Operations Manual

Stabilization Ponds

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Introduction

BACKGROUND

Stabilization ponds were first used for wastewater treatment in the midwest for remote communities, but have since found extensive use in various parts of the country. In addition to domestic uses, ponds are now treating various types of industrial wastes including vegetable, oil refinery, slaughterhouses, dairies and rendering plants.

PURPOSE OF THIS MANUAL

Even though precise process control is not required, there are a number of factors to be conscious of from an operation and maintenance standpoint for the operator, plant owner and consulting engineer. This manual is intended to serve several functions including:

- Supplement to the specific operation and maintenance manual prepared for municipal ponds.
- Provide basic information on pond theory and features the beginning operator should know.
- Provide tips on operation and maintenance for experienced operators based on information from various parts of the nation.
- Outline troubleshooting tips for handling various problems common to ponds.

MANUAL ORGANIZATION

The manual is divided into six main parts:

- The Basics
- Control Information for Ponds
- Operation and Maintenance for Ponds
- Troubleshooting for Ponds
- Safety
- Appendices

USE OF THE MANUAL

- **The Basics** – For those wanting to brush up on fundamentals or get aquainted with types of ponds, terminology and factors to consider in operation, this section will be helpful.

- **Control Information for Ponds** – This portion of the manual considers sampling, flow control and use of information gained from either visual, nasal or laboratory investigation.

- **Operation and Maintenance for Ponds** – After gathering information, some action may be necessary and this subject is covered here. Housekeeping and day-to-day activities are presented along with a suggested checklist which can be adapted for the individual plant.

- **Troubleshooting for Ponds** – This part of the manual presents a number of potential problems and gives solutions that other operators have found to be helpful.

- **Safety** – Many times only one person is on site making it doubly important to work safely. Major points are given here.

- **Appendices** – A glossary, sample calculations, flow measurement and references are some of the inclusions. A sample checklist which can be modified for the individual plant is also included.

PLANT MANAGEMENT

Operation of a wastewater treatment system is a joint effort by a number of people, directly or indirectly. The two entities that are most involved after the contractor moves off site are the plant "owner" and operator. Each have certain areas of responsibility.

Owner

The owner may be the private agency that had the pond constructed, the governing board of a sewerage agency, the city manager or city council. It is the individual or group of individuals that the operator is ultimately responsible to and who have the authority to make policy decisions in regard to pond operation.

The owner of a pond has the responsibility of providing an operator who is conscientious, in good physical condition, and is capable of operating and maintaining the facility after being provided proper instruction and orientation. The orientation period might initially require the full-time duties of the operator.

If the current operator leaves the employ of the owner, it is the owner's responsibility to obtain immediate replacement. The replacement should be provided with proper training to make up any possible deficiency.

The owner should encourage opportunities for plant personnel to expand their knowledge by attendance at meetings, short schools, special training courses, and utilizing other opportunities for increasing their technical competence.

The owner has the responsibility to establish a salary level scale that encourages tenure of trained and experienced personnel.

It is the responsibility of the owner to obtain from the appropriate regulatory agency any permit required for operation of the plant.

The owner is ultimately responsible for the performance of the treatment facility. To maintain such performance, the owner is responsible for general supervision of the operator, in addition to supplying him or her with all necessary tools, materials, and parts for proper plant operation and maintenance. It is also the responsibility of the owner to provide adequate funds for plant expansion as needed.

Operator

The plant operator is responsible for the conscientious and proper operation and maintenance of the installation. This includes maintenance of buildings, grounds, and equipment.

The operator is responsible for maintaining a safe working environment and being safety conscious in his or her actions.

The operator is required to make those tests and observations required for the proper operation of the pond and to satisfy the appropriate reporting agency regulations. All results should be made known to the owner in terms that can be easily understood.

The operator must have the ability to inter pret laboratory tests and apply their results to the operational control of the treatment plant.

The operator is responsible in notifying the owner as to the need for tools, parts, and supplies. Sufficient notice should be given so that such items will be available when needed.

The operator has the responsibility to become fully acquainted with the plant and the treatment process used. He should take advantage of training offered by the regulatory agency, manufacturer-supplier or local community college.

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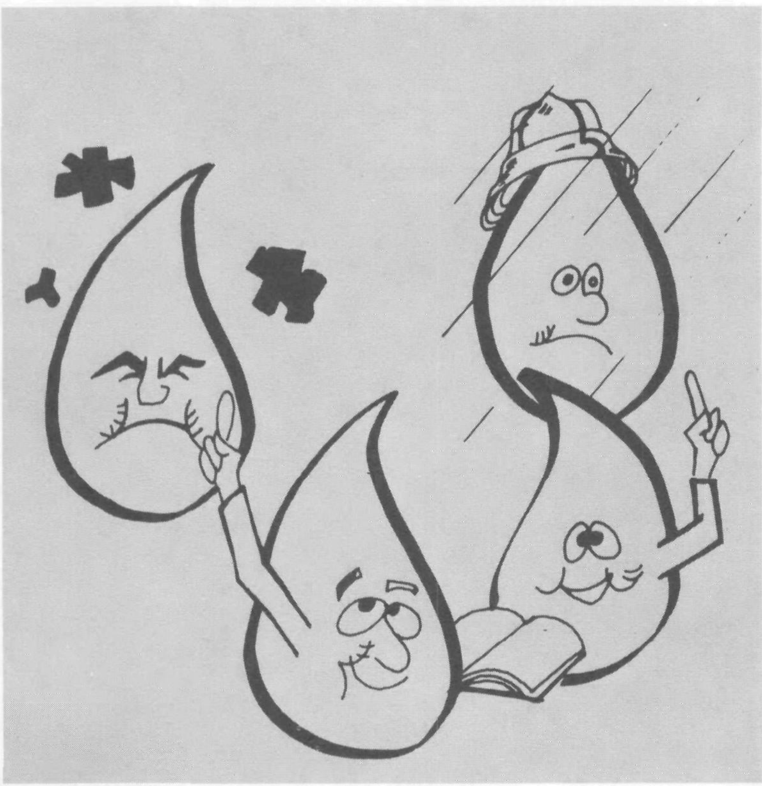

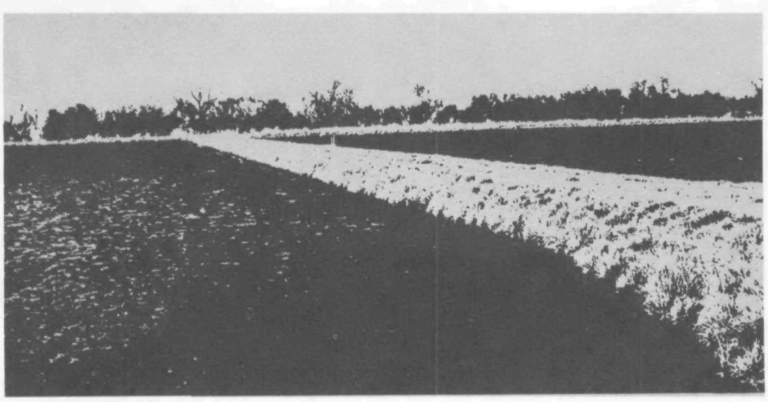

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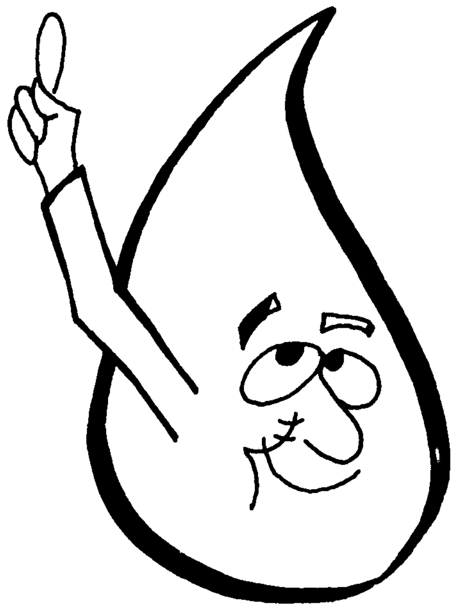
1. The Basics

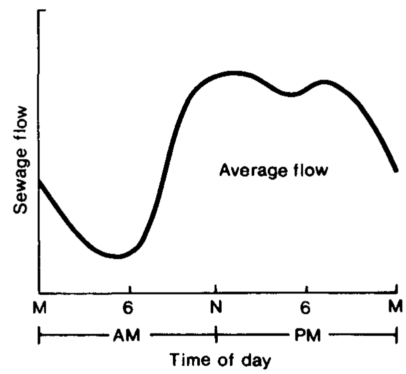


SOME INTERESTING FACTS ABOUT YOUR WASTEWATER

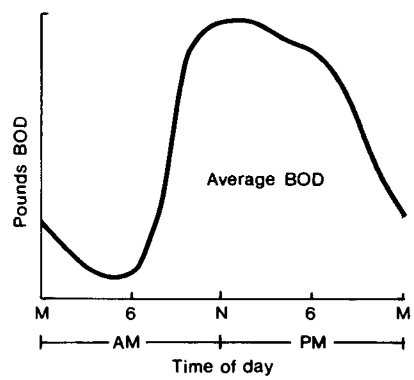
Water is used to carry man's waste products from homes, schools, commercial establishments and industrial enterprises. Water borne wastes are classified as being domestic or industrial.

The type of wastes discharged into the sewage collection system from industrial sources varies widely and may bring on treatment problems for the operator. In general, most contribute a high concentration of organic loading.

Domestic waste is pretty much the same throughout the country. We all cook, eat and clean up pretty much the same and during the same hours. These general habits create a pattern of loading throughout the day as shown in the following diagrams.



Variations in sewage flow



Variations in BOD

The average domestic sewage with well-constructed sewers will provide flows of 75 to 100 gallons containing about 0.2 lbs. or 240 mg/l of BOD per capita (person) per day.

Fresh domestic sewage is usually gray in color, similar to dishwater, with a kind of musty odor. If it becomes septic, it turns black with a strong, foul odor and the pH will be lower. The water temperature is usually a few degrees warmer than pond temperature but will vary with time of year. The solids are broken down according to their physical characteristics.

Dissolved Solids make up about 40 percent of the total solids and are dissolved in the water like sugar is dissolved in coffee. **Suspended Solids** are the remainder of the total solids. Of these, some are settleable when they enter the pond.

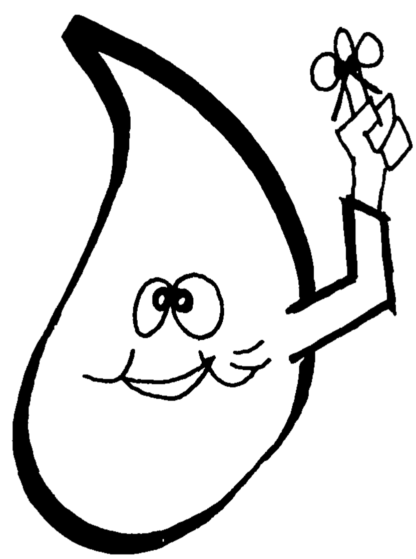
Common tests used to measure these solids are the Imhoff Cone test for settleable solids and a filtration-drying test for suspended solids. Domestic sewage usually contains about 0.2 lb. (0.9 kg) of suspended solids per capita per day, or about the same as BOD. Sewage can be described chemically in that it contains both inorganic and organic compounds.

The inorganic portion comes partly from the original sources from infiltration and from storm waters. Normal domestic sewage contains about 50 percent inorganic and 50 percent organic. The inorganic portion is relatively stable and not easily subject to decay. Inorganics consist of sand, grit, plastics, metal etc. If stormwater is connected to a sewer system or if infiltration occurs, the inorganic portion increases sometimes to troublesome proportions.

The organic portion is subject to decay (bacterial decomposition) containing proteins, carbohydrates and fats. The principal chemical elements are carbon, hydrogen, and oxygen which are often combined with nitrogen, sulfur and phosphorus.

As sewage ages, bacterial activity converts more of the insoluble organics to soluble organics which can then be used as food by the bacteria. The food is then converted into new growth and some by-products such as carbon dioxide and water.

Pollution comes from the organic portion of sewage. If it were to enter our waterways untreated, it would rob the stream of the oxygen needed by primary life forms. Contamination occurs because polluted water carries disease causing germs and bacteria. Therefore, from both an environmental and public health standpoint, it is absolutely necessary to reduce both pollution and contamination to acceptable levels. These levels are measured in terms of biological oxygen demand (BOD_5), dissolved oxygen (DO), pH, suspended solids (SS) and fecal coliform which are described in your Waste Discharge Permit.



KNOW YOUR PROCESS . . . . . .
Because it will provide better treatment and fewer upsets. And when the process becomes upset, you will know what corrections to make and why.

THE PHENOMENON OF POND LIFE

The process that takes place in a pond or lagoon is an interesting one because it is a natural cycle, continuous and a living phenomenon. As with humans, conditions and life are always changing. It is difficult to predict, with certainty, what will be happening. Changes may be due to temperature, weather, changes in the kinds of algae, and other living organisms as well as changes in the types of wastes.

Life in a pond is made up of billions of tiny microscopic plants and animals co-existing and depending on each other. In fact, it is this relationship that makes a pond work. The plant forms are the many different forms of bacteria and algae which can use soluble substances as food by absorbing it through their skin or membrane. The animal forms are higher species of free-swimming creatures who use solid matter and bacteria and algae as food by ingesting it through their mouth.

Paramoecium

Vorticella

The microbiology of a lagoon system is important to its operation. An inexpensive microscope can be used by the operator to identify what is happening in the pond. For example, most of the work is done by microscopic bacteria which utilizes the organic substances as food and under the right conditions will come together, form floc and become heavy enough to settle. Other undesirable bacteria may also form which are stringy (filamentous) and are difficult to settle. These become more numerous at low pH's, 6.5 or lower, or in a carbohydrous waste. Green algae of the Chlorella species are desirable because they are mobile and stay near the surface. Filamentous algae have a bluish-green color and are undesirable. Various other algae with different colors can be found in ponds, such as:

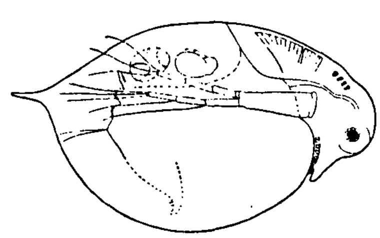
Pyrrophyta - greenish tan to golden brown
Phaeophyta - brown
Rhodophyta - red

The last two are found in marine lagoons. The color change is due to pigmentation.

The Role of Bacteria

Bacteria can be classified as those that must have oxygen to live (aerobic) and those that live in an environment without oxygen (anaerobic). Both types break down complex organic substances into soluble matter which passes through cell walls and is converted into energy, protoplasm and end products which diffuse out through the cell wall into the surrounding liquid. While the intake and conversion processes are much the same, the end products are not. Typical products produced by the aerobic bacteria are carbon dioxide, ammonia and phosphates. These are essential food elements for the oxygen producing algae. The anaerobic bacteria which live in the oxygen starved bottom layer of a pond produce carbon dioxide, hydrogen sulfide, ammonia and other soluble material which is diffused into the water as a gas or is used by the aerobic bacteria as food.

Rotifers and crustaceans are often found in ponds where they survive by feeding on the bacteria and algae. One of the most common forms are Daphnia. Oftentimes they can clean a pond of the green algae.

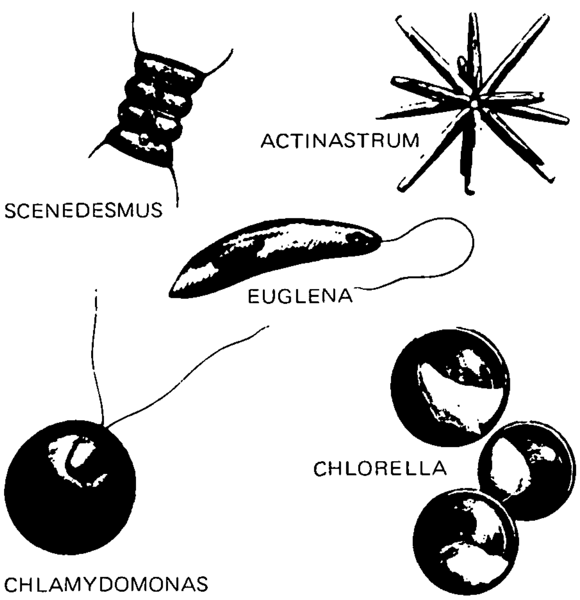


The Role of Algae

As stated earlier, the aerobic bacteria require oxygen for their respiratory system in order to stay alive. This use of oxygen is called **oxygen demand** and any oxygen remaining is measured as free **dissolved oxygen** (DO). Water will hold only a certain amount of dissolved oxygen, at which point it becomes saturated. Saturation is dependent upon water temperature. When more than this given amount is present in the water, the water is said to be supersaturated. Cold water can hold more oxygen than warm water per cubic foot.

The demand for oxygen increases as the bacteria and algae increase. And both the bacteria and algae increase as the food supply increases, i.e.: the organic loading.

There are two sources for oxygen. One source is diffusion of air into the water from the atmosphere. The other source is from algae.



Algae are microscopic plants and live in much the same manner as grass or your garden vegetables. They contain chlorophyll which converts sunlight into energy to degrade complex compounds into simpler products and for growth. This phenomenon is called **photosynthesis**. Other basic requirements are nutrients, principally carbon, nitrogen and phosphorus. And, like your garden vegetables, they grow best under warm temperatures and die off with cold temperatures. The most important role that algae perform in a pond is the production of the major portion of the oxygen.

Since algae need sunlight, they will be found near the surface of a pond. This is called the aerobic layer. The depth of this layer is dependent upon climate and density of algae. It is normally between 6 and 18 inches (15-46 cm), but this layer may extend down to 4 ft. (125 cm) in a well mixed pond. At night, algae will require oxygen in their respiratory system. Thus, when the sun goes down, the algae do not die, but continue to function and consume oxygen, although they have stopped oxygen production. This explains why the dissolved oxygen level will be at its lowest point immediately after sunrise.

There are many forms of algae to be found in ponds, however, two important classifications appear which can be related to the quality of the pond.

1. One is the so-called green algae which gives a pond a green color and indicates a good healthy condition. They are associated with a high pH and with a waste high in nutritional value.

2. The blue-green algae are filamentous and appear when the nutrient and pH levels are low or survive when the higher animal forms such as protozoa devour the green algae. Therefore, the appearance of blue-green algae in a pond is an indication of poor conditions.

Pond loading has a direct bearing on microbial (bacteria and algae) life within a pond.

A. The microbial population will be greatest near the influent and decreases toward the outer edge of a pond.

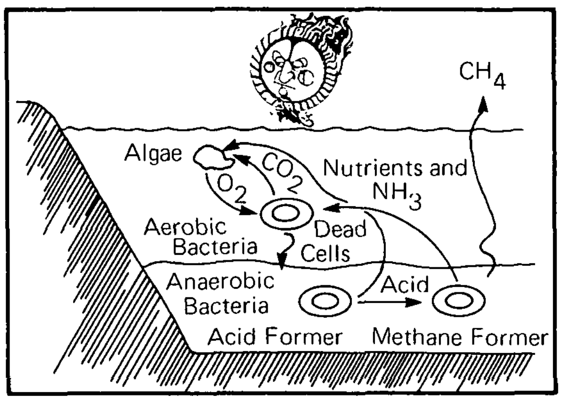
B. At low organic loadings, various protozoa (predators) will appear such as Daphnia and Paramecium, which utilize the algae and bacteria as food. Operationally you would not expect to see any of these forms in a primary cell but, would see them in the polishing pond. There have been cases where the predators have caused a pond to clear up and other cases where predators are found, the pond remains green. This is because blue-green filamentous algae is present, which the predators do not touch.

C. Overloaded ponds create a rapid growth by both bacteria and algae, which in turn creates an oxygen demand that cannot be satisfied by either the algae or wind action. This results in algae die off as seen by floating mats of algae and a decrease in dissolved oxygen. It can easily reach a state where the entire pond will become anaerobic.

One of the biggest problems or deficiencies of oxidation and stabilization ponds is the amount of algae contained in the pond discharge. Algae, in this case, contributes significantly to the suspended solids being discharged to a receiving stream. The most common method used to reduce the amount of algae is to use a draw off point below the algae layer. In the mid-part of the nation, discharge is limited to twice per year when algal content is low and effluent is in the best condition.

