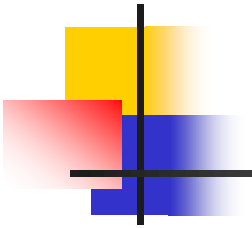
Activated Sludge Microbiology

Denise L. Seman
Youngstown WWTP

Activated Sludge

- Activated sludge is a type of secondary treatment whose primary role is to remove most of the dissolved solids remaining in the waste stream after primary treatment.



- Activated sludge is an enrichment culture of micro and macro organisms that remove (or change) components considered to be pollutants.

- The balance of organisms present in the sludge will indicate the overall health and ability of the activated system

Activated sludge tank

Mixed Liquor

- Mixed liquor is the mixture of primary effluent wastewater and microorganisms present in the treatment process BY DESIGN

Mixed Liquor

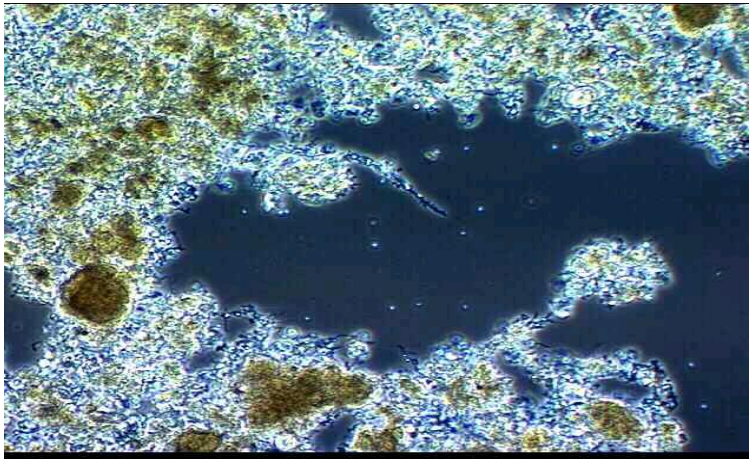
- The wastewater serves as a food source for the microorganisms
- The microorganisms remove organic material from the wastewater (the "food")

Mixed Liquor

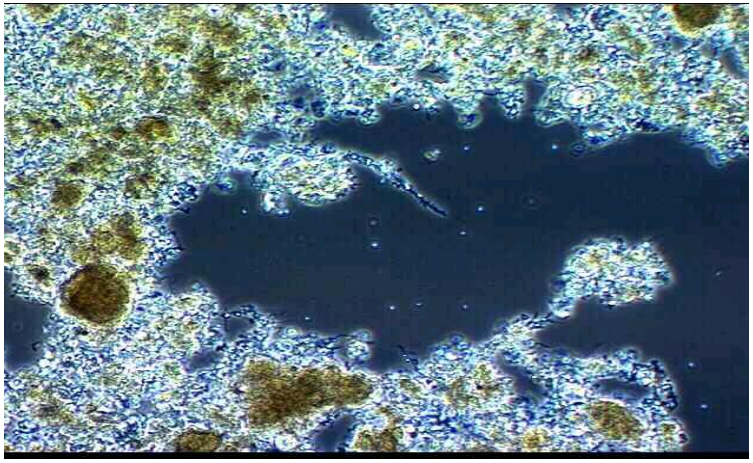
- The microorganisms settle out as sludge
- The portion returned to the aeration tanks is called Return Activated Sludge
- The portion wasted is called Waste Activated Sludge

Activated sludge

- Aerobic floc in a healthy state is commonly referred to as activated sludge.



- Aerobic floc has a metabolic rate approximately ten times higher than anaerobic sludge



Activated sludge

- Metabolic rate of aerobic floc can be boosted by the introduction of an abundance of oxygen.

- Activated sludge tank using aerobic bacteria can reduce organic material in approximately 4-6 hours

Activated sludge

- Septic tanks takes several days to reduce organic material through use of anaerobic bacteria
- The use of aerobic bacteria allows a much higher degree of overall process efficiency.

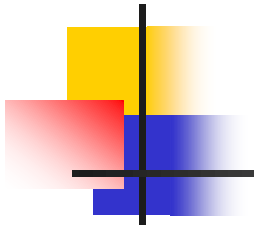
Activated sludge

- Frequently, most treatment efficiencies and removal levels are so improved that additional downstream treatment components are dramatically reduced or totally eliminated.

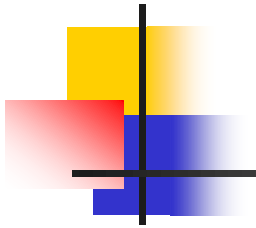
- The balance of organisms present in the sludge will indicate the overall health and ability of the activated system

Sludge Bulking

- Sludge bulking can occur when the filamentous organisms grow in large amounts, approximately 10^7um filaments per mL of activated sludge



- Bulking can result in loss of sludge inventory to the effluent, resulting in environmental damage to the receiving waters, NPDES violations, and failure of the facility to properly treat the wastewater



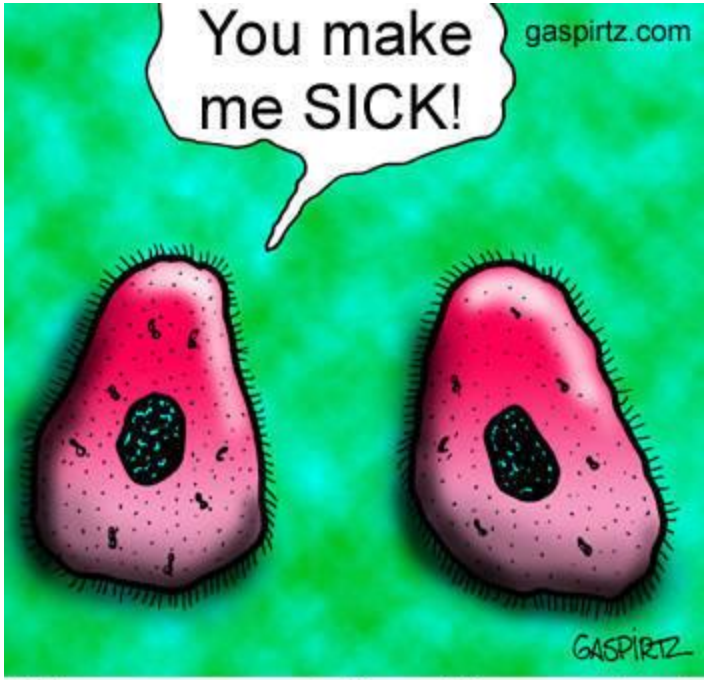
- Waste activated sludge with a bulking problem (1-2% solids) can occupy 2 to 4 times the volume of non-bulking sludge (3-4% solids)

