The Role of Water Quality in Food Safety: Does Water Matter?

International Association for Food Protection

Part 1:

Drinking Water Treatment 2018 Update: Regulations and Technology.

This IAFP webinar will explain EPA municipal water standards and what food processors can and can't expect from the Safe Drinking Water Act protections.

Hear from the EPA, CDC and other experts how the EPA regulations might impact your water supply and the safety of your product.

Hear a case analysis from a leading Industry Water Engineer on how water treatment has changed as food processing has evolved.

Monday, April 9 2018, 11:00 a.m. Central Time U.S.

Sponsored by **IAFP's Water Safety and Quality PDG**
&
Atlantium Technologies

Speakers

Kenneth Rotert,
Physical Scientist
US Environmental Protection Agency (EPA)

Vincent Hill,
Chief, Waterborne Disease Prevention Branch –
Division of Foodborne, Waterborne and Environmental Diseases, (CDC)

Prof Nicholas Ashbolt,
Alberta Innovates Translational Health Chair in Water
Public School of Health
University of Alberta

Rajendra Gursahaney,
Senior Engineering Director
Pepsi Beverages Company

Moderator

Phyllis Butler Posy,
Chair - Water Quality Safety PDG

Vice President of Strategic and Regulatory Affairs
Atlantium Technologies

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Atlantium Technologies
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Webinar Housekeeping

Audio is being transmitted over the computer so please have your speakers 'on' and volume turned up in order to hear. A telephone connection is not available.

During the session you can submit questions via the Q & A section.

Questions will be answered at the end of the presentation.

This webinar is being recorded and will be available for access by IAFP members at www.foodprotection.org.

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The Role of Water Quality in Food Safety: Does Water Matter?

Kenneth Rotert
U.S. EPA Office of Ground Water and Drinking Water

Sponsored by **IAFP's Water Safety and Quality PDG** & **Atlantium Technologies**

Overview

- EPA's Regulatory Role in Drinking Water
- EPA's Microbial Rules for Drinking Water
- Example of a Water Treatment Process
- Revised Total Coliform Rule: Key Changes
- Relevance EPA Standards to Food Processing
- Range of Scenarios: Monitoring to Public Notification

EPA's Regulatory Role in Drinking Water

- Mission of the U.S. EPA
  - Protect human health and the environment
- Safe Drinking Water Act (1974, amended 1986 and 1996)
  - Authorizes EPA to set national standards for drinking water to protect against health effects from exposure to naturally-occurring and man-made contaminants.

EPA's Regulatory Role in Drinking Water

- Primary Enforcement Authority
  - EPA develops minimum standards that must be met by all public water systems.
  - States develop standards at least as stringent as the EPA standards. States implement and enforce the standards.
  - EPA directly implements the drinking water program for Wyoming, the District of Columbia, some territories, and the tribes (except for the Navajo Nation).
- Applicability of Drinking Water Standards
  - Standards only apply to public water systems – at least 15 service connections or serves $\geq$ 25 people for at least 60 days a year

EPA's Microbial Rules for Drinking Water

- Revised Total Coliform Rule
  - Microbial indicator monitoring to determine the water quality in distribution systems.
  - Assessment and possible corrective actions when bacteria exceed prescribed levels.
- Ground Water Rule
  - Treatment as necessary, triggered by fecal indicator results from source water monitoring.
  - Sanitary Surveys required.

EPA's Microbial Rules for Drinking Water

- Surface Water Treatment Rules
  - Treatment of water from surface water sources to address microbial contamination (those sources with exposure to the atmosphere or subject to runoff).
  - Disinfection for all systems (at the treatment plant and within the distribution system), as well as filtration (unless granted filtration avoidance) and sanitary surveys.
  - Monitor disinfectant residuals in the same location and at the same frequency as for total coliforms (TC).

Example of Water Treatment Process

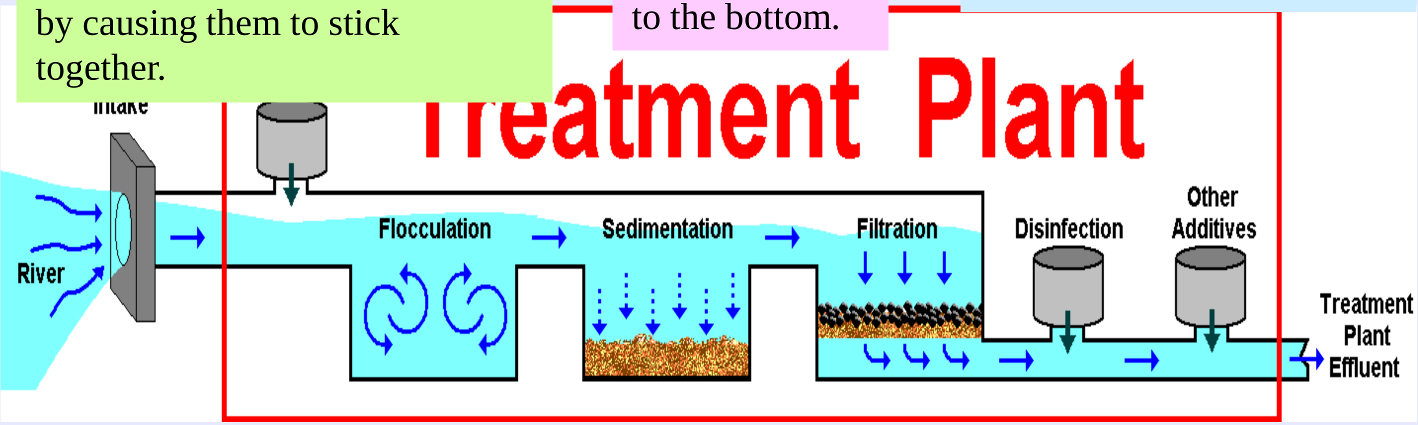
COAGULATION

A coagulant, usually aluminum sulfate, is added to the raw, untreated water as it flows to sedimentation basins. Coagulants help remove suspended particles in the water by causing them to stick together.

SEDIMENTATION Water flows into sedimentation basins, where particles settle to the bottom.

DISINFECTION
Chlorine is usually added to kill bacteria and viruses.

Ammonia can also be added. Chlorine and ammonia combine to form chloramine compounds.



FLOCCULATION

The water is gently stirred with large paddles to distribute the coagulant so that sticky globs or flocs are formed.

FILTRATION
Water at the top of the basins flows to large gravity filters, traveling through layers of small pieces of hard coal, sand and gravel.

OTHER ADDITIVES **Orthophosphates** form a protective coating on pipes to prevent lead from leaching into water. **Fluoride** voluntarily added by some PWSs to reduce tooth decay. **Calcium hydroxide** can reduce corrosion in the pipes and equipment in the distribution system. **Powdered activated carbon** is occasionally used for taste and odor control.

Revised Total Coliform Rule: Key Changes

- Monitoring:
  - Systems monitor for TC to indicate the potential for fecal contamination, or a potential pathway for contamination in general.
    - The original TCR had a monthly maximum contaminant level (MCL) for total coliforms which was eliminated in lieu of assessments and corrective actions.
  - Number of TC samples taken depends on the number of people served. Range from one to 480 samples per month. For most system sizes this equates to roughly one sample per 1,000 people.
    - The sample numbers are unchanged from the TCR.
  - Positive TC samples must be analyzed for the presence of *E. coli*.
    - Fecal coliforms as a fecal indicator were allowed in the TCR, but not in the Revised TCR.

Revised Total Coliform Rule: Key Changes

- Assessment and Corrective Actions:
  - If TC or *E. coli* monitoring results exceed prescribed levels the system must conduct an assessment to determine the cause of the exceedance. Corrective actions required of any contamination causes found.
    - No assessment or corrective action requirement in the TCR.
  - Systems must notify the public if they fail to conduct the assessment or implement corrective actions.
    - TCR required notification if they exceeded the total coliform MCL.
  - If monitoring results indicate the presence of *E. coli*, the system must notify the State and the public within 24 hours.

Relevance EPA Standards to Food Processing

- Finished drinking water in compliance with EPA standards is not sterile
  - Not all potential microbial contaminants are regulated.
  - Treatment of surface water sources is not 100% effective. Requirements call for treatment to 2-log *Cryptosporidium*, 3-log *Giardia lamblia*, and 4-log virus reduction.
  - Ground water systems are required to treat only as necessary.
  - Contamination can occur in the distribution system (e.g., through cracks, leaks). These can also be related to distribution system vulnerabilities (e.g., main breaks).
  - Under the RTCR systems do not have to conduct an assessment until 5.0% or more of samples over a month are positive for total coliforms (unless *E. coli* positive).

Relevance EPA Standards to Food Processing

- Finished drinking water in compliance with EPA standards is not sterile (cont.)
  - Systems can have up to 5% of samples without a disinfectant residual in the distribution system each month. Systems can measure heterotrophic bacteria as a proxy, with up to 500 bacteria per mL being acceptable.
  - For filtered systems turbidity limits must be met in 95% of monthly samples.
- Not all public water systems are in compliance with drinking water standards
  - Allaire et al, 2018 found that in 2015 nine percent of community water systems (those serving residential populations) serving more than 500 people had health-based violations. From 1982-2015, 4.6% of systems had total coliform violations.

Range of Scenarios: Monitoring to Public Notification

Time* until:	Fastest Possible Scenario (In-house lab, 24-hr method)	Longer Scenario (Contract lab closed on weekends, 48-hr method)
Routine Sample Collected	Monday	Monday
Notified of routine TC+/EC+	Tuesday afternoon (Day 2)	Thursday afternoon (Day 4)
Collect repeat samples	Wednesday morning (Day 3)	Monday morning (Day 8)
Notified of repeat TC+/EC+	Thursday afternoon (Day 4)	Thursday afternoon (Day 11)
Public Notification	Friday afternoon (Day 5)	Friday afternoon (Day 12)

* Note: Times can vary depending on other factors not included in these examples.

