Wastewater Treatment Plants

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DESCRIPTION

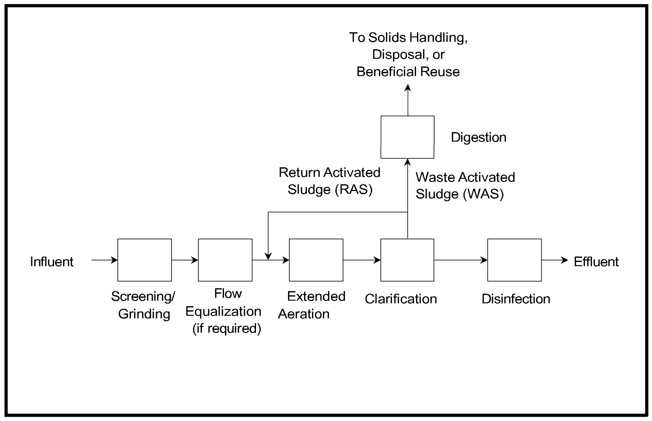
Package plants are pre-manufactured treatment facilities used to treat wastewater in small communities or on individual properties. According to manufacturers, package plants can be designed to treat flows as low as 0.002 MGD or as high as 0.5 MGD, although they more commonly treat flows between 0.01 and 0.25 MGD (Metcalf and Eddy, 1991).

The most common types of package plants are extended aeration plants, sequencing batch reactors, oxidation ditches, contact stabilization plants, rotating biological contactors, and physical/chemical processes (Metcalf and Eddy, 1991). This fact sheet focuses on the first three, all of which are biological aeration processes.

Extended aeration plants

The extended aeration process is one modification of the activated sludge process which provides biological treatment for the removal of biodegradable organic wastes under aerobic conditions. Air may be supplied by mechanical or diffused aeration to provide the oxygen required to sustain the aerobic biological process. Mixing must be provided by aeration or mechanical means to maintain the microbial organisms in contact with the dissolved organics. In addition, the pH must be controlled to optimize the biological process and essential nutrients must be present to facilitate biological growth and the continuation of biological degradation.

As depicted in Figure 1, wastewater enters the treatment system and is typically screened immediately to remove large suspended, settleable, or floating solids that could interfere with or damage equipment downstream in the process. Wastewater may then pass through a grinder to reduce large particles that are not captured in the screening process. If the plant requires the flow to be regulated, the effluent will then flow into equalization basins which regulate peak wastewater flow rates. Wastewater then enters the aeration chamber, where it is mixed, and oxygen is provided to the microorganisms. The mixed liquor then flows to a clarifier or settling chamber where most microorganisms settle to the bottom of the clarifier and a portion is pumped back to the incoming wastewater at the beginning of the plant. This returned material is the return activated sludge (RAS). The material that is not returned, the waste activated sludge (WAS), is removed for treatment and disposal. The clarified wastewater then flows over a weir and into a collection channel before being diverted to the disinfection system.



Source: Parsons Engineering Science, 2000.

FIGURE 1 PROCESS FLOW DIAGRAM FOR A TYPICAL EXTENDED AERATION PLANT

Extended aeration package plants consist of a steel tank that is compartmentalized into flow equalization, aeration, clarification, disinfection, and aerated sludge holding/digestion segments. Extended aeration systems are typically manufactured to treat wastewater flow rates between 0.002 to 0.1 MGD. Use of concrete tanks may be preferable for larger sizes (Sloan, 1999).

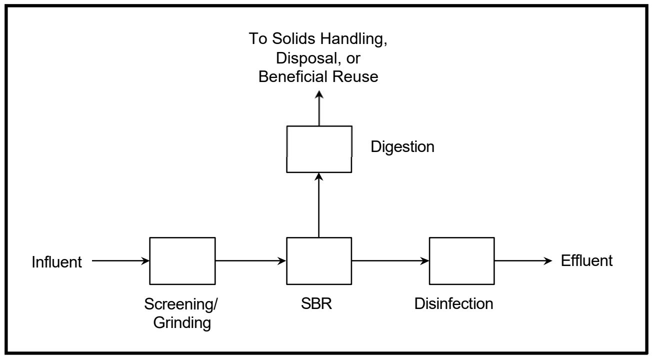
Extended aeration plants are usually started up using "seed sludge" from another sewage plant. It may take as many as two to four weeks from the time it is seeded for the plant to stabilize (Sloan, 1999).

