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

International Association for Food Protection®

Sponsored by **IAFP's Water Safety and Quality PDG,** Microbial Modeling & Risk Analysis PDG & **Atlantium Technologies**

Part 3:

Does Water Quality Matter To My Food Company?

Monday, June 4, 2018, Noon, Eastern Daylight Time U.S.

Part 1 gave the basics of EPA rules and how time lags might impact food processors.

Part 2 described what hazards could be in compliant municipal Drinking water.

Now In Part 3, learn what to do about it!

First, University of Arizona's **Dr. Chuck Gerba** explains the basics of Quantitative Microbial Risk Assessment (QMRA) and how to determine your risk profile. EPA's **Ken Rotert** highlights which EPA Rules and standards might impact food processing & where to get info on your water supplier; **Dr. Vince Hill** of the CDC explains why we don't hear much about water causing food contamination. Finally, hear valuable advice from **Will Daniels**, President, Produce Division, IEH Laboratories, with practical ideas on how to control your risk.

Speakers

Dr. Chuck Gerba,
Professor
University of Arizona

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

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

William C. Daniels,
President, Produce Division
IEH Laboratories & Consulting Group

Moderator

Phyllis Butler Posy,
Chair - Water Quality Safety PDG

Vice President of Strategic and Regulatory Affairs
Atlantium Technologies

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WEBINAR HOUSEKEEPING

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The Basics Of Quantitative Microbial Risk Assessment of Water for Food Processors

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EPA Drinking Water Rules Relevant to Food Processors

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

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Why don't we hear more about Water Associated Food Illness?

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

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What Can I do That Will Make a Difference?

Will Daniels
President, Produce Division
IEH Laboratories and Consulting Group

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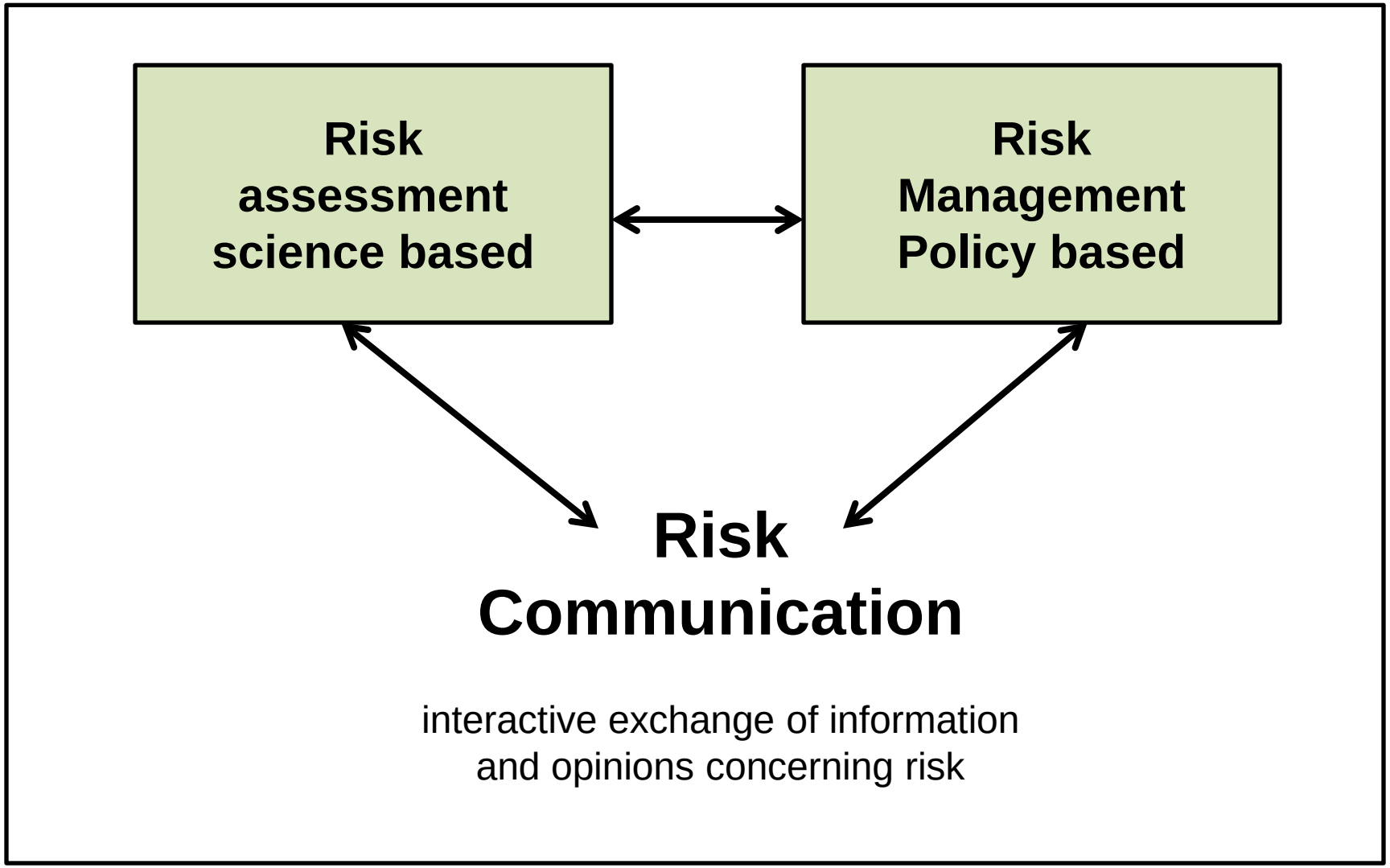
Risk Assessment

- Estimation of potential adverse effects associated with exposure of individuals or populations to hazards