Summary

- EPA Sets Standards for Drinking Water Quality
  - Standards apply to systems meeting the definition of a public water system
  - Primacy agencies implement and enforce the standards
  - Some standards apply to the microbial quality of drinking water, including bacteria, viruses, and protozoa
  - Changes to the TCR focus on assessment and corrective action provisions
- EPA-Compliant Drinking Water is not Sterile
- Time Lag from Monitoring for Microbial Contamination to Notifying the Public can be Significant

Contact Information

Kenneth Rotert

US EPA Office of Ground Water and Drinking Water

rotert.kenneth@epa.gov

202-564-5280

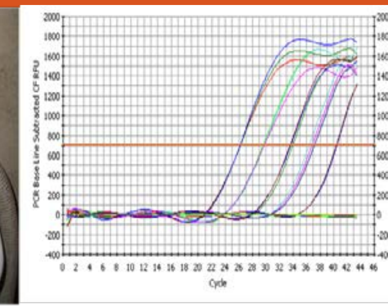
Understanding and Applying CT Values for Food Processing Operations

Vincent Hill, PhD
Waterborne Disease Prevention Branch,
Division of Foodborne, Waterborne and Environmental Diseases

Sponsored by **IAFP's Water Safety and Quality PDG** & **Atlantium Technologies**





Understanding and Applying CT values for food processing operations

Vincent Hill, PhD

Waterborne Disease Prevention Branch,

Division of Foodborne, Waterborne and Environmental Diseases

IAFP Webinar

April 9, 2018

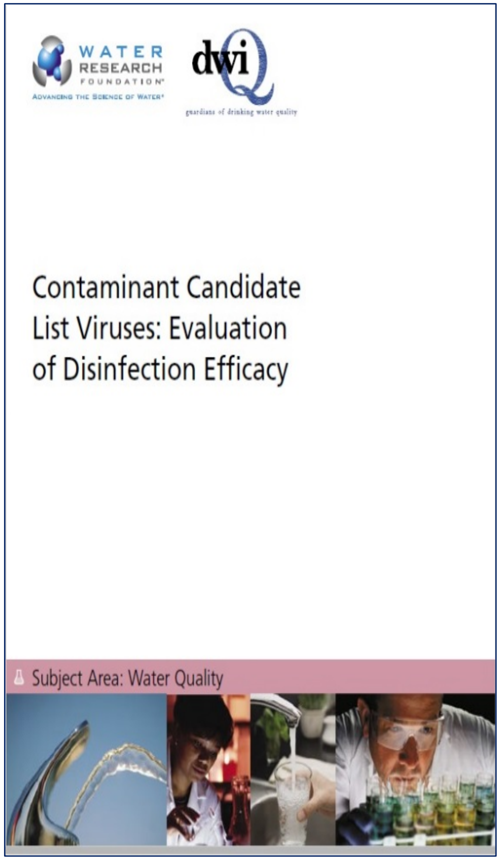
The Water We Eat

The Water We Eat: Drinking water

- Drinking water quality is guided and protected by numerous federal regulations, including the Safe Drinking Water Act, Surface Water Treatment Rule, and Ground Water Rule
- Drinking water is not sterile or free of chemicals
- Illness and outbreaks occur from
  - Insufficient water treatment
  - Contamination in distribution systems (intrusion, biofilm-associated)
  - Contamination in facilities (e.g., water stagnation, cross connections)
- Little data implicating municipal water in food-related outbreaks or illness
- Important to determine “fitness” for specific uses, including food production

Water Research Foundation Project 3134

- *Contaminant Candidate List Viruses: Evaluation of Disinfection Efficacy* (2010)
  - Goal: Obtain disinfection efficacy data for CCL viruses Objectives
  - Study chlorine and monochloramine disinfection
  - Focus on human adenovirus, coxsackievirus, echovirus, and murine norovirus (a calicivirus)
  - Evaluate effects of water quality, pH, temperature, disinfectant concentration, and aggregation state



EPA Guidance Manual for Water Treatment

- Surface Water Treatment Rule and Ground Water Rule require ≥4-log reduction in virus loads by water treatment facility
- Disinfection **Ct** = Disinfectant **c**oncentration (in mg/L) x exposure **t**ime (minutes)
- EPA Guidance Manual (1990)*
  - Ct values in the Manual were based on HAV inactivation studies performed with dispersed viruses (factor of safety of 3 was applied)
  - $Ct_{99.99}$ value of 8 mg·min/L for chlorination at 5 °C, pH 6-9

*Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources

Uncertainty Underlying Drinking Water Disinfection

- General differences in disinfection susceptibility (chlorine-based disinfection)

bacteria < viruses < bacterial spores < parasites

- Can be wide variability within microbe classes
- Disinfection process affected by water quality (e.g., pH, organic content, turbidity)
- Disinfection efficacy affected by microbial aggregates and association with particles, surfaces (like biofilm)
- Dynamics of secondary disinfection in distribution systems can be challenging to monitor and manage

3134 Project Structure

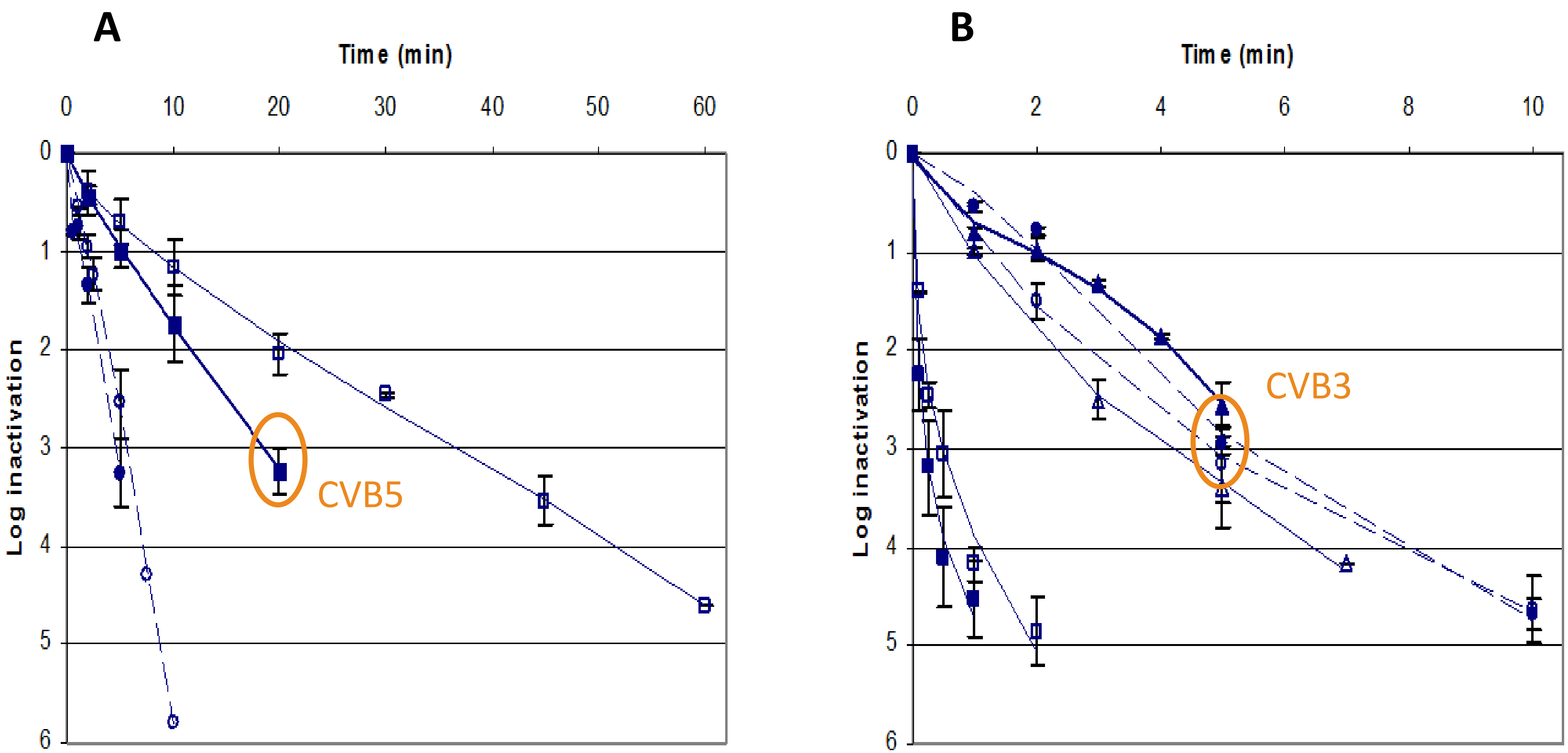
- Prepared monodispersed and cell-associated virus stocks
  - Enteroviruses: coxsackieviruses B5 and B3, echoviruses 1 and 11
  - Human adenoviruses 2, 40 and 41
  - Murine norovirus
- Viruses seeded into chlorine-demand-free (CDF) buffered-saline (DPBS), reagent-grade water (RGW), and treated source water (from three water treatment plants) containing free chlorine (@0.2 or 1 mg/L)
- Baseline experiments @ 5 °C, pH 7 or 8 in water bath or environmental chamber
- Source water experiments @ 5 and 15 °C, pH 7 or 8

Experimental set-up

- Water bath contained reaction flasks
  - Replicate experimental flasks
  - Virus titer control flask
  - Disinfectant monitoring flask
  - pH monitoring flask (for long expts)
- Sodium thiosulfate used as disinfectant quencher

- Surviving viruses quantified using tissue culture plaque assays
- **Ct estimates:** Efficiency factor Hom (EFH) model (Haas and Joffe 1994) calculated predicted survival ratios at time points using inactivation rate constant (k), disinfectant residual (C), and first-order decay constant (k')

