

CHAPTER 4: SEWAGE TREATMENT FACILITIES

4.1 INTRODUCTION

Sewage treatment is a multi-stage process designed to treat sewage and protect natural water bodies. Municipal sewage contains various wastes. If improperly collected and improperly treated, this sewage and its related solids could hurt human health and the environment.

A treatment plant's primary objectives are to clean the sewage and meet the plant's discharge standards. The treatment plant personnel do this by reducing the concentrations of solids, organic matter, nutrients, pathogens and other pollutants in sewage. The plant must also help protect the receiving water body, which can only absorb a certain level of pollutants before it begins to degrade, as well as the human health and environment of its employees and neighbours.

One of the challenges of sewage treatment is that the volume and physical, chemical, a limited quantity of pollutants and biological characteristics of sewage continually change. Some changes are the temporary results of seasonal, monthly, weekly or daily fluctuations in the sewage volume and composition. Other changes are long-term, being the results of alterations in local populations, social characteristics, economies, and industrial production or technology. The quality of the receiving water and the public health and well-being may depend on a treatment plant operator's ability to recognize and respond to potential problems. These responsibilities demand a thorough knowledge of existing treatment facilities and sewage treatment technology.

4.2 PUMP EQUIPMENT

Refer to Chapter 3 of the Part B Manual. (Sec.3.6 "Pump Equipment")

4.3 FINE SCREEN AND GRIT CHAMBER

Refer to Chapter 3 of the Part B Manual. (Sec.3.4 "Screen" and Sec.3.5 "Grit Removal")

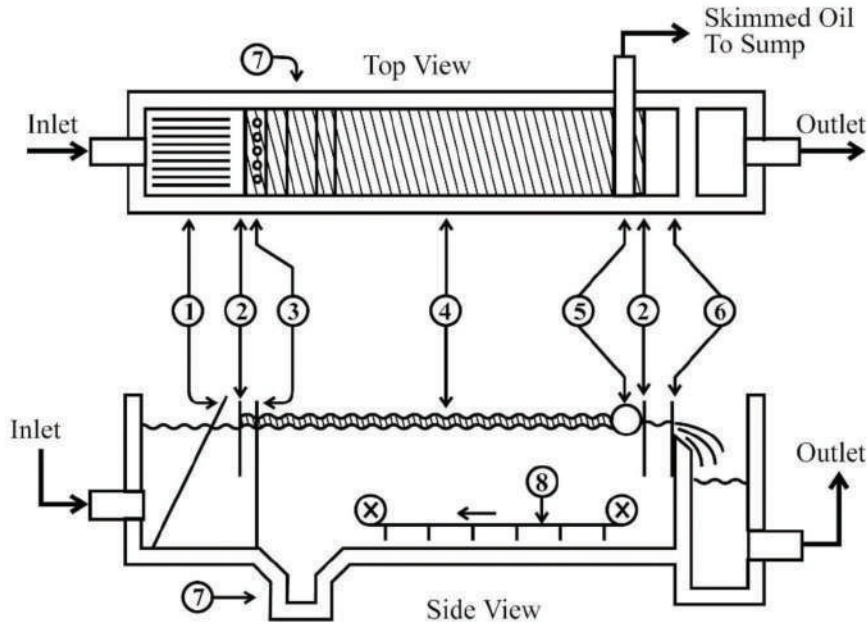
4.4 OIL AND GREASE REMOVAL

4.4.1 Manual Process

The oil and grease removal unit consists of simple tanks with an underflow baffle where the floating oil and grease is retained on the sewage surface. These are fit only for small STPs of about 1 MLD capacity or less. The floating oil & grease is removed by a rotating slotted pipe as in Figures 4.1 & 4.2 overleaf.

In actual operation, the scum of oil and grease is removed by rotating the slotted pipe so that the scum flows over the slit, through the pipe and goes to a holding high-density polyethylene (HDPE) tank below the pipe on the outside. The scum is then sold to pollution board-authorized oil re-refining firms. The grit that settles in the trough below is drained to a sump and pumped to the beginning of the grit chamber.

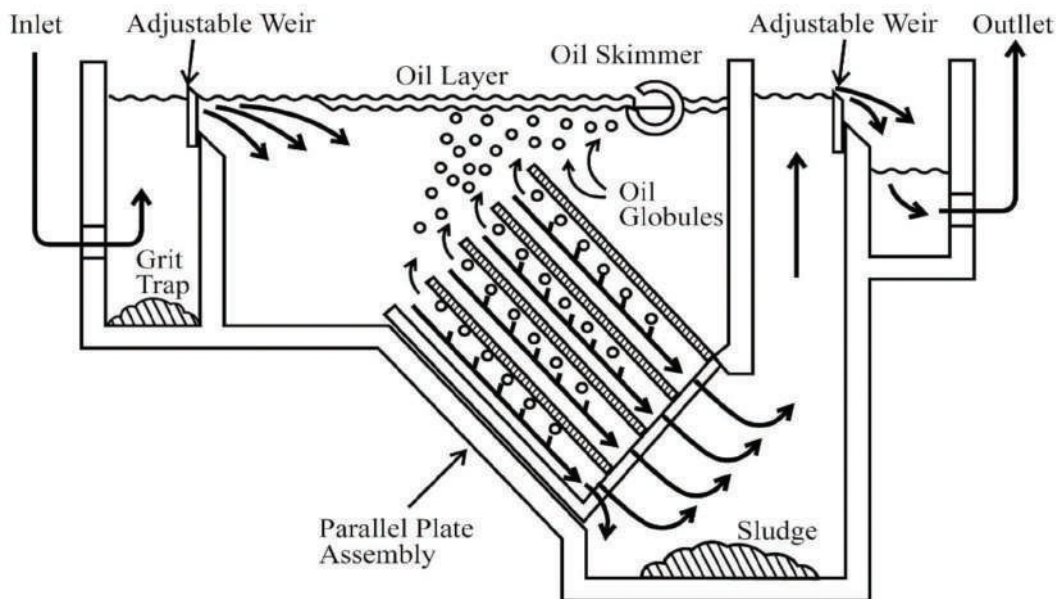
The maintenance is very simple and requires periodic cleaning only.



1. Trash Trap (Inclined Rods)
2. Oil Retention Baffles
3. Flow Distributors (Vertical Rods)
4. Oil Layer
5. Slotted Pipe Skimmer
6. Adjustable Overflow Weir
7. Sludge Sump
8. Chain and Flight Scraper

Source: http://en.wikipedia.org/wiki/Industrial_wastewater_treatment

Figure 4.1 Typical gravity type oil and grease removal unit

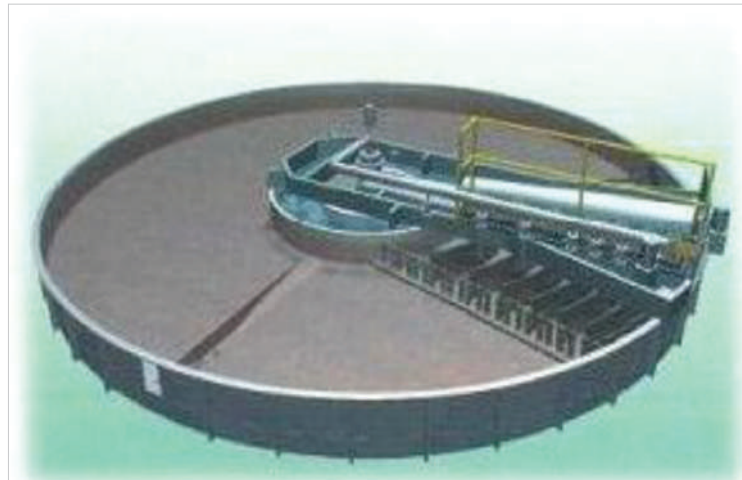


Source: http://en.wikipedia.org/wiki/Industrial_wastewater_treatment

Figure 4.2 Parallel plate separator

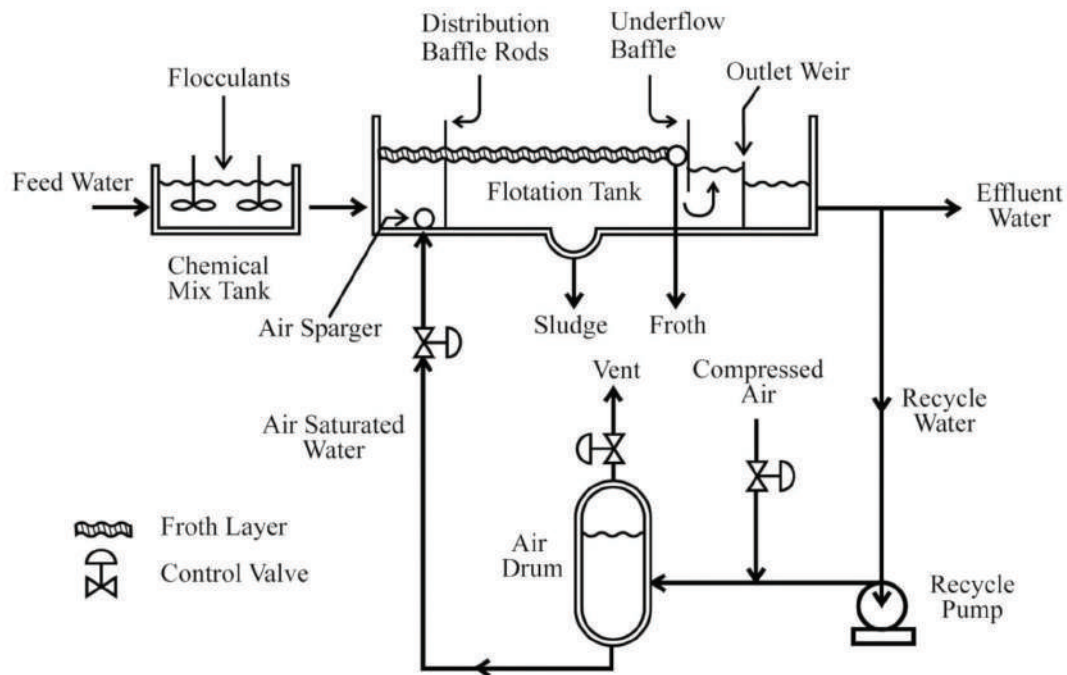
4.4.2 Mechanized Process

This process involves floating the oil and grease by either fine bubbles of compressed air or directly by steam liberated near the floor. The same process as in Figures 4.1 & 4.2 can also be used by releasing fine bubbles of compressed air or steam near the floor. The air is dispersed into very fine bubbles in the raw sewage and the mixture is released in a shallow tank, where the fine bubbles coalesce with the oil and rise to the surface and are skimmed-off by a scoop pipe as shown in Figure 4.3 and is typically called a dissolved air flotation (DAF) unit as shown in Figure 4.4.



Source: <http://www.tradeindia.com>

Figure 4.3 DAF unit



Source: <http://www.sciencedirect.com>

Figure 4.4 Schematic of DAF unit

All these units are almost patented types and there are no fixed O&M guidelines. Each unit has to follow the guidelines of the respective manufacturer.

4.5 EQUALIZATION

Flow equalization can be either side stream or in-line. With in-line flow equalization, all of the flow enters the flow equalization basin, and a constant outflow rate is maintained. With side stream flow equalization, only that portion of the flow above a given flow rate (typically the average flow) is diverted into the flow equalization basin. The accumulated flow is then released during low-flow periods to adjust the total flow to average rate of flow for the day.

