WATER TREATMENT

Everett Windover

Culligan Water Technologies

Colchester, VT

E.coli / Total Coliform

Total Coliform

Total coliforms are a group of bacteria commonly found in the environment

- Soil
- Vegetation
- Intestines of Mammals, including Humans

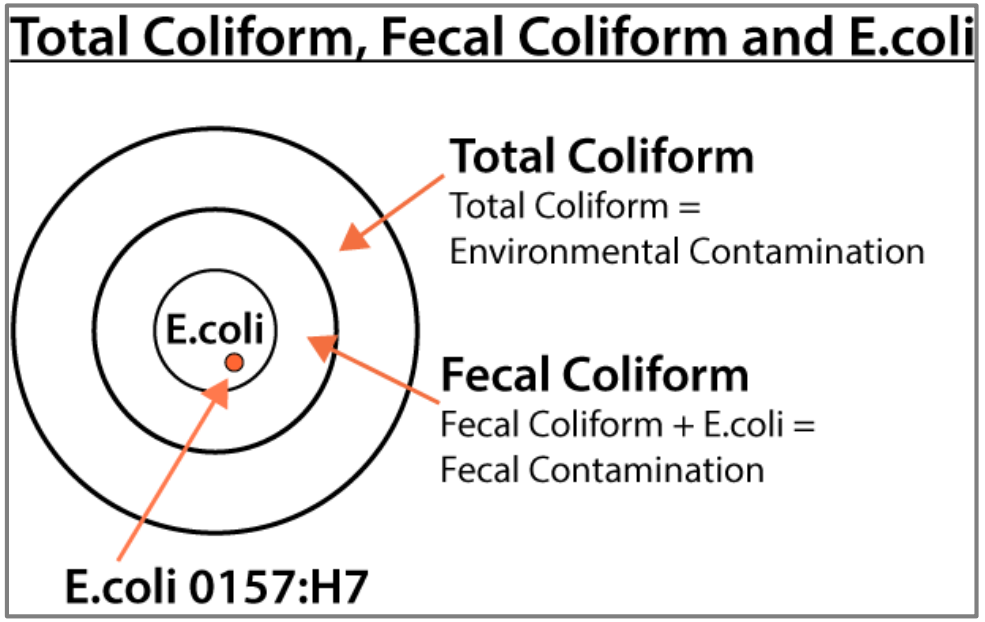
Total coliform bacteria are not likely to cause illness, but their presence indicates that your water supply may be vulnerable to contamination by more harmful microorganisms.

E. Coli Escherichia

- Escherichia coli (E.coli) is the only member of the total coliform group of bacteria that is found only in the intestines of mammals, including humans.

- The presence of E.coli in water indicates recent fecal contamination and may indicate the possible presence of disease-causing pathogens, such as bacteria, viruses, and parasites.

- Although most strains of E.coli bacteria are harmless, certain strains, such as E.coli 0157:H7, may cause illness.



Health Risk

- In water, coliform bacteria have no taste, smell, or color.
- They can only be detected through a laboratory test.
- The MCL Guideline for total coliform is none detectable per 100 m/l.
- The MCL Drinking Water Quality Guideline for Escherichia coli (E.coli) is none detectable per 100 m/l.
- Maximum Acceptable Concentration for Drinking Water = none detectable per 100 m/l
  - This means that in order to conform to the guideline: For every 100 m/l of drinking water tested, no total coliform or E.coli should be detected.

Ultraviolet (UV) Light

- The UV disinfection method, which does not involve chemicals, has long been popular for commercial use, but is becoming more common in homes.
- UV systems expose water to light at just the right wavelength for killing microbes. It's a way to kill bacteria, viruses, fungi, protozoans, and cysts that may be present in the water.
- The effectiveness of UV treatment depends on the strength and intensity of the light, the amount of time the light shines through the water, and the quantity of particles present in the water.
- The light source must be kept clean and the UV lamp replaced periodically.
- UV light treatment can't remove gases, heavy metals, and particulates; for that reason higher-end systems may include additional filtration such as activated carbon or other filtration methods.

