

## A Teachers Guide to Water Quality

Please note that underlined words are included within the glossary

### What is water?



- Water is an essential component of life. Life could not exist without water.
- Water is a molecule composed of two hydrogen atoms and one oxygen atom. It is also written in chemical form as “H<sub>2</sub>O.”
- Water is a unique substance in that it has the ability to form weak bonds, known as hydrogen bonds, between separate molecules. The ability to form these weak bonds gives water unique chemical and physical properties. For example, the solid form of water (ice) floats within liquid water. In general, the solids of most other molecules would sink within the corresponding liquid. The reason that ice floats in water is because of the hydrogen bonds.
- Another unique feature of water is that it is commonly found in its liquid, solid, or gaseous form within the environment.

### What are the sources of water?

- Water is found in rivers, in the oceans, as vapor in the atmosphere, and frozen within glaciers. Water is even found underground. In Florida for example, the primary source of drinking water is ground water that is pumped from underwater aquifers.
- There are two primary categories of water: fresh water and salt water. Examples of freshwater sources include most ground waters and rivers. A typical example of salt water is seawater. Humans consume fresh water. Salt water can be converted to fresh water through evaporation or specialized filtration processes, but these processes are very expensive to include in a water treatment plant.
- Water will naturally cycle between different reservoirs through the hydrologic cycle. Sea water will be heated by the sun and water will evaporate as water vapor. The water vapor rises into the atmosphere, condenses, and forms rain. A portion of the rainwater will fall on land. On the land the rain water will then flow into rivers and into the ground. Most of the water that falls on land will naturally move towards to ocean due to the effects of gravity.

### The Human Induced Water Cycle.

- Water is usually withdrawn from freshwater sources for human consumption. This water when used becomes contaminated. This contaminated water or sewage is usually treated and then ultimately released into the environment.

### What is Sewage?

- Sewage is liquid or solid waste carried away from its source through underground conduits.
- There are two forms of sewage: sanitary sewage and storm sewage.

- Sanitary sewage includes any wastewater from residential, commercial, and industrial areas. Residential wastewater includes wastewater from sinks, toilets, showers, dish-washing, and laundry. Commercial and industrial wastewater include special wastes. For example, a pesticide manufacturing facility will release pesticide residues into the wastewater.
- The origin of storm sewage is rainfall. As rain accumulates on the ground it is drained away from paved areas. This drainage is referred to as storm sewage.
- When there's a reference to a "sewage spill" the implication is that it is a "sanitary sewage spill" given that storm sewage in many instances is drained intentionally towards waterways.
- For pictures of a sewage spill go to:

<http://www.stlwaterfrontcouncil.org/sewage.htm>

### How is Sanitary Sewage Treated ?

- Sanitary sewage can be treated on-site or at a centralized wastewater treatment plants.
- An example of an on-site wastewater treatment system is a septic tank system. A septic tank is a tank located underground next to a home. This septic tank stores the residential wastewater for a period of about 24 hours. During this period, a fraction of the impurities are removed. After this holding time, the wastewater from the septic tank is released through a drainfield. A drainfield is a set of perforated pipes imbedded within gravel. Theoretically, it is assumed that as the wastewater moves out through the drainfield and into the soil, the impurities including the microbes that cause illness are removed. For pictures and more discussion go to <http://www.thenaturalhome.com/septic.html>
- If sewage is treated at a centralized wastewater facility a set of conduits transport the sewage to the wastewater treatment plant. There are two types of conduits: gravity sewers and force mains. As the name implies gravity sewers move sewage by gravity. Essentially the pipes that are underground are sloped for the water to move in a particular direction. Gravity sewers are not designed to be perfectly watertight. Sewage can potentially leak out of them or leak into them. Force mains are special pipes that are designed to be water tight and transport the sewage under pressure towards the wastewater treatment plant.
- Wastewater that reaches the wastewater treatment plant is treated through a series of processes. Processes are included to: 1) remove the sediment or settled material, 2) remove organic material that has a tendency to deplete the oxygen of water, and 3) microbes. Microbes are removed through disinfection of the water with chlorine, for example. The disinfection process is designed to remove most of the microbes but not all. For more information go to:

<http://www.fao.org/docrep/T0551E/t0551e05.htm>

### Human Health Effects of Sewage

- Infectious microbes multiply within the body of a human, thus making that human ill. These microbes are then released into the environment (through sneezing, bleeding, or feces) where they may come in contact with another human. Different diseases

are transmitted different ways. One way that diseases are transmitted is through water. These diseases are also called waterborne diseases.

