# Microbiology of Septic Systems


Maine Center for Disease Control and Prevention

An Office of the Department of Health and Human Services

Paul R. LePage, Governor

Mary C. Mayhew, Commissioner

# Microbiology of Septic Systems

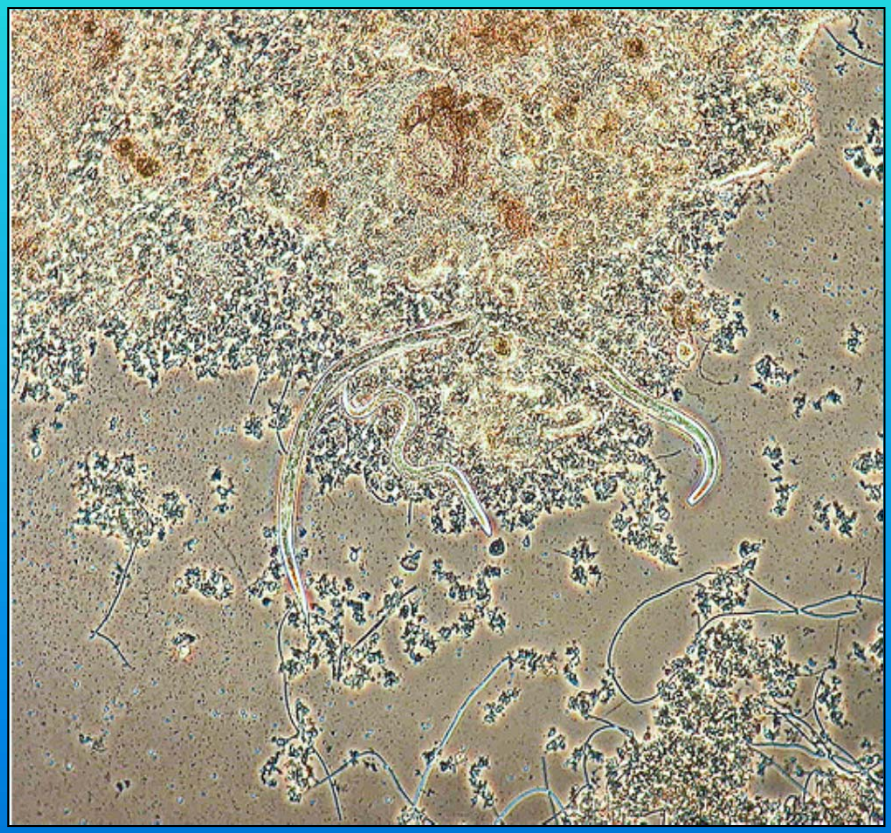
The purpose of this discussion is to provide a fundamental background on the relationship between microbes, wastewater, and septic systems.

- What microbes are present in septic systems?
- What role do they play in the treatment process?
- What concerns are associated with them?

# Microbiology of Septic Systems

## The Microbes

The microbes associated with septic systems are bacteria, fungi, algae, protozoa, rotifers, and nematodes. Bacteria are by a wide margin the most numerous microbes in septic systems.



# Microbiology of Septic Systems

Bacteria constitute a large domain of prokaryotic (single cell, no nucleus) micro-organisms. They are present in most habitats on the planet and the live bodies of plants and animals.

*Escherichia coli*

# Microbiology of Septic Systems

Fungi are a large group of eukaryotic (having a nucleus and organelles) organisms that includes yeasts and molds as well as mushrooms.

They are classified as a kingdom separate from plants, animals, and bacteria.

*Saccharomyces cerevisiae*

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**Protozoa** are a diverse group of unicellular eukaryotic organisms, many of which exhibit animal-like behavior, e.g., movement. Examples include ciliates, amoebae, sporozoa, and flagellates.

Assorted protozoa

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Rotifers are a phylum of microscopic and near-microscopic pseudo-coelomate animals, common in freshwater environments throughout the world. They eat particulate organic detritus, dead bacteria, algae, and protozoans.


Typical rotifer.

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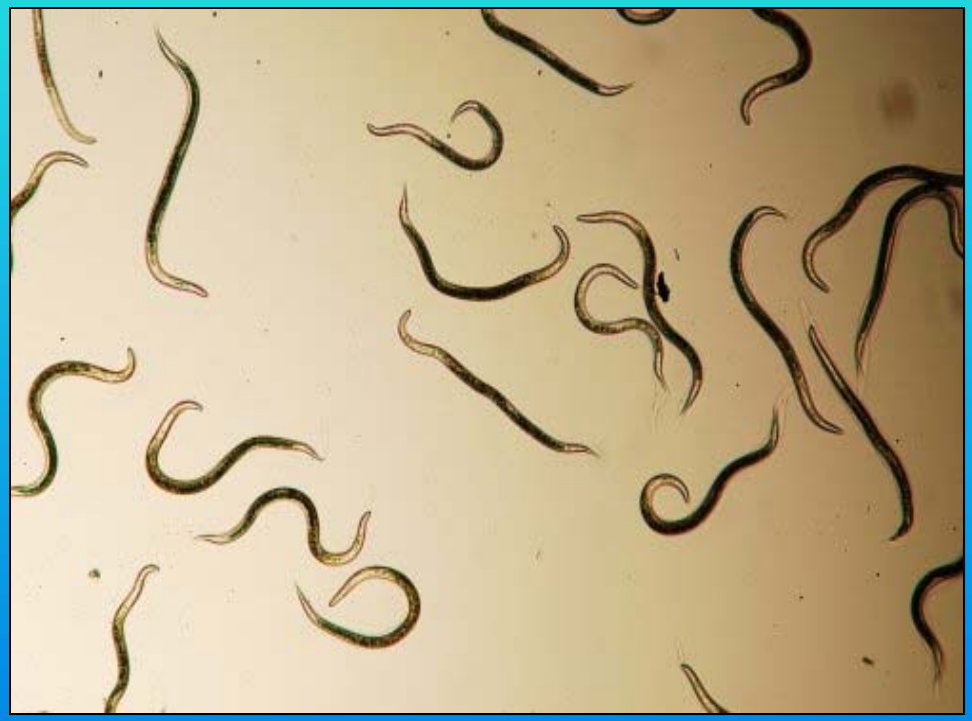
Nematodes , or roundworms, are one of the most diverse of all animal phyla. Over 28,000 species have been described, of which over 16,000 are parasitic. The total number of species has been estimated to be about 1,000,000.



Typical nematodes.