Chlorination

- The treatment process in which chlorine gas or a chlorine solution is added to water for disinfection and control of microorganisms.

- Chlorination is also used in the oxidation of dissolved iron, manganese, and hydrogen sulfide impurities. This method of disinfection involves adding chlorine to water to make it safer to drink. It's common, cost-effective, and quick, killing many pathogenic microorganisms. It can even oxidize or break down iron, manganese, and hydrogen sulfide, which can result in water that is clearer and tastes better.

- Some people find that chlorine gives water its own objectionable chemical taste and odor. It also can produce disinfection byproducts (which may cause health issues) by reacting with other substances in water when stored. These byproducts can often be filtered out with activated carbon.

Lead

Lead in Drinking Water

- Lead has a tendency to be complexed and precipitated by a large number of substances.
- Studies indicate that nearly all the lead in users' tap water does not come from the primary water source or from the municipal treatment plant, but as a result of corrosion that occurs after the water leaves the treatment facility.
- Lead can enter the home drinking water by leaching from service connections, solder used in copper piping and from brass fixtures.

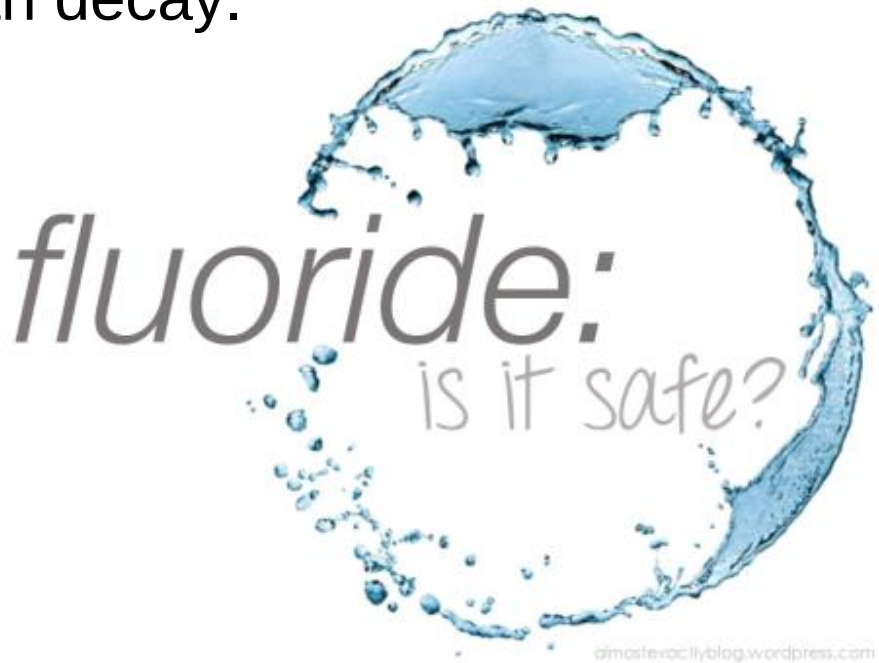
Sources & Treatment of Lead

Contaminant	In Water As	Action Level
Lead (Pb)	$Pb(OH)_2$, $PbCO_3$, and Pb_2O	**US EPA:** Action Level* = 0.015 mg/L MCGL** = 0.00 mg/L (or ppm) **WHO_+ Guideline** = 0.01 mg/L
Sources of Contaminant	•Mostly lead service lines, lead containing solder, and brass fittings of different types •Industrial processes, mines, and smelting (not a direct source into water)	
Potential Health Effects	•Children are more at risk than adults •Reduced intelligence, impaired hearing and decreased growth in children •Damage to the brain, kidneys, and bone marrow •Damage nervous system and red blood cells	
Treatment Methods **Point-of-Entry (POE)** **Point-of-Use (POU)**	•Reverse Osmosis •Solid Block and Precoat Adsorption Filters (properly designed submicron filtration and absorption adsorption media) •Strong Acid Cation Exchange (Na^+ Form) •Distillation	