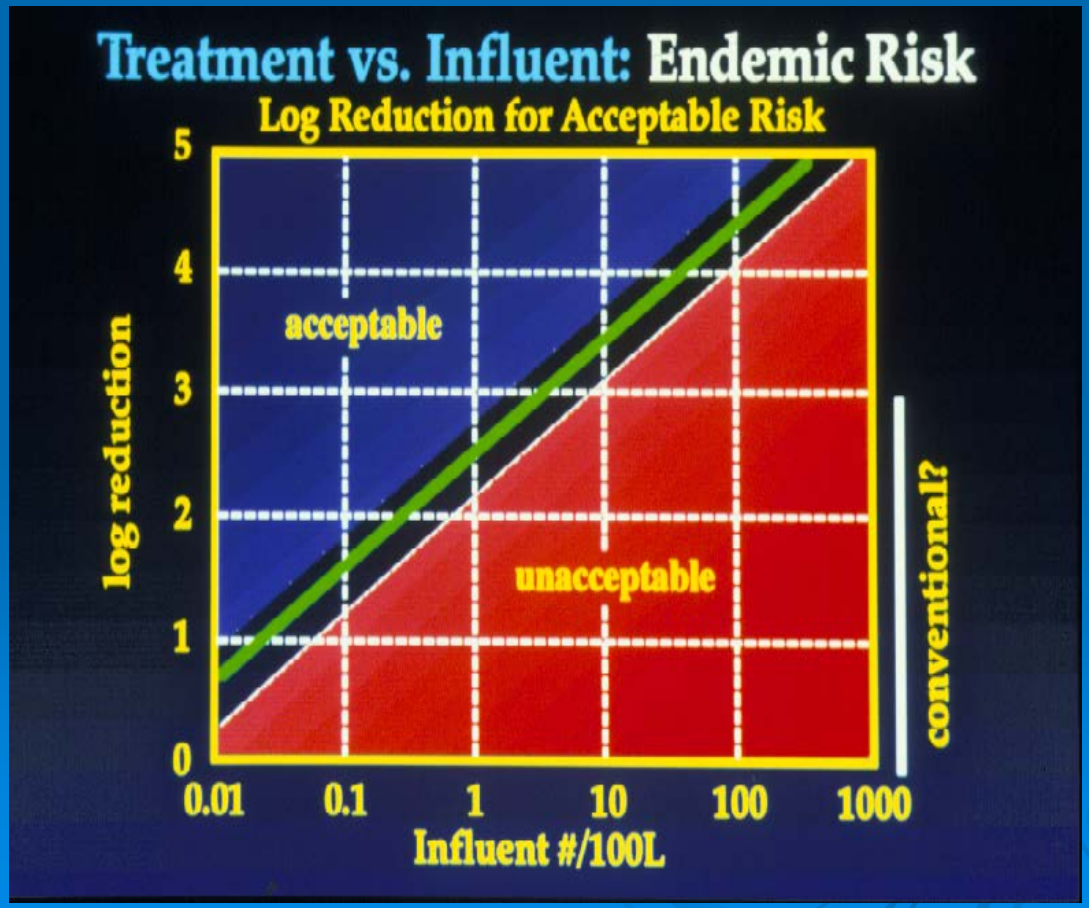
Risk analysis framework

How do we use risk analysis for water ?

Develop treatment standards for drinking water treatment

Assess cost: benefits of regulations

How do we use microbial risk assessment ?



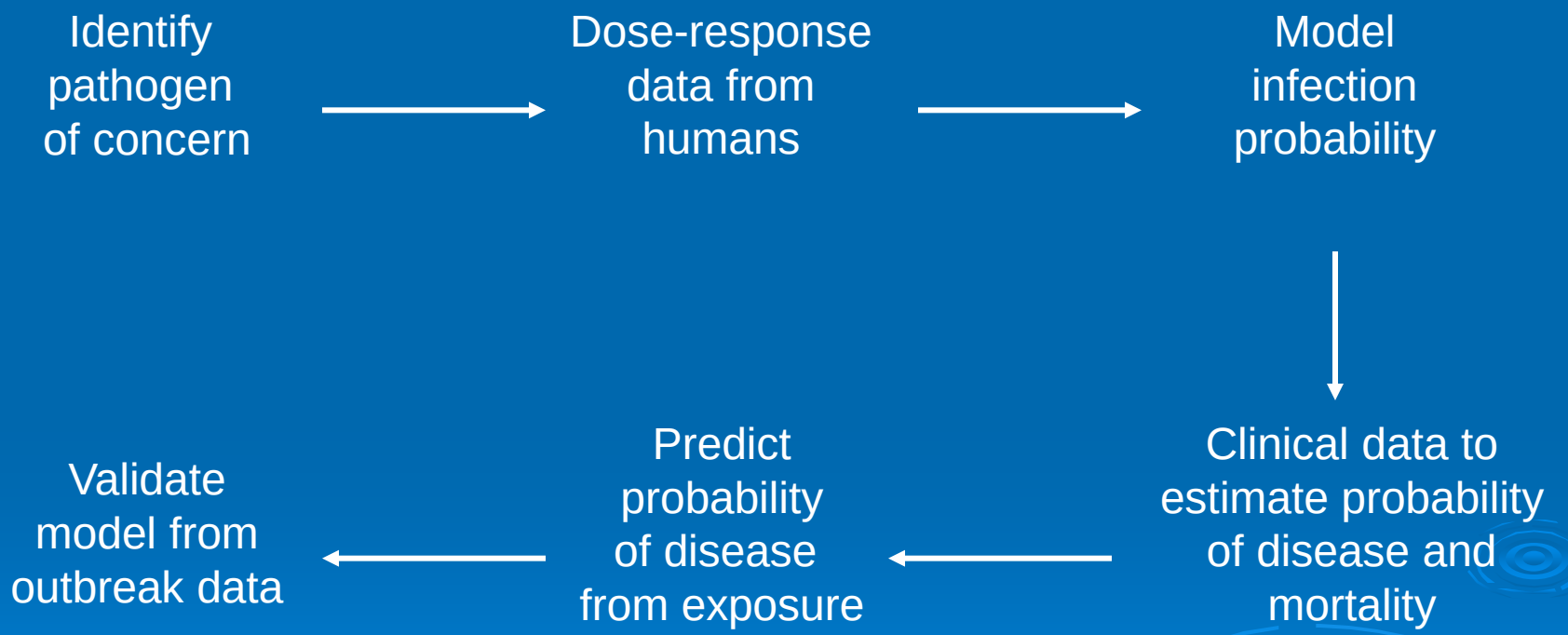
Development of treatment standards for drinking water treatment to remove pathogens from water

Microbial Risk Assessment

- Determine degree of drinking water treatment needed to reduce the risk of infection to 1:10,000 per year (Surface Treatment Rule) or ~1:1,000,000 per day
- Used to determine how much to treat the water for intented purpose
  - Drinking water
  - Recreational waters
  - Irrigation waters
  - Process waters

