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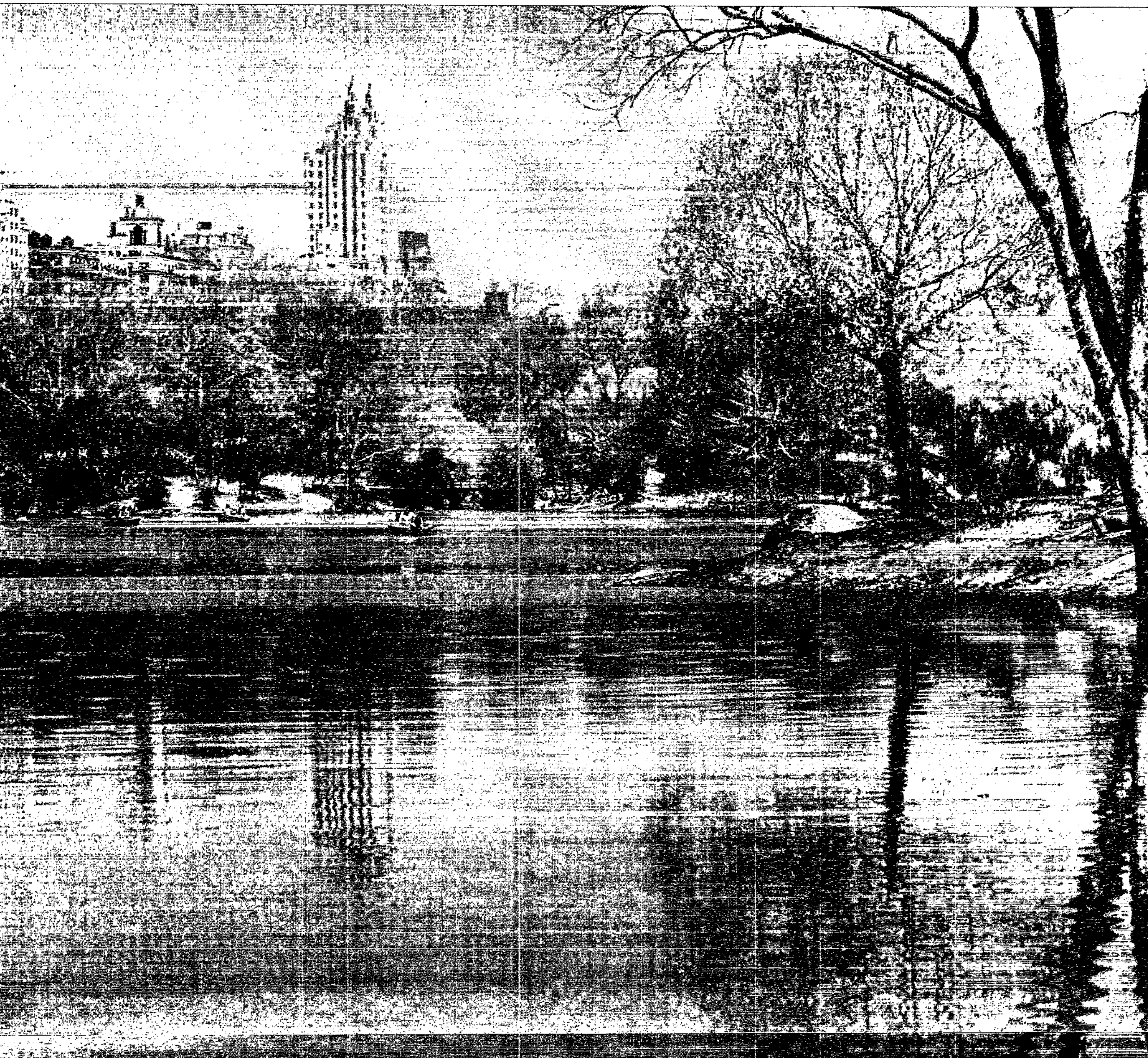
Primer for Wastewater Treatment



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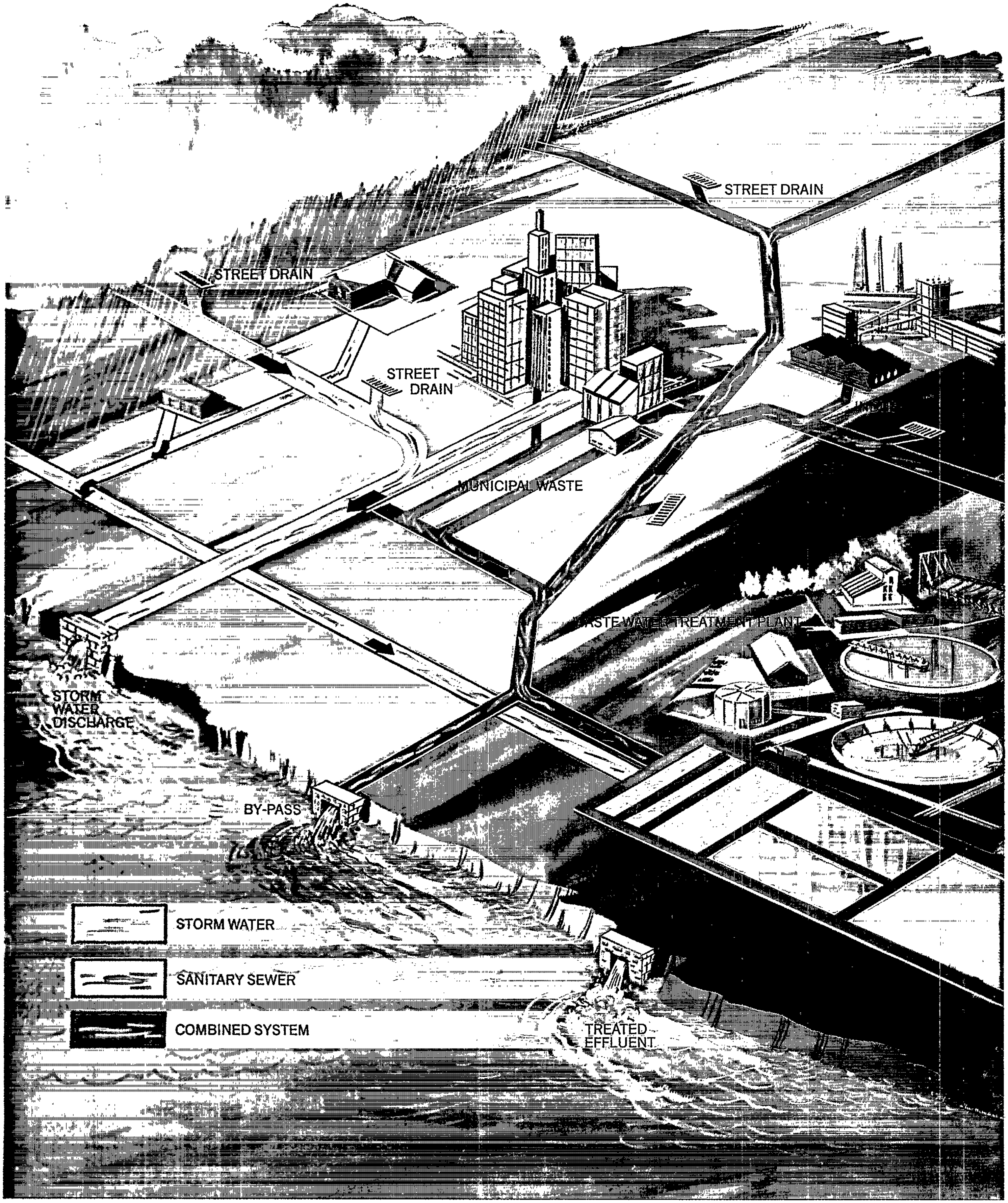
Under the 1972 Amendments to the Federal Water Pollution Control Act (Public Law 92-500) and the more recent Clean Water Act of 1977 (Public Law 95-217), enacted in December 1977, thousands of municipal waste treatment plants are being constructed or expanded across the Nation to control or prevent water pollution.

The 1972 law authorized grants totaling $18 billion and the 1977 law authorized an additional $24.5 billion; all to help towns and cities to construct waste treatment facilities. An additional $1.480 billion was made available under other laws. The grants under the 1972 Act funded 75 percent of the eligible cost of facilities.

The law also established the National Pollution Discharge Elimination System which calls for limitations on the amount and quality of effluents and requires all municipal and industrial dischargers to obtain permits. The permits include effluent clean-up dates which are enforceable by State or Federal Government. Further, the law sets this goal: water clean enough for swimming, boating, and protection of fish, shellfish, and wildlife by 1983.

Construction of the needed municipal treatment plants won't happen overnight. From drawing board to operation takes time. But progress is being made, and more and more people are watching this progress. And they want to know more about wastewater treatment.

This primer explains the methods used now and processes being developed for the future to treat wastewater discharges and to give the Nation clean water.


STREET DRAIN
STREET DRAIN
STREET
DRAIN
MUNICIPAL WASTE
WATER TREATMENT PLANT
STORM
WATER
DISCHARGE
BY-PASS
STORM WATER
SANITARY SEWER
COMBINED SYSTEM
TREATED
EFFLUENT

Collecting and Treating Wastes

The most common form of pollution control in the United States consists of a system of sewers and waste treatment plants. The sewers collect the wastewater from homes, businesses, and many industries and deliver it to the plants for treatment to make it fit for discharge into streams or for reuse.

There are two kinds of sewer systems — combined and separate. Combined sewers carry away both water polluted by human use and water polluted as it drains off homes, streets, or land during a storm.

In a separate system, one system of sewers, usually called sanitary, carries only sewage. Another system of storm sewers takes care of the large volumes of water from rain or melting snow.

Each home has a sewer or pipe which connects to the common or lateral sewer beneath a nearby street. Lateral sewers connect with larger sewers called trunk or main sewers. In a combined sewer system, these trunk or main sewers discharge into a larger sewer called an interceptor. The interceptor is designed to carry several times the dry-weather flow of the system feeding into it.

During dry weather when the sewers are handling only the normal amount of wastewater, all of it is carried to the waste treatment plant. During a storm when the amount of water in the sewer system is much greater, it may be necessary to allow part of the water — including varying amounts of raw sewage — to bypass directly into the receiving streams. (These large "slugs" of combined raw sewage and storm water discharged to streams can be damaging to water quality and efforts are underway to control them.) The rest of the wastes are sent to the treatment plant. If part of the increased load of water were not diverted, the waste treatment plant would be overloaded and the purifying processes would not function properly. (Technology has been developed that will, when applied, control and treat the storm water discharges and the general runoff of rainwater polluted by dirt and other contaminants.)

Interceptor sewers are also used in sanitary sewer systems as collectors of flow from main sewers and trunks, but do not normally include provisions for bypassing.

A waste treatment works' basic function is to speed up the natural processes by which water purifies itself. In many cases, Nature's treatment process in streams and lakes was adequate before our population and industry grew to their present size.

Separate systems . . . storm sewer outfall

However, these natural processes, even though accelerated in a waste treatment plant, are not sufficient to remove other contaminants such as disease-causing germs, excessive nutrients such as phosphates and nitrates and chemicals and trace elements.