There are several other methods available to reduce the algae concentration; rapid sand filtration, submerged rock filters, alum coagulation, mixed media filters, and chlorination. Of the listed methods, all except chlorination will add considerable cost and man-hours for algae removal. Chlorination can effectively kill the algae but, the dead algae cells will release stored organics and thus contribute to the BOD load being discharged. It is true that this BOD is quite stable and inoffensive, but it will decrease the oxygen in the receiving stream.

When wastewater is discharged into a pond, the heavy solids settle out near the inlet where two types of anaerobic bacteria stabilize the organic matter. This is shown in the following simple diagram.

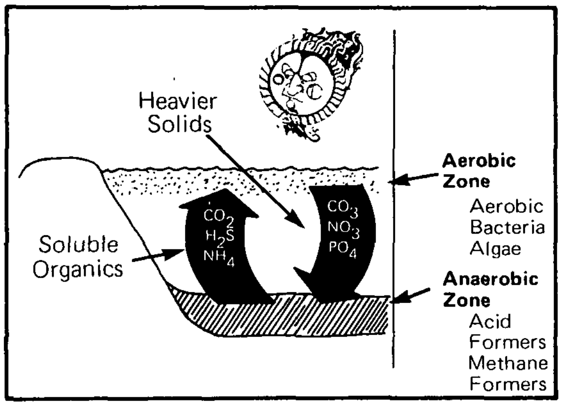


Waste stabilization occurs in two steps:

1. **Acid bacteria** break down the complex organics and use the **soluble matter** as food which is converted into **organic acid**.

2. The organic acid is used as food by the **methane bacteria** which convert the acid into carbon dioxide (CO_2), ammonia (CH_4), hydrogen sulfide (H_2S) and methane gas.

The byproducts of anaerobic decomposition are soluble in water and become food material for the aerobic bacteria and algae. Algae require carbon, nitrogen, nutrients and sunlight. Sufficient sunlight energy may be available in depths from 12 to 18 inches (30 to 46 cm), hence, algae are only found near the surface. When these are available the algae produce free oxygen which is required by the aerobic bacteria. When light energy is not available, such as nighttime or when the surface is covered with ice or duckweed, the algae do not convert the carbon dioxide, therefore no oxygen is produced. The aerobic bacteria in the surface layer, using the free oxygen, feed on the soluble organics in the raw waste as well as the soluble by-products of anaerobic decomposition. In turn they produce some inert material, which settles to the bottom, and dissolved sulfate, nitrate, phosphate and carbonate compounds required as the source of energy by the anaerobic bacteria. Thus, in most ponds the treatment process is a complex interaction between two separate bacterial communities and algae. Each is doing something useful for the other. This is shown below.



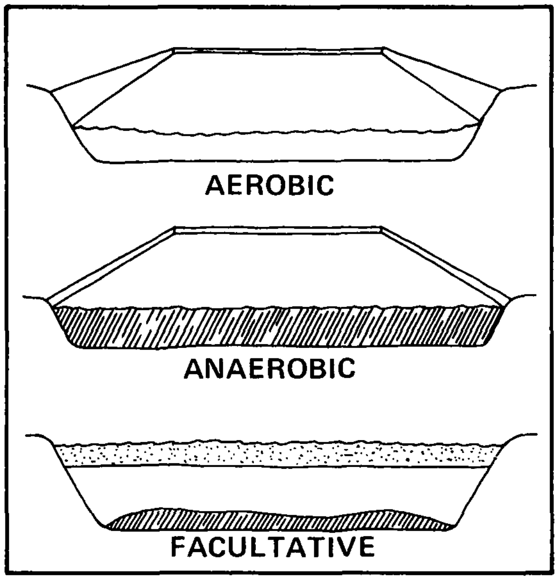
HOW ARE WASTES TREATED

Regardless of the treatment devices used, treatment usually proceeds along similar lines. Settleable solids are removed first either in a pond or in separate primary clarifiers. If the solids are removed from the flow by settling in a primary clarifier, the solids will be handled in separate facilities such as anaerobic digesters. If raw solids enter a pond, the settleable solids will settle out near the inlet and undergo anaerobic decomposition as in an anaerobic digester. This is one reason why the first cell in a series is called a **primary cell**.

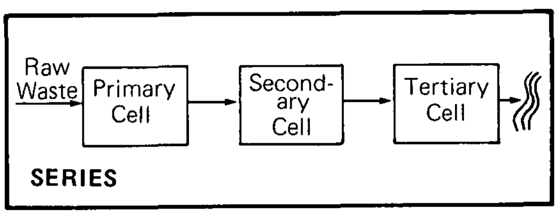
The next step in treatment of wastes is called secondary treatment. This is a biological reaction step in which organic dissolved and suspended matter is oxidized (converted) by bacteria into **stable** end products, thus reducing the BOD and suspended solids. In ponds, this step is usually accomplished in both the primary and secondary cells. A third step in treatment is often designed into a treatment system which involves polishing treated wastewater. These ponds are lightly loaded and used to remove additional BOD and suspended solids. They are referred to as **tertiary** or **polishing** ponds and can be the last cell in a system or as a single pond following conventional secondary treatment.

TYPES OF PONDS

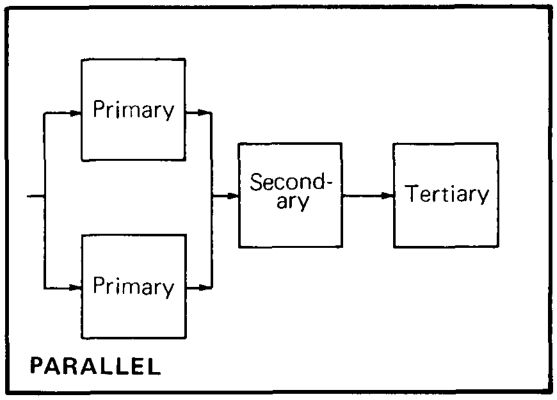
Oxygen demand determines the type of ponds required. Aerobic types have oxygen distributed throughout the water. Anaerobic ponds are devoid of oxygen. Facultative systems have an aerobic surface layer and an anaerobic bottom layer.



Wastewater is treated in various types of ponds or lagoons which are named according to the type of treatment involved. Lagoons are bodies of water confined within natural boundaries, while ponds are shallow and manmade. Treatment usually occurs in two or more ponds called **cells**. These cells are arranged in series with water flowing from one cell into another. For example, in a stabilization pond, influent enters a primary cell, then flows into a secondary cell, then into the polishing cell.



Many systems are arranged so that two or more primary cells can receive the plant flow. In these cases, the plant flow enters a distribution manhole or a box which is gated or valved to divide and direct the flow into the primary cells. This is called parallel operation. Effluent from these cells then follows the usual series pattern to obtain the maximum solids and algae removal prior to discharge. From an operational viewpoint, series operation normally will provide the best treatment if the actual loading is below the design loading. This is because of the detention time. Parallel operation for the primary cells is most often practiced when loadings exceed the design and for winter operation.



Ponds and lagoons are designed as continuous discharge, controlled discharge, or no discharge. Ponds designed and operated as continuous discharge must usually disinfect the plant effluent with chlorine in order to destroy the pathogenic (disease causing) organisms.

Controlled discharge is used when the wastewater is held for long periods of time before discharging. The discharge periods are usually twice a year. The selected period is based on two factors: the condition of the pond contents and the condition of the receiving stream. In general, these ponds discharge shortly after the ice break up in the spring and shortly after the first frost in the fall. One reason these periods are selected is that the algae mass is at its lowest concentration. Deep ponds often experience a "spring turnover" problem when the ice melts and the pond warms up. This is due to increased biological activity and bottom sludge floating to the surface causing temporary odor problems. Most of the time, this will last between 2 to 15 days.

No discharge ponds are those designed to take advantage of an area's evaporation rate and/or ground percolation. In these cases the rate of evaporation and/or percolation equals or exceeds the inflow rate. Often one of the most difficult operating problems associated with these ponds is controlling water depth to discourage weed growth. This can be helped by deliberately adding water to the pond.

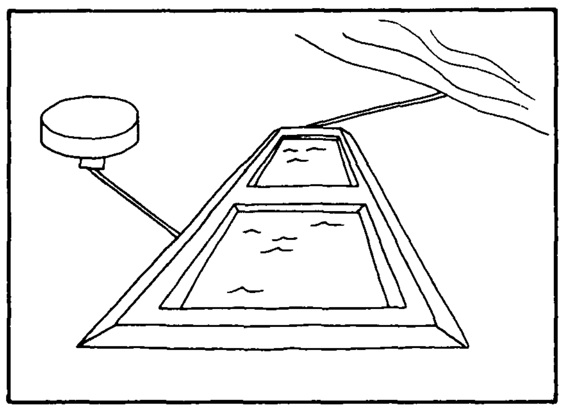
Regardless of type of pond, best operation is only achieved when the entire pond is used. When no water movement occurs in a portion of a pond, a condition called **short-circuiting** results. Short-circuiting can be caused by poor design of inlet and outlet piping arrangements or by uncontrolled growth of water weeds. If either of these conditions occur, they must be corrected.

As mentioned previously, the three major categories of ponds are aerobic, anaerobic, and facultative, other ways of describing them are found in textbooks or are in common use in different parts of the nation.

Some of these definitions are given below. The reader should remember that these are examples of one or more of the above major types.

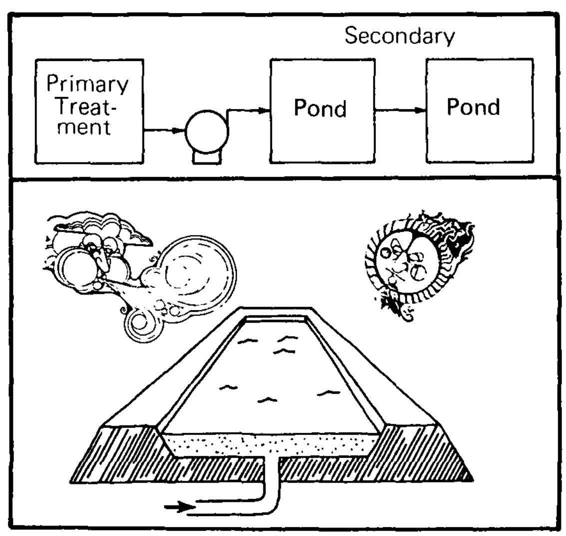
STABILIZATION PONDS

Receive raw untreated wastes and usually consist of two or more cells (individual ponds). The first cell which receives the untreated waste is called a primary cell. The following cell is a secondary cell which is often followed by a polishing cell (or tertiary cell). Stabilization ponds are often designed with two or more primary cells so that they can be operated in parallel to prevent overloading problems.



OXIDATION PONDS

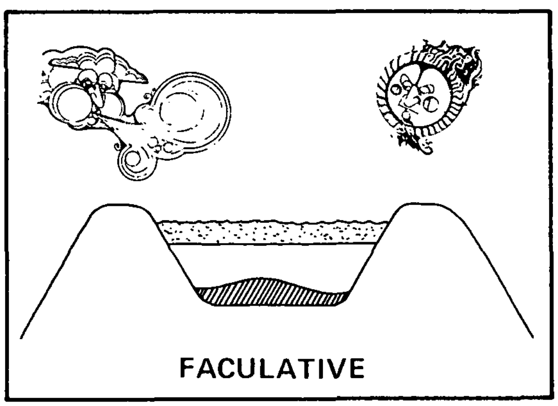
Ponds receiving treated waste and operated in series are called oxidation ponds. These may serve as secondary treatment following a standard primary plant.



Most stabilization and oxidation ponds stabilize organic wastes through a complex natural process involving sunlight, oxygen, water currents, algae and bacterial action. Stabilization and oxidation ponds require large surface areas, shallow depths and long detention times for natural stabilization to occur.

FACULTATIVE PONDS

Facultative ponds are the most common type of ponds used for stabilization and oxidation lagoons. They have two zones of treatment: an aerobic surface layer and an anaerobic bottom layer. Facultative ponds operate with 3 to 8 feet (1 to 2.4 m) of water depth and are usually loaded between 15 and 80 lbs. BOD per acre (17 and 90 kg per ha) per day. Oxygen for aerobic stabilization in the surface layer is provided by algae and wind action. Decomposition of the sludge in the bottom zone takes place anaerobically. The lagoons are usually designed to provide sufficient waste dilution and natural aeration to insure that the surface liquid will remain aerobic.



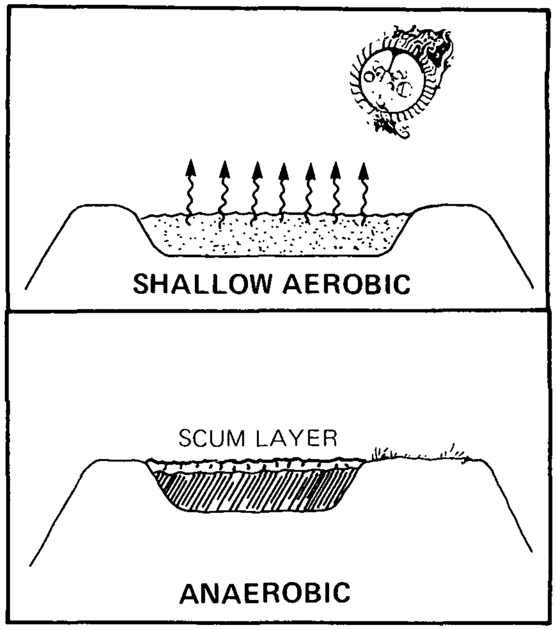
An existing stabilization or oxidation pond can be upgraded by either increasing its detention time or decreasing its surface BOD loading or both. Another method is to deepen the pond and install mechanical aeration. Generally speaking, cold climates may favor the use of compressed air. Intermittent seasonal operation or high oxygen requirements usually favor mechanical aerators or diffused aeration pipelines.

Other ponds are built to serve special purposes.

SPECIALTY PONDS

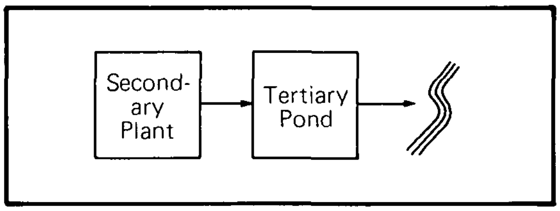
These include high rate aerobic ponds, anaerobic ponds, tertiary ponds, and aerated lagoons.

High Rate Aerobic Ponds are usually limited to applications where a high algal mass is desired for harvesting. The algae is then used as food for cattle. These ponds are shallow (about 12-18 inches [30-46 cm]) and usually loaded from 60 to 200 lbs. of BOD per acre (67 to 224 kg per ha) per day.

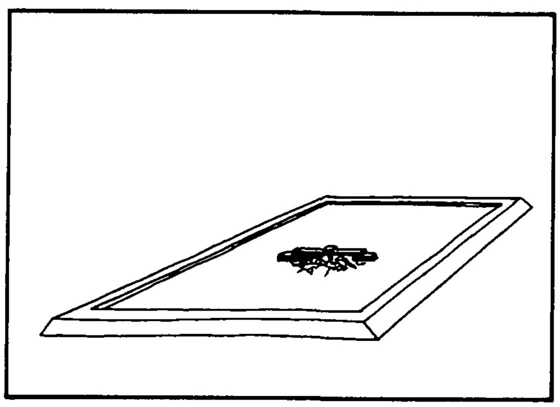


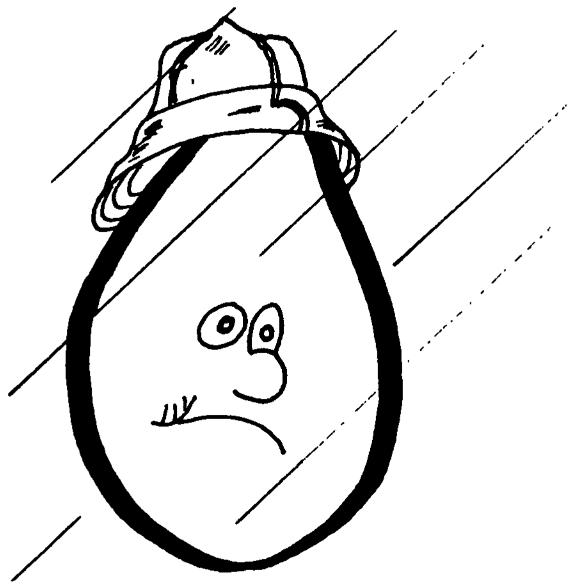
Anaerobic Lagoons are ponds designed to treat high oxygen demand wastes such as slaughterhouse wastes. The organic loads are so high in these ponds that anaerobic conditions prevail throughout. These ponds are similar to anaerobic digesters or septic tanks.

Tertiary Ponds are used for polishing effluents from conventional secondary treatment processes. They are also often used as the last pond of a stabilization or oxidation pond system to remove algae before the effluent is discharged. These ponds are similar to facultative ponds except that they are very lightly loaded, usually less than 15 lbs BOD per acre (17 kg per ha) per day.



Aerated Ponds are employed in those cases where supplemental oxygen is needed due to high organic loadings. For example, when a facultative pond becomes overloaded it uses more oxygen than it produces and turns anaerobic. One method to increase oxygen is to install powered aeration equipment. Many ponds are being designed and operated with aeration systems to permit higher loadings in smaller spaces. These ponds then get essentially all of their oxygen by mechanical means and very little algal mass is formed.





WHAT NATURAL FACTORS AFFECT THE PROCESS

Wind Action

Wind action creates surface mixing on ponds increasing with surface area. Large ponds need riprap on dikes for protection. Wind also tends to remove oxygen from the water when the pond is supersaturated. When the dissolved oxygen is less than saturation, wind action helps to drive oxygen into the water.

Temperature

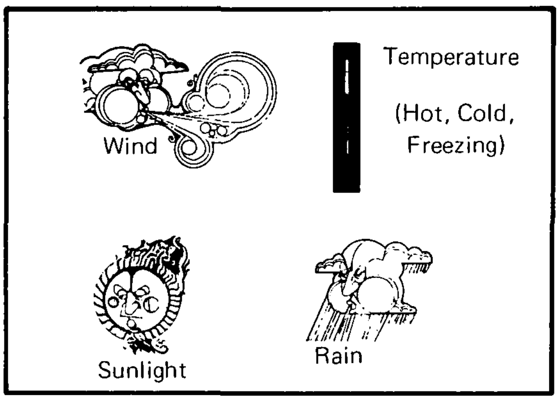
Water will hold more oxygen per cubic foot at a cold temperature than at a warm temperature. As an example, water in the winter time will hold almost twice as much oxygen as in the summertime. However, in colder climates, ice cover prevents adding DO by wind and snow cover prevents algal action for DO production.

Biological activity decreases with temperature, a 10-degree drop in temperature will reduce microbial activity by one-half.

Best conditions are when it is warm with good sunlight and a moderate breeze. This produces the greatest bacterial activity and hence the highest BOD removals from the raw waste.

Normal slow changes in temperature produce long-term seasonal effects such as changes from spring to summer.

Abrupt or sudden temperature changes bring about short-term problems. For example, a sudden rise in temperature causes the bacteria to multiply at a rapid rate causing the oxygen demand rate to increase faster than the slower algae can supply the necessary oxygen. This may result in a more turbid effluent than is normal. A sudden drop in temperature can cause a pond to clear up. This occurs because the algae activity slows down and they settle out. An example of this is a sudden frost in the spring or fall. This is normally the time when ponds with controlled discharge are lowered.



As the weather gets colder and daylight becomes shorter, bacterial and algae activity gradually gets slower. In northern freezing climates during extended cold periods the rate of biological activity becomes quite slow. Ponds located in areas where they are covered with ice may experience a "spring turnover" when the weather warms enough to melt the ice if drastic changes occur. This condition is accompanied by rising chunks of sludge and unpleasant odors which may persist for a month or so. Cold weather also brings about an increase in the concentration of ammonia nitrogen as compared to the warm months.

Example: Jan. 6-10 mg/l
May 3.0-0.1 mg/l

The concentration of phosphorus is greatest during cold weather. On the other hand, suspended solids is lowest during cold weather due to decreased algae activity.

