Small Water System Working Group

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Island Health
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Why Monitor Water Quality

- Assess risk to consumers
- Reduce risk to consumers
- Detect trends over time – will the system work tomorrow
- For system historical reliability
- For system performance and management
  - does the current treatment/disinfection process work
  - will we need a different technology tomorrow
  - are there impacts to our system i.e. pH , solids

Note: without monitoring you really never know what the water quality is.

What Parameters Should Be Monitored/Tested

- Decide using DWO, Operating Permit Conditions, Provincial, Federal and International Standards
  - Drinking Water Protection Regulation
  - BC Surface Water Quality Objectives
  - Guidelines for Canadian Drinking Water Quality
  - US EPA, WHO

What Should We Monitor For and How Often Should We Monitor – Develop Objectives

- Raw water – where, why and how often and for what parameters
- Finished water – where, why, how often and for what parameters
- Disinfection and treatment processes – where, why, how often and for what parameters

What to Do With the Test Results

A. Put them in a book and forget about it
B. Share them with the consumers
C. Share them with the HA
D. Compare results over time
E. Compare results between sample sites

Pathogen List (Partial) to choose from

- Viruses – hepatitis, norovirus, adenovirus
- Protozoa- giardia, cryptosporidium
- Bacteria- salmonella, campylobacter, *E. coli* 0157

Chemical List (partial) to Choose From

- Metals, physical, cations, anions, nucleotides, pesticides, herbicides, hydrocarbons, pharmaceuticals, trihalomethanes, tannins and lignins, organic carbon, dissolved oxygen

Chemicals continued

- Alkalinity
- Aluminum
- Arsenic
- Barium
- Biochemical oxygen demand
- Chemical oxygen demand
- Boron
- Calcium
- Chloride
- Chlorophyll a
- Copper
- Fluoride
- Iron
- Lead
- Magnesium
- Manganese
- Nitrogen, ammonia
- Nitrogen, nitrate
- Nitrogen, nitrite
- pH
- Phosphorus
- Potassium
- Selenium
- Sodium
- Sulphate
- Total dissolved solids
- Total suspended solids
- Zinc

Risks to the Water (both chemical and microbiological)

- Fecal contamination from humans and animals
  - Wildlife
  - Farm/pets
  - Improper sewage systems
  - Runoff
- Chemical Contamination from humans
  - Accidents and spills
  - Long term impacts from industry and agriculture
- Naturally Occurring Chemicals
  - Arsenic

Source Water

- Inadequate treatment
- Treatment system failure
- Cross connection (backflow)
- Infiltration through water line breaks/leaks

Water Works

Greatest Risk

Pathogens versus Chemicals

Pathogens pose the greatest risk

- Can change from day to day.
- Pathogens are not evenly distributed in the water
- What is not here today may be here tomorrow.

Chemistry changes slowly over time.

- Chemistry is evenly distributed in the water supply e.g. iron
- http://www.nccph.ca/docs/SDWS_Water-borne_EN.pdf 46 of 48 events investigated were due to microbial causes. Only 2 were chemical.

Pathogens; Three distinct groups (birds, mammals and reptiles)

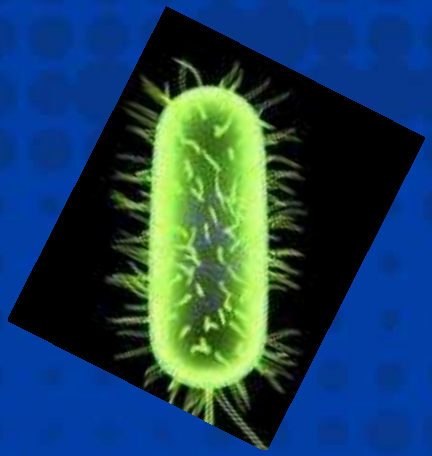
- Protozoa size 8000 nm
- Bacteria size 500 nm
- Viruses size 20-90 nm

There are many different types of bacteria, viruses and protozoa but only a few are disease causing (pathogenic). Some are actually helpful