The in-line flow equalization is the easiest to control. Typically, the flow is pumped out using flow-controlled variable-speed pumps or is pumped in and flows out by gravity using a flow control valve and flow meter. If the latter is used, careful selection of the flow control valve is needed to prevent clogging, even if screened or primary treated sewage is to be equalized.

For side stream flow equalization, flow control gates or variable speed pumps can be used. If a constant elevation side weir is used, achieving a controlled flow rate over the side weir is difficult and is not recommended. Variable speed pumps are a better choice.

4.5.1 Operation

The fill-and-draw mode is the most efficient method of operating an equalization basin. The basin is filled during the day when peak flows are occurring, and then it is pumped at night when the plant is receiving low flows and, hence, is more capable of treating excessive flow. If an equalization basin is not operated in fill-and-draw mode, it will act as a mass loading equalization basin only, assuming the basin is completely mixed.

The successful operation of equalization basin requires proper mixing & aeration. The design of mixing equipment provides for blending the contents of the tank and preventing deposition of solids.

Mechanical aerators, which offers a method of providing both mixing and aeration, have higher oxygen transfer in clean water under standard conditions than in sewage. The minimum operating depth for floating aerators are typically 1.5 m and varies with the motor kilowatts and design of the unit. Low-level shutoff controls are needed to protect the unit. If the equalization basin floor is subject to erosion (earthen basins), concrete pads on the basin floor are recommended. Baffling may be necessary to ensure proper mixing, particularly with a circular tank configuration.

Some of the recommended monitoring elements required in flow equalization basins are

1. Basin liquid level
2. Basin dissolved oxygen level
3. Influent pH
4. Mixers and/or aeration blower status
5. Influent/effluent status pumps
6. Influent/effluent flow

4.5.2 Maintenance

Because grit removal is rarely provided before equalization, grit tends to accumulate in the basins. Therefore, provisions for collecting these solids should be made in the design. If the primary purpose of the equalisation basin is flow equalising, then, after the basin has been emptied, following the peak flow event, primary sludge solids will be present in the basin floor. Water cannons or strategically placed cleaning hoses, ideally supplied with plant effluent water, will allow for cleaning the basins. Other equalization basin types that do not operate in a fill/draw mode will also accumulate solids over a period of time and will have to be emptied.

The cleaning interval depends on the influent sewage characteristics and has to be established by operational experience.

4.6 PRIMARY TREATMENT

4.6.1 Primary Sedimentation Tank Management

This is a simple gravity controlled separation for removing the settleable solids and the Biochemical Oxygen Demand (BOD) that is caused by the settleable solids.

4.6.2 Preventive Maintenance

Preventive maintenance of the equipment should be done by the equipment supplier as per the manual.

4.6.3 Day to Day Maintenance

The most important is the daily cleaning of the overflow weirs and the weekly scraping of the floor and walls of the launder. Moreover, periodical checking of the walkway for corrosion is important. In actual day-to-day working, the operator should not lean or put his weight on the handrails.

4.6.4 Troubleshooting

Troubleshooting is as given in Appendix B.4.1.

4.7 ACTIVATED SLUDGE PROCESS (ASP)

The activated sludge process is still the most widely used biological treatment process for reducing the concentration of organic pollutants in sewage. Well-established design standards based on empirical data have evolved over the years.

The basic ASP has many different process modifications. The process selected in a specific STP depends on the treatment objectives, site constraints, operational constraints, etc.

The process can be categorized by loading rates, reactor configuration, feeding and aeration patterns, and other criteria including various biological nutrient removal (BNR) processes.

A typical plan layout of a basic ASP is illustrated in Figure 4.5 overleaf.

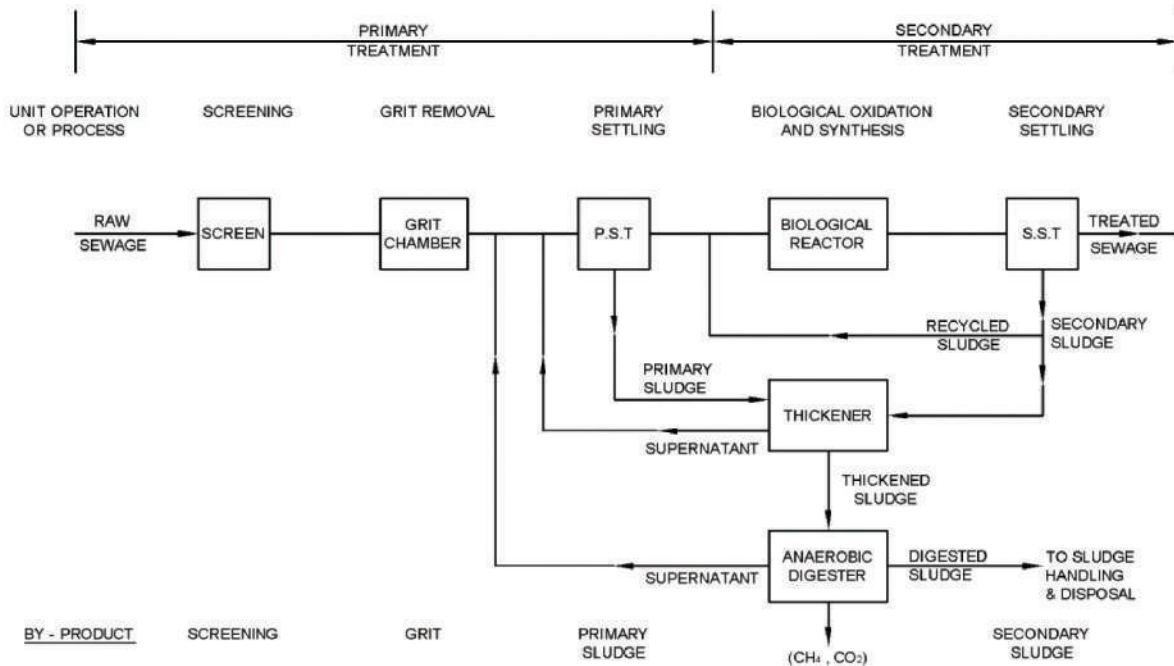


Figure 4.5 Typical plan layout of activated sludge plant

4.7.1 Description of ASP

4.7.1.1 Biological Treatment Processes

In the biological treatment of sewage, the stabilisation of organic matter is accomplished biologically using a variety of microorganisms, principally bacteria. They convert the colloidal and dissolved carbonaceous matter into gases and non-degradable matter and incorporate it into their cell tissue. The resulting cell tissue has a specific gravity slightly greater than that of water. The portion of organic matter that has been converted to various gaseous and non-degradable end products, which itself is organic, will be measured as the difference between the inlet and outlet.

The conversion of organic matter can be accomplished either by aerobic, anaerobic or facultative processes. Oxidation of organic matter to various end-products is carried out to obtain the energy required for the synthesis of new cell tissues. In the absence of organic matter, the cell tissue undergoes endogenous respiration. In most treatment systems, these three reactions, oxidation, synthesis and endogenous respiration occur simultaneously.

The microbial mass comprises a heterogeneous population of microorganisms, mostly heterotrophic bacteria. Various groups of organisms carry out their metabolic reactions independently as well as sequentially. The combination of organisms in the treatment process occurs naturally, depending upon the sewage characteristics and the environmental conditions maintained.

4.7.1.2 Design and Operational Parameters

The ASP operation is commonly controlled by maintaining the design Mixed Liquor Suspended Solids (MLSS), or sometimes, by maintaining the design Food to Microorganisms (F/M) ratio. The latter approach takes care of fluctuations in the quality of raw sewage.

If actual F/M is to be assessed, then measurement of active biomass measured as Mixed Liquor Volatile Suspended Solids (MLVSS) is needed.

The solids retention time (SRT), which is directly related to F/M, is not being used for operational control. Some of the important design and operational parameters are as follows.

The operational parameters and their formula are explained in Appendix B.4.2 and examples of their calculations are described in Appendix B.4.3.

4.7.1.3 Choice between SRT and F/M as Operation Control Parameter

The evaluation of the active mass of microorganism often makes the use of F/M as a control parameter impractical. Biological solids are commonly measured as volatile suspended solids.

This parameter is not entirely satisfactory because of the variety of volatile matter not related to active cellular material.

On the other hand, the evaluation of SRT as a plant control parameter is simple. Since SRT is the ratio of total suspended solids in the system and the total suspended solids wasted per day, it requires only measurement of the suspended solids in the system and the solids wasted, either from the aeration tank or from the recycle line is the same. Use of SRT as a plant control parameter becomes simpler if sludge wasting is done directly from aeration tank, as the ratio of “total solids in system to solids wasting per day” reduces to the ratio of “aeration tank volume to volume of sludge wasted per day,” provided the mass of solids escaped in treated effluent is negligible.

4.7.1.4 Effect of SRT on Settling Characteristics and Drainability of Sludge

It has been established that as a system is operated at higher solids retention time, the settling characteristics of the biological flocs improve. For domestic sewage, SRT of the order of 3 to 4 days are required to achieve effective settling. Further, it is established that drainability of waste sludge also improves when a system is operated at higher SRT.

The SRT at which a process is operated approximately represents the average age of biomass present in the process. As the biomass ages, it contains increasing proportion of dead cells and inert matter. Presence of higher proportion of mineralised sludge in a process operated at high SRT is responsible for better setting characteristics and better drainability of sludge.

4.7.1.5 Effect of SRT on Excess of Sludge Production

SRT is inversely related to F/M ratio. A higher operational SRT represents a low F/M ratio, a condition of limiting substrate. The Bacteria undergoes endogenous respiration or decay under a limiting substrate environment. More biomass undergoes endogenous respiration, resulting in lesser net bacterial growth.

Therefore, excess sludge production is reduced if a system is operated at high SRT. Further, since the settling characteristic of sludge improves at high SRT, concentrated underflow can be withdrawn from the sedimentation tank. This results in reduction in excess sludge.

4.7.1.6 Excess Sludge Wasting

Excess bio-sludge is commonly wasted from return sludge line. It can also be wasted directly from aeration tank. If excess bio-sludge is directly wasted from aeration tank, then increased volume of sludge is a disadvantage. However, if excess bio-sludge is mixed with influent of primary settling tank and wasted as mixed sludge of primary settling tank, then direct wasting from aeration tank has no influence on final volume of sludge and therefore, can easily be adopted.

The operator of a plant needs to have an idea of actual volume of excess sludge wasting required.

4.7.1.7 Return Sludge Flow

Sufficient return sludge capacity should be provided if the biological solids are not to be lost in the effluent. However, a return flow rate higher than what is required unnecessarily increases solids loading on settling tank and results in withdrawal of dilute sludge. The ratio of return sludge flow to average flow can be set on the basis of sludge volume index (SVI). It is defined as the volume in ml occupied by one gram of activated sludge mixed liquor solids, dry weight, after settling of 30 min. in a 1,000mL graduated cylinder.

The procedure of SVI measurement is shown in Figure 4.6.

