

# MICROBIOLOGY OF ACTIVATED SLUDGE



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- ❑ 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.
- ❑ The wastewater serves as a food source for the microorganisms.
- ❑ The microorganisms remove organic material from the wastewater (the “food”).
- ❑ 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

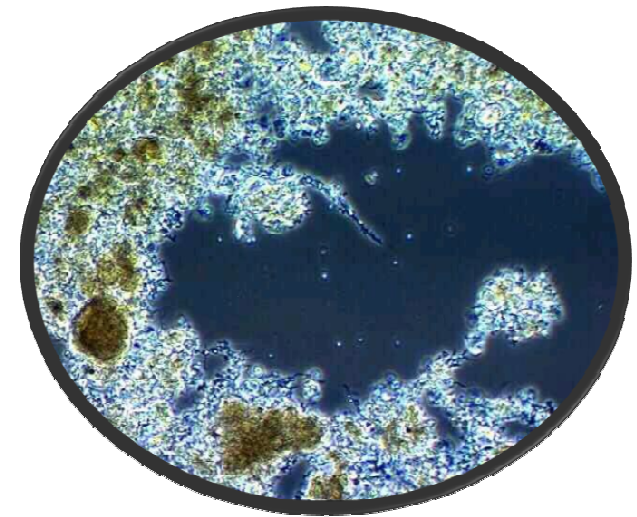
❑ Aerobic floc in a healthy state is commonly referred to as activated sludge.

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

❑ 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

❑ 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.
- 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

# **MICROORGANISMS**

□ Five major groups generally found in the aeration tanks of an activated sludge system:

✓ **Bacteria**

✓ **Protozoa**

✓ **Metazoa**

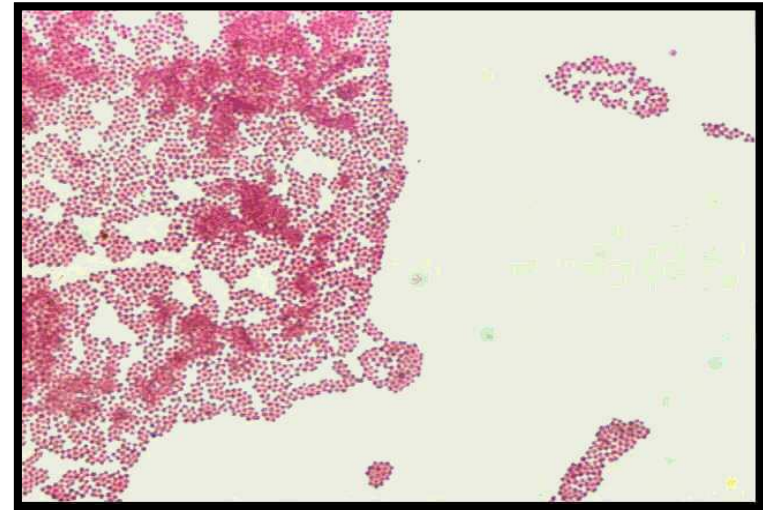
✓ **Filamentous bacteria**

✓ **Algae and fungi**

# BACTERIA

➤ Bacteria have the main role of removing the nutrients from the wastewater.

➤ Bacteria can be classified in several ways.





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

# PROTOZOA

- Larger than bacteria
- Come in a variety of shapes
- Definitely more interesting to observe under a microscope
- Make up about 3 percent of activated sludge microorganisms
- 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
- 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

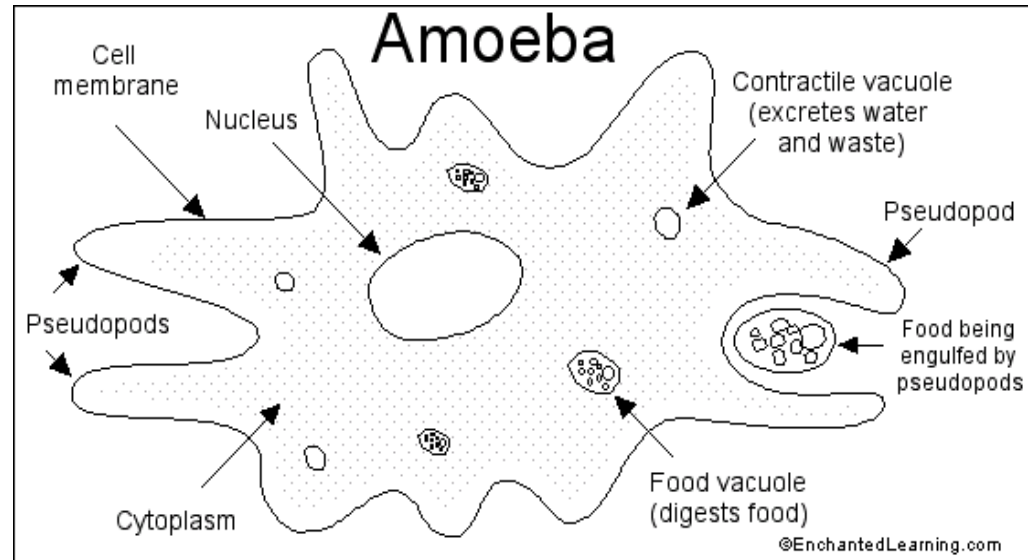
# Amoebae

- ❑ Most primitive form of protozoa
- ❑ Contribute very little to the overall treatment of wastewater
- ❑ Present only in very young sludge

