Drinking Water Pathogens

Drinking water pathogens may be divided into three general categories: bacteria, viruses and parasitic protozoa. Bacteria and viruses contaminate both surface and groundwater, whereas parasitic protozoa appear predominantly in surface water. The purpose of disinfection is to kill or inactivate microorganisms so that they cannot reproduce and infect human hosts. Bacteria and viruses are well-controlled by normal chlorination, in contrast to parasitic protozoa, which demand more sophisticated control measures. For that reason, parasitic protozoan infections may be more common than bacterial or viral infections in areas where some degree of disinfection is achieved.

<table>
<thead>
<tr>
<th>#</th>
<th>Pathogen</th>
<th>#</th>
<th>Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Escherichia coli</td>
<td>9</td>
<td>Norwalk Virus</td>
</tr>
<tr>
<td>2</td>
<td>Enterococci</td>
<td>10</td>
<td>Rotavirus</td>
</tr>
<tr>
<td>3</td>
<td>Fecal coliforms</td>
<td>11</td>
<td>Microsporidia</td>
</tr>
<tr>
<td>4</td>
<td>Bacteroides</td>
<td>12</td>
<td>Giardia Lamblia</td>
</tr>
<tr>
<td>5</td>
<td>Salmonella</td>
<td>13</td>
<td>Cryptosporidium</td>
</tr>
<tr>
<td>6</td>
<td>Clostridium</td>
<td>14</td>
<td>Helicobacter pylori</td>
</tr>
<tr>
<td>7</td>
<td>enteroviruses</td>
<td>14</td>
<td>Campylobacter jejuni</td>
</tr>
<tr>
<td>8</td>
<td>Hepatitis</td>
<td>16</td>
<td>Shigella</td>
</tr>
</tbody>
</table>

Bacteria

Bacteria are microorganisms often composed of single cells shaped like rods, spheres or spiral structures. Prior to widespread chlorination of drinking water, bacteria like Vibrio cholerae, Salmonella typhi and several species of Shigella routinely inflicted serious diseases such as cholera, typhoid fever and bacillary dysentery, respectively. As recently as 2000, a drinking water outbreak of E. coli in Walkerton, Ontario sickened 2,300 residents and killed seven when operators failed to properly disinfect the municipal water supply. While developed nations have largely conquered waterborne bacterial pathogens through the use of chlorine and other disinfectants, the developing world still grapples with these public health enemies.

Several bacterial species (E. coli, Enterococci, fecal coliforms, the Bacteroides-Prevotella group, Salmonella, Clostridium) and viral species (coliphage, Enterovirus, Hepatitis, Norwalk, Rotavirus) have been studied to determine their suitability as indicator organisms of ambient water quality.

Escherichia coli is a bacterium that is commonly found in the lower intestine of warm-blooded animals. Most E. coli strains are harmless, but some, such as serotype O157:H7, can cause serious food poisoning in humans, and are occasionally responsible for costly product recalls. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K2, or by preventing the establishment of pathogenic bacteria within the intestine.
Enterococci are Gram-positive cocci which often occur in pairs (diplococci) and are difficult to distinguish from Streptococci on physical characteristics alone. Two species are common commensal organisms in the intestines of humans: E. faecalis (90-95%) and E. faecium (5-10%). Enterococci are facultative anaerobic organisms, i.e. they prefer the use of oxygen, but they can survive in the absence of oxygen. They typically exhibit gamma-hemolysis on sheep’s blood agar. Important clinical infections caused by Enterococcus include urinary tract infections, bacteremia, bacterial endocarditis, diverticulitis, and meningitis.

Fecal coliforms are facultatively-anaerobic, rod-shaped, gram-negative, non-sporulating bacteria. They are capable of growth in the presence of bile salts or similar surface agents, oxidase negative, and produce acid and gas from lactose within 48 hours at 44 ± 0.5°C. The fecal coliform assay should only be used to assess the presence of fecal matter in situations where fecal coliforms of non-fecal origin are not commonly encountered. Fecal coliforms include the genera that originate in feces; Escherichia as well as genera that are not of fecal origin; Enterobacter, Klebsiella, and Citrobacter. The assay is intended to be an indicator of fecal contamination, or more specifically E. coli which is an indicator microorganism for other pathogens that may be present in feces. In general, increased levels of fecal coliforms provide a warning of failure in water treatment, a break in the integrity of the distribution system, or possible contamination with pathogens. When levels are high there may be an elevated risk of waterborne gastroenteritis.

Bacteroides is a genus of Gram-negative, rod-shaped bacteria. Bacteroides species are non-endospore-forming, anaerobes, and may be either motile or non-motile, depending on the species. Bacteroides are normally commensal, making up the most substantial portion of the mammalian gastrointestinal flora, where they play a fundamental role in processing of complex molecules to simpler ones in the host intestine. The family Prevotella is composed of a single genus of environmental bacteria.
**Salmonella** is a genus of rod-shaped Gram-negative enterobacteria that causes typhoid fever, paratyphoid fever, and foodborne illness. Salmonella species are motile and produce hydrogen sulfide.

**Clostridium** is a genus of Gram-positive bacteria, belonging to the Firmicutes. They are obligate anaerobes capable of producing endospores. Individual cells are rod-shaped, which gives them their name, from the Greek kloster or spindle. Clostridium includes common free-living bacteria as well as important pathogens. There are four main species responsible for disease in humans:

*Clostridium botulinum*, an organism producing a toxin in food/wound that causes botulism.

*Clostridium difficile*, which can overgrow other bacteria in the gut during antibiotic therapy, can cause pseudomembranous colitis.

*Clostridium perfringens*, causes a wide range of symptoms, from food poisoning to gas gangrene.

