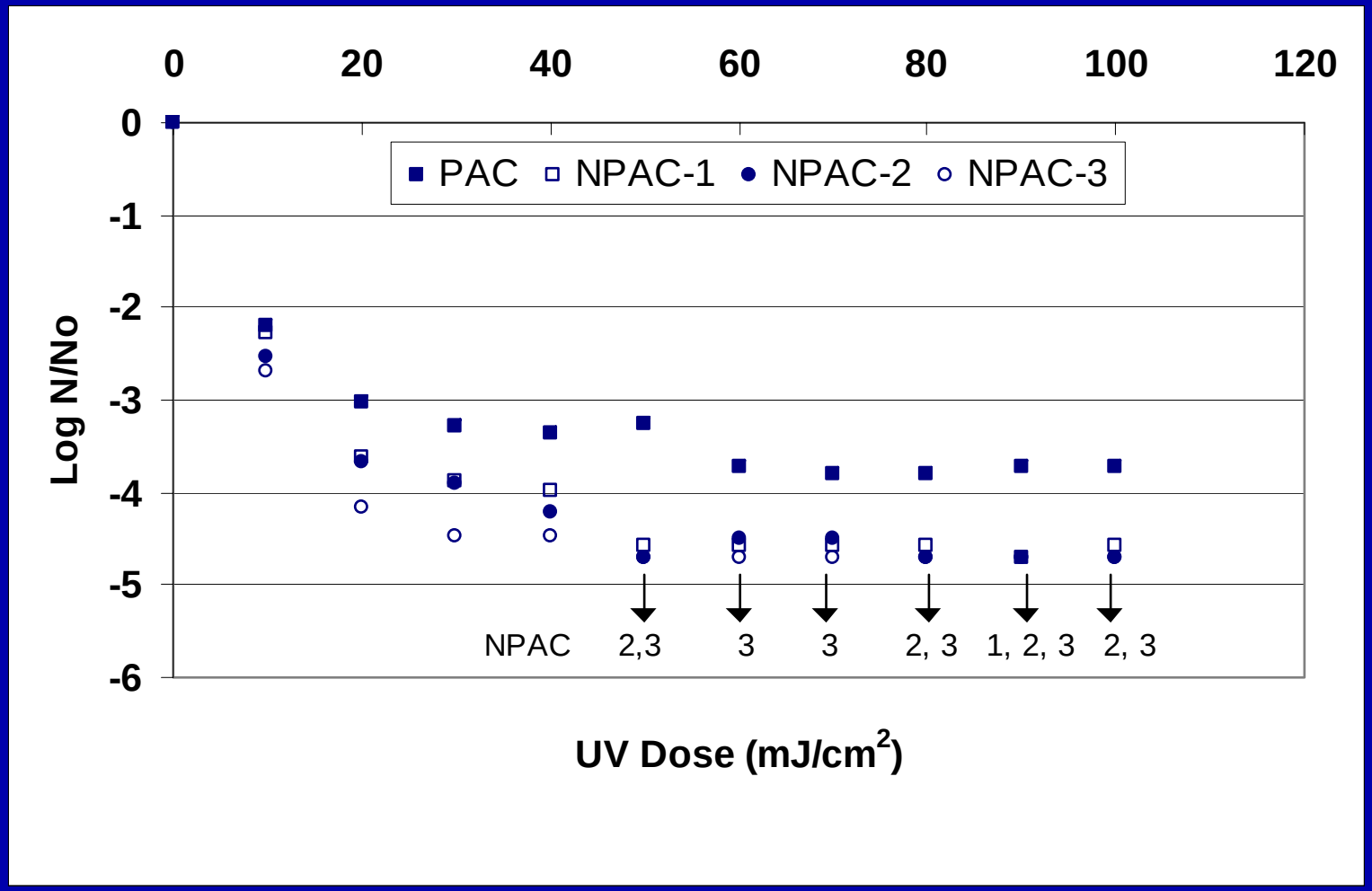
Results - UV Inactivation of PAC/NPAC



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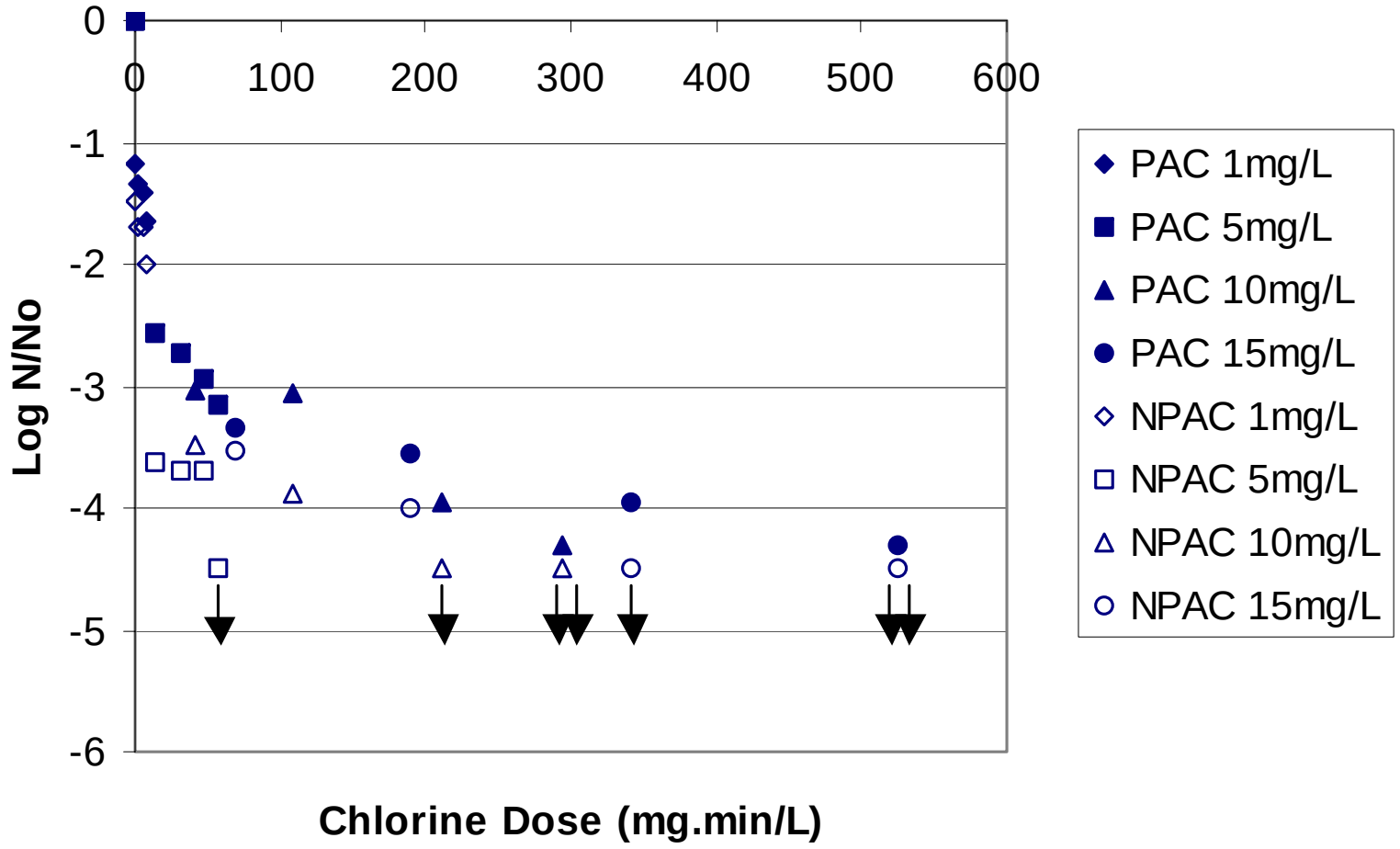
Results - Chlorine inactivation of PAC/NPAC



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Importance

- PAC can survive UV and chlorine disinfection at doses that are typically encountered in a treatment plant