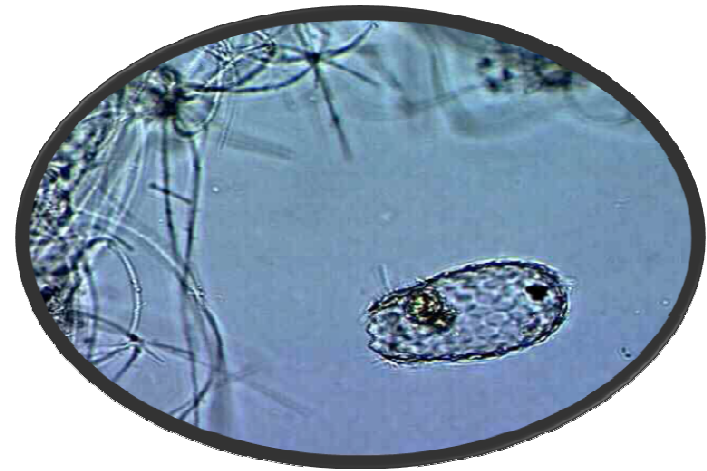
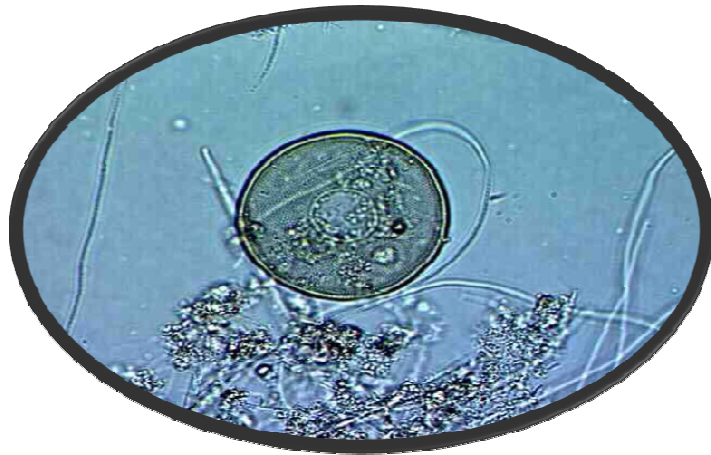
2 types:

testate and non- testate

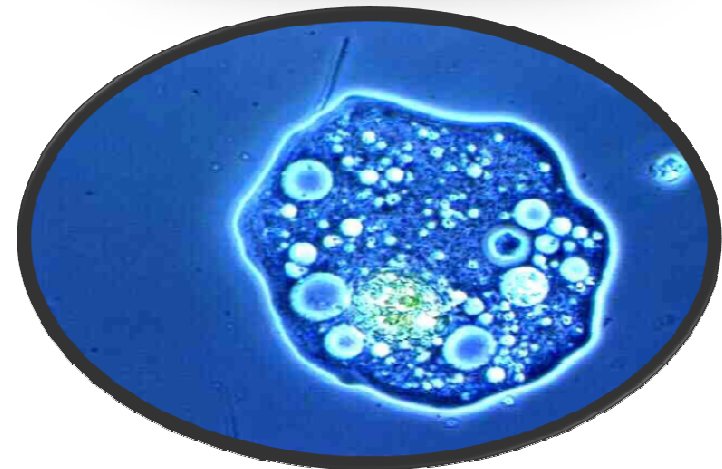
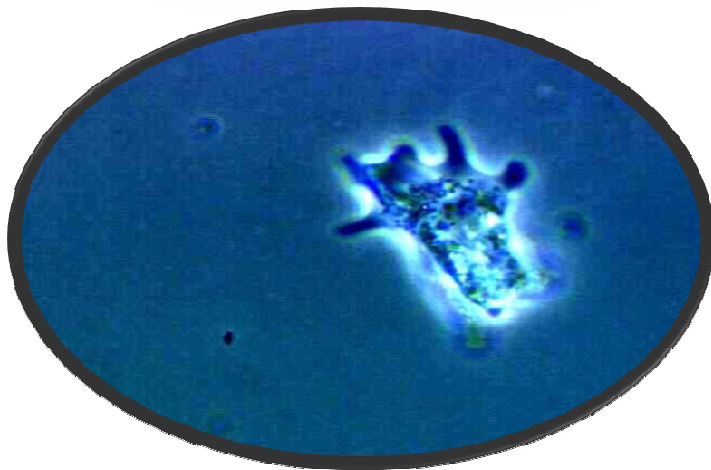
Testate has a shell



