

Drinking Water Disinfection

For Community Members

Water Supply Sources

- Surface Water:
 - Water that runs off surfaces and collects in lakes and ponds
 - Surface water withdrawn using intake
- Groundwater:
 - Precipitation or surface water that has filtered through the soil to underlying aquifers
 - Groundwater withdrawn using well and pump

Surface Water Quality

- Affected by:
 - Rainfall intensity and duration
 - Soil composition
 - Slope of ground
 - Vegetation on the ground
 - Human activities and structures (agriculture, cities, industry, dams, deforestation and recreation.

Sources of Contamination

- At the source of supply
- At the treatment plant
- In storage systems or reservoirs
- In distribution systems:
 - Bacterial re-growth is common in dead end water mains
 - High sediment accumulation breeds bacteria – flushing is required
- Cross connections:
 - Cross connection can be deadly
 - Important to have a CCC program in place
- Infiltration:
 - Negative pressure can draw contaminants into pipe through any leaks that may be present
- Water main breaks:
 - Keep positive pressure in main before repairs
 - Ensure contaminants do not enter water main

Disinfection

- Goal of water disinfection is to kill and/or inactivate waterborne microorganisms that can cause illness or death
- Typical waterborne microorganisms of concern include
 - Bacteria
 - Viruses
 - Protozoa
- Dedicated disinfection step is required to inactivate the microorganisms



E. coli

- *E. coli* used as definite indicator of recent faecal contamination of water
- Maximum Allowable Concentration (MAC) : none detectable/100 mL sample
- *E. coli* can cause gastrointestinal issues such as vomiting, diarrhea – some can be life threatening
- Walkerton, Ont., 2000 - 2300 people fell ill, 7 died due to *E. coli* and *Campylobacter* contamination

Protozoa

- Some protozoa are pathogenic, can live in the gut of animals or humans
- Can enter drinking water through direct or indirect contamination with animal or human faeces
- *Giardia* and *Cryptosporidium* are protozoans that are most often associated with drinking water contamination and water borne illness
- The absence of *E. coli* in a sample does not necessarily mean that pathogenic protozoans are not present

Giardia and Cryptosporidium

- *Giardia* – Also known as “Beaver Fever”
 - *Giardia* causes the illness giardiasis; the illness is also known as beaver fever
 - Can result from contamination from beaver, muskrat or cattle faeces
 - Causes gastrointestinal symptoms such as diarrhea, vomiting, weight loss etc.
- *Cryptosporidium*
 - *Cryptosporidium* causes the illness cryptosporidiosis
 - Commonly caused by direct or indirect contamination with livestock
 - Causes gastrointestinal symptoms such as diarrhea, vomiting, weight loss etc.

Viruses

- Main form of contamination is through human faeces. Can be from sewage plant effluents, septic tank leakages, etc.
- Viruses common for water borne illness include Enterovirus, Norovirus and Rotavirus
- Symptoms from consuming contaminated water can include diarrhea, vomiting, dehydration, fever, headaches

Boil Water Advisories

- Boil Water Advisories (BWA) are put in place when there is a risk of or known contamination of the drinking water supply
- Typically are put in place when there are known issues with the disinfection system such as
 - Not enough disinfectant in the system
 - Mechanical failure
 - Changes in incoming water quality due to weather
 - Disturbance in distribution system

Boil Water Advisories

- Water for the following activities must be boiled:
 - Drinking
 - Preparing infant formula
 - Preparing juice and ice cubes
 - Washing fruits and vegetables
 - Cooking
 - Dental Hygiene
- Cold water taps should be used; do not consume water from hot water taps
- Consumers should hold water at a rolling boil for at least one minute
- Water can be boiled in a pot or kettle on a stove

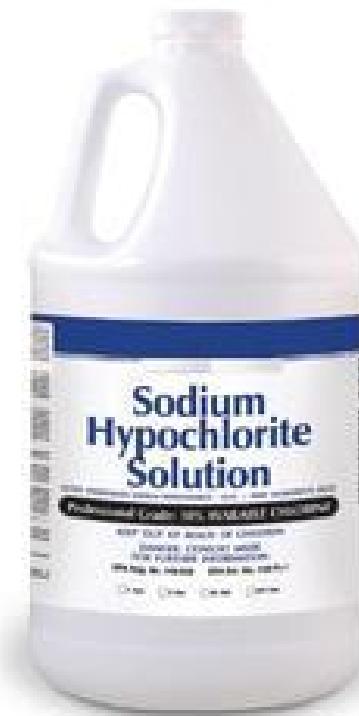
Primary vs Secondary Disinfection

- Primary disinfection is the removal, inactivation or destruction of pathogenic organisms.
- Newfoundland and Labrador requires $CT = 6 \text{ mg/L}$ for primary disinfection
- Secondary disinfection is the maintenance of a disinfectant residual within the distribution system to prevent bacterial regrowth
- Newfoundland and Labrador requires a detectable free chlorine residual throughout the distribution system
- Typically primary and secondary disinfection are performed in one step