- Survival of PAC may indicate the survival of other more resistant health related microorganisms
- Since coliform bacteria are over 100-fold larger than viruses, it may be even more difficult to disinfect particle-associated viruses

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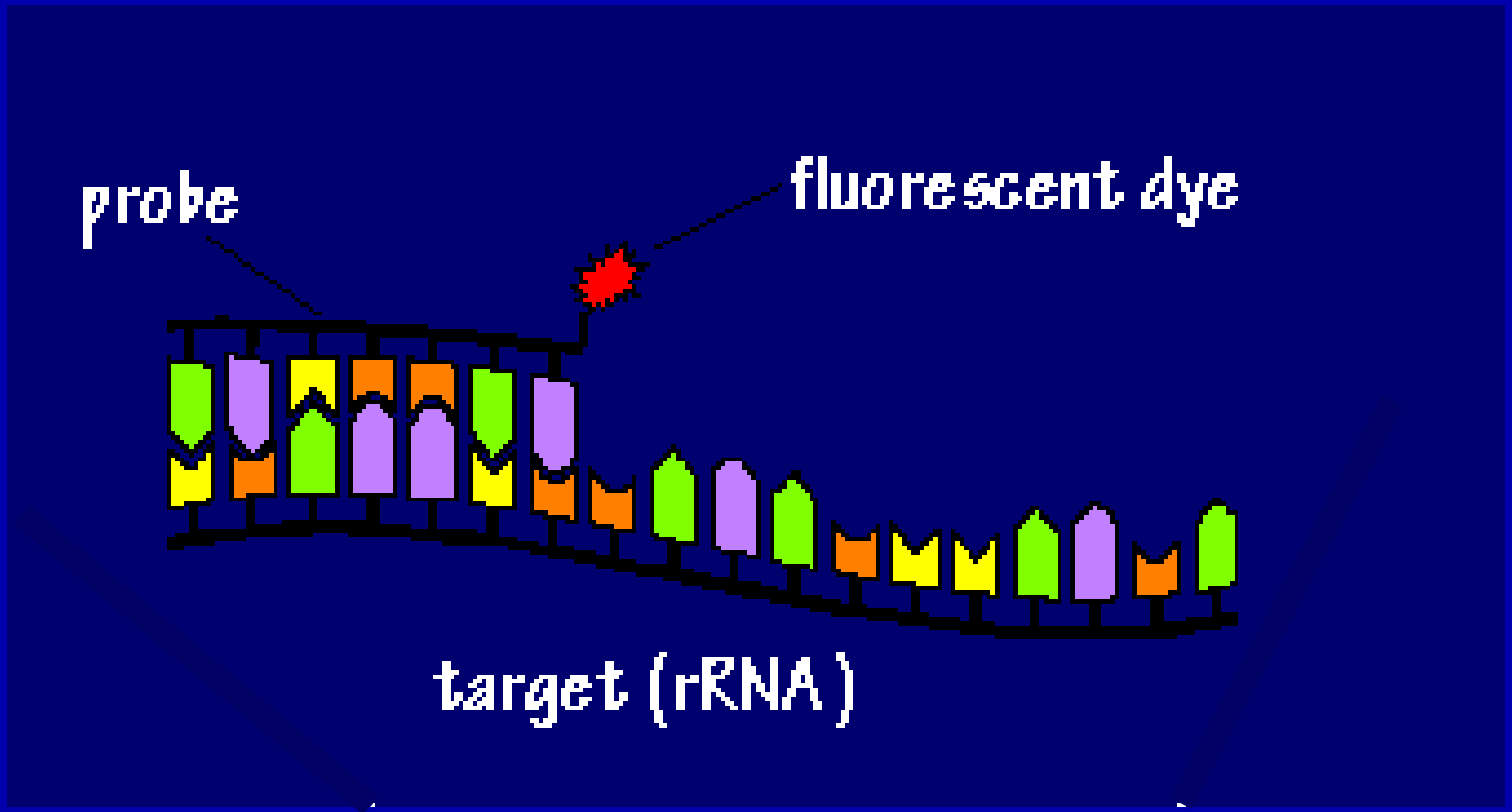
FISH – Fluorescence In-Situ Hybridization