Sequencing batch reactors

A sequencing batch reactor (SBR) is a variation of the activated sludge process. As a fill and draw or batch process, all biological treatment phases occur in a single tank. This differs from the conventional flow through activated sludge process in that SBRs do not require separate tanks for aeration and sedimentation (Kappe, 1999). SBR systems contain either two or more reactor tanks that are operated in parallel, or one equalization tank and one reactor tank. The type of tank used depends on the wastewater flow characteristics (e.g., high, or low volume). While this setup allows the system to accommodate continuous influent flow, it does not provide for disinfection or holding for aerated sludge.

There are many types of SBR systems, including continuous influent/time based, non-continuous influent/time based, volume based, an intermittent cycle system (a SBR that utilizes jet aeration), and various other system modifications based on different manufacturer designs. The type of SBR system used depends on site and wastewater characteristics as well as the needs of the area or community installing the unit. Package SBRs are typically manufactured to treat wastewater flow rates between 0.01 and 0.2 MGD, although flow rates can vary based on the system and manufacturer.

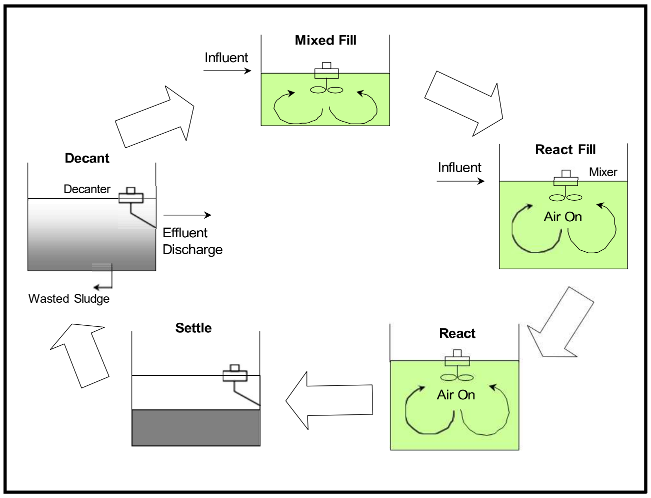
As seen in Figure 2, the in-fluent flow first goes through a screening process before entering the SBR. The waste is then treated in a series of batch phases within the SBR to achieve the desired effluent concentration. The sludge that is wasted from the SBR moves on to digestion and eventually to solids handling, disposal, or beneficial reuse. The treated effluent then moves to disinfection. An equalization tank is typically needed before the disinfection unit in batch SBRs to store large volumes of water. If the flow is not equalized, a sizable filter may be necessary to accommodate the large flow of water entering the disinfection system. In addition, SBR systems typically have no primary or secondary clarifiers as settling takes place in the SBR.



Source: Parsons Engineering Science, 2000.

FIGURE 2 PROCESS FLOW DIAGRAM FOR A TYPICAL SBR

There are normally five phases in the SBR treatment cycle: fill, react, settle, decant, and idle. The length of time that each phase occurs is controlled by a programmable logic controller (PLC), which allows the system to be controlled from remote locations (Sloan, 1999). In the fill phase, raw wastewater enters the basin, where it is mixed with settled biomass from the previous cycle. Some aeration may occur during this phase. Then, in the react phase, the basin is aerated, allowing oxidation and nitrification to occur. During the settling phase, aeration and mixing are suspended and the solids are allowed to settle. The treated wastewater is then discharged from the basin in the decant phase. In the final phase, the basin is idle as it waits for the start of the next cycle. During this time, part of the solids is removed from the basin and disposed of as waste sludge (Kappe, 1999). Figure 3 shows this sequence of operation in an SBR.



Source: CASS Water Engineering, Inc., 2000.

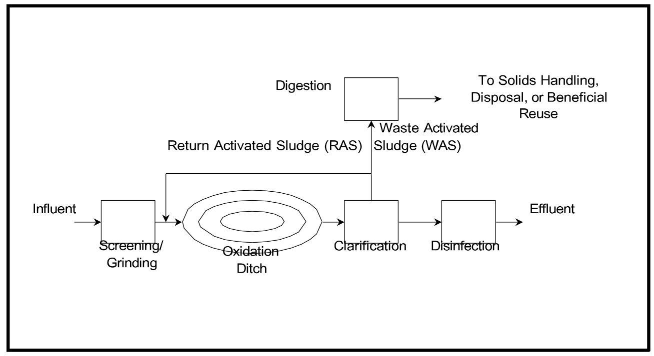
FIGURE 3 SBR SEQUENCE OF OPERATION

Sludge wasting is an important step in the SBR process and largely affects system performance. It is not considered a basic phase since the sludge is not wasted at a specific time during the cycle. The quantity and rate of waste is determined by performance requirements. An SBR system does not require an RAS system, as both aeration and settling occur in the same tank. This prevents any sludge from being lost during the react step and eliminates the need to return sludge from the clarifier to the aeration chamber (Metcalf and Eddy, 1991).

