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Assignment: 2

Activated Sludge Process

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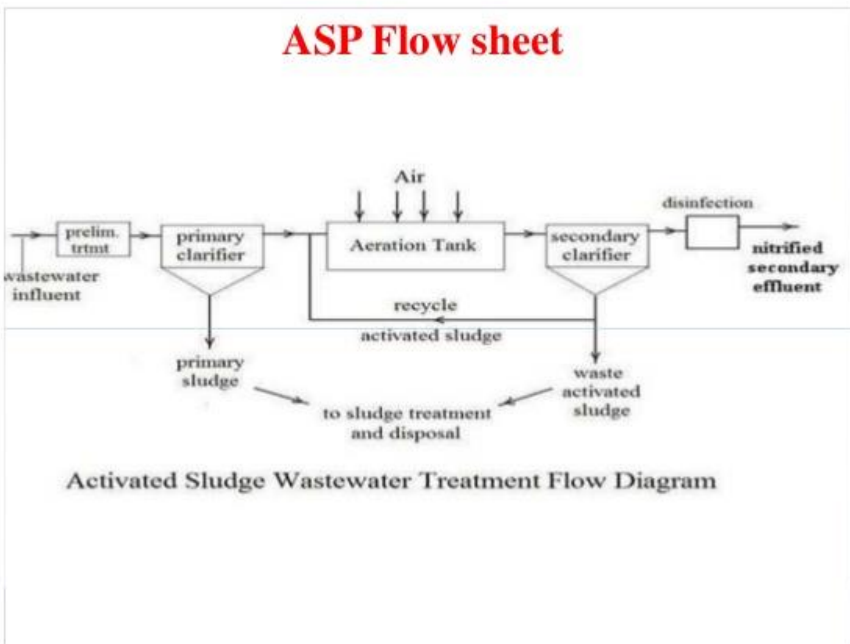
Biological Treatment Processes

To this point the biological systems discussed include trickling filters and rotating biological contactors. These systems are effective unit processes in treating wastewater. However, trickling filters and RBCs are temperature sensitive, remove less BOD, and trickling filters cost more to build than activated sludge systems. Although they are more expensive to build, the activated sludge systems are much more expensive to operate because of the need for energy to run pumps and blowers.

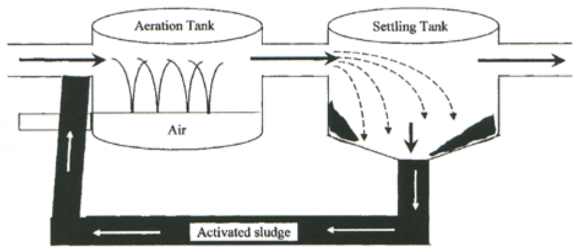
Activated Sludge Process

Activated sludge refers to biological treatment processes that use a suspended growth of organisms to remove BOD and suspended solids. As shown below, the process requires an aeration tank and a settling tank.



In addition, support equipment, including return pumps, waste pumps, flow measurement devices for return and waste, as well as equipment to provide aeration (mixers and/or blowers) is also required.

Note: Activated sludge processes may or may not follow primary treatment. The need for primary treatment is determined by the process modification selected for use. All activated sludge systems include a settling tank following the aeration tank.



Primary effluent (or plant influent) is mixed with return activated sludge to form mixed liquor. The mixed liquor is aerated for a specified length of time. During the aeration the activated sludge organisms use the available organic matter as food producing stable solids and more organisms. The suspended solids produced by the process and the additional organisms become part of the activated sludge. The solids are then separated from the wastewater in the settling tank. The solids are returned to the influent of the aeration tank (return activated sludge). Periodically the excess solids and organisms are removed from the system (waste activated sludge). Failure to remove waste solids will result in poor performance and loss of solids out of the system over the settling tank effluent weir.

There are a number of factors that affect the performance of an activated sludge treatment system. These include:

- **temperature**
- **return rates**
- **amount of oxygen available**
- **amount of organic matter available**
- **pH**
- **waste rates**
- **aeration time**
- **wastewater toxicity**

To obtain desired level of performance in an activated sludge system, a proper balance must be maintained between the amounts of food (organic matter), organisms (activated sludge) and oxygen (dissolved oxygen).

Activated Sludge Modifications

Many activated sludge process modifications exist. Each modification is designed to address specific conditions or problems. Such modifications are characterized by differences in mixing and flow patterns in the aeration basin, and in the manner in which the microorganisms are mixed with the incoming wastewater.

The major process modifications of the activated sludge process are:

1. **conventional**
2. **tapered aeration**
3. **complete mix**
4. **step aeration**
5. **contact stabilization**
6. **extended aeration**

7. **pure oxygen systems**

Conventional Modification

This configuration requires primary treatment, has the influent and returned sludge enter the tank at the head end of the basin, mixing is accomplished by the aeration system, and provides excellent treatment. On the downside, this modification requires large aeration tank capacity, higher construction costs, high initial oxygen demand, and is very sensitive to operation problems, such as bulking.

Tapered Aeration

The tapered aeration system is similar to the conventional activated sludge process. The major difference is in the arrangement of the diffusers. The diffusers are close together at the influent end where more oxygen is needed. Toward the other end of the aeration basin, the spacing of the diffusers is increased.