When the sewage of previous years was dumped into waterways, the natural process of purification began. First, the sheer volume of clean water in the stream diluted the small amount of wastes. Bacteria and other small organisms in the water consumed the sewage or other organic matter, turning it into new bacterial cells, carbon dioxide, and other products.

But the bacteria normally present in water must have oxygen to do their part in breaking down the sewage. Water acquires this all-important oxygen by absorbing it from the air and from plants that grow in the water itself. These plants use sunlight to turn the carbon dioxide present in water into oxygen.

The life and death of any body of water depend mainly upon its ability to maintain a certain amount of dissolved oxygen. This dissolved oxygen — or DO — is what fish breathe. Without it they suffocate. If only a small amount of sewage is dumped into a stream, fish are not affected and the bacteria can do their work; the stream can quickly restore its oxygen loss from the atmosphere and from plants. Trouble begins when the sewage load is excessive. The sewage will decay and the water will begin to give off odors. If carried to the extreme, the water could lose all of its oxygen, resulting in the death of fish and beneficial plant life.

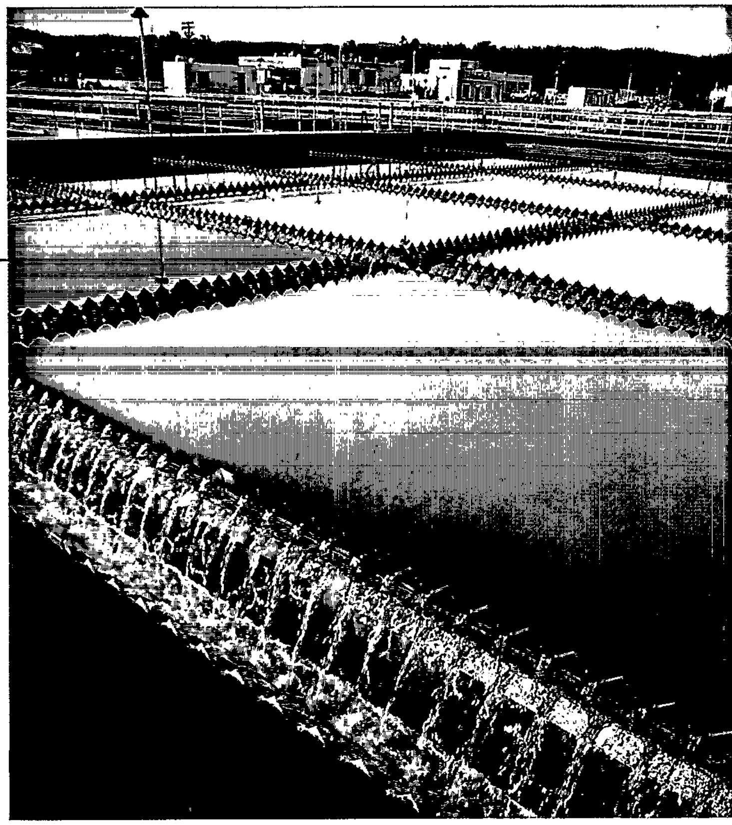
Since dissolved oxygen is the key element in the life of water, the demand placed on the natural supply of dissolved oxygen is used as a measure in telling how well a sewage treatment plant is working. This measuring device is called biochemical oxygen demand, or BOD. If the effluent or the end-product from a treatment plant has a high content of organic pollutants, the effluent will have a high BOD. In other words, it will demand more oxygen from the water to break down the sewage and consequently will leave the water with less oxygen (and more pollutants).

With the growth of the Nation, the problems of pollution have become more complex. The increased amounts of wastes and the larger demands for water have reduced the capacity of running water to absorb waste water and purify itself. Consequently, cities and industries have had to begin to remove as much as possible of the oxygen-demanding and other pollutants from their sewage.

Adequate treatment of wastes along with providing a sufficient supply of clean water has become a major concern.

At present there are two basic stages in the treatment of wastes. They are called primary and secondary. In the primary stage of treatment, solids are allowed to settle and are removed from the water. The secondary stage uses biological processes to purify the wastewater even further. In some cases, the two stages may be combined into one basic operation.

Basic Treatment



Sedimentation tanks

Primary Stage

As sewage enters a plant for treatment, it flows through a screen. The screen removes large floating objects such as rags and sticks that may clog pumps and small pipes. The screens vary from coarse to fine — from those with parallel steel or iron bars with openings of about half an inch or more to screens with much smaller openings.

Screens are generally placed in a chamber or channel in an inclined position to the flow of the sewage to make cleaning easier. The debris caught on the upstream surface of the screen can be raked off manually or mechanically.

Some plants use a device known as a comminutor which combines the functions of a screen and a grinder. These devices catch and then cut or shred the heavy solid material. In the process, the pulverized matter remains in the sewage flow to be removed later in a settling tank.

After the sewage has been screened, it passes into what is called a grit chamber where sand, grit, cinders, and small stones are allowed to settle to the bottom. A grit chamber is highly important for cities with combined sewer systems because it will remove the grit or gravel that washes off streets or land during a storm and ends up at treatment plants.

The unwanted grit or gravel from this process is usually disposed of by filling land near a treatment plant.

In some plants, another screen is placed after the grit chamber to remove any further material that might damage equipment or interfere with later processes.

With the screening completed and the grit removed, the sewage still contains dissolved organic and inorganic matter along with suspended solids. The latter consist of minute particles of matter that can be removed from the sewage by treatment in a sedimentation tank.

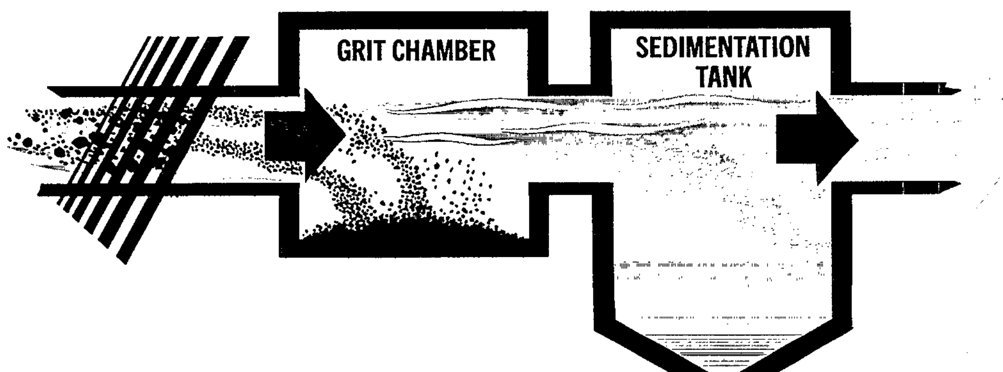
When the speed of the flow of sewage through one of these tanks is reduced, the suspended solids will gradually sink to the bottom. This mass of solids is called raw sludge.

Various methods have been devised for removing sludge from the tanks.

In older plants, sludge removal was done by hand. After a tank had been in service for several days or weeks, the sewage flow was diverted to another tank. The sludge in the bottom of the out-of-service tank was pushed or flushed with water to a pit near the tank, and then removed, usually by pumping, for further treatment or disposal.

Almost all plants built within the past 30 years have had a mechanical means for removing the sludge from sedimentation tanks. Some plants remove it continuously while others remove it at intervals. To complete the primary treatment, the effluent from the sedimentation tank is usually disinfected with chlorine before being discharged into a stream or river. Chlorine is fed into the water to kill and reduce the number of disease-causing bacteria. Chlorination also helps to reduce objectionable odors.

In the past, 30 percent of the municipalities in the United States did not treat their sewage beyond the primary stage. This amount of treatment alone was inadequate to meet today's water quality requirements. To meet these requirements, cities and industries will have to remove even more contaminants at the secondary stage, and in some cases, use advanced treatment.



Basic treatment . . . primary stage

Secondary Stage

The secondary stage of treatment removes up to 90 percent of the organic matter in sewage by making use of the bacteria in it. The two principal techniques used in the secondary stage are trickling filters and the activated sludge process.

After the effluent leaves the sedimentation tank in the primary stage of treatment, it flows or is pumped to a facility using one or the other of these processes. A trickling filter is simply a bed of stones from three to six feet deep through which the sewage passes. More recently, interlocking sheets of corrugated plastic or other types of synthetic media have also been used for trickling filter beds. Bacteria gather and multiply on these stones until they can consume most of the organic matter in the sewage. The cleaner water trickles out through pipes in the bottom of the filter for further treatment.

The sewage is applied to the bed of stones in two principle ways. One method consists of distributing the effluent intermittently through a network of pipes laid on or beneath the surface of the stones.

Attached to these pipes are small, vertical pipes which spray the sewage over the stones.

Another much-used method consists of a vertical pipe in the center of the filter connected to rotating horizontal pipes which spray the sewage continuously upon the stones.

From the trickling filter, the sewage flows to another sedimentation tank to remove the bacteria. Disinfection of the effluent with chlorine is generally used to complete the secondary stage of basic treatment.

The trend today is toward the use of the activated sludge process instead of trickling filters. There is, however, a renewed interest in trickling filters because of their relative ease of operation and efficient use of energy. The activated sludge process speeds up the work of the bacteria by bringing air and sludge heavily laden with bacteria into close contact with the sewage. After the sewage leaves the settling tank in the primary stage, it is pumped to an aeration tank where it is mixed with air and sludge loaded with bacteria and allowed to remain for several hours. During this time, the bacteria break down the organic matter.

The sludge, now activated with additional millions of bacteria and other tiny organisms, can be used again by returning it to an aeration tank for mixing with new sewage and ample amounts of air.

The activated sludge process, like most other techniques, has advantages and limitations. The size of the units necessary for this treatment is small, thereby requiring less land space and the process is free of flies and odors. But it is more costly to operate than the trickling filter, and the activated sludge process sometimes loses its effectiveness when faced with complex industrial wastes.

An adequate supply of oxygen is necessary for the activated sludge process to be effective. Air is mixed with sewage and biologically active sludge in the aeration tanks by three different methods.

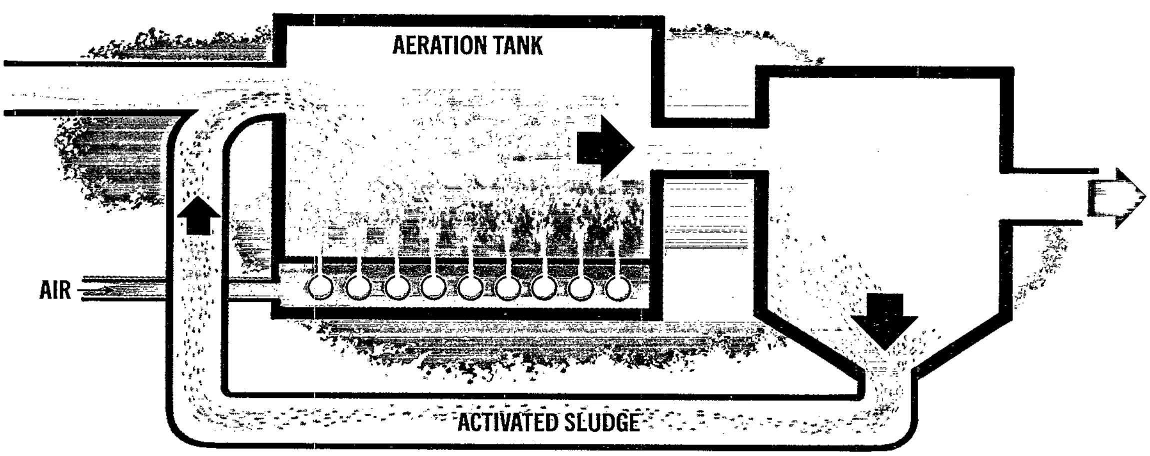
The first, mechanical aeration, is accomplished by drawing the sewage from the bottom of the tank and spraying it over the surface, thus causing the sewage to absorb large amounts of oxygen from the atmosphere.

