DOWN the DRAIN?

WHAT HAPPENS TO OUR WASTEWATER?

by Terry Kirschenman

Flush it. Dump it. Pour it down the drain. What happens to all that "stuff" known as wastewater?

Wastewater treatment is a service taken for granted by the general public, and few realize the complexity of the operation, the usefulness of its byproducts and the relative bargain of this service. Despite their complexity, wastewater treatment plants are designed for two basic purposes — to speed up the natural purification processes that occur in rivers, lakes and streams and reduce pollutants that may interfere with these processes. Designing treatment plants to do these things is a science constantly developing to provide efficient treatment at the lowest cost. However, the goal remains the same — to produce a stream of water that is safe to return to the environment.

HISTORY

Treatment plants as we know them are a fairly recent development. The science of bacteriology was not developed until the last half of the nineteenth century. The Bible may record the first law mandating separation and land application of human wastes. Sewers constructed in Roman times until the 1840s were principally for storm drainage only. Human waste was not specifically directed to the sewers of London until 1815, Boston until 1833, and Paris until 1880.

Treatment facilities constructed from 1900 to 1930 were built primarily to remove suspended solids and oxygen-demanding pollutants. From 1930 to 1960, emphasis was on reducing the toxic pollutants and controlling the release of disease-causing bacteria and viruses. Since 1960, additional emphasis has been on protecting the receiving stream from pollutants such as ammonia nitrogen, which is toxic to fish and other aquatic life. Adequately controlling residual sludges generated from the treatment process and recycling these solids for beneficial use has been more recent.

The degree of treatment required for each community depends on the waste quantity and uses of the receiving stream. Larger streams can handle higher pollutant loads without adverse environmental effects. Small streams generally handle less. The federal Clean Water Act of 1972 set minimum treatment standards for all plants, and a goal of fishable and swimmable streams throughout the United States. At many locations, the Iowa DNR requires more advanced treatment than the federal minimum to protect streams for specific uses. Therefore a treatment plant must have adequate capacity to handle the volume of water, microorganisms to convert the organic pollutants in the water to a solid biomass, and settling or straining processes to remove waste solids and microorganisms.

Wastewater is 99.9 percent water by weight. Hence, the name "wastewater." The size of treatment plants is often an issue of wastewater volume. Only a small fraction of the untreated wastewater is solid matter. The treatment challenge is removing that small objectionable fraction quickly before the treated water is discharged into the receiving stream.

Many cities have sewer collection systems allowing the wastewater to flow by gravity to a treatment plant. Municipalities are required by law to properly treat all polluted waters and all wastewater treatment plants are limited in the amount of flow that can be accommodated. A tight collection system will produce average flows of less than 100 gallons per person per day.

A wastewater treatment plant typically consists of several process units designed to remove different pollutants. The various units have specific tasks, with an overall objective of removing at least 85 percent of the oxygen-demanding pollutants and suspended solids. To a certain extent, all receiving streams have an ability to handle limited pollutants naturally, and for this reason, it is not necessary to remove 100 percent of the organic wastes from the water.

The primary measurement made is BOD — biochemical oxygen demand. This is not a pollutant, but rather an indication of the amount of oxygen in the water necessary for decomposition of organic wastes. The greater the BOD, the greater the degree of pollution. If it is not reduced by the treatment plant, the oxygen-demanding pollutants may deplete the oxygen in the receiving stream, killing fish and the aquatic life they feed on. Fish and other aquatic life need an adequate supply of dissolved oxygen to survive.

Suspended solids may also contain many BOD pollutants, and are reduced to not only meet BOD requirements, but also for reasons of aesthetics and public health.

TREATMENT PROCESSES

Most treatment plants include the same basic processes — preliminary treatment, primary treatment, biological oxidation and final clarification. The solids generated from the treatment processes are concentrated into a sludge. This sludge is further treated or stabilized so it can be disposed of or used as a soil conditioner without posing any health problems.

Preliminary treatment includes the physical removal of large debris that has found its way into the collection system — sand, bricks, rags and wood. This stage normally includes screening facilities and grit removal. The screens have steel bars with spacings of about one inch. The grit removal equipment removes sand and small stones. Grit removal tanks are designed to slow the water just enough to let the heavy sand and gravel drop to the bottom. Some grit removal systems spin the wastewater as it moves through the tank; the cyclonic effect helping separate the grit from the wastewater.