Warm weather brings about a great increase in algae growth. Operators can expect to see clouds of "algae blooms" which stops light penetration and reduces oxygen production. The increase in algae growth also causes an increase in suspended solids plus an increase in oxygen demand (BOD) in the effluent of flow through ponds.

Warm weather increases evaporation rates which will change the detention time and may affect the amount of effluent that is discharged.

The arrival of spring also brings on heavy growth of water weeds which may change the pattern of water movement. Scum mats also form on the surface. Both scum and water weeds form excellent breeding grounds for mosquitoes and other insects.

Periods of heavy rainfall affect pond operations as the increased volume of water coming into the pond dilutes the organic waste, it may change pond temperature, will cause a sudden increase in water depth and may shorten detention time.

Sunlight

Sunlight is indispensable to effective operation of stablization ponds through photosynthesis of algae in producing oxygen.

The percentage of available annual sunlight varies throughout the country which is governed by latitude (which governs seasons), elevation and cloud cover. The amount of available sunlight helps to determine how well the pond operates and the area and depth needed for proper operation.

The depth of sunlight penetration determines the extent to which the pond volume participates in oxygen production and hence, the optimum pond operating depth. Loss of light by reflection increases up to 30 percent when the surface is roughened by the wind.

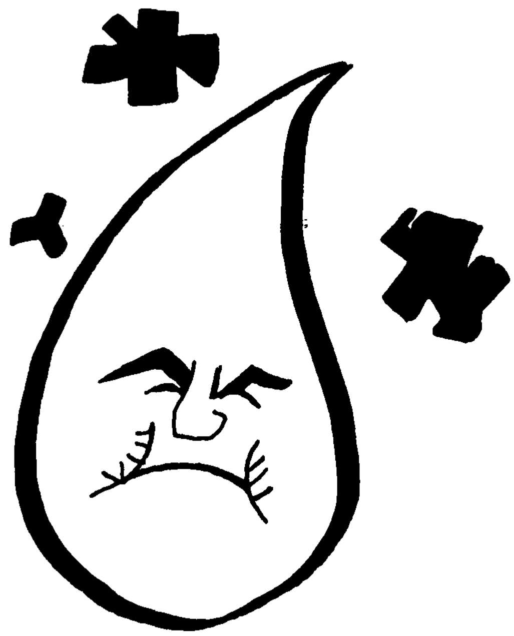
Algal density, which varies from season to season and pond to pond, determines the depth of light penetration and intensity. In general, with good algal growth and dispersion, oxygen production will be good up to about 24 inches (60 cm) in depth. Oxygen production does not meet the oxygen demand beyond this depth without vertical mixing by wave action. The pond operator can do much to maintain optimum oxygen production by removing duckweed or other materials that reduce light exposure.

All of the preceding remarks can be related to operation by the following summary.

A. Do not decrease water depth to less than three feet (1 m) for warm weather operation.

B. Keep algal blooms dispersed.

C. Keep pond free from duckweed hyacinth or similar weeds.



HOW PHYSICAL FACTORS AFFECT TREATMENT

Surface Area

Surface area is determined by organic loading (lbs. of BOD per acre per day) and is called the **surface loading rate**. Surface loading determines the type of pond. For example:

- Aerobic Ponds 60-200 lbs. BOD/Acre/Day (67-224 kg per ha)
- Facultative Ponds 15-30 lbs. BOD/Acre/Day (17-35 kg per ha)
- Anaerobic Ponds 200-1000 lbs. BOD/Acre/Day (224-1120 kg per ha)
- Tertiary Ponds 5-15 lbs. BOD/Acre/Day (6-17 kg per ha)

Sometimes surface loading is related to the connected population such as 100 persons per acre per day for facultative systems, but the type of pond will determine the exact figure.

As an example of surface loading, if the organic load is 300 lbs./day, (336 kg/day) on a facultative pond, a minimum of 10 acres (4 hectares) may be required.

Water Depth

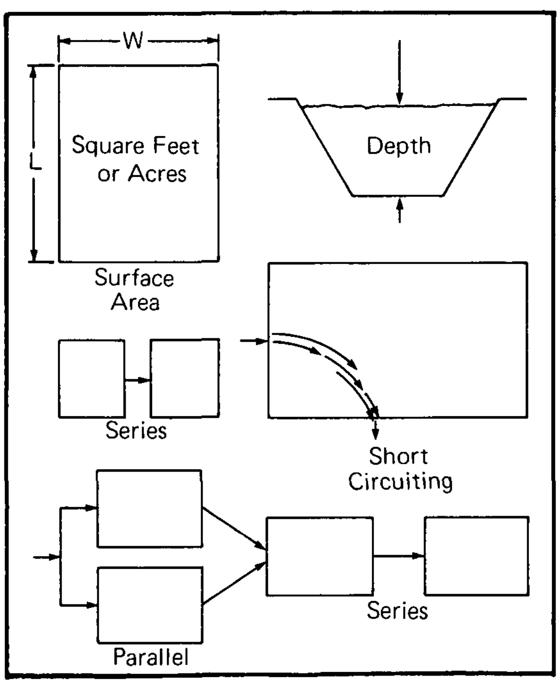
Water depth will vary, particularly in ponds that are being filled for the first time or in systems that operate on a seasonal cycle for controlled discharge.

To start a new pond, two feet (0.6 m) of water should be added prior to fresh starting wastewater feed. In controlled discharge systems, primary cell should not drop below three feet (0.9 m).

Maintaining a minimum level is necessary to prevent exposing sludge blankets on the bottom to atmosphere thus preventing odors and also to prevent allowing the pond bottom to dry out and crack.

Short Circuiting

Regardless of type of pond, best operation is only achieved when the entire pond is used. When no water movement occurs in a portion of a pond, a condition called **short circuiting** results. Short circuiting can be caused by poor design of inlet and outlet piping arrangements, unlevel bottoms, shape of cells, predominant wind direction, or by uncontrolled growth of water weeds. If any of these conditions occur, they must be corrected. Methods of correction are described in the troubleshooting section. Short circuiting in ponds leads to many problems, including dead spots which reduce the area of effective treatment and also contribute to odor problems and sludge mats.

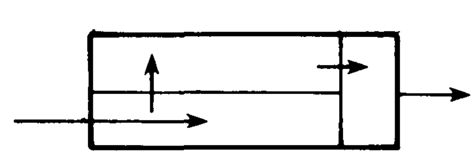


Series Operation

Series operation, particularly when three or more ponds are used, tends to minimize the amount of algae in the last cell and should result in better quality effluent. As a result, ponds are often operated in series during the warmer months, when algae production is highest.

Series operation during winter leads to special problems when ponds are under an ice cover. The first cell can become overloaded and, when warm weather returns, the cell may be septic and produce unwanted odors and sludge which has floated to the surface.

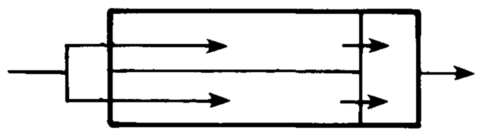
Plants that are designed with at least three cells have the ability to operate the first two as primary cells and during summer months run these in series to minimize algae growth when the flow reaches the secondary cell. Those plants that use controlled discharge during spring and fall find the best results by allowing the first cell to fill to at least three feet (9 m) or more then transfer to the next cell in succession in increments of 6 inches (0.15 m) until the ponds are at maximum or time for discharge arrives.



SERIES WITH 2 PRIMARY CELLS

Parallel Operation
Parallel operation is used to reduce organic loading in the primary cells. Parallel operation is especially advantageous during winter months so that sewage solids can be distributed over a wider area.

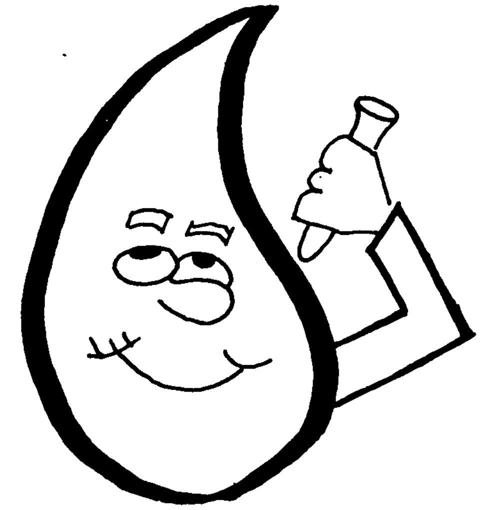
Winter month operation in parallel has the advantage of distributing the load over more surface pond area and this is particularly important when ice covers develop and activity is low. Again, for plants with three cells, the first two should be used in parallel and if the system operates on a controlled discharge, primary cells should be filled at the same time once both are at the 3-foot (9 m) depth and then alternately discharge 6 inches (0.15 m) at a time into the secondary cell until it reaches the same depth as both primaries.



PARALLEL WITH 2 PRIMARY CELLS

Recirculation
Recirculation is a means of improving pond conditions. This allows oxygen that has been produced by the algae in one pond, or part of the pond, to be mixed with low oxygen areas of the system. Other advantages include a mixing to help prevent odors and anaerobic conditions in the feed zone.

The most common method of recirculation is to recycle effluent from a secondary cell to the effluent of the primary cell. This method obtains the greatest amount of dissolved oxygen.



HOW CHEMICAL FACTORS AFFECT TREATMENT

Oxygen
Oxygen is necessary for maintaining the life forms in an aerobic pond. It is used by the bacteria to stay alive. Oxygen combines with many substances to form oxides and break up many complex organic molecules into simpler molecules making them more available to the bacteria. Since oxygen is used to oxidize these organics, the DO (dissolved oxygen) will decrease in proportion to the amount of organic material present. This is known as the **oxygen demand** of the waste.

Water will only hold a certain amount of dissolved oxygen. When the amount of air/oxygen entering the water equals the amount leaving the water, it is said to be **saturated**. In ponds containing algae, the water can become super-saturated with oxygen (more oxygen enters water than is used).

Wind also tends to remove oxygen from the water when the pond is super-saturated. When the dissolved oxygen is less than saturation, wind action helps to drive oxygen into the water.

The strength of the waste can be indirectly measured by the biochemical oxygen demand

(BOD) test. The test measures the amount of oxygen used by the bacteria over a 5-day period. If the demand for oxygen is greater than the supply, the aerobic bacteria will die off and anaerobic conditions will develop along with operational problems. Low dissolved oxygen concentrations result in turbid effluents, bad odors, and the growth of filamentous type of bacteria.

Nutrients

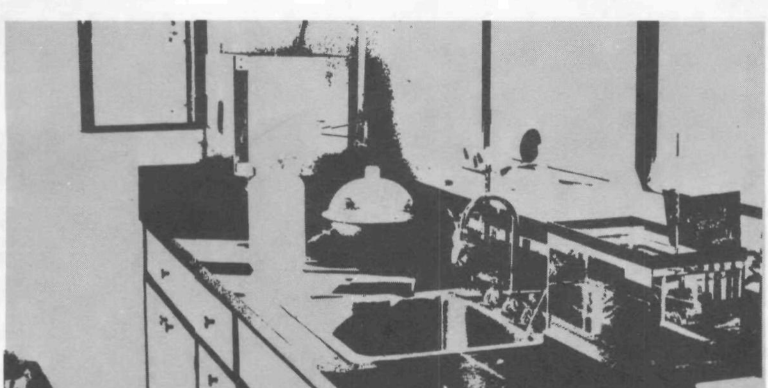
Without a sufficient supply of nutrients (nourishment), the bacteria will not be able to grow and multiply. Although several elements are needed, nitrogen and phosphorus are the principal elements required. Domestic wastes usually contain enough of both. Nitrogen is in the form of ammonia (NH_3).

pH

This test indicates whether a pond is acid or alkaline. Both the aerobic and anaerobic systems require an alkaline environment for best operation. Operators should check pH of the pond effluent to determine if any toxic materials are entering the pond. The pond color is related to pond pH and should help operators to forecast any impending problems. Green shows a high pH (alkaline). Yellowish-green indicates a lowering pH (acidic). Color may not relate to pH when a strong wind stirs up silt from the bottom or highly colored industrial wastes influence the pond's color.

A lowering pH can be corrected by letting the cell rest for a few days. The pH will change throughout the day and will usually be at its lowest in the early morning and highest in the late afternoon, because algae are most active during daylight and cause chemical reactions that drive pH upward. (CO_2 produced by bacteria at night causes the pH to be lowered.)

2. Control Information for Ponds



Sample collection
Types of samples
Sample point locations
Tests and measurements
Important visual indicators
Other daily data

2. Control Information for Ponds

Adequate control of the process is necessary to meet assigned discharge requirements. It is necessary to know the quantity, concentration, and type of waste entering the plant. It is also necessary to know what is happening in the pond and what is going out of the pond. Therefore, there are three major points of measurements: The plant influent, the pond and the plant effluent. Several tests must be run on samples of wastewater taken at each of the major points. These are: Flow, temperature, pH, dissolved oxygen (DO), BOD, suspended solids (SS), fecal coliform, and also chlorine residual when disinfecting with chlorine.

The results of these control tests are often referred to as **control parameters** and are used to determine how well treatment is progressing to predict operational changes and to assess the results of treatment. For continuous flow through systems the following tests, flow, temperature, pH, and chlorine residual, can be easily performed by the operator on a daily basis with simple equipment such as a glass electrode pH meter, DO meter or DO kits, and a colorimetric comparator. BOD, SS, and fecal coliform tests require more time, costly equipment, and technical know-how. A small, part-time operation may therefore elect to collect samples for these tests, but send them to local chemical laboratories for analysis.

Systems that operate on a controlled discharge basis will need to concentrate testing during the period prior to and during discharge as required by their regulatory agency.

Weather is one of the most important factors affecting pond operation. Knowledge of weather conditions will help to explain many things about pond operation.

SAMPLE COLLECTION

The collection of test samples of wastewater is the basis for obtaining accurate test results. **TEST RESULTS ARE ONLY AS GOOD AS THE SAMPLE.** Test samples must be **REPRESENTATIVE** of the waters being sampled. This requires selecting a point that will give a uniform sample. If the sample is to be stored before testing, it must be refrigerated. Sample containers must always be clean before sampling to avoid getting the wrong results. Temperature, pH, residual chlorine, and DO should always be taken immediately to avoid deterioration and should be taken at the same time each day. Occasionally though, it is a good idea to check these parameters at other times during the day to get a feel for the daily changes that occur. For example, if tests are normally run at 8:00 a.m. each morning, then perhaps every two months, take additional tests at 10 a.m., 2 and 4 p.m.

TYPES OF SAMPLES

A grab sample is a single sample taken at no set time or flow. Grab samples are used to measure temperature, pH, DO, fecal coliforms and chlorine residual.

Chosing the correct time to sample may be a problem because grab samples are only representative of conditions at the moment. Raw sewage flow varies in content, as well as volume, during a typical day. One sample at any time of day cannot possibly be used for compiling data on a whole day's operation. For that matter, neither can three, four, or five samples. It remains for a decision to be made as to how many samples can conveniently be taken in a 24-hour period.

Samples of the pond will yield the most information if taken at sunrise and in mid-afternoon, with separate analyses run on the two samples.

Samples of effluent from controlled discharge ponds should be taken during discharge - perhaps one sample every two hours and combined into one composite sample. Each individual state has guidelines that are specific for their particular situation and should be consulted by the operator.

Composite samples are taken by gathering individual samples at regular intervals over a selected period of time. The individual samples are then mixed together proportionally to the flow at the time of sampling. For example, a composite sample might be made for Tuesday covering the period from 8 a.m. with a sample collected at 8 a.m., 10 a.m., 12, 2 p.m., and 4 p.m. Each individual sample must be refrigerated immediately to avoid deterioration.

At each sampling time the flow must be recorded for use at the end of the sampling period. At the end of the sampling period, remove the samples from the refrigerator. Then, stir each one and pour an amount of the samples proportional to the flow at the time the sample was taken.

Composite samples are needed to test and measure for BOD and suspended solids.

See Appendix B for a sample calculation on compositing.

Automatic Samplers. There are a number of kinds of automatic samplers on the market. Some are battery-powered and self-contained; others must have an external power source. All offer sampling at chosen intervals, some as frequently as every 10 minutes, and compositing of samples on the spot. This equipment is most valuable for sampling raw sewage flow but can be used for effluent as well. Whether this type of equipment should be purchased for waste stabilization ponds would depend, somewhat, on the loading and the ease of getting representative composite samples by hand.

Handling and Preservation of Samples. Sewage samples deteriorate rapidly if subjected to summer temperatures and to some extent, freezing. Exclusion of sunlight is also recommended. For these reasons, collected samples should be transferred to a refrigerator where they can be stored until removed for analysis. A temperature of 40 degrees Fahrenheit (4° Celcius) will prevent deterioration for 24 hours.

Containers used for sample storage need to be kept as clean as possible. Stoppered glass bottles or wide-mouth jars are preferred and are easiest to use for mixing and cleaning.

SAMPLE POINT LOCATIONS

Pond Influent

Samples of the raw wastewater can be obtained from several points:

1. The wet well of the influent pump station. One method is to use a bucket or container attached to a rod. The sample must be taken from a turbulent well-mixed point.
2. A manhole at the inlet diversion control structure.

Ponds

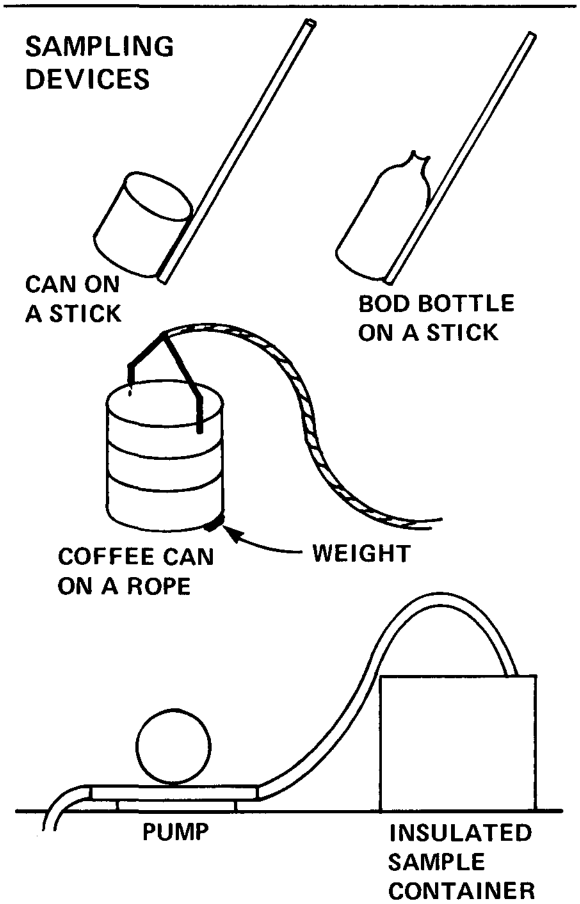
Pond samples should be composited consisting of four equal portions from four corners of the pond.

The sample should be taken eight feet (2.5 meters) out from waters edge and one foot (0.3 meter) below the water surface. This should be done carefully to avoid stirring up material from the pond bottom.

Pond samples should not be taken during or immediately after high winds or storms since solids will be stirred up after such activity.

Pond Effluent

Samples of pond effluent should be taken from the outlet control structure, or a well-mixed point in the outfall channel.



TESTS AND MEASUREMENTS

Test results along with visual indicators are used to operate the lagoon – to keep it alive and healthy. Following is a description of the important tests and measurements and what they do.

Temperature

The temperature of the raw wastewater can be used to detect infiltration and some industrial wastes. A sudden decrease in temperature may indicate warm industrial wastes. Since dissolved oxygen varies with temperature, it is often necessary to know how close to saturation the DO test is when it is run. This can be determined by the following oxygen saturation table.