In the second method, large amounts of air under pressure are piped down into the sewage and forced out through openings in the pipe. The third method is a combination of mechanical aeration and the forced air method. Relatively pure oxygen which can be produced by means of a number of different manufacturing processes has also been used to provide oxygen to the sewage.

From the aeration tank, the sewage flows to another sedimentation tank to remove the bacteria.

There are some recent developments in biological secondary treatment processes which are essentially variations or combinations of the trickling filter and activated sludge methods of treatment. These include the use of synthetic discs in place of stationary media in trickling filters. In this case the discs are rotated through the sewage to contact the bacteria with the organic matter in the sewage. There are also variations of the activated sludge process which have been

Secondary stage . . . activated sludge process



adapted for smaller and moderate-sized communities. These systems provide longer contact of the sewage with the bacteria to facilitate easier operation. Conventional rectangular and circular tanks or racetrack shaped basins have both been used in these systems.

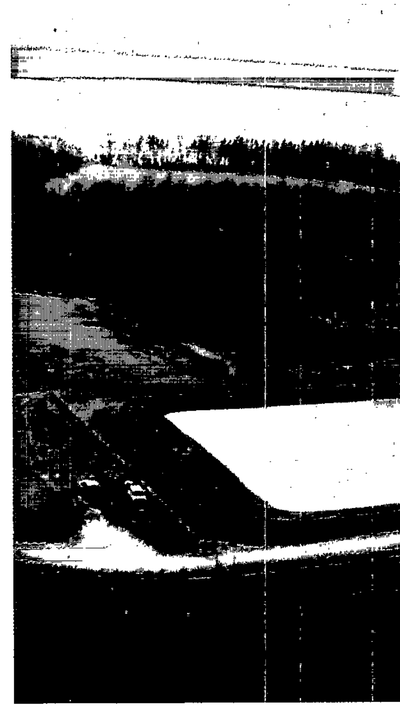
The final step again generally consists of the addition of chlorine — the most common method of disinfection — to the effluent coming from the trickling filter or activated sludge process. Chlorine is usually purchased in liquid form, converted to a gas, and injected into the effluent 15 to 30 minutes before the treated water is discharged into a water course. If done properly, chlorination will kill more than 99 percent of the harmful bacteria in an effluent.

Some municipalities are now manufacturing chlorine solution on site to avoid the necessity of transporting and storing large amounts of chlorine gas. Alternates to chlorine disinfection, such as ozone, are also being used in a number of situations where chlorine in sewage effluents can be harmful to fish and other aquatic life.

Aeration tank

Trickling filter

Wastewater Treatment Ponds



Lagoons, or as they are usually called, wastewater treatment ponds also have several advantages when used correctly.

They can be used to treat sewage to the secondary stage of treatment or they can be used to supplement other processes. Treatment ponds, predominantly in smaller communities, account for more than one-fourth of the municipal wastewater treatment facilities in this country.

A treatment pond is a scientifically constructed pond usually three to five feet deep, in which sunlight, algae, and oxygen in-

Sewage treatment lagoons

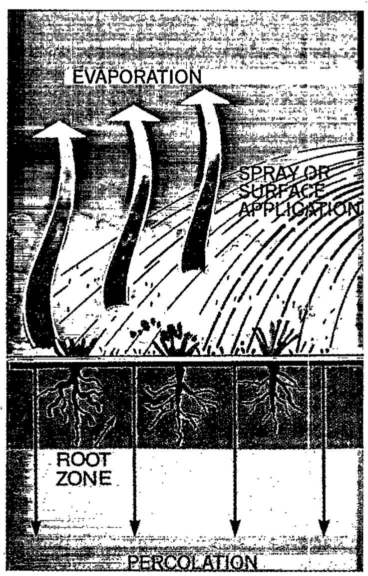
teract to restore water to a quality that is often equal to effluent from the secondary treatment stage. Changes in the weather may change the effectiveness of lagoons.

Ponds also can be used with other basic waste treatment processes. A good example of this is the Santee, California, water reclamation project. After conventional basic treatment by activated sludge, the town's waste water is kept in a lagoon for 30 days. Then the effluent, after chlorination, is pumped to land immediately above a series of lakes and allowed to trickle down through sandy soil into the lakes. The resulting water is of such good quality, the residents of the area can swim, boat, and fish in the lake waters.

Land Application

Land application can provide basic treatment as well as advanced wastewater treatment (described later in this publication). Land application systems can remove pollutants not removed in other basic treatment, and in many cases, reuse or renovate the wastewater. Three techniques are used: crop irrigation, rapid infiltration, and overland flow, or a combination of all three.

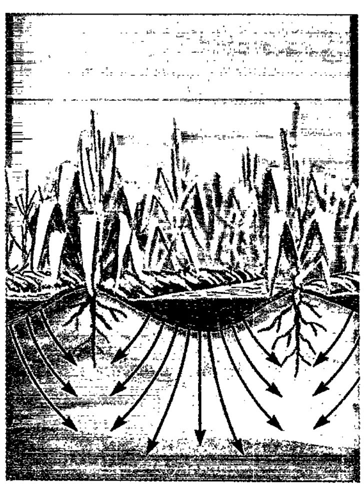
In the arid western States, municipal wastewater has been used for a number of years to irrigate crops. In recent years, land application and crop irrigation has spread to all sections of the country. Land application of many types of industrial wastewater is also common.



Irrigation

In the case of crop irrigation (or slow rate infiltration) the wastewater penetrates into the ground where the natural filtering and straining action of the soil removes most of the pollutants. Part of the water evaporates or is absorbed by plants. The remainder is either collected underground for surface discharge or is allowed to percolate to the groundwater.

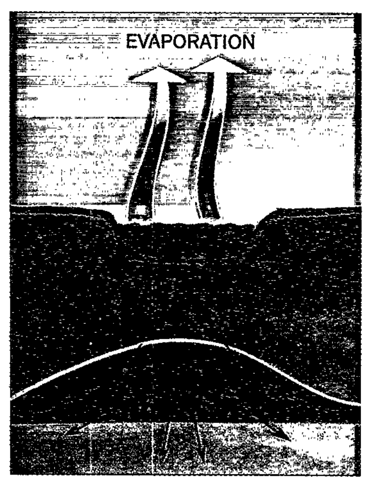
Crop irrigation is the most commonly used land application technique. It not only reuses the water, but the minerals and nutrients in it. The wastewater is sometimes disinfected before use, depending on the end use of the crop and the irrigation method. The wastewater is applied to the land by spraying, flooding, or ridge and furrow irrigation. The method selected depends on cost considerations, terrain, and the crops grown. Much of the water and most of the nitrogen are absorbed by the plants. Phosphorus and trace elements are removed to the soil by adsorption.



Rapid Infiltration

Unlike slow rate systems, the rapid infiltration process is used mainly to treat and recover wastewater for reuse. Since the rapid infiltration process is the simplest land application technique, and is effective in cold or wet weather, it has been used frequently in the northeastern States.

Large amounts of wastewater are applied to a limited land area and allowed to infiltrate the ground surface and percolate through the soil below. If the water is to be reused, it can be recovered by drilling wells to draw it to the surface. Normally, however, the water will seep downward to the ground water. Because this process depends on the soil's ability to absorb a large amount of water quickly and efficiently, good soil drainage is important. Impervious soils may be better suited to the overland flow process.



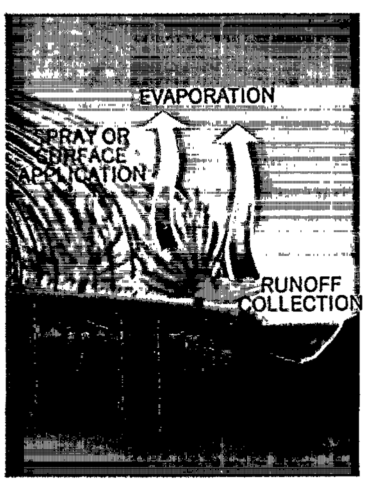
Small Onsite Systems

Overland Flow

This method has been used successfully in the food-processing industries to remove bacteria and nutrients from wastewater. And it has been used to a limited extent in treating municipal wastewater for many years.

The wastewater is allowed to flow down a sloped surface that is planted with vegetation to control runoff and erosion. As the water runs down the slope, the soil and its micro-organisms remove the bacteria and nutrients. Most of the water is recovered at the bottom of the slope for reuse. The remainder evaporates. This process is well suited to clay or clay-type soils with little or no adsorption capacity.

Whatever method is used, land appliction may be an economic alternative, particularly when compared to more costly advanced treatment plants. Research is also being conducted to determine what levels of nutrients and trace elements can be allowed to build up in the soil without harming agricultural plants, or posing health hazards when the crops may enter the human food chain.



Septic Tanks

A septic tank is simply a tank buried in the ground to treat the sewage from a home. Wastewater from the home flows into the tank where bacteria in the sewage may break down the organic matter and the cleaner water flows out of the tank into the ground through sub-surface drains. Periodically the sludge or solid matter in the bottom of the tank must be removed and disposed of.

In a rural setting, with the right kind of soil and the proper location, the septic tank can be a

reasonable means of disposing of strictly domestic wastes. Septic tanks should always be located so that none of the effluent can pollute the ground water used as a drinking water source.

Granular Filtration Aerobic Units

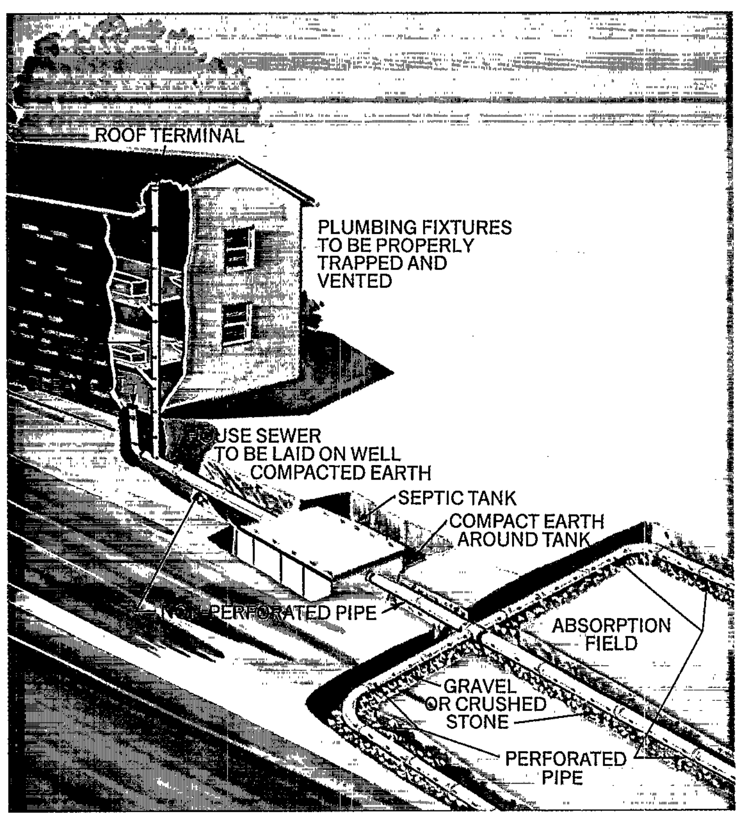
These are similar to septic tanks, but air is introduced and mixed with the wastewater in the tank. Aerobic bacteria (utilize oxygen) consume organic substances in the sewage and liquefy most of the solids. The liquid discharges to an absorption field where treatment continues as it leaches into soils.