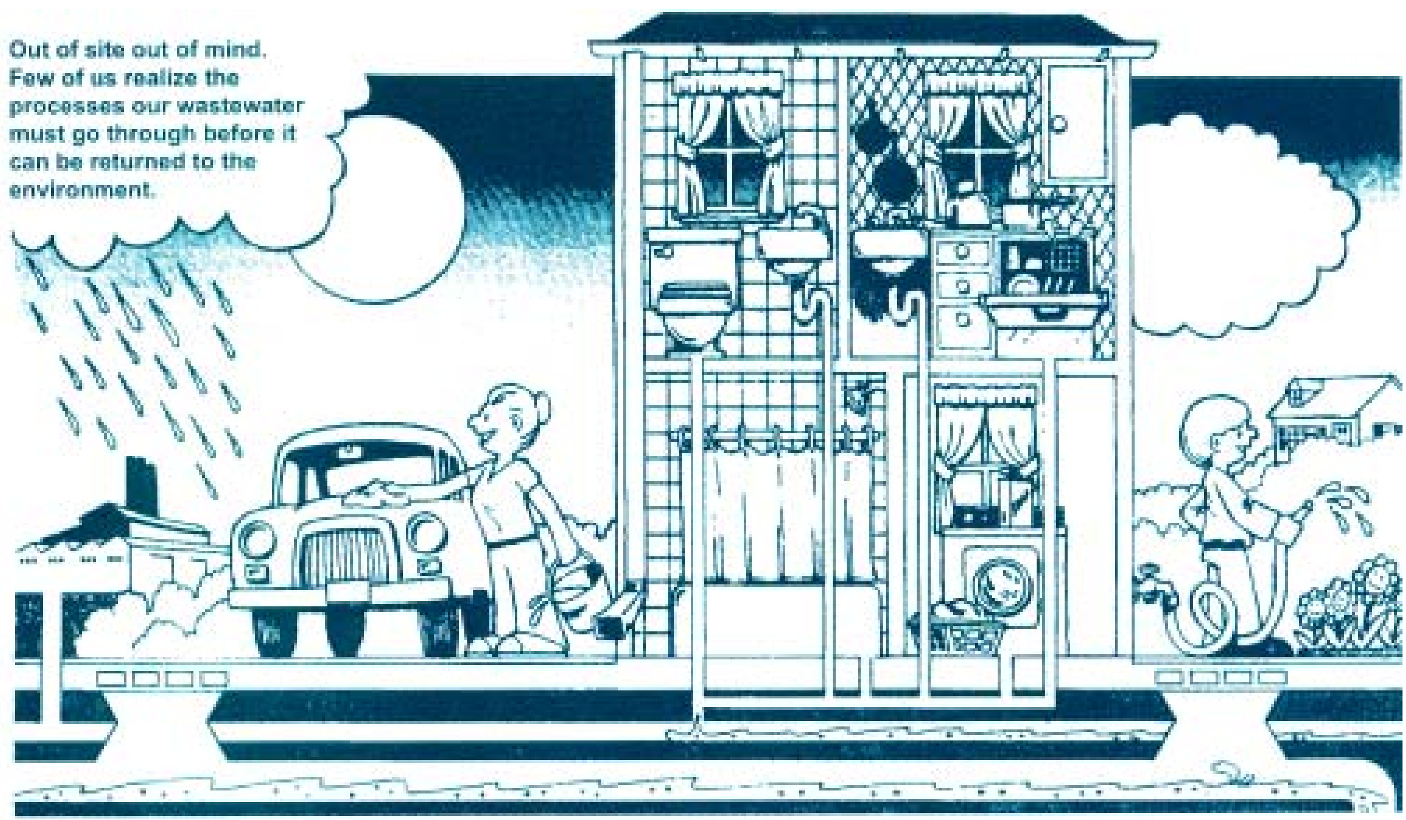
These two units remove the large material that tends to plug pipes, clog pumps, cause wear on equipment or collect in later treatment. The grit and debris is collected, lime stabilized to reduce odor and bacteria, and hauled to a sanitary landfill.

In **primary settling** the wastewater goes to clarifiers — typically, circular tanks eight feet deep. These settling tanks provide a period of several hours to allow most suspended solids to settle to the bottom. This mass of settled solids is called raw sludge. Up to 60 percent of the solids and more than 30 percent of the BOD pollutants are removed by the primary clarifiers. A mechanical scraper at the bottom of the tank collects the settled sludge, and surface skimmers collect any rising oil and grease. The wastewater is collected near the top of the tank and directed to the next process.