*Clostridium tetani*, the causative organism of tetanus (lockjaw).

**Viruses**

Viruses are infectious agents that can reproduce only within living host cells. Shaped like rods, spheres or filaments, viruses are so small that they pass through filters that retain bacteria. Enteric viruses, such as hepatitis A, Norwalk virus and rotavirus are excreted in the feces of infected individuals and may contaminate water intended for drinking. Enteric viruses infect the gastrointestinal or respiratory tracts, and are capable of causing a wide range of illness, including diarrhea, fever, hepatitis, paralysis, meningitis and heart disease (American Water Works Association, 1999).

A *coliphage* is a type of bacteriophage that infects Escherichia coli. Examples include Bacteriophage lambda and Leviviridae.

The enteroviruses are a genus of (+)ssRNA viruses associated with several human and mammalian diseases. Historically the most significant has been the Poliovirus (which is now nearly extinct). Enterovirus are the most common cause of aseptic meningitis and can cause serious disease especially in infants and the immunocompressed.
**Hepatitis** (plural hepatitides) implies injury to liver characterised by presence of inflammatory cells in the liver tissue. Etymologically from ancient Greek hepar or hepato meaning 'liver' and suffix -itis denoting 'inflammation'. The condition can be self limiting, healing on its own or can progress to scarring of the liver. Hepatitis is acute when it lasts less than 6 months and chronic when it persists longer. A group of viruses known as the hepatitis viruses cause most cases of liver damage worldwide. Hepatitis can also be due to toxins (notably alcohol), other infections or from autoimmune process. The patient becomes unwell and symptomatic when the disease impairs liver functions that include, among other things, screening of harmful substances, regulation of blood composition, and production of bile to help digestion.

**Norwalk Virus**, or Norovirus, an RNA virus of the Caliciviridae taxonomic family, causes approximately 90% of epidemic non-bacterial outbreaks of gastroenteritis around the world, and is responsible for 50% of all foodborne outbreaks of gastroenteritis in the US. Norovirus affects people of all ages. The viruses are transmitted by faecally contaminated food or water and by person-to-person contact.

**Rotavirus**, the leading cause of severe diarrhea among infants and young children, is a genus of double-stranded RNA virus in the taxonomic family Reoviridae. By the age of five, nearly every child in the world has been infected with rotavirus at least once.[1] With each infection, immunity develops and subsequent infections are less severe. Rotavirus infects cells that line the small intestine, and produces an enterotoxin. The toxin causes gastroenteritis with severe diarrhoea and potentially fatal dehydration. Large quantities of rotavirus are excreted by infected people, and the infection is spread by the fecal–oral route.

**Protozoan Parasites**
Protozoan parasites are single-celled microorganisms that feed on bacteria found in multicellular organisms, such as animals and humans. Several species of protozoan parasites are transmitted through water in dormant, resistant forms, known as cysts and oocysts. According to the World Health Organization, Cryptosporidium parvum oocysts and Giardia lamblia cysts are introduced to waters all over the world by fecal pollution. The same durable form that permits them to persist in surface waters makes
these microorganisms resistant to normal drinking water chlorination (WHO, 2002). Water systems that filter raw water may successfully remove protozoan parasites.

**Microsporidia** are protozoan parasites that infect animals, fish, insects and humans around the world, causing a wide variety of infections in the respiratory, urinary and gastrointestinal tracts. The bacteria-sized microsporidia are difficult to detect. In those with normal immune systems, microsporidia usually cause milder illnesses, such as traveler’s diarrhea, although corneal infections and other conditions are possible.

These parasites Giardia Lamblia (blue-green round) and Cryptosporidium (brown with spikes) are as mean and nasty as they look. Both are very common in the natural environment, are found in every region of the United States, and can be extremely contagious. They live in the intestines of infected humans or animals, water from swimming pools, hot tubs, jacuzzis, fountains, lakes, rivers, ponds, streams, and springs that are contaminated with fecal matter. Fever, nausea, vomiting, stomach cramps, diarrhea, are some of the symptoms of an infection. Some people show little or no symptoms. These cysts are considered by the Center for Disease Control to be one of the most common causes of waterborne disease in the United States. In other words, these bugs are nothing to play with, and if you feel you are infected, get medical attention as quickly as possible. Although boiling water for at least one minute will kill these microorganisms, they are highly resistant to disinfection methods like chlorination, ultraviolet light, but can be removed by a filtration system with special filters that have a rating of (< 1) less than one micron.
Until Helicobacter pylori (H. pylori) were discovered in 1982, it was thought that most stomach and duodenal ulcers were caused by hot spicy food, excess stomach acid, stress, or unhealthy lifestyles. Now it is widely understood that 80%-90% of people with chronic active and persistent stomach ulcers have an infection from this microorganism. If left untreated, infected persons have an increased chance of 2 to 6 fold of developing gastric cancer or mucosal-associated-lymphoid-type (MALT) lymphoma. Several tests have been developed to diagnose this infection, and treatment with common antibiotics like amoxicillin and tetracycline are used to eradicate this organism. Since the discovery of H. pylori, well water systems around the country have tested positive for this bacteria. It is also possible to get this infection from fecal to oral and oral to oral routes. Water testing for this is available – but it is quite expensive. Ultraviolet light disinfection and chlorination are among recommended treatment methods.

If you have ever gone to Mexico and heard people say “whatever you do, don’t drink the water—you’ll get Montezuma’s Revenge!”, these bacteria Campylobacter jejuni (stained red) and Shigella (stained green) are the microscopic problem you are trying to avoid. Unlike some other bacteria to which American’s have some resistance, these are almost never found in our water supply. Subsequently, vacationers can ingest these bugs and ruin their stay – but other than a bad upset stomach for a few days – it’s rarely more than that.