Common Disinfectant Chemicals

- Chlorine is the most common chemical used for disinfection of drinking water
- Maintains residual in distribution system to prevent biological regrowth
- Readily available
- Relatively inexpensive
- Typically added using:
 - Sodium hypochlorite (liquid)
 - Calcium hypochlorite (powder)
 - Chlorine gas
- All chemicals used in drinking water treatment must be NSF 60 Certified

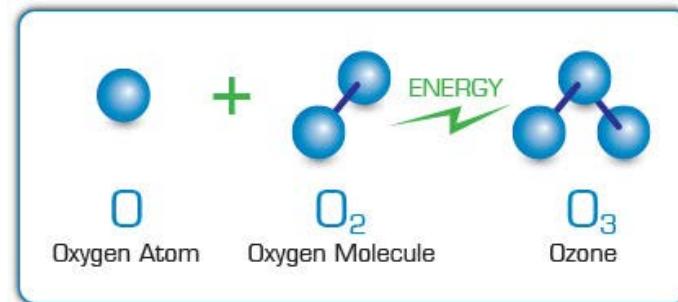
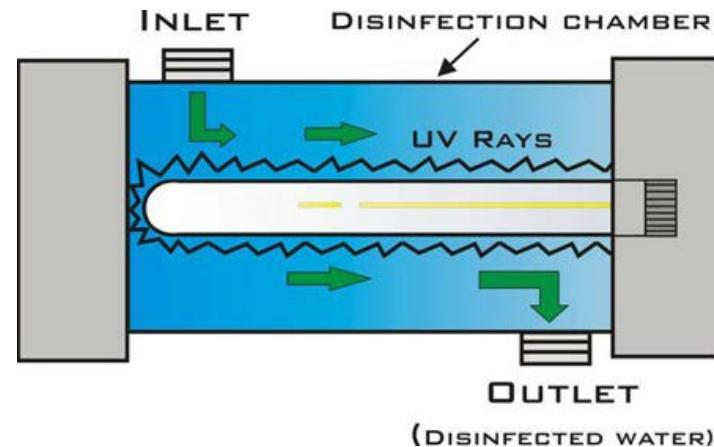


The Chemistry of Chlorination

- $\text{Cl}_2 + \text{H}_2\text{O} \longrightarrow \text{HOCl} + \text{HCl}$
(Hypochlorous Acid) + (Hydrochloric Acid)
- Dissociation
 $\text{HOCl} \longleftrightarrow \text{H}^+ + \text{OCl}^-$
(Hypochlorite Ion)
- Balance of HOCl to OCl⁻ dependant on pH

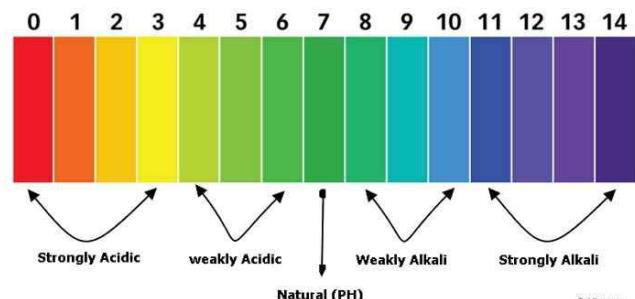
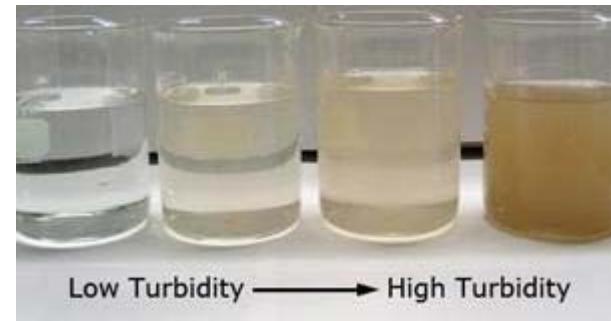
Alternative Disinfectants

- Other forms of disinfection can be used:
- Primary Disinfection:
 - Ozone
 - Ultraviolet (UV)
 - Chlorine Dioxide
- Secondary Disinfection
 - Chloramines



Factors Impacting Chlorination

- pH
 - Ideal pH for chlorination is less than 7.0
- Temperature
 - Lower temperatures slow chlorine activity
- Turbidity
 - Can hide pathogens from disinfectant contact
- Concentration
 - Higher dose increases chlorine in system
- Chlorine demand
 - Organic matter, iron, manganese etc. can consume chlorine



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Disinfection By-Products

- Disinfection By-Products (DBPs) are formed through reactions between a disinfectant and compounds in the water
- Two most common groups
- THMs- maximum allowable concentration (MAC) in drinking water of 0.10 mg/L
- HAAs- MAC = 0.08mg/L
- Can be controlled by reducing organic concentrations in the water before disinfection



Questions