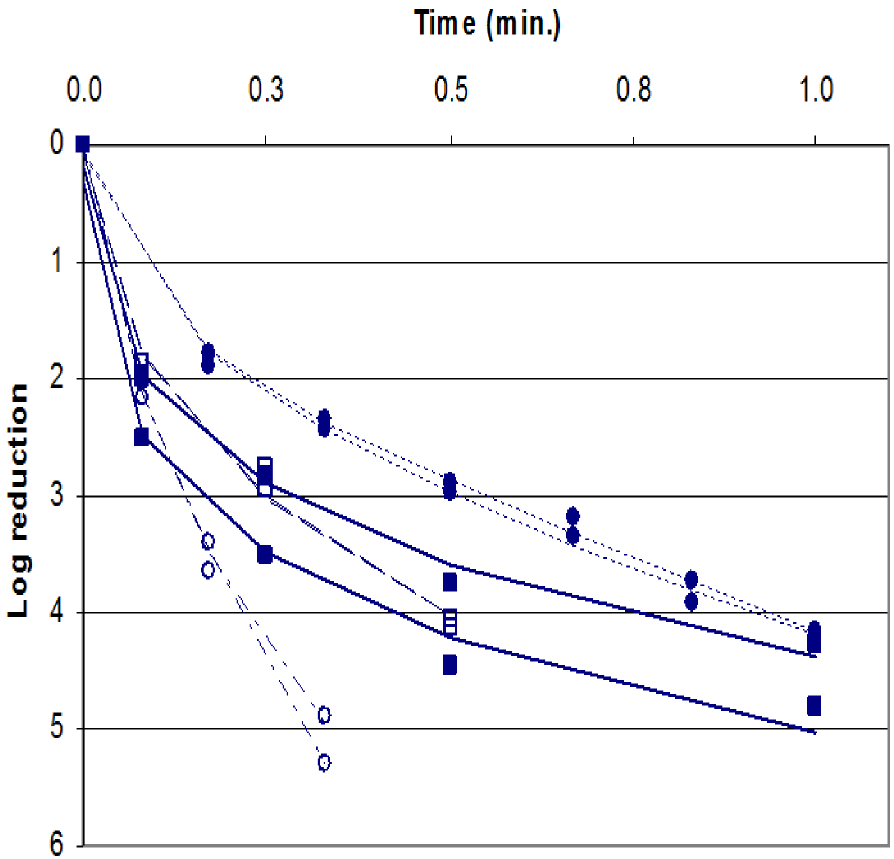
Wide range in disinfection susceptibility



A: Free chlorine inactivation of coxsackievirus B5 (squares) and echovirus 1 (circles)
B: Free chlorine inactivation of adenovirus 2 (squares), coxsackievirus B3 (circles), and echovirus 11 (triangles); closed shape = pH 7, open shape = pH 8

Cromeans TL et al (2010) *Appl Environ Microbiol*, 76:1028-1033

Source water quality matters



Inactivation curves for adenovirus 2 at pH 7 and 5 °C, using 0.2 mg/L free chlorine in four different source waters.

- Closed circles: Wash. DC surface water
- Open squares: GA surface water
- Open circles: GA ground water
- Closed squares: Reagent-grade water

Kahler AM et al (2010) *Appl Environ Microbiol*, 76:5159.

Disinfection systems affect microbes differently

Max $Ct_{99.9}$ values for monochloramine treatment of 3 source waters

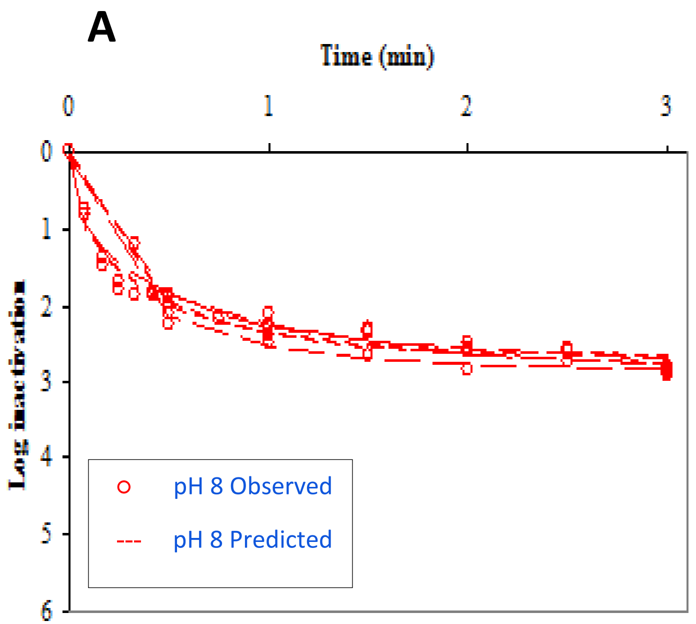
Temp (°C)	pH	AdV2	CVB5	E11	MNV
5	7	2600	1100	1700	88
	8	3300	1200	2300	110
15	7	820	320	950	44
	8	2000	400	870	46

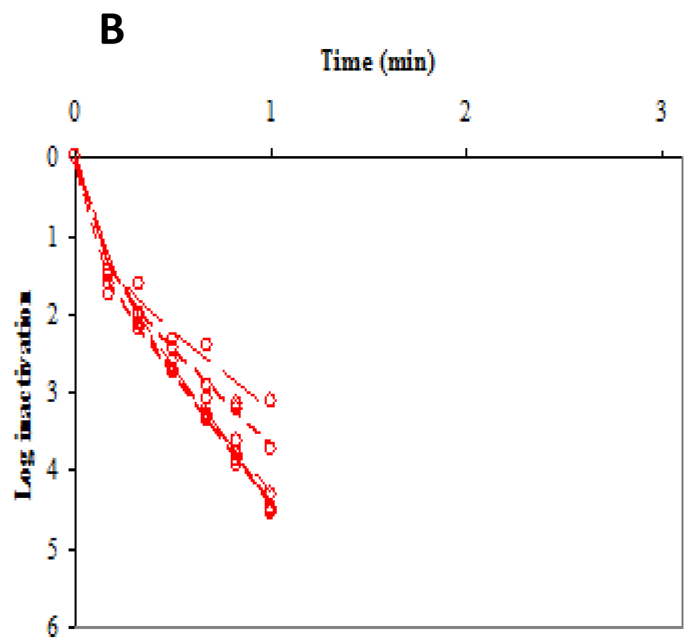
Max $Ct_{99.9}$ values for chlorine treatment of 3 source waters

Temp (°C)	pH	AdV2	CVB5	E11	MNV
5	7	0.099	5.2	0.79	0.023
	8	0.12	7.9	1.2	0.034
15	7	0.063	2.0	0.48	0.015
	8	0.061	3.6	0.84	0.021

2010 Water Research Foundation & UK Dept for Environment, Food & Rural Affairs

Effect of aggregation on disinfection efficacy





Inactivation curves for aggregated (A) and monodispersed (B) adenovirus type 2 in surface water with 0.2 mg/L free chlorine at 5 °C

Ct_{99} = 0.16 (aggregated), 0.077 (monodispersed)

2010 Water Research Foundation & UK Dept for Environment, Food & Rural Affairs

Project 3134 conclusions and implications for food

- Chlorination Ct value of **10** or higher would be required for 4-log inactivation of all study viruses (driven by CVB5) at pH 8 @ 5 °C
  - USEPA Guidance Manual recommends a $Ct_{99.99}$ of **8** (@pH 6-9)
- Aggregated AdV2 Ct values were 2x higher than for monodispersed AdV2 for chlorine
  - Chlorine $Ct_{99.99}$ with aggregation: **20**
- Other researchers have also reported higher Ct values than EPA Guidance
- Implications for food systems
  - Operators should understand where their source water comes from and the quality of the water they receive
  - Disinfection efficacy can be substantially affected by water conditions

After the treatment plant: Water quality changes during distribution and in premise plumbing

- Finished water flows through miles of pipe to reach end users
- Quality may be affected by
  - Intrusion
  - Chemical reactions in water and with piping and plumbing components
  - Biofilm growth
  - Main breaks, repairs, and low-pressure events
- Distribution systems effectively ecosystems; biological activity affects chemical and microbial quality

Drinking water microbiome

- More than just *Legionella* et al
  - Viruses, bacteria, amebas, fungi
- “Opportunistic premise plumbing pathogens” (OPPPs)
  - Includes *Pseudomonas*, *Legionella*, *Mycobacteria*, free-living amebas (e.g., *Naegleria fowleri*, *Acanthamoeba*)
- Also, other microbes like food spoilage microbes
- Affected by numerous factors
  - Environmental: water source, seasonality, temperature
  - System operations: disinfection residual, water age, pipe material

Conclusions

- US drinking water standards effective for providing safe and healthy drinking water
  - Little data collected regarding contribution to foodborne illness
- Variability in microbial susceptibility to water treatment/disinfection
  - Affects what leaves the plant
- Water quality changes during distribution
  - Monitoring points and parameters may not reflect these changes
- Additional water quality characterization can inform “fit for use”
  - Inform facility water use procedures, possibly justify supplemental treatment
  - Help develop a water management plan

Acknowledgments

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  - Amy Kahler
  - Jothikumar Narayanan
  - Theresa Cromeans

Thank you!

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

Drinking Water Sampling and What it Means

Nicholas Ashbolt
Professor and Alberta Innovates Translational Research Chair in Waterborne Disease Prevention

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Drinking Water sampling and what it means

Nicholas ASHBOLT
Professor and Alberta Innovates Translational Research Chair in Waterborne Disease Prevention – Ashbolt@Ualberta.ca

Reactive vs Proactive management

E. coli

Enterococcus

Traditional coliform/E. coli reactive verification monitoring

- *For last 100 years based on controlling bacterial diseases (cholera /typhoid) from raw sewage contamination*
- *Problems include:*
  - *Pathogens are acute hazards, outbreaks often from short-duration events*
  - *Events can be missed with weekly or even daily sampling*
  - *Enteric bacteria easiest to remove/kill, residual infectious enteric viruses and protozoa largely the issue today*

Solution, Proactive Management based on Health Target of 'tolerable' risk, to estimate reduction in enteric pathogens (viruses, bacteria and parasitic protozoa)

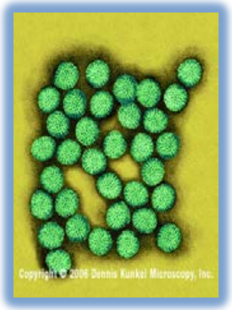
EPA Enhanced surface treatment rule (ESWTR-2*)

Based on national surface water studies, and quantitative microbial risk assessment (QMRA) modeling to meet annual risk of < 1 infection per 10,000

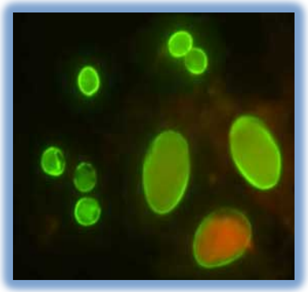
EPA require treatment of surface waters:

- *3 $\log_{10}$ (99.9%) parasitic protozoan removal*
- *4 $\log_{10}$ (99.99%) enteric virus removal*

In production of drinking water



Norovirus



(*Cryptosporidium* & *Giardia* oo/cysts)
Parasitic protozoa

** Long Term 2 Enhanced Surface Water Treatment Rule. Toolbox Guidance Manual EPA 815-D-03-009*
Office of Water, United States Environmental Protection Agency: 2003

Verification monitoring required to demonstrate that drinking water is acceptable 95 % of the time (<10^{-4} infection/y)