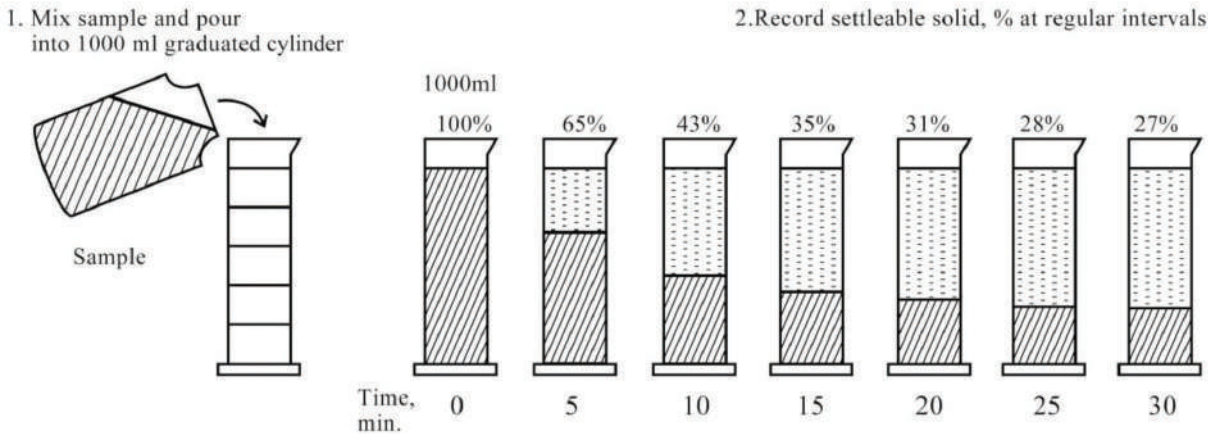


Figure 4.6 Sludge settling analysis

$$SVI \text{ (ml / g)} = \frac{\text{Sludge in settled mixed liquor in 30 min (ml / L)}}{\text{Suspended matter in mixed liquor (mg / L)}} \times \frac{1,000\text{mg}}{1\text{g}} \quad (4.1)$$

- a. Collect a sample of mixed liquor or return sludge.
- b. Gently mix sample and pour into a 1,000mL graduate cylinder. (Vigorous) shaking or mixing tends to break up the flocs and produces slower setting or poorer separation and should be avoided.
- c. Record settleable solids percentage at regular intervals.

Table 4.1 provides SVI values and probable indication of settling properties of activated sludge. For all cases refer to remedies in Troubleshooting in Appendix B.4-1.

Table 4.1 Relations between Sludge Volume Index and settling characteristics of sludge

No	SVI	Indication
1	Less than 50 ml/g	Pin floc potential
2	50 to 100 ml/g	Good range
3	100 to 150 ml/g	Filament growth
4	150 to 200 ml/g	Bulking at high flows
5	200 to 300 ml/g	Bulking
6	More than 300 ml/g	Severe bulking

Source: JICA, 2011

The quantity of return sludge flow is linked to settled sludge volume as in Figure 4.7.

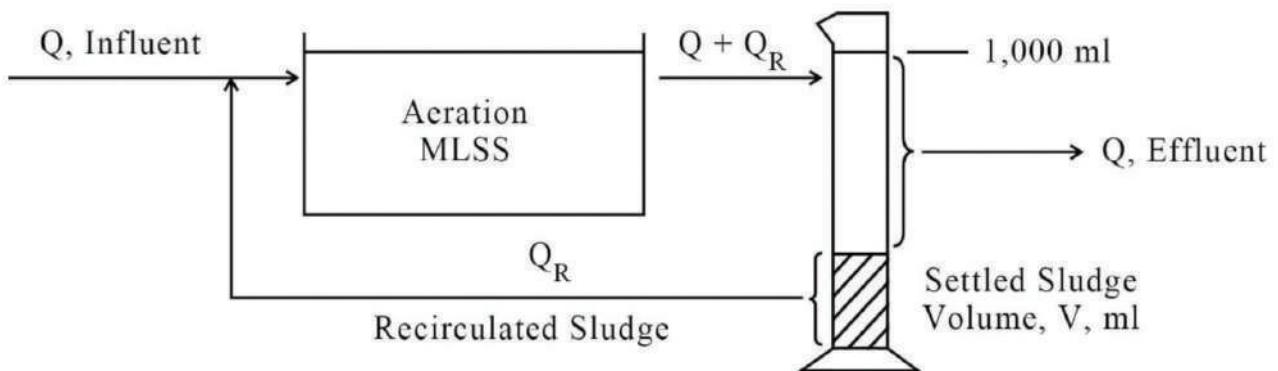


Figure 4.7 Recirculated sludge flow ratio

4.7.2 Conventional Activated Sludge Process

The conventional activated sludge process typically consists of a concrete aeration tank followed by a concrete clarifier.

Sewage and return activated sludge (RAS) enter together or separately into the reactor and leave as mixed liquor.

This mixed liquor flows into the clarifier where it is allowed to settle and the treated effluent separates from the activated sludge.

The settled sewage from the process flows over the clarifier weirs.

The settled activated sludge is recycled to the aeration tank and a portion wasted out of the system as waste activated sludge (WAS).

This is shown in Figure 4.8 overleaf.

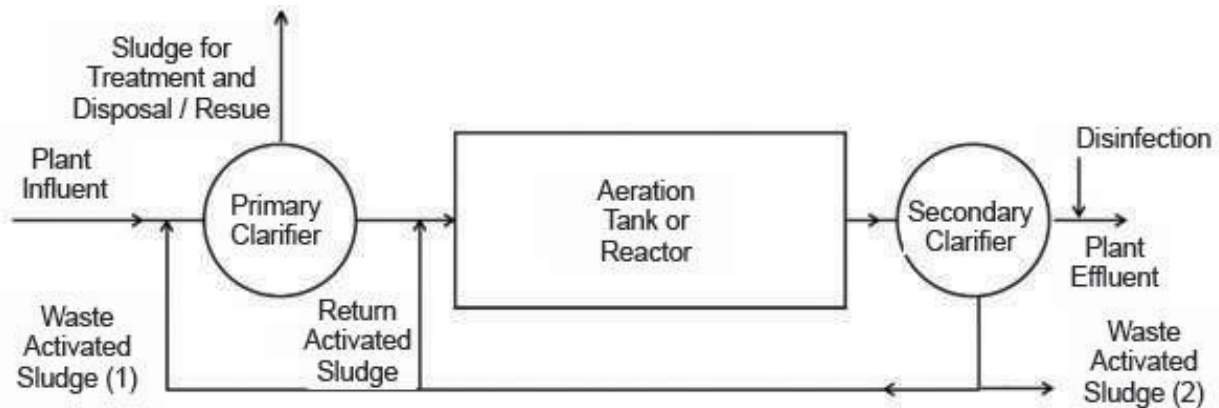


Figure 4-8 Conventional activated sludge process

4.7.2.1 Start Up

The start-up help should be available from the design engineer, vendors, nearby operators, or other specialists. During start-up, the equipment manufacturer should be present to be sure that any equipment breakdowns are not caused by improper start-up procedures.

The operator may have several options in the choice of start-up procedures with regard to number of tanks used and procedures to establish a suitable working culture in the aeration tanks. The method described in this section is recommended because it provides the longest possible aeration time, reduces chances of solids washout and provides the opportunity to use most of the equipment for a good test of its acceptability and workability before the end of the warranty.

First, start the air blowers and have air passing through the diffusers before primary effluent is admitted to the aeration tanks. This prevents diffusers clogging from material in the primary effluent and is particularly important if fine bubble diffusers are used.

Fill both aeration tanks to the normal operating sewage depth, thus allowing the aeration equipment to operate at maximum efficiency. Using all of the aeration tanks will provide the longest possible aeration time. The operators are trying to build up a micro-organism population with a minimum amount of seed organisms, and this will need all the aeration capacity available to give the organisms a chance to reach the settling stage.

After a biological culture of aerobes is established in the aeration tanks, sufficient oxygen must be supplied to the aeration tank to overcome the following demands:

1. Dissolved Oxygen (DO) usually is low in both influent sewage and return sludge to the aerator.
2. Influent sewage may be septic, thus creating an immediate oxygen demand.
3. Organisms in the presence of sufficient food create a high demand for oxygen.

The effluent end of the aeration tank should have a dissolved oxygen level of at least 1.0 mg/L. DO in the aeration tank should be checked every two hours until a pattern is established.

Thereafter, DO should be checked as frequently as needed to maintain the desired DO level and to maintain aerobic conditions in the aerator. Daily flow variations will create different oxygen demands. Until these patterns are established, the operator will not know whether just enough or too much air is being delivered to the aeration tanks. Frequently, DO is high during early mornings when the inflow waste load is low and may be too low during the afternoon and evening hours because the waste load tends to increase during the day.

If sewage enters the tank before air is diffused, the diffusers could become plugged. If the plant is the diffused-air type with airlift pumps for return sludge, the airline valve to the pumps will have to be closed until the settling compartment is filled. Otherwise, all the air will attempt to go to the empty compartment and no air will go to the diffusers. Once the settling compartment is filled from the overflow of the aeration tank, the air lift valves may be opened. They will have to be adjusted to return a constant stream of water and solids to the aeration tank. This adjustment is usually two to three turns of opening on the air valve to each air lift.

There may be a build-up of foam in the aeration compartment during the first week or so of start-up. A 25mm water hose using local surplus fresh water with a lawn sprinkler may be used to keep it under control until sufficient mixed liquor solids are obtained.

Try to build up the solids or MLSS as quickly as possible during start-up.

This can be achieved by not wasting sludge until the desired level of MLSS is achieved.

4.7.2.2 Routine Operation and Maintenance

4.7.2.2.1 Aeration Tanks

The operational variables in an activated sludge plant include:

1. Rate of flow of sewage
2. Air supply
3. MLSS
4. Aeration period
5. DO in aeration and settling tanks
6. Rate of sludge return and sludge condition.

The operator should possess a thorough knowledge of the type of system adopted, namely, conventional, high rate, extended aeration or contact stabilisation so that effective control of the variables can be exercised to achieve the desired efficiency of the plant.

Inspection of mechanical aerators should be done for bearings, bushes and transmission gears.

The lubrication of the bearings, bushes and transmission gears should be carried out as per the schedule suggested by the manufacturer.

The whole unit should be thoroughly inspected once a year, including replacement of worn out parts and painting with anti-corrosive paints to achieve the desired efficiency of the plant. A record of operations should be maintained.

When inhibitory substance for activated sludge (such as industrial sewage) is contained in influent, the treatment may be affected. To avoid such an inhibition, colour and odour of plant influent should be checked through daily inspections such as at the grit chambers or the primary sedimentation tanks where sewage flows in at first. If any abnormal condition is observed, report to a person in charge of water quality or the plant manager.

4.7.2.2 Sewage Flow

Since the activated sludge treatment is biochemical in nature, conditions in the aeration tank should be maintained as uniform as possible at all times. A sudden increase in the rate of flow or sludge of flow should be avoided. If supernatants from digester containing more than 3,000mg/L of SS are taken into the settling tank, then they should be pre-treated as otherwise heavy load will be imposed on the activated sludge system. Measurement of sewage flow and the BOD applied to the aeration tank should be made.

4.7.2.3 Air Supply

Frequent checks of DO at various points in the tank and at the outlet end should be made; it should not be less than 1mg/L. It will help in determining the adequacy of the air supply. The uniformity of air distribution can be easily checked by observing bubbling of the air at the surface, which should be even over the entire surface area of the tank. If the bubbling looks uneven, clogging of diffusers is indicated. Clogging is also confirmed by the increase of 0.01 to 0.015 MPa in the pressure gauge reading. Adding chlorine gas to the air may help in removing clogging of diffusers on air side if it is due to organic matter. Other methods of cleaning will have to be resorted to if this procedure does not clear up the clogging. Air flow meters should be checked periodically for accuracy; air supply and air pressures should be recorded hourly and daily, respectively, to avoid over-aeration or under-aeration. Mechanical or surface aerators should be free from fungus or algae by cleaning them periodically.