Step Aeration

In step aeration, the returned sludge is applied at several points in the aeration basin. Generally, the tank is subdivided into three or more parallel channels with around-the-end baffles, and the sludge is applied at separate channels or steps. The oxygen demand is uniformly distributed.

Complete Mix Aeration

In complete mix aeration the influent and the returned sludge are mixed and applied at several points along the length and width of the basin. The contents are mixed, and the mixed liquor suspended solids (MLSS) flows across the tank to the effluent channel. The oxygen demand and organic loading are uniform along the entire length of the basin.

Contact Stabilization

In contact stabilization, primary treatment is not required. The activated sludge is mixed with influent in the contact tank where the organics are absorbed by microorganisms. The MLSS is settled in the clarifier. The returned sludge is aerated in the reaeration basin to stabilize the organics. The process requires approximately 50% less tank volume and can be prefabricated as a package plant for flows of 0.05 to 1.0 MGD. On the downside, this system is more complicated to control because many common control calculations do not work.

Extended Aeration Activated Sludge

Extended aeration does not require primary treatment. It utilizes a large aeration basin where a high population of microorganisms is maintained. It is used for small flows from subdivisions, schools, etc. Prefabricated package plants utilize this process extensively. It has a channel in the shape of a race track, with rotors being used to supply oxygen and maintain circulation. Typically the process produces high-quality effluent and less activated sludge. (Oxidation ditch is a variation of extended aeration process).

Pure Oxygen Systems

Oxygen is diffused into covered aeration tanks. A portion of gas is wasted from the tank to reduce the concentration of carbon dioxide. The process is suitable for high-strength wastes where space may be limited. Special equipment for generation of oxygen is needed.

Operation

Operation of the activated sludge process requires more operator control than the other treatment processes discussed. The operator must adjust aeration, return rates and waste rates to maintain the balance of food, organisms and oxygen. Operators must observe operation of the aeration basin to check on mixing pattern, type and amount of foam (normally small amounts of crisp white foam), color of activated sludge (normally dark, chocolate brown), and odors (normally musty or earth odor). In regard to the settling tank, observations include flow pattern (normally uniform distribution), settling, amount and type of solids leaving with the process effluent (normally very clean).

In process control operations, sampling and testing are important. Testing may include settle ability testing to determine the settled sludge volume; suspended solids testing to determine influent and mixed liquor suspended solids, return activated sludge solids, and waste activated sludge concentrations; determination of the volatile content of the mixed liquor suspended solids; dissolved oxygen and pH of the aeration tank; BOD and/or COD of the aeration tank influent and process effluent; and microscopic evaluation of the activated sludge to determine the predominant organism.

Activated Sludge Process Control Calculations

Activated sludge process control calculations may include determination of the third- and sixty-minute settled sludge volume (SSV_{30} and SSV_{60}), sludge volume index (SVI) and pounds of waste activated sludge removed from the process.

Settled Sludge Volume

$$SSV = \frac{\text{Settled Sludge Volume (SSV), mL} \times 1{,}000\ \text{mL/Liter}}{\text{Sample Volume, mL}}$$

Here is a sample problem using the above formula:

A 2,000 mL sample of activated sludge is allowed to settle for thirty minutes. At the end of the settling time the sludge volume is 1,100 mL. What is the thirty-minute settled sludge volume (SSV_{30})?

$$SSV_{30} = \frac{1{,}100\ \text{mL} \times 1{,}000}{2{,}000\ \text{mL}} = 550\ \text{mL/L}$$

Sludge Volume Index

Sludge volume index is a quality indicator. It reflects the settling quality of the sludge. As the SVI increases, the sludge settles slower, does not compact as well, and is likely to result in more effluent suspended solids.

$$SVI = \frac{\text{Settled Sludge Vol}_{30}\text{, mL/L} \times 1{,}000}{\text{Mixed Liquor Suspended Solids, mg/L}}$$

Here is a sample problem using the formula above:

The sample used in the previous example (SSV) has an MLSS concentration of 2,800 mg/L. What is the SVI?

$$SVI = \frac{550 \text{ mL/L} \times 1{,}000}{2{,}800 \text{ mg/L}} = 196.43$$

Waste Activated Sludge

Control of the activated sludge process requires accurate information on the quantity of solids removed from the process as waste activated sludge.

$$\text{Waste, lb/day} = \text{WAS Conc., mg/L} \times \text{WAS Flow, MGD} \times 8.34 \text{ lb/MG/mg/L}$$

The operator wastes 0.44 MGD of activated sludge. The waste activated sludge has solids concentration of 5,840 mg/L. How many pounds of waste activated sludge are removed from the process?

$$\text{Waste, lb/day} = 5{,}840 \text{ mg/L} \times 0.44 \text{ MGD} \times 8.34 = 21{,}430 \text{ lb/day}$$

Review

Activated sludge refers to biological treatment processes that use a suspended growth of organisms to remove BOD and suspended solids. Primary effluent (or plant influent) is mixed with return activated sludge to form mixed liquor. The mixed liquor is aerated for a specified length of time. During the aeration the activated sludge organisms use the available organic matter as food producing stable solids and more organisms. The suspended solids produced by the process and the additional organisms become part of the activated sludge. The solids are then separated from the wastewater in the settling tank. The solids are returned to the influent of the aeration tank (return activated sludge).