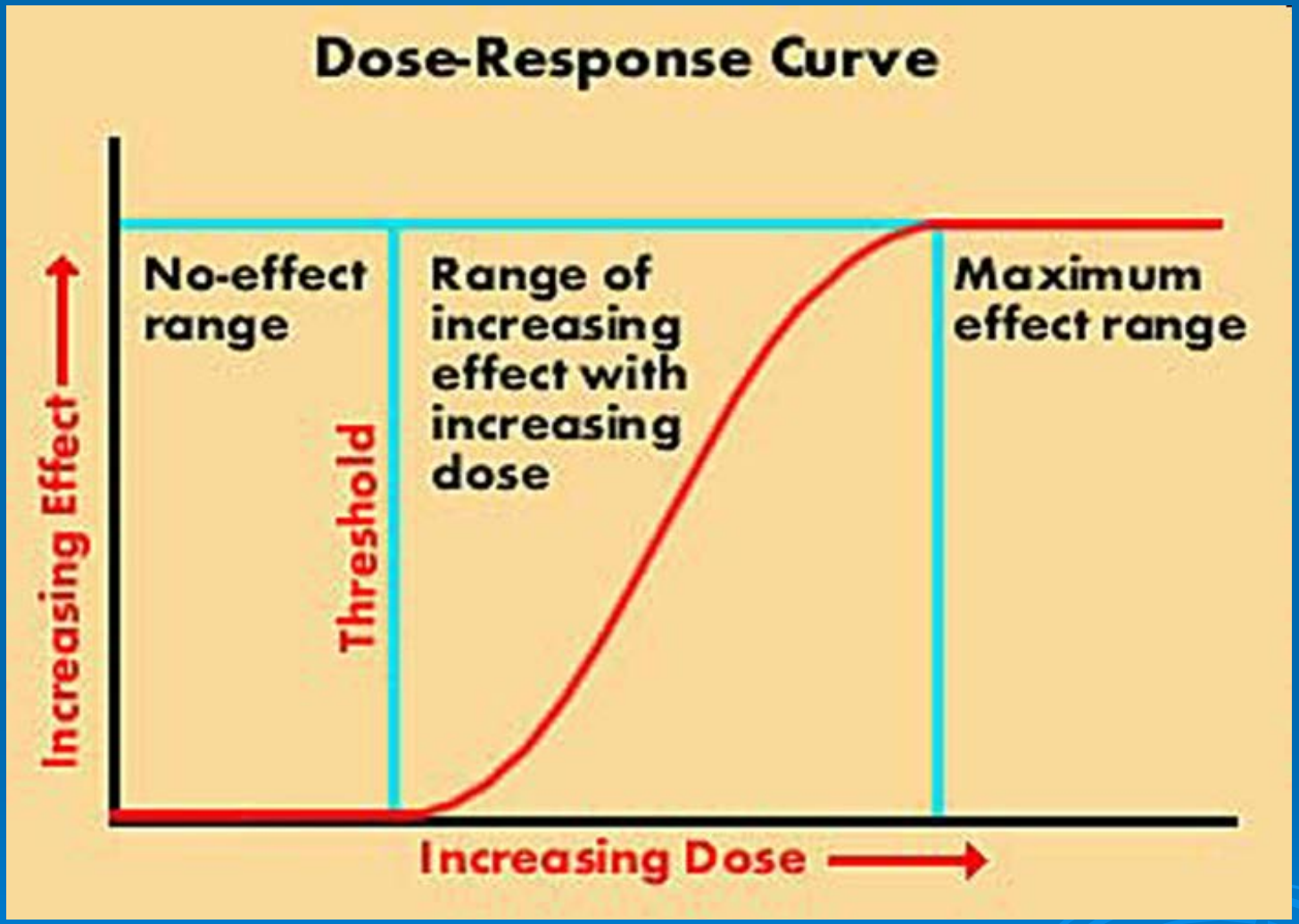
Quantitative Microbial Risk Assessment is an approach that allows the expression of risks in a quantitative fashion in terms of infection, illness, or mortality from microbial pathogens