Fluoride

Fluoride In Drinking Water

- Fluorine is a natural trace element and exists in almost all soils.
- Fluoride is classified as any binary compound of fluorine with another element. Perhaps the most widely known use of fluoride is its addition to public drinking water supplies at about one milligram per liter (mg/L) of a fluoride salt, measured as fluoride, for the purpose of reducing tooth decay.



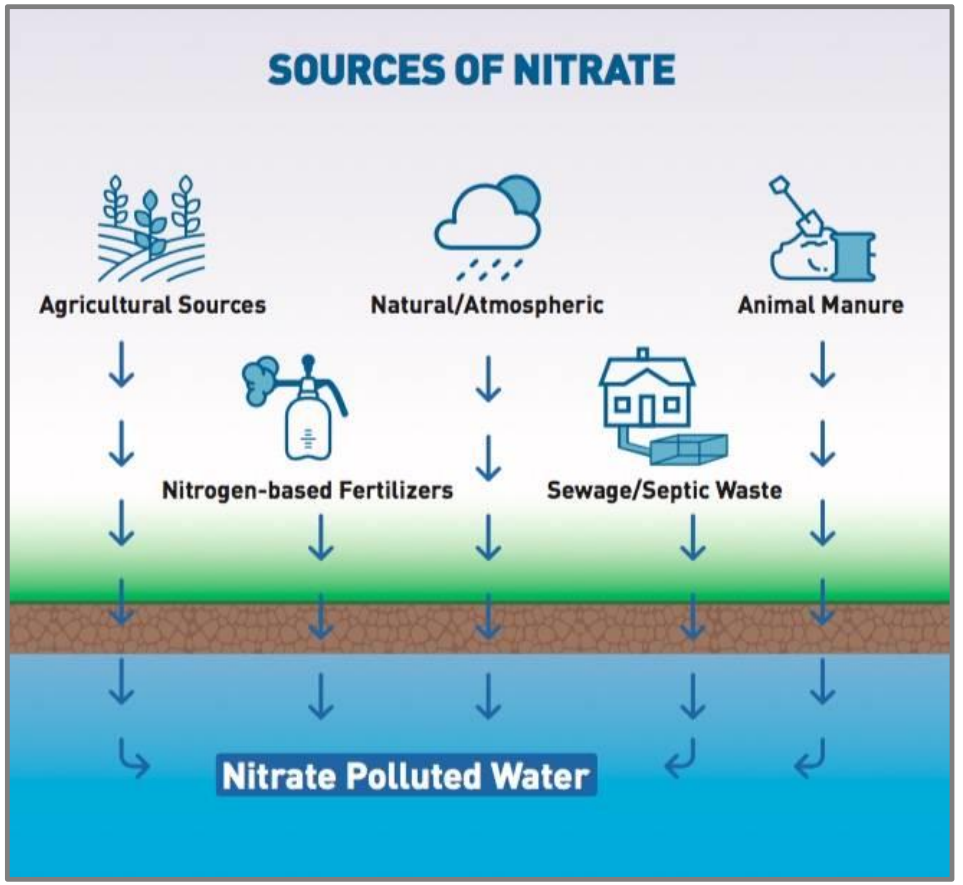
Fluoride In Drinking Water

Contaminant	In Water As	Maximum Contaminant Level
Fluoride (F)	Fluoride, F^-	US EPA: MCL* = 4.0 mg/L or ppm Secondary Standard** = 2.0 mg/L or ppm WHO† Guideline = 1.5 mg/L
Sources of Contaminant	Natural deposits Municipally treated drinking water (>2 mg/L, potentially as a result of poorly monitored or malfunctioning feeding equipment)	
Potential Health Effects	Skeletal fluorosis, from long-term consumption >4 mg/L (a serious bone disorder resembling osteoporosis and characterized by extreme density and hardness and abnormal fragility of the bones)	
Potential Aesthetic Effects	Mottling (discoloration) of teeth in children under 9 years of age (from long-term consumption at >2 mg/L) Disfiguration/pitting of teeth in children	
Treatment Methods Point-of-Entry (POE) Point-of-Use (POU)	Reverse osmosis Strong base anion exchange (Cl^- form) Activated alumina adsorption media Distillation	