Absorption Field

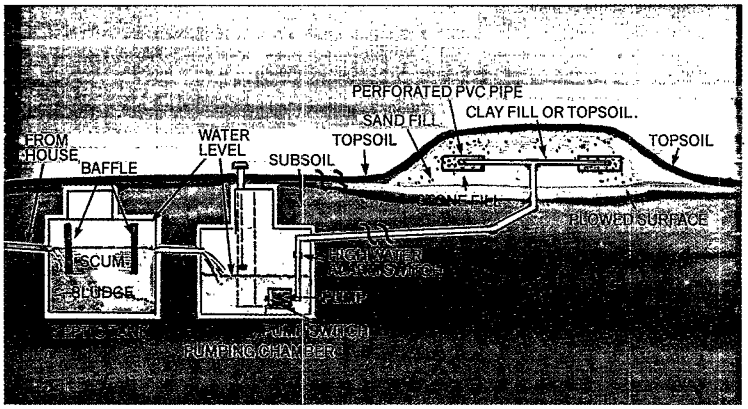
Soil conditions permitting, the most common method of disposing of septic tank or aerobic system effluent is by means of the absorption field. It consists mainly of a series of perforated parallel pipes laid in gravel or crushed stone. The effluent drains through the stone and into the soil which becomes an aerobic treatment medium. Granular filtration occurs as treated effluent flows through a ground level or buried sand pit. Liquid enters a perforated pipe at the top and filters through sand and gravel to a pipe in the bottom of the pit. The bottom pipe conducts the liquid to a disinfection tank before discharge to a stream or ditch.

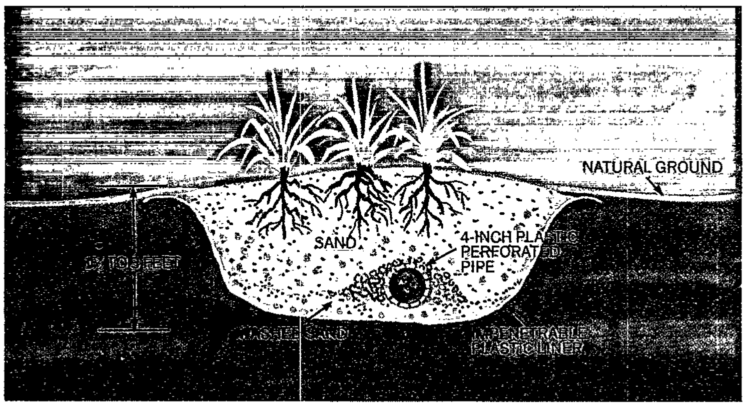
Modified Absorption Fields

If proper soil for the installation of a regular absorption field is not available, other methods can be utilized to dispose of the effluent. They are:



Mound System





Evapotranspiration System

1. *Mound System*
This system is used in conjunction with the septic tank or aerobic unit. The absorption field is located above natural ground. The tile drainage system is laid in a mound of sand. The liquid goes from the septic tank into a pumping chamber. Here it is stored until there is sufficient liquid to pump. Once this level is reached the liquid is pumped to the mound where it is spread evenly. The liquid moves laterally until it is absorbed by the less permeable soils below.

2. *Evapotranspiration System*
This system is similar to the absorption field with the difference that no liquid is allowed to enter the undisturbed earth beneath the system. The treated effluent is disposed of by evaporation into the atmosphere and by transpiration through plants. This system depends to some extent on the climatic conditions of the area.

Other Alternative Systems
1. Pressure Sewers
A pressure sewer is a small-diameter plastic pipe that transports wastewater under pressure. When soil conditions do not permit the use of an absorption field to dispose of the wastewater, pressure sewers can be utilized to carry wastewater to a central or alternative treatment and disposal system.

Two major pressure sewer systems are the "grinder pump" (GP) and the "septic tank effluent pump" (STEP). In the GP system, a grinder pump housed in an underground storage tank that receives raw sewage directly from the building grinds the raw sewage and pumps it directly into the pressure sewer.
In the STEP system, wastewater flows from a septic tank to a storage tank that contains an effluent pump. The pump then forces the partially treated wastewater into the small-diameter pressure sewer which carries it to an alternate treatment and disposal system.

The sludge remains in the septic tank or aerobic unit and must be removed every 2 to 3 years.

2. Recirculating Toilets
Recirculating toilets utilize a closed loop water system to transport black water (carrying urine and fecal material) to a complete treatment center usually housed in the basement of the building. There the wastewater is cleansed and recirculated back to the toilet tank to be used again.

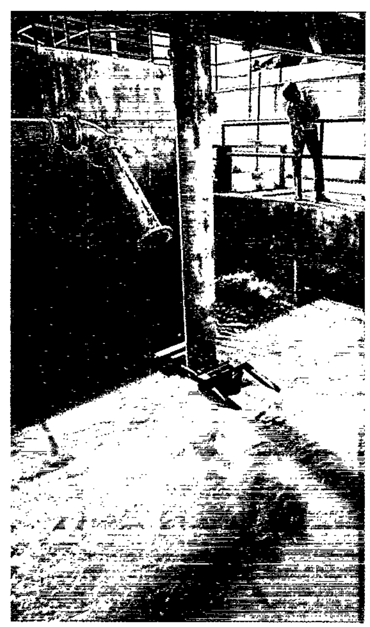
3. Waterless Systems
There are other individual systems for the handling of domestic wastewater that do not utilize water for transport of wastes. These include:
a) composting toilets
b) recirculating oil flush toilets
c) incinerating toilets
d) chemical toilets

Operation and Maintenance

Wastewater treatment plants, septic tanks and other alternative systems can clean the Nation's waters and prevent pollution. But to accomplish this purpose, they must be maintained and operated efficiently.

EPA studies have shown that many wastewater treatment plants are not meeting water quality requirements. A common reason for this failure is poor operation and maintenance. A sufficient number of well-trained operators and maintenance people and a well-equipped water-testing laboratory will contribute to satisfactory reduction of pollutants.

The failure of septic tanks and other onsite systems is mainly due to improper design, construction or maintenance. If proper care is exercised during construction and the system is properly maintained the system can outlive the residence or facility it was designed to serve.



The Need For Further Treatment of Wastes

In the past, pollution control was concerned primarily with problems caused by domestic waste and the simpler wastes of industry. Control was aimed principally towards protecting downstream public water supplies and stopping or preventing nuisance conditions.

Pollution problems were principally local in extent and their control a local matter.

This is no longer true. National growth and change have altered this picture. Progress in abating pollution has been outdistanced by population growth, the speed of industrial progress and technological developments, changing land use, and many other factors.

The increased production of goods has greatly increased the amounts of common industrial wastes. New processes in manufacturing are producing new, complex wastes that sometimes defy present pollution control technology. The increased application of commercial fertilizers and the development and widespread use of a vast array of new pesticides are resulting in a host of new pollution problems from water draining off land.

The growth of the nuclear energy field and the use of radioactive materials foreshadow still another complicating and potentially serious water pollution situation.

Long stretches of both interstate and intrastate streams are subjected to pollution which ruins or reduces the use of the water for many purposes. Conventional, biological waste treatment processes are hard-pressed to hold the pollution line, and for a growing number of our larger cities these processes are no longer adequate.

Our growing population not only is packing our central cities but spreading out farther and farther into suburbia and exurbia. Across the Country, new satellite communities are being born almost daily. The construction of facilities to handle the wastes generated in these communities has sometimes not matched either the growth rate or changes in growth patterns.

Sea water intrusion may be a growing problem in coastal areas. It is usually caused by the excessive pumping of fresh water from the ground which lowers the water level, allowing salt water to flow into the ground water area.

The Types of Pollutants

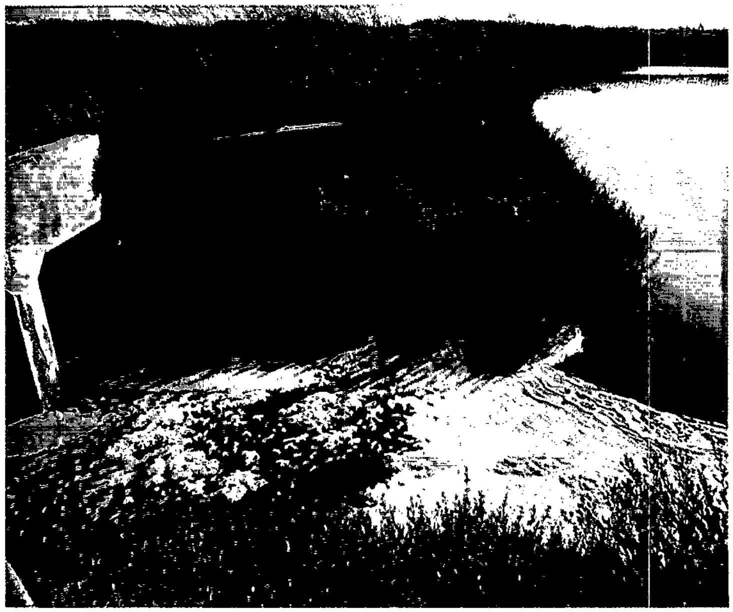
Present day problems that must be met by sewage treatment facilities can be summed up in eight types of pollutants affecting our waters.

The eight general categories are: common sewage and other oxygen-demanding wastes; disease-causing agents; plant nutrients; synthetic organic chemicals; inorganic chemicals and other mineral substances; sediments; radioactive substances; and heat.