Quantitative Microbial Risk Assessment

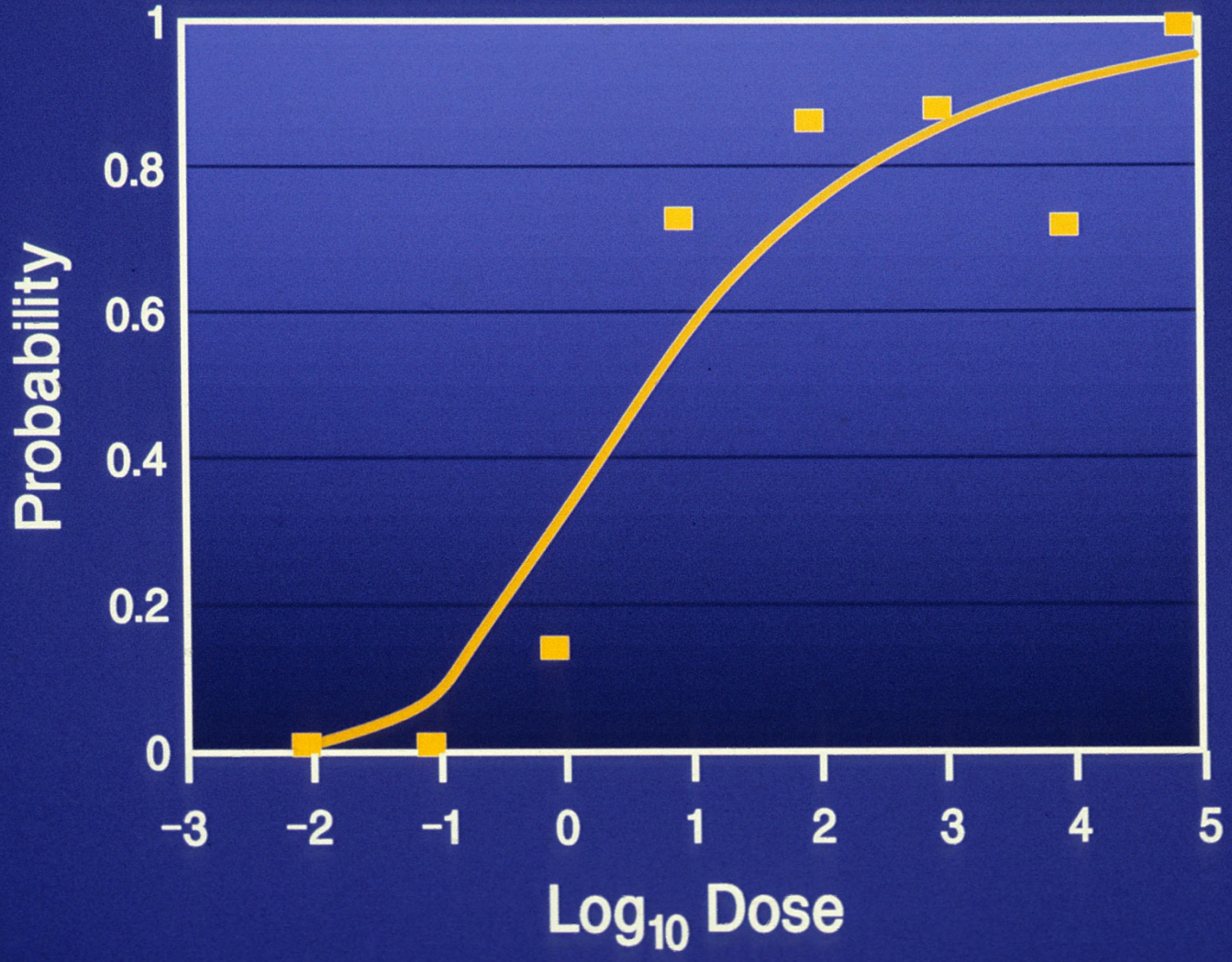


Four Basic Steps in Risk Assessment

- Hazard Identification - identifying the contaminate (i.e. Salmonella, norovirus)
- Dose-Response Assessment - relationship between concentration of and the probability of infection
  - Data may come from human/animal feeding studies or outbreaks


Dose-Response Curve
No-effect range
Threshold
Range of increasing effect with increasing dose
Maximum effect range
Increasing Effect
Increasing Dose

Probability of Infection with Human Rotavirus



Dose Response studies have been conducted in humans for

- Poliovirus
- Rotavirus
- Norovirus
- Salmonella
- E. coli 0157:H7
- Campylobacter
- Shigella
- Cryptosporidium
- Giardia

Dose Response Models for Microorganisms

Beta-Poisson
(Simple log-normal)

$$P = 1 - \left(1 + \frac{N}{\beta}\right)^{-\alpha}$$

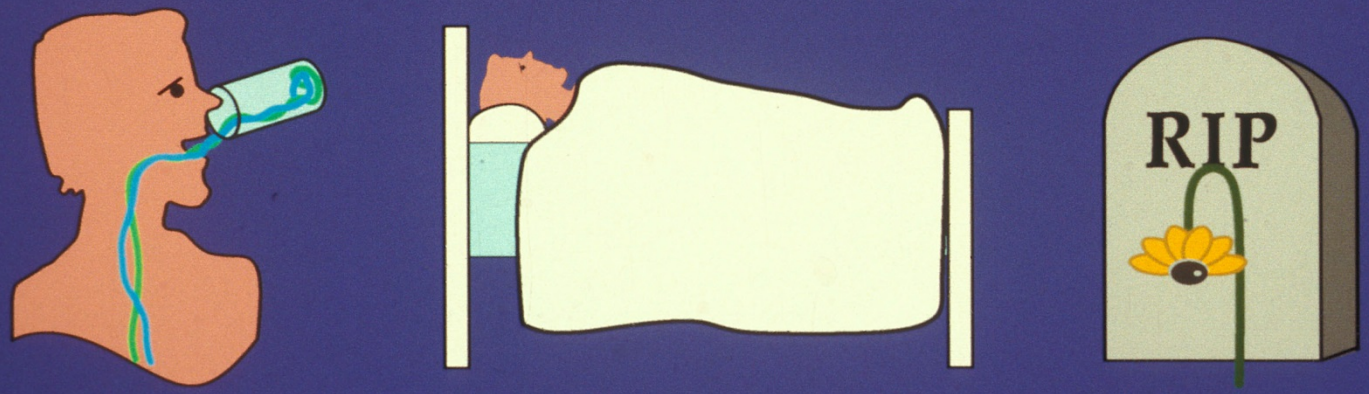
Exponential

$$P = 1 - \exp(-rN)$$

P = Probability of infection from a single exposure
N = Number of organisms ingested
α and β = parameters characterizing the host-organism interaction
r= fraction of the ingested organisms that survive to initiate infections

Outcomes of Microbial Exposure

Infection → Disease → Mortality



Case-Fatality Rates for Enteric Pathogens

Organism	Case-fatality (%)
Coxsackie virus B	0.59 – 0.94
Echovirus	0.27
Hepatitis E (pregnant women)	2 – 3 20 – 40
Shigella	0.2
Salmonella	0.1
E. coli O157:H7	0.2
Ascaris	0.02

Case Fatality Observed for Enteric Pathogens in Nursing Homes vs. General Population

Organism	*Case Fatality (%) In General Population*	*Case Fatality (%) In Nursing Homes*
Campylobacter jejuni	0.1	1.1
Escherichia coli 0157:H7	0.2	11.8
Salmonella	0.1	3.8
Shigella	0.2	-
Rotavirus	0.01	1.0
Snow Mountain Agent	*	1.3

*Only documented deaths have been in the elderly in nursing homes.

