ALABAMA COOPERATIVE Extension SYSTEM

ALABAMA A&M AND AUBURN UNIVERSITIES

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Municipal Wastewater Treatment

Wastewater Collection And Treatment Processes

Collection of stormwater and drainage dates from ancient times, but collection of wastewater can be traced only to the early 1800s. Treatment of wastewater began in Europe in the late 1800s after the science of bacteriology developed and doctors began to support the germ theory of polluted water causing diseases.

Treatment of wastewater in the United States received little attention until the early 1900s because of the vast land and water resources available for dumping wastes and wastewater. By this time nuisance problems and health conditions associated with land and water disposal of waste and wastewater were causing real problems especially in the larger cities. Cities were having trouble obtaining areas for disposal, and this led to more intensive methods of treatment.

Today wastewater collection and treatment services are largely taken for granted; however, they play a major role in maintaining the quality of our nation's waters and the quality of life as we know it in the United States.

Wastewater is about 99 percent water by weight and is generally referred to as **influent** at the treatment plant. The other 1 percent is made up primarily of organic solids that are suspended or dissolved in the water. Most of the organics found in wastewater can be decomposed by natural biological processes.

All sewage treatment processes are designed to remove pollutants which would otherwise harm our waters. A number of physical, chemical, and biological principles are applied in wastewater treatment.

Wastewater Collection

Homes, businesses, industries, and institutions are connected to a network of below-ground pipes which transport wastewater to treatment plants before it is released to the environment. The modern sewer system is an engineering marvel.

Ultimately, water flows through the supply system and into a home where you may use it to wash your dishes or to brush your teeth. At this point the water begins its return trip to nature and the hydrologic cycle. It drains from your bathroom or kitchen sink into the community's sanitary sewer system, unless you have a private septic tank, and is on its way to the public treatment plant. Here it is joined by millions of gallons of wastewater coming from other homes, businesses, industries, and institutions and is treated by a variety of processes that remove pollutants.

At a typical wastewater treatment plant, several million gallons of wastewater flow through each day—50 to 100 gallons for every person using the system. There are no holidays for wastewater treatment, and most plants operate 24 hours per day every day of the week.

The amount of wastewater handled by the treatment plant may vary with the time of day and the season of the year. Some communities do not have separate sewer systems for wastewater and runoff from rainfall; therefore, flow during heavy rains or snow melts can be much higher than normal.

In most cases, wastewater is not just "sewage" but also includes commercial and industrial sources as well as stormwater runoff and even ground water seepage where sewer lines are cracked or leaking. Sanitary sewers carry only domestic and industrial wastewater while combined sewers carry wastewater and stormwater runoff. Most cities in Alabama have separate sewer systems for stormwater discharges.

After being treated, the cleansed wastewater is usually released to a lake or stream where it flows toward the ocean. It will generally be used again and again along the way for irrigation, by industry, and as drinking water, or it will evaporate into the atmosphere and return again as rain in some other part of the world. Wastewater treatment plants operate at a critical point in the water cycle to help nature defend water from excessive pollution.

Wastewater Treatment Processes

Treatment plants appear very complex with all their machines, pumps, pipelines, tanks, and towers. However, they are really designed to do only two basic things: speed up the natural purification processes that occur in lakes and streams and reduce toxic contaminants that might otherwise interfere with the natural processes.

Wastewater treatment usually consists of two major steps—primary treatment and secondary treatment—along with a process to dispose of solids (sludge) removed during the two steps. In some areas where receiving waters are more sensitive to pollution or where specific pollutants have not been removed by secondary treatment, a third step called advanced waste treatment (also called tertiary treatment) may be required. Some plants use prechlorination for hydrogen sulfide and odor control prior to beginning any treatment processes.

Primary Treatment. In primary treatment, the objective is to physically remove sand, grit, and larger solids from the wastewater by screening, settling, or floating. Screens, settling tanks, and skimming devices are most commonly used for the separation. Primary treatment removes 45 to 50 percent of the pollutants.

After primary treatment, wastewater still contains solid materials either floating on the surface, dissolved in the water, or both. Under natural conditions, these substances would provide food for such organisms as fungi, algae, and bacteria that live in streams or lakes.