Nitrates

Nitrates in Drinking Water

- The principle sources of nitrate contamination in water are through fertilizers, animal waste and septic tanks.
- The water supplies most vulnerable to nitrate contamination are in agricultural areas and in well waters having a close or hydraulic relationship to septic tanks.
- Nitrate in drinking water can be responsible for a temporary blood disorder in infants called methemoglobinemia (blue baby syndrome).



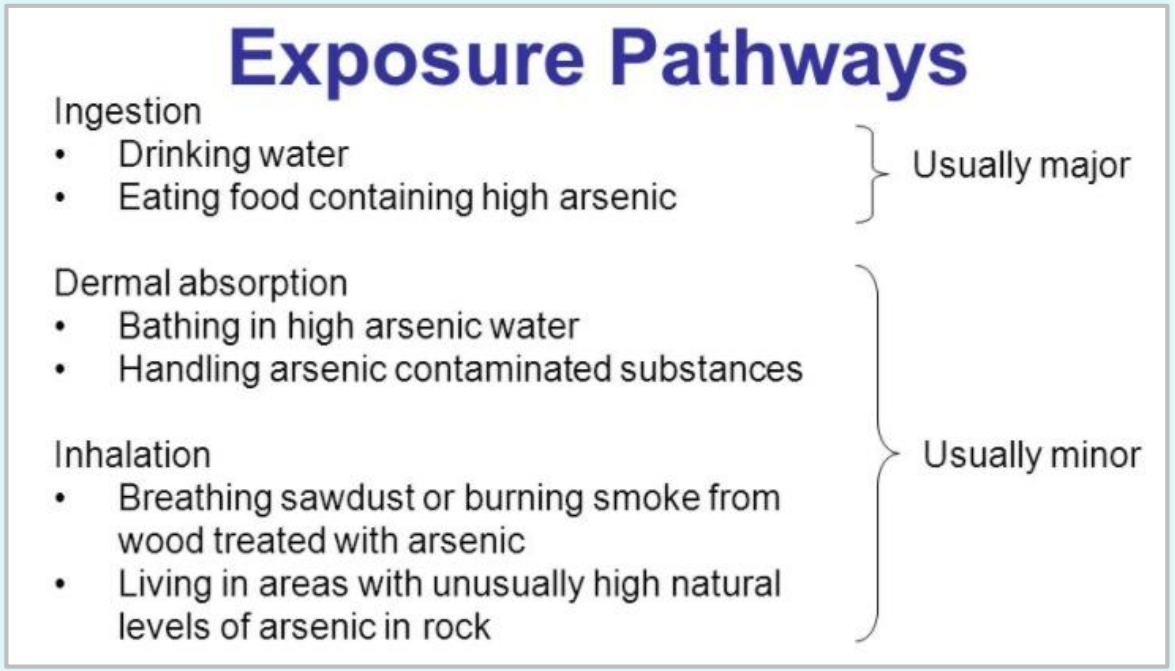
Nitrates & Nitrites in Drinking Water

Contaminant	In Water As	Maximum Contaminant Level
Nitrate	No_3^{-1}	US EPA: MCL* = 10.0 mg/L (as N) MCLG** (goal) = 10.0 mg/L (as N) Health Canada MAC** = 10 mg/L (as N) WHO† Guideline: 11.3 mg/L (as N) 50 mg/L (as NO3-1)
Nitrite	No_2^{-1}	**US EPA:** MCL*= 1.0 mg/L (as N) MCLG** (goal) = 1.0 mg/L (as N) **Health Canada** MAC*** = 1 mg/L (as N) **WHO† Guideline** = 1 mg/L (as N)
Sources of Contaminant	•Human sewage and livestock manure •Fertilizers •Erosion of natural deposits	
Potential Health Effects	•Methemoglobinemia (blue baby syndrome) •Most potential health effects are seen in infants under the age of 6 months	
Treatment Methods **Point-of-Entry (POE)** **Point-of-Use (POU)**	•Reverse Osmosis with thin film composite membrane •Anion Exchange (Type I and II, Cl^- form, subject to competing sulfates) •Nitrate "Selective" Anion Exchange resins •Distillation •Electrodialysis	

Arsenic

Arsenic Background

- Naturally occurring throughout US & Southern Canada
- Exists as either Arsenic +3 or Arsenic +5
  - Oxidize arsenic 3 to arsenic 5
- Arsenic 5 easier to remove, Arsenic 3 more active For total arsenic, 10 ppb (Federal)
  - No limit for individual species



Arsenic

Health Effects:

- Skin
- Immune system
- Nervous system
- Respiratory system
- Cardiovascular health
- Endocrine system
- Liver, kidney, bladder & prostate

Uranium

Uranium in Drinking Water

- Uranium is a common naturally occurring and radioactive substance.
- It is a normal part of rocks, soil, air and water. Uranium occurs in nature in the form of minerals, but never as a metal.
- Uranium enters water by leaching from soil and rocks, or in releases from processing plants.
- Uranium has demonstrated toxic effects on human kidneys leading to their inflammation and changes in urine composition.