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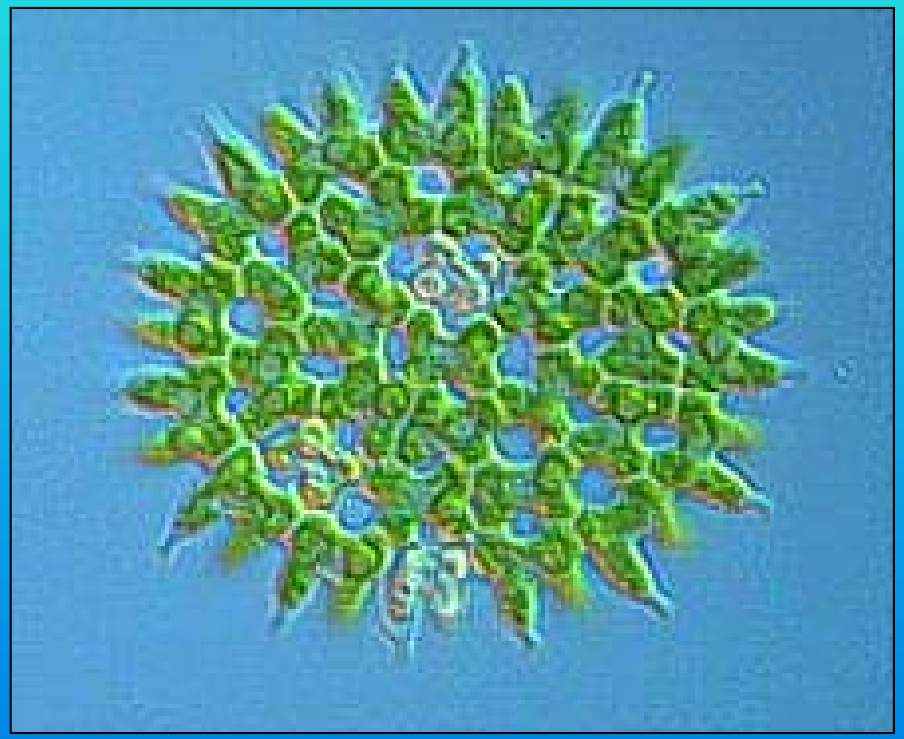
Algae are distinguished from animals, fungi, and protozoans by their ability to make their own food through photo-synthesis and are distinguished from plants by their relative simplicity of structure.



*Pediastrum boryanum*

# Microbiology of Septic Systems

## Why Do We Care?

Whether in municipal treatment facilities or in individual subsurface systems, microbes do the heavy lifting for us when it comes to protecting water quality, particularly ground waters in the case of septic systems.

This matters because:

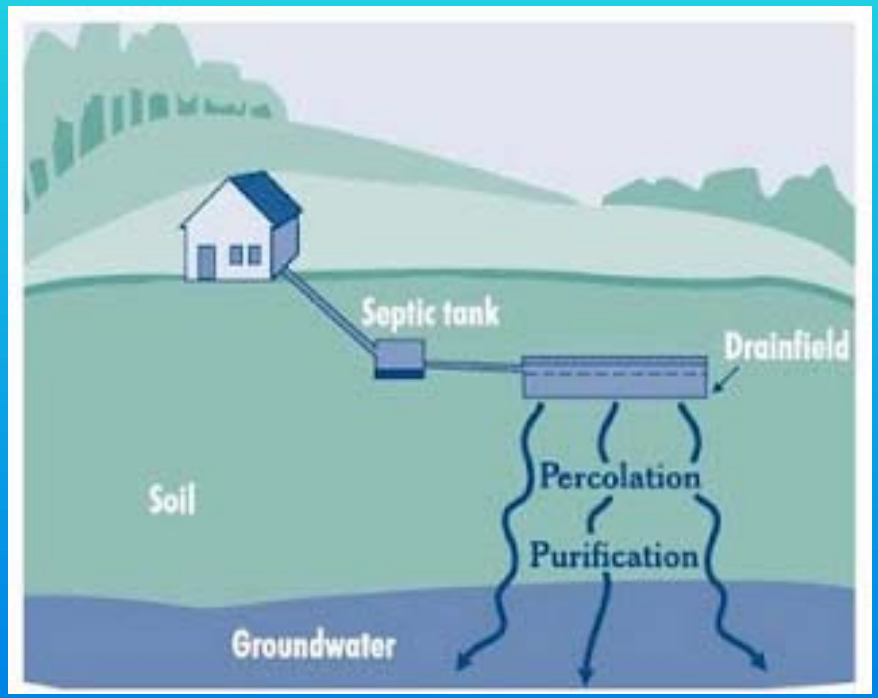
# Microbiology of Septic Systems

Approximately 50% of the population relies on groundwater for drinking, either from private wells or public sources. The other 50% relies upon surface water sources for potable water. Both need to be protected to ensure the public health.

# Microbiology of Septic Systems

The purpose of any treatment system, public or onsite, is to protect ground and surface waters by reducing the amount of nutrients and pathogens in effluent.

What happens when this is not effective?



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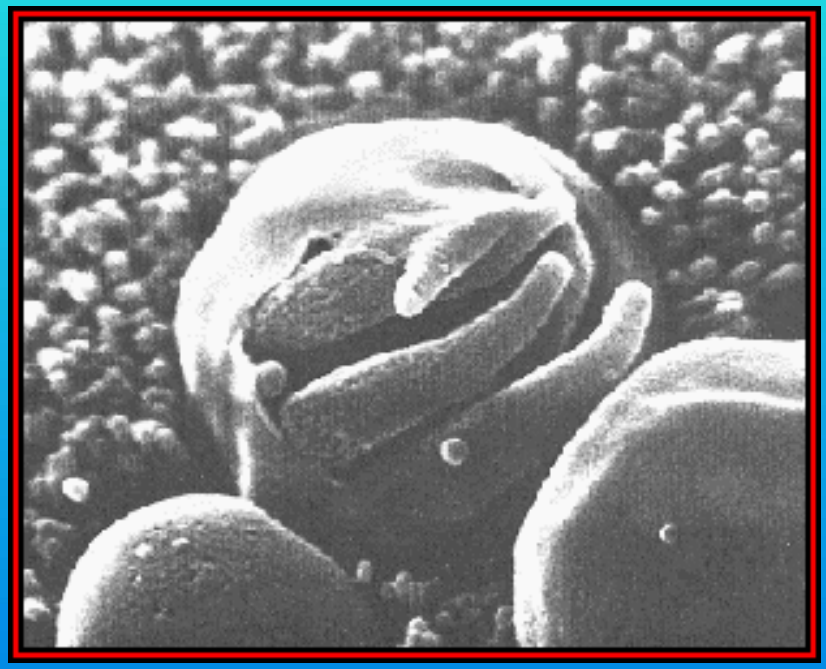
In 1993 Milwaukee, WI experienced the largest documented waterborne disease outbreak in United States history. The Howard Avenue Water Purification Plant was contaminated by the Cryptosporidium protozoan, leading to an extensive cryptosporidiosis outbreak.



# Microbiology of Septic Systems

Over a span of approximately two weeks, 403,000 residents became ill with the acute stomach cramps, fever, diarrhea and dehydration caused by the organism. At least 104 deaths have been attributed to the outbreak, mostly among the elderly and immune-compromised people.