Secondary Treatment. The goal of secondary treatment is to biologically remove contaminants that are dissolved in wastewater. In secondary treatment air is supplied to accelerate the growth of bacteria and other organisms which consume most of the waste materials. The wastewater is then separated from the organisms and solids, disinfected by chlorine or ultraviolet light to kill any remaining harmful bacteria, and released to a nearby lake, river, or stream. At this point 85 to 90 percent of the pollutants have been removed.

The treated wastewater may be dechlorinated with sodium bisulfite or sulfur dioxide where low level chlorine residuals could be toxic to aquatic organisms in receiving waters. This treated wastewater discharge is now referred to as **effluent.**

Tertiary Treatment. Any additional processing after secondary treatment is called tertiary treatment. Tertiary treatment can remove more suspended solids, organic matter, nitrogen, phosphorus, heavy metals, or bacteria. This treatment relies on the addition of chemicals or on filter beds of rock, sand, or other materials.

Treatment Of Sludge. The solid material that is removed from wastewater, called sludge, requires proper treatment and disposal and can often be reused. The ultimate disposal of this material is one of the most difficult and expensive problems of wastewater treatment.

The goal of sludge treatment is to destroy harmful organisms and remove water. The end product of the sludge handling process is a relatively dry material known as "cake." It can be applied to agricultural land as a soil conditioner, placed in landfills, or cleanly burned. At some plants, sludge serves as a fuel to produce energy. For land application, sludge is often kept in a liquid slurry form for ease of handling and for subsurface injection into soils with special equipment.

Wastewater Treatment Methods

Primary treatment (the mechanical removal of floating, settleable, or suspended solids) and secondary treatment (the biological removal of dissolved organic material) can be accomplished by several different methods including ponds, lagoons, filters, and land application.

Stabilization Ponds. Stabilization ponds are large, shallow ponds that collect sewage and hold it for a certain time. Solids settle out and decomposition occurs with the help of sun, wind, algae, bacteria, and air. There are two kinds of ponds: controlled discharge, where sewage stays 6 to 12 months in the pond before being released, and flow-through, where sewage flows out continuously but at a slow rate.

The advantages of stabilization ponds are low energy use, low construction and maintenance costs, and ease of operation. Maintenance requires controlling weed growth and removing sludge about once every 10 years.

The disadvantage can be relatively large land use (85 acres for a 1 million gallon per day flow), trouble meeting requirements for suspended solids because of the algae, and odor problems if oxygen is low. Putting the pond water through a sand filter before discharge to improve water quality is a problem, but this is now done on a limited basis because wetland areas and aquatic plants can be used to reduce suspended solids.

Lagoons. Lagoons account for about 25 percent of the municipal wastewater treatment facilities in the United States. Lagoons are relatively shallow and rely on a biological interaction of sunlight, algae, and oxygen to clean the water. They are most effective in breaking down low concentrations of organic matter.

An aerated lagoon is essentially a stabilization pond where oxygen is added by low-speed mechanical aerators or compressors. This system provides more effective secondary treatment than stabilization ponds. An aerated lagoon has mechanical parts that require energy and maintenance, but it treats sewage faster and better than a stabilization pond and requires up to 75 percent less land. Usually there are several small lagoons rather than a single large lagoon. Aerated lagoons have the advantage of producing a minimum of sludge.

Plants that do not de-water their sludge commonly pump it to sludge disposal lagoons, which are earth basins about 4 to 5 feet deep. There the organic solids are stabilized by aerobic and anaerobic decomposition. This practice is used primarily in remote locations because the decomposition may cause objectionable odors. At some time these lagoons will become full of solids that have stabilized and settled to the bottom. Usually these solids are then applied to nearby land resources because disposal regulations for landfilling are becoming increasingly stringent.

Aeration. Conventional activated sludge plants use this method to de-water their sludge. Sewage is held in an aeration tank for 6 to 8 hours. Submerged turbine units provide high oxygen-transfer rates for adequate aeration. Aeration requires a considerable investment of energy and maintenance.

An extended aeration plant is very similar to a conventional activated sludge plant except that it holds sewage in the aeration tank for a much longer period of time—24 hours rather than 6 to 8 hours. Sewage usually flows directly into the aeration tank with minimum primary treatment. Because the sewage is held longer, there is a higher level of treatment, and the sludge decomposes more, leaving less for disposal.