The wastewater is subjected to **biological oxidation** in the next treatment stage by a separate unit containing microorganisms, including protozoa, fungi, algae, and a wide variety of bacteria, numbering in the millions. Biological oxidation speeds up the natural decay of the wastes. It is the heart of the treatment plant.

With the solids removed in the previous stages, most of the pollutants in the wastewater, at this point, are dissolved. In the biological oxidation stage, treatment units provide an oxygen-rich environment allowing the microorganisms to use the organic pollutants as food. When the process is completed, the microorganisms are removed from the wastewater by settling or straining.

The most common units used for biological oxidation are trickling filters or activated sludge tanks. In trickling filter plants, the microorganisms attach



themselves as a slime to the surface of corrugated plastic. When the wastewater is trickled over the corrugated plastic, the attached microorganisms feed on the pollutants as they drip and trickle past. Some older treatment plants use rock as a media, but modern trickling filter towers use corrugated plastic about 20 feet deep. The air spaces in the corrugated plastic give the microorganisms access to the oxygen they need.

In activated sludge facilities, the microorganisms are suspended in a tank filled with wastewater by mixing equipment and/or air pumped into the wastewater. The microorganisms are usually mixed in this oxygen-rich solution for 4 to 12 hours. Activated sludge process technology has been used for many years.

Final Clarification - At first glance the final clarifiers look the same as primary settling tanks, but they are typically deeper and larger. Their main function is to capture the microorganisms leaving the biological oxidation units. As in the primary tanks, these units still the water to provide settling and separation. Once the microorganisms are collected at the bottom of the tank, the sludge solids, which are mostly microorganisms, are sent back to the activated sludge tank to continue their job or diverted to a sludge digestion unit if they are no longer needed. The wastewater is clear at this point and is collected near the top of the tank. The wastewater is now either discharged to the receiving stream or gets disinfected.

Disinfection - Disinfection eliminates disease-causing bacteria and viruses remaining in the wastewater. The need to provide disinfection depends on the uses of the receiving water. Treated wastewater discharging into a stream used for swimming, water skiing or other water contact recreation must be disinfected.

Disinfection is typically done by mixing in small doses of chlorine. The chlorine destroys most of the remaining bacteria and viruses contained in the wastewater. Another type of disinfection uses ultraviolet (UV) light. UV light does not kill the bacteria, but it eliminates the threat of disease in the wastewater by making the bacteria or virus unable to reproduce. It employs tubes with UV lamps located in the flow path of the wastewater. Both types of disinfection are effective. Chlorine disinfection has been used routinely since 1911 whereas UV disinfection technology is more recent.

Sludge Digestion - The wastewater sludge solids collected from the settling tanks must be further treated or "digested" prior to disposal to reduce odors and the potential for disease. Two types of digestion tanks are employed — one uses oxygen, one does not. With adequate temperature, either digestion process can be used to significantly reduce the disease-causing bacteria in the wastewater sludge. Both are biological processes using concentrated sludge as a source of food for microorganisms.

> Despite their complexity, wastewater treatment plants are designed for two basic purposes — to speed up the natural purification processes that occur in rivers, lakes, and streams and reduce pollutants that may interfere with these processes.

Concrete pads and tanks, glass lined steel tanks, or earthen basins designed to protect the groundwater are used to store the resulting "biosolids" prior to disposal. Most communities in Iowa apply their biosolids (digested sludge) to farmland as a fertilizer.

ADDITIONAL TREATMENT PROCESSESS

There are numerous other types of treatment processes and combinations of the above — sand filters, stabilization lagoons and aerated lagoons — all of which employ physical processes to remove solids from the wastewater such as settling or filtering in addition to the biological oxidation. Lagoons are the most common approach used by small communities in the Midwest. They differ from the previously described mechanical treatment plants by accomplishing all treatment in two or three ponds, and do not have an elaborate means of removing sludge solids after settling. After many years of use, the lagoons must be cleaned of the wastewater sludge sediments.

While the appearance of treatment plants has changed with time and new technology, the need to dispose of the residue has not changed. Pollutants remain misplaced resources in the same way weeds can be misplaced flowers. There always has and always will remain only three places to dispose of waste — air, land and water. If we remove it from the water, it must go in the air or on the land. We all have a stake in ensuring pollutants can be turned into resources for our children and grandchildren.

Terry Kirschenman is an environmental engineer for the department's wastewater construction section in Des Moines.

Reprinted from the March/April 1996 *Iowa Conservationist*.