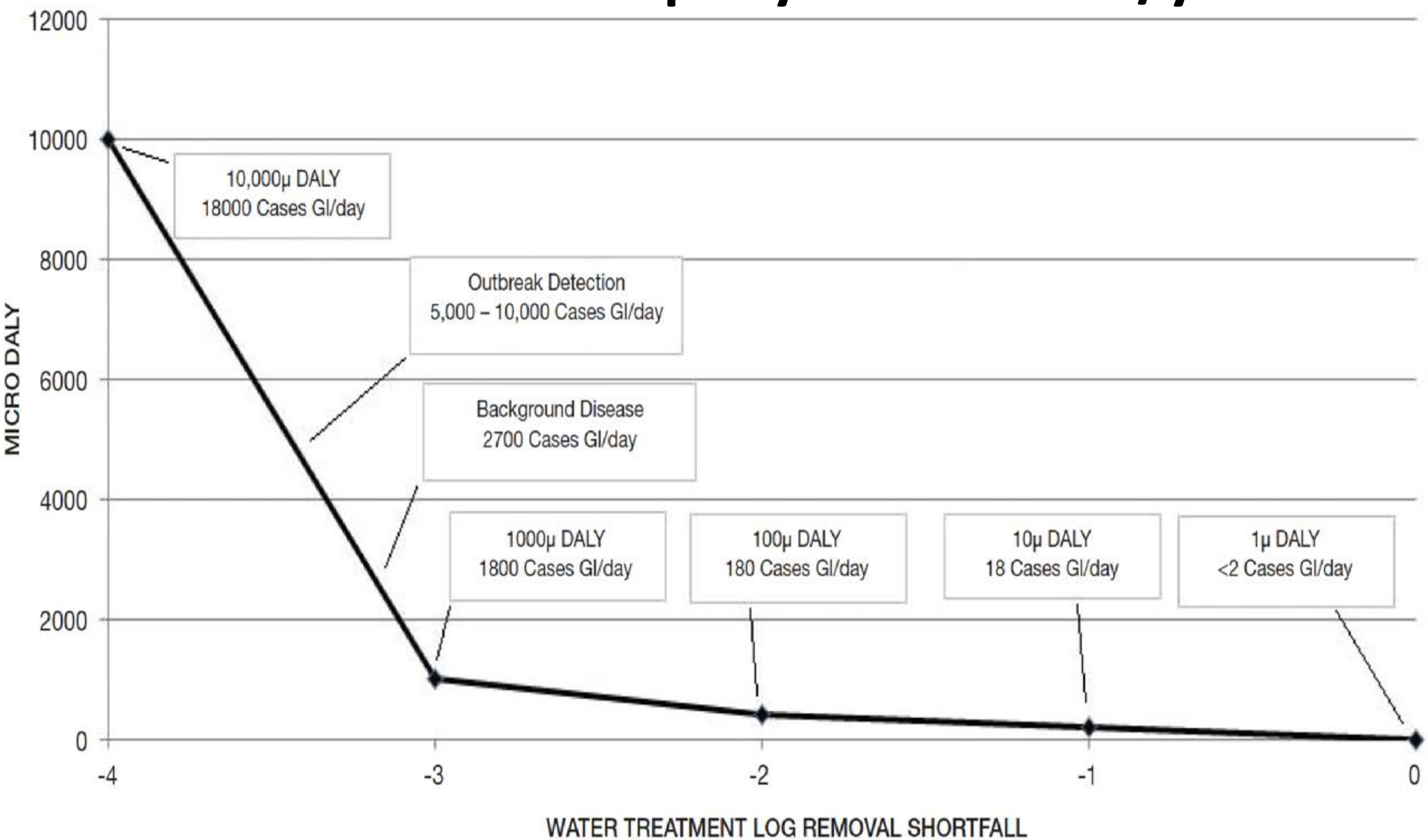
Nominal $\log_{10}$ reduction	# samples/year	Monitoring interval
0.05	1	1 year
1	30	1 week
2	300	1 day
3	3,000	3 hours
4	**30,000**	**15 min**
5	300,000	2 min
6	3,000,000	10 sec
7	30,000,000	1 sec

SDWA target

E. coli used

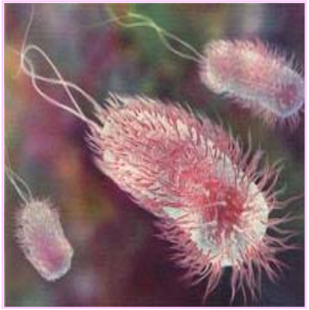
Smeets *et al.* (2010) *Water Science & Technology 61*(6): 1561-8

Water Safety Continuum (Why epi surveillance is too insensitive): *Cryptosporidium* in DW city 1 million people and goal $< 10^{-6}$ DALY per year = 10^{-4} inf/y



Walker (2016) *Water e-Journal 1*(2): 1-6

So what to monitor to verify drinking water?


E. coli


Enterococcus

Traditional faecal indicators

- *Arise from faecal and non-faecal sources*
- *Less indicative of health risk when sewage is not a significant contaminant or is disinfected (E. coli)*
- *Typically high spatial and temporal (CFU) variability*

Newer molecular faecal indicators (e.g. qPCR for Bacteroidales)

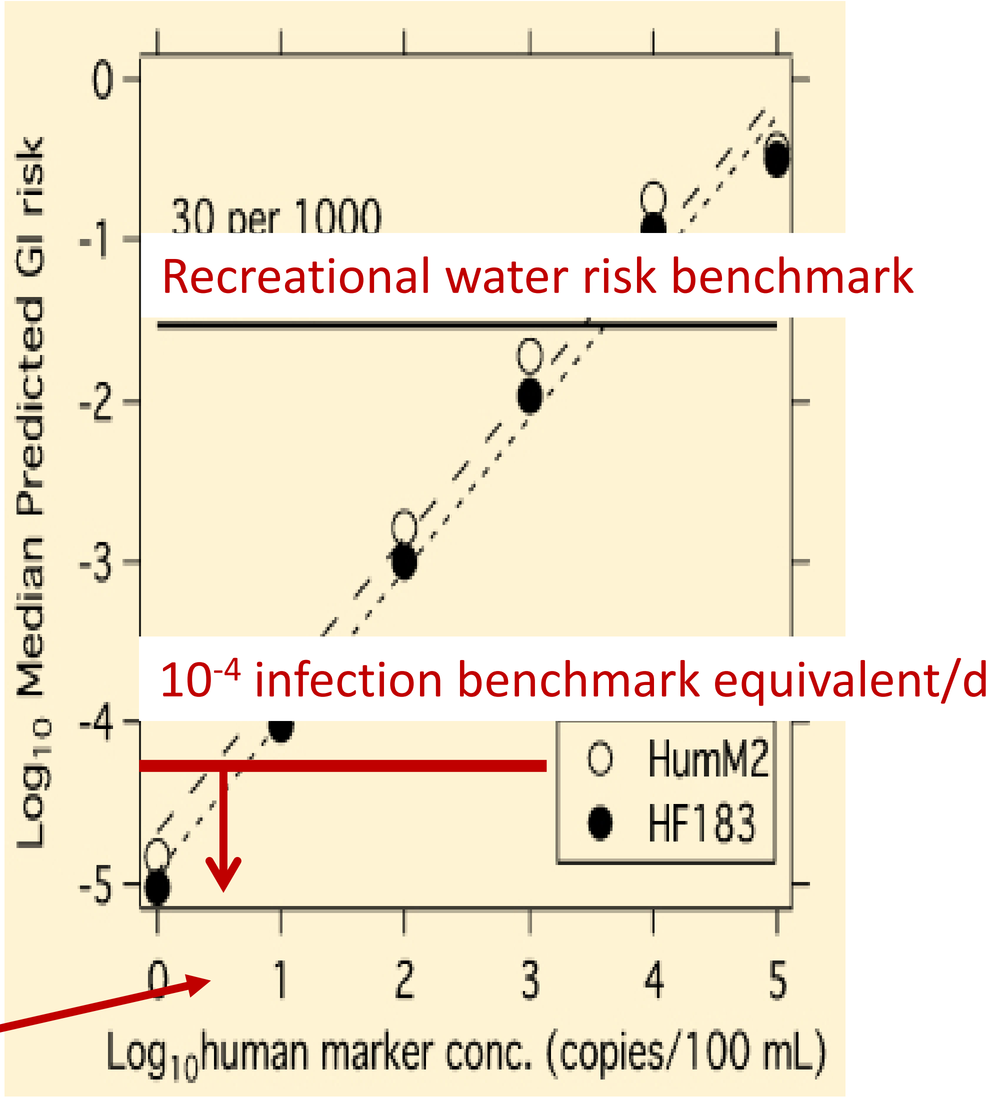
- *Ecological sources & behavior not well understood*
- *So still reliant on sound sanitary understanding*
- *qPCR for Enterococcus best FIB with epi-health link*

Use of Human sewage markers & link to GI risk from recreational water exposures

A benchmark illness rate of 30 GI illnesses per 1000 swimmers occurred at median concentrations of

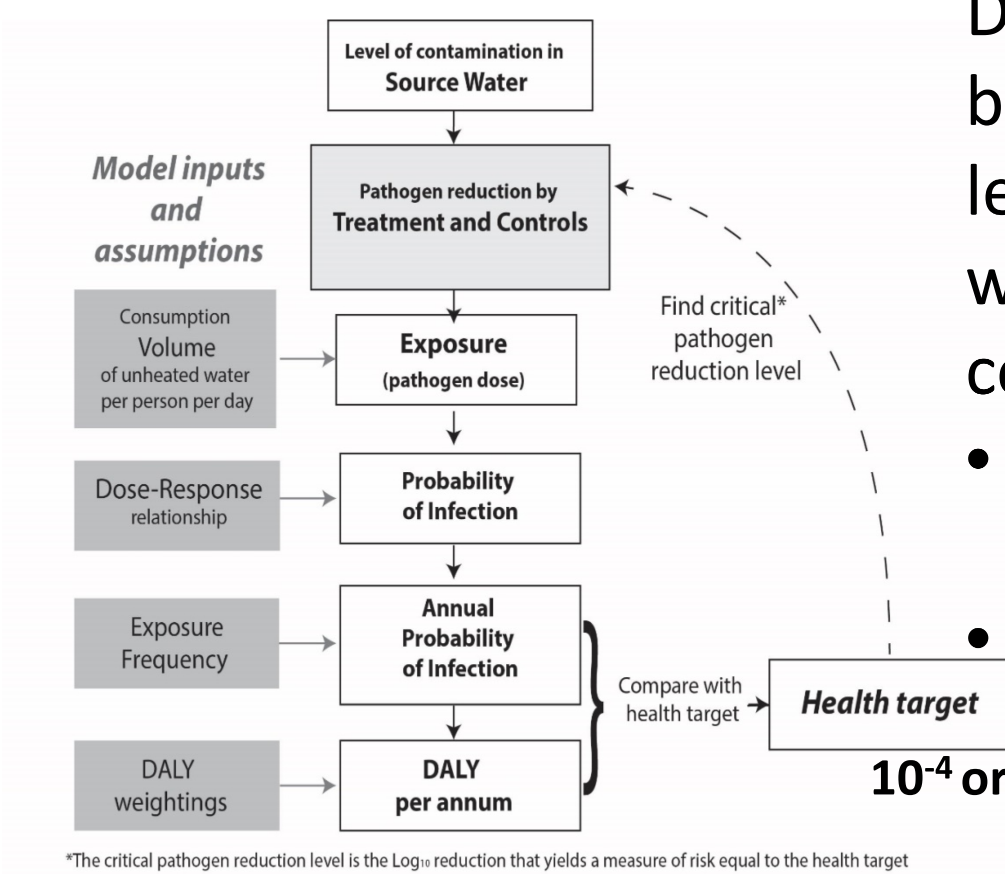
- *4200 copies of HF183*
- *2800 copies of HumM2 per 100 mL of recreational water*

