Water Quality 101: Land-Based Pollution in Hawaii

A watershed that supports good water quality and healthy reefs has…..



- Native forest and vegetation
- Controlled invasive mammals
- Natural streamflow
- Undeveloped, natural coastlines
- Fewer paved surfaces
- Sustainable agriculture
- Minimal fertilizer use
- Advanced wastewater treatment



? Did You Know ?
222 miles of streams and rivers and 28 of coastal water bodies in Hawaii are considered “impaired” by the EPA

What are the causes of water pollution?

Agriculture

Agriculture contributes to water pollution via pesticides, herbicides and nutrients from fertilizer.



Invasive Animals



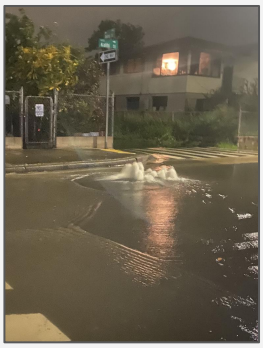
Pigs, goats and deer harm and uproot native plants, which increases sedimentation, and introduce their waste products to the watershed.

Cesspools and sewage spills

Sewage pollution can contain many types of harmful bacteria, parasites, and viruses. It also has high nutrient levels and contain chemicals of emerging concern like pharmaceuticals.



Stormwater



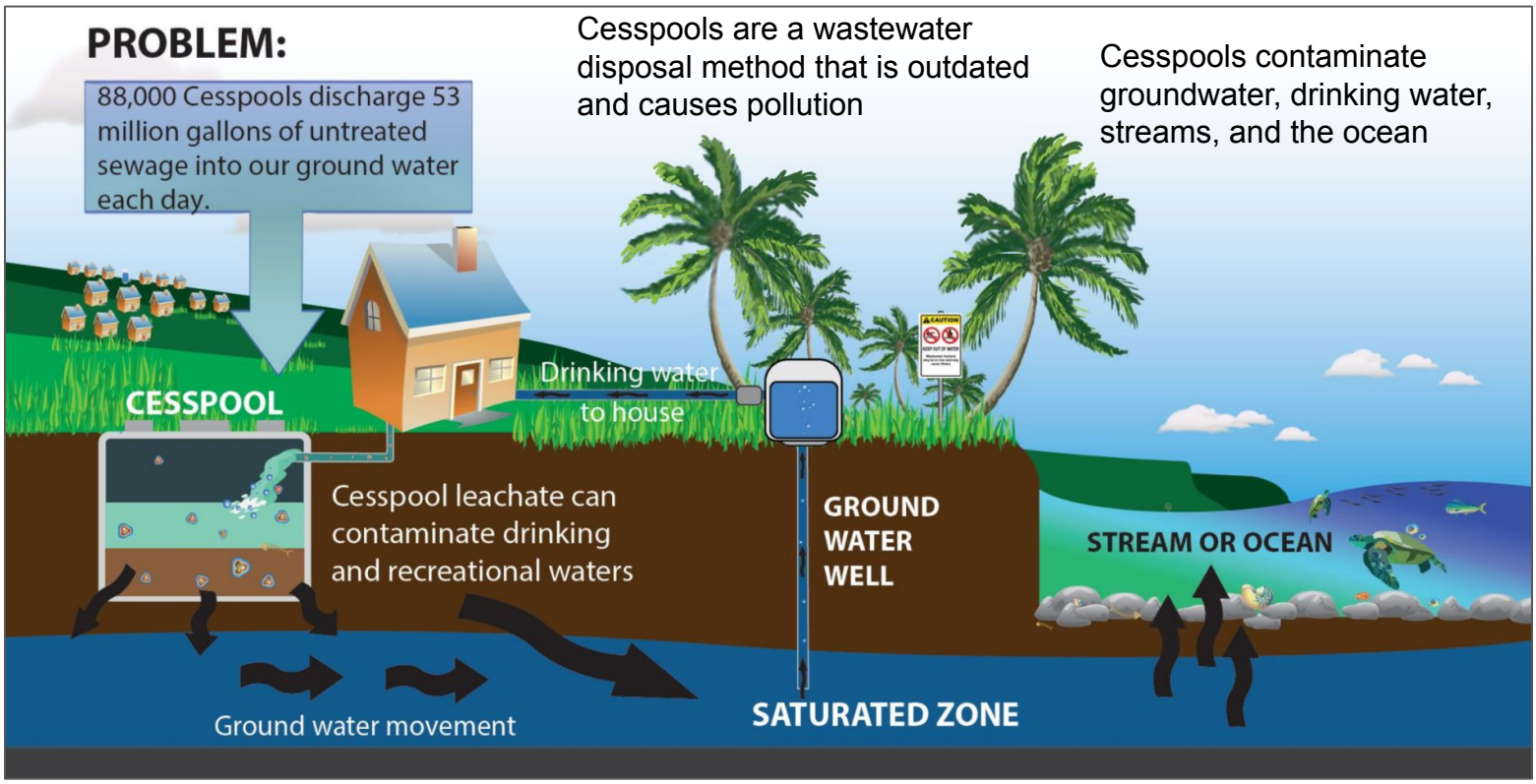
Stormwater pollutants include fertilizers, animal wastes, oil, grease, heavy metals, and litter.