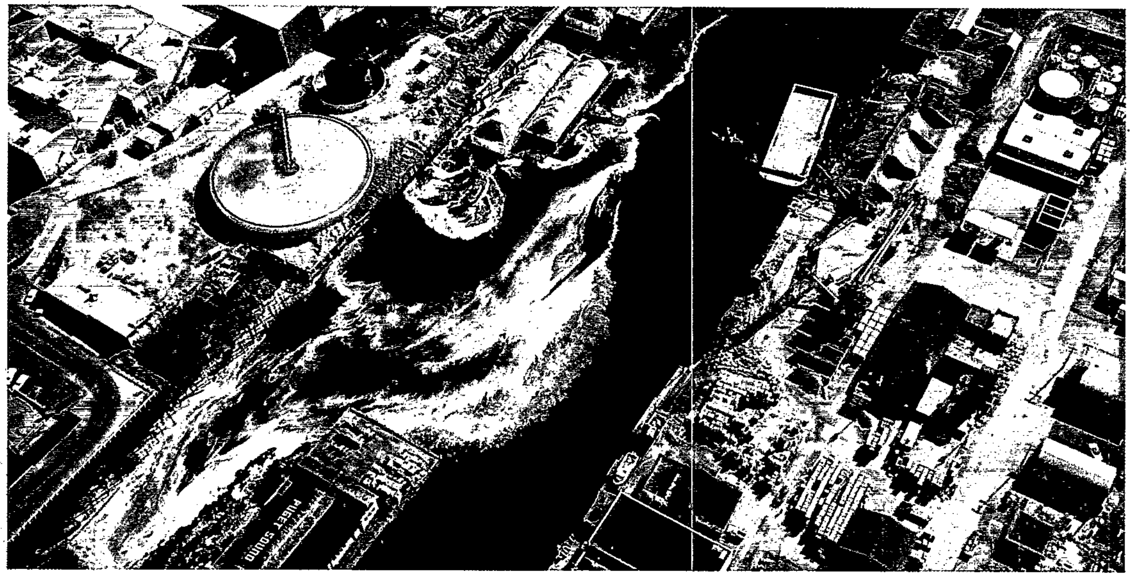
Oxygen-demanding wastes - These are the traditional organic wastes and ammonia contributed by (1) domestic sewage, and (2) industrial wastes of plant and animal origin. In the latter case, such wastes result from food processing, paper mill production, tanning, and other manufacturing processes. These wastes are usually destroyed by bacteria if there is sufficient oxygen present in the water. Since fish and other aquatic life depend on oxygen for life, the oxygen-demanding wastes must be controlled, or the fish die.

Disease-causing agents - This category includes infectious organisms which are carried into surface and ground water by sewage from cities and institutions, and by certain kinds of industrial wastes, such as tanning and meat packing plants. Man or animals come in contact with these microbes either by drinking the water or through swimming, fishing, or other activities. Although modern disinfection techniques have greatly reduced the danger of this type of pollutant, the problem must be watched constantly.

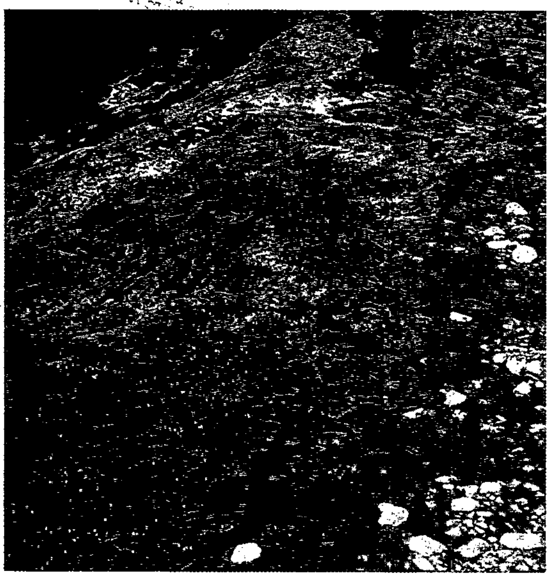
Plant nutrients - These are the substances in the food chain of aquatic life, such as algae and water weeds, which support and stimulate their growth. Carbon,



Domestic sewage



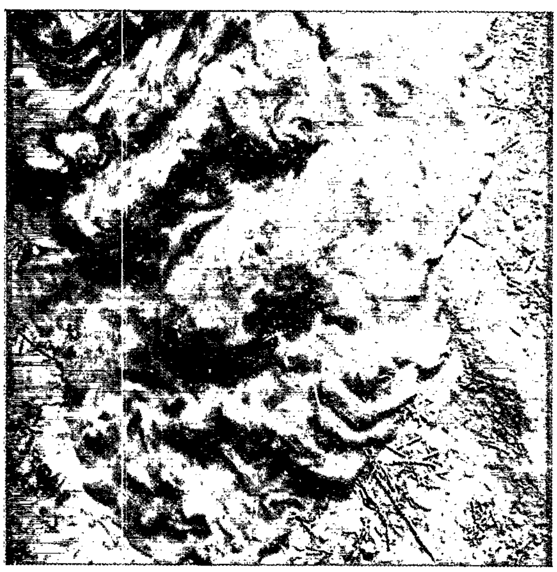
Industrial wastes



Algae

Chemicals

Acid drainage

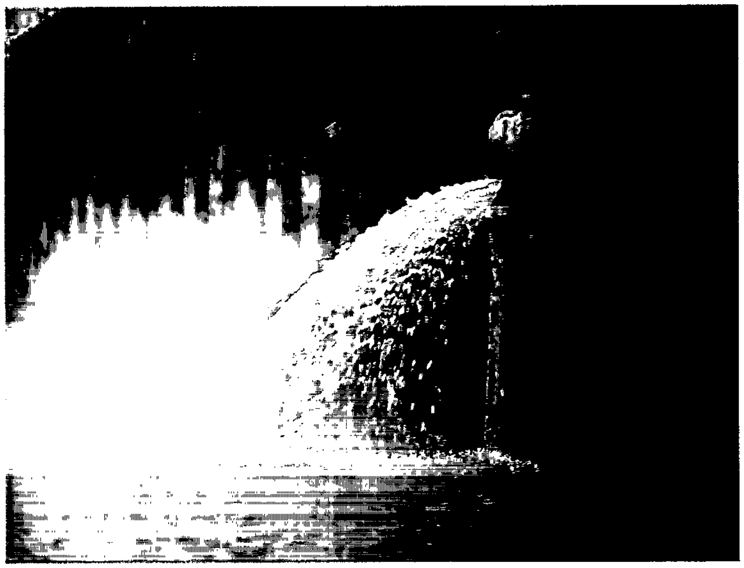


Sediment

nitrogen and phosphorus are the three chief nutrients present in natural water. Large amounts of these nutrients are present in sewage, certain industrial wastes, and drainage from fertilized land. Biological waste treatment processes do not remove the phosphorus and nitrogen to any substantial extent — in fact, they convert the organic forms of these substances into mineral form, making them more usable by plant life. The problem starts when an excess of these nutrients overstimulates the growth of water plants, causing unsightly conditions, interfering with water treatment processes, and causing unpleasant and disagreeable tastes and odors in the water.

Synthetic organic chemicals - Included in this category are detergents and other household aids, all the new synthetic organic pesticides, synthetic industrial chemicals, and the wastes from their manufacture. Many of these substances are toxic to fish and aquatic life and possibly harmful to humans. They cause taste and odor problems, and resist conventional waste treatment. Some are known to be highly poisonous at very low concentrations. The long-term effects, if any, of small doses of toxic substances is not yet known.

Inorganic chemicals and mineral substances - A vast array of metal salts, acids, solid matter, and many other chemical compounds are included in this group. They reach our waters from mining and manufacturing processes, oil field operations, agricultural practices, and natural



Thermal pollution

sources. Water used in irrigation picks up large amounts of minerals as it filters down through the soil on its way to the nearest stream. A wide variety of acids are discharged as waste by industry, but the largest single source of acid in our water comes from mining operations and mines that have been abandoned.

Many of these types of chemicals are being created each year. They interfere with natural stream purification; destroy fish and other aquatic life; cause excessive hardness of water supplies; corrode expensive water treatment equipment; increase commercial and recreational boat maintenance costs; and boost the cost of waste treatment.

Sediments - These are the particles of soil, sand, and minerals washed into the water from the land and from paved areas of communities. Construction projects are often large sediment producers. While not as invidious as some other types of pollution, sediments are a major problem because of the sheer magnitude of the amount reaching our waterways. Sediments fill stream channels and harbors, requiring expensive dredging, and they fill reservoirs, reducing their capacity and useful life. They erode power turbines and pumping equipment, and reduce fish and shellfish populations by blanketing fish nests and food supplies.

More importantly, sediments reduce the amount of sunlight penetrating the water. The sunlight is required by the green aquatic plants which produce the oxygen necessary to normal stream balance. Sediments greatly increase the treatment costs for municipal and industrial water supplies and for sewage treatment where combined sewers are in use.

Radioactive substances - Radioactive pollution results from the mining and processing of radioactive ores; from the use of refined radioactive materials in power reactors and for industrial, medical, and research purposes; and from fallout following nuclear weapons testing. Increased use of these substances poses a potential public health problem. Since radiation accumulates in humans, control of this type of pollution must take into consideration total exposure in the human environment — water, air, food, occupation, and medical treatment.

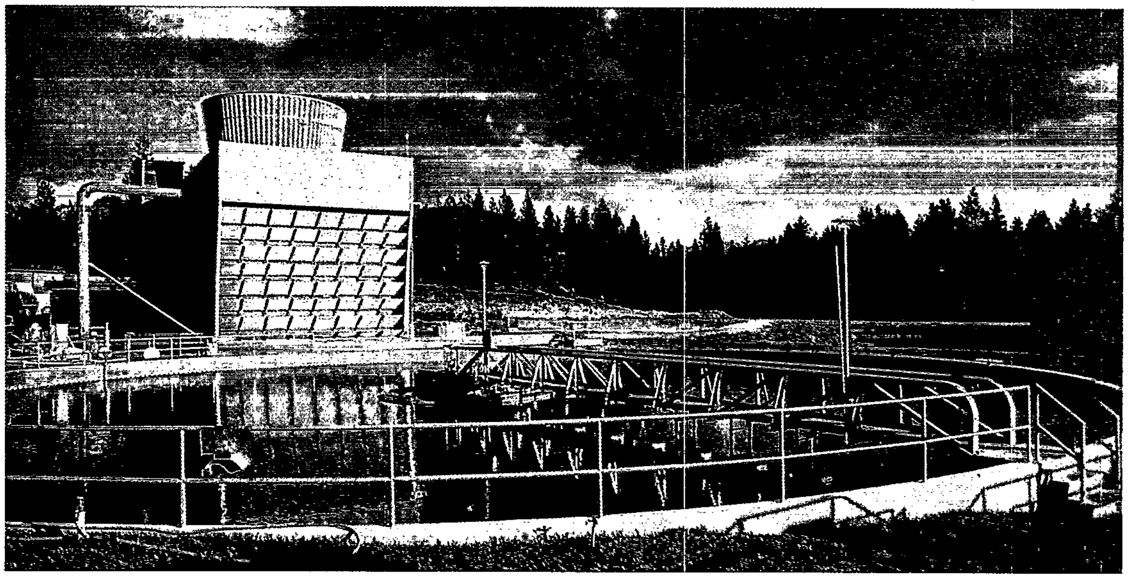
Heat - Heat reduces the capacity of water to absorb oxygen. Tremendous volumes of water are used by power plants and industry for cooling. Most of the water, with the added heat, is returned to streams, raising their temperatures. With less oxygen, the water is not as efficient in assimilating oxygen-consuming wastes and in supporting fish and aquatic life. Unchecked discharges of waste heat can seriously alter the ecology of a lake, a stream, or even part of the sea.