4.7.2.4 Mixed Liquor Suspended Solids

Control of the concentration of solids in the mixed liquor of the aeration tanks is an important operating factor. It is most desirable to hold the MLSS constant at the suggested concentration. The test of MLSS should be done at least once a day on large plants, preferably during peak flow. As the MLSS will be minimum when the peak flow starts coming in and will be maximum in the night hours when the flow drops, operating MLSS value would be the average hourly value in a day; the same should be verified at least once a month. In case of large plants, daily check at a fixed time is desirable.

4.7.2.5 Return Sludge

The return sludge pumps provided in multiple units should be operated according to the increase or decrease in return sludge rate of flow required to maintain the necessary MLSS in aeration unit, based on the SVI. The SVI should be determined daily to know the condition of sludge.

A value of over 200 definitely indicates sludge bulking. A good operation calls for prompt removal of excess sludge from the secondary tanks to ensure that the sludge is fully aerobic. This should be recorded daily. The excess sludge is sent directly or through the primary settling tank.

4.7.2.2.6 Foaming

Foaming or frothing is sometimes encountered in activated sludge plants when the sewage contains materials, which reduce the surface tension, the synthetic detergents being the major offender. Froth, besides being unsightly, is easily blown away by wind and contaminates all the surfaces it comes into contact with. It is a hazard to workers because it creates a slippery surface even after the foam collapses. Foam problems can be overcome by the application of a spray of screened effluent or clear water, increasing MLSS concentration, decreasing air supply or addition of other special anti-foam agents. The presence of synthetic anionic detergents in sewage also interferes with the oxygen transfer and reduces aeration efficiency.

4.7.2.2.7 Microscopic Examination

Routine microscopic examination of solids in aeration tank and return sludge to identify the biological flora and fauna will enable good biological control in the aeration tanks.

4.7.2.2.8 Records

Activated sludge operation should include recording of flow rates of sewage and return sludge, DO, MLSS, MLVSS, biota, SRT (sludge age), air, BOD, COD (Chemical Oxygen Demand) and nitrates in both influent and effluent.

4.7.2.2.9 Biological Uptake Rate Procedure

After de-aerating the sample of at least 250 mL of mixed liquor with sodium meta-bi-sulphite start the diffuser and record the dissolved oxygen with time by a dissolved oxygen probe and plot the saturation deficit with time in semi log paper. The slope of the graph is the uptake rate. Generally this is not for a plant control test. It is used for alpha value by comparing it with the value for tap water.

4.7.2.2.10 Nutrient Control

Nutrient control should be as in subsection 5.8.1.7.6, 5.8.1.7.7 and 5.8.1.7.8 in the Part A manual.

4.7.2.2.11 DO Saturation

DO saturation table should be referred as in Table 5-9 and 5-10 in the Part A manual.

4.7.2.3 Aeration Equipment

4.7.2.3.1 Air Blowers

The blower system is designed to provide sufficient airflow to meet the system process requirements. Blower systems are available with either positive displacement (PD) or centrifugal units.

Typically, PD units are used for plants with smaller air volume requirements. Output airflow from a PD blower remains relatively constant with varying discharge pressure. Centrifugal blower systems are generally equipped with additional controls to regulate the flow as the discharge pressure varies.

A. Positive Displacement Blowers

The positive displacement blower provides a constant volume (cubic meters) output of air per revolution for a specific set of rotors or lobes. Blower output is varied by changing the rotor or lobe speed or revolutions per minute (RPM). The higher the RPM, the greater is the air output.

Small positive displacement blowers are usually installed to be operated at a fixed volume output. These smaller units are directly driven by electric motors through a direct coupling or through belts and pulleys.

If a change in air volume output is required, it is accomplished by changing the motor to one with a higher or lower RPM or by changing the pulleys to increase or decrease blower rotor or lobe RPM, thus increasing or decreasing air output.

Note: These small units are commonly used with package plants, pond aeration systems, small aerobic digesters, gas mixing in digesters and gas storage compressors.

Large positive displacement blowers may also be driven by internal combustion engines or variable speed electric motors in order to change blower outputs as required in activated sludge plants.

By increasing or decreasing engine or motor RPM, the positive displacement blower output can be increased or decreased.

The air pipeline is connected to the blower through a flexible coupling in order to keep vibration to a minimum and to allow for heat expansion. When air is compressed, heat is generated; thus increasing the discharge temperature as much as 56 °C or more.

A check valve follows next, which prevents the blower from operating in reverse should other blowers in the same system be operating while this blower is off.

The discharge line from the blower is equipped with an air relief valve, which protects the blower from excessive back pressure and overload. Air relief valves are adjusted by weights or springs to open when air pressure exceeds a point above normal operating range, around 0.04 to 0.07 MPa in most STPs. An air-discharge silencer is also installed to provide decibel noise reduction.

Ear protective devices should be worn when working near noisy blowers.

The impellers are machined on all exterior surfaces for operating at close tolerances; they are statically and dynamically balanced. Impeller shafts are made of machined steel and are securely fastened to the impellers. Timing gears accurately position the impellers.

Lubrication to the gears and bearings is maintained by a lube oil pump driven from one of the impeller shafts. An oil pressure gauge monitors the system oil pressure.

An oil filter is located in the oil sump to ensure that the oil is free from foreign materials. An oil level is maintained in the gear housing so that gears and bearings will receive lubrication in case of lube oil pump failure. Air vents are located between the seals and the impeller chamber to relieve excessive pressure on the seals.

B. Centrifugal Blowers

The centrifugal blower is a motor connected to a speed-increasing gear-driven blower that provides a variable air output.

Minimum to maximum air output is controlled by guide vanes. These guide vanes are located on the intake side of the blower. These vanes are positioned manually or by plant instrumentation based on either DO in the aeration tanks or plant influent flows.

The blower consists of an impeller, volute casing, shaft and bearings, speed-increasing gearbox and an electric motor or internal combustion engine to drive unit. Air enters the volute casing through an inlet nozzle and is picked up by the whirling vanes of the impeller where it is hurled by centrifugal force into the volute casing.

Air enters the volute in its smallest section and moves in a circular motion to the largest section of the volute where it is discharged through the discharge nozzle.

The air pipeline is connected to the blower through flexible couplings in order to keep variation to a minimum and to allow for heat expansion. The air suction line is usually equipped with manually operated butterfly valves that are usually electrically or pneumatically operated.

The impeller is machined on all surfaces for operating at close tolerances and is statically and dynamically balanced. The impeller shaft is supported in a shaft-bearing stand, which contains a thrust bearing and journal bearings.

Lubrication to the bearings and gears is maintained by a positive displacement main oil pump, which is driven by the speed-increasing gear-unit.

An auxiliary centrifugal oil pump is also used to provide oil pressure in the event of failure of the main oil pump and to lubricate the blower shaft bearings before start-up and after shutdown.

The oil reservoir is located in the blower base plate. Cartridge or disc-and-space oil filter is based on the degree of filtration required.

Due to the very high speeds of operation and the resultant high oil temperature, an oil cooler unit is installed. This unit, in most cases, is a shell-and-tube, oil-to-water heat exchanger.

A typical schematic of centrifugal blower is shown in Figure 4.9 overleaf.

C. Air Filters

Filters remove dust and dirt from air before it is compressed and sent to the various plant processes. Clean air is essential for the protection of blowers and downstream equipment.

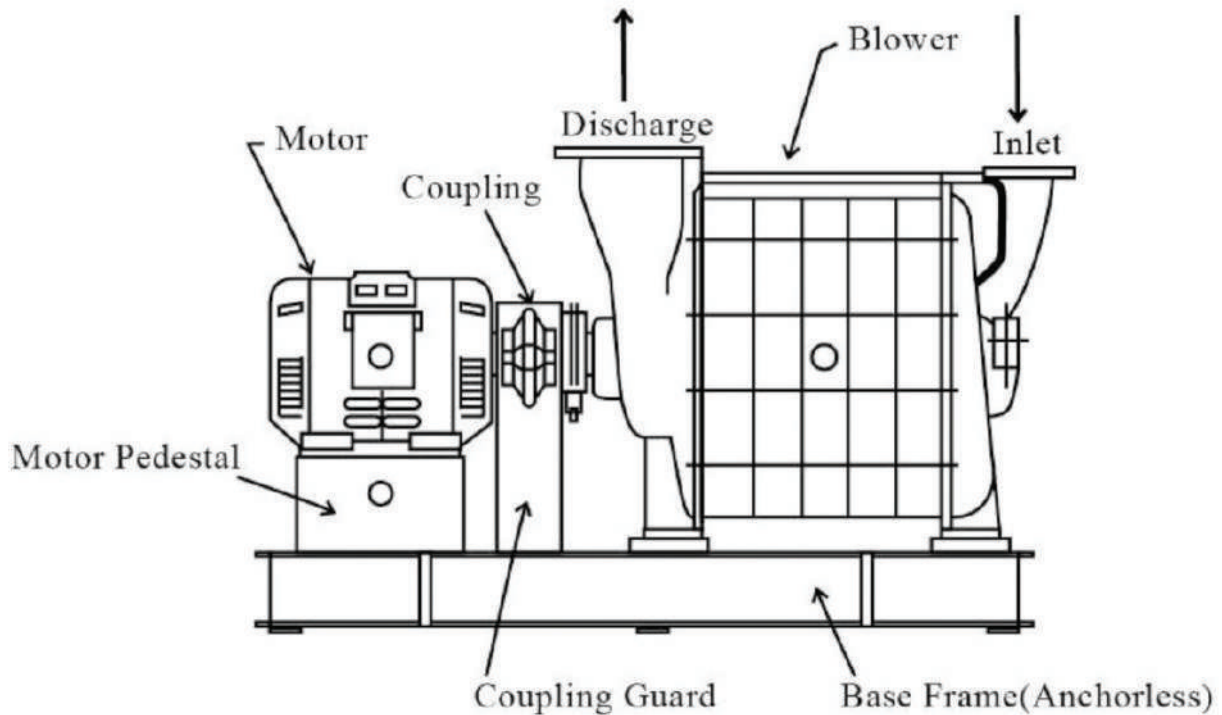


Figure 4.9 Schematic of centrifugal blower

1. Large objects entering the impellers or lobes may cause severe damage on blowers.
2. Deposits on the impellers or lobes reduce clearances and cause excessive wear and vibration problems on blowers.
3. Clean air prevents fouling of air conduits, pipes, tubing or dispersing devices on diffusers.

The filters may be constructed of a fibre mesh or metal mesh material that is sandwiched between the screen material and encased in a frame. The filter frames are then installed in a filter chamber. Other types of filters include bags, oil-coated traveling screens and electrostatic precipitators.

The preventive maintenance schedule for the blowers is as follows:

1. Weekly
 - a. Maintain proper lubricant level
2. Quarterly
 - a. Check for abnormal noises and vibration
 - b. Check if air filters are in place and not clogged
 - c. Check motor bearing for rise in temperature
 - d. Check that all covers are in place and secure
 - e. Lubricate motor ball-bearings
 - f. Check that electrical connections are tight
 - g. Check wiring integrity

3. Biannually

- a. Lubricate motor sleeve bearing
- b. Inspect and clean rotor ends, windings and blades
- c. Check that electrical connections are tight and corrosion is absent

4. Annually

- a. Check bearing oil

4.7.2.3.2 Air Distribution

The air distribution system is to deliver air from the blowers to air headers in the aeration tanks and other plant processes and consists of:

1. Pipes,
2. Valves, and
3. Metering devices

An air-metering device should be located in a straight section of the air main on the discharge side of the blower. Air headers are located in or along the aeration tank and are connected to the air distribution system from which they supply air to the diffusers. The two most common types of air headers are the swing header and the fixed header. The swing header is a pipe with a distribution system connector fitting, a valve, a double pivot upper swing joint, upper and lower riser pipes, pivot elbow, levelling tee and horizontal air headers. An air blow-off leg, as an extension of the lower tee connection, is fabricated with multiple alignment flanges, gaskets and jackscrews for levelling of the header. The fixed header is a pipe with a distribution system connector fitting, a valve, union, a riser pipe, horizontal air headers and header support "feet." These headers are generally not provided with adjustable levelling devices; they rely on the fixed levelling afforded by the "feet" attached to the bottom of the horizontal air headers. Raising and lowering the air header is commonly found in package plants, channel aeration and grit chamber aeration. Header valves are used to adjust the airflow to the header assembly and to block the air flow to the assembly when servicing the header or diffusers. A typical air distribution system is shown in Figure 4.10.