Glockner F. O., 2002

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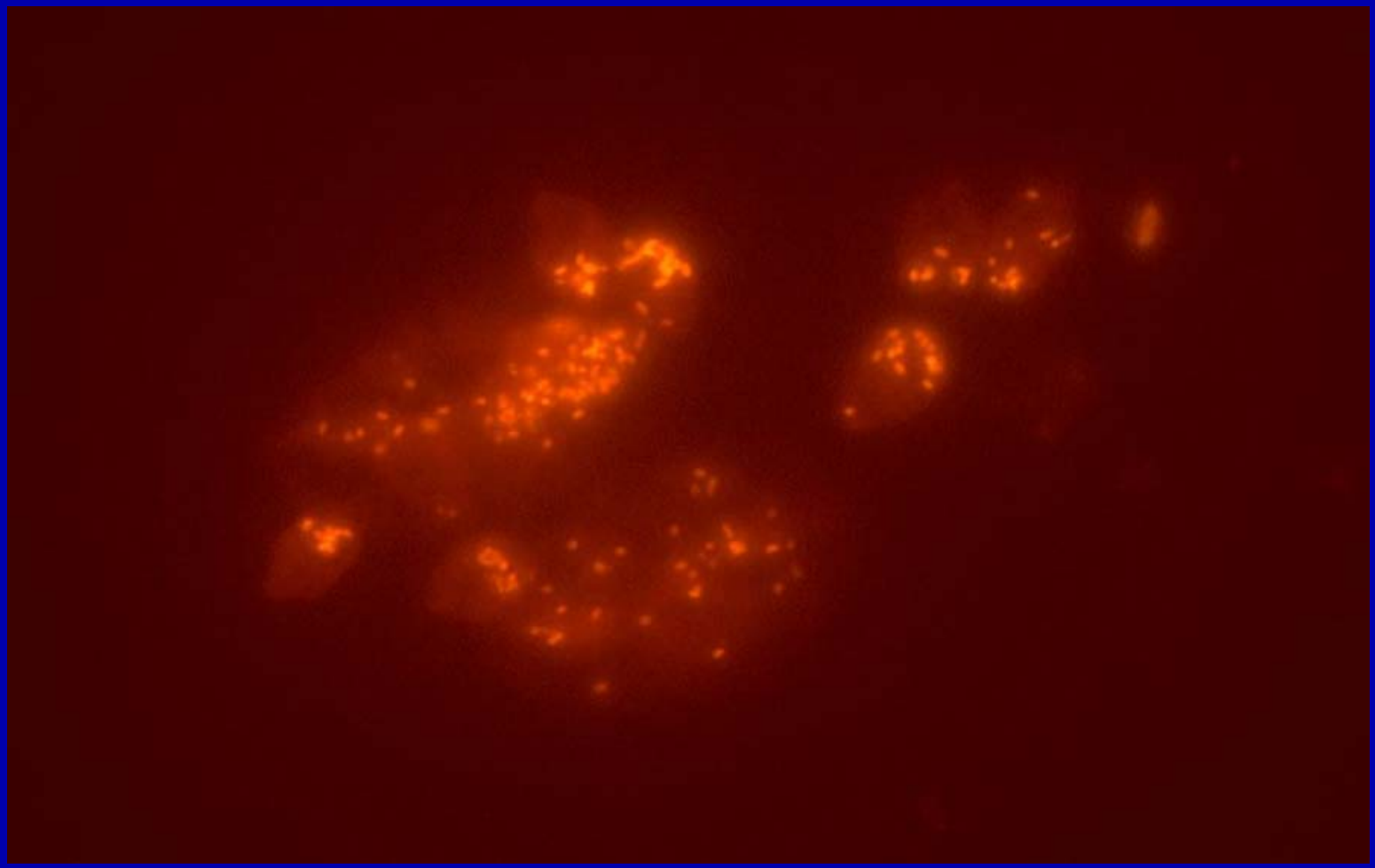
Results - CY3 Labeled EUB338



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Real-time disinfection monitoring

- Monitoring and predicting disinfection performance is an extremely important issue
- Currently, there is no method that can provide immediate information on the performance of UV and chlorine disinfection based on the quantity and viability of pathogenic microorganisms
- The culture methods (plate counts) take at least a day and can only provide information "after the fact"

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Challenge

- The mechanisms of UV and chlorine disinfection are very different
- Chlorine is a very strong oxidant, and achieves disinfection by mainly destroying the cell wall and oxidizing the cellular components
- UV light inactivates microorganisms by damaging their nucleic material
- The method should be able to detect both types of damage caused on the microorganisms