## Testate amoebae



## Non-Testate amoebae



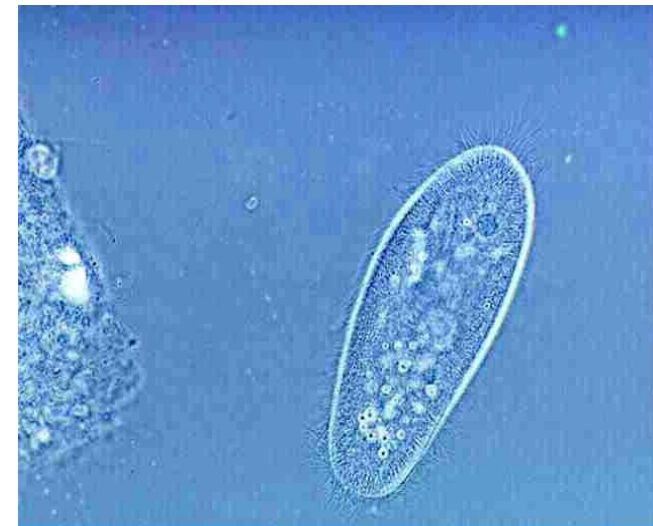
## FLAGELLATES

- ❑ Possess a whip-like structure that helps pull the organism through the water
- ❑ Have a tough outer membrane
- ❑ Feed primarily on soluble organic nutrients
- ❑ Present in young sludge



# CILIATES

- ❑ Completely or partially covered with short, dense hair like structures called cilia
- ❑ Cilia is the Latin word for eyelash
- ❑ Cilia provide a means of locomotion through the water
- ❑ Feed mostly on bacteria, algae, and yeast
- ❑ 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
- ❑ 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
- ❑ Feed mostly on suspended bacteria, algae or smaller protozoa
- ❑ Presence of stalked ciliates indicates a stable activated sludge process



# **METAZOA**

- Metazoa are multicellular
- Include all animals EXCEPT protozoa
- Have very little to do with wastewater treatment
- Dominance of metazoa indicates OLD sludge

## **TYPES OF METAZOA**

- ❖ Rotifers
- ❖ Nematodes
- ❖ Tardigrades (waterbear)

## ROTIFERS

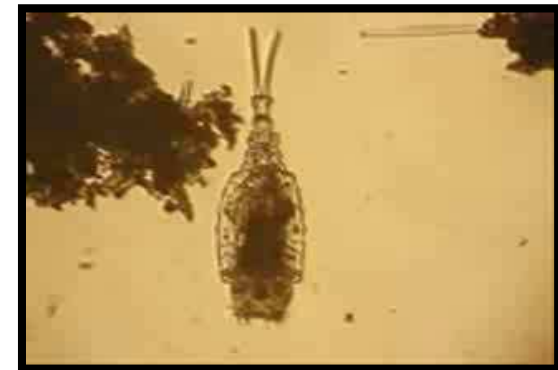
❑ Principle contribution is removal of leftover bacteria, algae or smaller protozoa