Sludge Foaming

- Extremely stable, viscous foam occurs that does not break up with water sprays and will resist most anti-foaming agents

- Filamentous organisms commonly causing activated sludge foaming are Nocardia and M. parvicella

- Nocardia and M. parvicella can be opportunistic pathogens



When germ relationships go bad

- High foam can freeze in winter months, and create odor problems in warm weather, in addition to creating treatment problems

Causes of bulking/ foaming

- Low DO
- Low F:M
- Septic wastes/ sulfides
- Nutrient deficiency (N and/or P)
- pH <6.0

Microorganisms

- 95 % of the organisms present in activated sludge are bacteria.
- Only 5% are higher organisms

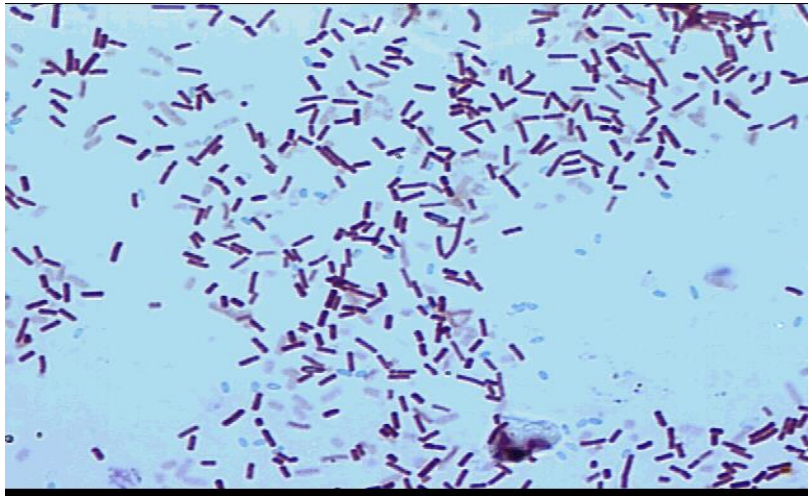
Microorganisms

- Five major groups generally found in the aeration tanks of an activated sludge system:
  - Bacteria
  - Protozoa
  - Metazoa
  - Filamentous bacteria
  - Algae and fungi

Bacteria

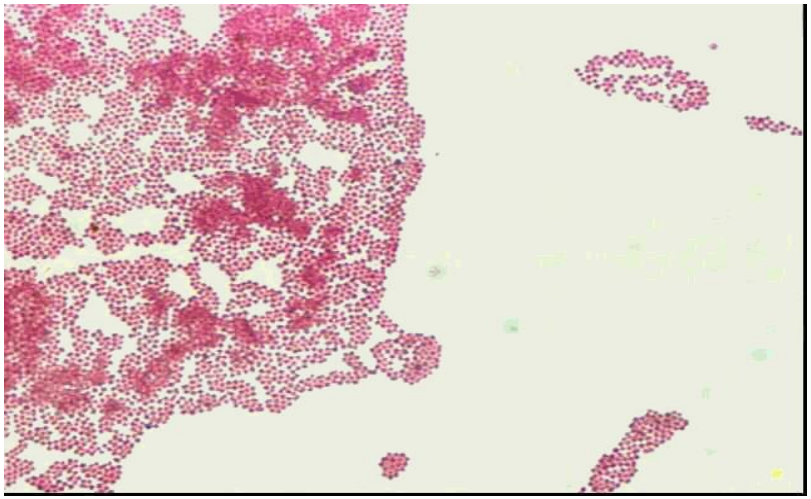
Bacteria

- Bacteria make up the majority of microorganisms present in activated sludge.



Bacteria

- Bacteria have the main role of removing the nutrients from the wastewater.
- Bacteria can be classified in several ways.



Bacteria

- They are frequently classified based on how they respond to oxygen.
  - Aerobic
  - Anaerobic
  - Facultative

Aerobic bacteria

- Aerobic bacteria require oxygen for growth and maintenance

Aerobic bacteria

- Aerobic bacteria do NOT survive when oxygen is absent
- Aerobic bacteria contribute to the decomposition of organic material

Anaerobic bacteria

- Anaerobic bacteria release hydrogen sulfide as well as methane gas, both of which can create hazardous conditions.

Facultative bacteria

- Facultative bacteria prefer oxygen, but can survive without it.
- Nature of individual bacteria is dependent upon their environment

Facultative bacteria

- Usually, facultative bacteria will be anaerobic
- This changes if oxygen is added to the wastewater.

Protozoa

Protozoa

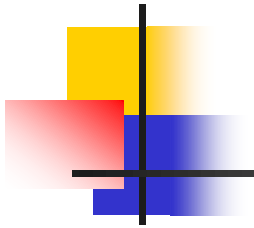
- Larger than bacteria
- Come in a variety of shapes

Protozoa

- Definitely more interesting to observe under a microscope
- Make up about 3 percent of activated sludge microorganisms

Protozoa

- Protozoa remove and digest free-swimming bacteria
- Protozoa remove other suspended particles present in the activated sludge
- This process improves the clarity of the effluent



- The relative dominance of different types of protozoa can give an indication of conditions in the treatment system

Protozoa

- Sudden changes in number and type of protozoa can predict problems unless adjustments are made