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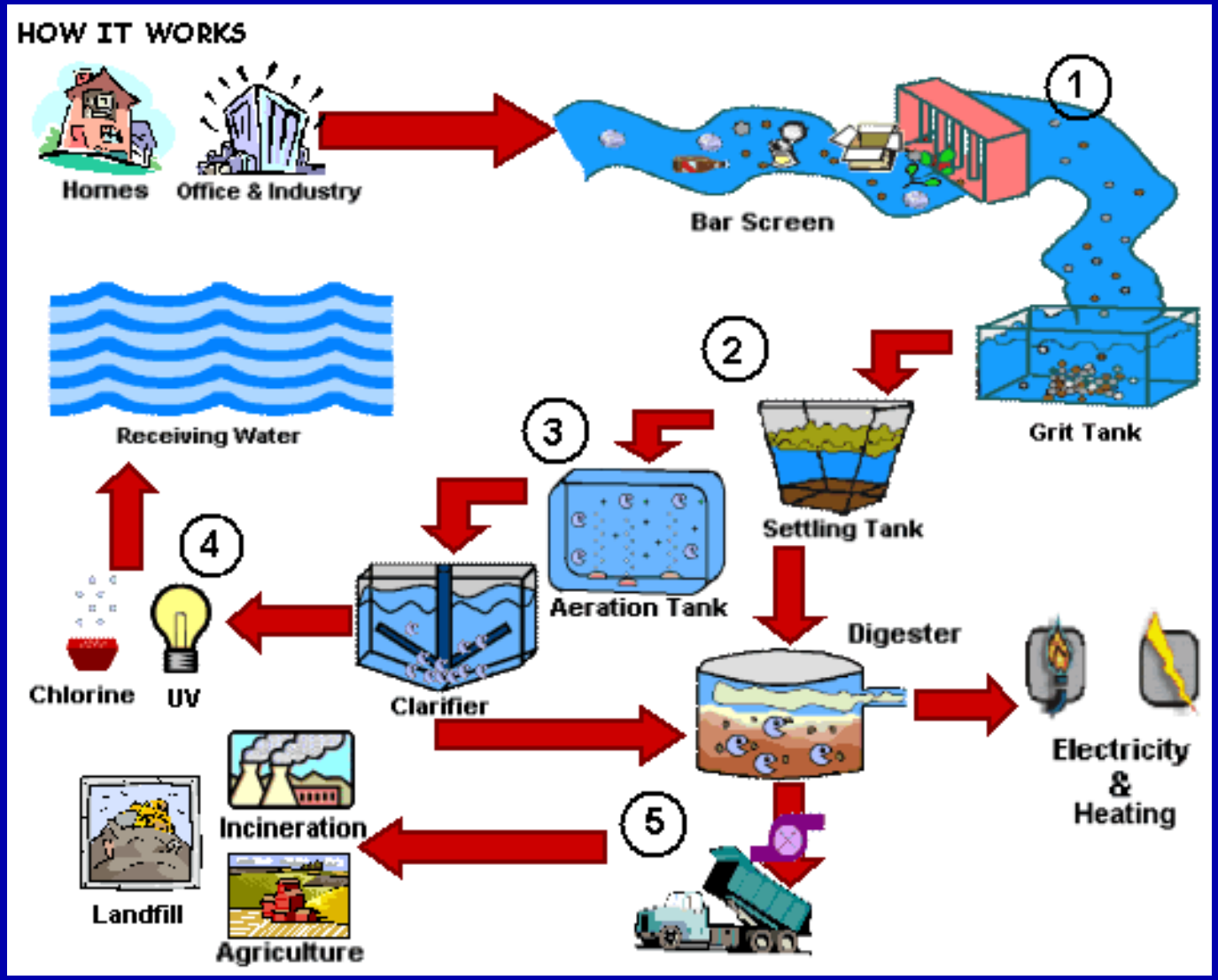
Benefits

- There is a major need in the market for a real time monitoring tool particularly for UV disinfection
- Real-time information on the disinfection performance would enable the treatment plant operators to intervene immediately to rectify a problem before pathogenic microorganisms can cause a public health threat
- Biological early warning system against possible natural or intentional contamination of water

Sludge treatment



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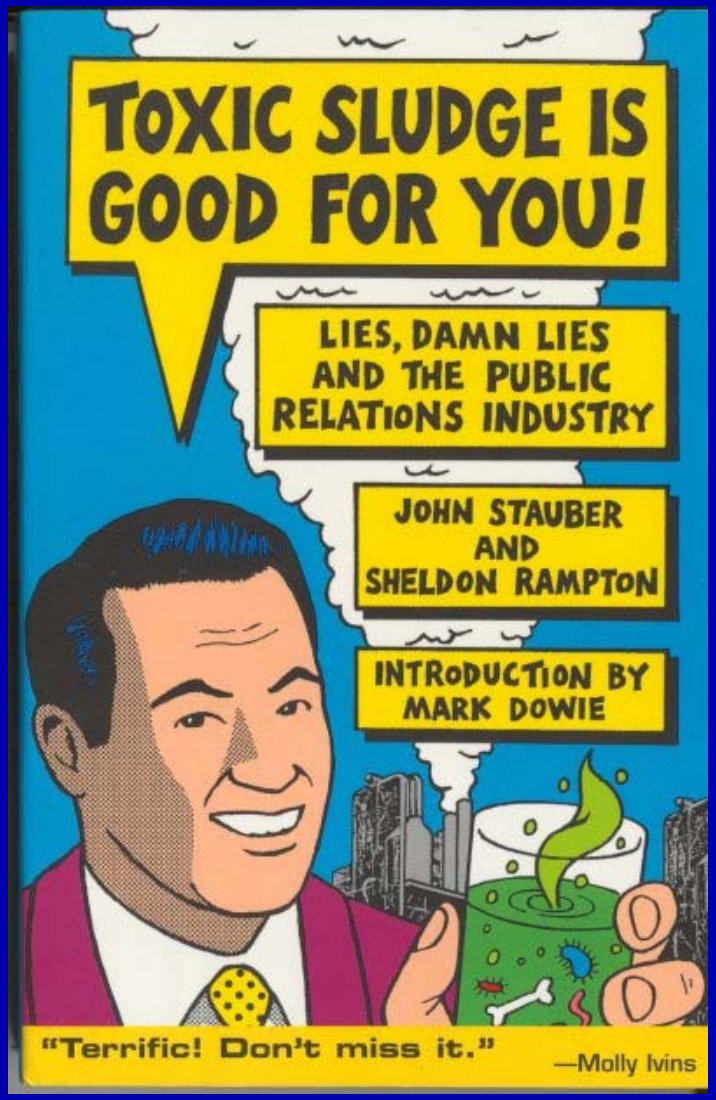
What is sludge?

- Sludge is a mixture of pathogens, organic matter, heavy metals, chemicals, and solids removed from wastewater treatment plants
- Final disposal is problematic: landfills, incineration, land application.