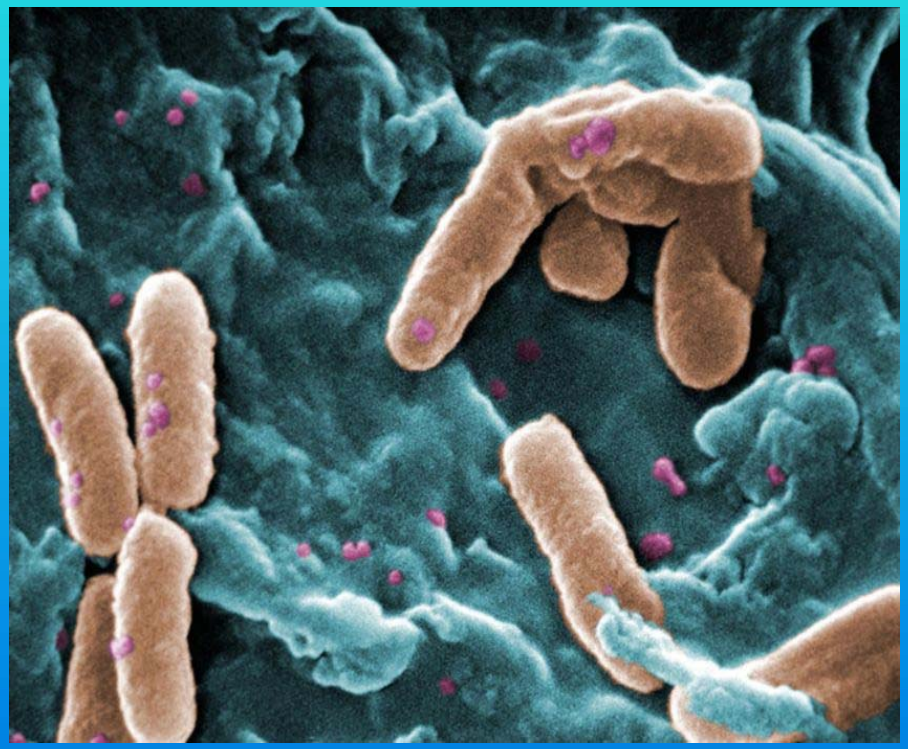
# Microbiology of Septic Systems

In 2009 a household on Swan's Island experienced a Hepatitis A outbreak . An infected individual contaminated the property's drilled well, and spread the virus to 8 other family members. The contamination occurred because the family had diverted laundry waste from a malfunctioning septic system to a hole in the ground. The first individual died.

# Microbiology of Septic Systems

## The Process

The basic mechanisms of biological treatment are the same for all treatment processes. Microorganisms, principally bacteria, metabolize organic material and inorganic ions present in wastewater during growth.



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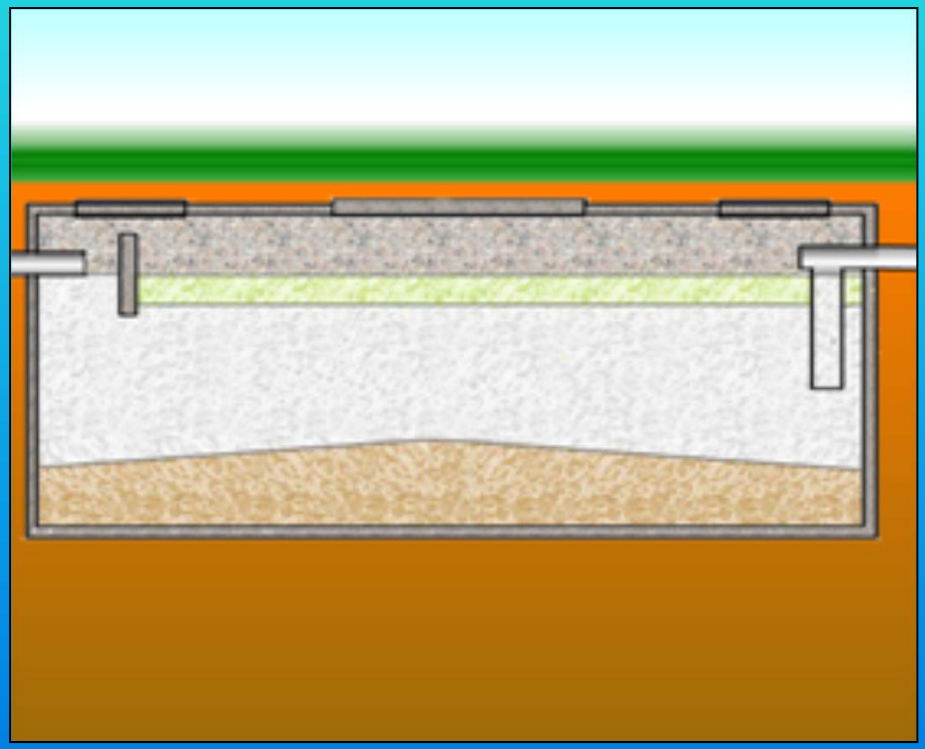
A typical septic system accomplishes treatment in a two phase process. In the first phase, raw wastewater is introduced to a septic tank for a combination of solids separation and anaerobic digestion.



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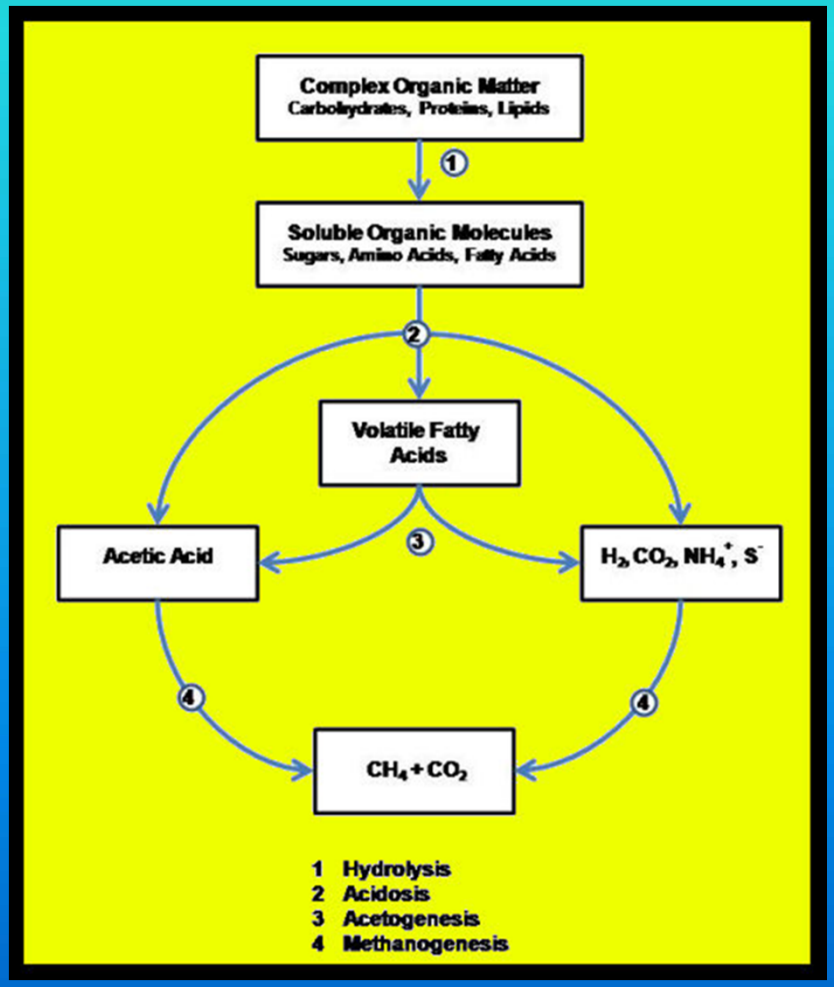
Anaerobic digestion which occurs in septic tanks represents an incomplete digestion. Methane, hydrogen sulfide, and sulfur dioxide gases are produced, as well as a sludge of high molecular weight hydrocarbons.