Erosion



Unsustainable land use, invasive plants, and invasive ungulates are increasing erosion and sediment runoff into streams

Water Quality 101: Sewage Pollution from Cesspools



Drinking Water Impacts

Cesspools that are far from the ocean can still have negative environmental impacts!



Nitrate concentrations in drinking water above 3.9 mg/L are linked to increased rates of bladder and colorectal cancers

Nitrate concentrations above 10 mg/L are linked to “Blue Baby Syndrome”

Impacts on Coral Reefs

Chemicals in sewage can influence reproductive success and increase disease in coral reef animals

Increased nutrient concentrations lead to invasive algae overgrowth on coral reefs, which reduces native biodiversity



Pharmaceuticals can cause reproductive harm in fish





Who's in the water?

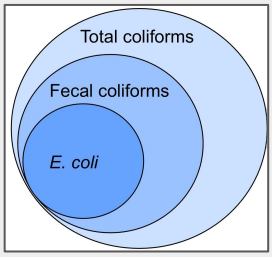
An introduction to sewage-related microorganisms

US EPA Fecal Indicator Bacteria (FIB)

These aren't typically responsible for diseases, but they are found in sewage and easy to detect

Fecal coliform and total coliform

- Rod-shaped bacteria
- Originates in intestines of warm-blooded animals (including humans)
- Includes *E. coli* and other similar bacteria
- Some E. coli may be waterborne pathogens, but it's a small percentage





Enterococcus spp.

- Cocci (small oval shape)
- Originates in intestines of warm-blooded animals (including humans)
- Replaced fecal coliform as federal standard for water quality in 2004



! Interpret with Caution !

These FIB are found in both human and animal feces



Enterococcus occurs naturally in tropical soils, confounding results if there is sediment in the sample

Clostridium perfringens

Researchers have found that this bacteria better indicator of sewage contamination in Hawaii waters than fecal coliform or *Enterococcus*, but is not officially used by the EPA

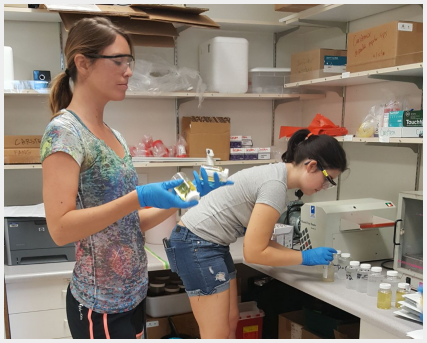


- Does not occur naturally in soils
- Common cause of food poisoning
- Can cause waterborne gastrointestinal illness

How do you test for fecal indicator bacteria?

Culturing methods - e.g. IDEXX

- Grow colonies from cells in the water sample
- Time to results: >24 hours
- Add nutrients, incubate, count
- Can be done by citizen scientists



Detect DNA - Quantitative PCR

- Polymerase Chain Reaction
- Time to results: 6 hours - 1 day
- Amplify target DNA in the lab
- Requires biological laboratory experience

The 1-2 day lag from sampling to results being shared means that people may be exposed to polluted water

New!! Rapidly detect DNA - LAMP

- Loop-mediated Isothermal Amplification
- 1-3 hours = same day results
- Amplify target DNA in the field
- Goal: can be done by citizen scientists

New methods in development, like LAMP, aim to provide near-real-time water quality information to protect ocean users

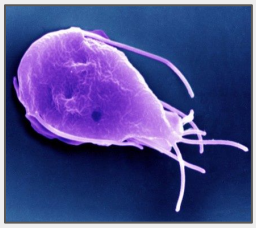
WAI WASTEWATER ALTERNATIVES & INNOVATIONS

Who's in the water?

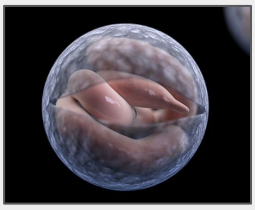
An introduction to sewage-related microorganisms

Protozoans / Parasites

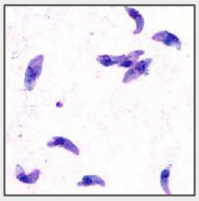
These parasites normally disappear on their own, but sometimes antiparasitic medication is used for treatment.



Giardiasis
Caused by the parasite *Giardia lamblia*
Found in contaminated drinking water
Diarrheal disease causing intestinal symptoms such as gas, stomach cramps, diarrhea, and dehydration



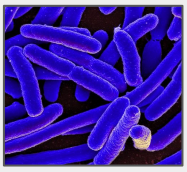
Cryptosporidiosis
Caused by the parasite *Cryptosporidium*
Found in contaminated drinking water
Diarrheal disease causing stomach cramps, diarrhea, and nausea



Toxoplasmosis
Caused by the parasite *toxoplasma gondii*
Found in contaminated recreational and drinking water
Causes severe illness and death in endangered Hawaiian monk seals

Pathogenic bacteria

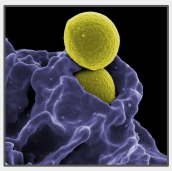
Pathogenic means that these bacteria are infectious and cause disease. Infections caused by these bacteria can be treated with antibiotics.