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Sludge Treatment

- Thickening
- Stabilization
- Conditioning
- Dewatering
- Disposal

$3 billion USD in 2005 in the U.S. alone

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Dewatering optimization is important

- Polymers are expensive
- While underdosing can decrease the efficiency of dewatering units, overdosing can increase the operational costs and create undesirable environmental impacts
- Sludge characteristics change, thus it is difficult to keep the polymer dose at the optimum dose

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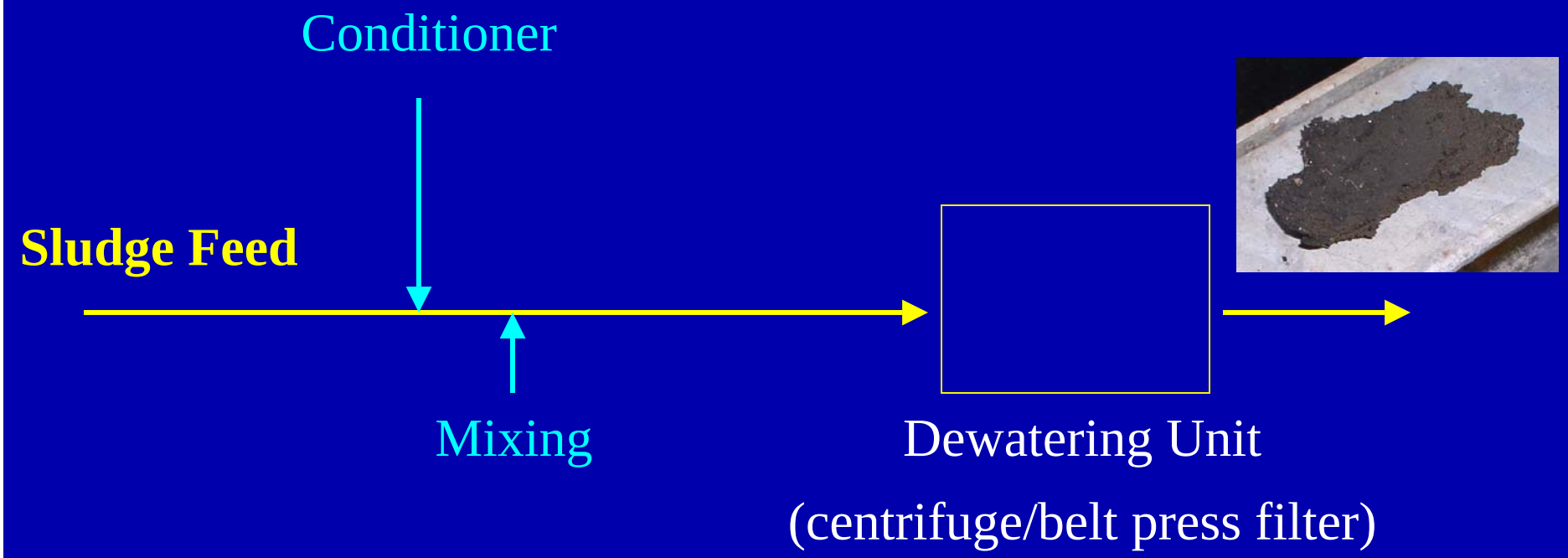

Current approach is largely empirical and is based on trial and error

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An automation system is needed that can detect the changes in sludge characteristics, and adjust the polymer dose, mixing conditions, and operational parameters of the dewatering device

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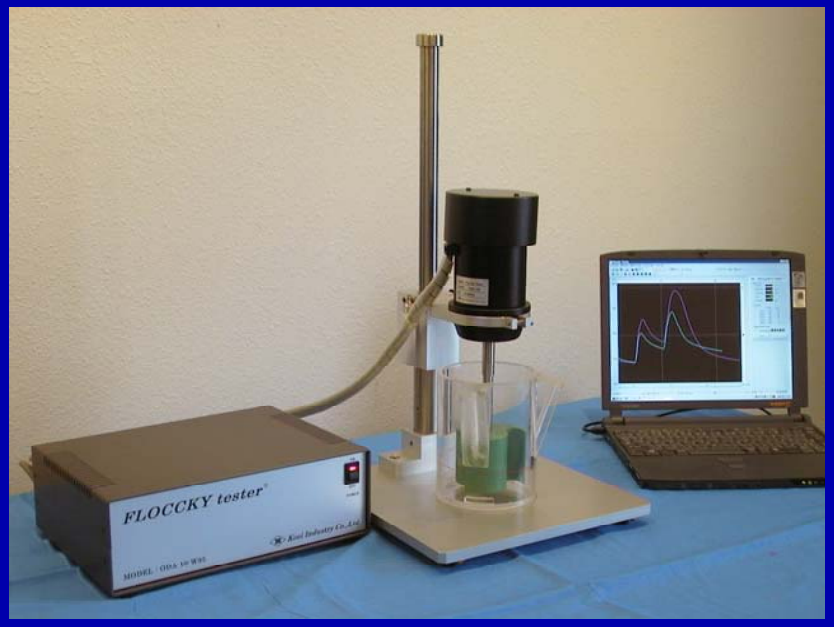
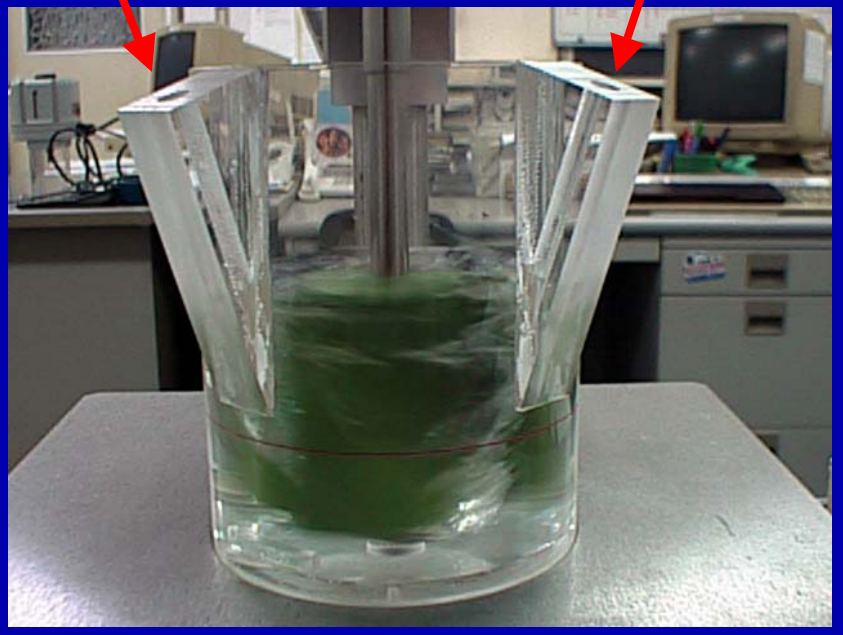
Floccky Torque Rheometer