Types of Protozoa

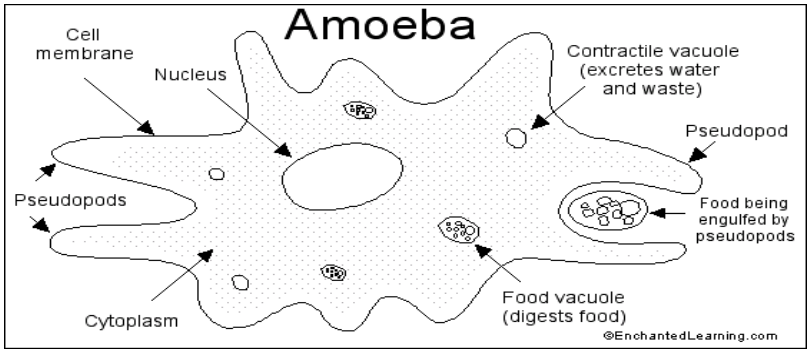
- Amoebae
- Flagellates
- Ciliates
  - Free-swimming ciliates
  - Crawling ciliates
  - Stalked ciliates

Amoebae

- Most primitive form of protozoa
- Contribute very little to the overall treatment of wastewater

Amoebae

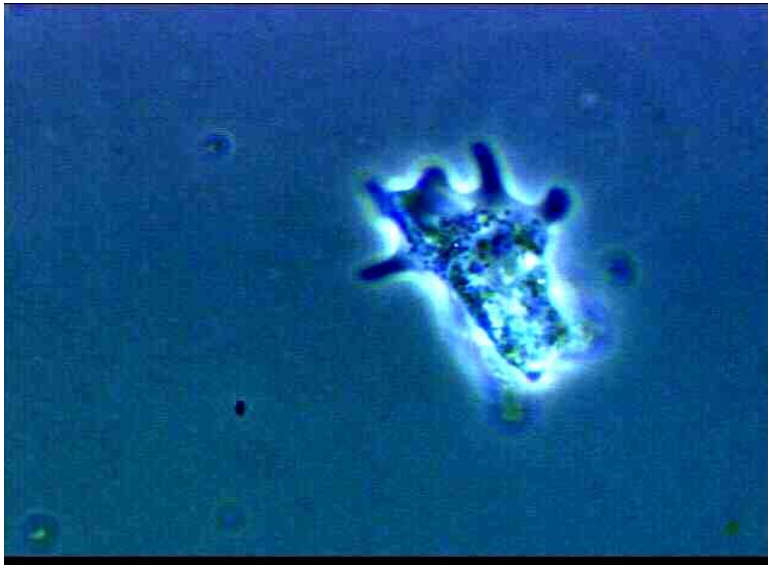
- Present only in very young sludge
- 2 types: testate and non- testate
  - Testate has a shell

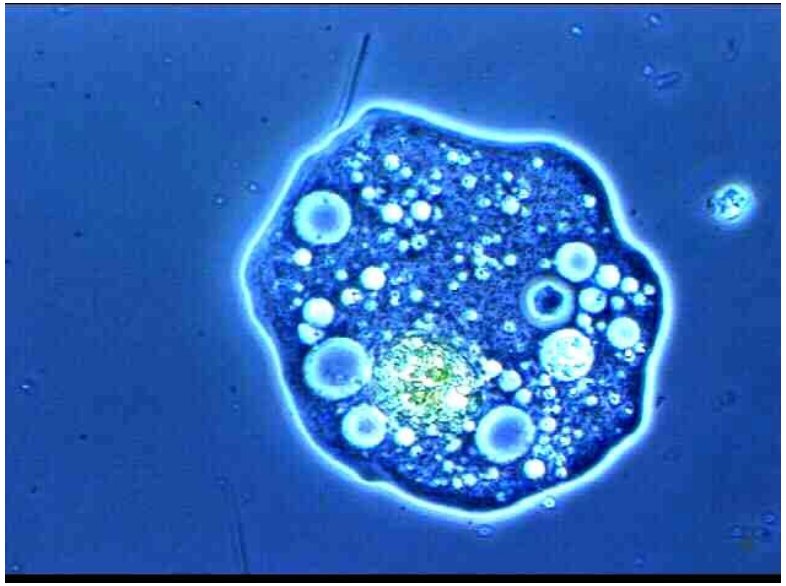


Testate amoebae

- Euglypha

Non-testate Amoebae





Flagellates

Flagellates

- Possess a whip-like structure that helps pull the organism through the water
- Have a tough outer membrane

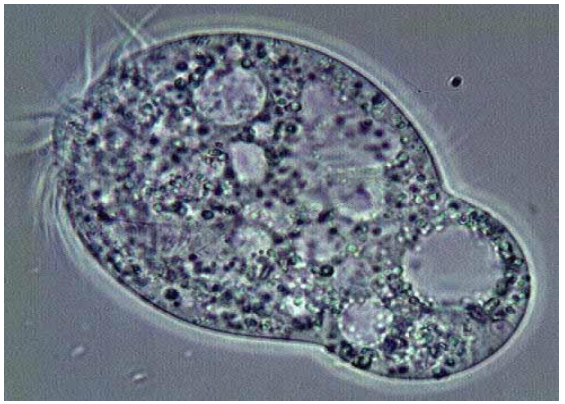
Flagellates

- Feed primarily on soluble organic nutrients
- Present in young sludge

Ciliates

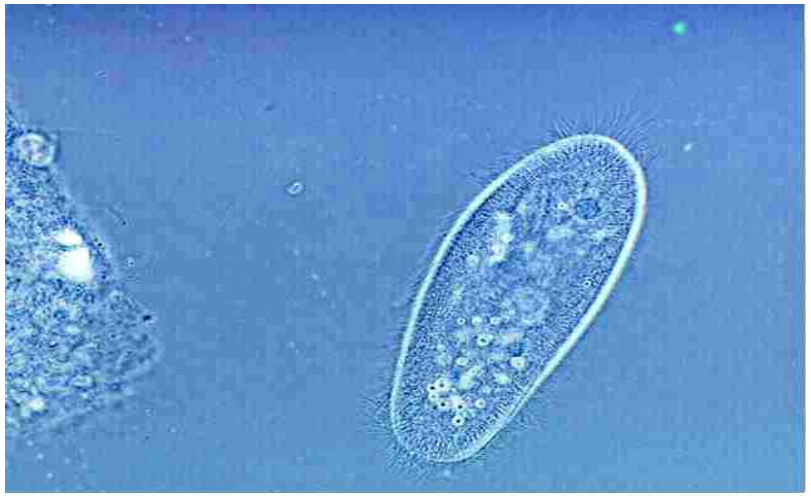
Ciliates

- Completely or partially covered with short, dense hairlike structures called cilia
- Cilia is the Latin word for eyelash