SOLUBILITY OF OXYGEN IN FRESH WATER

°C	°F	O_2 (PPM)	°C	°F	O_2 (PPM)
0	32.0	14.6	26	78.8	8.2
1	33.8	14.1	27	80.6	8.1
2	35.6	13.8	28	82.4	7.9
3	37.4	13.5	29	84.2	7.9
4	39.2	13.1	30	86.0	7.6
5	41.0	12.8	31	87.8	7.5
6	42.8	12.5	32	89.6	7.4
7	44.6	12.2	33	91.4	7.3
8	40.4	11.9	34	93.2	7.2
9	48.2	11.6	35	95.0	7.1
10	50.0	11.3	36	96.8	7.0
11	51.8	11.1	37	98.6	6.9
12	53.6	10.8	38	100.4	6.8
13	55.4	10.6	39	102.2	6.7
14	57.1	10.4	40	104.0	6.6
15	59.0	10.2	41	105.8	6.5
16	60.8	10.0	42	107.6	6.4
17	61.6	9.7	43	109.4	6.3
18	64.4	9.5	44	111.2	6.2
19	66.2	9.4	45	113.0	6.1
20	68.0	9.2	46	114.8	6.0
21	69.8	9.0	47	116.6	5.9
22	71.6	8.8	48	118.4	5.8
23	73.4	8.7	49	120.2	5.7
24	75.2	8.5	50	122.0	5.6
25	77.0	8.4	51	123.8	5.5

Flow

Flow measurement is necessary for all ponds. Measuring the influent flow tells the operator many things about the operation.

1. It determines hydraulic loading and tells when a pond has reached or exceeded its hydraulic capacity. A hydraulically overloaded pond may not provide complete treatment because the biological activity may not be complete before water leaves the pond.

2. It is the only clue to describing the extent of infiltration.

3. When related to BOD and SS reductions, it describes its effect on overall treatment.

4. It provides the basic data for determining mode of operation (when the operator has these options) such as use of series or parallel operation, retention time, and what operating depth to use.

   Use series operation when flows are below design. Compute hydraulic loadings on basis of gallons per acre per day (Appendix B) or population equivalent.

   Storage capacity and operating depth should be calculated to determine the amount of discharge for intermittent discharge ponds. Drawdown of the pond should not exceed the minimum pond depth of approximately three feet required for weed control. Sample calculations are given in Appendix B.

5. Flows are required to translate BOD and SS test results into pounds per day. These should then also be calculated into loading of pounds per acre per day. Appendix B contains sample calculations. This information is then used with hydraulic loading to determine which operational mode to use, and with DO to determine the need for supplemental aeration.

6. Flow information is required for calculating chemical dosages. Effluent flows are measured as part of the tests for NPDES permit requirements indicating the effect of effluent on receiving waters.

   Periodic checks between influent and effluent flows should be made to determine the extent of either evaporation or exfiltration (loss of water by seepage into soil).

   Some examples of flow measuring devices are Parshall Flumes, V-notch weirs, floats, irrigation flume with markings, and using a pump station wet well with a known depth and recording pumping time multiplied by pump capacity.

   See Appendix C for a more complete discussion of flow measurement, determining the flow, devices.

pH

The pH of the influent and effluent will vary throughout the country among neighboring lagoons, and throughout the day on a given pond. This pH variability is due to several causes: the natural alkalinity and hardness of the water, the type and volumes of commercial and industrial wastes and the pond itself.

The pH of incoming domestic sewage normally is between 6.8 and 7.6. Algal reactions in lagoons can be expected to raise the pH to as high as 9.5 or above. pH is closely tied to the production of oxygen by the algae as they convert inorganic carbon to organic carbon. The combination of organic metabolism, alkalinity and time are needed to produce oxygen. This means that there must be food for the bacteria, enough natural alkalinity and enough detention time. If any of these are missing within the lagoon the pH will start to decrease toward the acid side with a possible drop in DO. Other changes may also occur, such as the disappearance of the green algae and the color of the pond changing to a blue-green.

The pH can be a good indicator of the pond's condition. Some of the abnormal causes for a decreasing pH are septic wastes coming in as a result of low flows, or it may be due to an acid industrial waste. Fluctuations may also be due to normal activity. The pH may be reduced during the night as a result of increased bacterial action and lower algal activity. This will cause the values to be lower at the pond bottom than at the top.

Dissolved Oxygen

Dissolved Oxygen (DO) is a good indicator of the activity of an aerobic lagoon. By watching trends in oxygen levels of the influent the operator can tell something about the strength of the waste load coming in. If the average DO concentration in the pond drops when measured under the same day-to-day conditions, it is an indication that the BOD loading may be increasing and corrective action should be taken. This might include distributing the influent to other ponds, mechanical aeration or the addition of sodium nitrate. The DO level in the cell may be used to determine when a discharge can occur from controlled discharge ponds. This level should be at or near saturation. Use a grab sample and test immediately.

Chlorine Residual

Chlorine residual is a test to determine the amount of chlorine present after the necessary detention time for disinfection (destroy fecal coliform bacteria). The general rule of thumb is to have 0.5 milligrams per liter (mg/L) after a contact time of 1 hour. Use a grab sample and test immediately. The operator should check the NPDES permit for the exact requirement as some states may not require disinfection, others designate a prescribed coliform minimum and others may require dechlorination.

BOD_5

BOD (5-Day Biochemical Oxygen Demand) is a measurement of the amount of oxygen required in a 5-day period by the microorganisms in consuming the organic material in the wastewater.

Basically, BOD indirectly measures the organic strength of the wastewater. It is important to measure the strength of wastewater in coming to determine pond loading in terms of pounds of BOD per acre per day and compare this with the pond design for operational changes such as series or parallel operation. Another use is to measure the impact of the organic strength on the receiving stream and also the amount of BOD reduction received from treatment.

Normal domestic sewage varies from between 150 and 250 milligrams per liter (mg/L) per day and treatment must reduce this to less than the level defined in the plant waste discharge permit.

Understanding BOD

The BOD test has been defined as a method of measuring the amount of dissolved oxygen consumed by living aerobic organisms while feeding on the organic materials in the sample. The test requires:

1. 300 ml of sample to be tested. This may be a diluted or undiluted sample.

2. Controlled temperature at 68 degrees Fahrenheit (20 degrees C).

3. Exclusion of all sunlight.

4. Exclusion of air (stoppered).

5. An initial DO supply, enough to last 5 days, plus 40 to 60 percent excess.

6. A representative group of aerobic organisms.

The test attempts to measure the dissolved oxygen demand on the receiving stream were the raw sewage discharged without treatment or the demand of the treated effluent. From the test results, the effectiveness of treatment in the pond can be determined.

As an example, it is assumed that two BOD tests have been completed. Results on the raw sewage are 200 mg/L and the pond effluent 27 mg/L. What do these results tell the operator and what can be done with the results.

First, observe what happened during the 5 days the tests were being incubated and what the numbers 200 and 27 really stand for.

200 mg/L BOD indicates that the raw sewage carries a potential oxygen demand of 200 pounds of oxygen for every 1,000,000 pounds of raw sewage, the effluent 27 pounds. The question now becomes: What was the difference in the raw and effluent samples to produce the wide difference in oxygen demand? If the requirements for the test are checked it is seen that all 6 of the previously mentioned items were controlled equally, so the difference in the numbers must be associated with an unknown. That unknown is the organic material (food) in the 2 samples. The organisms grew, lived and reproduced in proportion to their food supply. They also used dissolved oxygen in the process - in direct proportion to their numbers and rate of activity.

Since their rate of growth was apparently limited by their food supply, it is noted that BOD is in proportion to the organic materials (food) contained in the sample. Waste treatment in the pond becomes a method of reduction of organic materials (food) which leaves the effluent with a lower biochemical oxygen demand (BOD).

Next, consider the receiving stream. Each plant has been issued a discharge permit stating maximum pounds BOD to be discharged per day. How was this figure arrived at? Each plant places an oxygen demand on the stream by discharging effluent and as the stream follows its course, others are also contributing wastes. The limit says that if the stream is to be given a fair chance to recover before reaching the next known contributor, no more than the stated pounds of BOD can be added from an individual upstream plant.

To fully comprehend the effect of even a low, BOD discharge, requires computation of total pounds BOD discharged.

Example:

Flow:	49,000 gpd
BOD Effluent:	27 mg/L

1. 49,000 gpd x 8.34 lbs/gal = 0.4 million lbs. flow

2. 0.4 million lbs. flow x 27 mg/L BOD = 11 lbs. BOD discharged

The effect on the receiving stream may be illustrated by the following example:

lbs. BOD discharged   11 lbs.

mg/L DO in stream   7.5 mg/L DO

7.5 mg/L DO means 7.5 lbs. DO/1 million lbs. stream flow

11 lbs. BOD divided by 7.5 = 1.5 million lbs. stream flow

1.5 million lbs., divided by 8.34 lbs/gal = 180,000 gal. stream flow

This means there are 11 pounds BOD discharged to a stream carrying 7.5 mg/L DO could entirely strip **180,000** gallons of stream flow of all dissolved oxygen. Actually, the stream, by wave and ripple action, plus algae, is continually replacing the oxygen used, but at a limited rate.

Efficiency of BOD Removal

Last, it is of value to compute the efficiency of removal of BOD by the pond.

Example:

Raw BOD: 200 mg/L

BOD Effluent: 27 mg/L

ppm BOD Removed: 173 mg/L

173 ppm divided by 200 mg/L = .865 x 100 = 86.5% removal of BOD

The pond has reduced the BOD of the raw sewage flow 86.5 percent.

(The preceding illustration was taken from the publication *Operating Waste Stabilization Ponds*, EPA Region VII produced by Kirkwood Community College.)

Suspended Solids

Suspended solids (SS) test measures the dry weight of solids retained on an asbestos or glass fiber or millipore filter and is expressed in milligrams per liter.

Suspended solids removal is as important as BOD removal for preventing stream pollution. In normal domestic sewage the concentration of SS and BOD are nearly the same. Suspended solids are difficult to remove from lagoon effluents due to the high concentration of algae. Equipment required for this test includes a drying oven, a dessicator and a weighing balance.

Tests must always be run on composited samples from both the influent and effluent.

Fecal Coliform

Fecal coliform test indicates the possible presence or absence of pathogens (disease causing organisms). The source of this group of organisms are man, mammals, and birds.

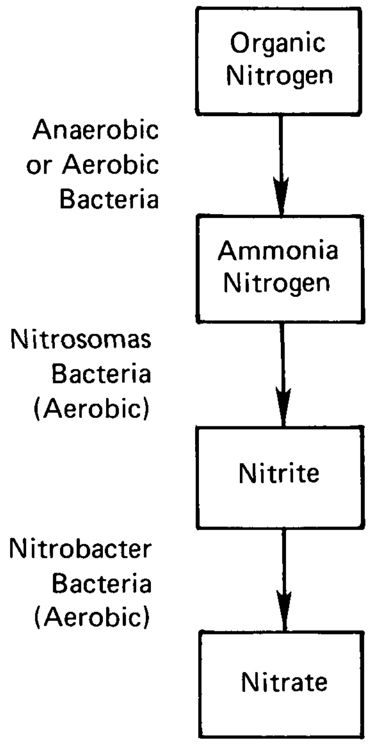
Tests are always run on grab samples collected in a sterile container and must be run within 6 hours of sampling.

Nitrogen

Nitrogen testing may be required of those plants discharging into a lake, reservoir or large body of water. Wastewater contains organic nitrogen which is an essential nutrient for algae. Organic nitrogen is converted to ammonia nitrogen by bacteria as protein is broken down. The ammonia nitrogen is further oxidized to nitrites and then to nitrates by nitrifying bacteria. This latter step is known as **nitrification**. In some cases, it is necessary to remove nitrate in order to control algae growth. Oxygen is removed under anaerobic conditions (the nitrate is a source of oxygen for the anaerobic bacteria), and the nitrate is reduced to nitrogen gas. This step is called **denitrification**.

As an indicator of pollution the presence of ammonia nitrogen indicates polluted waters, the presence of nitrites still shows pollution but nitrates indicate that nitrification has proceeded sufficiently to produce a stable nitrogen compound.

The following diagram illustrates the steps in nitrification.



In most oxidation ponds, nitrification does not appear, at least on a continuing level. The reason for this is explained by the fact that the nitrifying bacteria tend to settle or need to cling to some surface. Therefore, they are not exposed to compounds in solution.

It has been found that concentrations of more than 20 mg/L of nitrogen can be harmful to fish life, therefore, many pond discharges are required to test for total nitrogen.

Some plants are also required to test for nitrates and ammonia. The significance of these tests are:

A. If nitrification is occurring, there will be an increase in nitrate with a corresponding decrease in ammonia-nitrogen.

B. In well-nitrified effluent all of the ammonia nitrogen will be converted to nitrates.

IMPORTANT VISUAL INDICATORS

Color

The color of the pond is directly related to pH and DO. Below are listed the usual general color characteristics.

Dark sparkling green - good; high pH and DO

Dull green to yellow - not so good, pH and DO are dropping; blue-green type algae are becoming predominant

Gray to black - very bad; pond is septic with anaerobic conditions prevailing

Tan to brown - OK if due to a predominance of a type of brown algae. Not good if due to silt or bank erosion.

OTHER DAILY DATA

Weather

Weather has a great influence on the pond's activity as discussed in Chapter I. Records showing such factors as periods of sunshine, cloudiness, weather temperature, period and extent of rainfall and percent of ice cover, often explain what has happened in the pond, the quality of effluent and/or expected storage. For example, in continuous flow systems, for extended cloudy periods of two weeks the operator could expect to see an increase in BOD in the final effluent and a reduction in suspended solids. Weather forecasts are important too, especially for a pond that is near the design loading limit. Increasing BOD in the effluent could indicate to the operator that it is time to change flow patterns; such as to parallel operation for the winter season.

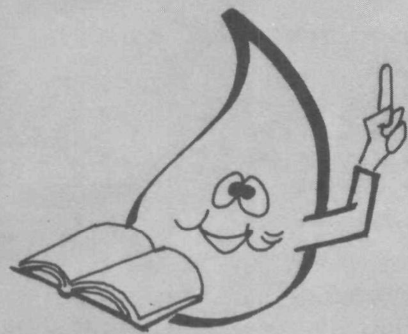
Water Depth

Water depth in continuous flow systems plays an important role in pond operations. Abrupt decreasing changes in water depth can signal a leak or excessive percolation, while a sudden increase may foretell a large spill into the system by a user, or that the collection system is experiencing storm water infiltration. Water depth that remains unchanged can indicate that pipelines are plugged. Water depth changes in controlled discharge systems are normally a part of regular operation and rapid changes are part of the operation procedures.

Ice Cover

Ice cover is important to record as it relates the extent of biological activity and which one is predominant, aerobic or anaerobic. The usual reporting shows percent of pond area covered and how long the ice cover lasts.

3. Operation and Maintenance for Ponds



3. Operation and Maintenance for Ponds

OPERATION AND MAINTENANCE GOALS FOR STABILIZATION PONDS

1. The pond effluent should:
   a. Meet the NPDES or other regulatory permit levels for BOD and SS for continuous flow systems.
   b. Discharge when it has the best quality and will effect the receiving stream the least.

2. The primary cells should have a deep green sparkling color which indicates high pH and DO.

3. Secondary or final cells should be high in DO and provide an effluent that will meet discharge limits.

4. The surface water should have wave action when wind is blowing. The absence of good wave action may indicate anaerobic conditions or an oily surface.

5. A good pond has no weeds growing in the water nor tall weeds on the bank to stop wave action.

6. Dikes are well seeded above the water line with grasses and kept mowed. This prevents soil erosion and insect problems.

7. Erosion of dikes is prevented at water's edge by the use of riprap, broken concrete rubble or a poured concrete erosion pad.

8. Inlet and outlet structures are clean. No floating debris, caked scum, or other trash that might produce odors or be unsightly.

9. Mechanical equipment is well maintained with the help of a written schedule and records are kept on lubrication and maintenance.

10. A good pond operation includes a schedule for getting things done. An available plant record shows weather data and basic test results such as pH, DO, BOD, SS, and chlorine residuals.

OPERATION AND MAINTENANCE GOALS FOR ANAEROBIC PONDS

1. Anaerobic ponds operate with no DO.

2. A well-operating anaerobic pond is covered entirely with a dense scum blanket which helps to keep the pond anaerobic and minimizes foul odors.

3. Two important operation considerations:

   a. Keep the pond pH at or near neutral (7.0) to keep the bacteria in balance.

   b. Control of odors by maintaining no DO and a heavy scum blanket.

4. Normally, the anaerobic pond is followed by additional treatment, such as

an aerated pond and polishing cells or a discharge to a separate municipal wastewater treatment plant. Records should be kept on:

a. Detention time

b. Load (BOD and SS)

c. Effluent quality (BOD, SS and pH)

d. Pond content information (pH, SS, alkalinity, volatile acids, scum and sludge depth)

5. The major on-site attendance will be needed mostly in:

a. Maintaining mechanical equipment

b. Keeping pipelines, diversion boxes and screens clean

c. Collecting samples

d. Running lab tests

e. Performing housekeeping

OPERATION AND MAINTENANCE GOALS FOR AERATED PONDS

1. Aerated ponds will require the same daily inspections and maintenance used for stabilization ponds plus special attention to the aeration equipment.

2. Maintain a minimum of 1 mg/L DO throughout the pond at heaviest loading periods.

3. Surface mechanical aerators should produce good turbulence and a light amount of froth.

a. Monitor DO at aerated cell outlet daily.

b. Keep logs and large pieces of wood out of the pond to prevent damage to the aerator.

4. For diffused air systems that use a blower and pipelines to diffuse air over entire bottom of pond:

a. Check blower daily

b. Visually inspect aeration pattern for "dead spots" or line ruptures. Repair if necessary to maintain even distribution of air.

c. Measure DO at several points in the pond weekly and adjust air to maintain even distribution.

5. Periodic maintenance must be performed, such as lubrication, adjustment and replacement. The best procedure is to make a checklist of maintenance tasks and frequency from the manufacturer's instructions bulletins.

PLANT CHECKLIST

A checklist is a handy tool for the plant operator to schedule activities. Most of the items are visual observations or maintenance needs that take little time if performed according to schedule. With regular attendance, the operator will develop ways to combine some of the duties. In many installations that are looked after regularly by a conscientious operator, the scheduled items can be accomplished in one to two hours a day, allowing the balance of the time for lab and other duties.

The blank form in the Appendix may be used as a guide.

Following is a sample operation and maintenance checklist for a pond operation. Although it is not a complete list of everything the operator should be observing, it will serve as a guide for setting up a schedule for his or her own plant. The schedule will help the operator organize work in a step-by-step fashion and it will also help relief operators or new personnel who are not familiar with the plant. For the design engineer, a checklist should be developed for the plant and included in the operation and maintenance manual.

	Frequency						
Operational and Preventive Maintenance	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary
Plant Survey							
Drive around perimeters of ponds taking note of the following conditions:							
1. Any buildup of scum on pond surface and discharge outlet boxes.	X						
2. Signs of burrowing animals.	X						
3. Anaerobic conditions. Noted by odor and black color.	X						
4. Water grown weeds.	X						
5. Evidence of dike erosion.	X						
6. Dike leakage.	X						
7. Fence damage.	X						
8. Ice buildup in winter.							X
9. Evidence of short circuiting.	X						
Plan, schedule, and correct problems found. (Use troubleshooting section of this manual for information.)							X
Pretreatment							
1. Clean inlet, screens, and properly dispose of trash.	X						
2. Check inlet flowmeter and float well.	X						

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary
If discharge is once or twice per year, the discharge permit may require the following:							
1. Odor		X					
2. Aquatic plant coverage of pond		X					
3. Pond depth		X					
4. Dike condition		X					
5. Ice cover		X					
6. Flow (Influent)	X						
7. Rainfall (or snowfall)	X						
Note: Each state has requirements for data collected prior to and during discharge that is defined in the plant discharge permit.							
If discharge is continuous, the discharge permit may require the following information:							
1. Weather	X						
2. Flow	X						
3. Condition of all cells	X						
4. Depth of all cells	X						
5. Lagoon effluent:							
a. DO and pH grab sample	X						
b. Chlorine residual	X						
c. BOD and SS run on composited samples							X
d. Fecal coliform							X
e. Record pounds of chlorine remaining and used	X						
Other tests and frequency information will be defined in the individual permit for the plant.							