Large (200 mL) sample reservoir

Floccky allows direct polymer injection



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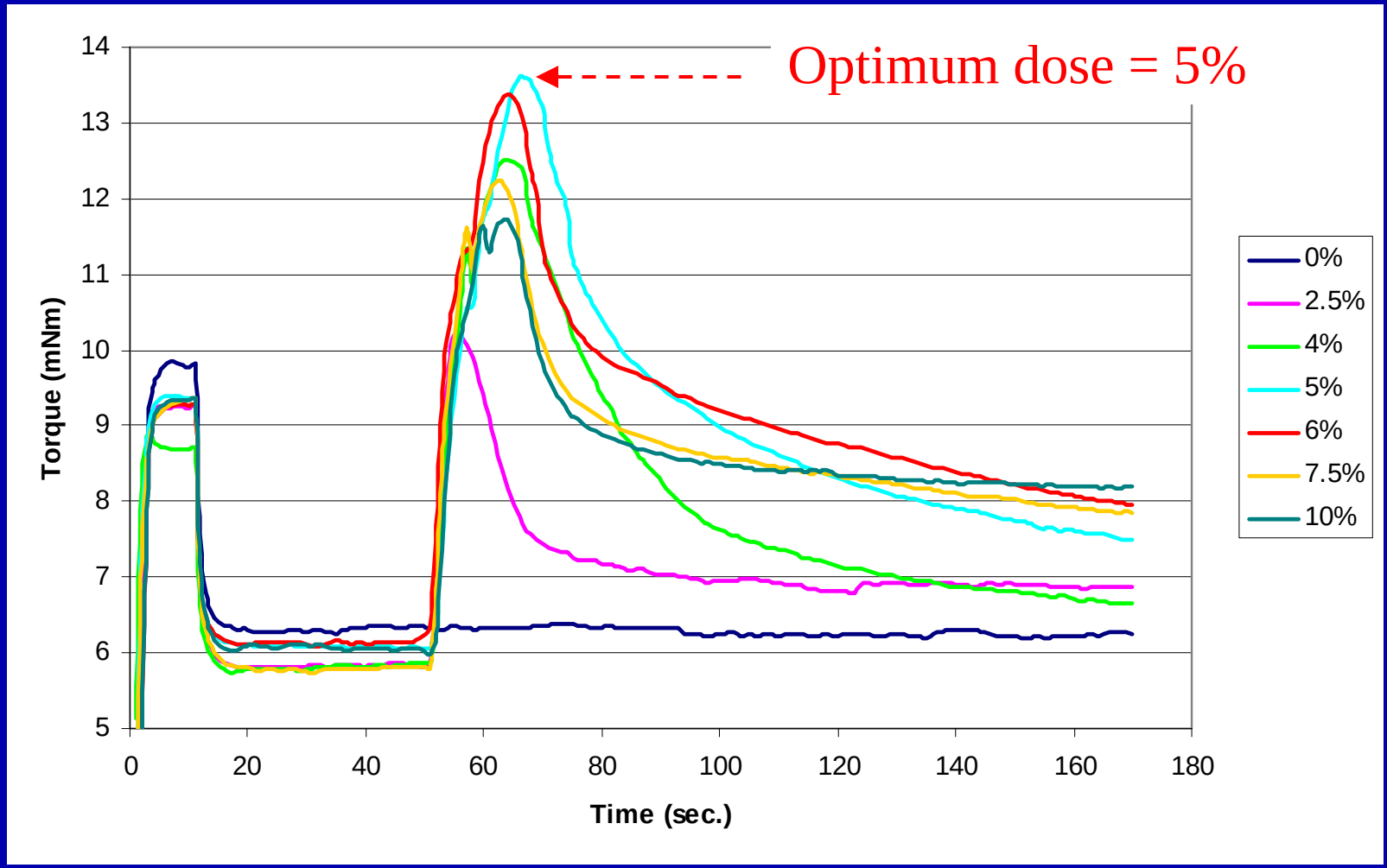
Full-scale testing at Charleston WWTP