❑ Should NEVER dominate the system



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

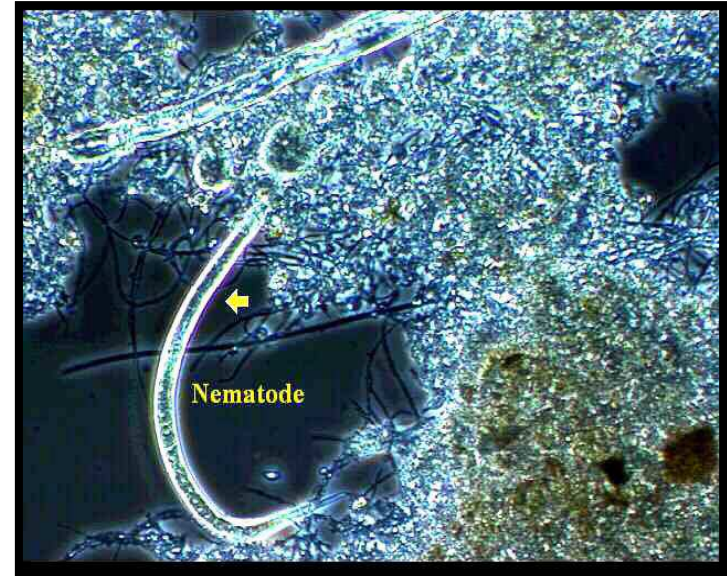


# NEMATODES

❑ Nematodes possess digestive, reproductive and nervous systems

❑ They feed on bacteria, fungi, small protozoa and sometimes other nematodes

❑ 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

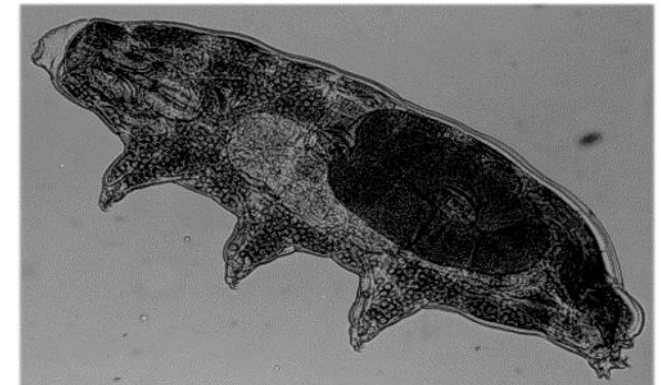
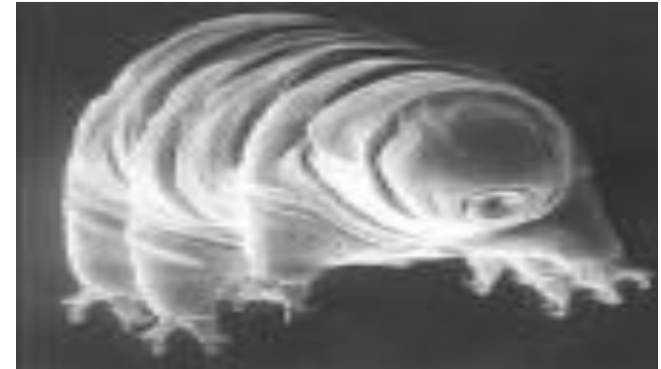


## TARTIGRADES (Waterbear)

❑ Aquatic organisms that depend on water to find food

❑ Able to withstand extreme environmental conditions

❑ Sensitive to toxic conditions

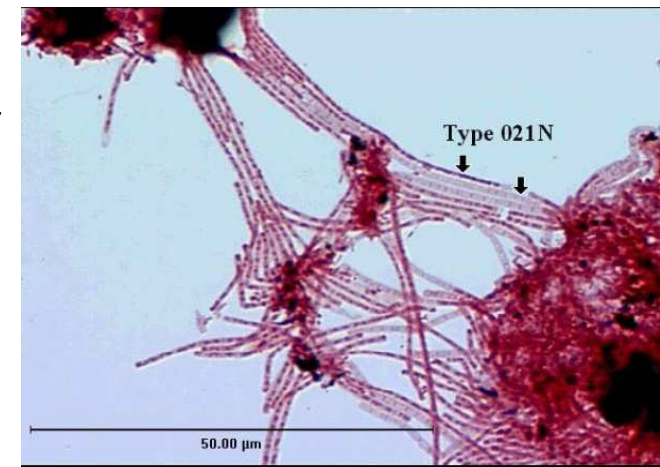


## FILAMENTOUS BACTERIA

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

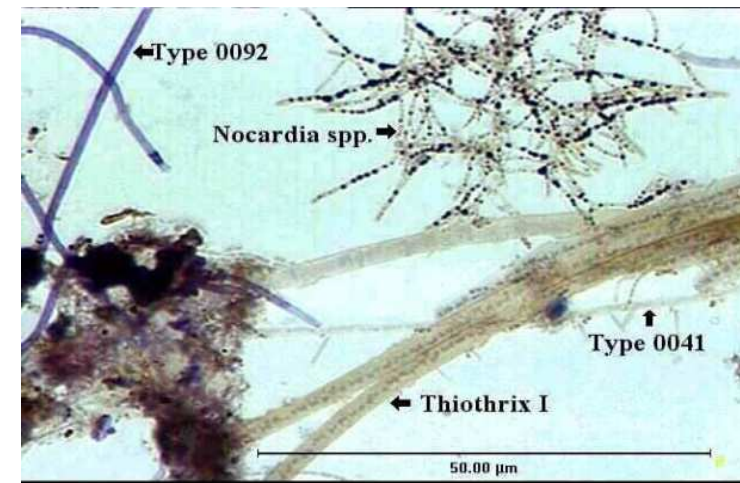
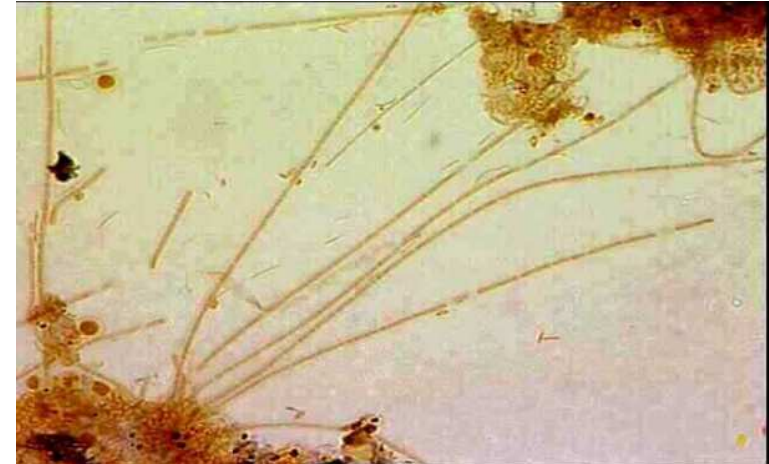