EXPOSURE

ROUTE

Inhalation, ingestion

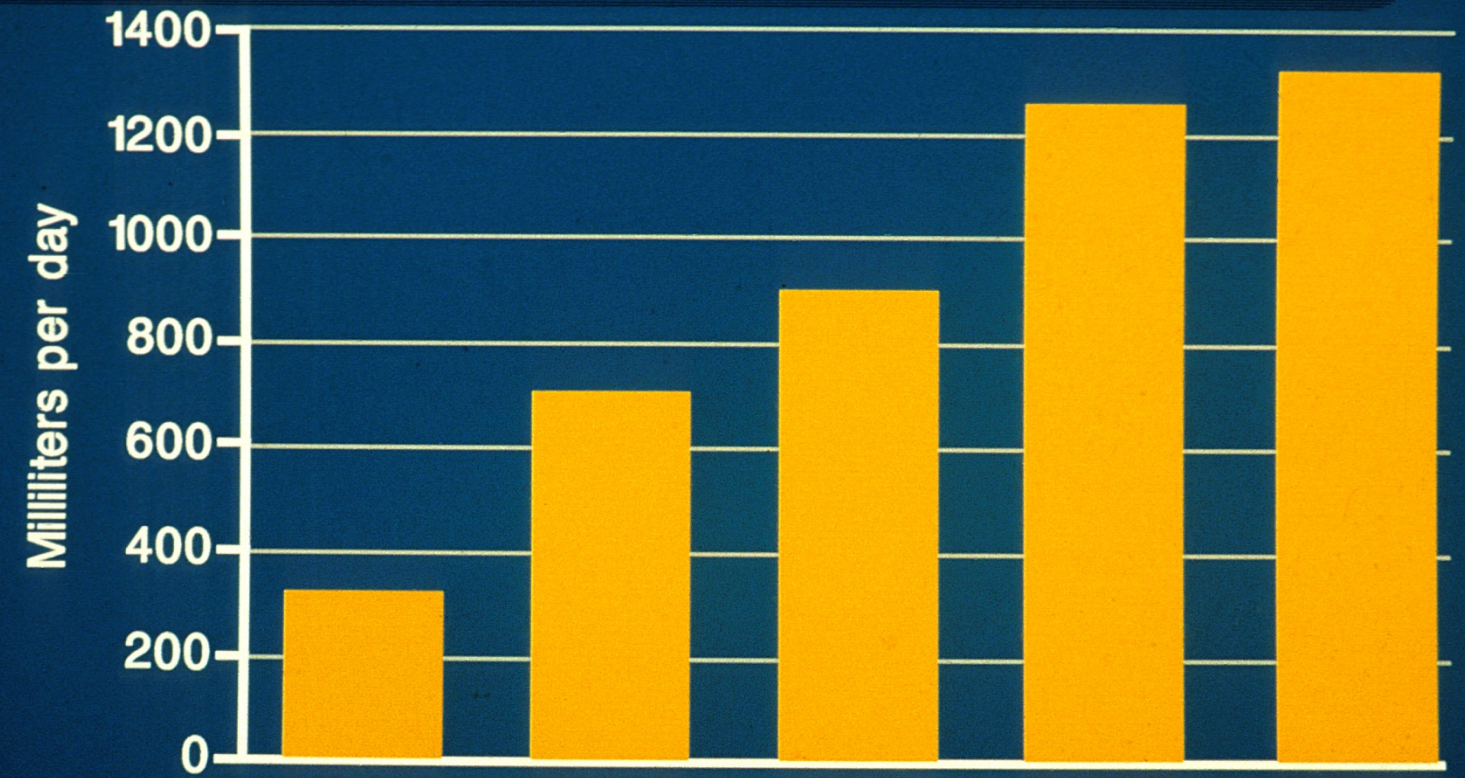
CONCENTRATION OF PATHOGEN

Organisms per ml, liter, gram of food, cubic meters of air

DURATION

Event, day, year

Average Tapwater Intake Rates



from Roseberry and Burmaster, 1992
Risk Analysis 12:99

Annual Risk of One or More Infections =

$$1 - (1 - P)^{365}$$

P = Probability of infection from a single exposure

RISK ASSESSMENT OF ROTAVIRUS IN DRINKING WATER

- Hazard = rotavirus
- Dose response from human ingestion on studies provide values for α and β. Ingestion of one virus will cause an infection in 15% of the people.
- Exposure 2/ liters per day ingested

RISK ASSESSMENT FOR ROTAVIRUS IN DRINKING WATER

Pathogen Identified

↓

Dose Response Model
(feeding studies)

↓

Exposure
(field studies)

↓

Risk Characterization
(2 liters/day ingestion)

Rotavirus

↓

Best fit Beta Poisson
$Pi = (1+N/\beta)-\alpha$

↓

4 Rotavirus/1,000 liters

↓

Risk of Infection
Day 1:200
Year 1:2

Quantitative Microbial Risk Assessment (QMRA) Wiki

How do to a QMRA and data needed to perform one can be found at

http://qmrawiki.canr.msu.edu/index.php/Quantitative_Microbial_Risk_Assessment_%28QMRA%29_Wiki

QMRAwiki

qmrawiki.canr.msu.edu/index.php/Quantitative_Microbial_Risk_Assessment_(QMRA)_Wiki

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Quantitative Microbial Risk Assessment (QMRA) Wiki

The QMRA Wiki is a community portal for current quantitative information and knowledge developed for the Quantitative Microbial Risk Assessment (QMRA) field evolving knowledge repository intended to be the go to reference source for the microbial risk assessment community. To learn more about how to contribute edit please follow the instructions **here**.

QMRA Basics **About Wiki** **Apps & Calculators** **QMRA News** **Editing Help** **Suggestio**

Explore the Risk Framework

Hazard Identification | Dose Response | Exposure Assessment | Risk Characterization | Risk Management | Case Studies

- Main page
- Case Studies
- Hazard ID
- Dose response
- Exposure assess.
- Risk char.
- Risk management
- QMRA tools
- Glossary
- Help

General wiki tools
- Random page
- Recent changes
- Pages by category
- Wish list
- Sandbox

Tools
- What links here
- Related changes
- Upload file
- Special pages
- Printable version
- Permanent link
- Page information
- Browse properties

QMRA Library

Check out this extensive library of QMRA-related articles, databases, videos, etc.

Dose Response Monograph

Find out more about the first compendium of dose-response models. If you would like to

Order the QMRA Textbook

On Amazon: **Here**

Dose Response

(Redirected from Dose Response (Home Page))

DOSE RESPONSE

Lead Editor:
Chuck Haas
EMAIL • BIO

Help
QMRA Library
Apps

What is Dose Response? | Recommended Best-Fit Parameters | Completed Dose Response Models | Mathematical & Statistical Approaches | Dosing Experin

What is dose response?

In the QMRA framework, the dose response assessment phase is an essential quantitative element of the risk estimate. It estimates the risk of a response (for example, infect
a known dose of a pathogen. Dose response models are mathematical functions that describe the dose response relationship for specific pathogens, transmission routes, an

Supporting agencies

**Center for Advancing Microbial
(CAMRA)**
301 Manly Miles Building
1405 South Harrison Road
East Lansing, Michigan 48823, U
Tel: 517-353-9858 · Fax: 517-353

Completed Dose Response Models

***Please click on the tab headings to navigate between tabs.**

- Bacillus anthracis: Dose Response Models
- Burkholderia pseudomallei: Dose Response Models
- Coxiella burnetii: Dose Response Models
- Escherichia coli: Dose Response Models
- Francisella tularensis: Dose Response Models
- Legionella pneumophila: Dose Response Models
- Listeria monocytogenes (Death as response): Dose Response Models
- Listeria monocytogenes (Infection): Dose Response Models
- Listeria monocytogenes (Stillbirths): Dose Response Models
- Mycobacterium avium: Dose Response Models
- Pseudomonas aeruginosa (Contact lens): Dose Response Models
- Pseudomonas aeruginosa (bacterimia): Dose Response Models
- Rickettsia rickettsi: Dose Response Models
- Salmonella Typhi: Dose Response Models
- Salmonella anatum: Dose Response Models
- Salmonella meleagridis: Dose Response Models

Main page
Case Studies
Hazard ID
Dose response
Exposure assess.
Risk char.
Risk management
QMRA tools
Glossary
Help
General wiki tools
Random page
Recent changes
Pages by category
Wish list
Sandbox
Tools
What links here
Related changes
Upload file
Special pages
Printable version
Permanent link
Page information
Browse properties

Brief example of a point-estimate risk characterization

What is point estimation?