***Escherichia coli* (*E. coli*)**
Bacteria in human and animal intestines
Found in sewage contaminated freshwater and agricultural runoff
Does not survive long in seawater
Causes bloody diarrhea, stomach cramping, and vomiting



Salmonella
Intestinal infection causing salmonellosis
Found in sewage polluted and contaminated recreational water
More common in freshwater
Causes diarrheal illness, food poisoning, and wound infections



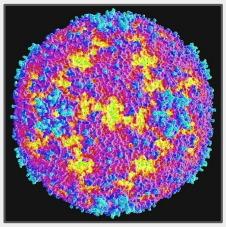
***Methicillin-resistant Staphylococcus aureus* (MRSA)**
Bacteria in the nose or on skin
Found in recreational water
Suspected link to sewage but not confirmed
Symptoms include skin infections
Can cause staph infections



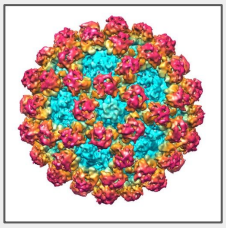
Vibrio vulnificus
Bacterial illness causing vibriosis
Found in sewage-contaminated recreational water
Causes diarrheal illness and dehydration
Detected in the Ala Wai by UH researchers

Pathogenic viruses

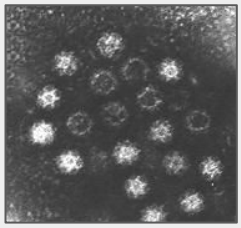
These viruses cause illness and cannot be treated with antibiotics.The viruses below have been found in recreational waters.



Enteroviruses (EnV)
Part of the Picornavirus family
Found in sewage polluted recreational or drinking water
Diseases include gastroenteritis, respiratory infection, diabetes, heart disease, bronchiolitis, conjunctivitis, meningitis, paralysis, and the common cold



Noroviruses
Also part of the *Caliciviridae* family
Found in sewage polluted recreational or drinking water
Diseases include gastroenteritis, commonly known as the stomach flu, causing vomiting or diarrhea



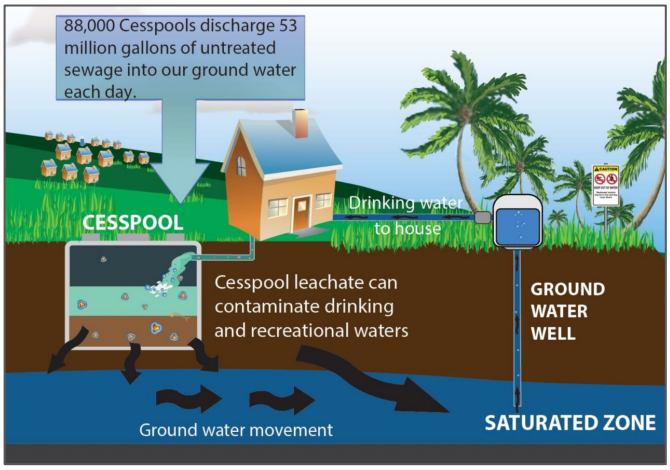
Human Caliciviruses (HuCV)
Part of the *Caliciviridae* family
Found in sewage polluted recreational or drinking water
Diseases include gastroenteritis, commonly known as the stomach flu, causing vomiting and diarrhea

Cesspools and Drinking Water

Hazards of aquifer contamination

How does drinking water get contaminated?

Cesspools leach untreated wastewater into the ground and groundwater. Depending on the location of cesspools, the pollution may contaminate drinking water wells with nitrate, pathogens, and contaminants of emerging concern.



Risks of Nitrate in Drinking Water

- 2.07 mg/L: Significantly increased risk of bladder cancer (Barry et al., 2020)
- 3.87 mg.L: Significantly increased risk of colorectal cancer (Schullehner et al., 2020)
- >12,000 nitrate-attributable cancers annually in US
- 10 mg/L: Blue-baby syndrome, where infants red blood cells are compromised and they do not transport enough oxygen to their tissues. Also known as “methemoglobenimia”



Risk Areas



Department of Health Priority Level 1 & 2
Many areas in Hawaii have already been identified as high risk for drinking water contamination

Case Study: Suffolk County, Long Island, NY



Image: Long Island Clean Water Partnership

Long Island, NY has the highest number of cesspools in the nation (though Hawaii has the highest number per capita). Environmental impacts to the coastal ocean are easily observed when harmful algal blooms occur (left). However, an insidious impact of cesspools is the introduction of nitrate pollution to drinking water. Since 1980, the groundwater nitrate concentration in Suffolk County has increased from a level of 2.4 ppm to an even more concerning 3.8 ppm.

Long Island has higher than expected rates of bladder cancer and kidney cancer