PROTOZOA

TOXOPLASMA
GIARDIA
CRYPTOSPORIDIUM

BACTERIA



E.COLI 0157
SALMONELLA
CAMPYLOBACTER

VIRUSES

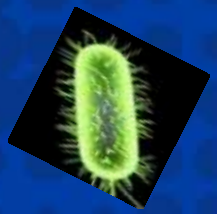
ROTAVIRUS
ADENOVIRUS
NOROVIRUS

Sizes of

PROTOZOA

8000 nm

BACTERIA



25x

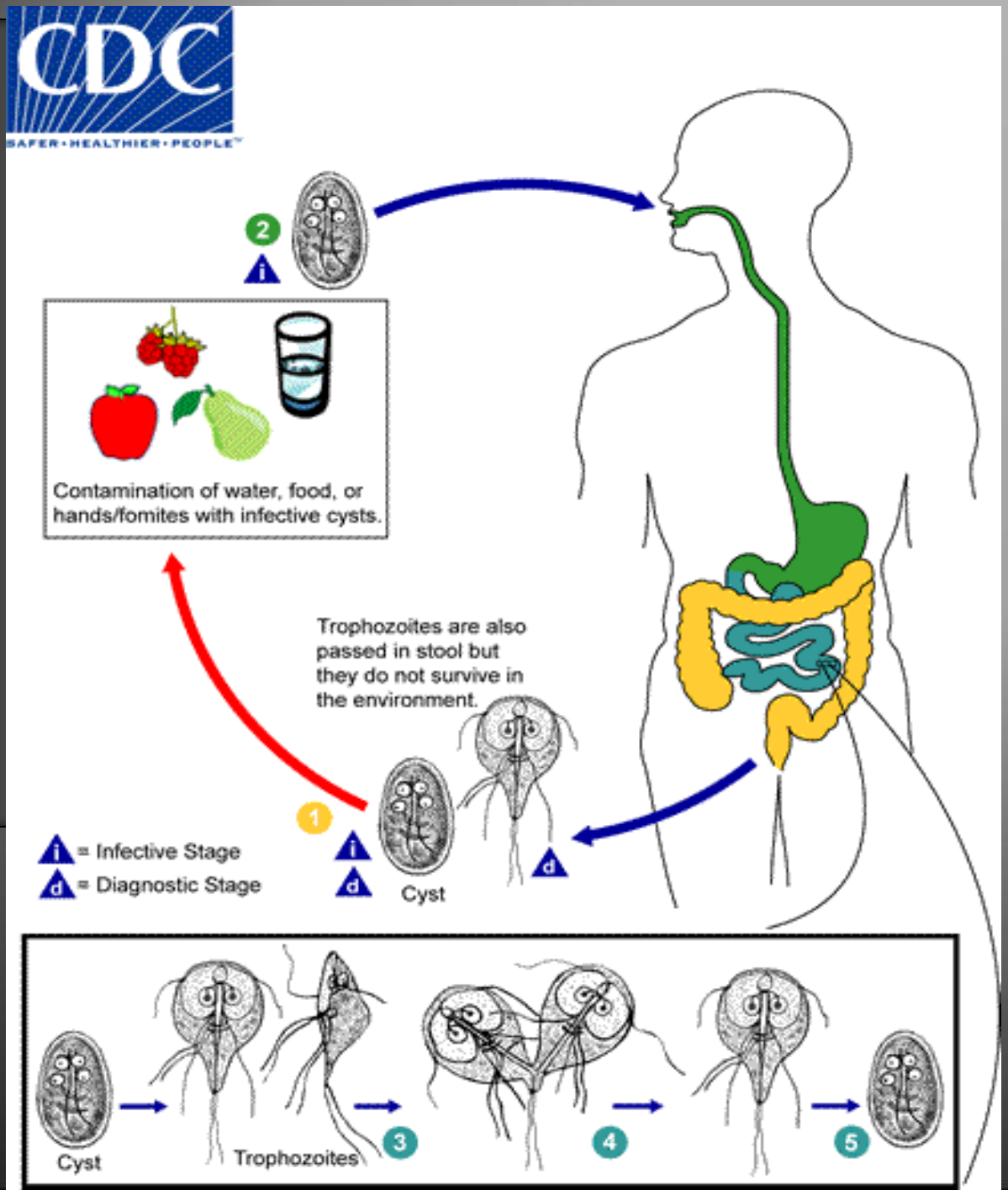
500 nm

VIRUSES

20 – 90 nm

Pathogenic Protozoa

- Giardia and Cryptosporidium
- Are single cell, 400X larger than viruses and 25X larger than bacteria
- Numbers to cause illness; as few as 10 cysts
- Multiply in the intestine of animals and humans
- Have a more complex reproduction cycle
- Conditions for reproduction do not exist in ground water or surface water
- In ground water, first pathogen to potentially be filtered by soil due to its size versus the size of soil pore spaces
- Cysts can survive in the environment for long periods of time.
- Not destroyed by chlorination