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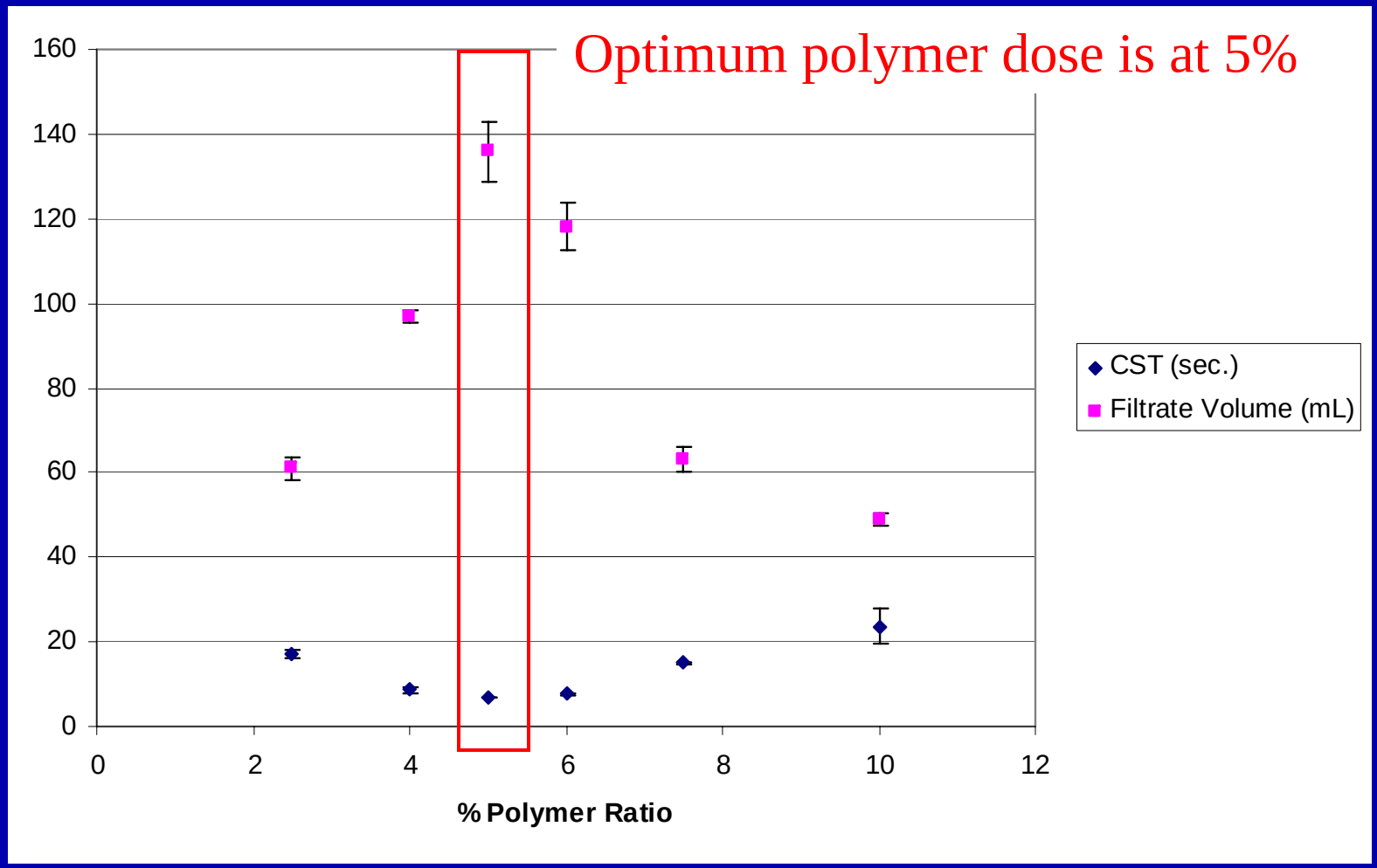
Dewaterability results



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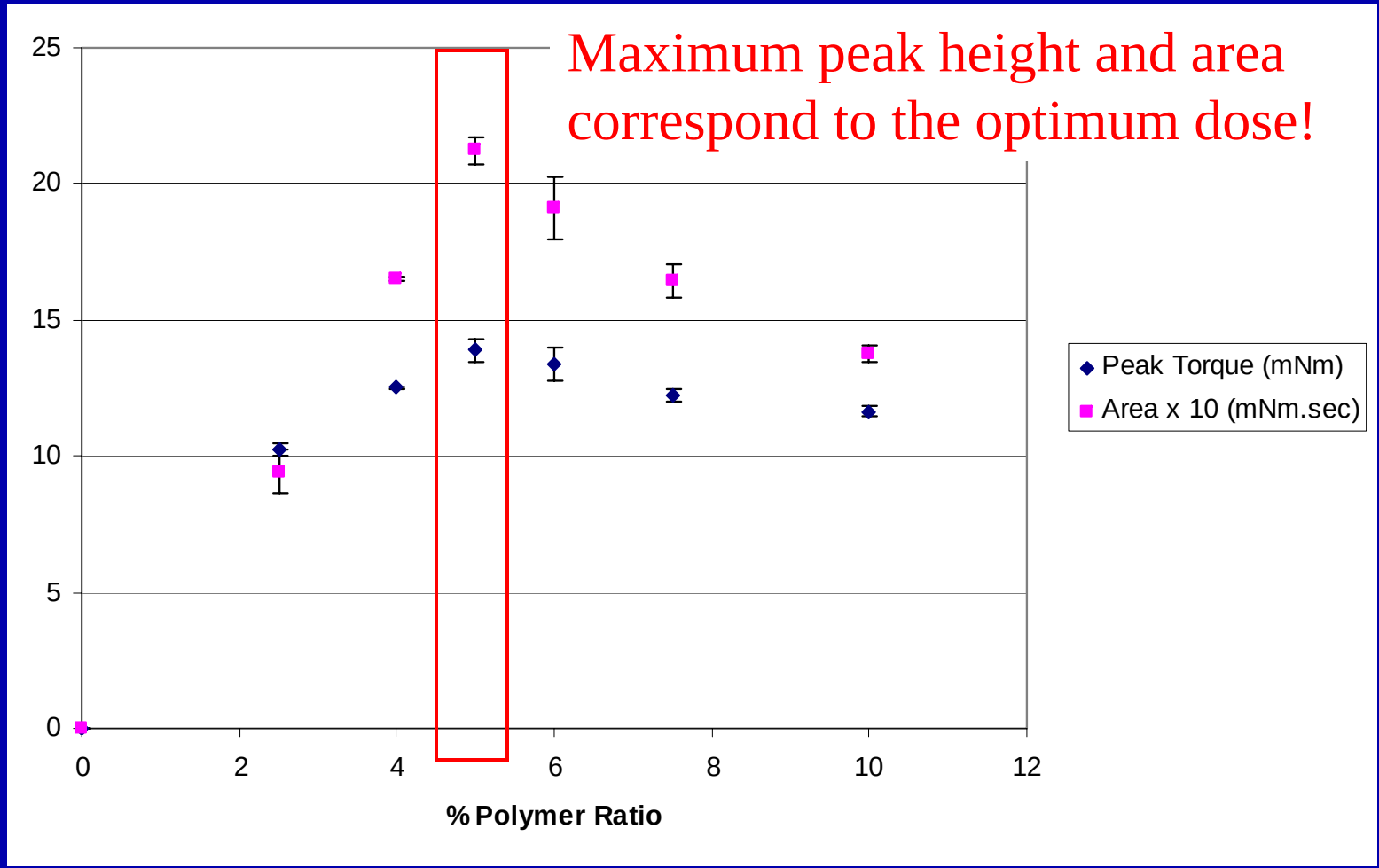
Peak height and area