Ciliates

- Cilia provide a means of locomotion through the water
- Feed mostly on bacteria, algae, and yeast

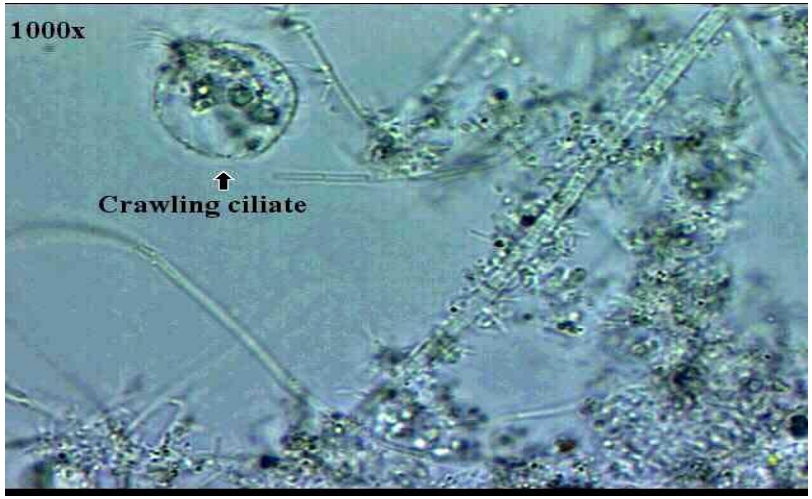


Ciliates

- Do nothing to contribute to the treatment of wastewater
- By consuming the organisms, they contribute to the clarity of the effluent

Crawling ciliates

- Very common in activated sludge
- Dominance of crawling ciliates indicates good treatment conditions

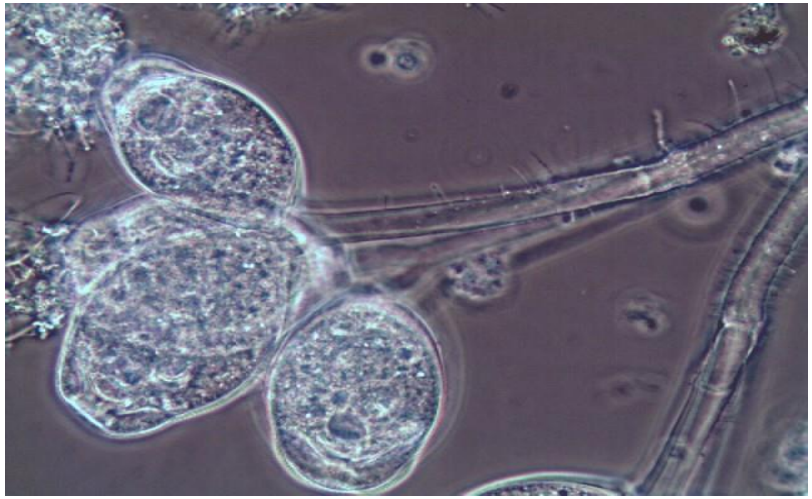


Crawling ciliates

- Dominance begins after most soluble nutrients have been removed
- Floc begins to form from dispersed bacteria

Stalked ciliates

- No actual cilia on their bodies outside of the fringe present around the mouth ends
- Cilia create a current that moves food into their mouths



Stalked ciliate

- Feed mostly on suspended bacteria, algae or smaller protozoa
- Presence of stalked ciliates indicates a stable activated sludge process

Metazoa

Metazoa

- Metazoa are multicellular
- Include all animals EXCEPT protozoa

Metazoa

- Have very little to do with wastewater treatment
- Dominance of metazoa indicates OLD sludge

Metazoa

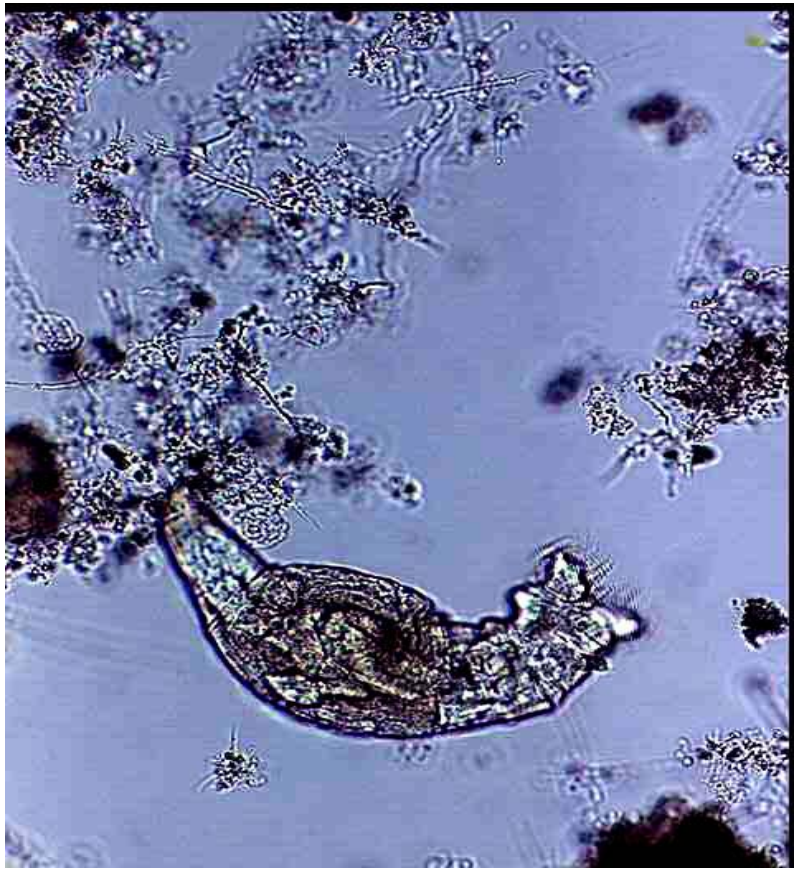
- Rotifers
- Nematodes
- Tartigrades (waterbear)

Rotifers

- Principle contribution is removal of leftover bacteria, algae or smaller protozoa
- Should NEVER dominate the system