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary
Mechanical Equipment							
Check mechanical equipment and perform **scheduled** preventive maintenance on the following pieces of equipment according to the manufacturer's recommendations:							
1. Pump stations:							
a. Remove debris	X						
b. Check pump operation	X						
c. Run emergency generator		X					
d. Log running times	X						
e. Clean floats, bubblers, or other control devices		X					
f. Lubricate							X
2. Comminuting devices:							
a. Check cutters		X					
b. Lubricate							X
3. Aerators:							
a. Log running time	X						
b. Check amperage				X			
4. Chlorinators:							
a. Check feed rate	X						
b. Change cylinders							X
5. Flow measuring devices:							
a. Check and clean floats, etc.	X						
b. Verify accuracy				X			
6. Valves and gates:							
a. Check to see if set correctly	X						
b. Open and close to be sure they operate			X				

HINTS TO IMPROVE OPERATION

Flow Regulation

Flow regulation is one of the most helpful operational tools available to a lagoon operator. Without the flexibility of being able to move water around where it is needed the operator would be severely handicapped.

In simple terms, an operator needs options. For example:

Single Cell Ponds:

The only flexibility an operator has in a single cell pond is depth control. The water level may have to be varied based on the season or to control weeds and mosquitoes.

Multiple Cell Ponds:

1. May need to hold wastewater in the primary cell, especially during seasonal discharge operations.
2. May need to move water from cell to cell to correct an oxygen deficiency problem.
3. May need to control liquid depth to get rid of weeds or mosquitoes.
4. May need to isolate a cell that has turned anaerobic or to hold a toxic waste.
5. May need to take advantage of both series and parallel operation to regulate loading.
6. May need to temporarily rest a cell for recovery.

Baffles and Screens

Screens, often homemade, are used around pond surface outlets to keep wind blown weed and surface trash from entering a pipe.

Baffles are quite commonly used for a large variety of purposes.

1. To direct the flow of water, especially around inlets. These may consist of nothing more than pilings of 2" x 8" driven into the pond bottom.
2. To allow selection of depth for pond draw-off and to keep surface scum and trash from entering.
3. To provide a stilling area ahead of a flow measuring device.
4. To reduce the force of a pump discharge.

Dike erosion from wave action can be prevented by using riprap in the form of rocks 3 to 8 inches (8 to 48 centimeters) laid along the water's edge. One unusual method employed is to sink two by six's upright into the lagoon floor extending above the water surface to break up and dissipate the waves. In another case, the lagoon operator had bags filled with a dry mix of sand, gravel and cement. These were laid side by side and stacked to form a system of neat functional riprap protection. Riprap should extend one foot above and below extreme operating levels. Other forms of riprap or bank stabilization include cribbing (snow fence) laid on the bank and reed canary grass. The canary grass is effective on ponds that are deep, have steep slopes and a stable water level. Sodding should be at least 3 inches (7.5 cm) square and placed not more than 3 feet (1 meter) apart.

POND CLEANING

If it becomes necessary to clean a pond the operator should have access to a suction pump, a "mudcat" or other means of removing mud or sludge off the bottom to control pond bottom levels and localized deposit areas. This is seldom necessary except for situations where grit or sand gets into the system. This occurred in a coastal city that had high amounts of infiltration where sewers were laid in sandy soil. Bottom solids can normally be disposed of in the same manner that digested solids are. Advice should be obtained from the consulting engineer and the regulatory agency.

STARTING A POND

Procedures

To Fill Primary Cell

1. Fill primary cell(s) with fresh water from a river or municipal system, if available, to the two-foot level. (Spring or early summer is the best time to startup to avoid low temperature and possible freezing.)

2. Begin the addition of wastewater.

3. Keep pH above 7.5. See Troubleshooting Guide.

4. Check DO daily. See Troubleshooting Guide.

5. If started during warm weather:

    a. Algal blooms usually will appear from 7 to 14 days.

    b. A good biological community will be established in about 60 days. Color will be a definite green as contrasted with blue or yellow-green.

This procedure tends to avoid odorous anaerobic conditions and weed growth during the start-up phase. If it is necessary to start in late fall or winter, level should be brought to 2½-3 feet (0.75-1 meter) and no discharge until late spring.

To Fill Successive Ponds

1. Begin filling when the water level in the first pond reaches 3 feet (1 meter).

2. Add fresh water to a depth of 2 feet (0.6 meters).

3. Begin adding water from previous pond observing the following:

    a. Use top draw-off to achieve good transfer. Do not draw off from a level below the bottom 18 inches (45 cm).

    b. Do not allow the water depth in the previous pond(s) to fall below 3 feet (1 meter).

    c. Equalize water depths in all ponds. This should be done by the following:

        (1) Hold the discharge until all ponds are filled.

        (2) Use effluent box with gates or valves to allow pumping the effluent to any pond in the system if system is designed with this capability.

        (3) Continuously recycle the effluent to the ponds that need the water level raised.

4. Repeat the "3.c." operation using 6-inch (15-cm) increments until ponds are at their operating depth.

5. Finally, start continuous or intermittent discharge, however the system is designed. See the following section.

DISCHARGE CONTROL PROGRAM FOR SEASONAL DISCHARGES

Preparation

1. Make a note of conditions in the stream to receive discharge.

2. Estimate duration of discharge and expected volume.

3. Obtain State Regulation Agency approval.

4. Isolate cell to be discharged. Allow to rest for at least 1 month, if possible.

5. Arrange for daily sample analysis of BOD_5, SS, pH, coliform and nutrients (if required).

6. Plan other work so as to spend full time on control of discharge throughout the period.

7. Sample contents of cell and analyze for DO; note and record turbidity, color and any unusual conditions.

Discharge Procedures

Many northern states use a seasonal discharge. Three or four weeks after ice break-up, the ponds generally return to normal operating conditions. The wastewater in the cells is tested and results are reported to the state. If the wastewater is of a quality suitable for discharging, the operator then follows state guidelines in discharging. The NPDES permit states the discharge quality the operator must maintain.

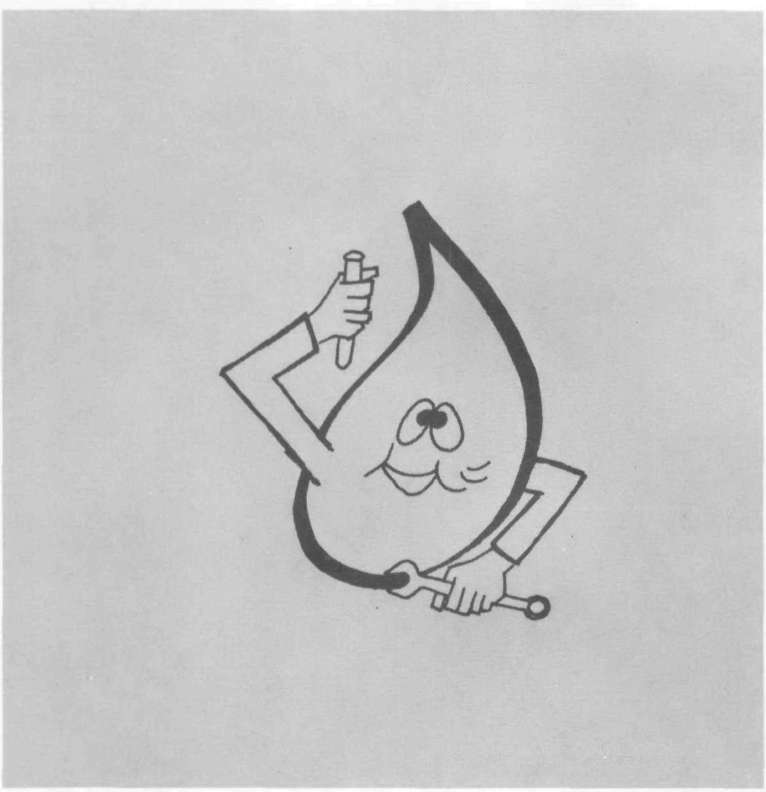
The quality of the receiving stream is usually determined by the State Pollution Control Agency as part of the discharge approval program. When discharge approval is obtained, proceed as follows:

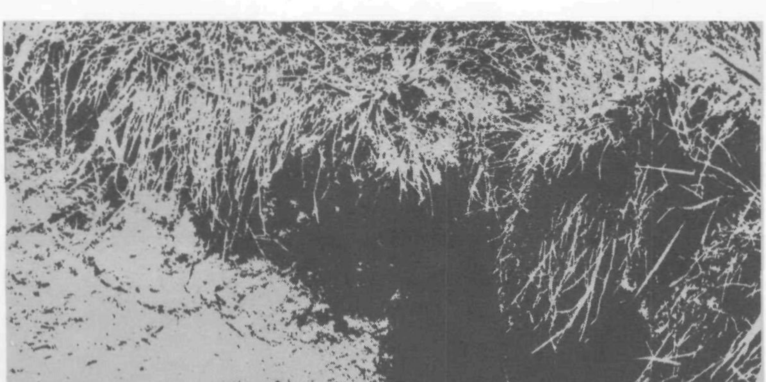
1. Begin the discharge program with the last cell in series.

2. Draw off the discharge from the best level at a time when the discharge is acceptable. Stop the discharge when ponds are upset.

3. Follow testing procedures outlined by your State Regulatory Agency.

4. Troubleshooting for Ponds





How to control water weeds
How to control burrowing animals
How to control dike vegetation
How to control scum
How to control odors
How to control blue-green algae
How to control insects
How to obtain best algae removal in the effluent
How to correct lightly loaded ponds
How to correct a low dissolved oxygen (DO)
How to correct overloading
How to correct a decreasing trend in pH
How to correct short-circuiting
How to correct anaerobic conditions
How to correct a high BOD in the effluent
How to correct problems in aerated ponds
How to correct problems in anaerobic ponds

4. Troubleshooting for Ponds

HOW TO CONTROL WATER WEEDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Weeds provide food for burrowing animals, cause short-circuiting problems, stop wave action so that scum can collect and make a nice home for mosquitoes, and odors develop in the still area. Duckweed stops sunlight penetration and prevents wind action thus reducing the oxygen in the pond. Root penetration causes leaks in pond seal.	Poor circulation, maintenance, insufficient water depth.	1. Pull weeds by hand if new growth. 2. Mow weeds with a sickle bar mower. 3. Lower water level to expose weeds, then burn with gas burner. 4. Allow the surface to freeze at a low water level, raise the water level and the floating ice will pull the weeds as it rises. (Large clumps of roots will leave holes in pond bottom, best results are obtained when weeds are young.) 5. Increase water depth to above tops of weeds. 6. Use riprap. Caution: If weeds get started in the riprap, they will be difficult to remove but can be sprayed with acceptable herbicides. 7. To control duckweed, use rakes or push a board with a boat, then physically remove duckweed from pond.

HOW TO CONTROL BURROWING ANIMALS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Burrowing animals must be controlled because of the damage they do to dikes. Rodents such as muskrats and nutria dig partially *submerged tunnels into dikes. If the water* level is raised, they will burrow further and may go on out the top thus weakening the dike.	Bank conditions that attract animals. High population in area adjacent to ponds.	1. Remove food supply such as cattails and burr reed from ponds and adjacent areas. 2. *Muskrats prefer a partially submerged* tunnel, if the water level is raised it will extend the tunnel upward and if lowered sufficiently, it may abandon the tunnel completely. They may be discouraged by raising and lowering the level 6-8 inches over several weeks. 3. If problem persists, check with local game commission officer for approved methods of removal, such as live trapping, etc.

HOW TO CONTROL DIKE VEGETATION

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
High weed growth, brush, trees and other vegetation provide nesting places for animals, can cause weakening of the dike and presents an unsightly appearance. Also may reduce wind action on the pond.	Poor maintenance.	1. Periodic mowing is the best method. 2. Sow dikes with a mixture of fescue and blue grasses on the shore and short native grasses elsewhere. It is desirable to select a grass that will form a good sod and drive out tall weeds by binding the soil and "out compete" undesirable growth. 3. Spray with **approved** weed control chemicals. **Note:** Be sure to check with authorities. Some states do not allow chemical usage. All others require that chemicals be bio-degradable. Examples of some herbicides that are used are: Dow Dalapon for cattails Dow Silvex for willows and emergent weeds Ortho Endo-thal for suspended weeds Copper sulfate for filamentous algae Simazine for weeds 4. Some small animals, such as sheep, have been used. May increase fecal coliform, especially to the discharge cell. Practice "rotation grazing" to prevent destroying individual species of grasses. An example schedule for rotation grazing in a 3-pond system would be: Graze each pond area for 2 months over a 6-month grazing season.

HOW TO CONTROL SCUM

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
It is necessary to control scum formations to prevent odor problems and to eliminate breeding spots for mosquitoes. Also, sizeable floating rafts will reduce sunlight.	Pond bottom is turning over with sludge floating to the surface. Poor circulation and wind action. High amounts of grease and oil in influent will also cause scum.	1. Use rakes, a portable pump to get a water jet or motor boats to break up scum formations. Broken scum usually sinks. 2. Any remaining scum should be skimmed and disposed of by burial or hauled to landfill with approval of regulatory agency.

HOW TO CONTROL ODORS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Odors are a general nuisance to the public.	The odors are generally the result of overloading, long periods of cloudy weather, poor pond circulation, industrial wastes or ice melt.	1. Use parallel feeding to primary cells to reduce loading. 2. Apply chemicals such as sodium nitrate, Dibrom or Micro-Aid to introduce oxygen. Application rate: 5-15 percent of sodium nitrate per pound of BOD on a pound-for-pound basis. Or apply 200 pounds sodium nitrate per million gallons. See literature for commercial products. Repeat at a reduced rate on succeeding days. Or use 100 pounds sodium nitrate per acre (112 kg/hectare) for first day, then 50 pounds per acre (56 kg/hectare) per day thereafter if odors persist. Apply in the wake of a motor boat. 3. Install supplementary aeration such as floating aerators, caged aerators, or diffused aeration to provide mixing and oxygen. Daily trips over the lagoon area in a motor boat also helps. **Note:** Stirring the pond may cause odors to be worse for short periods but will reduce total length of odorous period. 4. Recirculate pond effluent to the pond influent to provide additional oxygen and to distribute the solids concentration. Recirculate on a 1 to 6 ratio. 5. Eliminate septic or high-strength industrial wastes.

HOW TO CONTROL BLUE-GREEN ALGAE

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Low pH (less than 6.5) and dissolved oxygen (less than 1 mg/L). Foul odors develop when algae die off.	Blue-green algae is an indication of incomplete treatment, overloading and/or poor nutrient balance.	1. Apply 3 applications of a solution of copper sulfate. a. If the total alkalinity is above 50 mg/L apply 10 pounds of copper sulfate per million gallons in cell (1200 kg/m^3). b. If alkalinity is below 50 mg/L reduce the amount of copper sulfate to 5 pounds per million gallons (600 kg/m^3). **Note:** Some states do not approve the use of copper sulfate since in concentrations greater than 1 mg/L it is toxic to certain organisms and fish. 2. Break up algal blooms by motor boat or a portable pump and hose. Motor boat motors should be air cooled as algae may plug up water cooled motors.

HOW TO CONTROL INSECTS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Insects present in area and larvae or insects present in pond water.	Poor circulation and maintenance.	**Solution for Mosquito Control** 1. Keep pond clear of weeds and allow wave action on bank to prevent mosquitoes from hatching out. 2. Keep pond free from scum. 3. Stock pond with Gambusia (Mosquito Fish). 4. Spray with larvacide as a last resort. Check with state regulatory officials for approved chemicals. (Some that have been used are Dursban, Naled, Fenthion and Abate in dosages of 1 mg/L.) **Solution for Controlling Midges** 1. Stock pond with Gambusia. 2. Spray with approved insecticide. (Fenthion, Abate and Sursban have been used based on directions on the package.)

HOW TO OBTAIN BEST ALGAE REMOVAL IN THE EFFLUENT

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Most of the suspended solids present in a pond effluent are due to algae. Because many single-celled algae are motile and are also very small they are difficult to remove.	Weather or temperature conditions that favor particular population of algae.	1. Draw off effluent from below the surface by use of a good baffling arrangement. 2. Use multiple ponds in series. 3. The use of intermittent sand filters and submerged rock filters may also be used but will require modification and the services of a consulting engineer. 4. In some cases, alum dosages of 20 mg/L has been used in final cells used for intermittent discharge to improve effluent quality. Dosages at or below this level are not toxic.

HOW TO CORRECT LIGHTLY LOADED PONDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Lightly loaded ponds may produce filamentous algae and moss which limits sunlight penetration. These forms also tend to clog pond outlets.	Overdesign, low seasonal flow.	1. Correct by increasing the loading by reducing the number of cells in use. 2. Use series operation.

HOW TO CORRECT A LOW DISSOLVED OXYGEN (DO)

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
A low, continued downward trend in DO is indicative of possible impending anaerobic conditions and the cause of unpleasant odors. Treatment becomes less efficient.	Poor light penetration, low detention time, high BOD loading or toxic industrial wastes. (Daytime DO should not drop below 3.0 mg/L during warm months.)	1. Remove weeds such as duckweed if covering greater than 40 percent of the pond. 2. Reduce organic loading to primary cell(s) by going to parallel operation. 3. Add supplemental aeration (surface aerators, diffusers and/or daily operation of a motor boat). 4. Add recirculation by using a portable pump to return final effluent to the head works. 5. Apply sodium nitrate (see **How to Control Odors** for rate). 6. Determine if overload is due to industrial source and remove it.

HOW TO CORRECT OVERLOADING

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Overloading which results in incomplete treatment of the waste. Overloading problems can be detected by offensive odors, a yellow green or gray color. Lab tests showing low pH, DO, and excessive BOD loading per unit area should also be considered.	Short-circuiting, industrial wastes, poor design, infiltration, new construction (service area expansion), inadequate treatment and weather conditions.	1. Bypass the cell and let it rest. 2. Use parallel operation. 3. Apply recirculation of pond effluent. 4. Look at possible short-circuiting. 5. Install supplementary aeration equipment.

HOW TO CORRECT A DECREASING TREND IN pH

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
pH controls the environment for algae types, as an example, the green chlorella needs a pH from 8.0 to 8.4. pH should be on the alkaline side, preferably about 8.0 to 8.4. Both pH and DO will vary throughout the day with lowest reading at sunrise and highest reading in late afternoon. Measure pH same time each day and plot on a graph.	A decreasing pH is followed by a drop in DO as the green algae die off. This is most often caused by overloading, long periods of adverse weather or higher animals, such as Daphnia, feeding on the algae.	1. Bypass the cell and let it rest. 2. Use parallel operation. 3. Apply recirculation of pond effluent. 4. Check for possible short-circuiting. 5. Install supplementary aeration equipment if problem is persistent and due to overloading. 6. Look for possible toxic or external causes of algae die-off and correct at source.

HOW TO CORRECT SHORT-CIRCUITING

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Odor problems, low DO in parts of the pond, anaerobic conditions and low pH found by checking values from various parts of the pond and noting on a plan of the pond. Differences of 100 percent to 200 percent may indicate short-circuiting. After recording the readings for each location, the areas that are not receiving good circulation become evident. These areas are characterized by a low DO and pH.	Poor wind action due to trees or poor arrangement of inlet and outlet locations. May also be due to shape of pond, weed growth or irregular bottom.	1. Cut trees and growth at least 500 feet (150 m) away from pond if in direction of prevailing wind. 2. Install baffling around inlet location to improve distribution. 3. Add recirculation to improve mixing. 4. Provide new inlet-outlet locations, including multiple inlets. 5. Clean out weeds. 6. Fill in irregular bottoms.

HOW TO CORRECT ANAEROBIC CONDITIONS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Facultative pond that turned anaerobic resulting in high BOD, suspended solids and scum in the effluent in continuous discharge ponds. Unpleasant odors, the presence of filamentous bacteria and yellowish-green or gray color and placid surface indicate anaerobic conditions.	Overloading, short circuiting, poor operation or toxic discharges.	1. Change from a series to parallel operation to divide load. Helpful if conditions exist at a certain time each year and are not persistent. 2. Add supplemental aeration if pond is continuously overloaded. 3. Change inlets and outlets to eliminate short-circuiting. See **How to Correct Short-Circuiting.** 4. Add recirculation (temporary-use portable pumps) to provide oxygen and mixing. 5. In some cases temporary help can be obtained by adding sodium nitrate at rates described elsewhere in this manual. 6. Eliminate sources of toxic discharges.

HOW TO CORRECT A HIGH BOD IN THE EFFLUENT

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
High BOD concentrations that are in violation of NPDES or other regulatory agency permit requirements. Visible dead algae.	Short detention times, poor inlet and outlet placement, high organic or hydraulic loads and possible toxic compounds.	1. Check for collection system infiltration and eliminate at source. 2. Use portable pumps to recirculate the water. 3. Add new inlet and outlet locations. 4. Reduce loads due to industrial sources if above design level. 5. Prevent toxic discharges.

