



IDENTIFICATION AND ANALYSIS OF

ORGANISMS FOUND IN WASTEWATER

The primary reduction of organic material within a wastewater treatment plant is performed by a number of different types of microorganisms. Most of the organisms can be categorized as either bacteria, protozoans or metazoans. These organisms are present in the air, the soil and most, if not all, warm blooded animals, including man. Identifying and understanding the various types of organisms, their functions and properties provides insight into the treatment process and process control decisions. The bacteria, single-celled and multi-celled animals that constitute the majority of these organisms are generally identified by the term "sludge". The absence or presence of free oxygen will determine if the sludge is anaerobic or aerobic. The lowest life form identified within treatment plant sludge is bacteria. One of the properties of bacteria is that they usually live in a colonial structure called floc. The structural nature and characteristics of a significant portion of the floc particles directly affect physical properties that contribute to treatment plant efficiency. The floc particles may be identified for shape, size, strength, surface area, density and the presence of higher life forms.

FACULTATIVE BACTERIA

Most of the bacteria that absorb the organic material in a wastewater treatment system are facultative in nature. This means they are adaptable to survive and multiply in either anaerobic or aerobic conditions. The nature of individual bacteria is dependent upon the environment in which they live. Usually, facultative bacteria will be anaerobic unless there is some type of mechanical or biochemical process used to add oxygen to the wastewater. When bacteria are in the process of being transferred from one environment to the other, the metamorphosis from anaerobic to aerobic state (and vice versa) takes place within a couple of hours.

ANAEROBIC BACTERIA

Anaerobic bacteria live and reproduce in the absence of free oxygen. They utilize compounds such as sulfates and nitrates for energy and their metabolism is substantially reduced. In order to remove a given amount of organic material in an anaerobic treatment system, the organic material must be exposed to a significantly higher quantity of bacteria and/or detained for a much longer period of time. A typical use for anaerobic bacteria would be in a septic tank. The slower metabolism of the anaerobic bacteria dictates that the wastewater be held several days in order to achieve even a nominal 50% reduction in organic material. That is why septic tanks are always followed by some type of effluent treatment and disposal process. The advantage of using the anaerobic process is that electromechanical equipment is not required. Anaerobic bacteria release hydrogen sulfide as well as methane gas, both of which can create hazardous conditions. Even as the anaerobic action begins in the collection lines of a sewer system, deadly hydrogen sulfide or explosive methane gas can accumulate and be life threatening.

AEROBIC BACTERIA

Aerobic bacteria live and multiply in the presence of free oxygen. Facultative bacteria always achieve an aerobic state when oxygen is present. While the name "aerobic" implies breathing air, dissolved oxygen is the primary source of energy for aerobic bacteria. The metabolism of aerobes is much higher than for anaerobes. This increase means that 90% fewer organisms are needed compared to the anaerobic process, or that treatment is accomplished in 90% less time. This provides a number of advantages including a higher percentage of organic removal. The by-products of aerobic bacteria are carbon dioxide and water. Aerobic bacteria live in colonial structures called floc and are kept in suspension by the mechanical action used to introduce oxygen into the wastewater. This mechanical action exposes the floc to the organic material, while treatment takes place. Following digestion, a gravity clarifier separates and settles out the floc. Because of the mechanical nature of the aerobic digestion process, maintenance and operator oversight are required.

ACTIVATED SLUDGE

Aerobic floc in a healthy state are referred to as activated sludge. While aerobic floc has a metabolic rate approximately ten times higher than anaerobic sludge, it can be increased even further by exposing the bacteria to an abundance of oxygen. Compared to a septic tank, which takes several days to reduce the organic material, an activated sludge tank can reduce the same amount of organic material in approximately 4-6 hours. This allows a much higher degree of overall process efficiency. In most cases treatment efficiencies and removal levels are so much improved that additional downstream treatment components are dramatically reduced or totally eliminated.

IDENTIFICATION AND ANALYSIS OF ORGANISMS (Cont.)