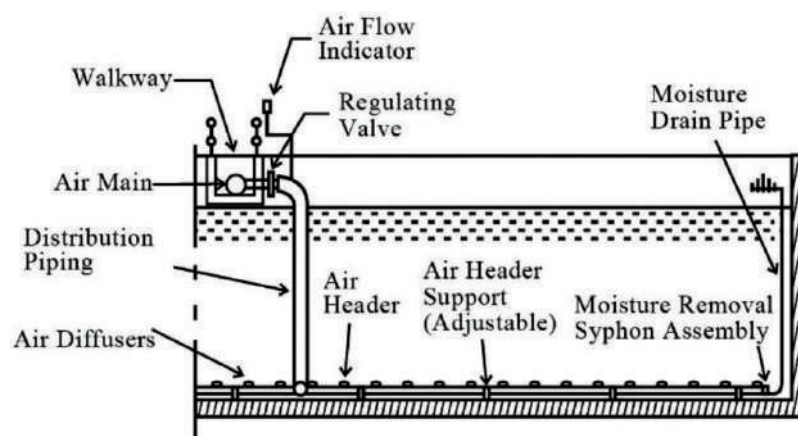


Figure 4.10 Typical air distribution system in aeration tank

4.7.2.3.3 Diffusers

An air diffuser or membrane diffuser is an aeration device used to transfer air and oxygen with oxygen into sewage. Oxygen is required by microorganisms/ bacteria resident in the water to break down the pollutants. Diffusers use the following to produce fine or coarse bubbles.

1. Rubber membrane, or
2. Ceramic elements

The shapes of the diffusers can be:

1. Disc
2. Tube
3. Plate

A. Bubble size

The subject of bubble size is important because the aeration system in a STP consumes an average of 50 – 70 % of the energy of the entire plant. Increasing the oxygen transfer efficiency decreases the power the plant requires to provide the same quality of effluent water.

- Fine bubble
 - Fine bubble diffusers produce very small air bubbles, which rise slowly from the floor of tank and provide substantial and efficient mass transfer of oxygen to the water.
 - Fine bubble diffusers evenly spread out (often referred to as a “grid arrangement”) on the floor of a tank and provide the operator of the plant a great deal of operational flexibility.
 - This can be used to create zones with high oxygen concentrations (toxic or aerobic), zones with minimal oxygen concentration (anaerobic) and zones with no oxygen (anoxic). This allows for more precise targeting and removal of specific contaminants.
- Coarse bubble
 - There are different types of coarse bubble diffusers from various manufactures, such as the stainless steel wide band type coarse bubble diffuser.
 - Fine bubble diffusers have largely replaced coarse bubble diffusers and mechanical aerators in most of the developed world and in much of the developing world

B. Maintenance

The preventive maintenance schedule of bubble diffusers is as follows:

- Daily maintenance
 - Check biological reactor surface pattern

- Check air mains for leaks
- Check and record operating pressure and airflow
- Weekly maintenance
 - Purge water and moisture from distribution piping
 - Check bumps in the diffuser system
- Annual maintenance
 - Drain biological reactor
 - Remove excess solids that may accumulate in the reactor
 - Clean diffusers
 - Check that retaining rings are in place and are tight
 - Check that fixed and expansion joint retaining rings are tight

4.7.2.3.4 Surface Aerators

A surface aerator is a mechanical aeration device for various types of aerobic sewage treatment systems. Surface aerators may be either stationary or floating. The major components of the mechanical surface aerators are motor, gear box and impeller/ aerator/ propeller. More commonly, these components come combined, for the purpose of maintenance, they can be easily separated.

Floating aerators generally employ reinforced fibreglass foam-filled pontoons connected to the aerator platform by a triangular tubular structural frame. The platforms are sized to provide adequate work area around the drive. pontoons are placed to minimise any interference with the flow pattern and maximise stability. Each of the pontoons has a ballast compartment, which can be filled with water or other liquid or other suitable material to adjust submergence and level the unit.

4.7.3 Extended Aeration Process

This is a modification of the activated-sludge process using long aeration periods to promote aerobic digestion of the biological mass by endogenous respiration as in Figure 4.11.

The process includes stabilization of organic matter under aerobic conditions and disposal of the gaseous end products into the air. The plant effluent has finely divided suspended and soluble matter.

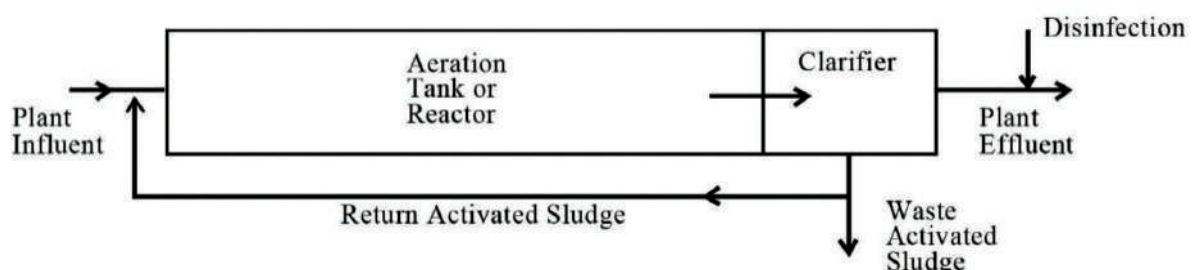


Figure 4.11 Typical extended aeration plant

Extended aeration is similar to a conventional activated sludge process except that the organisms are retained in the aeration tank longer and do not get as much food. The organisms get less food because there are more of them to feed. Mixed liquor suspended solids (MLSS) concentrations are from 3,000–5,000 mg/L and F/M ratio is 0.1 – 0.18. In addition to the organisms consuming the incoming food, they also consume any stored food in the dead organisms.

The new products are carbon dioxide, water, and a biologically inert residue. Extended aeration does not produce as much waste sludge as other processes; however, wasting is still necessary to maintain proper control of the process.

4.7.3.1 Operation of Aeration Equipment

Aeration equipment should be operated continuously 24 x 7, non-stop. In a diffused-air system, the operator controls air flow to the diffuser with the header control valve. This valve forces excess air to the air lifts in the settling compartment. The operator can judge how well the aeration equipment is working by the appearance of the water in the settling compartment and the effluent that goes over the weir. If the water is murky or cloudy and the aeration compartment has a rotten egg (H₂S) odour, it means not enough air is being supplied. The air supplied or aeration rate should be increased slightly each day until the water is clear in the settling compartment. If the water is clear in the settling compartment, the aeration rate is probably sufficient. Try to maintain a DO level of around 2 mg/L throughout the aeration tank, if the operator has a DO probe or lab equipment to measure the DO. Try to measure the DO at different locations in the aeration tank as well as from top to bottom.

4.7.3.2 Operation and Maintenance

Two methods are commonly used to supply oxygen from the air to the bacteria. They are mechanical aeration and diffused aeration. Mechanical aeration devices agitate the water surface in the aerator to cause spray and waves by paddle wheels mixers, rotating brushes or some other method of entraining the air into the sewage so that oxygen can be dissolved into the mixed liquor. Mechanical aerators in the tank tend to be lower in installation and maintenance costs. Usually, they are more versatile in terms of mixing, production of surface area of bubbles, and oxygen transfer per unit of applied power. Diffused air systems break up the air stream from the blower into fine bubbles in the mixed liquor. The smaller the bubble, the greater is the oxygen transfer due to the greater surface area of rising air bubbles surrounded by water. Unfortunately, fine bubbles will tend to regroup into larger bubbles while rising unless they are broken up by suitable mixing energy and turbulence.

Record the pumping time and weekly waste solids for this period if results are satisfactory. If the extended activated sludge plant does not have an aerobic digester, applying waste activated sludge to drying beds may cause odour problems. If odours from waste activated sludge drying beds are a problem, consider the following solutions:

- Waste the excess activated sludge into an aerated holding tank. This tank can be pumped out and the sludge disposed of as in chapter 6 of the Part A manual. If aerated long enough, the sludge could be applied to drying beds.

- Arrange for disposal of the excess activated sludge at a nearby treatment plant. Annually, check the bottom of the hoppers for rocks, sticks, and grit deposits. Also, check the tail pieces of the air lifts to be sure that they are clear of rags and rubber goods and in proper working condition

Frequency and amount of wasting may be revised after several months of operation by examining:

- The amount of carryover of solids in the effluent
- The depth to which the MLSS settle in a one litre measuring jar
- The appearance of flocs and foam in the aeration compartment as to colour, settleability, foam makeup, and excess solids on the surface of the tank
- Results of laboratory testing: a white, fluffy foam indicates low solids content in the aerator while a brown, leathery foam suggests high solids concentrations. If the operator notices high effluent solids levels at the same time each day, the solids loading may be too great for the final clarifier. Excessive solids indicate the MLSS is too high for the flows and more solids should be wasted.

4.7.3.3 Normal Operation

Extended aeration activated sludge plants should be visually checked every day.

Each visit should include the following:

- Check the appearance of the aeration and final clarification compartments.
- Check the aeration unit for proper operation and lubrication.
- Check the return sludge line for proper operation. If air in the airlift is not flowing properly, briefly close the outlet valve, which forces the air to go down and out of the tail piece. This will blow it out and clear any obstructions.
- Reopen the discharge valve and adjust to desired return sludge flow.
- Check the comminuting device for lubrication and operation.
- Hose down the aeration tank and final compartment.
- Brush the weirs when necessary.
- Skim off grease and other floating material such as plastic and rubber goods.
- Check the plant discharge for proper appearances, grease, or material of sewage origin that is not desirable.

4.7.3.4 Abnormal Operation

Remember that changing conditions or abnormal conditions can upset the microorganisms in the aeration tank. As the temperature changes from season to season, the activity of the organisms speeds up or slows down. Also, the flows and waste (food as measured by BOD and suspended solids) in the plant influent change seasonally.

All of these factors require the operator to gradually adjust aeration rates, return sludge rates and wasting rates. Abnormal conditions may consist of high flows or solids concentrations as a result of storms or weekend loads.

4.7.3.5 Counter Measures

Extended aeration plant problems may cause solids in the effluent, odours, and foaming. These problems could be caused by under-or-over aeration, too little or too much solids in the aeration tank, improper return sludge rate, improper sludge wasting or disposal of waste activated sludge, and abnormal influent conditions such as excessive flows or solids or toxic wastes.

When problems develop in the activated sludge process, try to identify the problem, the cause of the problem, and select the best possible solution. Remember that the activated sludge process is a biological process and may require from three days to a week or longer to show any response to corrective action. Allow seven or more days for the process to stabilize after making a change in the treatment process.

