Operation, Maintenance, and Management of Small Wastewater Systems

CONTRIBUTING WRITER
Lorene Lindsay

Options for small system treatment include package plants (top) and oxidation ditches (bottom). Photos courtesy of Lorene Lindsey.

Small wastewater treatment systems have become a viable method for providing wastewater treatment in rural areas. These small systems have filled an important niche by providing good treatment alternatives at a reasonable cost.

For many rural areas, a large, centralized wastewater treatment system is not a viable option due to financial, regulatory, or technological problems. The older decentralized systems used a rule of thumb that a conventional collection system required at least 50 connections per mile of sewer to be economically feasible. Newer, small-diameter sewers, which include low-pressure systems, STEP (septic tank effluent pump) systems, grinder pump systems, and even vacuum sewers, have provided a low-cost method for small rural areas to collect wastewater and treat it with some type of small system located close by.

The growth in technology to provide treatment by small systems has been explosive, and we have many options, including recirculating sand filters; biofilters that use geotextile, peat, or plastic media; small aeration plants; constructed wetlands; sequencing batch reactors; and more traditional activated sludge treatment, such as oxidation ditches. This wealth of technology has enabled many small communities to provide high-quality wastewater treatment at a reasonable cost.

However, to keep these small systems viable for the long term, good operations, skilled maintenance, and reliable management systems must be implemented. One reason the regulatory community has been slow in some cases to embrace the concept of small decentralized systems is that without operation, maintenance, and management, many of these small systems will fail.

Operational Concerns

Wastewater treatment involves a complex interaction of physical, chemical, and biological processes that work together to remove pollutants. Small systems require operational control to keep these processes functioning as designed. Without operational control, the system will fail and poor effluent quality will result. The operator of a small system must understand how these processes occur and keep conditions optimum for the treatment process.

Collection

Physical treatment processes involve some method of separating the solids and scum from the liquid wastewater. In the case of a STEP system, the larger solids and scum should be retained by the septic tank that is placed at each home. The septic tank must be sized to handle the flow it receives and provide enough detention time to allow the solids to settle. The tank must also have baffles to catch the scum and keep it contained in the tank. Operators must understand how the tank functions and recognize when the tank is not operating properly. The operational controls on the tank include checking for the level of sludge build-up in the tank, correct placement of the baffles, and keeping screens and filters clean and functional.

In a grinder pump system, the solids are ground up by cutter blades located on the pump impeller. The small solids produced by this process are transported through a low-pressure, small diameter pipe to a treatment process. Depending upon the type of treatment process, the wastewater may be filtered or allowed to settle by gravity prior to the next biological treatment process. Operational controls include keeping the grinder blades sharp to produce small solids that can be kept in suspension and moving through the small diameter sewer. If solids are allowed to accumulate in the pipe, clogging and anaerobic conditions will develop that may negatively impact the treatment process.

The operator must understand how to keep the collection system operational and be ready to respond when the system experiences problems. Understanding what types of wastes can and cannot be treated by the system is important. The operator must work with the users of the system to exclude unacceptable wastes and flows, such as infiltration/inflow, and keep the system within the operational parameters for which it was designed.

Treatment

The complex interaction of biological treatment processes is the most challenging, but also the most important aspect of wastewater treatment. All treatment processes depend upon a complex mix of bacteria, protozoa, fungi, and other small organisms to decompose the organic matter in the waste and produce a clear, clean effluent. The specific microorganisms that develop in the treatment process depend upon the type of treatment and the characteristics of the wastewater; however, from an operational view these microorganisms have the same basic needs. Aerobic microorganisms are the most efficient at decomposing wastes and are usually favored by most treatment systems. The anaerobic and facultative microorganisms are usually present in wastewater and may play an important role in some types of treatment systems; however, the aerobic microbes are the most important for efficient treatment.

Natural aeration occurs in constructed wetlands and is provided by sunlight, wind, and wave action. Photo courtesy of Lorene Lindsey.

In order to provide good treatment, the system must maintain conditions that favor the development of a complex mix of microorganisms. The operational factors that affect the microbial population include temperature, dissolved oxygen, pH, and nutrients. The operator should keep these factors optimal for microbial growth and understand how to respond when conditions change.

Microbial activity increases with increasing temperature. Although the operator cannot usually control the temperature of the wastewater directly, other operational strategies may be implemented to minimize the negative effects of changing temperatures. When temperatures begin to decrease, the microbial activity slows down, and more time may be required for good treatment. Increasing the recirculation rate within the system may provide more treatment time. Increasing recirculation may also function to conserve heat and keep the water temperature more stable. The detention time in the final clarifier may also be increased to promote better settling.

The amount of dissolved oxygen in an aeration tank is controlled by mechanical or diffused aeration. Photo courtesy of Lorene Lindsey.

The pH is another factor that may not be under the direct control of the operator; however, understanding changes in pH may help the operator keep the process functional. Anaerobic conditions in the collection system may lead to a lower pH in the treatment plant itself. Level controls in the collection system may need to be adjusted to pump the wastewater more frequently to prevent the development of anaerobic conditions.

The pH must remain between 6.00 and 9.00 to keep the microbial population active and growing. Strong wastes that have a pH lower or higher than these optimum conditions may need to be excluded from the system and receive pretreatment to adjust the pH before the wastes can be treated. In some cases, a lower pH in the treatment process may favor the development of filamentous microorganisms that do not produce the best quality effluent. In extreme cases, some form of pH adjustment through chemical treatment may be needed to get a system back within the optimum pH conditions.