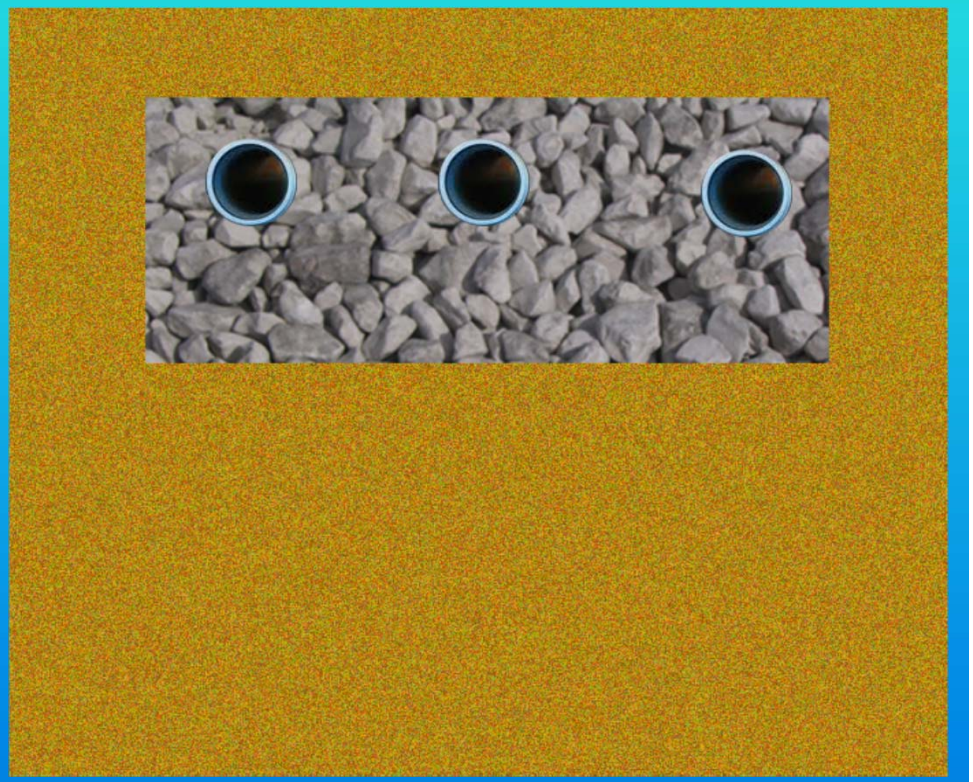


# Microbiology of Septic Systems

The resulting sludge will readily decompose further when exposed to oxygen and aerobic bacteria. This generally will take place in a municipal sewage treatment plant or landfill if either of these places is used to dispose of sludge pumped periodically from septic tanks.

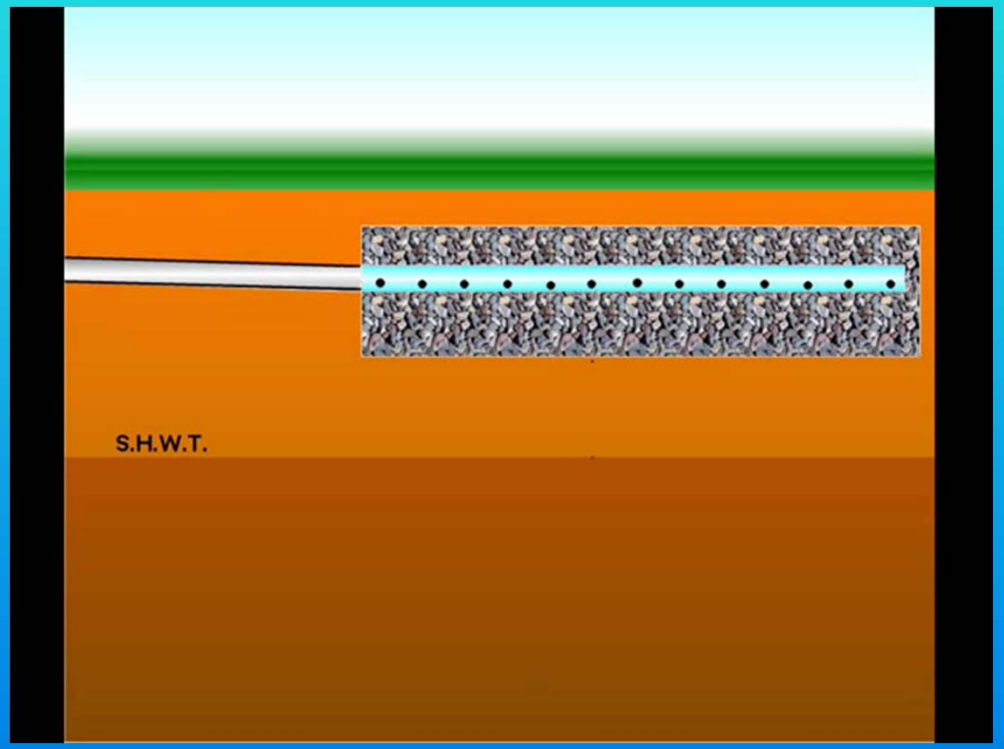
# Microbiology of Septic Systems

In the second phase, the primary effluent from the septic tank is treated by physical and biological processes in the disposal area and surrounding soil.



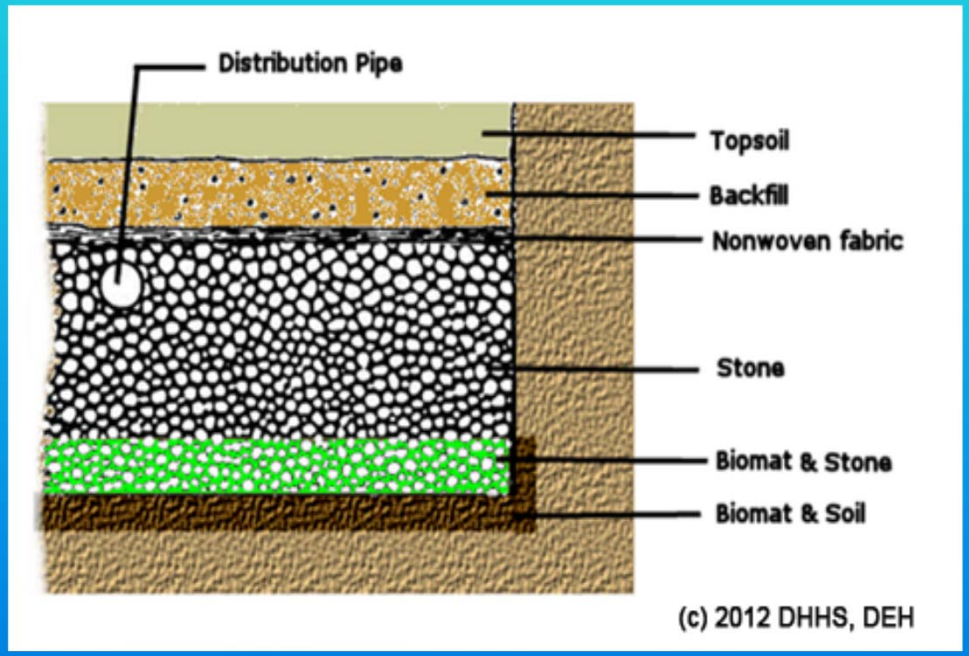
# Microbiology of Septic Systems

Biological mats develop on the sides and bottoms of the trenches and add to a biological filtration of the effluent passing through it into the soil environment.