A. Solids in the Effluent

- i If effluent appears turbid (muddy or cloudy), the return activated sludge pumping rate is out of balance. Try increasing the return sludge rate. Also, consider the possible presence of something toxic to the microorganisms or a hydraulic overload washing out some of the solids.
- ii If the activated sludge is not settling in the clarifier (sludge bulking), several possible factors could be causing this problem. Look for too low a solids level in the system, low dissolved oxygen concentrations in the aeration tank, strong, stale, septic influent, high grease levels in influent, or alkaline wastes from a laundry.
- iii If the solids level is too high in the sludge compartment of the secondary clarifier, solids will appear in the effluent. Try increasing the return sludge pumping rate. If odours are present and the aeration tank mixed liquor appears black as compared with the usual brown colour, try increasing aeration rates and look for septic dead spots.
- iv If light-coloured floating sludge solids are observed on the clarifier surface, try reducing the aeration rates. Try to maintain the DO at around 2 mg/L throughout the entire aeration tank.

B. Odours

- i If the effluent is turbid and the aeration tank mixed liquor appears black as compared with the usual brown colour, try increasing aeration rates and look for septic dead spots.
- ii If clumps of black solids appear on the clarifier surface, try increasing the return sludge rate. Also, be sure the sludge return line is not plugged and that there are no septic dead spots around the edges or elsewhere in the clarifier.
- iii Examine the method of wasting and disposing of waste activated sludge to ensure this is not the source of the odours.

- iv Poor housekeeping could result in odours. Do not allow solids to accumulate or debris removed from sewage to be stored in the plant in open containers.

C. Foaming/Frothing

Foaming is usually caused by too low a solids level while frothing is caused by too long a solids retention time.

- i If too much activated sludge was wasted, reduce wasting rate.
- ii If over aeration caused excessive foaming, reduce aeration rates.
- iii If plant is recovering from overload or septic conditions, allow time for recovery.
- iv Foaming can be controlled by water sprays or commercially available de-foaming agents, until the cause is corrected by reducing or stopping, wasting and building up solids levels in the aeration tank.
 - i. Learn more about the operation of an activated sludge process under both normal and abnormal conditions. The operator can also use the troubleshooting guide for activated sludge plants.

4.7.3.6 Maintenance

Maintenance of equipment in extended aeration plants should follow the manufacturer's instructions. Items requiring attention include:

A. Plant Cleanliness

Wash down tank walls, weirs, and channels to reduce the collection of odour-causing materials.

B. Aeration Equipment:

- i. Air blowers and air diffusion units
- ii. Mechanical aerators

C. Air Lift Pumps

D. Scum Skimmer

E. Sludge Scrapers

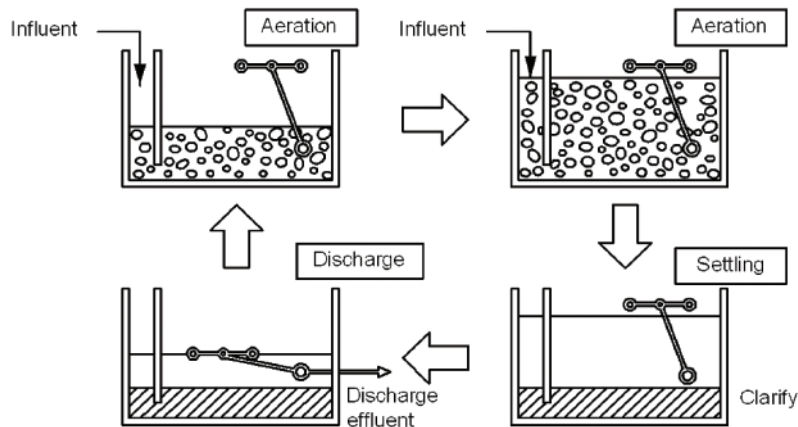
F. Froth Spray System

G. Weirs, Gates and Valves

H. Raw Sewage Pumps

4.7.4 Sequencing Batch Reactor (SBR)

In SBR operations, the cycle processes Fill-react, React, Settle and Decant are controlled by time intervals to achieve the objectives of the operation. Each process is associated with particular reactor conditions (turbulent/quiescent, aerobic/anaerobic) that promote selected changes in the chemical and physical nature of the sewage. These changes lead ultimately to a fully treated effluent. Figure 4.12 shows a typical SBR operation.



Source: Nishihara Environment Co., Ltd.

Figure 4.12 Operating cycles of intermittent SBR process

- Fill or Fill-react

The purpose of Fill-React operation is to add substrate (raw sewage) to the reactor. The addition of substrate can be controlled either by limit switches to a set volume or by a timer to a set time period. If the volume is set, the Fill-React process typically allows the liquid levels in the reactor to rise from 50–80 %– 100 %. If controlled by time, the Fill-React process normally lasts approximately 25 %– 50 % of the full cycle time. Period of aeration and/or mixing during the fill are critical to the development of organisms with good settling characteristics and to biological nutrient removal (Nitrogen (N), Phosphorus (P)). An advantage of the SBR system of time control is its ability to modify the reactor conditions during the phases to achieve the treatment goals. This phase ends when the liquid level in the tank reaches a predetermined level.

- Settle

The purpose of Settle is to allow solids separation to occur and providing a clarified supernatant to be discharged as effluent. In the SBR, this process is normally more efficient than in a continuous flow system, because in the Settle mode the reactor contents are completely quiescent. The Settle process is controlled by time and is usually fixed between 30 minutes to an hour so that the sludge blanket remains below the withdrawal mechanism during the next phase.

- Decant/Discharge

The purpose of Decantation is to remove the clarified, treated water from the reactor.

Sludge wasting is another important step in SBR operation that greatly affects process performance. It is not included as one of the three basin processes because there is no set time-period within the cycle dedicated to wasting. The amount and frequency of sludge wasting is determined by process requirements, as with conventional continuous flow systems. In an SBR operation, sludge wasting usually occurs during the Settle or Decant phases. A unique feature of the SBR system is that the RAS system is in the SBR basing itself. Since the aeration and settling occurs in the same tank, no sludge is lost in the reaction phase and none has to return from clarifier to maintain the MLSS in the aeration tank. This eliminates the hardware of the conventional ASP.

The sludge volume and, thus, sludge age in the reactor of the SBR system is controlled by sludge wasting only.

The manual given by the equipment supplier should be followed. Usually these units are controlled automatically by programmable logic controllers (PLCs). The precaution needed is to make sure that power supply is available continuously. If power supply fails, immediately bring the genset on-line. If there is no genset or if there is no diesel, do not operate the SBR and close it. Inform the plant in charge and also report to the official responsible for overall O&M in the head office directly.

4.7.4.1 Process Control

The SBR has in built process control. Depending on the BOD load, it adjusts the Dissolved Oxygen (DO) supply by sensing the residual DO and varying the speed of air compressor and hence the rate of air supply. The most important thing for day-to-day testing is to understand the SBR as designed. It may have fully aerobic or anoxic and aerobic or anaerobic, anoxic and aerobic cycles.

If anaerobic cycle is there, check whether the floor level mixer is working and if it is out of order, start the installed standby mixer. If both are not in order, enter in the site register and inform the plant in charge. Make sure that hydrogen sulphide gas is not sensed in the ambient air near the SBR. If it is sensed by smell, then going near the tank is not advisable. Make sure it is entered in the site register and it is reported directly to the plant-in-charge. The operator should not try and remedy the position. The supervisor should institute and take steps to get the designer, contractor and O&M team together and rectify the situation. There is a theory that COD to sulphate ratio is deciding the process. This needs to be checked and corrected. A method of correcting the imbalance will be to recycle the treated effluent from a treated sewage sump to dilute the COD of incoming sewage. The daily tests shall be pH, COD and dissolved phosphate measured by colorimetric method or Nessler Tubes of 50 ml with fresh standards prepared every week. BOD can be a weekly test.

In the anoxic cycle, check whether the floor level mixer is working and if it is out of order, start the installed standby mixer. If both are not in order, enter it in the site register and inform the plant in charge. Daily tests will be nitrate estimated by Nesslerization procedure in 50 ml Nessler tubes. The test is to be done in the beginning, in the mid cycle and at the completion of the cycle of anoxic phase. If there is no reduction in the nitrate, then something is not in order. Proceed to check the MLVSS. It should be at least 75 %. If this is not so, enter the value in the site register and inform the plant-in-charge. The supervisor should institute and take steps to get the designer, contractor and O&M team together and rectify the situation.

In the aeration cycle, check the residual DO. This is to be indicated by the built in sensor. If the sensor is not working use the Winkler method by collecting the mixed liquor and filtering it through Whatman filter paper number 4 in a BOD bottle and with the tip of the funnel connected by a rubber tubing so that the filtrate enters the BOD bottle in the submerged condition always and avoids additional aeration. A procedure for easy use in the field for instantly testing the BOD is to use a "Palintest tube." This has been introduced in the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) by M/S Severn Trent of UK as part of a twinning arrangement. Details of the tube can be obtained from CMWSSB. A photograph of the CMWSSB chemist using the tube is shown in Figure 4.13.



Source: CMWSSB

Figure 4.13 Use of a BOD tube for instantaneous assessment of the BOD at site

The principle of the test is related to the BOD caused by colloidal and suspended organics as related to the BOD. The BOD related to suspended solids is inbuilt in the calibration. This tube is developed only for sewage and not for industrial effluents. The test is performed by holding the tube as in the photo after filling the treated sewage to incremental heights and finding out at which point, the black coloured + mark at the bottom vanishes. There is a reading etched on the side of the tube and this is read at the sewage level when the + mark vanishes from sight. The principle is the colloidal solids and SS have their portion of BOD. The more the volume needed to “hide” the bottom + mark, the less is the colloidal solids and SS and hence, the lesser is the BOD due to this portion. It is a combination of nephelometry and theory. Usually the results are within 90% accuracy .

The Palintest tube

The Palintest Tube is a specially calibrated plastic tube and is the simplest possible method of performing the instantaneous probable BOD and SS tests on secondary treated sewage in the field to help the operator to get a feel of these parameters quickly. The test kit is a tube graduated at 30 to 500 turbidity units. A double length tube with additional graduations from 5 to 25 turbidity units is optionally available. These were calibrated by the Department of Public Health Engineering, University of Newcastle upon Tyne. It has an etched black cross mark at bottom.

- Procedure
 - Hold the tube vertically over a white surface and view downwards.
 - Gradually pour secondary sewage and watch the cross mark.
 - Stop pouring when the cross mark is no longer visible.
 - Read the graduation at the top of the sample in the tube.
 - This represents the turbidity in Jackson Turbidity units (JTU).
 - For secondary sewage, the graduation may also be taken as SS.
 - Half the value of JTU plus 5 is also the probable BOD.

If the DO is lesser than 20 % of the design value, enter it in the site register and inform the plant in charge. Check the MLVSS if the above situation occurs. This can be a weekly test. Check the COD. In the settling cycle, check the SS of the decanted effluent and its COD. There is no need to check the BOD at the end of every cycle. Prepare a curve of BOD to COD for the treated sewage and verify the BOD by testing for the COD. This will show the trend every two hours itself instead of 3 days for BOD actual test. This can however be a weekly test. If the SS and BOD varies by more than 10 % in the treated sewage, enter the values in the site register and inform the plant-in-charge. The decanter cannot be subjected to preventive maintenance in a functioning SBR. The raw sewage has to be bypassed with prior permission of the supervisor before this is carried out. The electrical drive of the decanter will require its greasing in some equipment. Make sure there is a grease guard and grease does not fall into the SBR basin. Where the rope and pulley method is used, change the rope every month.

4.7.4.2 Records

The limited parameters as above and the flow rate and cycle times are the records.