Not yet sensitive enough for DW monitoring



Boehm *et al*. (2015) *Environ Sci & Technol Lett*, *2*(10): 27

Risk-defined treatment requirements



10^{-4} or 10^{-2}

10^{-6} or 10^{-4}

Petterson & Ashbolt (2016) J Wat Health 4(4): 571-589

WHO (2016) *Quantitative Microbial Risk Assessment, Geneva*

Defines safe viral, bacterial & protozoan levels for any source water & end use combination:

- Drives log-reduction regs
- Needs for surrogates to demonstrate pathogen reductions at control points (barriers)
- Identifies mitigation needs

Site-specific Pathogen log$_{10}$ reduction targets (LRT) for viruses, bacteria & parasitic protozoa

Benchmark infection risk =

$$S * \left(1 - \prod_{n_i}\left[1 - DR\left(V_i * 10^{log_{10}(C) - \mathbf{LRT}}\right)\right]\right)$$

But solved for LRT in a forward, stochastic QMRA

S is the susceptible fraction exposed to each reference pathogen

DR is a dose-response function for the reference pathogen

V_i is the volume of water ingested per day for activity i

n_i is the number of days of exposure per year for activity i

C is pathogen concentration in untreated, source drinking water

For full description see: Schoen *et al.* (2017) *Microbial Risk Analysis 5*: 32-43

'New' monitoring approaches

Validation testing: A treatment technology challenge testing with target or surrogate pathogens over a defined range of operating conditions, usually conducted at a test facility or in-situ

Field validation: Performance confirmation study, using biological and/or chemical surrogates, conducted typically during commissioning, and repeated later if needed. In some cases, indigenous organisms can be used for process validation

Continuous verification monitoring: Ongoing verification of system performance using sensors for continuous observation of selected parameters, including surrogate parameters that are 'correlated' with pathogen LRT needs

HACCP/Water safety plan quantifiable questions

What is my health target (10^{-4} infections/y)?

System assessment	Assemble team	
	Describe water supply	What is my health target?
	Conduct hazard analysis	What are the priority hazards? What is the significance of hazardous events?
	Identify Control Measures	Is my overall treatment adequate to produce drinking water that meets the health target?
Operational monitoring	Define Operational Limits	What are appropriate critical limits?
	Establish monitoring	How much monitoring is necessary?
Management & communication	Establish corrective actions	What level of corrective actions is needed?
	Establish record keeping	
	Establish validation + verification	

Medema, G., Loret, J.-F., Stenström, T.A. and Ashbolt, N. (2006) Quantitative Microbial Risk Assessment in the Water Safety Plan. Final Report on the EU MicroRisk Project, European Commission, Brussels.

Acknowledgments

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- **Drs Qiaozhi Li, Megan Beaudry & Norm Neumann** - School of Public Health, University of Alberta

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Case Analysis: Impact of Water Safety Rules on Risk Assessment & Water Usage Practices

Guru / Rajendra Gursahaney
Senior Engineering Director
Pepsi Beverages Company

Sponsored by **IAFP's Water Safety and Quality PDG** & **Atlantium Technologies**

Impact of Water Safety Rules
On
Risk Assessment &
Water Usage Practices

A Case Study

RM Gursahaney
Apr-09-2018

Disclaimer

The matter presented on these slides and discussions during the webinar are based upon my observations and learnings gained from my personal experience while operating and interacting with numerous experts in the beverage industry for many years.

Factors that affect Water Treatment Practices

- ***Regulations***

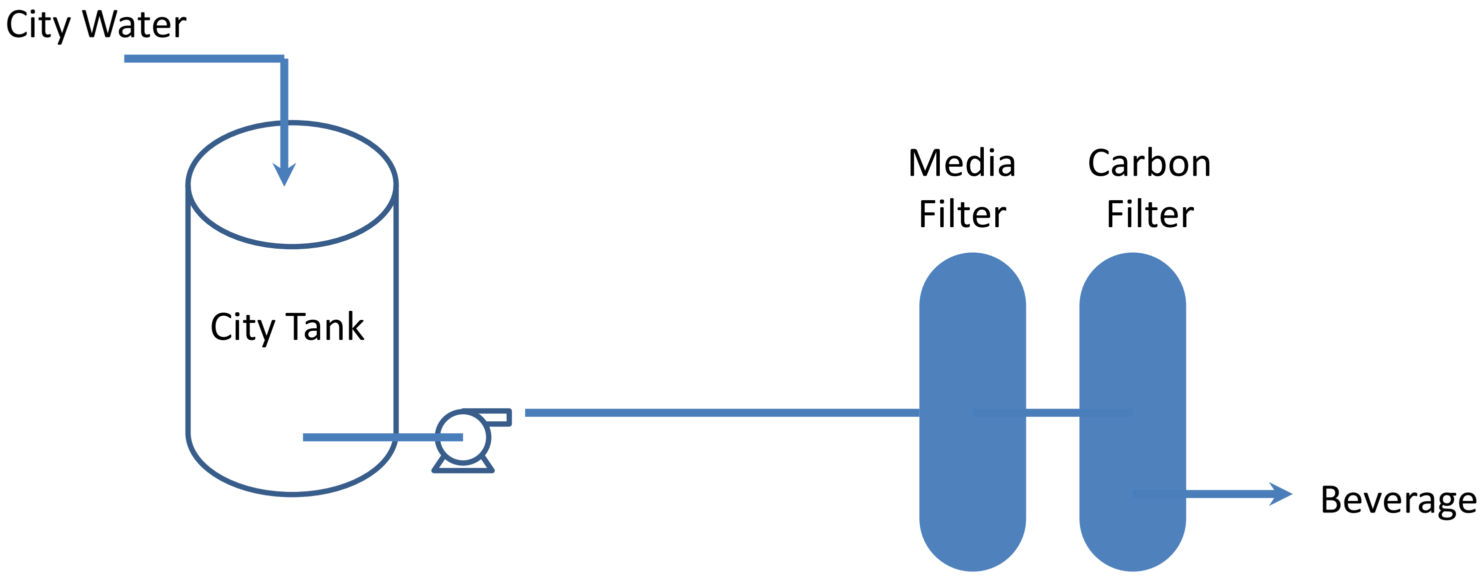
Other factors affecting system design

- *Product portfolio*
- *Space Requirements*
- *Investment*
- *Operating Cost*
- *Sustainability*
- *Simplicity of Operation*

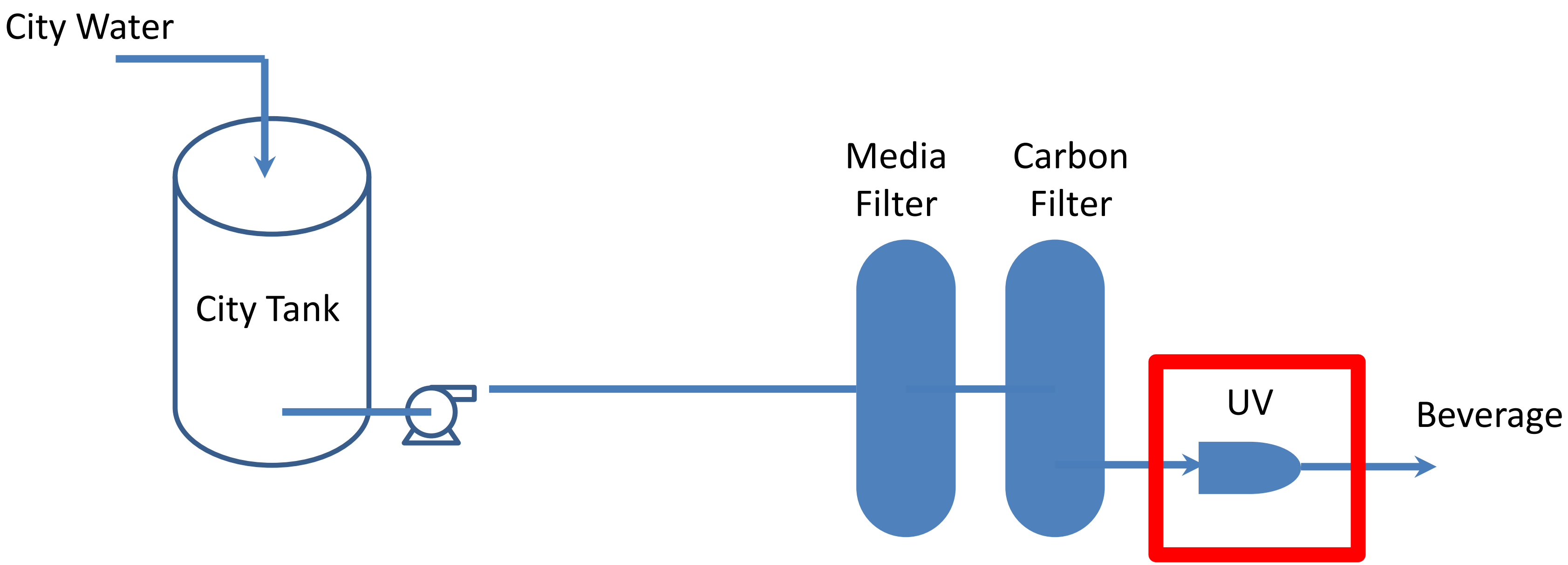
1960s-1970s

- **Going back in history**
  - In the 1960s – 1970s
    - Beverage products were predominantly carbonated beverages
    - Acidic : pH = 2.0 – 4.0 range
    - Carbon dioxide
  - All above conditions were detrimental to bacteria growth
    - Focus was on bacteria as the primary concern
  - Water Treatment was simple filtration, with reliance on municipal water
    - If city provided water good enough to drink it was good enough to make soda
    - Maybe add a UV light
  - Regular CiP practices kept microbial contamination at bay
    - **The focus → to put out safe potable product**

