Subjects/Target Grades

Science and Social Studies

Grades 7-12

Duration/ Location

50-60 minutes

Classroom setting

Materials

Per class

- Septic Systems teacher resource

Per small group

- Septic system model materials (container for the model, straws, milk cartons, clay, sand, room temperature coffee-prepared with grounds)

Per student

- Bacteria and Water Quality student reading

Lesson Three Explore: Managing Pathogens-

pages 9 & 10 from lesson 3

Activity Overview

Students explore pathogens as a source of non-point source pollution and create a model of a septic system.

Lesson Procedure

1) Show the video on *Communities for Clean Water: Managing Pathogens.*

2) To help students understand the design of a basic septic system, use the *Septic Systems* teacher resource as a guide to demonstrate and have students create a model of a septic system in an aluminum pan or plastic container using milk cartons (house and settling tank), straws (pipes), straws with holes (drainage field), clay (connectors), and sand for the soil.

3) Have students run their system by adding various amounts of wastewater (Colored water with used coffee grounds). The solid portion of the wastewater will settle to the bottom of the tank, while the liquid (effluent) will exit the tank into the drainfield. (Scum can be represented by cooking oil.) Students should note that the system has a limited capacity. *Teacher Note:* This activity is intended to show students the general design of a septic system. The above design will not will not completely filter out the colored water.

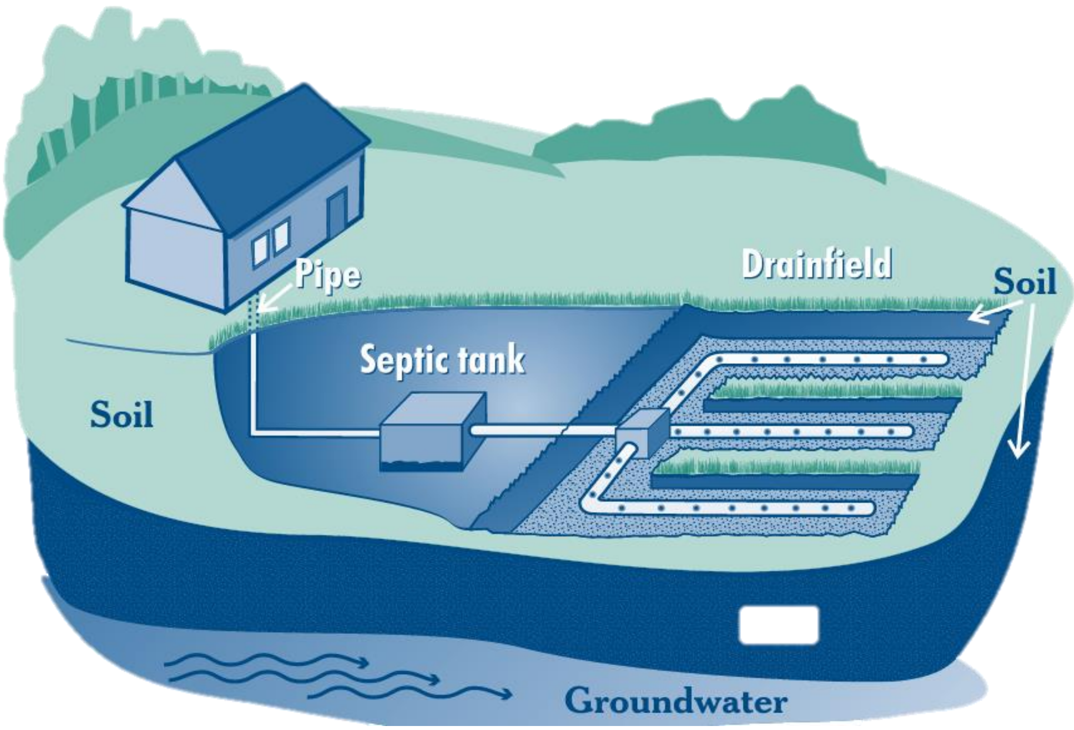
4) Remind students that their model is missing the important component of microbes in the septic system.