4.7.4.3 Housekeeping

In all SBR systems, verify the build-up of slime on the sidewalls in the freeboard. If noticed, scrub it down into the SBR basin itself during the filling phase. This can be done by standing on the peripheral walkway and using a long handle wire brush. If there is no such walkway, leave the slime as it is.

4.7.5 Oxidation Ditch

An oxidation ditch (OD) is a modified activated sludge biological treatment process that utilizes long Solids Retention Times (SRTs) to remove biodegradable organics. OD are typically complete mix systems, but they can be modified to approach plug flow conditions. (Note: As conditions approach plug flow, diffused air must be used to provide enough mixing. The system will also no longer operate as an oxidation ditch). Typical OD treatment systems consist of a single or multichannel configuration within a ring, oval, or horseshoe-shaped basin. As a result, OD are called “racetrack type” reactors. Horizontally mounted rotors or vertically mounted aerators provide circulation and aeration in the ditch.

Preliminary treatment, such as bar screens and grit removal, normally precedes the OD. Primary settling prior to an OD is sometimes practiced, but is not typical in this design.

Flow to the OD is aerated and mixed with return sludge from a secondary clarifier. A typical process flow diagram for an activated sludge plant using an OD is shown in Figure 4.14 overleaf.

There is usually no primary settling tank or grit removal system used in this process. Inorganic solids such as sand, silt and cinders are captured in the OD and removed during sludge wasting or cleaning operations. The raw sewage passes directly through a bar screen to the OD.

The bar screen is necessary for the protection of the mechanical equipment such as rotor and pumps. Comminutors or barminutors may be installed after the bar screen or instead of a bar screen.

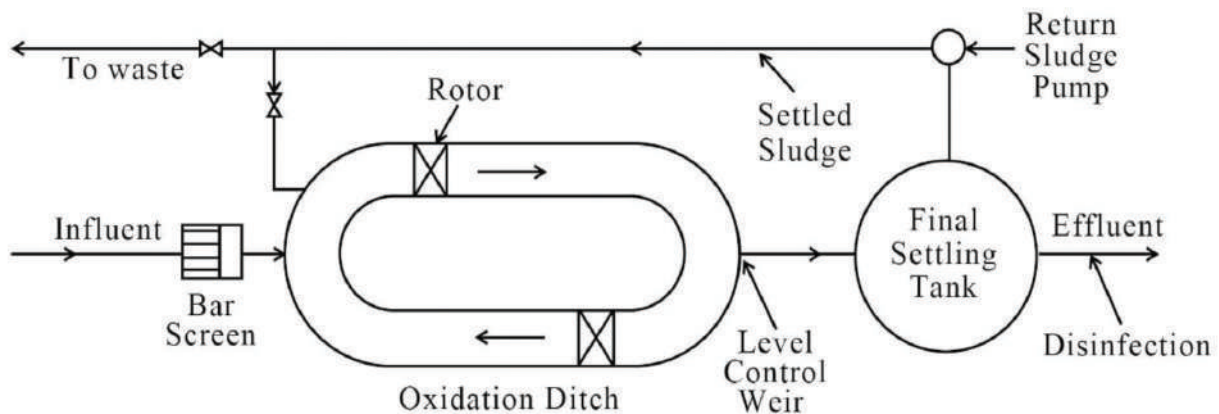


Figure 4.14 Oxidation ditch

The OD forms the aeration basin and here the raw sewage is mixed with previously formed active organisms. The rotor is the aeration device that entrains (dissolves) the necessary oxygen into the liquid for microbial life and keeps the contents of the ditch mixed and moving.

The velocity of the liquid in the OD must be maintained to prevent settling of solids, normally 0.3 to 0.45 m/sec. The ends of the OD are well rounded to prevent eddying and dead areas, and the outside edges of the curves are given erosion protection measures.

The mixed liquor flows from the OD to a clarifier for separation. The clarified water passes over the effluent weir and is chlorinated. Plant effluent is discharged either to a receiving stream, percolation ditch, a subsurface disposal or leaching system.

The settled sludge is removed from the bottom of the clarifier by a pump and is returned to the OD or wasted. Scum that floats to the surface of the clarifier is removed and either returned to the OD for further treatment or disposed of by burial.

Since the OD is operated as a closed system, the amount of volatile suspended solids will gradually increase. It will periodically become necessary to remove some sludge from the process. Wasting of sludge lowers the MLSS concentration in the OD and keeps the microorganisms more active.

4.7.5.1 Operation

Process controls and operation of an OD are similar to the activated sludge process. To obtain maximum performance efficiency, the following control methods must be maintained.

A. Proper Food Supply for the Microorganisms

Influent flows and waste characteristics are subject to limited control by the operator. Municipal ordinances may prohibit discharge of materials that are damaging to treatment structures or to human safety. Control over wastes dumped into the collection system

requires a pre-treatment facility inspection programme to ensure compliance. Alternate means of disposal, pre-treatment, or controlled discharge of significantly damaging wastes may be required in order to permit dilution to an acceptable level by the time the sewage arrives at the STP.

B. Proper DO Levels

Proper operation of the process depends on the rotor assembly supplying the right amount of oxygen to the waste flow in the OD. For the best operation, a DO concentration of 0.5 to 2.0 mg/L should be maintained just upstream of the rotors. Over oxygenation wastes power and excessive DO levels can cause a pinpoint flocs to form that does not settle and is lost over the weir in the settling tank. Control of rotor oxygenation is achieved by adjusting the OD outlet level control weir. The level or elevation of the rotors is fixed but the deeper the rotors submerge in the water, the greater the transfer of oxygen from the air to the water (greater DO). The ditch outlet level control weir regulates the level of sewage in the OD.

C. Proper Environment

The OD process with its long-term aeration basin is designed to carry MLSS concentrations of 3,000 to 5,000mg/L. This provides a large organism mass in the system. Performance of the OD and its environment can be evaluated by conducting a few simple tests and general observations. The colour and characteristics of the flocs in the OD as well as the clarity of the effluent should be observed and recorded daily. Typical tests are settleable solids, DO upstream of the rotor, pH, and residual chlorine in the plant effluent.

Laboratory tests such as BOD, COD, suspended solids (SS), volatile solids (VS), total solids(TS), and microscopic examinations should be performed periodically by the plant operator or an outside laboratory. The results will aid operator in determining the actual operating efficiency and performance of the process.

OD solids are controlled by regulating the return sludge rate and waste sludge rate. Remember that solids continue to deteriorate as long as they remain in the clarifier. Adjust the return sludge rate to return the microorganisms in a healthy condition from the clarifiers to the OD. If dark solids appear in the clarifier, either the return sludge rate should be increased (solids remaining too long in clarifier) or the DO levels are too low in the OD.

Adjusting the waste sludge rate regulates the solids concentration (number of microorganisms) in the OD. The appearance of the surface of the OD can be a helpful indication of whether the sludge wasting rate should be increased or decreased. If the foam on the surface is white and crisp, reduce the wasting rate. If the foam on the surface is thick and dark, increase the wasting rate. WAS may be removed from the ditch by pumping to a sludge holding tank, to sludge drying beds, to sludge lagoons, or to a tank truck. Ultimate disposal may be to larger treatment plants or as in chapter 5.

Remember that this is a biological treatment process and several days may be required before the process responds to operation changes. Make operator changes slowly, be patient, and observe and record the results.

D. Proper Treatment Time and Flow Velocities

Treatment time is directly related to the flow of sewage and is controlled by an adjustable weir. Velocities in the ditch should be at 0.3 to 0.45 m/sec to prevent the deposition of flocs.

E. Proper Water/Solids Separation

MLSS that have entered and settled in the secondary clarifier are continuously removed from the clarifier as return sludge, by pump, for return to the OD. Usually, all sludge formed by the process and settled in the clarifier is returned to the ditch, except when wasting sludge. Scum that is captured on the surface of the clarifier also is removed and either returned to the OD for further treatment or disposal by burial.

F. Observations

Some aspects of the operation of an OD can be controlled and adjusted with the help of some general observations. General, daily observations of the plant are important to help operator determine whether the oxidation ditch is operating as intended. These observations include colour of the mixed liquor in the ditch, odour at the plant site, and clarity of the ditch and clarifier surfaces.

i. Colour

Operator should note the colour of the mixed liquor in the ditch daily. Mixed liquor from a properly operating OD should have a medium to rich, dark brown colour. If the MLSS, following proper start-up, changes colour from a dark brown to a light brown and the MLSS appears to be thinner than before, the sludge waste rate may be too high, which may cause the plant to lose efficiency in removing waste materials. By decreasing sludge wasting rates before the colour lightens too much, the operator can ensure that the plant effluent quality will not deteriorate due to low MLSS concentrations.

If the MLSS becomes black, the OD is not receiving enough oxygen and has gone anaerobic. The oxygen output of the rotors must be increased to eliminate the black colour and return the process to normal aerobic operation.

This is done by increasing the submergence level of the rotor.

ii. Odour

When the OD is operating properly, there will be little or no odour. Odour, if detected, should have an earthy smell. If any odour other than this is present, the operator should check and determine the cause. Odour similar to rotten eggs indicates that the ditch may be anaerobic, requiring more oxygen or a higher ditch velocity to prevent deposition of solids. Odour may also be a sign of poor housekeeping. Grease and solids build-up on the edge of the ditch or clarifier will cause odours and become anaerobic.

In an OD, odours are much more often caused by poor housekeeping than by poor operation.

iii. Clarity

In a properly operating OD, a layer of clear water or supernatant is usually visible about a meter upstream from the rotor. The depth of this relatively clear water may vary from almost nothing to as much as five or more cm above the mixed liquor. The clarity will depend on the ditch velocity and the settling characteristics of the activated sludge solids. Two other good indications of a properly operating OD are the clarity of the clarifier water surface and the OD surface free of foam build-up. Foam build-up in the ditch is usually caused by insufficient MLSS concentration. Most frequently foam build-up is only seen during plant start-up and will gradually disappear. Clarity of the effluent from the secondary clarifier discharged over the weirs is the best indication of plant performance. A very clear effluent shows that the plant is achieving excellent pollutant removals. A cloudy effluent often indicates a problem with the plant operation.

4.7.5.2 Equipment Maintenance

Scheduled equipment maintenance must be performed regularly according to manufacturers' instruction manuals. The operator should check each piece of equipment daily to see that it is functioning properly. There may be very few mechanical devices in the oxidation ditch plant, but they are all important.

The rotors and pumps should be inspected to ensure that they are operating properly. If pumps are clogged, the obstructions should be removed. Listen for unusual noises. Check for loose bolts. Uncovering a mechanical problem in its early stages could prevent a costly repair or replacement at a later date.

Lubrication should also be performed with a fixed operating schedule and properly recorded. Follow the lubrication and maintenance instructions furnished with each piece of equipment. Make sure that the proper lubricants are used. Over lubrication is wasteful and reduces the effectiveness of lubricant seals and may cause overheating of bearings or gears.

4.7.6 Chemical Clarification

Chemicals are used for a variety of municipal treatment applications, such as to enhance flocculation / sedimentation, condition solids, add nutrients, neutralize acid base, precipitate phosphorus, and disinfect or to control odours, algae, or activated-sludge bulking. Chemical precipitation is a widely used, proven technology for the removal of metals and other inorganics, suspended solids, fats, oils, greases, and some other organic substances (including organophosphates) from sewage.