Simple Filtration



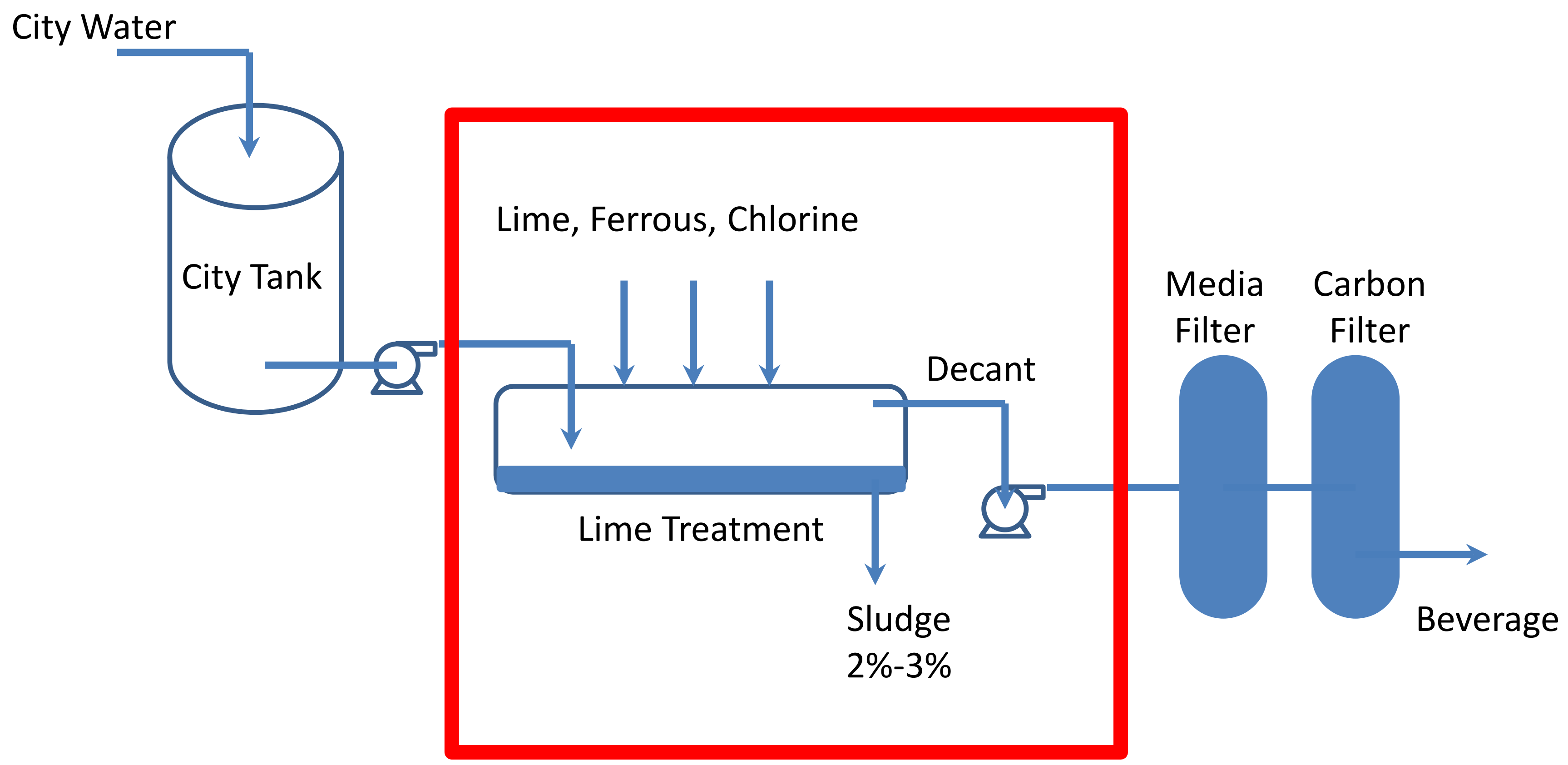
Simple Filtration with UV



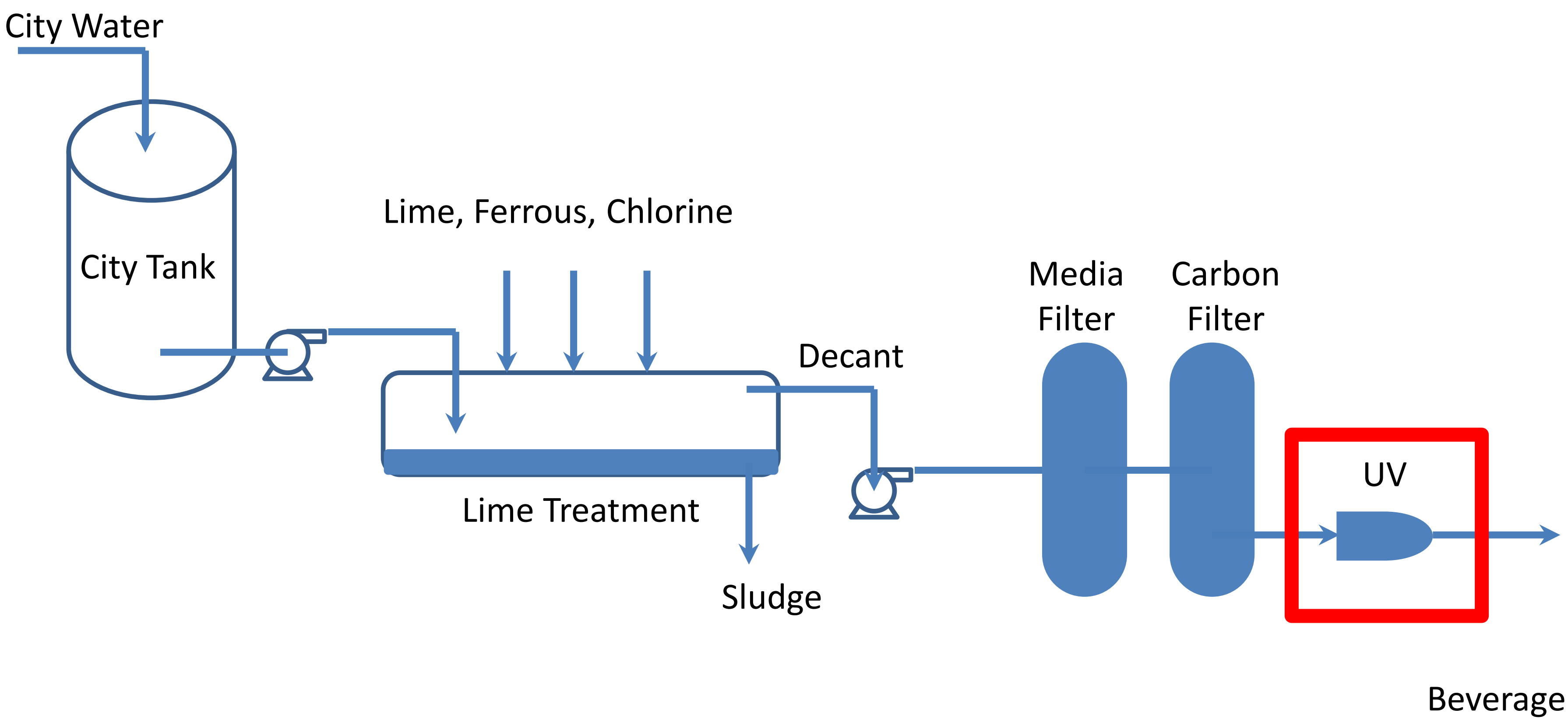
1970s-1980s

- **Contaminants in city water understood better**
  - Beverage : Sugary products ➔ Diet products
    - ❖ Still acidic , pH = 2.0 – 4.0 range
    - ❖ Carbon dioxide
    - ❖ Water : 500ppm TDS was adequate given nature of product
  - Lime Treatment Coagulation systems
    - ❖ Lime + Ferric Sulfate + chlorine > precipitate inorganic impurities
    - ❖ Large footprint
    - ❖ Handling of dry chemicals (and sometimes chlorine gas)
    - ❖ Positive bacteria control via chlorine
  - Additional complexity & human intervention
    - ❖ Higher capital investment, but relatively low operating cost
    - ❖ 2% - 3% water loss thru sludge
    - ❖ Undesirable contaminants from coagulants ??

Lime Treatment



Add a UV light



1980s

- **Benzene scare in Europe**
  - Role of organic contaminants in water better understood
  - Regulations widened to encapsulate known organic matter
  - City treatment systems upgraded
    - Chlorine
    - Chloramine
  - Issue of THMs in water
    - Carbon Towers were harbor source
    - Implemented carbon steaming regime to volatilize THMs
  - Impacts
    - Cost (energy, labor, carbon replacement)
    - Downtime for steaming (8 hours every 3-6 weeks)
    - Investment (boiler system, spare carbon towers ?)