- Since sanitary sewage contains human wastes (feces, “poop”) it can contain microbes that cause disease. A person coming in contact with sanitary sewage therefore may become ill with a waterborne disease.
- In summary, when a sewage main breaks into marine recreational waters and beaches, this means that human waste have been dumped into these waters and beaches.

### What organisms can live in human waste (feces, “poop”)?

- Humans, both people with symptoms and those with no symptoms (known as “carriers”) can have a wide variety of organisms in their waste because these organisms can live in the human gastrointestinal track. These organisms include bacteria, viruses, and parasites. And many of these organisms can be transmitted to other humans, other animals and even marine organisms (like shellfish) through contact with contaminated marine waters. For more information visit:

<http://www.cdc.gov/ncidod/dpd/parasites/waterborne/default.htm>  
<http://www.nap.edu/books/0309048265/html/203.html>

### What are the possible routes of exposure?

- Oral, accidentally or intentionally
  - Drinking the water, or
  - Eating contaminated seafood
- Dermal
  - getting contaminated water on your skin with contamination of open cuts or rashes
- Aerosol, inhaling water droplets
  - from breaking waves

### What are the possible diseases?

- If an oral exposure to contaminated marine water occurs, in general the disease is called **gastroenteritis** or an infection of the gastrointestinal tract. Gastroenteritis is the most commonly reported illness associated with exposure to contaminated water. Some of the organisms can cause **hepatitis**, an infection specific to the liver. If the exposure was dermal, then it is possible for open cuts or rashes to get **infected**. Finally, if the exposure was respiratory aerosol, then it is possible to see **gastroenteritis**.

### What are the symptoms?

- **Gastroenteritis** can affect different parts or the whole of the gastrointestinal track. Symptoms of gastroenteritis include: vomiting, abdominal pain, fever, and/or diarrhea. Some of these diseases can cause severe dehydration (loss of water and electrolytes) due to severe vomiting and/or diarrhea, especially in little children or persons already sick with other conditions.

- **Hepatitis** can look exactly like gastroenteritis. Sometimes if it is severe, people can become jaundiced or yellow because the liver is not able to clear out its own waste products known as bile.
- **Infected cuts or rashes** look swollen, red and may have a discharge called pus. There is usually a lot of pain at the site of the rash or cut. Sometimes people may have a fever with the infected rash or cut. Of note, eyes and ears can be infected in the same way.
- For more information go to:

<http://www.hse.gov.uk/pubns/indg197.htm>

### What is the risk to people from using sewage-contaminated recreational marine waters?

- Pruss (1998) reviewed all significant existing studies on the human health effects from exposure to recreational water. She found that most of these studies reported a dose-related increase of health risk in swimmers with an increase in the indicator bacteria counts in recreational water (ie. As the bacterial counts increased, the risk for sickness in the humans increased). The indicator organisms that correlated best with the health outcomes were enterococci/fecal streptococci for marine and freshwater, and *E. coli* for freshwater. In both marine and freshwater, the increased risk of gastrointestinal symptoms was associated with water quality values ranging from only a few indicator counts/100 ml to about 30 indicator counts/100 ml. These values are low compared to water qualities frequently encountered in coastal recreational waters. Of note, the majority of these studies were conducted in the US and UK, with few studies evaluated in tropical marine recreational waters.
- Haile et al. (1999) among others evaluated the risk of reported gastrointestinal symptoms and other symptoms with respect to reported distance from storm drains with untreated run off in the County of Los Angeles. Over 22,000 persons were interviewed 9 days after their facial immersion exposure to recreational beach waters concerning their symptoms. An increased risk of adverse health outcomes associated with swimming in ocean water contaminated by untreated urban runoff was found with a significant dose response relationship (ie the closure the person swam to a storm drain, the greater their risk of having symptoms).