FILAMENTOUS ORGANISMS

The majority of filamentous organisms are bacteria, although some of them are classified as algae, fungi or other life forms. There are a number of types of filamentous bacteria which proliferate in the activated sludge process. Filamentous organisms perform several different roles in the process, some of which are beneficial and some of which are detrimental. When filamentous organisms are in low concentrations in the process, they serve to strengthen the floc particles. This effect reduces the amount of shearing in the mechanical action of the aeration tank and allows the floc particles to increase in size. Larger floc particles are more readily settled in a clarifier. Larger floc particles settling in the clarifier also tend to accumulate smaller particulates (surface adsorption) as they settle, producing an even higher quality effluent. Conversely, if the filamentous organisms reach too high a concentration, they can extend dramatically from the floc particles and tie one floc particle to another (interfloc bridging) or even form a filamentous mat of extra large size. Due to the increased surface area without a corresponding increase in mass, the activated sludge will not settle well. This results in less solids separation and may cause a washout of solid material from the system. In addition, air bubbles can become trapped in the mat and cause it to float, resulting in a floating scum mat. Due to the high surface area of the filamentous bacteria, once they reach an excess concentration, they can absorb a higher percentage of the organic material and inhibit the growth of more desirable organisms.

PROTOZOANS AND METAZOANS

In a wastewater treatment system, the next higher life form above bacteria is protozoans. These single-celled animals perform three significant roles in the activated sludge process. These include floc formation, cropping of bacteria and the removal of suspended material. Protozoans are also indicators of biomass health and effluent quality. Because protozoans are much larger in size than individual bacteria, identification and characterization is readily performed. Metazoans are very similar to protozoans except that they are usually multi-celled animals. Macroinvertebrates such as nematodes and rotifers are typically found only in a well developed biomass. The presence of protozoans and metazoans and the relative abundance of certain species can be a predictor of operational changes within a treatment plant. In this way, an operator is able to make adjustments and minimize negative operational effects simply by observing changes in the protozoan and metazoan population.

DISPERSED GROWTH

Dispersed growth is material suspended within the activated sludge process that has not been adsorbed into the floc particles. This material consists of very small quantities of colloidal (too small to settle out) bacteria as well as organic and inorganic particulate material. While a small amount of dispersed growth in between the floc particles is normal, excessive amounts can be carried through a secondary clarifier. When discharged from the treatment plant, dispersed growth results in higher effluent solids.

TAXONOMY

Taxonomy is the science of categorizing life forms according to their characteristics. Eighteen different categories are used to define life forms from the broadest down to the most specific. They are: Kingdom, Phylum, Subphylum, Superclass, Class, Subclass, Cohort, Superorder, Order, Suborder, Superfamily, Family, Subfamily, Tribe, Genus, Subgenus, Species and Subspecies. Identifying the genus is usually specific enough to determine the role of the organisms found in a wastewater treatment system.

PROCESS INDICATORS

Following taxonomic identification, enumeration and evaluation of the characteristics of the various organisms and structures present in a wastewater sample, the information can be used to draw conclusions regarding the treatment process. Numerous industry references, such as WASTEWATER BIOLOGY: THE MICROLIFE by the Water Environment Federation, can be used to provide a comprehensive indication of the conditions within a treatment process. As an example, within most activated sludge processes, the shape of the floc particles can indicate certain environmental or operational conditions. A spherical floc particle indicates immature floc, as would be found during start-up or a process recovery. A mature floc particle of irregular shape indicates the presence of a beneficial quantity of filamentous organisms and good quality effluent. An excess of dispersed growth could indicate a very young sludge, the presence of toxic material, excess mechanical aeration or an extended period of time at low dissolved oxygen levels. Certain protozoans, such as amoebae and flagellates dominate during a system start-up. Free swimming ciliates are indicative of a sludge of intermediate health and an effluent of acceptable or satisfactory quality. A predominance of crawling ciliates, stalked ciliates and metazoans is an indicator of sludge with excellent health and an effluent of high quality.

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