1980s

- ***Meanwhile product portfolio was also changing.***
- ***CSDs complemented by Non carb beverages (eg tea) and Sports drinks***
    - *Product pH trend towards 5.0-7.0 range*
    - *Lower TDS to not affect taste*
    - *No carbon dioxide*
- *Hence vulnerability to bacteria growth*
- *Water Treatment was no longer simple filtration or LTS*
- *Introduction of Reverse Osmosis*
    - *Capital intensive, space neutral vs LTS*
    - *High operating costs (membrane, electric, chemicals, brine stream)*
    - *Very water wasteful – sustainability*

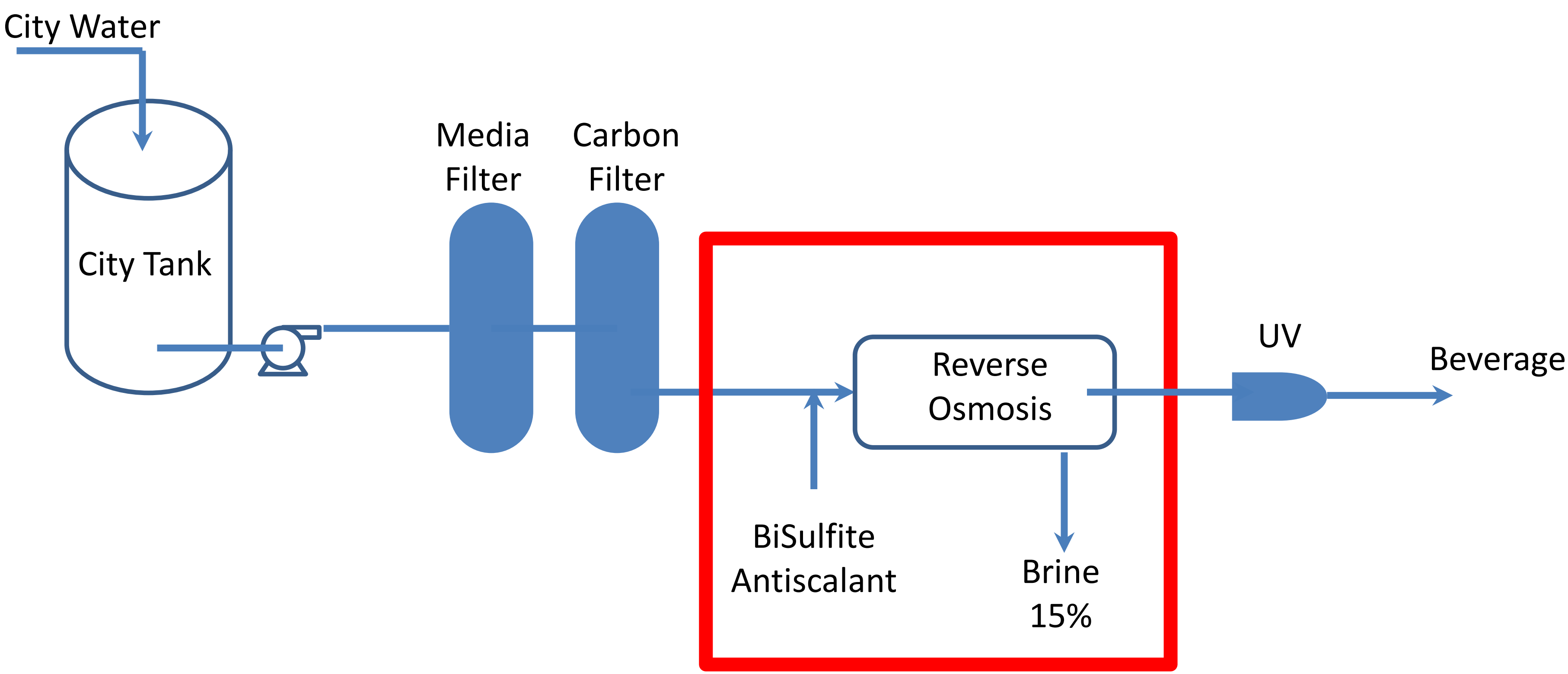
Regulations

and

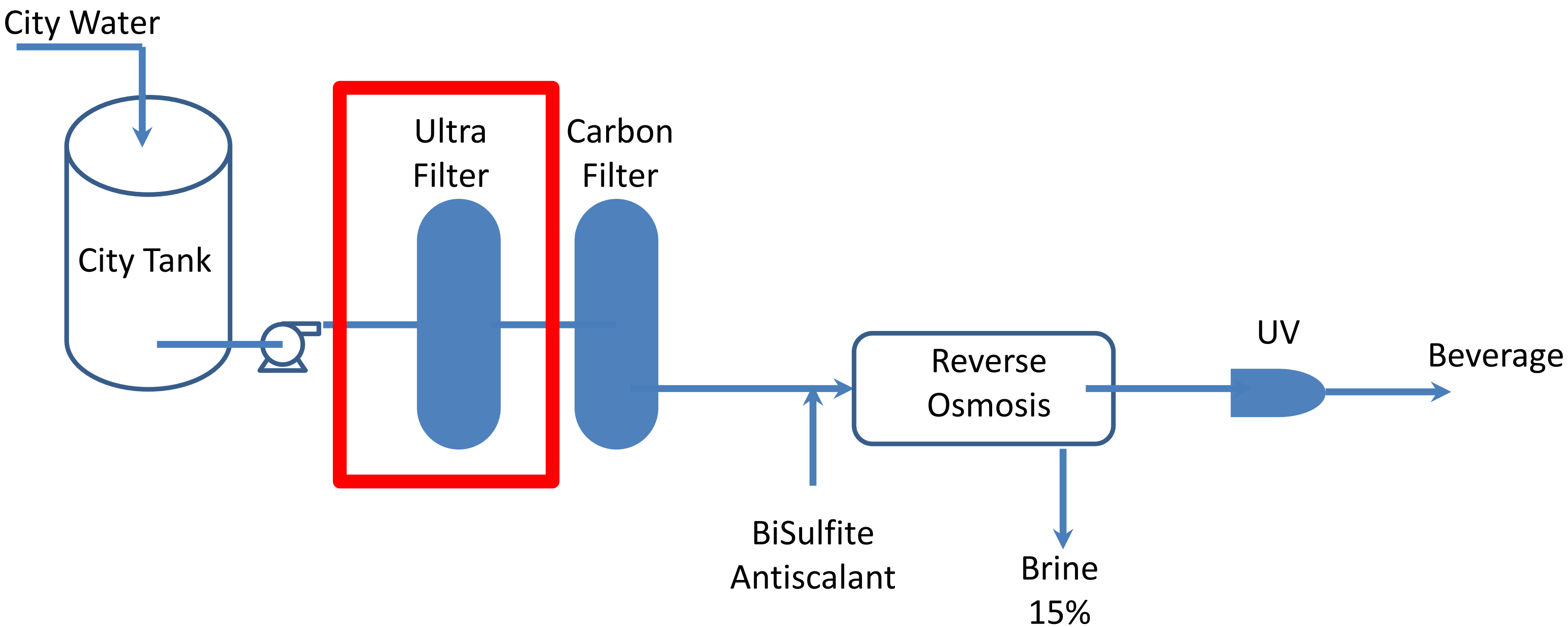
Product

jointly drove system design

Reverse Osmosis



Extend membrane life ➔ Pre-filter with UF



1990s

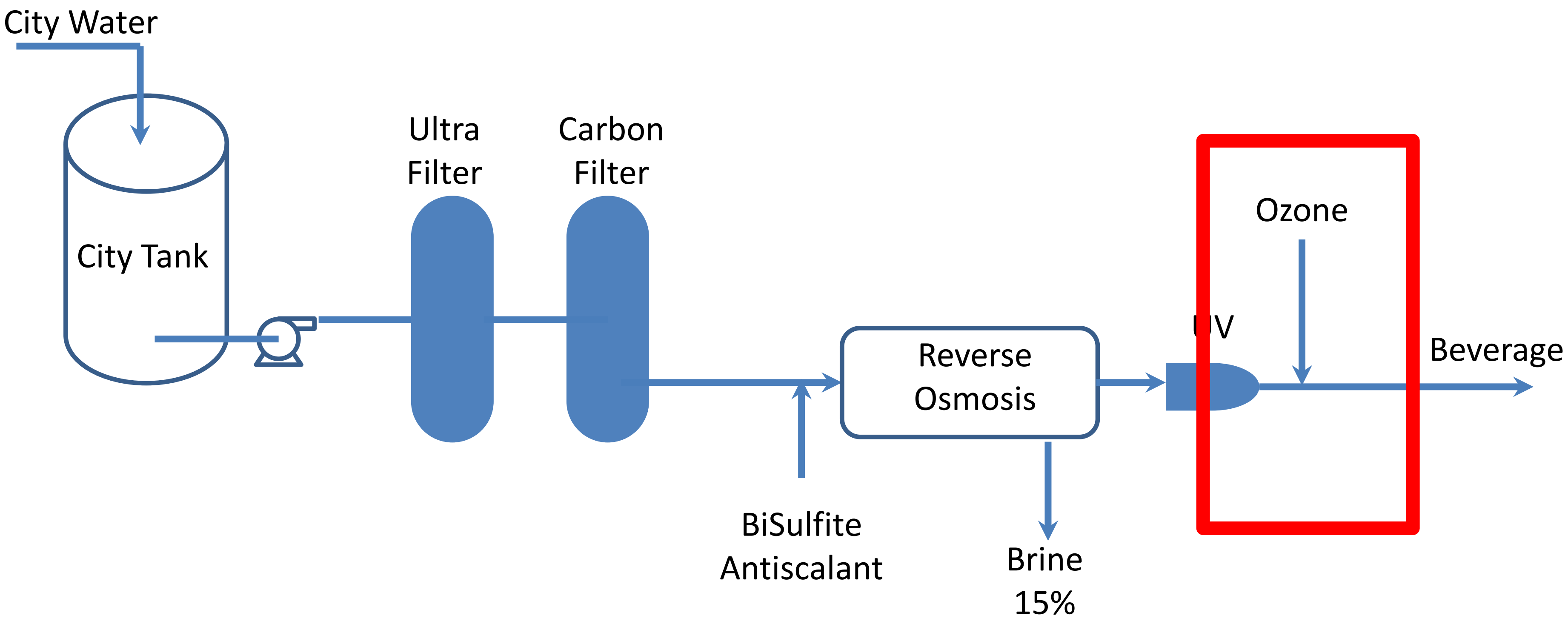
- ***Consumer getting "smarter"***
  - *Tighter regulations*
  - *The role of media in consumer education*
    - *Corporate responsibility to address and put out safe products*
    - *Required removal of contaminants down to the ppb levels where in the past ppm was adequate*
- ***Consumer trends changing***
  - *Better understanding of health impact of many newer contaminants : Why not plain water ?*
    - *Less sugar, more healthy*
  - *City water in many parts of the world deemed "not good enough"*

1990s

- **Thus was born table water or purified water**
  - No sugar, but no preservatives, no CO_2
  - Ozone treatment to manage bacteria spoilage
  - CiP systems need upgrade (heat, more effective chemicals)
  - Eliminate chemical additions altogether
  - More "deemed harmful" contaminants identified