CDC
SAFER • HEALTHIER • PEOPLE™
2
i
Contamination of water, food, or hands/fomites with infective cysts.
Trophozoites are also passed in stool but they do not survive in the environment.
1
i
d
Cyst
i = Infective Stage
d = Diagnostic Stage
Cyst
Trophozoites
3
4
5

Pathogenic Bacteria

- Campylobacter, *E. coli* 0157, Salmonella
- Single cell , size 500 nm
- Multiply in the gut of animals and humans
- Doses to cause illness;
  - Salmonella 100 MO's 10%-20% 1,000,000 MO's 60%-80%
- Conditions for reproduction do not exist in ground water or surface water. They may survive for a while but will not multiple.
- Ground water and surface water are not primary reservoirs.
- Destroyed by chlorination and UV disinfection

Pathogenic Viruses

- Very very small , 20 nm – 70 nm
- Not even as large as a single cell
- They are not cellular microorganisms but rather DNA/RNA genetic material surrounded by a protein, lipid or glycoprotein coat
- Considered an obligate intracellular parasite
- Human to human transmission
- They must be inside a living cell to reproduce
- Numbers to cause illness; as low as 18 for Norovirus
- They do not replicate in ground water or surface water
- Because of their small size they can travel through soil pore spaces (silt 200 – 50,000 nm)
- Inactivated by chlorination and UV disinfection

Should We Test for Individual Pathogens

- Giardia $210 (analysis) + 100 litres + filter
- Salmonella $35
- Campylobacter $40
- Virus $1000

Cost prohibitive and time consuming and too specific

Yes, during an outbreak

Instead we use Indicator Organisms

Total coliform bacteria group

- Bacteria group (not virus or protozoan)
- Live in the environment (water and soil)
- Are not naturally present in deep ground water (filtered out of soil or naturally removed)
- Can reproduce in many places in the environment (primary reservoir)
- Easily destroyed by simple disinfection
- Fast and inexpensive test $25
- Presence in the drinking water source means? Well vs. surface water?
- Presence in the finished water supply means?

E. coli Bacteria Indicator Group

E. coli bacteria group

- Subset of the total coliform bacteria group
- Lives only in the intestinal tract of animals and humans (primary reservoir)
- Is an indicator of recent fecal contamination
- Does not survive long in the environment (secondary reservoir)
- Easily destroyed by chlorination and UV disinfection
- Fast and inexpensive test $25
- Its presence in the drinking water source means? Well vs. surface water?
- Its presence in the finished water supply means?

Pathogen Survivability

Microorganism	Freshwater	Ground Water
Viruses	11 days – 304 days	11 days – 1 year
Salmonella	1 day – 2 months	
Vibrio Cholera	5 days – 25 months	10 days – 35 days
Protozoan cysts	176 days, 18+ months	2 – 6 months
E. Coli indicator group	30 days, 90 days	40 days

What Other Indicators Could be Used as a Potential Sign of Trouble

- Chlorine demand and residual
- Temperature
- Turbidity
- Conductivity
- pH
- Treatment/Disinfection system performance
- TOC

Benefits of These Other Indicators

- Real time measurement
- No waiting for bacteria lab results
- Provides clues to other water quality issues not just microbiological concerns
- Inexpensive

Summary

- Total Coliform and *E. coli* are easily destroyed by simple disinfection
- Total coliform are abundant in the environment
- Total coliform are not an indicator of fecal contamination
- *E. coli* is from feces
- *E. coli* is an indicator that the water is contaminated by feces and that pathogens could be present
- *E. coil* does not persist long in the environment (water)
- *E. coli* and total coliform are bacteria….not viruses and not protozoa
- The total coliform and *E. coli* test is not a test for protozoa or viruses

Exercise

- Untreated Surface Water (lake)
- Dug Well 25 ft deep in an unconfined sand and gravel aquifer. Water table 10 ft below ground's surface
- Drilled well 135 feet deep into a confined aquifer. Water table 100 ft below ground's surface

For each of these water sources consider three different sample results.

Sample A) L1 total coliform and L1 *E. coli* per 100 ml

Sample B) est. 15 total coliform and L1 *E. coli per 100 ml*

Sample C) 53 total coliform and est. 12 *E. coli per 100 ml*

Note: L = less than and est. = estimated