### How do I know if the marine water is contaminated?

- Traditionally, similar to drinking water, monitoring of water quality for marine coastal waters used for recreational purposes has been regulated by measuring concentrations of indicator microbes.
- Indicator microbes do not necessarily cause disease . They are “indicators” of the potential presence of microbes that cause disease such as those microbes that cause hepatitis and gastroenteritis.
- The indicator microbes utilized are those typically found in human feces in high concentrations. Examples of these microbes include: total coliform, fecal coliform, *E. coli*, and enterococci. *E. coli* is a particular species of bacteria that live naturally within the human gastrointestinal tract. Fecal coliform and enterococci are two different groups of bacteria which can grow at temperatures similar to that of the temperature of the human body and are also found naturally within the human

gastrointestinal tract. One distinguishing feature between fecal coliform and enterococci is that fecal coliform are rod-shaped and enterococci are round or cocci shaped. Total coliform is a group of rod-shaped microbes that can grow at temperatures below human body temperature. It is important to keep in mind that *E. coli* are a subset of fecal coliform and fecal coliform are a subset of total coliform. See diagram below.

- Various agencies have developed standards that would indicate when a water body has been contaminated by sewage or human waste and therefore unsafe for recreational use. When these standards are exceeded health advisories are issued for the affected beaches. A summary of these standards is provided in the table below.

Agency Setting Standard	Standard
U.S. Environmental Protection Agency  <a href="http://www.epa.gov/ost/beaches/local/sum2.html">http://www.epa.gov/ost/beaches/local/sum2.html</a>	Freshwater: <i>E. coli</i> < 126/100 ml Enterococci < 33 /100 ml  Saltwater: Enterococci < 35/100 ml
Florida Department of Environmental Protection  <a href="http://www.epa.gov/OST/beaches/local/sumtable.html">http://www.epa.gov/OST/beaches/local/sumtable.html</a>	Total coliform < 1000/100 ml on average  Fecal coliform < 200/100 ml on average

- Go to the following sites for more information:

<http://www.sccwrp.org/pubs/annrpt/97/ar16.htm>  
<http://es.epa.gov/ncercqa/progress/grants/95/water/sobsey99.html>

### How can I prevent sickness from contaminated marine water?

- The easiest way to prevent sickness from marine water contaminated with sewage is to avoid exposure. Therefore, swimming, drinking, any skin contact, and aerosol contact should be avoided. Furthermore, many of these organisms can live in seafood, especially shellfish, so that eating particularly uncooked shellfish from contaminated areas should be avoided.
- For more information go to:

[www.cdc.gov/ncidod/dpd/parasiticpathways/swimming/healthy\\_swimming\\_tips.htm](http://www.cdc.gov/ncidod/dpd/parasiticpathways/swimming/healthy_swimming_tips.htm)

### Limitations in the Use of Indicator Microbes

- Again as mentioned above, indicator microbes indicate the potential presence of microbes that cause disease. They are not necessarily disease causing in and of themselves. The primary exception is a rare strain of *E. coli*, (*E. coli* O157:H7)

- which is disease causing. Go to the following web page for more information <http://www.epa.gov/safewater/ecoli.html>
- The lack of indicator microbes does not necessarily mean the lack of disease causing microbes in all cases. The indicator microbes are all bacteria. Some disease causing microbes are viruses (such as Hepatitis) or protozoans (such as Cryptosporidium). Viruses and protozoans react differently to chlorination than do bacteria. Some viruses and especially the protozoans are more resistant to chlorination than the indicator bacteria. So if chlorination is used as the primary means to disinfect water, and there are no indicator bacteria present, that does not necessarily mean that the water is free from microbes that cause disease.
  - Studies have also found that the indicator bacteria are capable of multiplying in warm humid climates, in the absence of a sewage source of contamination. An important question that has not yet been answered is, "If the indicator bacteria can multiply, are the disease causing microbes also capable of multiplication." Some may argue that the presence of indicator bacteria in sub-tropical climates such as that found in South Florida may not necessarily indicate a human health risk.
  - Other sources of indicator microbes include animals. Animals and humans share very few diseases and thus feces from animal sources are not as infectious to humans as feces from human sources.

### **Additional Websites**

#### **INFORMATION FOR SWIMMERS:**

##### **Prevention of Recreational Water Illnesses**

[http://www.cdc.gov/ncidod/dpd/parasiticpathways/swimming/faq\\_swimmers.htm](http://www.cdc.gov/ncidod/dpd/parasiticpathways/swimming/faq_swimmers.htm)