A point estimate is a single numeric calculation of risk. The particular input parameter values chosen for exposure and dose response correspond to the desired interpretation. One common point estimate is to select the most likely values of the various inputs and calculate a single "best estimate" of risk. Alternatively, one might choose values of inputs that are plausible but conservative (tend to result in higher risk estimates) in order to make a point estimate of the maximum reasonable exposure, or 'worst credible case'.

Point estimation is relatively simple to implement. Multiple point estimates across different scenarios and inputs can help to characterize uncertainty. For more complex models and more detailed analyses, probabilistic risk assessment methods (link to PRA content) are recommended. However, point estimates remain useful for teaching examples or 'back of the envelope' risk characterizations.

Example: *Cryptosporidiosis* risk

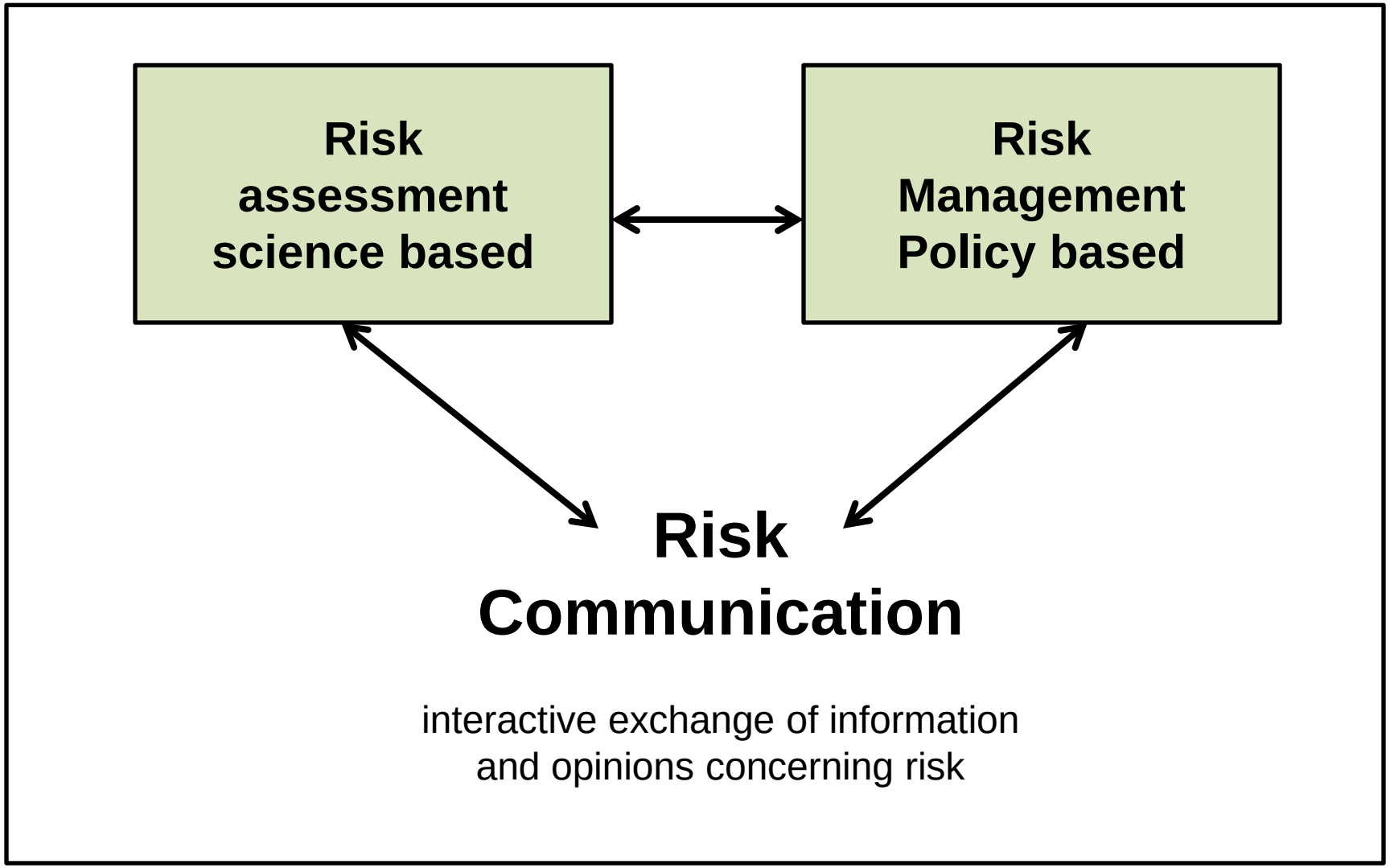
If *Cryptosporidium* is present in a water body, what is the risk of infection from swimming in this water? What are the risks of illness or death? Point estimates of these risks can be quickly calculated using likely exposure and dose response parameter values.

Exposure assessment

- Assume 10 infective oocysts/liter in a particular water body
- 0.13 liters ingested per swim, 7 swims per year [1]
- Dose = contact rate x concentration: 0.13 liters/swim x 10 oocyst/liter = 1.3 oocysts ingested per swim

The number of swims per year will be used later.

Dose response



Risk analysis framework

Summary

- Quantitative microbial risk assessment of QMRA can be used to
  - Determine needed treatment to reduce risk of infection by specific waterborne pathogen – what degree of treatment you might need for a given application (i.e. produce washing, irrigation waters, etc)
  - Assess the reliability of a treatment processes over time and variation in water quality

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EPA Drinking Water Rules Relevant to Food Processors

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

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EPA Drinking Water Rules Relevant to Food Processors

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

June 4, 2018

Overview

- Drinking Water Regulation Applicability and Coverage
- Some EPA Rules that may Impact Food Processing Operations
- Relevance of EPA Standards to Food Processing
- Understanding the Water you Get

Regulation Applicability and Coverage

- Applicability of Drinking Water Standards
  - Standards only apply to public water systems – at least 15 service connections or serves ≥ 25 people for at least 60 days a year
- Public Water System Coverage (Safe Drinking Water Act Amendments of 1996 – Part B)
  - EPA Drinking Water Standards do not apply to a public water system:
    - Which consists only of distribution and storage facilities (and does not have any collection and treatment facilities
    - Which obtains all of its water from, but is not owned by, a public water system to which such regulations apply
    - Which does not sell water to any person; and
    - Which is not a carrier which conveys passengers in interstate commerce