- **Cost Impact**
  - All previous RO costs, plus
  - Heat energy, ozone & associated safety controls

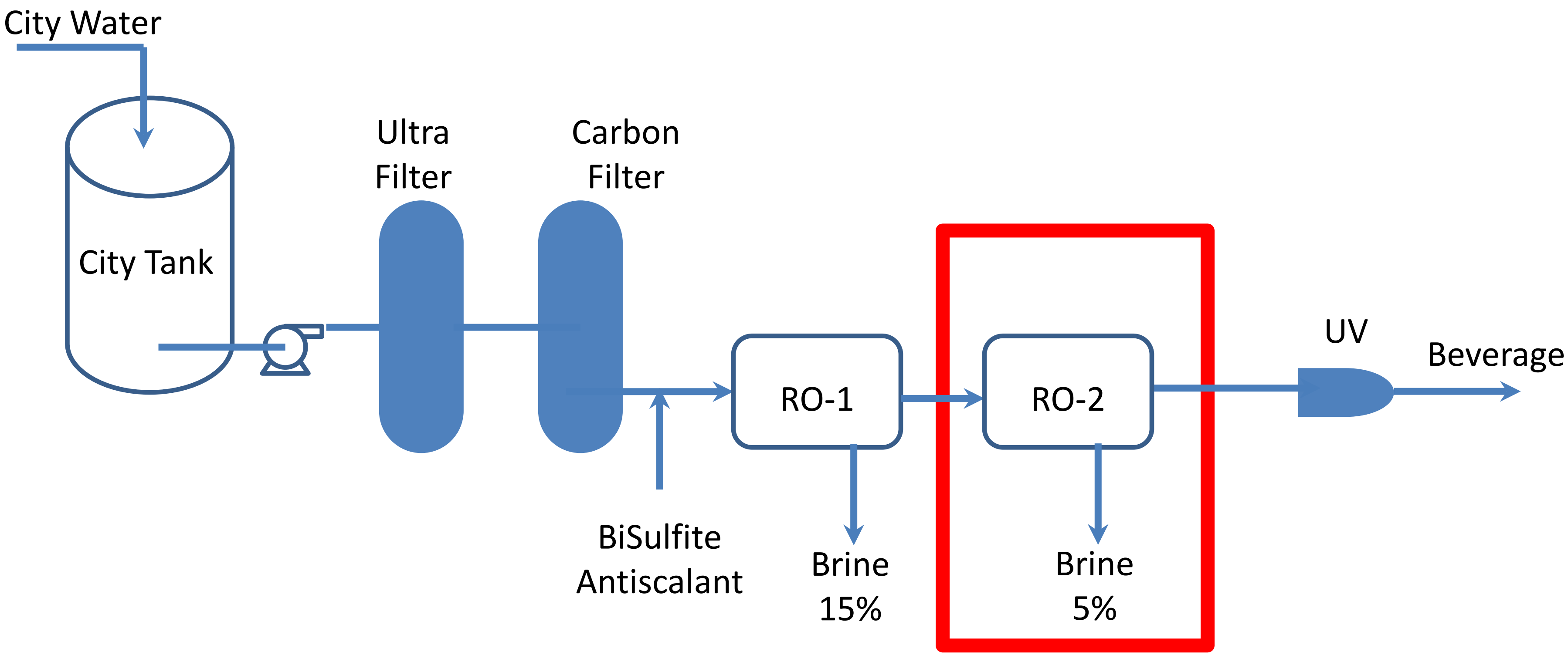
Ozone for additional protection



2000-2010

- ***Significant trend away from CSD to healthy drinks***
  - *Water overtakes soda in overall sales*
- ***Is Bromate an issue ?***
  - *Mere single stage RO treatment might not be adequate if incoming water contained bromide*
    - *6ppb bromide → 10ppb Bromate, which is the maximum allowed health standard*
  - *Are bromides being introduced from chlorine treatment*
    - *Eliminate any addition of chemicals to water after RO treatment*
- ***Cost Impact***
  - *Two RO systems in tandem ?*
    - *Even higher water wastage*

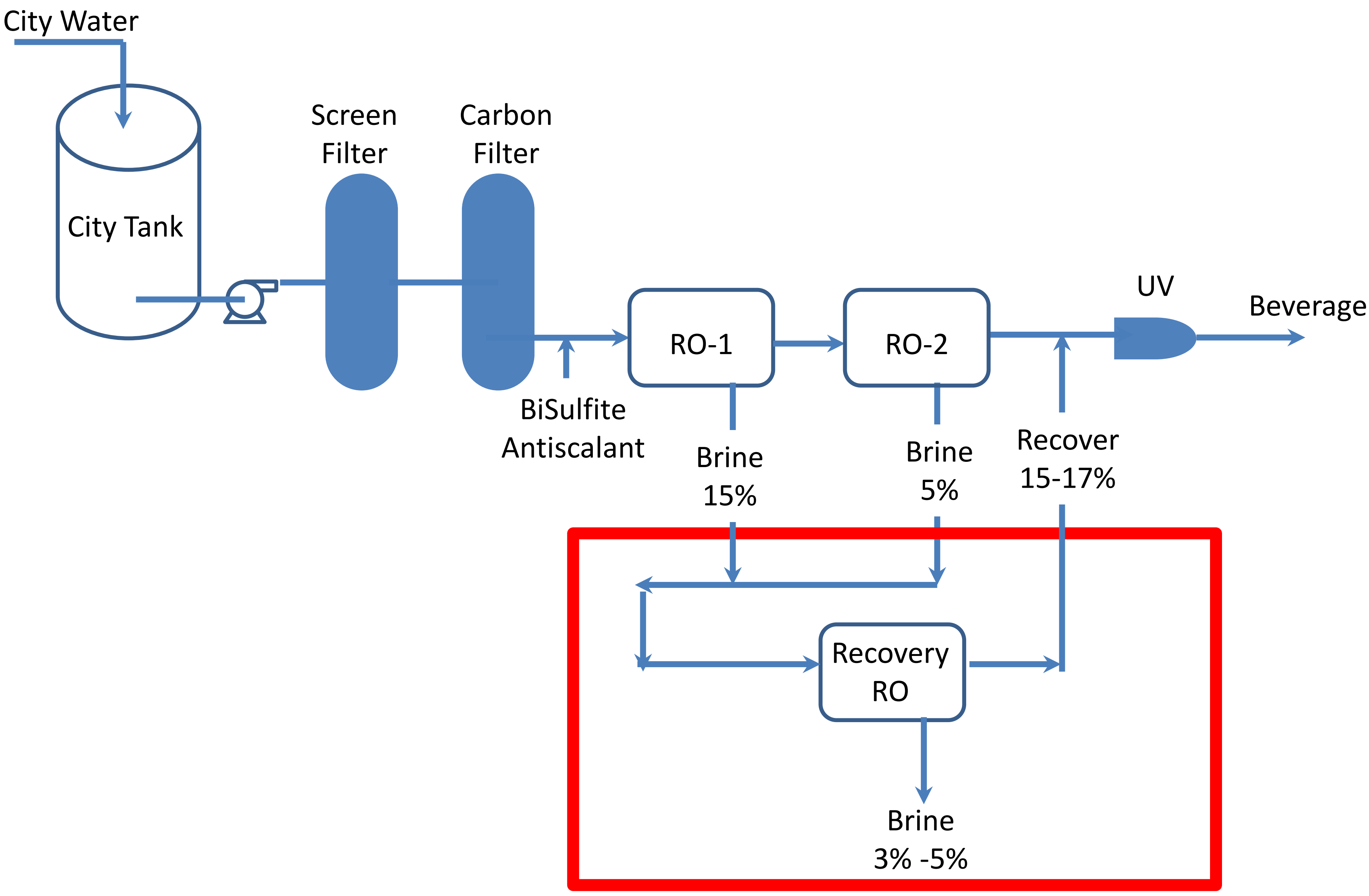
Double RO


City Water
City Tank
Ultra
Filter
Carbon
Filter
BiSulfite
Antiscalant
RO-1
Brine
15%
RO-2
Brine
5%
UV
Beverage

Last few years

- **Resource conservation is a major concern**
    - Regulatory & consumer influence and public & NGO pressure
    - Sustainability requirement ➔ License to do business
- **Many players in the market**
    - Manufacturer margins under pressure
- **How far have we come ?**
    - From simple filtration to double RO
    - From low cost chemicals to hot CiP
    - From low water wastage to average 15% on RO systems
- **Which has led to water recovery systems**
    - Evaluating technologies that get us back to almost 97% overall recovery to match LTS systems

RO Recovery


City Water
City Tank
Screen
Filter
Carbon
Filter
BiSulfite
Antiscalant
RO-1
RO-2
UV
Beverage
Brine
15%
Brine
5%
Recover
15-17%
Recovery
RO
Brine
3% -5%

Water Treatment Practices : The Evolution

- *Simple Filtration*
  - *Addition of UV systems*
    - *Lime Treatment Systems*
      - *Reverse Osmosis*
        - *Reverse Osmosis with Ultra Filtration*
          - *Ozone*
            - *Double Reverse Osmosis*
              - *Brine Water Recovery*

Driven by Regulation <u>AND</u> many other factors !!

Thank You

The Role of Water Quality in Food Safety: Does Water Matter?

International Association for Food Protection

COME BACK FOR Part 2:

What Could Be In Municipal Water?

Monday, April 30 2018, 11:00 a.m. Central Time U.S.

Part 1 gave the basics of EPA rules and what they might mean.

But what could be in the water you get?

Learn what municipal water indicators indicate and whether they predict the presence of microbes that may impact the safety of your product.

Hear from **Dr. Shay Fout**, recently retired from the EPA about what indicators do and do not indicate, from leading researcher Arizona State University's **Dr. Paul Westerhoff** about De facto reuse, how wet weather and variability can impact food safety and the latest on heat resistant microbes from University of Calgary Professor **Norman Neumann** and what they could mean to food processors.

Sponsored by **IAFP's Water Safety and Quality PDG**
&
Atlantium Technologies

Speakers

Paul Westerhoff,
Vice Dean for Research and Innovation –
Ira A. Fulton Schools of Engineering
Arizona State University

ret. G. Shay Fout,
RET. U.S. EPA, National Exposure Research Laboratory

Norman Neumann,
Professor
School of Public Health
University of Alberta

Moderator

Elisabetta Lambertini, PhD ,
Principal Investigator, Research Scientist
Food Safety and Environmental Health Risk
Center for Health and Environmental Modeling
RTI International