Biological Succession and Sludge Development

The process by which one microlife community replaces another is called succession. In sludge development, the floc microlife community that ends succession is the climax community-a stable, diverse assemblage of microorganisms that are highly efficient in metabolizing waste stream organics. Increasing microlife biodiversity equals stability.

At the start-up of a plant, or recovery of a plant from an upset condition, aerobic bacteria begin to increase in number with the aeration of organic waste stream. Various bacteria types, mostly rod and sphere eubacteria, as well as cyanobacteria, begin to colonize substrates and begin laying down a slime film. Amoebae generally are the first protozoa to appear in large numbers, graze on the developing biofilm. Simultaneously, a thin mixed liquor develops, with motile rod and spiral bacteria and flagellates appearing. With the rapid proliferation of bacteria, small, spherical floc particles (bacteria and organics) begin to appear in the activated sludge process. Motile and crawling ciliates appear to feed on bacteria "lawns" within floc particles in the biofilm and on bacteria in the open liquor. Various ciliates, with growing diversity in numbers and kinds, appear to feed on bacteria and flagellates. Other microlife forms, such as rotifers-again with growing diversity and kinds-begin to appear to feed on motile and crawling ciliates. Also, stalked ciliates appear on the biofilm feeding on bacteria and smaller flagellates and ciliates.

Within months, a stable biofilm with a diverse community of bacteria, protozoa and micro-invertebrates appear in the mature floc.

1. Bacteria

Bacteria are responsible for the stabilization of wastes coming into a treatment plant. Many of these bacteria form flock particles, or clusters of bacteria that break down waste. Floc particles also serve as sites on which waste can be adsorbed and broken down later. The majority of bacteria found in flock particles are spherical, rod-shaped or spiral-shaped.

Filamentous bacteria form trichomes, or filaments. These chains of bacteria provide a backbone for the floc particles, allowing the particles to grow in size and withstand the shearing action in the treatment process. When filamentous bacteria are present in excessive numbers or length, they often cause solids/liquids separation or settleability problems.

2. Protozoa

Protozoa are microscopic, unicellular organisms. They are found in large numbers in the activated sludge are found in large numbers in the activated sludge process. Protozoa perform many beneficial roles in the treatment process, including the clarification of the secondary effluent through the removal of bacteria, the flocculation of suspended material and as bio-indicators of the health of the sludge.

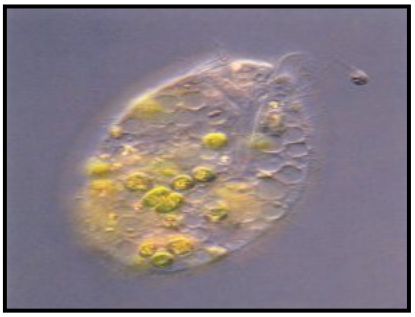
Protozoa that inhabit the activated sludge process are capable of movement in at least one stage of their development. They can be

placed into one of five groups according to their means of locomotion. These groups are the amoebae, flagellates, free-swimming ciliates, crawling ciliates and stalked ciliates.

Amoeba Proteus (length: 600 µm)

A member of the Amoebae, this protozoan lacks a specific shape due to its flexible cell membrane. The protozoan moves by the flowing action of the cytoplasm within the cell membrane. Amoebae usually are present in high numbers during start up of a treatment plant recovery from a toxic discharge to the treatment plant or low dissolved oxygen levels. If amoebae are present as the dominant protozoan group, this could indicate an unstable wastewater environment and a sludge that is in poor health.

Bodo candatus (length: 10-25 µm)



A member of the flagellates, this protozoan is oval in shape and has two flagella or long tails. The protozoan moves in a "jerking" or "corkscrew" fashion created by the whipping action of its flagella. Flagellates usually are present in high numbers during type up of a treatment plant, during recovery from a toxic discharge to the treatment plant, or at low dissolved oxygen levels. If flagellates are present as the dominant protozoan group, this could indicate an unstable wastewater environment and a sludge that is in poor health.

Chilodonella uncinata (length: 100-150 µm)

A member of the free-swimming ciliates, this protozoan is oval in shape and possesses numerous short hairs, or cilia, on the body. The rapid beating of the cilia permits the organism to move in a straight line. Free-swimming ciliates are found in large numbers when the bacterial population and dissolved oxygen concentration of the treatment process are relatively high. If free-swimming ciliates are present as the dominant protozoan group, this could indicate a wastewater environment that is not yet stabilized and a sludge that is intermediate in health.

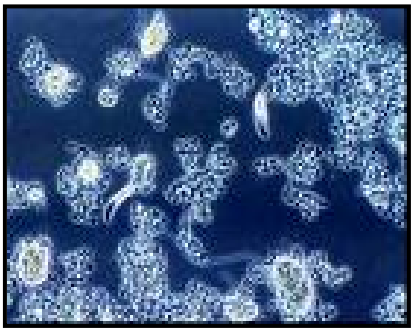
Aspidisca cicada (length: 25-80 µm)

A member of the crawling ciliates, this protozoan is flat from top to bottom. The cilia appear only on the lower surface of the organism. The beating of the cilia gives the appearance of a protozoan that is crawling as it moves across the surface of floc particles. Crawling ciliates are found in large numbers when the bacterial population and dissolved oxygen concentration of the treatment process are high and the wastewater environment is stable. Crawling ciliates indicate a stable wastewater environment and a healthy sludge.