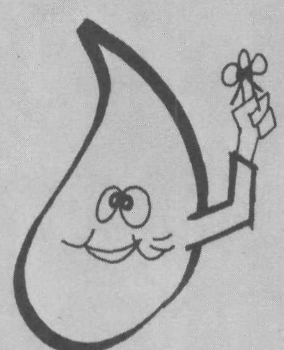
HOW TO CORRECT PROBLEMS IN AERATED PONDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Fluctuating DO, fine pin floc in final cell effluent, frothing and foaming, ice interfering with operation.	Shock loading, overaeration, industrial wastes, floating ice.	1. Control aeration system by using time clock to allow operation during high load periods, monitor DO to set up schedule for even operation, holding approximately 1 mg/L or more. 2. Vary operation of aeration system to obtain solids that flocculate or "clump" together in the secondary cell but are not torn apart by excessive aeration. 3. Locate industrial wastes that may cause foaming or frothing and eliminate or pretreat wastes. Examples are slaughter house, milk or some vegetable wastes. 4. Operate units continuously during cold weather to prevent freezing damage or remove completely if not a type that will prevent freeze-up.

HOW TO CORRECT PROBLEMS IN ANAEROBIC PONDS

INDICATORS/OBSERVATIONS	PROBABLE CAUSE	SOLUTIONS
Odors Hydrogen sulfide, (rotten egg) odors or other disagreeable conditions due to sludge in a septic condition.	Lack of cover over water surface and insufficient load to have complete activity which eventually forms scum blanket.	Use straw cast over the surface or polystyrene planks as a temporary cover until a good surface sludge blanket has formed.
Low pH pH below 6.5 accompanied by odors are the result of acid bacteria working in the anaerobic condition.	Acid formers working faster than methane formers in an acid condition.	The pH can be raised by adding a lime slurry of 100 pounds of hydrated lime to 50 gallons (580 kg/200 liters) of water at a dosage rate of 1 pound of lime for every 10,000 gallons (120 g/10,000 liters) in the pond. The slurry should be mixed while being added. The best place to put the lime in is at the entrance to the lagoon so that it is well mixed as it enters the pond.

5. Safety Around Ponds



Public health aspects

5. Safety Around Ponds

PUBLIC HEALTH ASPECTS

Stabilization ponds, like other wastewater treatment facilities, must be treated with caution and respect from a safety and public health standpoint by operators and the general public alike. This means that stabilization ponds must be utilized for their designed purpose only, and not for public recreation.

The relative amount of water surface of stabilization ponds is insignificant in comparison to the many natural bodies of open water in most localities. In some areas, however, stabilization ponds represent the only sizeable body of water and have been sources of attraction to children as well as adults for recreation purposes. Incidents of boating, ice-skating, extensive waterfowl hunting and even swimming in ponds have been reported. Recreational use should be discouraged and safety practices encouraged for several important reasons.

First, even though the efficiency of bacterial removal as measured by the MPN method is very high, the possibility of contamination or infection from pathogenic organisms does exist when one comes in contact with wastewater in a stabilization pond.

Second, although most stabilization ponds attain a depth of only 5 feet, there is still sufficient depth to drown a person. Also, clay liners used in sealing ponds become very sticky when water is added. Should anyone fall in the pond, this clay liner would make it extremely difficult for anyone to get out.

Another factor to be considered is the existence of mosquitos. However, on a well-maintained pond system, mosquitoes usually are not a nuisance.

According to studies made by the U.S. Public Health Service, the density of the mosquito population is directly proportional to the extent of weed growth in the ponds. Where weed growth in the ponds and along the water line of the dikes is negligible and where wind action on the pond is not unduly restricted, the production of mosquitoes in stabilization ponds is low.

To discourage use of the ponds for recreation the entire area should be fenced and warning signs displayed.

Personal Hygiene

It is in the interest of your health and the health of your family that this list of Do's and Don'ts for personal hygiene is made. Use it, don't abuse it!

1. Never eat your lunch or put anything into your mouth without first washing your hands.

2. Refrain from smoking while working in manholes, on pumps or other parts of the operation where hands may become contaminated.

3. Don't wear your coveralls or rubber boots in your car or home.

4. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.

5. Keep your fingernails cut short and clean as they are excellent carriers of dirt and germs.

Safety

Sewer Maintenance Safety Precautions

1. Remove and replace heavy manhole covers carefully and only with the proper tools.

2. Descend into any manhole cautiously to guard against defective steps or rungs.

3. See part regarding noxious gases that may be found in sewers.

Pumping Station and Stabilization Pond Safety Precautions

1. Maintain a high level of good housekeeping. This involves keeping floors, walls and equipment free from dirt, grease and debris. Keep tools properly stored when not in use.

2. Keep walkways clean and free from slippery substances. If ice forms on walks, apply salt or sand or cover with earth or ashes than can be removed later.

3. Be especially cautious when working with an electrical distribution system and related facilities. Never work on electrical equipment and wire with wet hands or when clothes or shoes are wet. Always wear appropriate safety gloves for electrical work. Never use a switchbox for anything other than a switchbox.

4. Keep all personnel safety conscious by reminding them of specific safety instructions. Such instructions should include information on how to contact the nearest medical center and fire station, rescue techniques, resuscitation and first aid techniques.

5. Make certain that a sufficient number of capable personnel with proper equipment are assigned and present whenever it is necessary to perform any hazardous work.

6. A life preserver must be used when using a boat on stabilization ponds. Also, never work alone around the ponds because of the danger of drowning and other accidents. One of the requirements for a pond operator should be that he can swim at least 100 feet in normal work clothing.

7. Sufficient fire extinguishers (Underwriter's Laboratories approved) should be placed in readily accessible locations.

Body Infection and Disease Safety Precautions

1. Treat all cuts, skin abrasions and similar injuries promptly. When working with wastewater, the smallest cut or scratch is potentially dangerous and should be cleaned and treated immediately with a 2 percent solution of tincture of iodine.

2. See a doctor for all injuries.

3. Provide first aid training for all personnel.

4. Be innoculated for waterborne diseases, particularly typhoid and para-

typhoid fever. Keep a record of all immunizations in an employee health record to assure yourself of receiving up-to-date boosters, etc.

5. In laboratory work, use pipet bulbs rather than the mouth so as not to introduce contamination to the mouth. Don't drink water from laboratory glassware. Paper cups should be provided in laboratories for drinking purposes. Never prepare food in a laboratory.

Noxious Gases, Explosive Mixtures and Oxygen Deficiency

1. The principal gas hazards associated with wastewater treatment are accumulations of **sewer gas** and its mixture with other gases or air which may cause death or injury through explosion or by asphyxiation as a result of oxygen deficiency. The term sewer gas is generally applied to the mixture of gases in sewers and manholes containing high percentages of carbon dioxide, varying amounts of methane, hydrogen, hydrogen sulfide and low percentages of oxygen. Such mixtures sometimes accumulate in sewers and manholes where organic matter has been deposited and has undergone decomposition. The actual hazards from sewer gas exist in the explosive amount of methane, hydrogen sulfide or in oxygen deficiency. Hydrogen sulfide is toxic at very low concentrations and one's sensitivity to the odor is quickly deadened.

2. **Chlorine gas**, which is irritating to the eyes, respiratory tract and other mucous membranes, may settle in low, still areas. The gas forms an acid in the presence of moisture. The gas escapes by leakage from cylinders and feed lines and finds its way to these places.

Safety Equipment

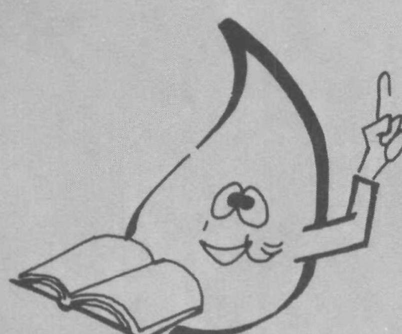
The types of safety equipment which a wastewater facility should have are as follows:

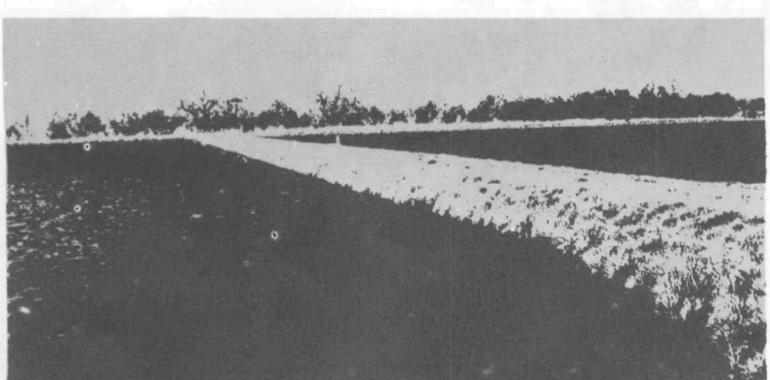
1. Detection equipment (for gases and oxygen deficiencies).
2. Masks (self-contained air packs for oxygen deficiencies).
3. Safety harnesses, lines and hoists.
4. Proper protective clothing, footwear and head gear.
5. Ventilating equipment.
6. Nonsparking tools.
7. Communications equipment.
8. Portable air blower.
9. Explosion-proof lantern and other safe illumination.
10. Warning signs and barriers.
11. Emergency first aid kits.
12. Proper fire extinguishers.
13. Eye wash and shower stations in laboratory areas.
14. Safety goggles for work in laboratories and other dangerous areas.

Additional Sources of Information

- New York Manual, Ch. 14
- WPCF, MOP No. 1, Safety in Wastewater Works
- Texas Manual, Ch. 35
- Sacramento State Home-Study Course, Ch. 12

Appendices





A Glossary of terms

ACRE-FOOT – A volume term referring to that amount of liquid, 1 acre in area, 1 foot deep. (43,560 cubic feet)

AERATED POND – A wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.

AEROBIC – A condition characterized by the presence of free dissolved oxygen in the aquatic environment.

AEROBIC BACTERIA – Bacteria that require free dissolved oxygen for growth.

AEROBIC STABILIZATION – The stabilization of organic matter through metabolism into more complex matter by bacteria in the presence of dissolved oxygen.

ALGAE – Primitive one- or many-celled plants, usually aquatic, that produce their food by photosynthesis.

ALGICIDE – Any substance or chemical applied to kill or control algal growths.

ANAEROBIC BACTERIA – Bacteria which grow in the absence of free dissolved oxygen and must obtain their oxygen by chemically breaking down organic compounds which contain combined oxygen.

ANAEROBIC DECOMPOSITION – The breakdown of complex organic matter by bacteria in the absence of dissolved oxygen.

AQUATIC VEGETATION – That vegetation which will grow in or near water.

BACTERIA – A group of microscopic organisms lacking chlorophyll and organic nutrients as a food source.

COLIFORM GROUP – A group of bacteria that inhabit the intestinal tract of man, warm blooded animals and may be found in plants, soil and air and the aquatic environment.

DISSOLVED OXYGEN (DO) – Dissolved molecular oxygen usually expressed in mg/L, ppm or percent saturation.

DIURNAL – Having a daily cycle.

EFFLUENT – A liquid flowing out of a chamber, treatment unit or basin.

FACULTATIVE BACTERIA – Those bacteria that can adapt to aerobic or anaerobic conditions. Can utilize dissolved or combined oxygen (oxygen bound in a compound by a chemical action).

FUNGI – Simple or complex organisms without chlorophyll. The simpler forms are one-celled; higher forms have branched filaments and complicated life cycles. Examples are molds, yeasts and mushrooms.

GRAB SAMPLE – A single sample not necessarily taken at a set time or flow. An instantaneous sample.

HYDRAULIC LOADING – The volume of flow per day per unit area.

INFLUENT – That liquid entering a process unit or operation.

INORGANIC MATTER – Chemical substances of mineral origin.

MILLI – An expression used to indicate 1/1000 of a standard unit of weight, length or capacity (metric system).

milliliter (ml)	- 1/1000 liter (L)
milligram (mg)	- 1/1000 gram (g)
millimeter (mm)	- 1/1000 meter (m)

MILLIGRAMS PER LITER (mg/L) – A unit of concentration on weight/volume basis, milligrams per liter. Equivalent to ppm when speaking of water or wastewater.

ORGANIC LOADING – The number of pounds of BOD added to treatment unit per day.

OXYGEN AVAILABLE – That part of the oxygen available for aerobic stabilization of organic matter. Includes dissolved oxygen and that available in nitrites or nitrates, peroxides, ozone and certain other forms of oxygen.

OXYGEN DEPLETION – The loss of oxygen from water or wastewater due to biological, chemical or physical action.

pH – Expresses the intensity of acidity or alkalinity of a liquid.

PHOTOSYNTHESIS – A process in which chlorophyll-containing plants produce complex organic (living) materials from carbon dioxide, water and inorganic salts, with sunlight as the source of energy. Oxygen is produced in this process as a waste product.

POPULATION EQUIVALENT – The calculated population which would normally contribute the same amount of biochemical oxygen demand as the wastewater. A common base is 0.2 lb. (0.09 kg) of 5-day BOD per capita per day.

SETTLEABLE SOLIDS – Those solids which will settle out when a sample of sewage is allowed to stand quietly for a one-hour period.

SHORT-CIRCUITING – The hydraulic conditions in a tank, chamber or basin where time of passage is less than that of the normal flow-through period.

SLUDGE BANKS – The accumulation of solids including silt, mineral, organic and cell mass material that is produced in an aquatic system.

STABILIZATION – The process of reducing a material using a biological and chemical means to a form that does not readily decompose.

STANDARD METHODS – Methods of analysis prescribed by joint action of the American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF).

SUPERSATURATION – The situation in which water holds more oxygen at a specified temperature than normally required for saturation.

SUSPENDED SOLIDS – The concentration of insoluble materials suspended or dispersed in waste or used water. Generally expressed in mg/L on a dry weight basis. Usually determined by filtration methods.

TOTAL SOLIDS – Refers to the solids contained in dissolved and suspended form in water. Determined on weighing after drying at 103 degrees Celsius.

VOLATILE SOLIDS – The quantity of solids in water that represent a loss in weight upon ignition at 550 degrees Celsius.

B Formulas and problems

SYMBOLS

A	=	Area	L	=	Length	V	=	Volume
B	=	Base (length of)	P	=	Perimeter	Vel	=	Velocity
C	=	Circumference	Q	=	Flow	W	=	Width (length of)
D	=	Diameter	R	=	Radius	π	=	Pi = (3.14)
H	=	Height (length of)	S	=	Side (length of)	/	=	Per (as gallons/day)

LENGTH CONVERSION FACTORS

1 foot	=	12 inches		
1 yard (yd)	=	3 feet (ft)		
1 rod	=	5½ yards	=	16½ ft
1 chain	=	4 rods	=	66 ft
1 mile	=	5,280 feet	=	1,760 yds
1 nautical mile	=	6,076 feet		

.001 kilometer = 1 meter = 100 centimeters = 1,000 millimeters

AREA CONVERSION FACTORS

1 square foot (ft^2)	=	144 sq inches ($inch^2$)
1 square yard (yd^2)	=	9 sq ft (ft^2)
1 square rod (rd^2)	=	272¼ sq ft (ft^2)
1 acre	=	43,560 sq ft (ft^2) = 4,840 sq yds
1 square mile	=	640 acres or 1 section

1 hectare = 10,000 square meters = 0.1 square kilometers

CALCULATION OF AREAS

1. Square of Rectangle $= L \times W$
2. Triangle $= 1/2\ B \times H$
3. Trapezoid $= \dfrac{(B_1 + B_2) \times H}{2}$
4. Circle:
   a. $A = \pi R^2$
   b. $A = \dfrac{\pi D^2}{4}$
   c. $A = 0.785\ D^2$

CALCULATION OF VOLUMES

VOLUME CONVERSION FACTORS

1 cubic foot (ft^3)	=	1,728 cu in (in^3)
	=	7.5 gallons
1 cubic yard (yd^3)	=	27 cu ft (ft^3)
1 acre- foot	=	43,560 cu ft (ft^3)
	=	325,851 gallons
1 gallon (gal)	=	231 cu in (in^3)
	=	4 quarts

0.001 cubic meters = 1 liter = 1,000 cubic centimeters = 1,000 milliliters

1. Rectangular Solids $V = L \times W \times H$

2. Cylinders:
   a. $V = \pi R^2 \times H$
   b. $V = 0.785\ D^2 \times H$
   c. $V = \frac{\pi D^2 \times H}{4}$

3. Cones $V = \frac{\pi R^2 \times H}{3}$

4. Pyramids $V = \frac{A \times H}{3}$ (A = Area of Base)

WEIGHT CONVERSION FACTORS

1 gal	=	8.34 lbs of water
1 cu ft	=	62.4 lbs of water
1 ft of water	=	0.434 psi
0.001 kilograms (kg)	=	1.0 g = 1,000 mg
1 ton (metric)	=	1,000 kg
1 psi	=	$\frac{1}{0.433}$ ft
	=	2.31 ft of water

VELOCITY

1. Velocity $= \frac{\text{Distance}}{\text{Time}}$
   a. mile per hour $= \frac{\text{mile}}{\text{hour}}$
   b. ft per min $= \frac{\text{feet}}{\text{minute}}$
   c. ft per sec $= \frac{\text{feet}}{\text{second}}$

   Velocity (ft per sec)

   $$= \frac{\text{Flow Rate } (ft^3 \text{ per sec})}{\text{Cross Sectional Area } (ft^2)}$$

2. Gal per min (gpm)
   = cu ft per sec x 60 sec per min x 7.5 gal per ft^3
   OR
   gpm = ft^3 per sec x 60 sec per min x 7.5 gal per ft^3

VELOCITY CONVERSION FACTORS

1 cu ft per sec (cfs)	=	7.5 gal per sec (gps)
	=	450 gal per min (gpm)
1 gal per sec	=	0.133 cu ft per sec (cfs)
	=	7.98 ft^3 per min

COMMONLY USED FORMULAS

1. Gal/day (gpd) = gal/min (gpm) x 1,440 min/day
   = gal/hr (gph) x 24 hrs/day

2. Million Gal/Day (mgd) $= \frac{\text{gal/day}}{1{,}000{,}000}$
   $= \frac{\text{gpd}}{1{,}000{,}000}$

3. Pounds/Day (lbs/day) =
   (BOD,TSS,SVS,Cl_2,etc.)

   lbs/day = milligrams/liter x million gal/day x 8.34 lbs/gal

   OR

   lbs/day = mg/L x mgd x 8.34 lbs/gal

   OR

   lbs/day = population equivalent x population equivalent factor

4. Population Equivalent (BOD or TSS)

   $= \frac{\text{Daily Loading in Pounds}}{\text{Population Equivalent Factor}}$

5. **Volume in Gallons**

   a. Rectangular Tank

   V = L x W x H x 7.5 gal/ft^3

   b. Circular Tank

   V = πR^2 x H x 7.5 gal/ft^3
   V = $0.785D^2$ x H x 7.5 gal/ft^3

6. Efficiency (% of Removal) $= \frac{\text{(influent - effluent)}}{\text{influent}}$ x 100

7. Organic Loading on Primary Cell

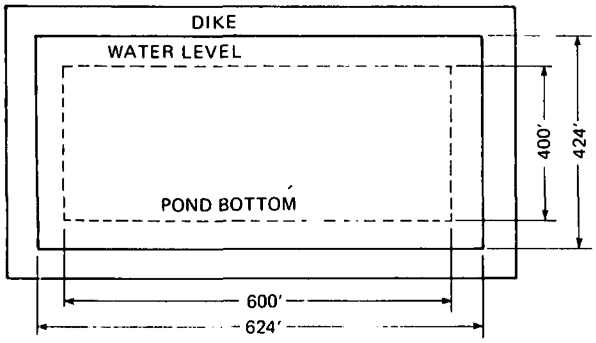
   $= \frac{\text{influent lbs of BOD/day}}{\text{acres (primary)}}$

8. Storage Volume of a Pond
   = avg surface area (ft^2)
   x design operation depth (ft)
   x 7.5 gal/ft^3

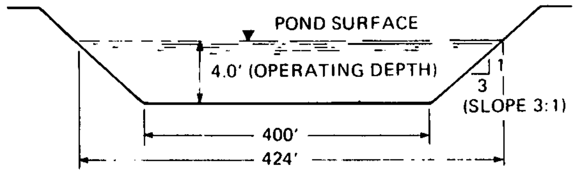
9. Daily Rise in Inches

   $= \frac{\text{total flow/day (gal) x design operating depth (inches)}}{\text{volume of pond (gal)}}$

SAMPLE PROBLEM



PLAN



PROFILE

Essential Data:

Avg Influent Flow Rate	= 250,000 gpd
Avg Influent BOD_5	= 380 mg/L
Avg Effluent BOD_5	= 190 mg/L
Population Served	= 2,000 persons
Industry Served	= One (BOD unknown)

CALCULATIONS

A. **Find the Operating Surface Area of Pond (Acres)**

Surface Area in Sq Ft (SF)
= L x W
= 424' x 624' = 264,576 SF
One Acre
= 43,560 SF
Area
= 264,576 SF ÷ 43,560 SF/Acre
= 6.07 Acres
Answer
= 6.07 Acres
Rounded Off
= 6.1 Acres

B. **Find the Volume of Pond (Gallons)**

Volume = L x W x d

Since the pond has sloped sides, the cross-horizontal area decreases with depth. To calculate the volume of the pond, the average horizontal area is required.