- Uranium can decay into other radioactive substances, such as radium, which can cause cancer with extensive exposure over a long period of time (U.S. EPA, 2013).

Uranium in Drinking Water

Contaminant	In Water As	Maximum Contaminant Level
Uranium (U)	$UO_2(CO_3)_2^{-2}$ $UO_2(CO_3)_3^{-4}$	**US EPA:** MCL* = 0.030 mg/L (or ppm) MCLG** = zero mg/L (or ppm) **WHO† Guideline** = 0.030 mg/L
Sources of Contaminant	Naturally occurring mineral	
Potential Health Effects	Kidney toxicity Increased risk of cancer	
Treatment Methods **Point-of-Entry (POE)** **Point-of-Use (POU)**	Strong Base Anion Exchange Resins (Cl^- form) Reverse Osmosis Distillation	

Radium

Radium in Drinking Water

- Radium is formed when uranium and thorium undergo radioactive decay in the environment.
- Two of the main radium isotopes found in the environment are radium-226 and radium-228.
- Radium emits energy in the form of alpha particles and gamma rays, and will also decay to form radon.
- Radium in drinking water is of primary concern because this radiation may cause cancer, kidney damage and birth defects.
- The decay of radium into radon presents another contaminant of health concern in drinking water as well as in the air.

Radium

Contaminant	In Water As	Maximum Contaminant Level
Radium (Ra)	Ra^{2+}	US EPA (Radium 226 and 228 combined): MCL* = 5.0 pCi/L MCLG** = zero pCi/L WHO† Guideline: Radium 226 = 1 Bq/l Radium 228 = 0.1 Bq/l Health Canada (Radium 226 only): MAC*** = 0.5 Bq/L (13.5 pCi/L)
Sources of Contaminant	Radioactive decay of uranium and thorium in rocks and soil	
Potential Health Effects	Increased risk of cancer	
Treatment Methods	Cation Exchange Softening Reverse Osmosis Distillation Lime Softening	

Manganese

Manganese in Drinking Water

- Manganese is a metal found in some rocks and soils in Vermont and may get into groundwater.
- It can get into your drinking water if your well is drilled into or near bedrock containing manganese.
- Levels of manganese in drinking water are regulated by the Environmental Protection Agency (EPA) and the State of Vermont.
- The Health Department has set an advisory level for manganese at the EPA's lifetime health advisory of **0.300 mg/L (milligrams per liter)** to protect the nervous system.