❑ Excess filamentous bacteria in the system can create massive problems in operation/ treatment



## FILAMENTOUS BACTERIA cont.....

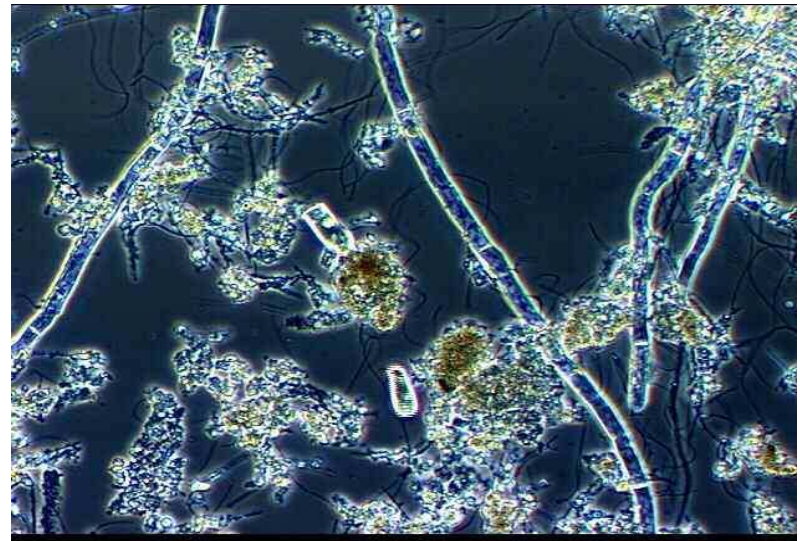
- ❑ Do not settle very easily, forming a bridge between floc and within floc
- ❑ Require high dosages of polymer
- ❑ Hold a lot of water preventing good dewatering of the sludge.
- ❑ Can increase polymer consumption
- ❑ Can increase solids handling costs
- ❑ Can cause bulking in the clarifiers or foaming in the aeration basins.