Average Horizontal Area

$$= \frac{\text{Surface (area)} + \text{Bottom (area)}}{2}$$

Surface A = 264,576 SF
Bottom A = 600 x 400 = 240,000 SF

$$\text{Avg Area} = \frac{264{,}576 \text{ SF} + 240{,}000 \text{ SF}}{2}$$

= 252,288 SF

$V = h\,(A_{avg\ horiz}) = 4(252{,}288)$
$= 1{,}009{,}152$ CF

1 CF = 7.5 gal

Volume in Gal
= 1,009,152 CF x 7.5 gal/CF
= 7,568,640 gal
One mg = 1,000,000 gal
Number mg = 7,568,640 ÷ 1,000,000
Number MG = 7.56864 mg
Rounded Off = 7.6 mg

C. **Calculate the Pounds of BOD_5 /Day (Influent)**

lbs BOD/day
= 8.34 x concentration (ppm) x flow (mgd)
= 8.34 x 380 x 0.25
= 792 lbs/day

D. **Calculate the Removal Efficiency (Based on BOD Reduction)**

$$\text{Efficiency} = \frac{\text{BOD in} - \text{BOD out}}{\text{BOD in}} \times 100\%$$

$$= \frac{380 \text{ mg/L} - 190 \text{ mg/L}}{380 \text{ mg/L}} \times 100\%$$

$$= 50\%$$

E. **Calculate the Organic (BOD) Loading (lbs BOD/Acre/Day)**

Loading = lbs BOD/day ÷ Surface Area (Acres)
= 792 ÷ 6.1 = 130
= 130 lbs BOD/Acre/Day

Note: Most stabilization ponds are designed for an organic loading of 15-30 lbs BOD/acre/day—this pond is overloaded at 130 lbs BOD/acre/day.

F. **Calculate the Population Loading (Number of Persons/Acre)**

Population Loading
= 2,000 persons ÷ 6.1
= 328 persons/acre

G. **Find the Population Equivalent**

Because industry increases the strength of the waste by adding organic materials, it is sometimes desirable to determine the **equivalent** population served, or the number of people that would be equal to the industry's effect.

Assume equivalent organic loading
= 0.2 lbs BOD/day/person

Total number lbs BOD arriving at pond
= 792 lbs/day

Equivalent population
= 792 lbs BOD/day ÷ 0.2 lbs BOD/person/day
= 3,960 persons

There are only 2,000 persons being served by this pond but because of the industry, the bond is being loaded as if there were 3,960 persons contributing waste. In essence, the industry load is equivalent to 3,960 minus 2,000 = 1,960 persons.

H. **Theoretical Retention Time (Days)**

Time = Volume of Pond ÷ Average Daily Flow
= 7.6 mg ÷ .25 mgd
= 30.4 days

Note: Most stabilization ponds are designed for a population loading of 100 persons per acre. The population loading in this example does not indicate as severe an overload condition as does the BOD loading figure. This is due to the fact that industry is adding organic material, thus increasing the BOD loading, but the contributing population remains the same.

C Flow measuring devices

RUNNING TIME OF PUMPS IN A LIFT STATION

Flow is calculated by multiplying the total minutes logged on each pump by the volume the pump will pump in one minute. The volume that the pump can pump in one minute can be computed as shown below.

Measure Change in Level of a Tank (Wet Well) Being Pumped in a Measured Time

$$\frac{\underset{\text{(in sq ft)}}{\text{area of tank}} \times \underset{\text{(in ft)}}{\text{change in level}} \times 7.5}{\text{minutes pumped}} = \text{gpm}$$

Example:

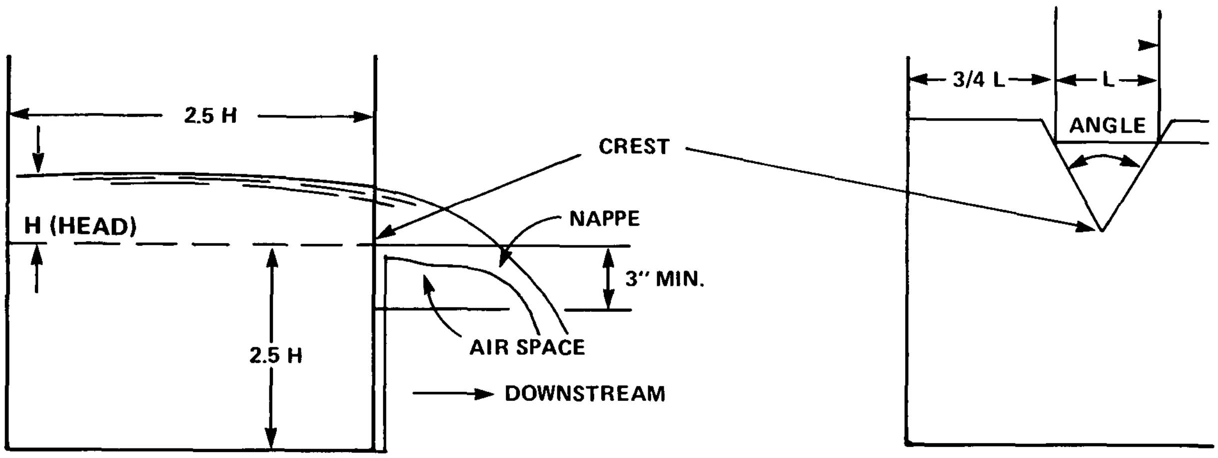
$$\frac{(25 \text{ sq ft}) \times (3 \text{ ft}) \times 7.5}{41 \text{ minutes}} = 13.9 \text{ gpm}$$

Knowing the pumping rate in gallons per minute, records can be maintained as in the following table in order to calculate the daily flow.

PUMP RUNNING TIME AND FLOW RECORD

DATE

Date	PUMP NO. 1 Reading (Hours)	PUMP NO. 1 Minutes (Hours x 60)	PUMP NO. 1 Minutes/ Day	PUMP NO. 2 Reading (Hours)	PUMP NO. 2 Minutes (Hours x 60)	PUMP NO. 2 Minutes/ Day	Total Mins. 1+2	(Gal) Minutes	Flow (Gal)
Start	00.0	0	-	0.0	0	-	0	-	-
1	12.2	732	732	17.5	1,050	1,050	1,782	13.9	24,769
2	25.7	1,542	810	33.5	2,010	960	1,770	13.9	24,603
3	39.7	2,382	840	51.5	3,090	1,080	1,920	13.9	26,668
4	50.9	3,054	672	68.1	4,086	996	1,668	13.9	23,185
5									
6									



V-NOTCH WEIR

The weir has the advantage of simplicity. To determine flow it is only necessary to measure the head of water above the crest of the weir. The sharp-crested weir may be a metal plate up to 1/4" (6 mm) in thickness. V-notch flow measurement weirs are usually constructed with either a 60-degree or 90-degree notch. The 60-degree V-notch weir is generally installed for measuring flows in the lower ranges.

The V-notch beveled weir is usually installed in a concrete flow structure which allows grit and heavy organic solids to settle out. This creates a condition that requires frequent cleaning and flushing of the flow channel. The V-notch of the weir catches and holds trash and debris. This requires frequent cleaning. The edges of the notch of the weir should be beveled on the downstream side to form a "sharp" crest or edge of about a 45-degree or more angle on the upstream side.

1. Confirm angle of "V" notch.

2. The measurement of head on the weir should be taken as the difference in elevation between the notch and the water surface at a point upstream from the weir a distance of at least 2 times and preferably 4 times the maximum head on the crest.

3. Liquid depth below crest should be at least 2.5 x head. The distance from the sides of the weir to the sides of the approach channel should never be less than 2H, where "H" is the head of the water above the notch.

4. Liquid downstream of weir plate should be no higher than 3" below crest of weir. Air should circulate freely both under and on the sides of the nappe.

5. Flow over weir is related to head (H) reading.

   Example: 90-degree V-Notch Weir

   1-1/2" head

   From table flow would be 6.05 gpm.

DISCHARGE FROM TRIANGULAR V-NOTCH WEIRS

Head (H) in Inches	Flow in Gallons Per Minute 90° Notch	Flow in Gallons Per Minute 60° Notch	Head (H) in Inches	Flow in Gallons Per Minute 90° Notch	Flow in Gallons Per Minute 60° Notch
1	2.19	1.27	6-3/4	260	150
1-1/4	3.83	2.21	7	284	164
1-1/2	6.05	3.49	7-1/4	310	179
1-3/4	8.89	5.13	7-1/2	338	195
2	12.4	7.16	7-3/4	367	212
2-1/4	16.7	9.62	8	397	229
2-1/2	21.7	12.5	8-1/4	429	248
2-3/4	27.5	15.9	8-1/2	462	267
3	34.2	19.7	8-3/4	498	287
3-1/4	41.8	24.1	9	533	308
3-1/2	50.3	29.0	9-1/4	571	330
3-3/4	59.7	34.5	9-1/2	610	352
4	70.2	40.5	9-3/4	651	376
4-1/4	81.7	47.2	10	694	401
4-1/2	94.2	54.4	10-1/2	784	452
4-3/4	108	62.3	11	880	508
5	123	70.8	11-1/2	984	568
5-1/4	139	80.0	12	1,094	632
5-1/2	156	89.9	12-1/2	1,212	700
5-3/4	174	100	13	1,337	772
6	193	112	13-1/2	1,469	848
6-1/4	214	124	14	1,609	929
6-1/2	236	136	14-1/2	1,756	1,014

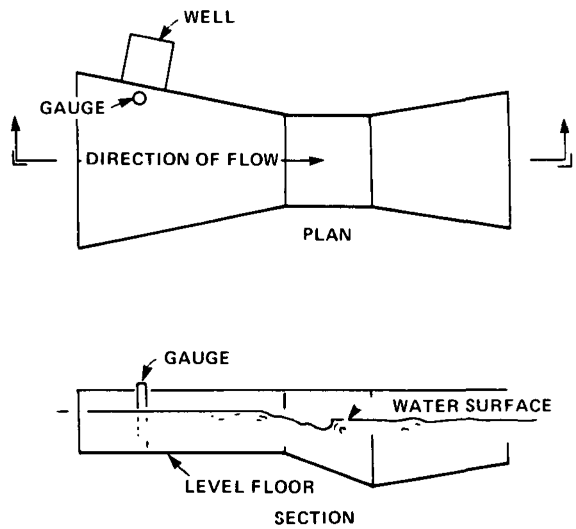
DISCHARGE OVER RECTANGULAR WEIR WITH STANDARD END CONTRACTIONS
DISCHARGE -- GALLONS PER MINUTE (gpm)

Head (H)	Length of Weir (L) Inches										
Inches	2	4	6	8	10	12	15	18	24	36	60
1/4	1	2	2	3	4	5	6	7	10		
1/2	2	4	6	9	11	13	16	19	26		
3/4	4	8	12	16	19	23	29	35	46		
1	6	12	18	24	30	36	45	54	72	108	180
1/4		17	25	33	42	50	63	76	100	150	250
1/2		22	33	44	55	66	83	99	132	197	330
3/4		28	42	55	69	83	104	124	166	248	415
2		34	51	68	85	101	127	152	202	303	505
1/4			61	81	101	121	152	183	242	363	605
1/2			71	95	118	142	178	213	284	426	710
3/4			82	109	136	164	205	246	328	492	820
3			93	124	155	187	233	280	374	561	935
1/4				140	176	210	264	316	420	630	1,050
1/2				157	197	235	294	353	470	705	1,180
3/4				174	218	261	326	392	522	783	1,310
4				190	239	287	358	431	574	861	1,430
1/4					262	314	392	472	628	942	1,570
1/2					285	343	429	515	686	1,030	1,710
3/4					310	374	465	559	748	1,120	1,860
5					334	403	500	605	806	1,210	2,010
1/4						433	540	650	866	1,300	2,160
1/2						464	580	695	928	1,390	2,320
3/4						496	620	745	992	1,480	2,480
6						528	660	791	1,050	1,850	2,640
1/4							701	842	1,120	1,680	2,800
1/2							743	893	1,190	1,790	2,980
3/4							785	934	1,260	1,890	3,150
7							830	1,000	1,330	1,990	3,320
1/4							875	1,050	1,400	2,100	3,500
1/2							920	1,100	1,470	2,200	3,680
3/4								1,160	1,540	2,310	3,850
8								1,210	1,620	2,430	4,050
1/4								1,270	1,700	2,550	4,250
1/2								1,340	1,780	2,670	4,450
3/4								1,400	1,860	2,790	4,650
9								1,460	1,940	2,910	4,850
1/4									2,020	3,030	5,050
1/2									2,100	3,150	5,250
3/4									2,180	3,270	5,450
10									2,270	3,400	5,670
1/2									2,450	3,680	6,120

PARSHALL FLUME

The parshall measuring flume is widely used to measure sewage flows because of its simplicity and its freedom from difficulties with sand or suspended solids.

The head over the crest of a Parshall Flume can be measured by placing a gauge stick in the sewage at the float in the flow channel or at the pipe leading to the float well and then taking a reading off the free-flow discharge chart.



FREE FLOW DISCHARGE - PARSHALL FLUME - GALLONS PER MINUTE

Head in Inches	3 Inches	6 Inches	9 Inches	12 Inches	18 Inches
1-3/16	10.3	22.4	40.0	-	-
1-13/16	22.4	44.9	76.3	-	-
2-3/8	36.7	71.6	116.9	157.1	229.0
3	51.6	103.3	166.1	219.9	318.7
3-5/8	69.0	139.2	219.9	287.3	422.0
4-3/16	68.0	175.1	278.0	359.0	534.0
4-13/16	104.0	215.5	341.1	444.3	659.0
5-3/8	130.0	260.0	404.0	534.0	790.0
6	152.0	310.0	476.0	624.0	925.0
6-5/8	180.0	359.0	552.0	727.0	1,073.0
7-3/16	202.0	413.0	628.0	826.0	1,225.0
7-13/16	233.0	467.0	714.0	934.0	1,387.0
8-3/8	257.0	525.0	799.0	1,046.0	1,553.0
9	294.0	588.0	889.0	1,158.0	1,728.0
9-5/8	315.0	651.0	978.0	1,280.0	1,912.0
10-3/16	357.0	714.0	1,073.0	1,400.0	2,096.0
10-13/16	378.0	781.0	1,171.0	1,530.0	2,289.0
11-3/8	420.0	853.0	1,274.0	1,661.0	2,491.0
12	448.0	925.0	1,377.0	1,795.0	2,692.0
13-3/16	-	1,077.0	1,594.0	2,074.0	3,119.0
14-3/8	-	1,234.0	1,822.0	2,370.0	3,564.0
15-5/8	-	1,400.0	2,060.0	2,675.0	4,035.0

If readings are to be recorded in gallons per day, multiply the answer in gpm by 1440.

Sample Calculations for Compositing

If the average flow rate is 50,000 gpd, the flow in gpm is:

$$\frac{50{,}000 \text{ gpd}}{1{,}440 \text{ min/day}} = 35 \text{ gpm}$$

Size of composite sample needed = 2,500 to 3,000 ml (sample size is dependent on type of test run).

A. Average size of sample for 24-hour composite (24 samples, each taken on the hour):

$$\frac{2{,}500 \text{ to } 3{,}000 \text{ ml}}{24 \text{ hourly samples}} = 105 \text{ to } 125 \text{ ml}$$

Sizing an individual sample based on the rate of flow at that instant:

$$\frac{105 \text{ to } 125 \text{ ml}}{35 \text{ gpm}} = \text{approx. } 3 \text{ to } 4 \text{ ml/gpm}$$

Example: Flow rate = 30 gpm;
Sample size = 4 x 30 = 120 ml

Note: It is safer to take too much than not enough, 504 ml/gpm is used. After thoroughly mixing the **total combined** *sample, the excess amount can be discarded.*

B. Average size of sample for NPDES composite (four 2-hour samples for an 8-hour composite, samples taken at 10 a.m., 12 noon, 2 p.m., and 4 p.m.):

$$\frac{2{,}500 \text{ to } 3{,}000 \text{ ml}}{\text{Four 2-Hour Samples}} = 625 \text{ to } 750 \text{ ml}$$

Sizing an individual sample based on the rate of flow at that instant. Consider that daytime flow rates will usually be greater than the average daily flow rate. Estimate that the daytime flow rate is approximately 40 gpm:

$$\frac{625 \text{ to } 750 \text{ ml}}{40 \text{ gpm}} = \text{approx. } 16 \text{ to } 19 \text{ ml/gpm}$$

Note: In this case, you might want to take 20 ml/gpm since this is an easier number to multiply by.

Example: Flow rate = 50 gpm;
Sample size = 20 x 50 = 1,000 ml

D Design considerations from an operation and maintenance viewpoint

Operating experience at many pond installations shows the need to pay attention to several important areas when designing ponds for optimum operational control.

Conservative design in this instance should reflect operational flexibility above that required at the moment. These considerations should include:

1. The capability to move water around within the system. The advantages of this provision include premixing the pond's contents with the incoming wastewater which provides oxygen to the incoming waste and assures a more completely mixed environment in the feed zone area. Two methods are available; using portable pumps or pond recirculation. The latter has been successfully used in California.

2. The use of multiple inlets and outlets to improve pond circulation.

3. The use of interpond transfer pipes with valves or gates to permit individual pond level control and to redistribute loading. This interpond flexibility will permit the operator to operate cells at those water levels which will give the best treatment. Operators with this capability will need to experiment with pond levels until the best plant effluent is obtained. For example, a primary cell might operate best at an 8-foot water depth, while the final cell is 3 feet.

4. A well-designed outlet structure which will permit control of pond depths and also the rate of discharge.

5. The use of reliable continuous-flow measuring devices such as V-notch or Cipoleti weirs or float-actuated electrically-timed recorders.