# Microbiology of Septic Systems

This mat normally penetrates 1/2 to 6 centimeters into the soil. It consists of septic tank effluent solids, mineral precipitates, micro-organisms, and the by-products of decomposition.



# Microbiology of Septic Systems

Anaerobic organisms living in the biomat digest suspended organic matter contained in the effluent before it reaches the soil, where digestion of dissolved components occurs by aerobic or facultative bacteria.

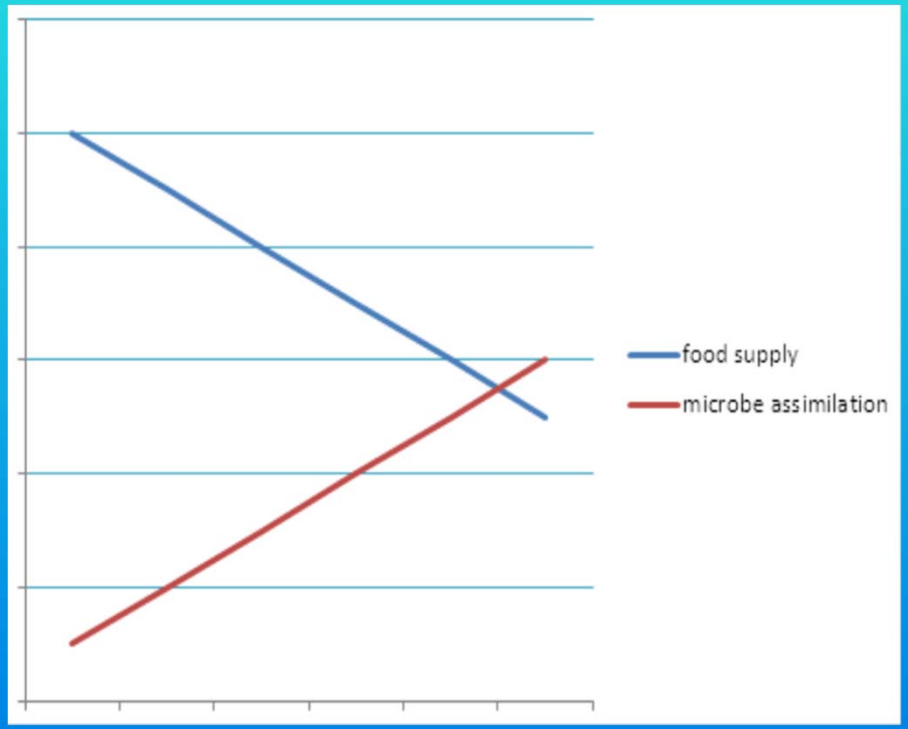
# Microbiology of Septic Systems

| Water Quality Parameter | % Removal In A Septic Tank | % Removal In A Leach Field |
|---|---|---|
| BOD (Biochemical Oxygen Demand) | 15% to 50% | 75% to 90% |
| TSS (Total Suspended Solids) | 25% to 45% | 75% to 90% |
| Settleable Solids | > 90% | 75% to 90% |
| Enteric Bacteria | 10% to 40% | 80% to 90% |
| Enteroviruses | No Significant Reductions | generally high but variable |
| Protozoa | No Significant Reductions | generally high but variable |

Removal rates for septic tanks and leach fields.

# Microbiology of Septic Systems

The biomat is in constant flux, building up, degrading, and creeping downward into the soil as a viscous fluid where it is dispersed. The process is self-cleaning, as microbes metabolize the biomass and each other during periods of low inflow.



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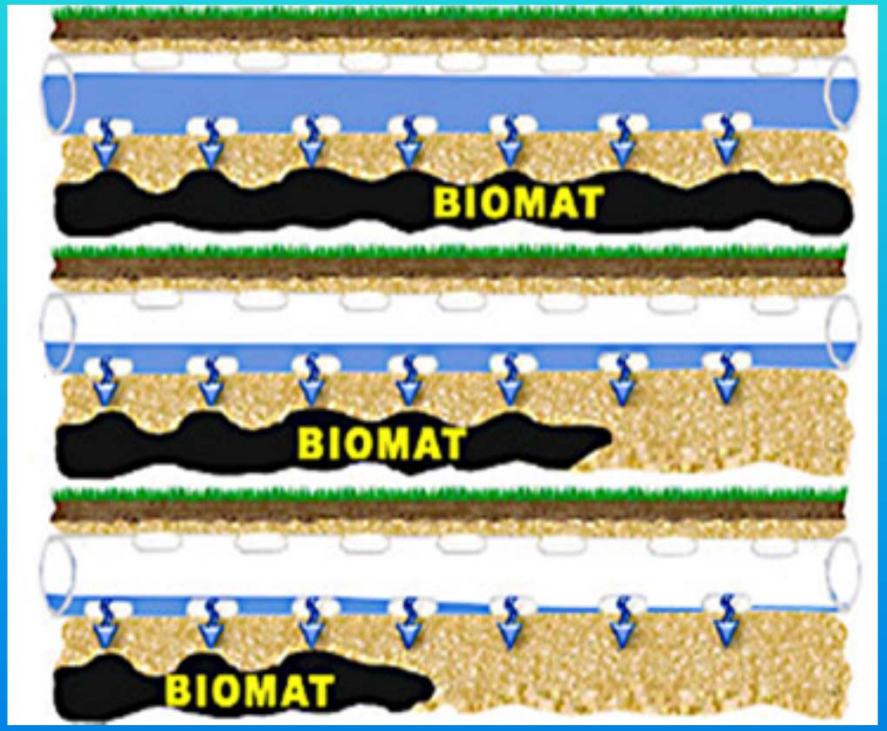
This self-cleaning property, along with a consistent septic tank effluent load, allows a properly designed disposal field to be passive and function without constant maintenance.