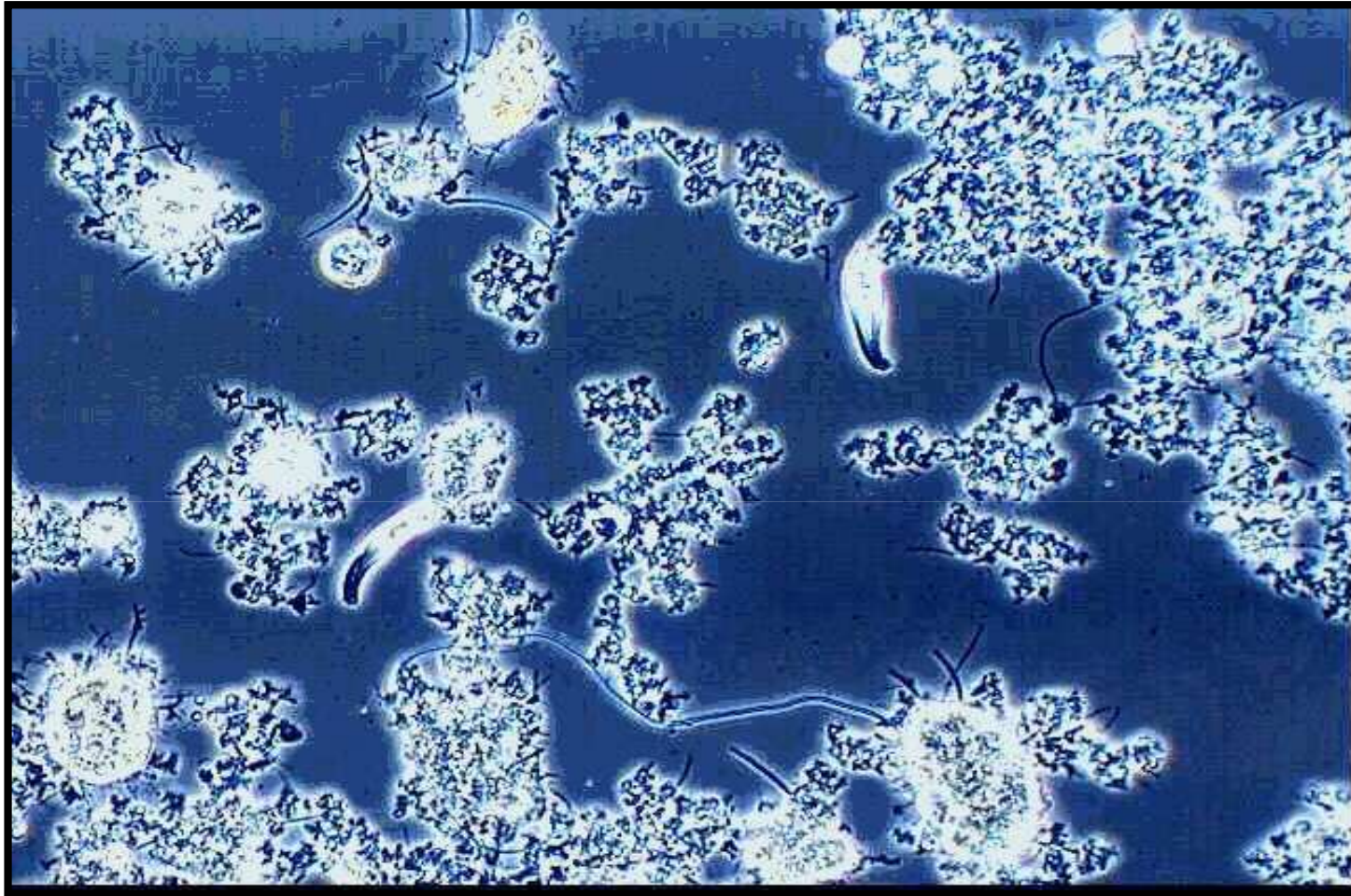


## ALGAE AND FUNGI

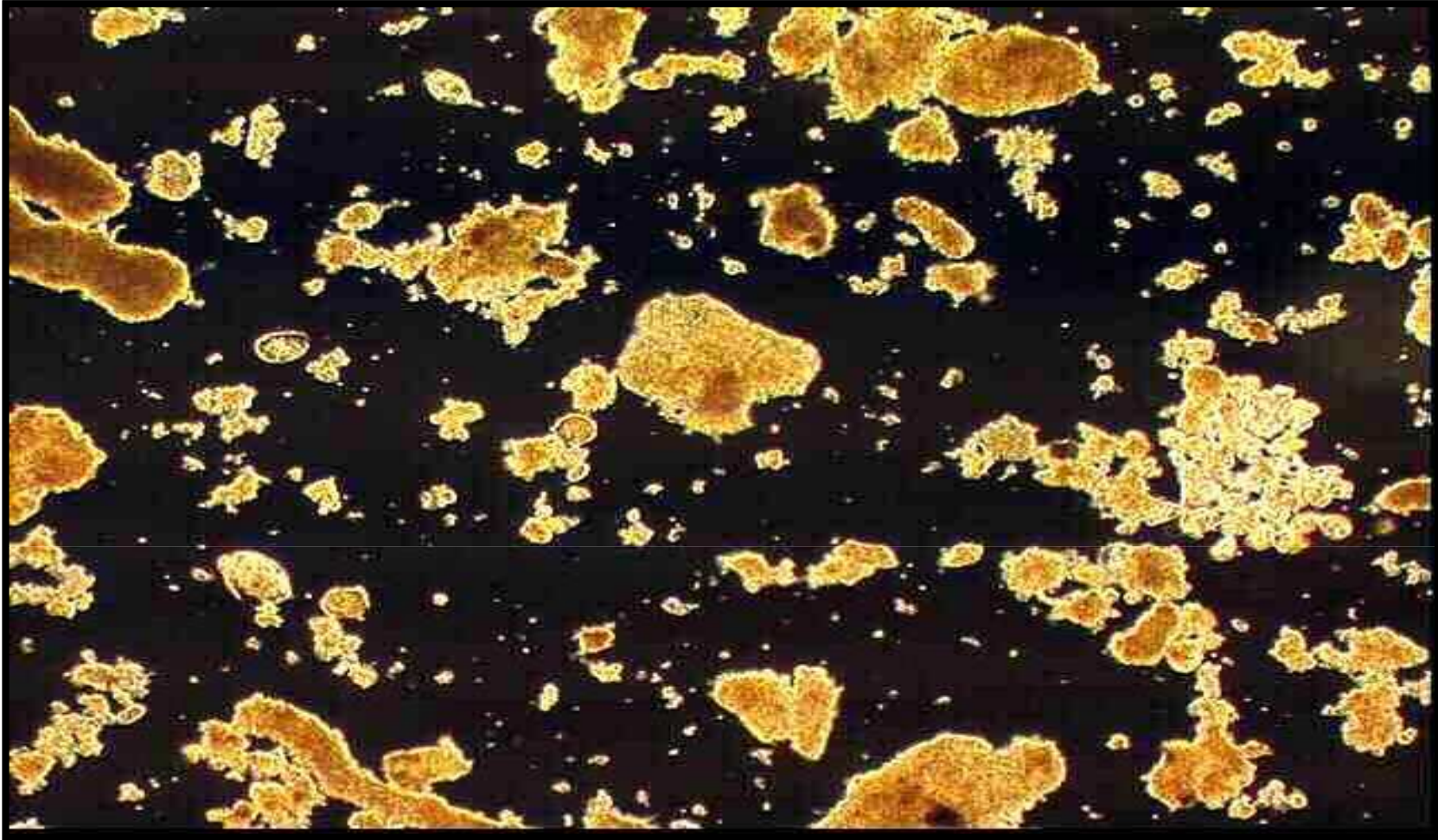
- ❑ Algae are usually found in lagoon systems.
- ❑ Algae do not normally cause problems in activated sludge systems
- ❑ Fungi feed on decaying matter
- ❑ Presence of fungi in activated sludge usually means the system has a pH problem and the sludge is old