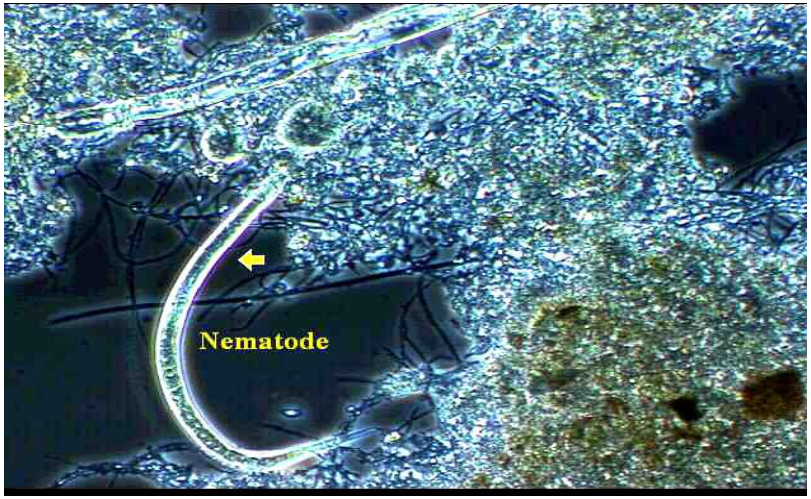
Rotifers

- Presence of dead rotifers in a fresh sample indicates toxic conditions occurring in the activated sludge



Nematodes

- Nematodes possess digestive, reproductive and nervous systems
- They feed on bacteria, fungi, small protozoa and sometimes other nematodes



Nematodes

- Some have teeth, and some have a spear to stick their prey with
  - They use the spear like a straw to suck in their food

Tartigrades (Waterbear)

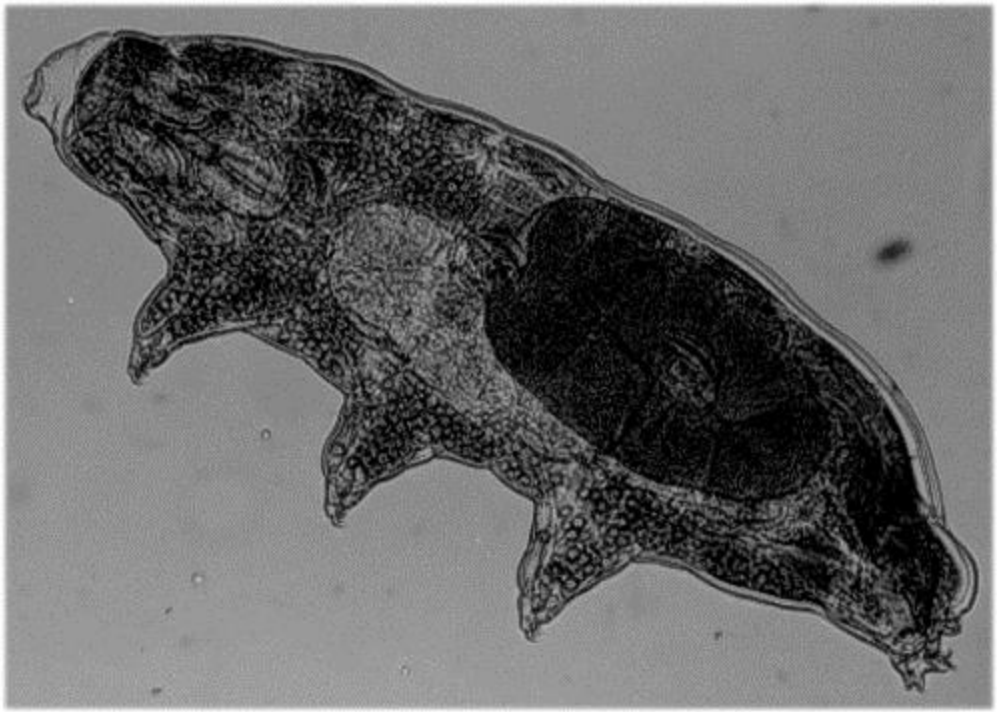
- Aquatic organisms that depend on water to find food

Tartigrades (Waterbear)

- Able to withstand extreme environmental conditions

Tartigrades (Waterbear)

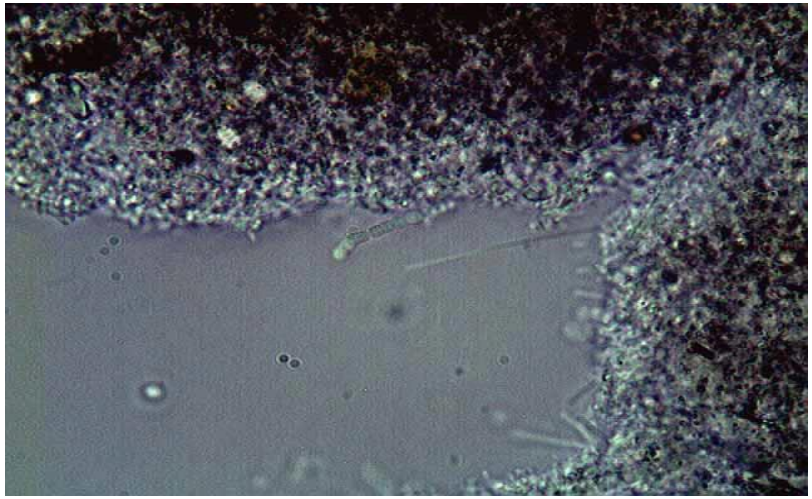
- Sensitive to toxic conditions



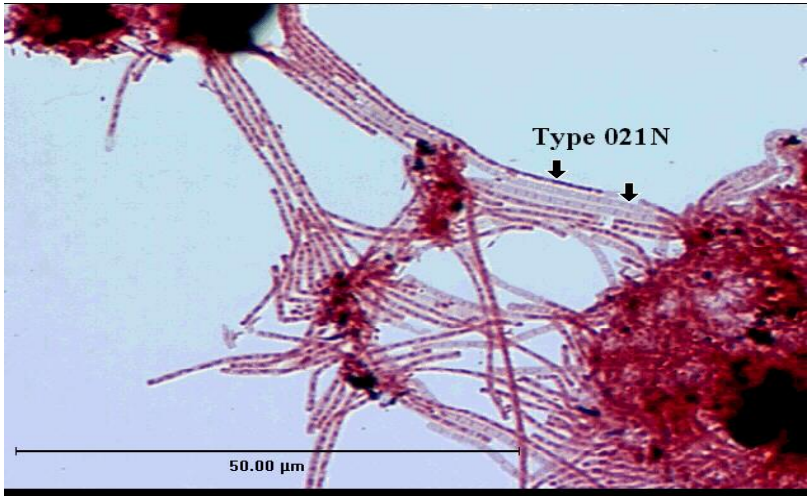
Filamentous Bacteria

Filamentous bacteria

- Some filamentous bacteria in the system can help with floc formation



- Excess filamentous bacteria in the system can create massive problems in operation/ treatment