Some EPA Rules that may Impact Food Processing Operations

- 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

Some EPA Rules that may Impact Food Processing Operations

- 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)

Some EPA Rules that may Impact Food Processing Operations

- Disinfection Byproduct Rules
  - Limit the amount of Trihalomethanes, Haloacetic Acids, Bromate and Chlorite in drinking water
  - Can be formed when disinfection byproduct precursors react with disinfectants added for microbial control
  - Monitored within drinking water distribution systems
  - Chronic exposures to DBPs have been associated with bladder cancer and other health effects

Relevance of EPA Standards to Food Processing

- Finished drinking water in compliance with EPA standards is low risk, not sterile
  - Not all potential microbial contaminants are regulated
  - Treatment of surface water sources does not necessarily remove 100% of microorganisms. 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 of 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

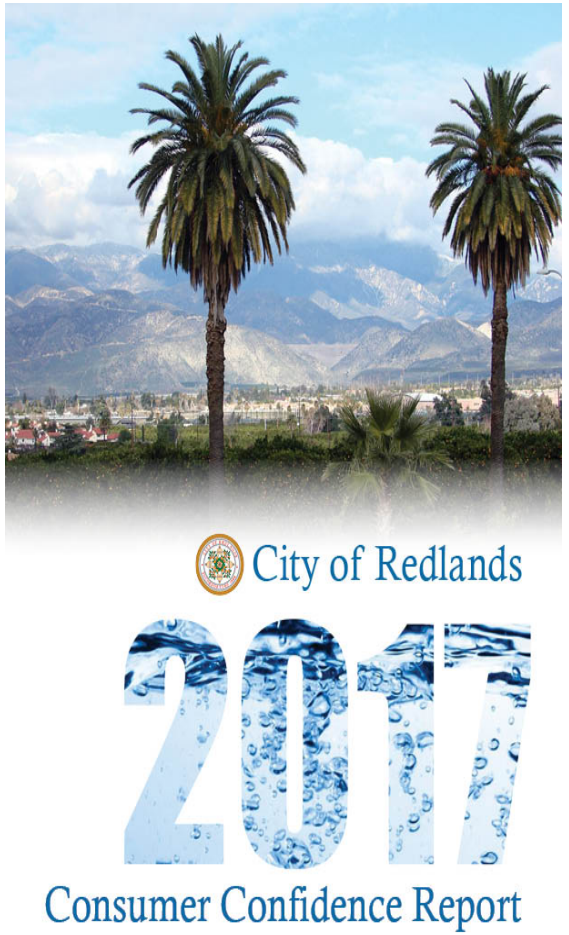
Range of Scenarios: Monitoring to Public Notification

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.

Understanding the Water you Get

- Consumer Confidence Reports (CCRs)
  - All Community Water Systems (CWSs) must provide all of their customers with an annual water quality report
  - Includes information on the water source, contaminants detected in finished water, health effects of contaminants when violations occur, likely sources of detected contaminants, and availability of source water assessments
  - Customers can make informed decisions regarding their use of drinking water
  - CCRs must be provided by July 1 each year



Understanding the Water you Get

- Safe Drinking Water Information System (SDWIS)
  - Federal database housing basic information on:
    - the system's name, ID number, city or county served, number of people served, type of system (residential, transient, non-transient), whether the system operates year-round or seasonally, characteristics of the system's source(s) of water
  - Also contains information on:
    - Violation information for each public water system (e.g, monitoring failures, treatment technique failures, Maximum Contaminant Level exceedances, public communication failures)
    - Enforcement information, including actions states or EPA have taken to ensure that a public water system returns to compliance if it is in violation of a drinking water regulation
  - State version available to house monitoring and other information
    - Some states have additional publicly accessible databases with more detailed information

Summary

- EPA drinking water regulations apply to Public Water Systems
  - These regulations generally address the quality of drinking water
- Finished water in compliance with EPA regulations is low risk, not sterile
- Several information sources are available on water quality from Public Water Systems

Contact Information

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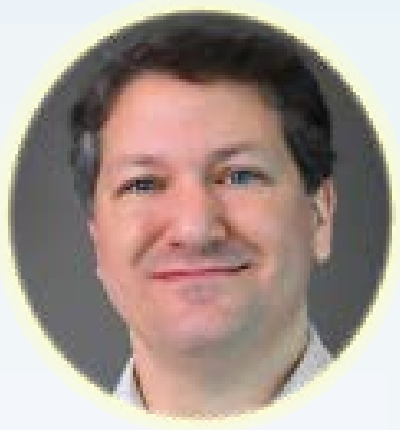

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Getting the Data We Need to Characterize Water Contributions to Foodborne Disease Outbreaks

Vincent R. Hill, PhD, PE

Chief, Waterborne Disease Prevention Branch

Division of Foodborne, Waterborne and Environmental Diseases

June 4, 2018

Water can impact food quality and contribute to foodborne outbreaks

Water-related foodborne disease outbreaks

- Foodborne outbreaks potentially related to irrigation water
  - 2003 hepatitis A virus on green onions (imported)
  - 2006 *E. coli* O157:H7 on spinach (domestic)
  - 2013 *Cyclospora* on spinach (imported)
  - Multiple berry-related outbreaks
  - Current *E. coli* O157:H7 on romaine?
- Rarely have environmental data to make etiology connections
- Traceback can identify implicated facilities, but environmental and production system assessment data needed for root cause analysis

Factors impacting field investigations

- Response time
  - Field investigations often delayed
  - Environmental investigations require partnerships, planning
- Water inputs and uses
- Pathogen sources
- Pathogen types

Understanding water inputs and uses

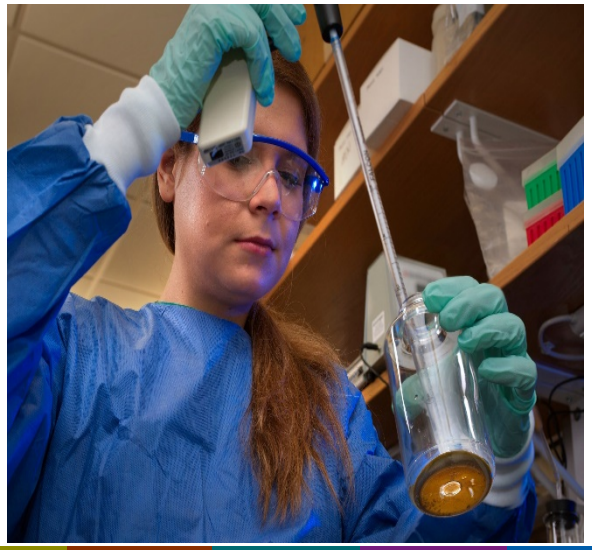
- Irrigation water
  - Surface water
    - Canals: Often many miles, fecal contamination flows downstream
    - Ponds: Dead ends; easier to characterize, but water quality can change quickly; can sample water and sediment
  - Ground water: contamination often more long-lasting
- Dump tanks and wash water systems
  - Water as vehicle for cross-contamination; systems emptied each day; system assessment needed to understand potential deficiencies
- Processing facility source water
  - Often municipal source; ground water sources may not be treated