# Microbiology of Septic Systems

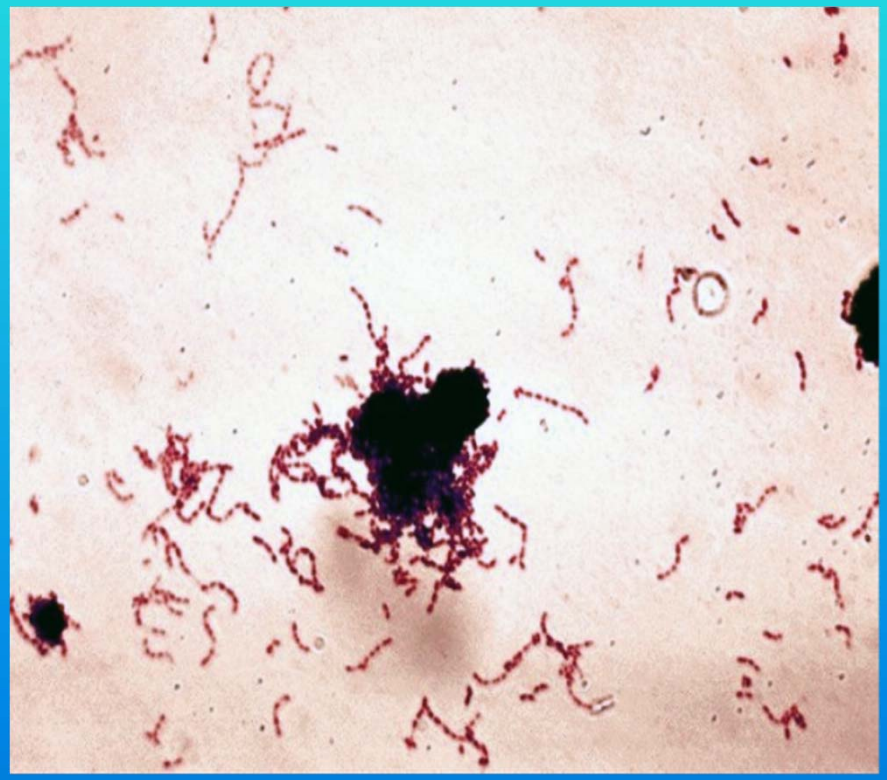
As the biomat matures, the infiltration rate through it decreases, stabilizing after 3 to 36 months. This is often referred to as the long term acceptance rate, although the term is more often associated with soil permeability.

# Microbiology of Septic Systems

One important characteristic of biomats is that they provide a variety of environments. They establish their own gradients of nutrients, oxygen saturation, and pH relative to the bulk environment.

# Microbiology of Septic Systems

Alternately facultative bacteria which can exist both with and without oxygen, or random seed bacteria which are everywhere in the soil can colonize a disposal area, as long as food is present.



# Microbiology of Septic Systems

## Pathogen Transmission

There are two factors that significantly affect mobility of bacteria and viruses through the subsurface. First, the size of existing water filled pores (including cracks & fissures) will affect mobility. Second, the velocity of water through these pores plays an important role in microorganism mobility.

There are also two mechanisms of retention of bacteria in the subsurface environment.

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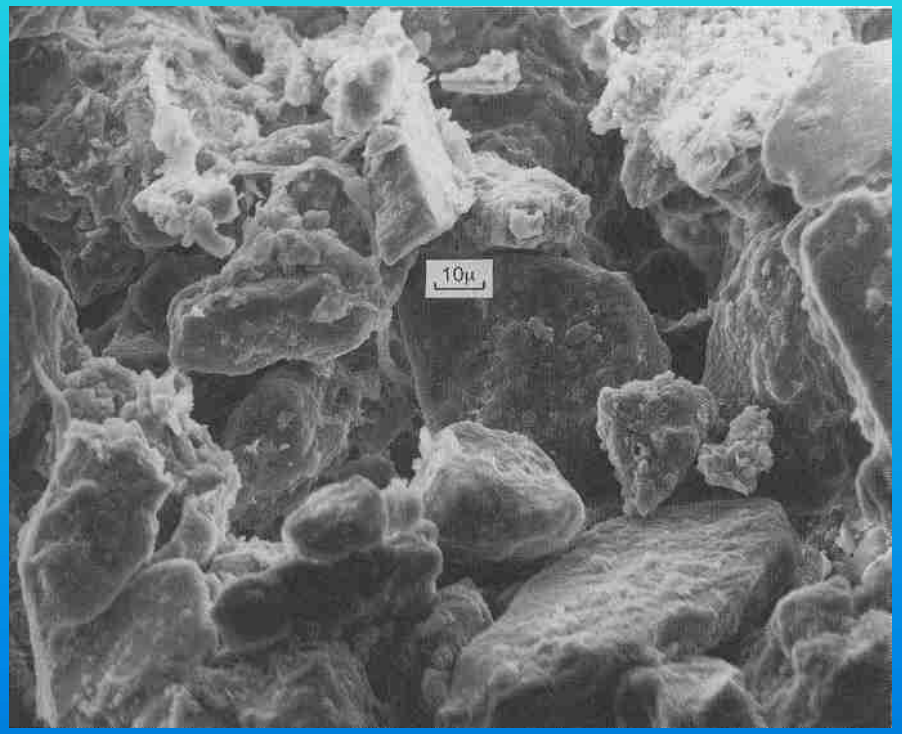
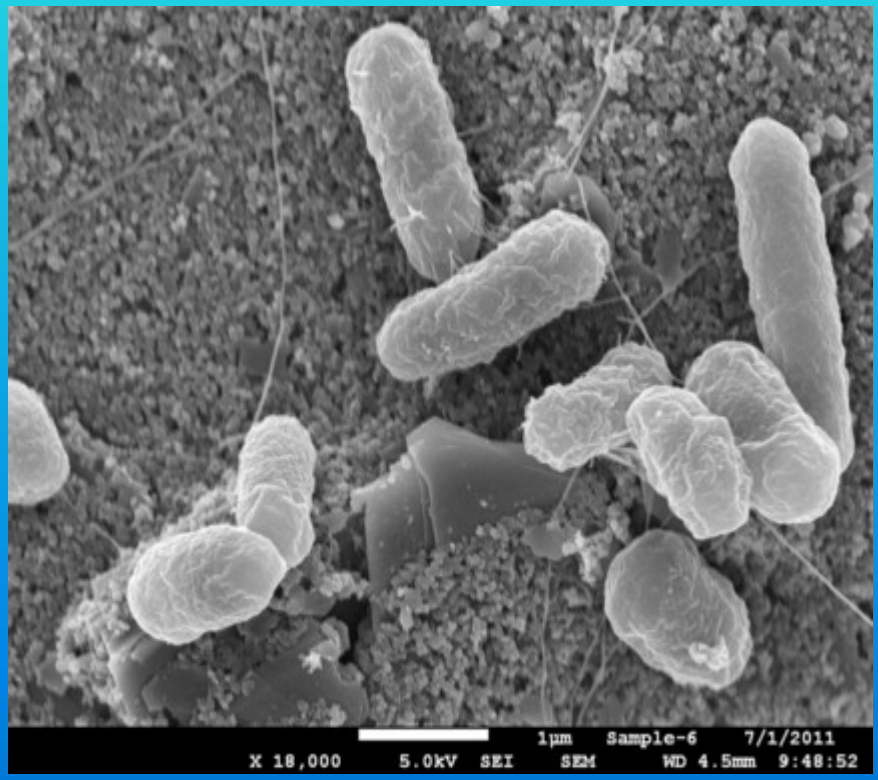
The first mechanism is filtration. This is the trapping of particles and bacteria in pore spaces. Larger suspended particles are trapped first. These then act as a filter for progressively smaller particles and bacteria. Eventually this system will become clogged and block further transport.