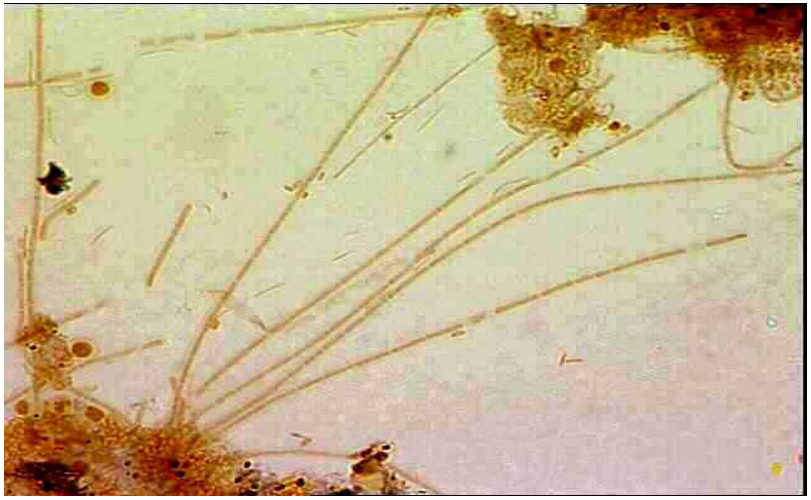


Filamentous bacteria

- Excellent BOD reducers
- Do not settle very easily, forming a bridge between floc and within floc
- Require high dosages of polymer

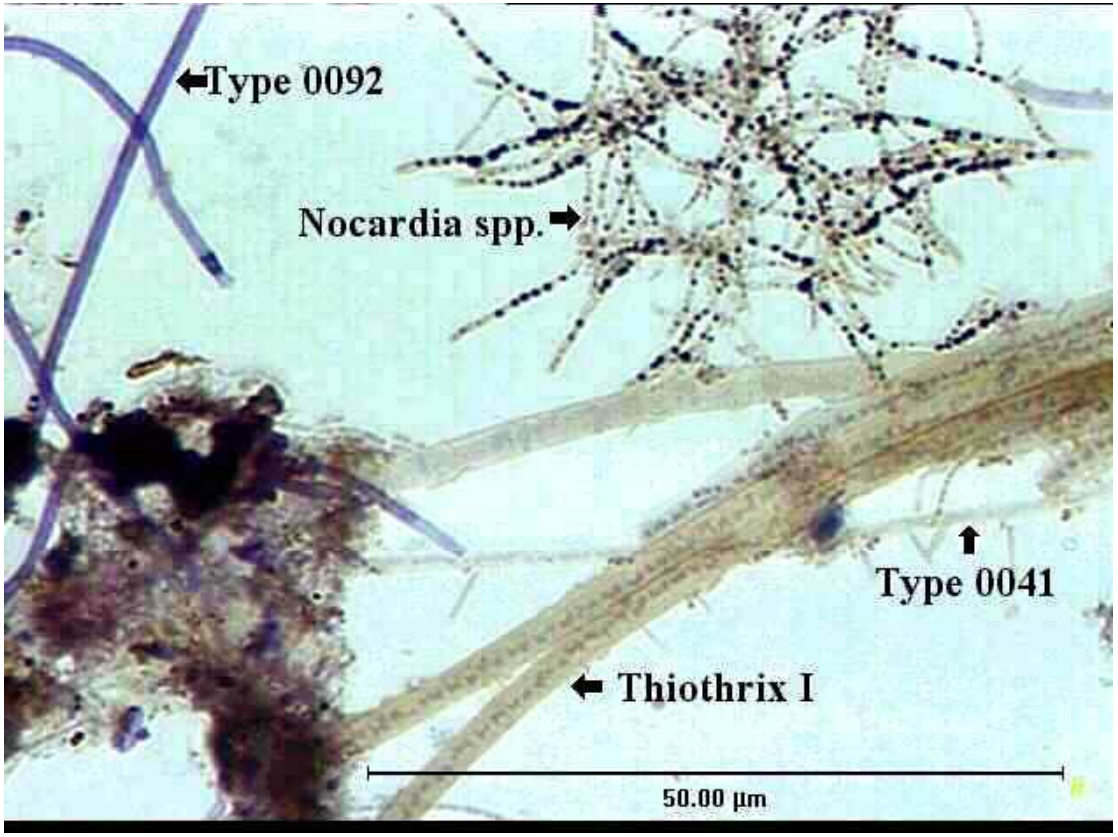
Filamentous bacteria

- Hold a lot of water preventing good dewatering of the sludge.
- Can increase polymer consumption



Filamentous bacteria

- Can increase solids handling costs
- Can cause bulking in the clarifiers or foaming in the aeration basins.