Dissolved oxygen is the most important operational control that the operator can adjust in response to changes in the treatment system. Oxygen is more soluble in water as the temperature decreases. This means that colder water will hold more oxygen, and so aeration equipment may need to be throttled down during colder temperatures.

Most wastewater treatment systems are designed to provide a dissolved oxygen level of 2.0 to 6.0 milligrams per liter. The dissolved oxygen in the effluent may be controlled by aeration equipment that provides either mechanical or diffused aeration. Both types of aeration provide oxygen and mixing to the system that are vital in keeping the microbes functioning. However, in some types of activated sludge treatment systems, too much mixing may cause the floc particles to shear, making them too small to settle easily in the final clarifier. In an activated sludge process, the operator must keep the aeration high enough to provide the mixing and dissolved oxygen needed for optimal microbial growth, but low enough to produce a large, good-settling floc. Operational problems due to poor settling may be caused by a variety of factors. In most cases these operational problems develop when the wrong type of microorganisms dominate the activated sludge

The level of dissolved oxygen in some treatment systems may be controlled through the recirculation rate. In the case of a fixed-film process, such as a sand filter, natural aeration is provided as the wastewater flows over the media. To increase the dissolved oxygen, the rate of recirculation is increased. The operator must find the proper recirculation rate to provide good oxygen transfer but not overload the system hydraulically.

Natural aeration also occurs in systems such as a lagoon or constructed wetland. These systems must be operated with natural aeration in mind so that sunlight, wind, and wave action are able to provide the dissolved oxygen needed for the system.

Nutrients, such as carbon, nitrogen, and phosphorous, are needed by all living organisms. To keep the bacteria healthy, these nutrients must be present and available to the microbes. Nutrients are normally readily available in wastewater; however, some industrial wastes and some recycled flows within the wastewater plant may not provide these nutrients in the proper ratio to keep the right types of microbes growing. Nutrient addition may be required in these situations to keep the proper type of microorganisms growing and healthy.

The wastewater treatment process depends upon a complex ecosystem of microbes. Operational controls may need to be adjusted to keep the proper mix of microbes to produce a good quality effluent. The operator must be aware of the growth factors affecting the microbes and understand how to adjust the treatment process to provide these growth factors.

Maintenance

Often we hear the term "low maintenance" used to describe a particular treatment process, especially for small systems. Low maintenance often means that energy costs or equipment requirements are low for the system. However, any treatment system that uses mechanical equipment must receive regular maintenance to remain functional. In the case of the so-called natural systems, such as constructed wetlands, a high level of hands-on physical labor to keep the system operational may replace mechanical maintenance.

Every wastewater treatment system will require some level of on-going maintenance. A small system may be able to function well with only a part-time operator, but preventive maintenance must be addressed if the system is to continue to provide a high level of treatment. The type of maintenance needed is specific to the treatment process, and a maintenance program must be included in the design and development of any wastewater treatment project.

Management: Personnel and Finances

Just as important as maintenance is the development of a management system for the project. Management in this sense means the implementation of a system to organize, staff, maintain, budget, and plan for the long-term operation of the treatment facilities. Proper management will provide the resources to keep the system operational throughout the life of the equipment, provide repair and replacement of equipment when needed, and keep the system at peak operational capability. Without a management system, small, decentralized wastewater treatment plants will be unable to acquire the resources needed to continue to produce high-quality effluent.

Management of these systems must begin with an understanding of the operational skills required to keep the system functioning. Qualified operators must be engaged either as part-time or full-time employees to operate and maintain the equipment. The management process must include policies and procedures that clearly establish the roles and responsibilities of all personnel. Adequate staff must be supplied and given the authority to properly operate and maintain the system. Many small systems may be able to contract with others to provide the necessary operational and management skills.

The management of these systems will also require the establishment of a financial structure that can generate the resources needed to run the facility and oversee the proper spending of revenues. Many small facilities have used existing administrative systems, such as public water districts, to provide services for billing and revenue collection. In addition to revenue generation, the facility must have established financial policies and procedures that govern the allocation of revenues to keep the system functional. The system should be managed so that funds are generated to pay current costs and provide long-term replacement costs for all capital equipment. Financial checks and balances must be provided to accurately track expenses and revenues and for the preparation of an annual expense report. The financial records must be managed and used to plan for future needs.

These systems will require all of the same management functions, planning, staffing, organizing, budgeting, and controlling, that a small company or other utility might require. If any one of these management functions is overlooked, the small wastewater treatment system will not be able to remain functional and provide users with an adequate level of service.

With new technology and "thinking outside the box," we have the opportunity to build small, decentralized wastewater treatment systems that provide high-quality treatment for a reasonable cost. This type of decentralized treatment can best serve many small communities, including resorts with intermittent use and geologically challenged sites. However, these small systems will require operation, maintenance, and management to keep them operating as designed.

Providing the human resources needed by these systems over the long term will determine the ultimate success of decentralized wastewater treatment. As we discuss the technical, regulatory, and financial issues surrounding these systems, we also need to discuss the training and ongoing commitment that will be required to keep these systems operationally sound and protecting our very important water resources.

Lorene Lindsay is the owner and president of Silver Springs Environmental Services, Route 3 Box 145 B, Moberly, MO 65270. She holds a Level A wastewater operator's license in Missouri, is a licensed onsite installer and onsite loan evaluator through the Missouri Department of Health, and a certified wastewater analyst. She can be contacted at **lorene@ssenvironmental.com** or (816) 797-7753.