5) Follow up this section with reflective reading of the *Bacteria and Water Quality* student reading

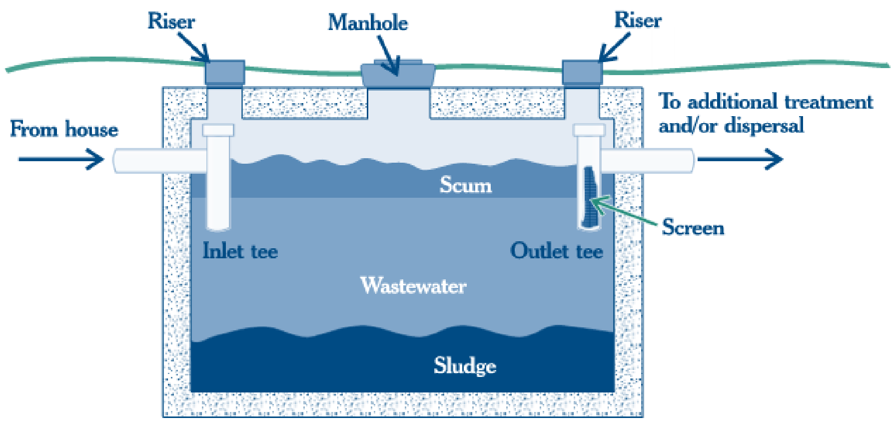
Vocabulary Terms

Septic systems- underground wastewater treatment structures that use a combination of natural and technological processes to treat wastewater from household plumbing

Septic Systems



Typical single-compartment septic tank with ground-level inspection risers and screen



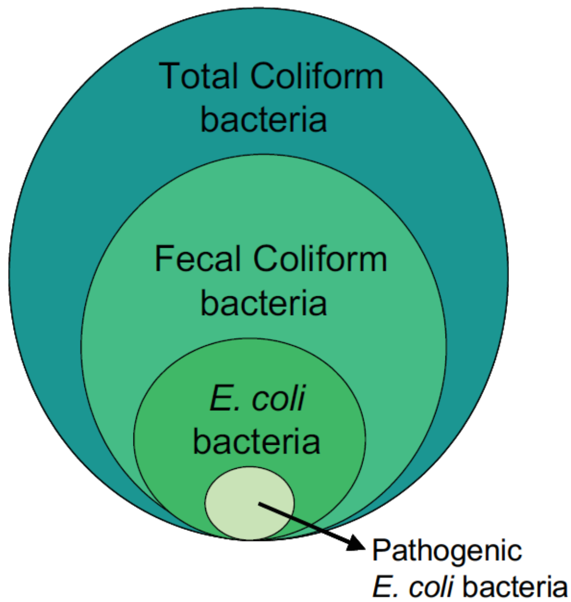
Homowner's Guide to Septic Systems
https://www.yorktownny.org/sites/default/files/fileattachments/engineering_amp_sewer/page/131/homeownersguidesepticsystem-yorktown.pdf

Bacteria and Water Quality

Introduction

Bacteria are among the simplest, smallest, and most abundant organisms on earth. Bacteria have a cellular structure lacking an organized nucleus and nuclear membrane. Instead of containing genetic information stored on several chromosomes, bacteria contain a single strand of DNA. These organisms reproduce by binary fission, which occurs when a single cell divides to form two new cells called daughter cells. Each daughter cell contains an exact copy of the genetic information contained in the parent cell. The generation time is the time required for a given population to double in size. This time can be as short as 20 minutes for some bacteria species (e.g., *Escherichia coli*).

While the vast majority of bacteria are not harmful, certain types of bacteria cause disease in humans and animals. Examples of **waterborne diseases** caused by bacteria are: cholera, dysentery, shigellosis, and typhoid fever. During the London cholera epidemics of 1853-1854, Dr. John Snow observed that nearly everyone who became ill obtained their drinking water from a specific well into which a cesspool was leaking. Those who became ill either drank water from the well or came into contact with fecally contaminated material while tending those already sick.