Type 0092
Nocardia spp.
Type 0041
Thiothrix I
50.00 µm

Algae and Fungi

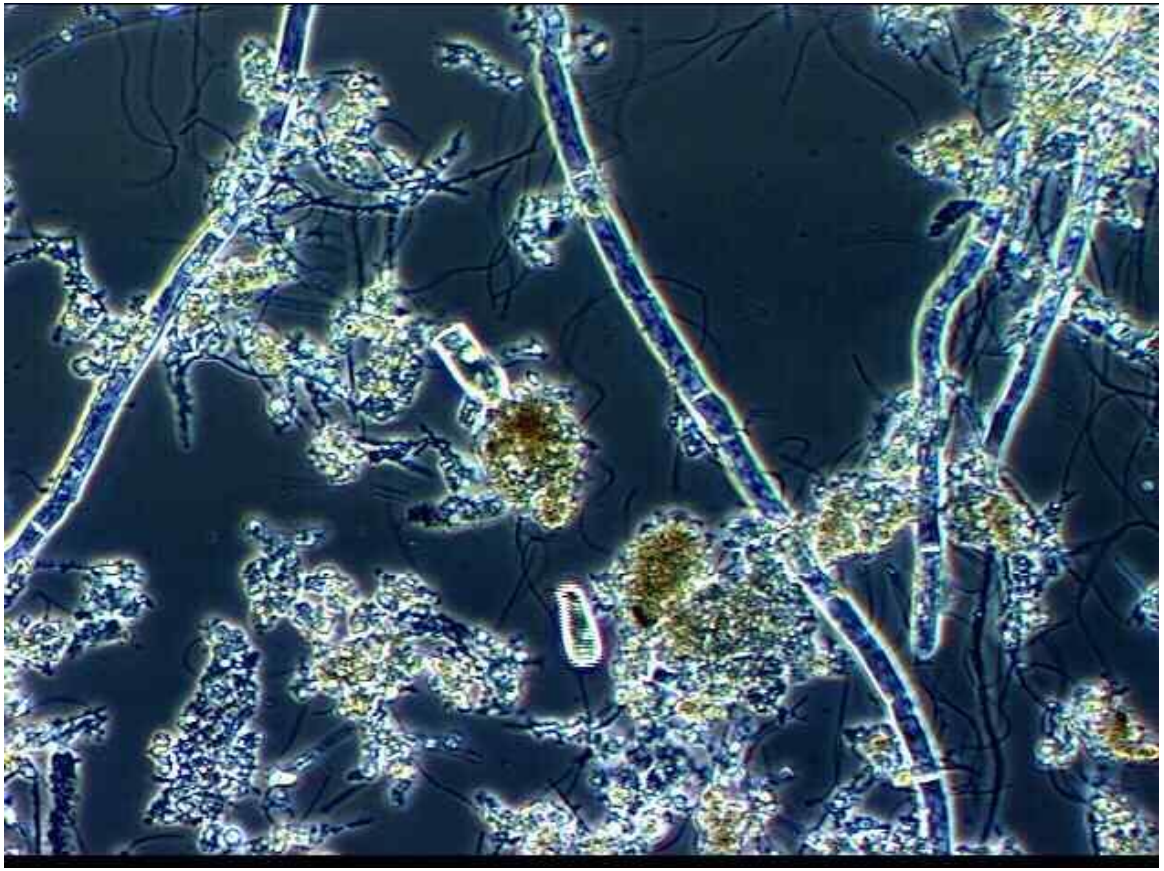
Algae

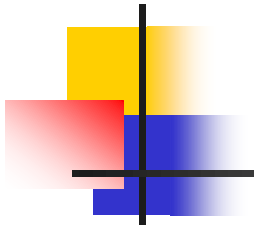
- Algae are usually found in lagoon systems.
- Algae do not normally cause problems in activated sludge systems

Fungi

- Fungi feed on decaying matter
- Presence of fungi in activated sludge usually means the system has a pH problem and the sludge is old