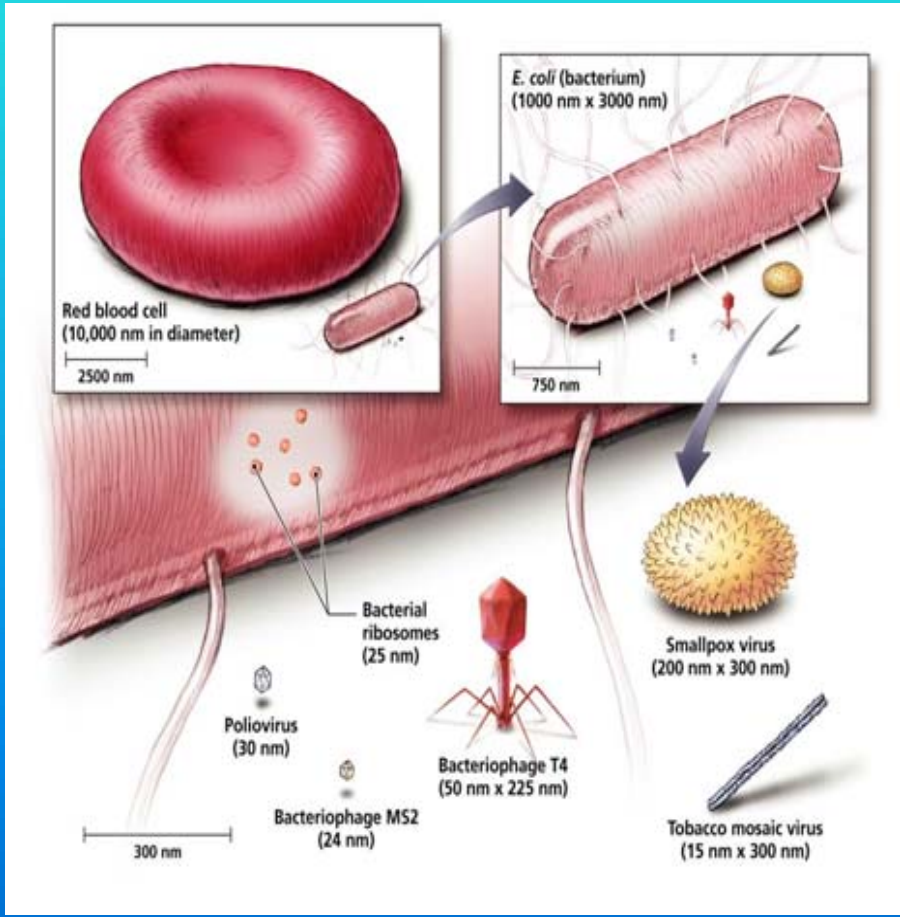
# Microbiology of Septic Systems

The second mechanism of retention of bacteria is adsorption, the adhesion of microbes to the surfaces of soil particles. Clays are ideal because of their small particle size, layered structure, and large surface-to-volume ratio. Thus, adsorption plays a more important role in soils that contain clays.



# Microbiology of Septic Systems

Because of the small size of viruses their retention is mainly by adsorption. The best retention usually happens between pH 3 to pH 7. Increased salt concentrations and the presence of cations will also increase adsorption. Rainfall can mobilize previously retained bacteria and viruses.



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Fortunately, pathogenic microorganisms not native to the subsurface environment generally don't multiply underground and will eventually die. Despite this they can move far enough and live long enough to be of concern around wastewater disposal areas. Of special concern, saturated flow conditions can lead to horizontal movement of microbes. Unsaturated conditions are optimal and lead to greater attenuation.

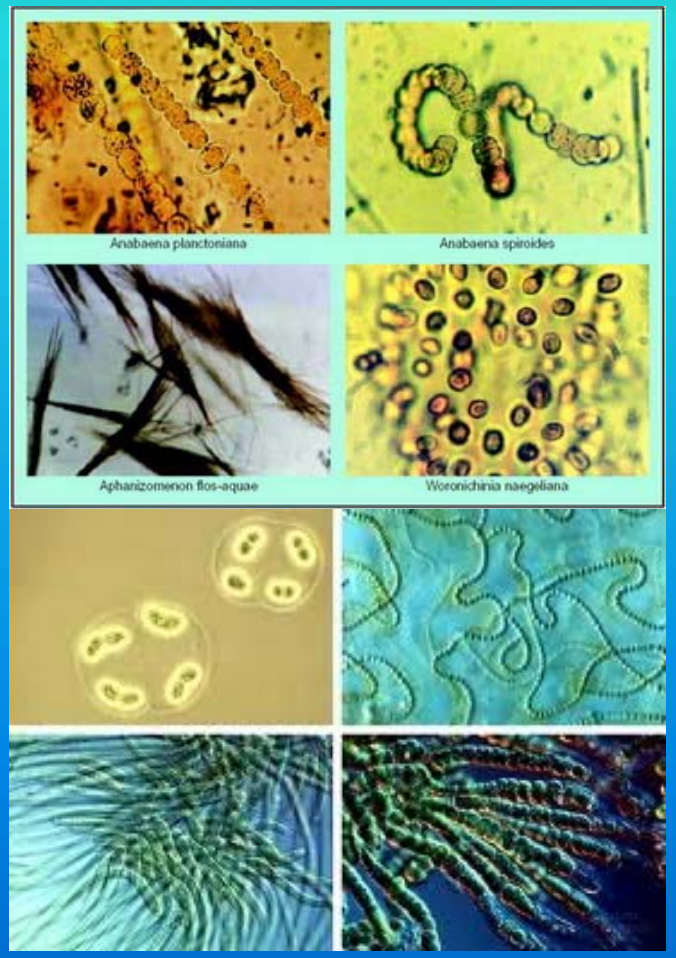
# Microbiology of Septic Systems

## Summary

The primary purpose of an onsite system is to reduce the amount of pollutants in effluent before it reaches ground or surface waters.