Fecal coliform bacteria which include E. coli are part of a larger group of colifom bacteria.

Citizens Monitoring Bacteria: A training manual for monitoring E. coli: http://blog.uvm.edu/kstepenu/files/2016/09/Final_ecoli_06c1.pdf

Concerns about bacterial contamination of surface waters led to the development of analytical methods to measure the presence of waterborne bacteria. Since 1880, **coliform bacteria** have been used to assess the quality of water and the likelihood of pathogens being present. Although several of the coliform bacteria are not usually pathogenic themselves, they serve as an indicator of potential bacterial pathogen contamination. It is generally much simpler, quicker, and safer to analyze for these organisms than for the individual pathogens that may be present. **Fecal coliforms** are the coliform bacteria that originate specifically from the intestinal tract of warm-blooded animals (e.g, humans deer, etc.). They are cultured in a special growth media and incubated at 44.5^{o}C. ***E. coli*** *bacteria* are a subset of coliform bacteria.

The first U.S. standards for drinking water, established by the Public Health Service in 1914, were based on coliform evaluations. It was reasoned that the greatest source of human pathogens in water was from human waste. Each day, the average human excretes billions of coliform bacteria. These bacteria are present whether people are ill or healthy. Monitoring for coliform bacteria was designed to prevent outbreaks of enteric diseases, rather than to detect the presence of specific pathogens. Today, coliform bacteria concentrations are determined using methods specified by the Environmental Protection Agency (EPA) and *Standard Methods for the Examination of Water and Wastewater*.

Sources of Bacteria

Point Sources

Human sources of bacteria can enter water via either point or nonpoint sources of contamination. Point sources are those that are readily identifiable and typically discharge water through a system of pipes. Communities with sewers may not have enough capacity to treat the extremely large volume of water sometimes experienced after heavy rainfalls. At such times, treatment facilities may need to bypass some of the wastewater. During bypass or other overflow events, bacteria-laden water is discharged directly into the surface water as either **sanitary sewer overflow (SSO)** or as **combined sewer overflow (CSO)**. Power outages and flooding can also contribute to the discharge of untreated wastewater.

Illicit connections to storm sewers are a source of bacteria in surface waters, even during dry periods. A connection to a storm sewer is “illicit” when the wastewater requires treatment prior to discharge and should be routed to the sanitary sewer. Only stormwater and certain permitted discharges (e.g. clear noncontact cooling water) should be discharged to a storm sewer.

Nonpoint Sources

Nonpoint sources are those that originate over a more widespread area and can be more difficult to trace back to a definite starting point. Failed on-site wastewater disposal systems (**septic systems**) in residential or rural areas can contribute large numbers of coliforms and other bacteria to surface water and groundwater. Animal sources of bacteria are often from nonpoint sources of contamination. **Concentrated animal feeding operations**, however, are often point source dischargers. Agricultural sources of bacteria include livestock excrement from barnyards, pastures, rangelands, feedlots, and manure storage areas. **Stormwater runoff** from residential, rural, and urban areas can transport waste material from domestic pets and wildlife into surface waters. Land application of manure and sewage sludge can also result in water contamination, which is why states require permits, waste utilization plans, or other forms of regulatory compliance. Bacteria from both human and animal sources can cause disease in humans.

Bacteria-laden water can either leach into groundwater and seep, via subsurface flow, into surface waters or rise to the surface and be transported by overland flow. Bacteria in overland flow can be transported freely or within organic particles. Overland flow is the most direct route for bacteria transport to surface waters. Underground transport is less direct, because the movement of water and bacteria is impeded by soil porosity and permeability constraints.

Source: https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/NPS/General/program-plan-2019.pdf?rev=5cb1793c407e46cc817bd15e3482a17b&hash=0670C180ADE0B41BE535CB2280895E59