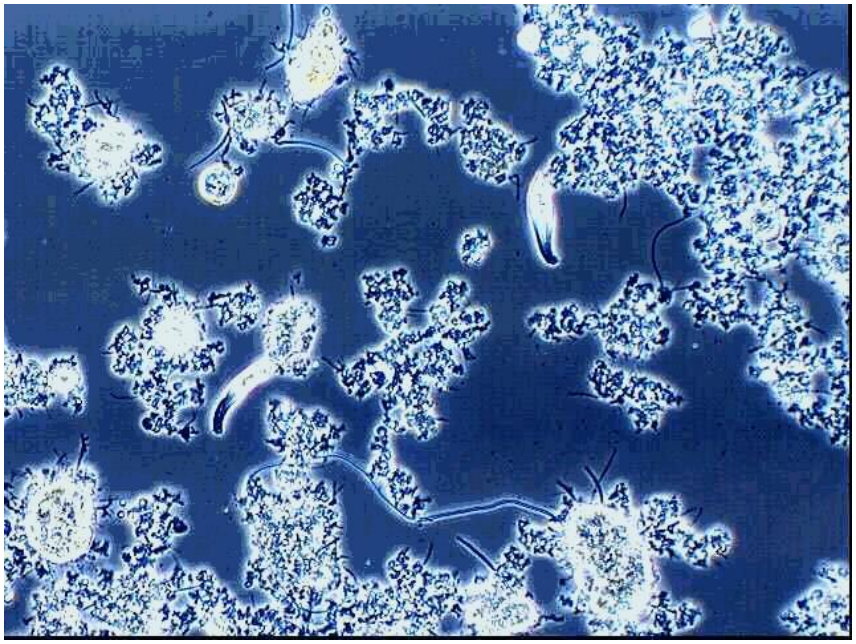
Fungi



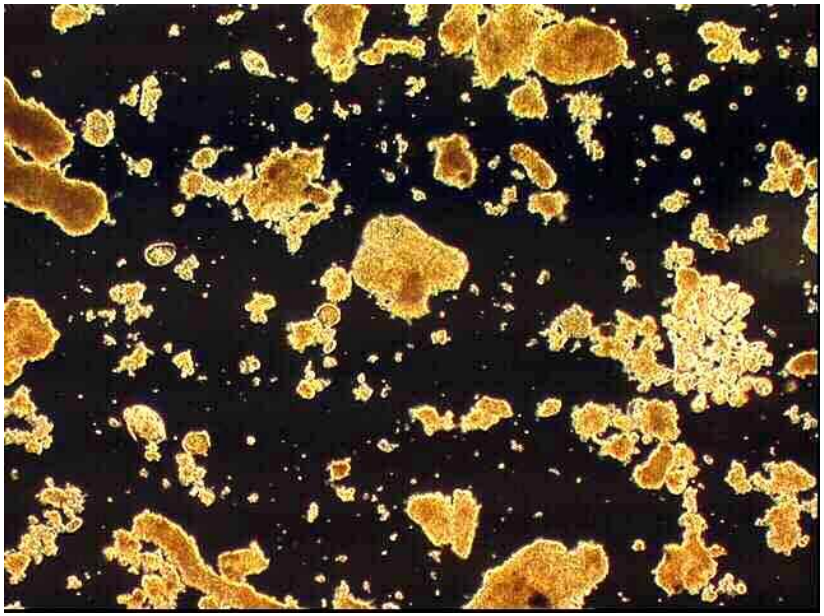


Healthy Activated Sludge

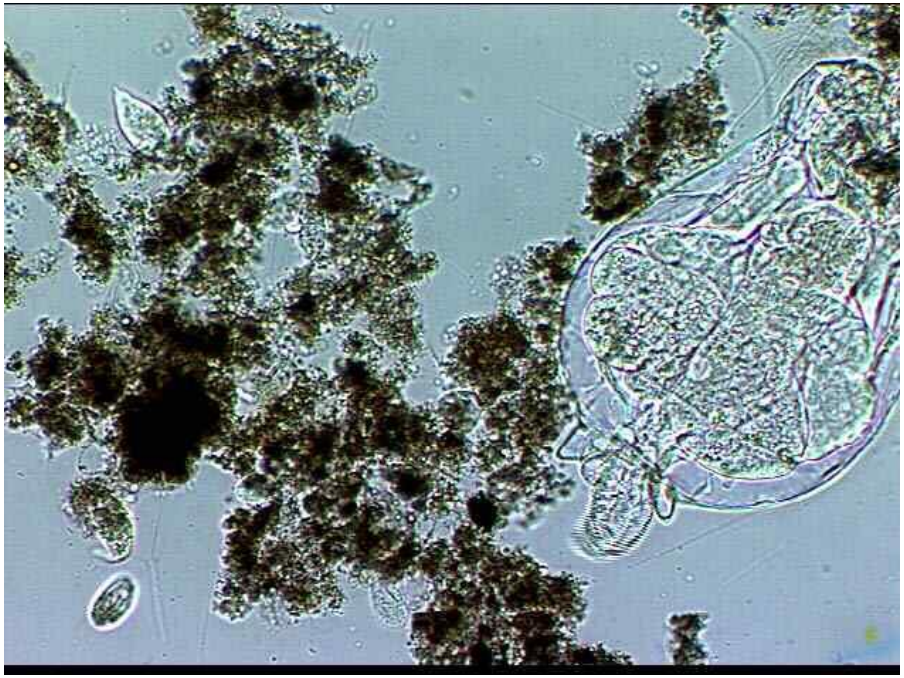
- Young sludge, clear with better floc formation

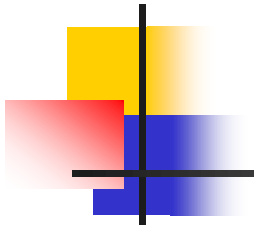


- Good, healthy sludge



- Old sludge



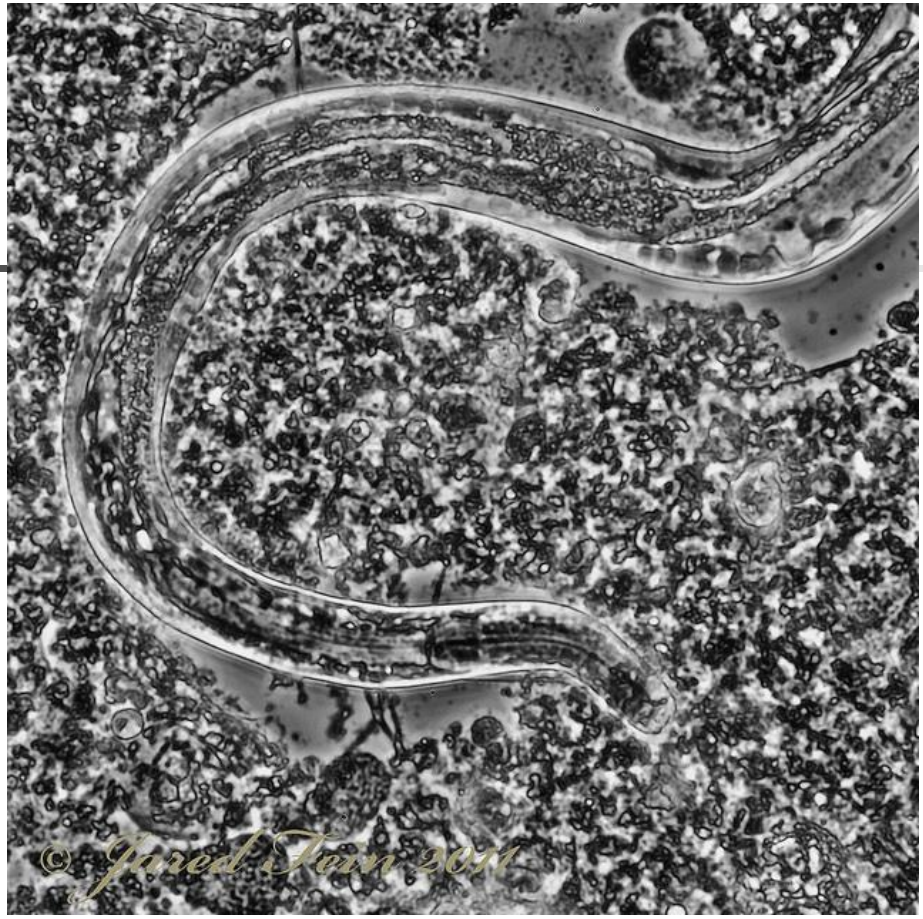


WHAT IS THIS???

Vorticella

Nocardia

Rotifer



nematode

References

- Wastewater Microbiology "A Handbook for Operators" by Toni Glymph. Published by AWWA
- Environmental Leverage, INC http://www.environmentalleverage.com/index.htm
- MOP 11, WEF

- Questions?

  - Contact info:

    Denise Seman

    City of Youngstown WWTP

    725 Poland Ave

    Youngstown, OH

    330-742-8820

    DSeman@CityofYoungstownOH.com