Water in lakes or stored in impoundments can be greatly affected by heat. Summer temperatures heat up the surfaces, causing the water to form into layers, with the cooler water forming the deeper layers. Decomposing vegetative matter from natural and man-made pollutants deplete the oxygen from these cooler lower layers with harmful effects on the aquatic life. When the oxygen-deficient water is discharged from the lower gates of a dam, it may have serious effects on downstream fish life and reduce the ability of the stream to assimilate downstream pollution.

To complicate matters, many of our wastes are a mixture of the eight types of pollution, making the problems of treatment and control that much more difficult.

Municipal wastes usually contain oxygen-consuming pollutants, synthetic organic chemicals such as detergents, sediments, and other types of pollutants. The same is true of many industrial wastes which may contain, in addition, substantial amounts of heat from cooling processes. Water that drains off the land usually contains great amounts of organic matter in addition to sediment. Also, land drainage may contain radioactive substances and pollutants washed from the sky, vegetation, buildings, and streets during rainfall.

Advanced Methods of Treating Wastes



Advanced wastewater treatment plant

New pollution problems of a modern society have placed additional burdens upon our waste treatment systems. Today's pollutants are more difficult to remove from the water. Increased demands upon our water supply aggravate the problem. During the dry season, the flow of rivers decreases to such an extent that they have difficulty in assimilating the effluent from waste treatment plants.

These problems are beginning to be met through better and more complete methods of removing pollutants at treatment plants or better means for preventing some wastes from even entering the sewer system. Pretreatment of industrial waste, for example, removes many troublesome pollutants at the source.

The best immediate answer to these problems is the widespread application of available waste treatment methods. Many cities still do not treat their sewage beyond the primary treatment stage. Many other cities need enlarged or modernized systems to treat wastewater at the secondary stage. With nationwide provision of secondary treatment only, discharge of oxygen consuming materials would still degrade water quality and inhibit aquatic life. Further treatment, land treatment, or wastewater reuse providing for removal of more pollutants will therefore be required in many cases.

The increasing need to reuse water now calls for better and better waste treatment. Every use of water—whether at home, in the factory or on the farm—results in some change in its quality.

To return water of more usable quality to receiving lakes and streams, new methods for removing pollutants are being developed. The advanced waste treatment techniques under consideration range from extensions of biological treatment capable of removing nitrogen and phosphorus nutrients to physical-chemical separation techniques such as adsorption, distillation, and reverse osmosis.

These processes in various combinations can achieve any degree of pollution control desired and, as waste effluents are purified to higher and higher degrees by such treatment, the point is reached where effluents become "too good to throw away."

Such water can be deliberately and directly reused for agricultural, industrial, recreational, or possibly even drinking water supplies. Complete water renovation will mean complete pollution control and at the same time more water for the Nation.

Nitrogen Control

Nitrogen in one form or another is present in all municipal wastewater and is not removed by secondary treatment. It can be harmful if discharged into lakes and streams. Nitrogen in the form of ammonia can place a direct demand on oxygen in certain surface waters or can stimulate the excessive growth of aquatic algae. As overgrowths of algae die and decompose, the process can deplete the supply of life-supporting oxygen in the water. Algae as well as the ammonia in wastewater effluent can also be directly toxic to fish in certain instances.

By providing additional biological treatment beyond the secondary stage, bacteria present in wastewater treatment can biologically change ammonia to nitrate in a process known as nitrification. In some instances where ammonia nitrogen is a concern because of oxygen demand or toxicity nitrification is sufficient to protect the environment. However, nitrogen in the form of nitrate is also a nutrient which can contribute to the excessive growth of aquatic algae.

In those instances where nitrogen must be completely removed from the effluent, an additional biological process can be added to the system to change the nitrate to nitrogen gas. Nitrogen gas of course comprises almost 80% of our air and causes no environmental harm when released into the atmosphere. As is the case with the other biological treatment processes, conversion of nitrate to nitrogen gas is done by bacteria in a process known as denitrification.

There are also methods of treating wastewater with chemicals to directly remove the ammonia. However, this has had only limited use in the municipal wastewater field to date, and can be very expensive.

As discussed in a previous section of this publication, land application is a promising method which can provide both basic treatment and advanced wastewater treatment. The plants and soil bacteria utilize phosphorus and nitrogen and in so doing remove it from the wastewater. The application of advanced techniques for waste treatment begins where primary and secondary treatment ends.

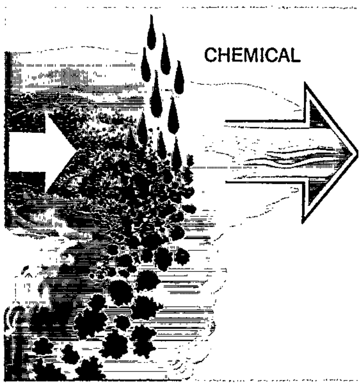
Coagulation-Sedimentation

The process known as coagulation-sedimentation may be used to increase the removal of solids from effluent after primary and secondary treatment. Besides removing essentially all of the settleable solids, this method can, with proper control and sufficient addition of chemicals, reduce the concentration of phosphate by over 95 percent.

In the process, alum, lime, or iron salts are added to the wastewater either during or after the secondary treatment stage. When the chemicals are added after the secondary treatment stage, the flow then passes through flocculation tanks where the chemicals cause the smaller particles to floc or bunch together into large masses.

The larger masses of particles or lumps will settle faster when the effluent reaches the next step — the sedimentation tank.

Although used for years in the treatment of industrial wastes and in water treatment, coagulation-sedimentation is classified as an advanced process because it had not previously been routinely applied to the treatment of municipal wastes. In many cases, the process is a necessary pre-treatment for some of the other advanced techniques.



Adsorption

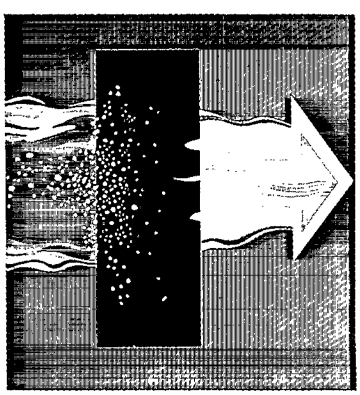
Technology has also been developed to remove refractory organic materials. This is organic matter which stubbornly resists removal by normal biological treatment.

The effects of the organics are not completely understood, but taste and odor problems in water, tainting of fish flesh, foaming of water, and fish kills have been attributed to such materials.

Adsorption consists of passing the effluent through a bed of activated carbon granules which will remove more than 98 percent of the organics. To cut down the cost of the procedure, the carbon granules can be cleaned by heat and used again.

With the exception of added salts, municipal waste water that has gone through the advanced treatment processes will be restored to a chemical quality almost the same as before it was used.

In waste treatment language, salt is not limited to common table salt. Salts include the many minerals dissolved by water; as it passes through the air as rainfall; as it trickles through the soil and over rocks; and as it is used in the home and factory.

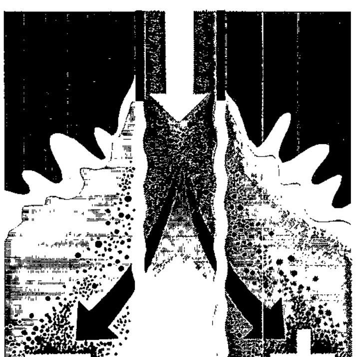


Electrodialysis

Electrodialysis is a rather complicated process by which electricity and membranes are used to remove salts from an effluent. A membrane is usually made of chemically treated plastic. The salts are forced out of the water by the action of an electric field. When a mineral salt is placed in water it has a tendency to break down into ions. An ion is an atom or a small group of atoms having an electrical charge.

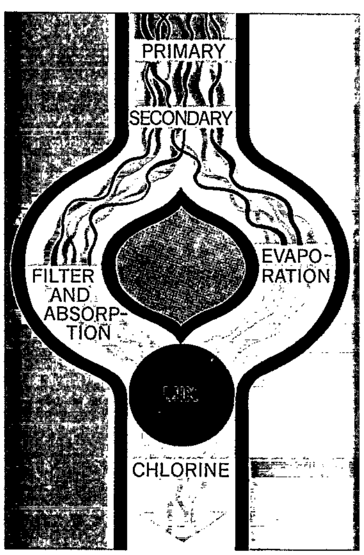
As a city uses its water, the amount of salts in the water increases by 300-400 milligrams per liter. Fortunately, electrodialysis can remove this buildup.

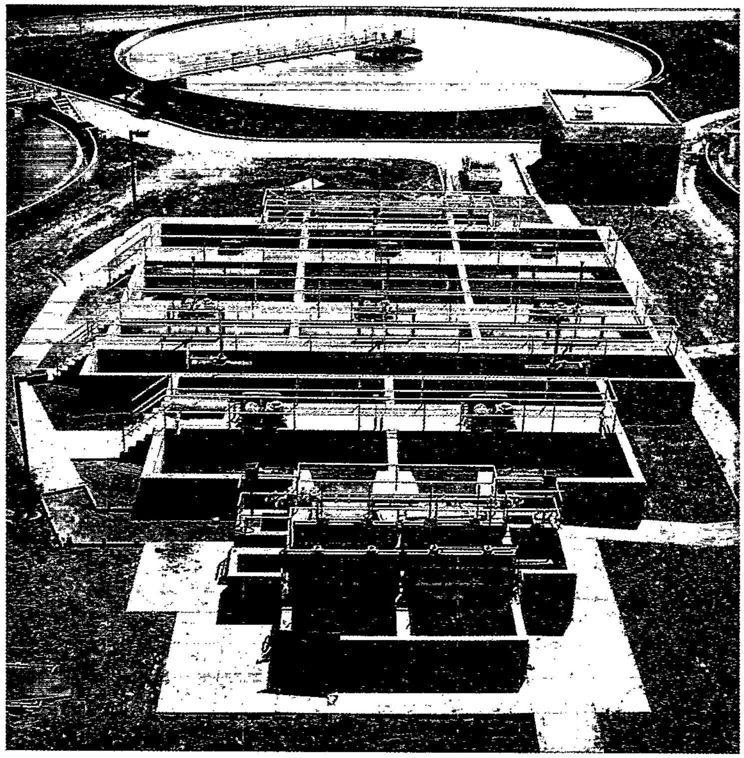
In fact, the process of electrodialysis can reduce the salt content of water to the level it was before the city received the water, or even lower.

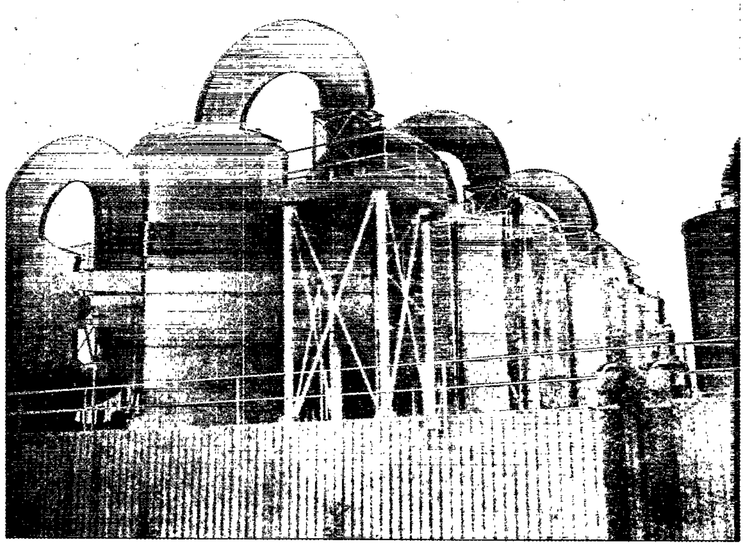


Properly designed and applied, the preceeding wastewater treatment methods are capable of providing treated water of any desired degree of purity for any desired reuse from irrigation to drinking water.