Epistysis sp. (length: 70-100 µm)

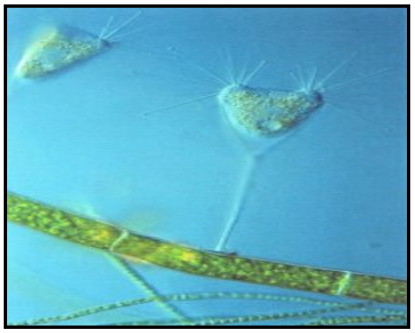
This is a stalked ciliate with a trumpet-shaped body. The organism is colonial. Its stalk is branched.

Lionotus sp. (length: 50µm)



This is a bottle shaped protozoa with cilia located only on its dorsal side.

Suctoria (length: 50-125 µm)



Suctoria are also stalked ciliated protozoa. However, these members possess tentacles rather than cilia and often prey upon other protozoa.

Vorticella sp. (length 50-150 µm)
Carchesium sp. (length 100-125 µm)

Members of the stalked ciliates, these protozoa possess a bell shaped body that is attached to a stalk. The mouth opening is ringed with cilia. Stalked ciliates are usually attached to a floc particle. In this position they are capable of contracting. They are also capable of swimming freely. This may occur during low dissolved oxygen levels within the treatment process. Verticella are solitary and their stalks do not branch. Carchesium are colonial and their stalks are branched.

Stalked ciliates are found in large numbers when the bacterial population and dissolved oxygen concentration of the treatment process are high, the wastewater environment is stable and a mature floc has developed. Stalked ciliates indicate a stable wastewater environment and a healthy sludge.

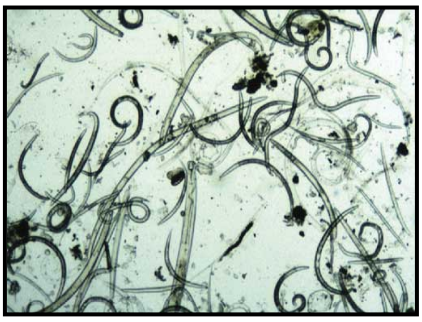
3. Rotifers

Epiphanes sp. (length 100-500 µm)
Euchlanis sp. (length 100-500 µm)

Epiphanes and Euchlanis are common inhabitants of the activated sludge. Both rotifers possess two gonads and belong in the Order Digononta. Rotifers with only one gonad belong in the Order Monogononta.

The rotifers are the most abundant macro invertebrates found in the activated sludge process. They vary in length from 100µm to 500µm. Important structural characteristics used to classify rotifers are body shape (sac, spherical or worm), size, number of gonads, foot development, number of toes and protective covering. The mouth opening of the rotifer is surrounded by two bands of cilia. The beating of the cilia creates water current for locomotion and food gathering. Rotifers move by swimming freely or crawling.

4. Freshwater Nematodes



Nematodes are aquatic animals present in fresh, brackish waters, salt waters, and soil worldwide. Freshwater nematodes can be present in sand filters and aerobic treatment plants. They are present in large numbers in secondary wastewater effluent, bio-filters or biological contactors. A freshwater nematode inhabits fresh water below the water table; a species utilizing oxygen dissolved in fresh water. Nematodes are part of the ecosystem serving as food for small invertebrates or fungi. Coexisting with nematodes in bio-filters are rotifers, protozoa, and many other invertebrates. Predaceous nematodes are numerous in fresh water, devouring other nematodes other small vertebrates and bacteria. Ingestion of algae and diatoms is unknown; however nematodes of the dorylaimidae family occasionally

are seen with bright amber, yellow, or green coloration as a result of algae in the gut.

Nematodes crawl upon floc particles and move in whip-like fashion when in the free-swimming mode. Nematodes also secrete a sticky substance to be able to anchor to a substrate (media) so that anchored nematodes can feed without interference by currents or turbulence. A lack of nematode activity can be one of the bio-indicators of a toxic condition that may be developing in the treatment process.

Summary

The time and establishment of mature aerobic microbiological cultures varies greatly. Several factors influence the progress of development and maturation. The number and diversity of organisms are the measure of the maturity and stability of the biological process.

Factors that can adversely influence the development and maintenance of a stable mature culture include sudden changes in physical or chemical characteristics coming from the inflow section or headworks. These would include: temperature fluctuations or inversions, marked changes in pH beyond the tolerable levels for the microbiology, insufficient food supply due to loss of circulation to the biofilm, chemical poisons, heavy metals and inorganic substances.

As biology grows and matures it becomes more stable. However the establishment period is delicate and may need from 1 month to 3 months to establish a mature site-specific culture. Any major interruptions or change in the environment of the developing culture may result in collapse. New application specific bacterial cultures will need to be inserted again to establish desired dominance of microbiology which uses the specific wastewater as it's preferred food source. The mature microbiology is necessary to be effective in eating the waste and reducing sludge.