Oxidation ditches

An oxidation ditch, a modified form of the activated sludge process, is an aerated, long term, complete mix process. Many systems are designed to operate as extended aeration systems. Typical oxidation ditch treatment systems consist of a single or multi-channel configuration within a ring, oval, or horseshoe-shaped basin. Horizontally or vertically mounted aerators provide aeration, circulation, and oxygen transfer in the ditch.

Package oxidation ditches are typically manufactured in sizes that treat wastewater flow rates between 0.01 and 0.5 MGD. As seen in Figure 4, raw wastewater is first screened before entering the oxidation ditch. Depending on the system size and manufacturer type, a grit chamber may be required. Once inside the ditch, the wastewater is aerated with mechanical surface or submersible aerators (depending on manufacturer design) that propel the mixed liquor around the channel at velocities high enough to prevent solids deposition. The aerator ensures that there is sufficient oxygen in the fluid for the microbes and adequate mixing to ensure constant contact between the organisms and the food supply (Lakeside, 1999).



Source: Parsons Engineering Science, 1999.

FIGURE 4 PROCESS FLOW DIAGRAM FOR A TYPICAL OXIDATION DITCH

Oxidation ditches tend to operate in an extended aeration mode consisting of long hydraulic and solids retention times which allow more organic matter to break down. Treated sewage moves to the settling tank or final clarifier, where the biosolids and water separate. Wastewater then moves to other treatment processes while sludge is removed. Part of it is returned to the ditch as RAS, while the rest is removed from the process as the waste activated sludge (WAS). WAS is wasted either continuously or daily and must be stabilized prior to disposal or beneficial reuse.

APPLICABILITY

In general, package treatment plants are applicable for areas with a limited number of people and small wastewater flows. They are most often used in remote locations such as trailer parks, highway rest areas, and rural areas.

Extended aeration plants

Extended aeration package plants are typically used in small municipalities, suburban subdivisions, apartment complexes, highway rest areas, trailer parks, small institutions, and other sites where flow rates are below 0.1 MGD. These systems are also useful for areas requiring nitrification.

Sequencing batch reactors

Package plant SBRs are suitable for areas with little land, stringent treatment requirements, and small wastewater flows. More specifically, SBRs are appropriate for RV parks or mobile homes, campgrounds, construction sites, rural schools, hotels, and other small applications. These systems are also useful for treating pharmaceutical, brewery, dairy, pulp and paper, and chemical wastes. While constant cycles with time-fixed process phases are sufficient in most cases, phases should be individually adapted and optimized for each plant. SBRs are also suited for sites that need minimal operator attendance and that have a wide range of inflow and/or organic loadings.

Industries with high BOD loadings, such as chemical or food processing plants, will find SBRs useful for treating wastewater. These systems are also suitable for facilities requiring nitrification, denitrification, and phosphorous removal. Most significantly, SBRs are applicable for areas where effluent requirements can change frequently and become stricter, as these systems have tremendous flexibility to change treatment options. However, part of the economic advantage of the SBR process is lost when advanced treatment processes must be added downstream since intermediate equalization is normally required.

Oxidation ditches

Oxidation ditches are suitable for facilities that require nutrient removal, have limitations due to the nature of the site, or want a biological system that saves energy with limited use of chemicals unless required for further treatment. Oxidation ditch technology can be used to treat any type of wastewater that is responsive to aerobic degradation. In addition, systems can be designed for denitrification and phosphorous removal.

Types of industries utilizing oxidation ditches include food processing, meat and poultry packing, breweries, pharmaceutical, milk processing, petrochemical, and numerous other types. Oxidation ditches are particularly useful for schools, small industries, housing developments, and small communities. Ultimately, this technology is most applicable for places that have a large amount of land available.

ADVANTAGES AND DISADVANTAGES

Some advantages and disadvantages of package plants are listed below.

Extended aeration plants

Advantages

- Plants are easy to operate, as many are manned for a maximum of two or three hours per day.
- Extended aeration processes are often better at handling organic loading and flow fluctuations, as there is a greater detention time for the nutrients to be assimilated by microbes.
- Systems are easy to install, as they are shipped in one or two pieces and then mounted on an onsite concrete pad, above or below grade.
- Systems are odor free, can be installed in most locations, have a relatively small footprint, and can be landscaped to match the surrounding area.
- Extended aeration systems have a relatively low sludge yield due to long sludge ages, can be designed to provide nitrification, and do not require a primary clarifier.

Disadvantages

- Extended aeration plants do not achieve denitrification or phosphorus removal without additional unit processes.
- Flexibility is limited to adapting to changing effluent requirements resulting from regulatory changes.
- A longer aeration period requires more energy.