But none of these processes will stand alone. They must be used in a series or a parallel plan. In a series, all the sewage passes through all the processes, one after another, each process making a particular contribution toward improving the water. For example, the conventional primary stage of treatment removes the material that will readily settle or float; the secondary biological step takes care of most of the decomposable impurities; coagulation-sedimentation, the third step, eliminates most of the suspended solids; carbon adsorption can remove the remaining dissolved organic matter; electrodialysis can return the level of the salts to what it was before the water was used; and, finally, disinfection provides a barrier against most disease-carrying organisms.




Wastewater filtration unit in the coagulation-sedimentation process


Denitrification plants remove excess nitrogen in advanced treatment

Polymers and Pollution

In discussing the coagulation-sedimentation process, mention was made of the use of chemicals to force suspended solids into larger masses. The clumping together helps speed up one of the key steps in waste treatment — the separation of solids and liquids.

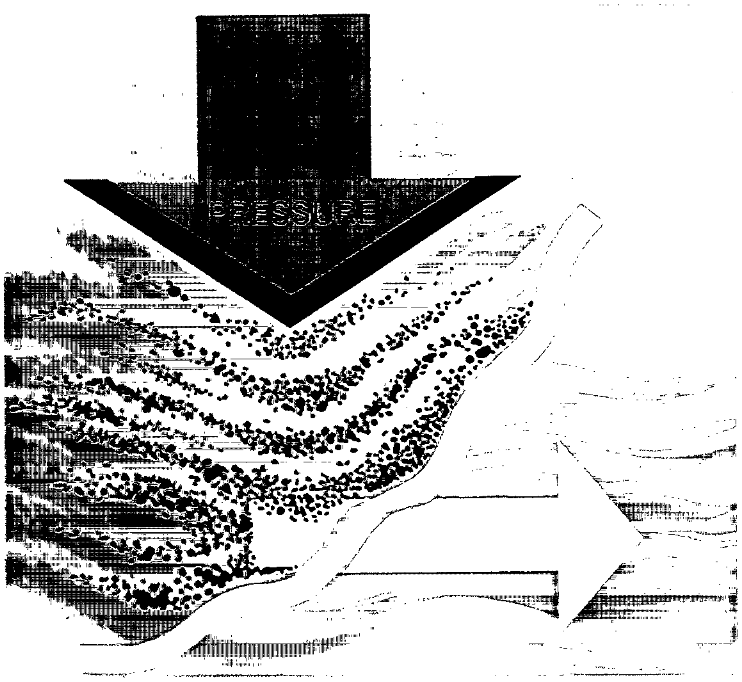
During the past 10 to 15 years, the chemical industry has been working on synthetic organic chemicals, known as polyelectrolytes or polymers, to further improve the separation step.

Formerly, polymers have proved effective when used at a later stage of treatment — the sludge disposal step. Sludge must be dewatered so that it can be more easily disposed of. By introducing polymers into the sludge, the physical and chemical bonds between the solids are tightened. When this happens, the water can be extracted more rapidly.

If polymers are put into raw sewage, waste treatment plants may be able to combine a chemical process with the standard primary and secondary stages. This method of removing solids could be applied immediately without adding expensive new facilities.

However the volume of sludge generated will greatly increase and methods of utilization or disposal of this additional sludge must be considered.

Polymer chemicals also hold promise as a means of speeding the flow of wastewaters through sewer systems, thus, in effect, increasing the capacity of existing systems.



Reserve osmosis

Chemical Oxidation

Chlorine and oxidants such as ozone have been used for many years to improve the taste and odor or to disinfect municipal drinking water. Such materials improve the quality of water by destroying or altering the structure of the chemicals in the water.

However, the concentration of the organic materials in drinking water supplies is much less than it is in the waste-bearing waters reaching treatment plants. Until recently, the cost of the oxidants has prevented the use of this process in the treating of wastes. When operated in conjunction with other processes, however, oxidation could become an effective weapon in eliminating wastes resistant to other processes.

Reverse Osmosis

When liquids with different concentrations of mineral salts are separated by a membrane, molecules of pure water tend to pass by osmosis from the more concentrated to the less concentrated side until both liquids have the same mineral content.

Scientists are now exploring ways to take advantage of the natural phenomena of osmosis, but in reverse. When pressure is exerted on the side with the most minerals, the natural force reverses itself, causing the molecules of pure water to flow out of the compartment containing a high salt concentration.

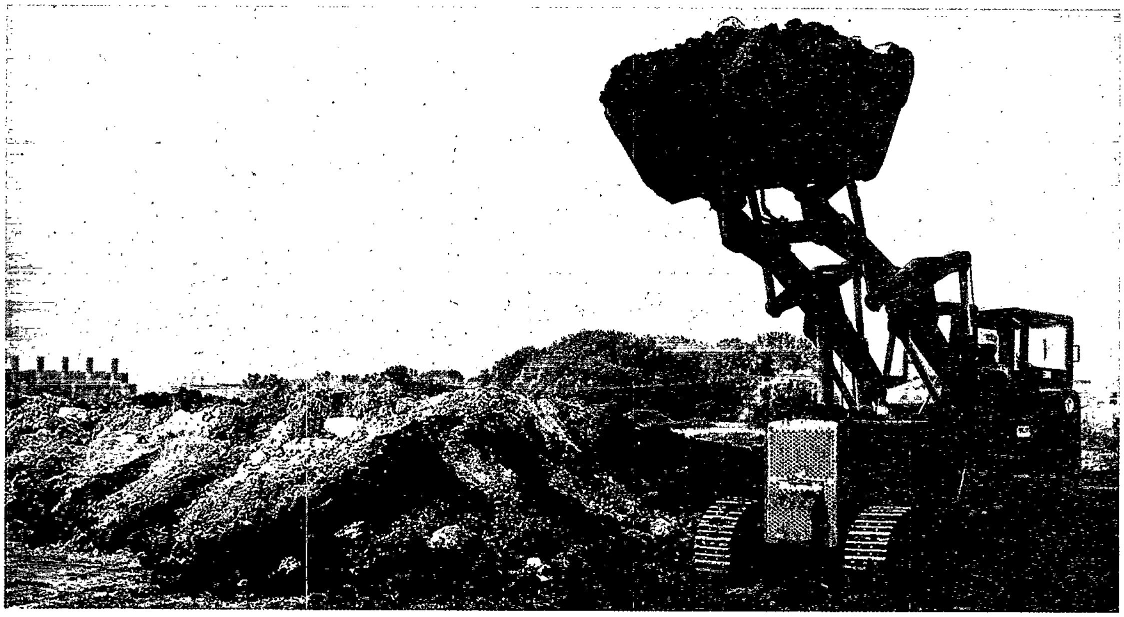
This means that perfectly pure water is being taken out of the waste, rather than taking pollutants out of water in the traditional way. And this process takes clean water away from everything — bacteria, detergents, nitrates.

Tests have shown that the theory works well, resulting in water good enough to drink. Efforts are now underway to develop large, long life membranes, along with matching processes and equipment for testing on a large scale.

The Use or Disposal of Wastewater Treatment Residues

When conventional treatment techniques are used, there is always something left over. It may be the rags and sticks caught on the screens at the very beginning of primary treatment. It could be brine. Or it could be sludge — that part of the sewage that settles to the bottom in sedimentation tanks. Whatever it is, there is always something that must be reused, burned, buried, or disposed of in some manner. The wastewater process is not completed until all waste is used or disposed in a way that does not harm the environment.

The utilization and disposal of sludge is being jointly addressed under the Clean Water Act and the Resource Conservation and Recovery Act. Both of these Federal laws emphasize the need to employ environmentally sound sludge management techniques and to beneficially use sludge whenever possible. At the same time, the national requirements for improved wastewater treatment will result in the production of a greater quantity of residuals. And possibly more concentrated forms of contaminants will be present in these residuals than ever before. As much as 40 percent of the construction grant funds for individual treatment plants provided under the Clean Water Act may be required to build adequate sludge management facilities. In addition, the permits required for effluent discharge from sewage treatment plants will be affected by and contain provisions related to the sludge management techniques employed by the facilities.



Sludge drying beds

Until recently all but about 20 percent of the Nation's sludge had been burned (incinerated), landfilled, or dumped into the ocean. Currently, much more attention is being given to sludge utilization by application to land as a soil conditioner or fertilizer and to combustion with or without solid waste in facilities designed to recover energy.

Prior to utilization or disposal, sludge may be stabilized to control odors and reduce the number of disease-causing organisms. The sludge may also be dewatered to reduce volumes to be transported or to prepare it for final processing.

Digestion of sludge takes place in heated tanks where the material can decompose naturally and the odors can be controlled. Anaerobic sludge digestion (without air) has the added benefit of producing methane gas which is usable as fuel.

Stabilization of sludge may also be accomplished by the addition of lime or by heating it under pressure. After stabilization the sludge can be spread on land as a liquid (2-10% solids) or additional water can be removed by use of dewatering processes such as pressure or vacuum filtration or centrifugation.

Liquid digested sludge has been used successfully as a fertilizer and for restoring areas disrupted by strip mining. Under this sludge management approach, digested sludge in semi-liquid form is transported to the spoiled areas. The slurry, containing nutrients from the wastes, is spread over the land to give nature a hand in returning grass, trees, and flowers to barren land. Restoration of the countryside will also help control the flow of acids that drain from mines into streams and rivers, endangering fish and other aquatic life and adding to the difficulty of reusing the water.

In some areas liquid sewage sludges are now being marketed to farmers as fertilizer. Liquid sludge is a good source of nitrogen and phosphorus which are nutrient elements required by plants.

Dewatering of sludge is often necessary prior to utilization or disposal. The liquid sludge, which contains 90-98% water, can be partially dewatered by a number of processes.

One such process, vacuum filtration, makes use of a slowly rotating filter drum and suction. As the drum rotates, the water is filtered out of the sludge and the residues are peeled off for utilization or disposal. For more effective dewatering, the sludge can be first treated with a coagulant chemical such as lime or ferric chloride to produce larger solid particles before the sludge reaches the filter. Centrifugation is a comparable process which relies on the principle of high speed rotation to "spin" the water out of the sludge.

After dewatering the sludge can be spread directly on the land as a soil conditioner if it has been previously stabilized. Undigested sludge can be further processed by appropriate stabilization techniques such as composting or drying, or it can be directly incinerated.

Composting of sewage sludge is a promising, new approach to sludge management that is being adopted by a number of cities. Sludge is transformed microbiologically in the presence of air to a dry peat-like form. The compost product has shown particular promise for use in production of soil for revegetation of top soil depleted areas, and as a potting amendment.