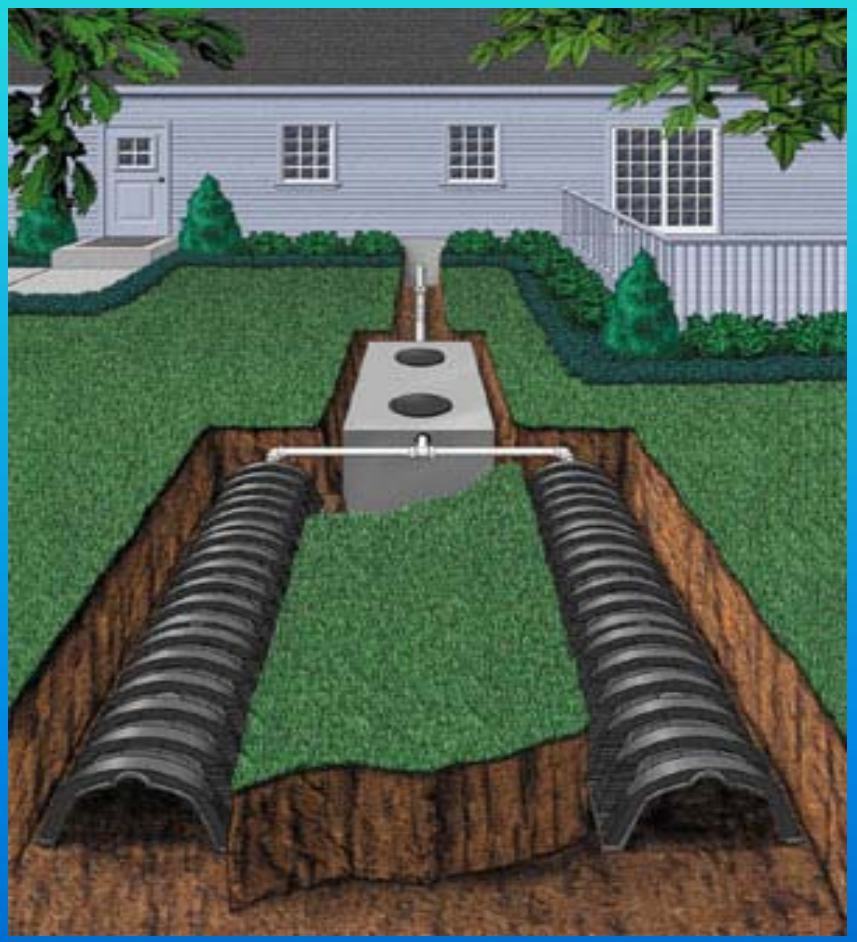
# Microbiology of Septic Systems

While bacteria may be the most prevalent organism in a septic system, there are actually a wide variety of organisms at work in a conventional septic system.



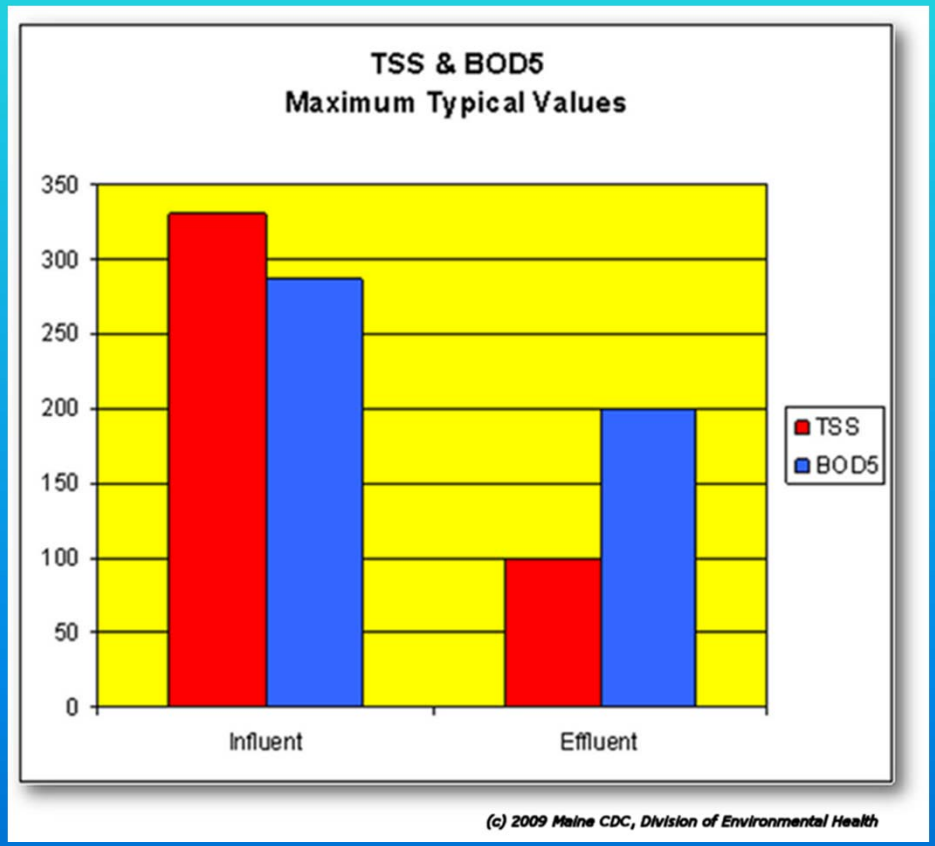
# Microbiology of Septic Systems

Treatment occurs in 2 phases, anaerobic digestion in the septic tank & aerobic and anaerobic digestion in the disposal area and filtration in the surrounding soils.



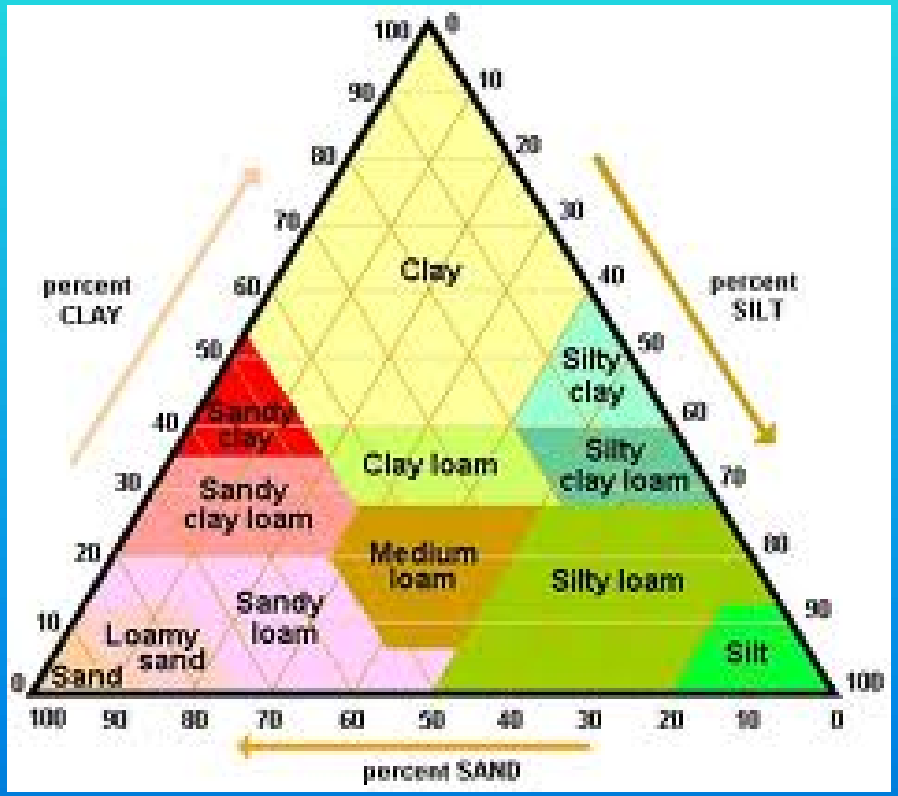
# Microbiology of Septic Systems

About ½ the pollutants are removed by anaerobic digestion and/or retained in the septic tank, and the remaining constituents are metabolized by microbes in and adjacent to the disposal area in both aerobic and anaerobic conditions.



# Microbiology of Septic Systems

Finely textured soils provide the best filtration and retention of microbes, and coarse soil the worst.
Retained microbes in dry soils can be released by surface or ground water saturation.



# Microbiology of Septic Systems

## The End