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50% reduction in polymer consumption!

- Previously, the treatment plant was dosing polymer at 10%, and the cake solids concentration was 18%
- The polymer dose was decreased to 5% at the full-scale, and 18% cake solids was maintained at this dose
- The treatment plant could achieve the same cake solids concentration and good centrate quality only at half of the polymer dose that it used to use

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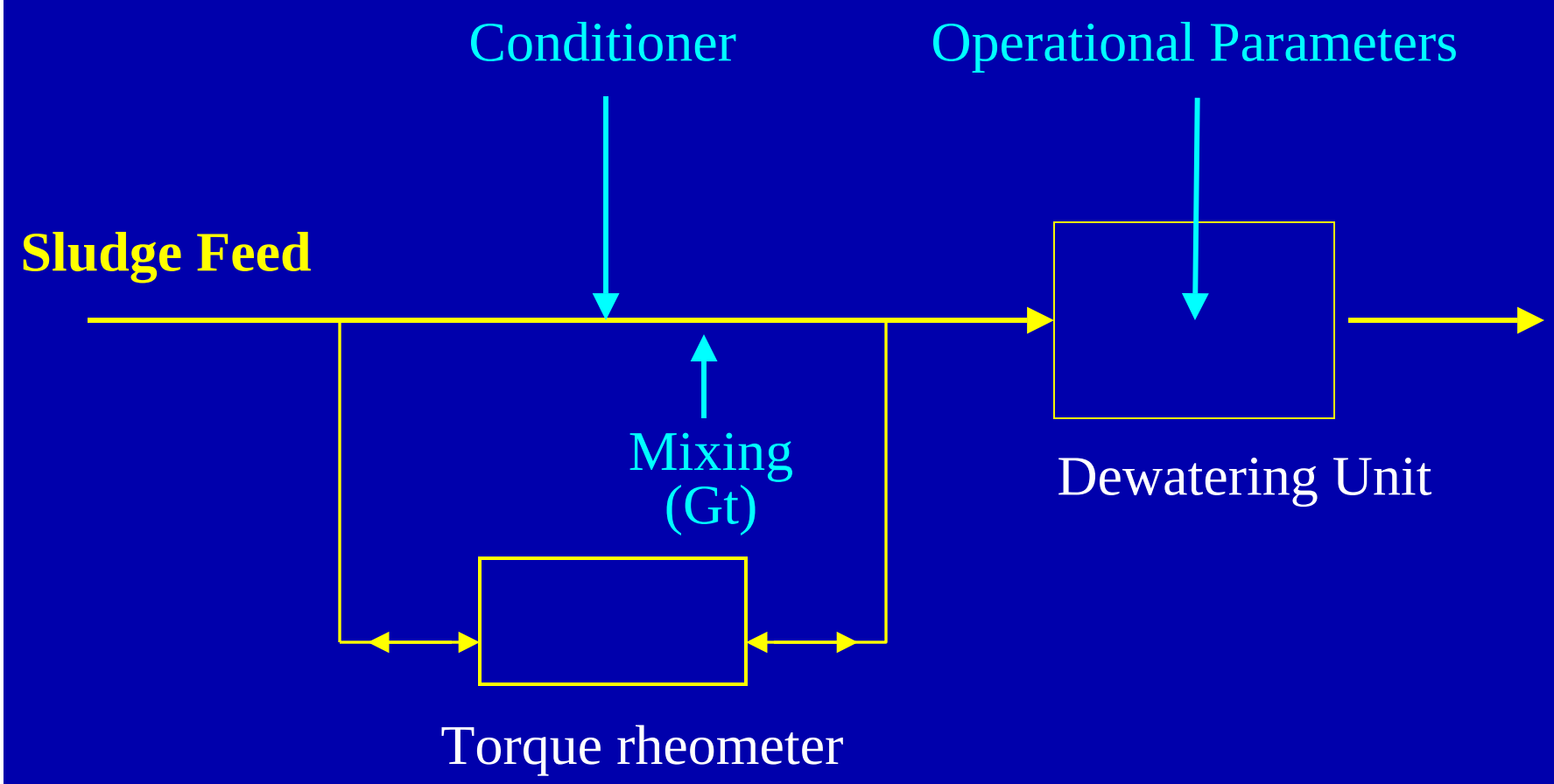
So What?

Torque rheology can potentially provide a useful tool for the optimization and automation of sludge dewatering.


Conditioner
Operational Parameters
Sludge Feed
Mixing
(Gt)
Dewatering Unit
Torque rheometer

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Decentralized treatment

- Improve performance of the septic tanks using simple approaches
- Minimize sludge volume and accumulation rate
- Improve anaerobic digestion
- Increase gas production
- Microaeration, enzymes, grinding, passive thermal

www.clearford.com

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Collaboration and funding

- Ontario Centres of Excellence
  - Interact, Proof of Concept, Champions of Innovation, Collaborative Research
- NSERC
  - Strategic grants - no matching funds!
- Many others…

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Thank you for your attention!

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