

# 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  - Surface water withdrawn using intake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  - Groundwater withdrawn using well and pump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

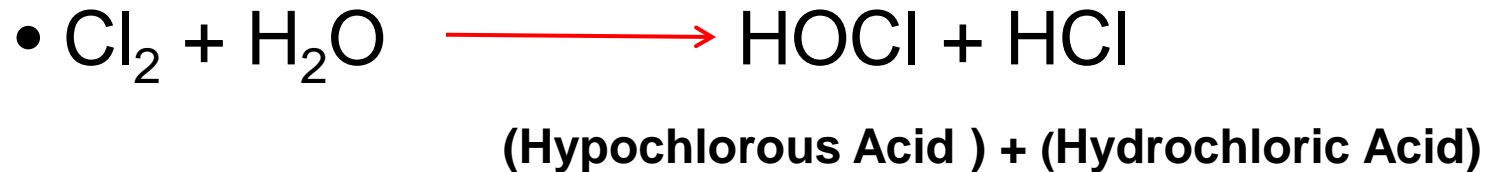
---

- 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

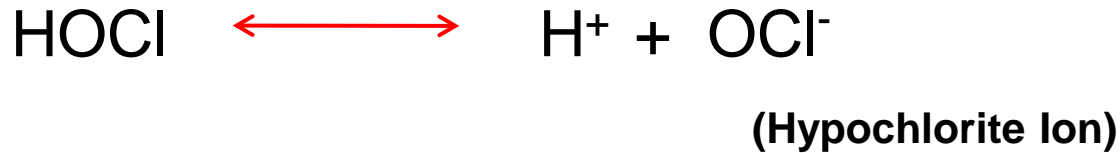


# The Chemistry of Chlorination

---



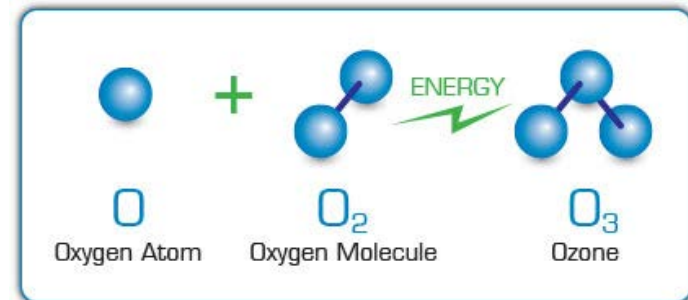
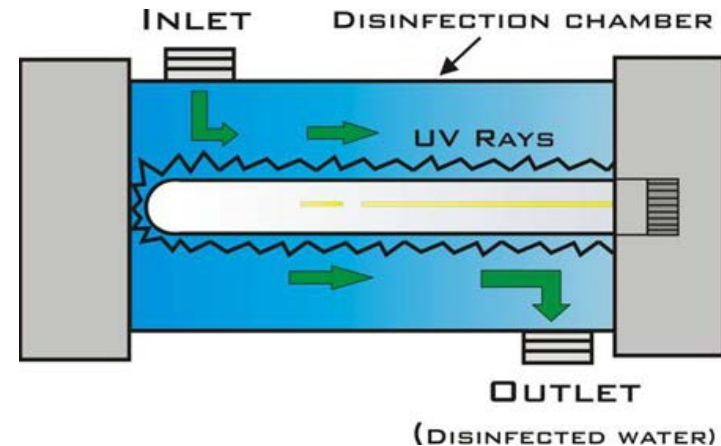
- Dissociation



- Balance of HOCl to  $\text{OCl}^-$  dependant on pH

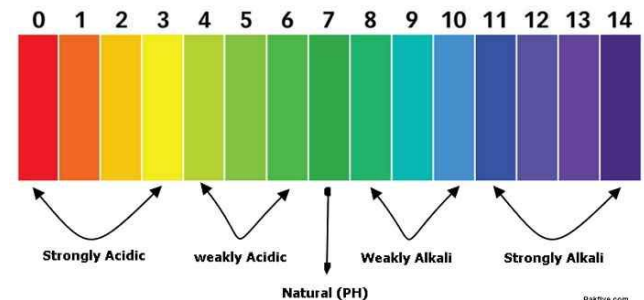
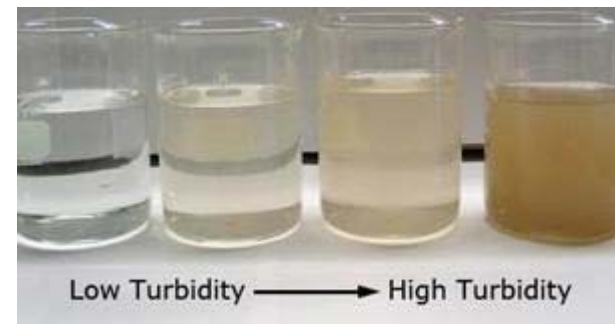
# Alternative Disinfectants

- 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



# 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

---