E Case histories

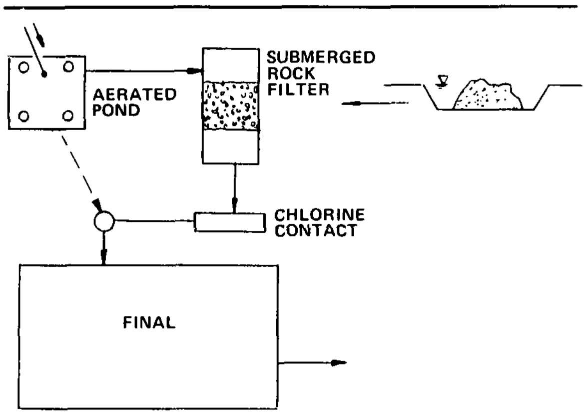
CASE 1 – COLORADO

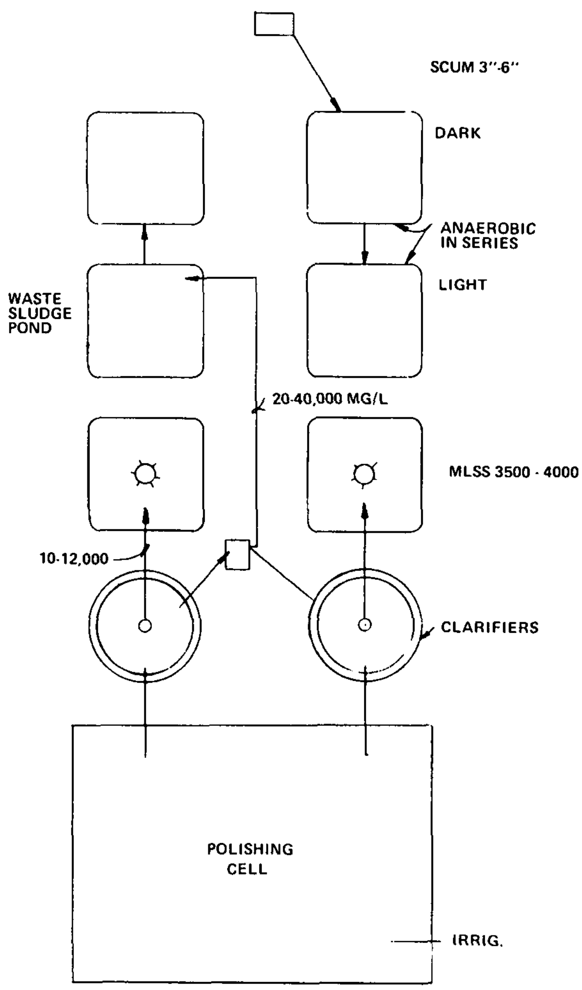
This plant in Colorado was visited because of rock filter built for algae removal. Filter will be discontinued because it does not work.

General impression of plant was that it was poorly-attended, if at all. Although a new facility, it had a goodly start on water weed growth but no cover on dikes. Dikes were showing signs of erosion. Algae growth in ponds OK.

Plant was designed for continuous discharge but had not needed to do so yet.

The filter will be abandoned because of plugging. Rock size too small, ranging from 2" to sand. Filter was uncovered and odorous. Evidence of spiders and midges.



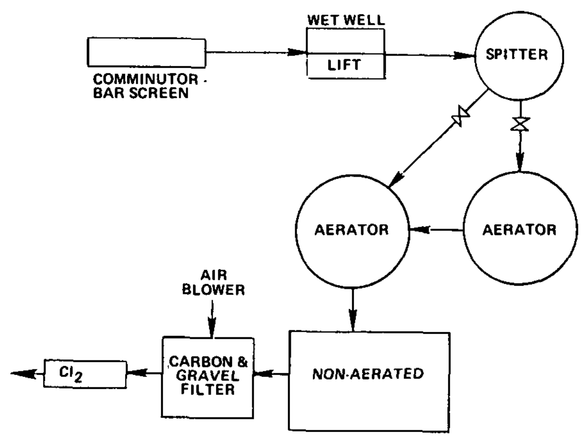


CASE 2 – COLORADO

Another plant in Colorado also has a different rock filter following the last cell and prior to chlorination.

This filter has an air blower used to keep the filter aerobic. However, the filter is not working, again due to plugging problems.

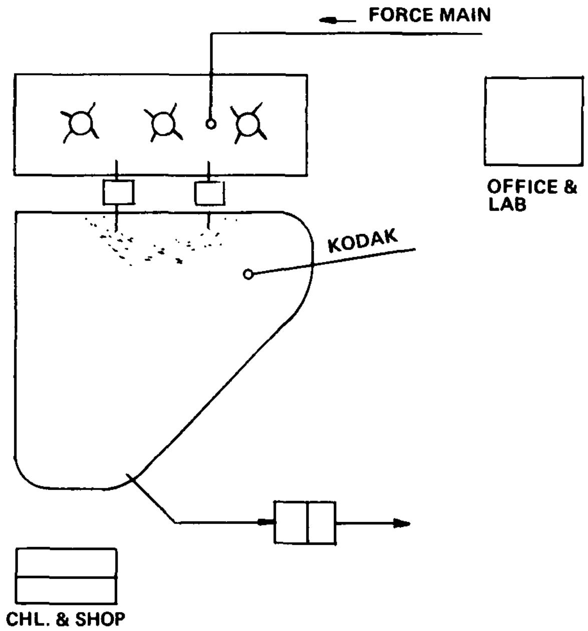
General comment on both filters would be to use larger rock (5 to 6" in diameter) as determined by O'Brian. Reference No. 6.



CASE 3 – COLORADO

This system shows evidence of being well run by a Certified IV Operator. Good algal growth in both ponds. Cells do not have the capability to control or vary the water level. Plant is continuous discharge into a nearby river. The lagoon receives both domestic sewage and pretreated industrial waste from a Kodak plant.

Domestic waste is discharged into the primary aerated cell, then into the secondary cell. The secondary cell also receives Kodak waste. Effluent is chlorinated prior to discharge. The effluent shows evdience of a high solids carryover (algae).



CASE 4 – COLORADO

Although this is a larger plant combining extended aeration and an oxidation pond system, it deserves a discussion because it is a well-run facility meeting its NPDES discharge requirements. Undoubtedly, its reason for success is that the operator knows the basics of the process and it is well attended. Daily operation and maintenance schedules are in force and carefully adhered to. An established wasting and lab testing program is also followed.

CASE 5 – COLORADO

(Anaerobic/Aerobic Lagoon)

This complex treats animal wastes from a livestock feed lot and the treated effluent is used for field irrigation. The raw waste enters an influent diversion structure, then flows through two anaerobic lagoons in series. The effluent is discharged into a complete-mix activated sludge process consisting of two aerated basins and two final clarifiers. Effluent from the clarifiers is discharged into a polishing lagoon. Return sludge is about 10,000 to 12,000 mg/L. Excess sludge ranging from 20,000 to 40,000 mg/L is pumped to a sludge holding basin. The solids level in the aerator is held between 3,500 and 4,000 mg/L.

A good scum blanket existed on both anaerobic ponds and there was an absence of bad odors. Operators said, however, that severe odors developed when starting a new pond. This condition held until a scum blanket was formed, usually about 1 month.

CASE 6 – COLORADO
The operator of this plant has an operational checklist that is worth mentioning. The treatment system is an oxidation ditch followed by lagoons as shown in the figure.

Daily Operational Checklist
1. Checks comminutor for operation to make sure nothing is clogged.

2. Reads flowmeter, checks press and rewinds (sets totalizer to 76,000) at 11:00 a.m. each day.

3. Checks second bar screen and cleans. Takes screenings to small landfill.

4. Checks and lubricates each cage aerator.

5. Checks sludge blanket.

6. Inspects cells.

7. Takes samples at outfall manhole and influent structure. Performs tests.

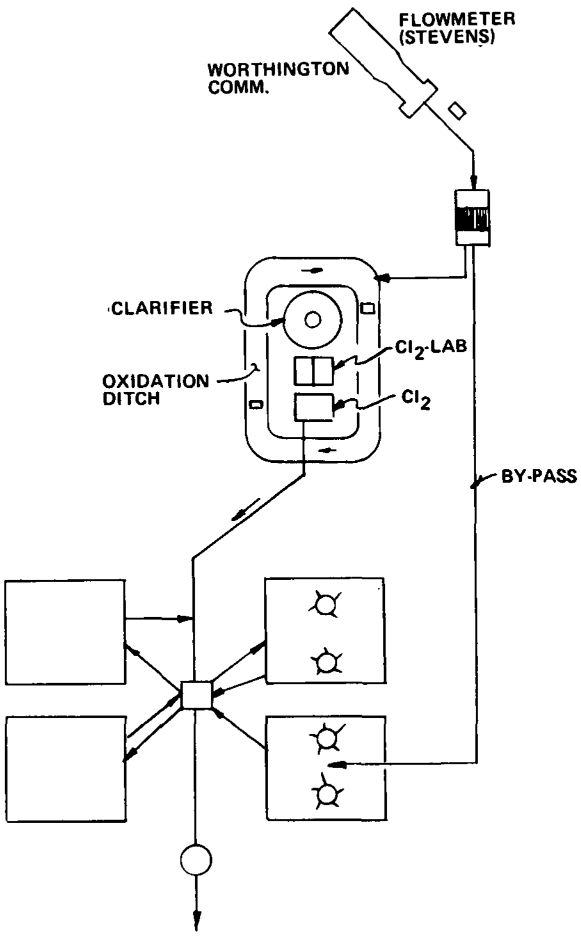
8. Checks Cl_2 feed rate. Keeps it between 7 and 12 lbs/day.

Other Duties
1. Wastes (2 times per week).

2. Isolates comminutor, greases, flushes comminutor and channel return to service.

3. Mows dike grass, pulls weeds.

4. Counts number of threads on valve stem when changing flow pattern.



CASE 7 – KANSAS
An overload in the primary cell was corrected by diverting all flow into Cell No. 2 and routing water from Cell No. 3 back to the primary cell for additional oxygen and dilution.

Low DO, following melting of the ice cover, was corrected by adding 50 to 100 pounds of sodium nitrate per acre.

CASE 8 – KANSAS
Anaerobic conditions in the primary cell were corrected by diverting part of influent flow into the second cell and adding water to keep both cells above a 3′ level. Duckweed growth is controlled by applying 2-4D in oil solution.

CASE 9 – KANSAS
Excessive foam in aerated pond, which was corrected by adding 1 quart of coconut oil.

CASE 10 – CALIFORNIA
Algae Control Using Phase Isolation
The facility at Woodland, California, has successfully shown that algae can be removed from the final discharge cell by starving it. The following represents their conclusions and observations.

Summary and Conclusions

Based upon 15 months of successful field scale operation, during which an average of 1.2 mgd has been treated to exceed the 1977 discharge requirements for BOD and suspended solids, it can be justifiably stated that the concept of "phase isolation" works under Woodland conditions.

It was not the scope of this investigation to ascertain **why** it works, but only if it **does** work. It appears that the reasons as to **why** it works are quite complex and is a fit subject for investigation by someone with sufficient technical resources.

Observations

1. Spectrophotometer determinations for suspended solids correlates reasonably well with "Standard Methods" in the upper range, but gives an "optimistic" low reading in the low range. However, a low reading on the spectrophotometer shows that it is the proper time to start testing by "Standard Methods." A plant operator, by viewing the phase isolation effluent in a glass jar, can rapidly learn when it is time to start laboratory tests because of its clarity.

2. Low suspended solids measurements and low BOD measurements generally accompany each other and when they do not, it was always proved to be a laboratory error.

3. During periods of rainfall or high wind, the colloidal silt of the unlined ponds would give a "high" reading on the suspended solids. A large population of waterfowl would also cloud the contents of the pond because of their bottom feeding habits.

4. Waterfowl and shorebirds preferred the phase isolation pond and the pond into which it discharged over the adjacent four 12-acre facultative ponds.

5. Attached filamentous algae at times obscured as much as 85 percent of the surface of the phase isolation pond, but caused no difficulty - in fact, the pond appeared to clear up quicker under these conditions. Filamentous algae and suspended algae do not appear to be compatible and generally it was observed that one excludes the other.

6. The algae precipitate out more rapidly on some occasions than on others. The fastest clearing up time was 2 days after shut-off of influent. At times the algae would not mix with the residual contents of the phase isolation pond, but would precipitate in the vicinity of the influent discharge pipe.

7. During the phase isolation period, inflow must be absolutely and totally shut off. A small leak can sustain the algae bloom in the pond and in every instance when the pond did not seem to be clearing as rapidly as was expected, it was found that leaking influent was the cause. Once the leak was stopped, the pond then got back on schedule.

8. Inflow and discharge should be accomplished in as short a time as practical to minimize pond area needs and to hasten the clearing of the pond.

Summary
Extremely good effluent has been obtained from the pond receiving overflow from the facultative ponds even though algae content of the influent has been high. The secret seems to be in taking advantage of a cycle the final pond goes through when the algae settles out leaving effluent with a quality that is well within the regulatory limits of 30/30, BOD/SS.

The facultative ponds with approximately 60 days detention time discharge into the final pond until the level is 3 to 4 feet deep. Flow is stopped and the condition of the contents are observed until maximum clarity is reached then the pond is drawn down to a level about 2 feet deep and the cycle is repeated.

By using this system, effluent quality has been measured at 4 mg/L BOD and 12 mg/L SS for sustained periods. The cycle for discharging has varied from a minimum of 4 days to approximately 20 days. More information on this project is given in an article in **Water and Sewage Works**, December 1975, p. 42.

F Metric equivalents

METRIC CONVERSION TABLES

Recommended Units

Description	Unit	Symbol	Comments	English Equivalents
Length	meter	m	*Basic SI unit*	39.37 in. = 3.28 ft = 1.09 yd
	kilometer	km		0.62 mi
	millimeter	mm		0.03937 in.
	centimeter	cm		0.3937 in.
	micrometer	μm.		3.937 X 10^{-3} = 10^3A
Area	square meter	m^2		10.744 sq ft = 1.196 sq yd
	square kilometer	km^2		6.384 sq mi = 247 acres
	square centimeter	cm^2		0.155 sq in.
	square millimeter	mm^2		0.00155 sq in.
	hectare	ha	The hectare (10,000 m^2) is a recognized multiple unit and will remain in international use.	2.471 acres
Volume	cubic meter	m^3		35.314 cu ft = 1.3079 cu yd
	cubic centimeter	cm^3		0.061 cu in.
	liter	l	The liter is now recognized as the special name for the cubic decimeter	1.057 qt = 0.264 gal = 0.81 X 10^{-4} acre-ft
Mass	kilogram	kg	*Basic SI unit*	2.205 lb
	gram	g		0.035 oz = 15.43 gr
	milligram	mg		0.01543 gr
	tonne	t	1 tonne = 1,000 kg	0.984 ton (long) = 1.1023 ton (short)
Time	second	s	*Basic SI unit*	
	day	day	Neither the day nor the year is an SI unit but both are important.	
	year	yr or a		
Force	newton	N	The newton is that force that produces an acceleration of 1 m/s^2 in a mass of 1 kg.	0.22481 lb (weight) = 7.5 poundals

Recommended Units

Description	Unit	Symbol	Comments	English Equivalents
Velocity				
linear	meter per second	m/s		3.28 fps
	millimeter per second	mm/s		0.00328 fps
	kilometers per second	km/s		2.230 mph
angular	radians per second	rad/s		
Flow (volumetric)	cubic meter per second	m^3/s	Commonly called the cumec	15,850 gpm = 2.120 cfm
	liter per second	l/s		15.85 gpm
Viscosity	poise	poise		0.0672/lb/sec-ft
Pressure	newton per square meter	N/m^2	The newton is not yet well-known as the unit of force and kgf cm^2 will clearly be used for some time. In this field the hydraulic head expressed in meters is an acceptable alternative.	0.00014 psi
	kilonewton per square meter	kN/m^2		0.145 psi
	kilogram (force) per square centimeter	kgf/cm^2		14.223 psi
Temperature	degree Kelvin	K	*Basic SI unit*	$\frac{5F}{9}$ − 17.77
	degree Celsius	C	The Kelvin and Celsius degrees *are identical.* The use of the Celsius scale is recommended as it is the former centigrade scale.	
Work, energy, quantity of heat	joule	J	1 joule = 1 N-m	2.778 X 10^{-7} kw hr = 3.725 X 10^{-7} hp-hr = 0.73756 ft-lb = 9.48 X 10^{-4} Btu
	kilojoule	kJ		2.778 kw-hr
Power	watt	W	1 watt = 1 J/s	
	kilowatt	kW		
	joule per second	J/s		

Application of Units

Description	Unit	Symbol	Comments	English Equivalents
Precipitation, run-off, evaporation	millimeter	mm	For meteorological purposes it may be convenient to measure precipitation in terms of mass/unit area (kg/m^3). 1 mm of rain = 1 kg/sq m	
River flow	cubic meter per second	m^3/s	Commonly called the cumec	35.314 cfs
Flow in pipes, conduits, channels, over weirs, pumping	cubic meter per second	m^3/s		
	liter per second	l/s		15.85 gpm
Discharges or abstractions, yields	cubic meter per day	m^3/day	1 l/s = 86.4 m^3/day	1.83×10^{-3} gpm
	cubic meter per year	m^3/yr		
Usage of water	liter per person per day	l/person day		0.264 gcpd
Density	kilogram per cubic meter	kg/m^3	The density of water under standard conditions is 1,000 kg/m^3 or 1,000 g/l	0.0624 lb/cu ft

Application of Units

Description	Unit	Symbol	Comments	English Equivalents
Concentration	milligram per liter	mg/l		1 ppm
BOD loading	kilogram per cubic meter per day	kg/m^3 day		0.0624 lb/cu-ft day
Hydraulic load per unit area; e.g. filtration rates	cubic meter per square meter per day	m^3/m^2 day	If this is converted to a velocity, it should be expressed in mm/s (1 mm/s = 86.4 m^3/m^2 day).	3.28 cu ft/sq ft
Hydraulic load per unit volume; e.g. biological filters, lagoons	cubic meter per cubic meter per day	m^3/m^3 day		
Air supply	cubic meter or liter of free air per second	m^3/s l/s		
Pipes				
diameter	millimeter	mm		0.03937 in.
length	meter	m		39.37 in. = 3.28 ft
Optical units	lumen per square meter	$lumen/m^2$		0.092 ft candle/sq ft

☆ U.S. GOVERNMENT PRINTING OFFICE: 1975-630-902

G References and suggested resource material

1. *Stabilization Pond Operation and Maintenance Manual*

   Minnesota Pollution Control Agency
   1935 West County Road B2
   Roseville, Minnesota 55113

2. *Operating Waste Stabilization Ponds - Course Manual for Operator Training*

   EPA No. T0077046-01
   Iowa Department of Environmental Quality
   Kirkwood Community College
   Cedar Rapids, Iowa

3. Palmer, C. Mervin, *Algae in Water Supplies: An Illustrated Manual on the Identification, Significance, and Control of Algae in Water Supplies*, PHS Pub. 657, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, reprinted 1962, 93 pp. National Technical Information Service Number PB 216 459.

4. *Operation of Wastewater Treatment Plants* (Chapters 9, 13 and 14)

   Department of Civil Engineering
   Sacramento State College
   6000 Jay Street
   Sacramento, California 95819

5. *Wastewater Treatment Ponds*

   EPA 430/9-74-011

6. *Upgrading Wastewater Stabilization Ponds to Meet New Discharge Standards* (Pages 15, 21, 31 and 8)
   Proceedings of a Symposium at Utah State University, 1974

   Utah Water Research Laboratory
   College of Engineering
   Utah State University
   Logan, Utah 84322

7. *Standard Methods for the Examination of Water and Wastewater*, 14 Edition (Note algae plates in color.)

   Water Pollution Control Federation
   2626 Pennsylvania Avenue, Northwest
   Washington, D. C. 20037

8. *Manual of Wastewater Operations* (Chapters 16 and 21)

   Texas State Department of Health
   Austin, Texas

H Plants visited

Lafayette, Oregon	Polishing ponds following a package plant.
Dundee, Oregon	Two-cell stabilization pond.
Bay City, Oregon	Two-cell stabilization pond.
Greeley, Colorado	Two-cell anaerobic pond followed by a complete-mix activated sludge plant, plus a sludge lagoon and a polishing pond.
Windsor, Colorado	Two-cell stabilization pond.
Louisville, Colorado	Four-cell polishing pond following an extended aeration facility.
Sunnyvale, California	Waste stabilization pond followed by an algae removal system which includes air flotation and multi-media filters.
Woodland, California	Oxidation ponds utilizing phase isolation for algae removal.
Modesto, California	Oxidation ponds.
Turlock, California	Oxidation ponds.
Eudora, Kansas	Three-cell stabilization pond.
Shawnee County, Kansas	Two-cell stabilization pond.
Topeka Truck Plaza, Kansas	Aerated lagoon ahead of stabilization pond.
Shawnee County Sewer Dist. No. 8, Kansas	Two-cell aerated pond.
City of Topeka, Kansas (Pauline Plant)	Three-cell stabilization pond.

Page 1-5 Right column - last paragraph

Ammonia (CH_4), ... is in error

Ammonia = ~~NH_4~~ NH_3

Methane = CH_4

J Checklist form

Operational and Preventive Maintenance	Frequency						
	Daily	Wk.	Mo.	3 Mo.	6 Mo.	Yearly	As Necessary