Oxidation canals or ditches are used in some plants to provide extended aeration. Aeration takes place in specially designed narrow continuous ditches or oval shaped channels where paddle wheel mechanisms circulate the sewage. In most plants secondary settling tanks follow the extended aeration cycle.

Trickling Filter. In a trickling filter plant, wastewater is given primary treatment and then applied to beds of stone 3 to 20 feet deep where microorganisms attached to the stones decompose the organic material in the water. The water is collected at the bottom of the filter and put into sedimentation basins. The water is then chlorinated and discharged.

Trickling filters cost more to build than activated sludge plants but are simpler to operate and use less energy. They are not as effective in removing pollutants as activated sludge plants and also require more land area.

Land Application Or Land Treatment. Treating wastewater by land application has regained popularity. Land treatment has the advantage of recycling the wastewater and its valuable nutrients. It can provide secondary sewage treatment as well as the equivalent of any advanced waste treatment process (tertiary treatment). Pollutants are removed by the physical filtering capacity of the soil, by various chemical processes, and by biological processes such as microorganisms decomposing organic material and plants taking up nutrients.

Land treatment requires a centralized sewage collection system and some pretreatment of the sewage. A storage system is required since wastewater cannot usually be applied to growing plants or soil on a year-round basis.

Methods of surface application include spreading by farm tractors, tank wagons, special applicator vehicles, or tank trucks and irrigation by either portable or fixed irrigation systems or by flooding.

Meadow/Marsh/Pond System. The meadow/marsh/-pond system is used by Disney World in Florida to achieve complete treatment of its sewage by using the natural cleansing properties of wetland areas. Sewage is first treated to remove the solids, then aerated in a holding pond, and pumped to a meadow. Seepage from the meadow enters surrounding marshes and from there flows to a stabilization pond. Effluent from the stabilization pond is either channeled into recharge basins or applied to a wooded area where it seeps into the ground. The vegetation that grows in this system can be harvested. No sludge is produced.

Monitoring And Permits

In a typical wastewater treatment plant, there may be as many as ten sampling points and more than thirty laboratory tests to determine the quality of the water coming in (influent) and the quality of the water going out of the plant (effluent). Some of the laboratory tests performed are as complicated as any used by the medical profession, and analytical instruments used in comprehensive monitoring programs can detect traces of substances down to one part of pollutant per million parts of water or even lower.

Since 1972, every wastewater treatment plant and every industrial or commercial facility that discharges directly to a body of water must have a special permit issued by the U.S. Environmental Protection Agency (EPA) or approved state agency. In Alabama this agency is the Alabama Department of Environmental Management (ADEM).

Monitoring requirements and pollutant discharge requirements are spelled out in a treatment plant's discharge permit. With the synthesis of organic chemicals that are harder to degrade and with greater restrictions on discharge concentrations, many wastewater treatment plants are finding it more difficult to meet discharge standards.

Future Treatment Needs And Costs

Effective wastewater treatment in the future will depend on the participation and support of all sectors of the American public, from legislators and regulatory officials to the individual citizen. The costs for collection, treatment, and ultimate disposal of wastewater in a manner that is safe and legally acceptable will likely increase in the foreseeable future. Many local governments that now have sufficient revenue to operate and maintain their existing wastewater treatment plants may have difficulty as standards change. If current trends continue, many treatment plants will have to be upgraded, or newer and more complex plants will have to be constructed. These plants will be much more expensive to construct and operate.

Conclusion

Public health and water quality are protected better today than ever before. But with the waste stream changing rapidly, greater efforts must be made to keep waste from the stream, or greater costs will be required to monitor and remove pollutants.

References

Marek, Linda G. 1984. Water And Sewage Treatment For Small Communities. BR. 1347. Vermont Cooperative Extension Service. University of Vermont. Burlington, VT.

Metcalf and Eddy, Inc. 1991. Wastewater Engineering: Treatment, Disposal, And Reuse. 3rd ed. McGraw-Hill, Inc. New York, NY.

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For more information, call your county Extension office. Look in your telephone directory under your county's name to find the number.

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