Incineration consists of burning the dried sludge to reduce the residues to a non-burnable ash. The ash can be disposed of by filling unused land. Because of the increasing premium placed on our fuel supplies, sludge incinerators now being considered make provisions for minimum dependence on auxiliary fuels and often include heat recovery features. Undigested sewage sludge has some fuel value as a result of its high organic content. However, to take advantage of the fuel potential of the sludge, the water content of the sludge must be less than that achieved by traditional dewatering processes. For this reason newer pressure filtration techniques are being used to obtain sludges which are sufficiently dry to burn without continual reliance on auxiliary fuels. In some cities sludge will also be mixed with refuse or refuse-derived fuel prior to burning. Generally, heat will be recovered to provide the greatest amount of energy efficiency.

Treated sludge may be used as fertilizer for some agricultural crops

The law now requires that disposal of sludge into the ocean be phased out by 1981. In the meantime interim permits are being issued to cities by EPA for ocean dumping provided that an active plan is being followed for cessation of this form of disposal.

The problem of how to best manage sludge can be lessened by pretreatment of industrial sewage wastes to prevent unwanted toxicants such as certain heavy metals and persistent organic metals from contaminating the sludge. Regulations to foster pretreatment have been developed in accordance with provisions of the Clean Water Act. The problem of what to do with sludge can be reduced even more by shifting from conventional forms of wastewater treatment to land treatment systems which produce only small quantities of sludge.

As this discussion shows, sludge or other waste concentrates are not always costly burdens. By drying and other processes, some cities have produced fertilizers from sludge which are sold to help pay part of the cost of treating wastes. Some municipalities use the soil enrichers on parks, road parkways, and other public areas.

Some industries have found they can reclaim certain chemicals during waste treatment processes and reuse them. Other firms have developed saleable byproducts from residues of waste treatment.

More studies are underway to find other beneficial uses for sludge and to help solve the problem of what to do with increasing volumes of wastewater treatment residuals — and to help offset the cost of waste treatment.

Common Waste Treatment Terminology

Activated Sludge: A process for removing organic matter from sewage by saturating it with air and adding biologically active sludge.

Adsorption is an advanced way of treating wastes in which activated carbon removes organic matter from wastewater.

Aeration Tank serves as a chamber for injecting air into water.

Aerobic refers to a life or process that occurs in the presence of oxygen.

Algae are plants which grow in sunlit waters and release oxygen into the water. They are a food for fish and small aquatic animals.

Alternative Systems: A system utilized in lieu of a conventional system.

Anaerobic refers to a life or process that occurs in the absence of oxygen.

Bacteria are small living organisms which often consume the organic constituents of sewage.

Black Water is the term given to any water that carries animal, human or food wastes.

BOD (Biochemical Oxygen Demand) is the dissolved oxygen required by organisms for the aerobic decomposition of organic matter present in water. It is used as a measure in determining the efficiency of a sewage treatment plant or ot determine the potential of an effluent to degrade a stream.

Chlorinator is a device for adding chlorine gas to sewage to kill infectious germs.

Coagulation is the clumping together of solids to make them settle out of the sewage faster. Coagulation of solids is brought about with the use of certain chemicals such as lime, alum and iron salts.

Combined Sewers carry both sewage and stormwater runoff.

Comminutor is a device for the catching and shredding of heavy solid matter in the primary stage of waste treatment.

Composting is the natural biological decomposition of organic material in the presence of air to form a humus-like material.

Conventional Systems are systems that have been traditionally used to collect municipal wastewater in gravity sewers and convey it to a central primary or secondary treatment plant prior to discharge to surface waters.

Diffused Air is a technique by which air under pressure is forced into sewage in an aeration tank. The air is pumped down into the sewage through a perforated pipe and bubbled through the sewage.

Digestion of sludge takes place in tanks when the materials decompose, resulting in partial gasification, liquefaction, and mineralization of pollutants.

Distillation in waste treatment consists of heating the effluent and then removing the vapor or steam. When the steam is returned to a liquid it is almost pure water. The pollutants remain in the concentrated residue.

Eligible Costs are those wastewater treatment works construction costs upon which Federal participation is based. EPA grants are awarded for 75% or 85% of the eligible cost depending on the project.

Effluent is the liquid that comes out of a treatment plant after completion of the treatment process.

Eutrophication: The normally slow aging process by which a lake evolves into a bog or marsh and ultimately assumes a completely terrestrial state and disappears. During eutrophication the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that algae and other microscopic plant life become super-abundant, thereby "choking" the lake, and causing it eventually to dry up. Eutrophication may be accelerated by many human activities.

Evapotranspiration is the loss of water from the soil both by evaporation and by transpiration from the plants growing thereon.

Floc is a clump of solids formed in sewage by biological or chemical action.

Flocculation is the process by which clumps of solids in sewage are made to increase in size by chemical, physical, or biological action.

Fungi are small, non-chlorophyll-bearing plants which may play a useful role in trickling filter treatment operations.

Gray Water is the term given to domestic wastewater composed of washwater from sinks, kitchen sinks, bathroom sinks and tubs and laundry tubs.

Grinder Pump is a mechanical device which shreds solids and raises the fluid to a higher elevation through pressure sewers.

Groundwater is the body of water beneath the surface of the ground. It is made up primarily of the water that has seeped down from the surface.

Incineration consists of burning the sludge to remove the water and reduce the remaining residues to a safe, non-burnable ash. The ash can be disposed of safely on land, in some waters, or into caves or other underground locations.

Infiltration is the penetration of water through the ground surface into sub-surface soil or the penetration of water from the soil into a pipe.

Infiltration/Percolation is a land application technique where large volumes of waste water are applied to land, allowed to penetrate the surface and percolate through the underlying soil.

Influent is the term given to identify water, wastewater or other liquid flowing into a reservoir, basin or treatment plant, or any unit thereof.

Interceptors are larger sewer lines that, in a combined system, control the flow of the sewage to the treatment plant. In a storm, they allow some of the sewage to flow directly into a receiving stream. This protects the treatment plant from being overloaded in case of a sudden surge of water into the sewers. Interceptors are also used in separate sanitation systems to collect the flows from main and trunk sewers and carry them to the points of treatment.

Ion is an electrically charged atom or group of atoms which can be drawn from waste water during the electrodialysis process.

Irrigation is a land application technique wherein wastewater is applied to the land to supply the water and nutrient needs of plants.

Land Application: The discharge of waste water onto the ground for treatment or reuse.

Lateral Sewers are the pipes that run under the streets of a city and receive the sewers from homes or businesses.

Mechanical Aeration uses mechanical energy to inject air into water, causing the waste stream to absorb oxygen from the atmosphere.

Microbes are minute plant or animal life. Some microbes which may cause disease exist in sewage.

Mixed Liquor is a mixture of activated sludge and waters containing organic matter undergoing activated sludge treatment in the aeration tank.

Nitrogeneous Wastes: Wastes of animal or plant origin that contain a significant concentration of nitrogen.

Nutrients: Elements or compounds essential as raw materials for organism growth and development; for example, carbon, oxygen, nitrogen and phosphorous.

Organic Matter is the carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.

Overland Flow is a land application technique that cleanses wastewater by allowing it to flow over a sloped surface. As the water flows over the surface, the contaminants are removed and the water is collected at the bottom of the slope for reuse.

Oxidation is the addition of oxygen which breaks down organic wastes or chemicals in sewage by bacterial and chemical means.

Oxidation Pond is a man-made lake or body of water in which wastes are consumed by bacteria. It is used most frequently with other waste treatment processes. An oxidation pond is basically the same as a sewage lagoon.

Percolation is the movement of water through sub-surface soil layers, usually continuing downward to the groundwater.

Phosphorous: An element that while essential to life, contributes to the eutrophication of lakes and other bodies of water.

Pollution results when animal, vegetable, mineral or heat wastes or discharges reach water, making it less desirable for domestic, recreation, industry, or wildlife uses.

Polyelectrolytes are synthetic chemicals used to speed the removal of solids from sewage. The chemicals cause the solids to flocculate or clump together more rapidly than chemicals like alum or lime.

Pressure Sewers is a system of pipes in which the water, wastewater or other liquid is transported to a higher elevation by applying a pumping force behind it.

Primary Treatment is a stage in basic treatment of sewage that removes material that floats or will settle. Screens remove floating objects, settling tanks remove heavy material.

Pump is a mechanical device for causing flow, for raising or lifting water or other fluid, or for applying pressure to fluids.

Receiving Waters are rivers, lakes, oceans, or other water courses that receive treated or untreated wastewaters.

Salts are the minerals that water picks up as it passes through the air, over and under the ground, and as the water is used by households and industry.

Sand Filters physically remove some suspended solids from sewage. Air and bacteria decompose additional wastes filtering through the sand. Cleaner water drains from the bed. The sludge accumulating at the surface must be removed from the bed periodically.

Sanitary Sewers, in a separate system, are pipes in a city that carry only domestic wastewater. The stormwater runoff is taken care of by a separate system of pipes.

Secondary Treatment is the second step in most waste treatment systems in which bacteria consume the organic parts of the wastes. It is accomplished by bringing together waste, bacteria and oxygen in trickling filters or in the activated sludge process.

Sedimentation Tanks help remove solids from sewage. The wastewater is pumped to the tanks where the solids settle to the bottom or float on the top as scum. The scum is skimmed off the top, and solids on the bottom are pumped to incineration, digestion, filtration or other means of final disposal.

Seepage is defined as the slow movement of water through small cracks or pores of a material, through the soil, or into or out of a body of surface or subsurface water.

Septic Tanks are used for domestic wastes when a sewer line is not available to carry them to a treatment plant. The wastes are piped to underground tanks directly from the home or homes. The bacteria in the wastes decompose the organic waste and the sludge settles on the bottom of the tank. The effluent flows out of the tank into the ground through drains. The sludge is pumped out of the tanks, usually by commercial firms, at regular intervals.

Sewers are a system of pipes that collect and deliver wastewater to treatment plants or receiving streams.

Sludge is the solid matter that settles to the bottom, floats, or becomes suspended in the sedimentation tanks and must be disposed of by filtration and incineration or by transport to appropriate disposal sites.

Soil Absorption Field is a subsurface area containing a trench or bed which has a minimum depth of 12 inches of clean stones and a system of distribution piping through which treated sewage may seep into the surrounding soil for further treatment and disposal.

Sterilization is the destruction of all living organisms. In contrast, disinfection is the destruction of most of the living organisms.

Storm Sewers are a separate system of pipes that carry only runoffs from buildings and land during a storm.

Sump Pump is a mechanism used for removing water or wastewater from a sump or wet well. It may be energized by air, water, steam or electric motors.

Suspended Solids are the small particles of solid pollutants which are present in sewage and which resist separation from the water by conventional means.

Transpiration is the process by which water vapor is lost to the atmosphere from living plants. The term can be also applied to the quantity of water thus dissipated.

Trickling Filter is a support media for bacterial growth, usually a bed of rocks or stones. The sewage is trickled over the bed so the bacteria can break down the organic wastes.

Waste Treatment Plant is a series of tanks, screens, filters, and other processes by which pollutants are removed from water.

Virus is the smallest form of microorganism capable of causing disease.

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