Understanding pathogen sources and types

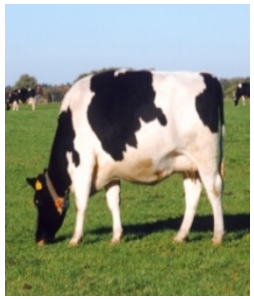
- Numerous potential sources of fecal waste
  - People (e.g., farm workers)
  - Wild animals (e.g., pigs, birds)
  - Farms (e.g., dairy, beef, swine)
  - Sewage (e.g., municipal sewage [breaks, overflows], septic tanks)
- Microbes have different environmental persistence characteristics
  - Enteric
    - Bacteria like *E. coli* O157 and *Salmonella* can die-off quickly
    - Longer persistence for viruses, and even longer for parasites
  - Environmental
    - *Listeria* contamination can last for long periods

New environmental investigation tools can help

- Large-volume water sampling
  - 100s to 1000s liters enables sensitive detection of pathogens and fecal indicators
- Sampling soil/sediment as reservoir for waterborne contamination
- Analytical tools
  - Microbial source tracking (MST) to characterize human and animal fecal sources
  - NextGeneration sequencing (metagenomics and whole genome sequencing [WGS])



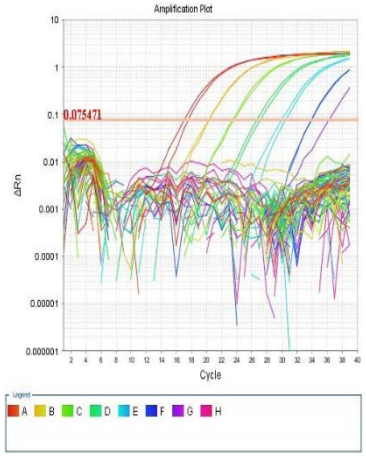
Microbial Source Tracking (MST)



1. Identify potential fecal sources

2. Collect water sample

3. Extract DNA

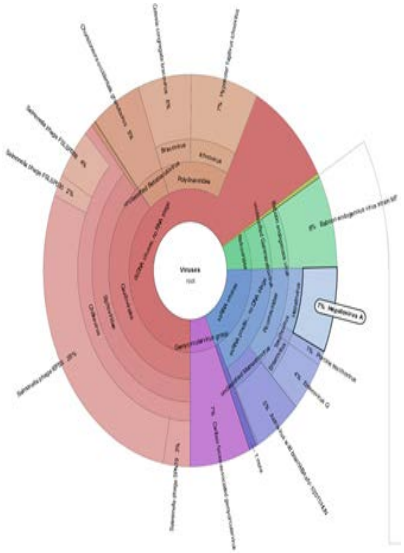


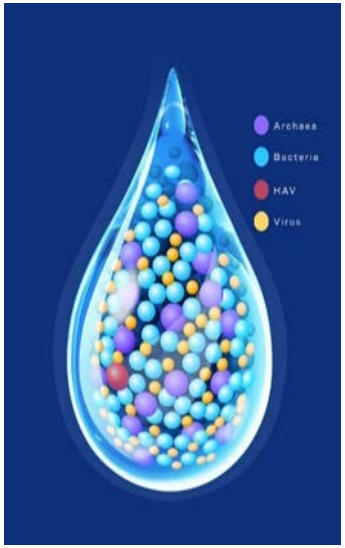
4. Species-specific qPCR

5. Fecal source identification

Metagenomics and Whole Genome Sequencing for Environmental Investigations

- Use metagenomics to understand
  - Diversity of pathogens and traits (e.g., AR) in environmental media, water and waste systems
  - Persistence and transmission of AR in environment
  - Identify areas of risk for human exposure, control points for contamination prevention
  - Link environmental data to outbreak clusters
- Use WGS to study
  - Methods to identify signature organisms in environmental samples
  - Conditions that support pathogen survival & transmission
  - Relationships of bacterial communities and pathogens





Thank you!

Contact:
Vincent Hill, vhill@cdc.gov

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

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Does Water Matter?
Part 3: Does Water Quality Matter To My Food Company?

International Association for Food Protection®

What Can I do That Will Make a Difference?

Will Daniels
President, Produce Division
IEH Laboratories and Consulting Group

Sponsored by **IAFP's Water Safety and Quality PDG,**
Microbial Modeling & Risk Analysis PDG
&
Atlantium Technologies

IAFP Webinar; Does Water Matter

Part 3: Does Water Quality Matter to My Food Company?.....Industry Perspective

June 4, 2018

Will Daniels
President, Produce Division
IEH Laboratories and Consulting Group

Water in the facility…

- Performs several functions:
  - Facilities, Operations, Sanitation
- Likely involves regulations/requirements from multiple entities:
  - Local, State, Federal, Internal, Customer
- Involves management both inbound and as waste
  - Rural, Municipal
- Is a risk that must be managed.

What practices increase my risk?

- Water as an ingredient
  - Water quality, chemistry, treated?
  - Regulatory requirements
- Re-using water
  - Wash system, transport system
    - ✓ Cooling treatments
    - ✓ Sanitizer treatments
    - ✓ Plumbing
- The unintended consequence
  - Water in a dry process
  - Sanitation

How can I lower my risk?

- Know your regulations
  - Who, what, when
- Know your supply
  - Treatment required?
- Perform a risk assessment
  - Know your process
  - Continuous improvement
  - External resources?
- Establish and ensure control
  - Monitoring/injecting
  - Validate system
- Educate
- Repeat!

If I need to mitigate, what should I do?

- Create obtainable targets
  - Does the plan align with the method?
- Identify the appropriate methods
  - Reliability/accuracy
  - Validate/verify
  - Preventative maintenance
- Be sure that you have a continuous improvement process in place to identify the ever changing landscape.

Thank you

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

International Association for Food Protection®

Part 3:

Does Water Quality Matter To My Food Company?

Sponsored by **IAFP's Water Safety and Quality PDG,** Microbial Modeling & Risk Analysis PDG & **Atlantium Technologies**

AUDIENCE QUESTIONS & ANSWERS

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