Treatment Options

- **Specialty Filters**
  Manganese is removed as the water flows through the filter.
- **Oxidation Filtration**
  This treatment that uses chlorine, air, or peroxide followed by a filter.
- **Cation Exchange Treatment**
  A conventional water softener (also called a cation exchange softener) exchanges manganese for sodium or potassium, which remains in the water. The manganese is flushed away with the wastewater when the softener is regenerated. This type of treatment is typically installed as a whole house system (point-of-entry).

Iron

Iron in Drinking Water

- Iron can be a troublesome chemical in water supplies. Making up at least 5 percent of the earth's crust, iron is one of the earth's most plentiful resources.

- Iron is mainly present in water in two forms: either the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish brown substance begins to form. This sediment is the oxidized or ferric form of iron that will not dissolve in water.

- What other issues having Iron present in your water supply cause.

- Complicates the treatment of Arsenic, Uranium, Radium.

Iron in Drinking Water

Symptoms	Form of Iron	Treatment Methods	Considerations
Tap water is first clear and colorless. After standing, reddish brown particles appear and settle to bottom of glass.	Dissolved ferrous iron	Aeration/Filtration	Temperature dependent
		Water softener	Hardness must be calculated.
		Chlorination/Filtration	Use of chlorine liquid or pellets. Requires frequent monitoring and proper water pressure. May require lengthy contact time.
		Manganese Greensand/Filtration [1]	Adequate pressure
		Catalytic filtration[2]	Dissolved oxygen, alkalinity, organic matter, chlorination, polyphosphate, and temperature limitations
		Ozonation	Cost
		Sequestering (adding chemical agents to water to keep iron to an insoluble, filterable form)	Method may not prevent staining and may require removal of sequestering agents and iron. Test for agents before choosing another treatment device.

pH

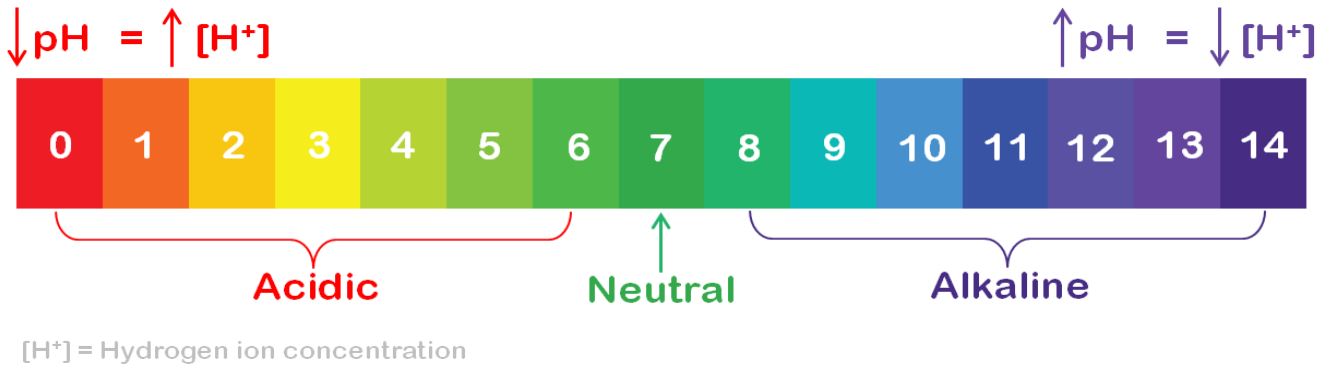
pH and Water

- pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic.

Importance of pH

- The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.).

How Does pH effect Water Quality



[H⁺] = Hydrogen ion concentration

THANK YOU!