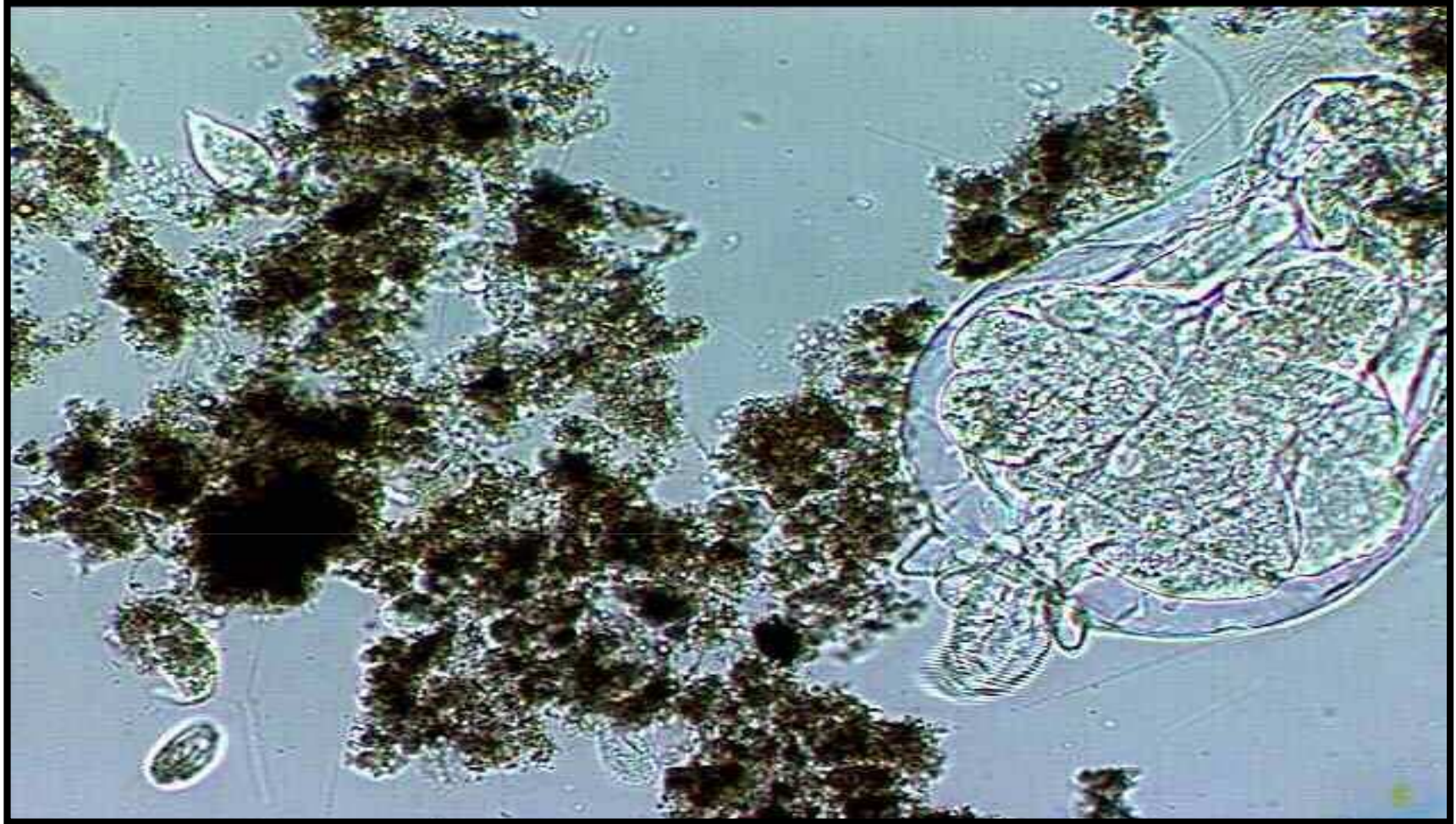
# HEALTHY ACTIVATED SLUDGE



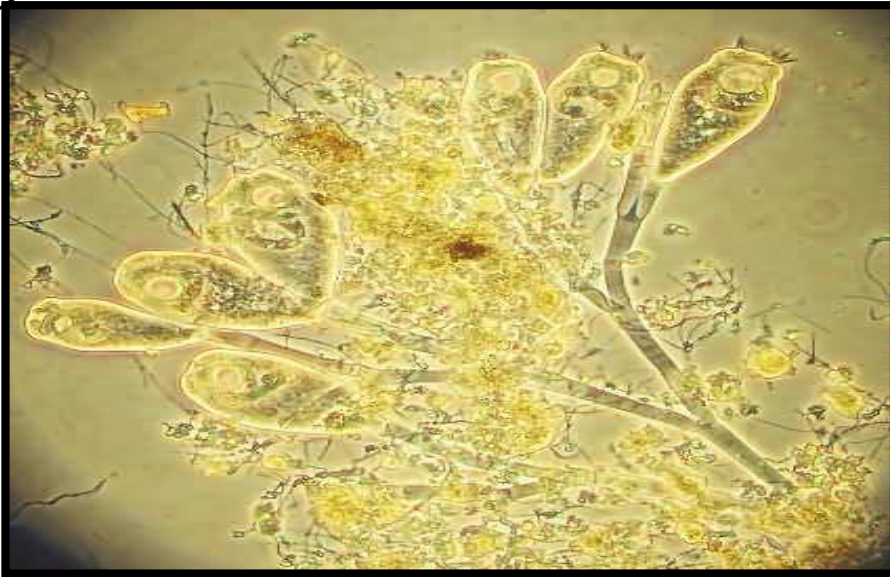
YOUNG SLUDGE, CLEAR WITH BETTER FLOC FORMATION



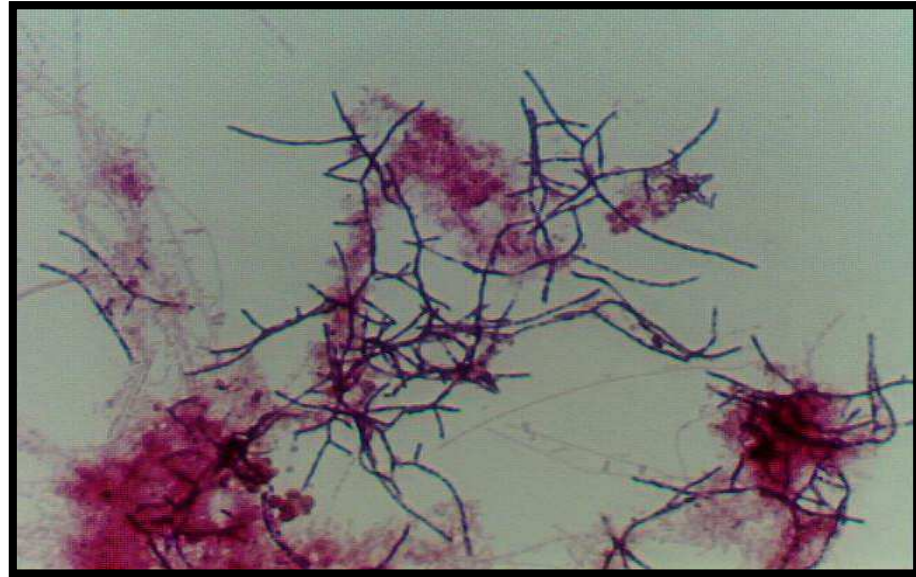
**GOOD, HEALTHY SLUDGE**



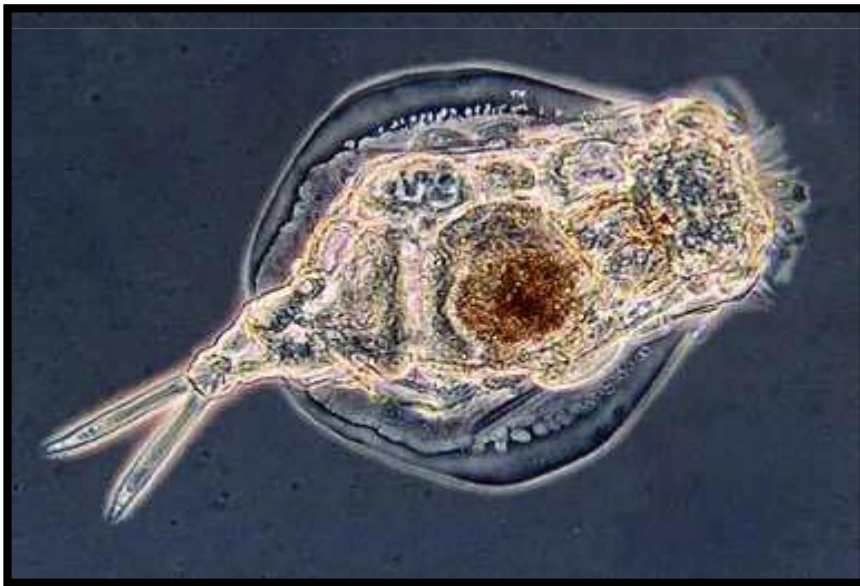
**OLD SLUDGE**



**VORTICELLA**



**NOCARDIA**



**ROTIFER**



**NEMATODE**

# REFERENCES

- ❑ Wastewater Microbiology “A Handbook for Operators” by Toni Glymph. Published by AWWA
- ❑ <http://www.environmentalleverage.com/index.htm>

THANKYOU

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