Precipitation is assisted through the use of a coagulant, an agent which causes smaller particles suspended in solution to gather into larger aggregates. Frequently, polymers are used as coagulants. The long-chain polymer molecules can be either positively or negatively charged (cationic or anionic) or neutral (non-ionic). Since sewage chemistry typically involves the interaction of ions and other charged particles in suspension, these electrical qualities allow the polymers to act as bridges between particles suspended in solution, or to neutralize particles. The specific approach used for precipitation will depend on the contaminants to be removed, as described below.

4.7.6.1 Metals Removal

Hardness is caused primarily by the dissolution of calcium and magnesium carbonate and bicarbonate compounds in water, and to a lesser extent, by the sulphates, chlorides, and silicates of these metals. The removal of these dissolved compounds, called water softening often proceeds by chemical precipitation. Lime (calcium oxide), when added to hard water, reacts to form calcium carbonate, which itself can act as a coagulant, sweeping ions out of solution in formation and settling. To achieve this with lime alone, a great deal of lime is typically needed to work effectively; for this reason, the lime is often added in conjunction with ferrous sulphate, producing insoluble ferric hydroxide. The combination of lime and ferrous sulphate is only effective in the presence of dissolved oxygen, however. Alum, when added to water containing calcium and magnesium bicarbonate alkalinity, reacts with the alkaline substances to form an insoluble aluminium hydroxide precipitate. Soluble heavy metal ions can be converted into insoluble metal hydroxides through the addition of hydroxide compounds. Additionally, insoluble metal sulphides can be formed with the addition of ferrous sulphate and lime.

Once the optimal pH for precipitation is established, the settling process is often accelerated by addition of a polymer coagulant, which gathers the insoluble metal compound particles into a coarse flocs that can settle rapidly by gravity. However, these reactions cannot occur in raw or primary treated sewage due to interference from organic matter.

4.7.6.2 Phosphorus Removal

Metal salts (most commonly ferric chloride or aluminium sulphate, also called alum) or lime, have been used for the removal of phosphate compounds from water. When lime is used, a sufficient amount of lime must be added to increase the pH of the solution to at least 10, creating an environment in which excess calcium ions can react with the phosphate to produce an insoluble precipitate (hydroxyl apatite). Lime is an effective phosphate removal agent, but results in a large sludge volume.

When ferric chloride or alum is used, the iron or aluminium ions in solution will react with phosphate to produce insoluble metal phosphates. The degree of insolubility for these compounds is pH dependent.

4.7.6.3 Suspended Solids

Finely divided particles suspended in solution can escape filtration and other similar removal processes. Their small size allows them to remain suspended over extended periods of time.

More often than not, the particles in sewage are negatively charged. For this reason, cationic polymers are commonly added to the solution, both to reduce the surface charge of the particles, and also to form bridges between the particles, thus causing particle coagulation and settling.

Alternatively, lime can be used as a clarifying agent for removal of particulate matter. The calcium hydroxide reacts in the sewage solution to form calcium carbonate, which also acts as a coagulant, sweeping particles out of solution.

4.7.6.4 Additional Considerations

The amount of chemicals required for treatment depends on the pH and alkalinity of the sewage, the phosphate level, and the point of injection and mixing modes, among other factors.

Competing reactions often make it difficult to calculate the quantities of additives necessary for chemical precipitation. Accurate doses should be determined by jar tests and confirmed by field evaluations. Chemicals are usually added by a chemical feed system that can be completely enclosed and may also include storage space for unused chemicals.

Choosing the most effective coagulant depends on jar test results, ease of storage, ease of transportation, and consideration of the O & M costs for associated equipment.

Chemical precipitation is normally carried out through a chemical feed system, most often a totally automated system providing for automatic chemical feeding, monitoring, and control. Full automation reduces manpower requirements, allows for less sophisticated operator oversight, and increases efficiency through continuous operation.

An automatic feed system may consist of storage tanks, feed tanks, metering pumps (although pumpless systems do exist), overflow containment basins, mixers, aging tanks, injection quills, shot feeders, piping, fittings and valves.

Chemical feed system storage tanks should have sufficient capacity to run for some time without running out and causing downtime. At least one month supply of chemical storage capacity is recommended, though lesser quantities may be justified when a reliable supplier is located nearby, thus eliminating the need for maintaining substantial storage space. Additive chemicals come in liquid and dry form.

4.7.6.5 Jar Testing

Secondary treated sewage from STPs may sometimes carry over the microbes from the clarifier. When chlorination of the treated sewage is to be carried out, these suspended microbes will consume the added chlorine before the organic matter in the treated sewage can be oxidized and pathogenic faecal organisms can be killed. Hence, it may be necessary to carry out coagulation, flocculation and sedimentation before chlorine is applied. For details of the theory of coagulation, flocculation and sedimentation, the CPHEEO Manual on Water Supply and Treatment may be consulted. The purpose of a jar test is to find out which chemical and at what dosage is needed to improve the clarity of secondary treated sewage. In general, such coagulation, flocculation and sedimentation are not recommended for raw sewage because the disposal of the resulting sludge becomes difficult due to a mix of biological and chemical sludge.

At the same time, the phosphorous present in sewage at even as low as 1 mg/L is known to form a coating around the flocs and prevent them from settling and this in fact increases the turbidity of raw sewage.

This is the reverse of addition of phosphate to cooling waters to prevent the precipitated scales from settling out in the heat exchanger surfaces.

Jar testing entails adjusting the amount of treatment chemicals and the sequence in which they are added to samples of raw sewage held in jars or beakers. The sample is then stirred so that the formation, development, and settlement of floc can be watched just as it would be in the full-scale treatment plant. A typical laboratory bench-scale jar test apparatus is shown in Figure 4.15.



Source: <http://www.neutecgroup.com>

Figure 4.15 Typical Jar Testing apparatus

The apparatus allows for six samples each of 1-2 litre in size, to be tested simultaneously. The procedure of jar testing is as follows;

The following jar test procedure uses alum (aluminium sulphate) a chemical for coagulation/flocculation in sewage treatment, and a typical six jar tester.

- A. First, using a 1,000 millilitre (ml) graduated cylinder, add 1,000 ml of raw water to each of the jar test beakers. Record the temperature, pH, turbidity, and alkalinity of the raw water before beginning of the test.
- B. Prepare a stock solution by dissolving 10.0 grams of alum into 1,000 ml distilled water. Each 1.0 ml of this stock solution will equal 10 mg/L (ppm) when added to 1,000 ml of water to be tested.
- C. Using the prepared stock solution of alum, dose each beaker with increased amounts of the solution. The increments and dosage are shown in Table 4.2 overleaf.
- D. After dosing each beaker, turn on the stirrers. This part of the procedure should reflect the actual conditions of the plant to the extent possible. This indicates that if the plant has a static mixer following chemical addition, followed by 30 minutes in a flocculator, then 1.5 hours of settling time before the filters, then the test also should have these steps. The jar test would be performed as follows: Operate the stirrers at a high RPM for 1 minute to simulate the rapid mixer.

Table 4.2 Dosing in Jar Test

Jar No.	ml Alum Stock Added	mg/L Alum Dosage
1	1.0	10.0
2	1.5	15.0
3	2.0	20.0
4	2.5	25.0
5	3.0	30.0
6	3.5	35.0

- E. Reduce the speed of the stirrers to match the conditions in the flocculator and allow them to operate for 30 minutes. Observe the floc formation periodically during the 30 minutes.
- F. At the end of 30 minutes turn off the stirrers and allow settling. Most of the settling will be complete after one hour.
- G. Use a pipette to draw a portion from the top of each beaker, and measure its turbidity.
- H. Plot supernatant turbidity versus alum dose as in Figure 4.16 for the sewage sample and comment on the shape of the graph .

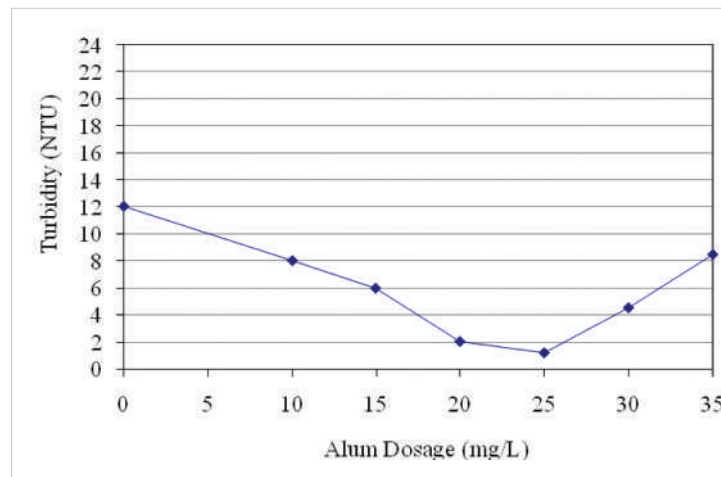


Figure 4.16 Supernatant turbidity vs. Alum dose

- I. Find out the optimum alum dose. i.e., 25 mg/L from Figure 4.16.

If none of the beakers appear to have good results, then the procedure needs to be run again using different dosages until the correct dosage is found

4.8 AERATED LAGOON

The aerated lagoon process consists of aeration of the facultative pond of the stabilization pond by means of an aerator. (Refer to Section 4.13 “Waste stabilization pond”)

Aerated lagoons are generally provided in the form of simple earthen basins with inlet at one end and outlet at the other to enable the sewage to flow through while aeration is usually provided by mechanical means to stabilize the organic matter. The major difference between activated sludge systems and aerated lagoons is that the clarifiers and sludge recirculation are absent in the later.

4.8.1 Process Control

Daily tests will be for SS and COD. The BOD will be obtained from the standard curve made out for this sewage from a curve of BOD to COD. The BOD tube is also useful. There is nothing much to do by way of process control in aerated lagoon except making sure that all surface aerators are in working condition. Some aerated lagoons have a final section of the lagoon itself as the settling compartment. Some other lagoons have a dedicated clarifier outside the lagoon. In such a case, the return sludge is also provided in some STPs. This return sludge arrangement must run continuously. The excess sludge disposal is not provided for in aerated lagoons normally. In case of clarifiers it may be used. Mechanical dewatering facilities are generally not advised because the MLSS concentrations will be much lesser than in conventional ASPs. Sludge drying beds with green cover to prevent direct rainfall on the beds is the answer to such situations.

The DO concentration in an aerated lagoon is the best means to determine if the lagoon is operating properly. Depthwise measurement of DO is to be carried out. Typical practice is to maintain 1 to 2 mg/l DO in the lagoon. A minimum DO level of 1 mg/l should be maintained in the lagoon during the heaviest loading periods. Often the heaviest oxygen demand is during the night when the algae are respiring. The pH range in the lagoon should range from 7 to 8. The pH can exceed 9 during algal blooms, especially in low-alkalinity sewage. Surface mechanical aerators when used should produce good turbulence and a light amount of froth.

4.8.2 Records

The limited parameters as above and the flow rate and cycle times shall be maintained as per records.

4.8.3 Housekeeping

Keep the bunds free of any grass or weeds. Do not allow branches of trees to hang over the lagoon. Follow all guidelines for motors. If high speed floating aerators are used, pull them out of the lagoon before attending to it. Check if the power cable is having sufficient slack. Verify that the power cable is tied at about 3m centers to vertical secure posts. Do not enter the lagoon unless you are wearing a life vest and are on a boat with an aide if the aerators are not connected by a platform.

In all aerated lagoons, weeds and over hanging tree branches shall be avoided. A photo of such a situation is shown in Figure 4.17 overleaf.

- The tree roots will enter the lining and break the concrete slab joints easily.
- Once this occurs, the slabs will lose their strength and start falling down into the lagoon itself.
- Once this sets in, the earth in the bund will be easily eroded in rains and the bund will cave in.

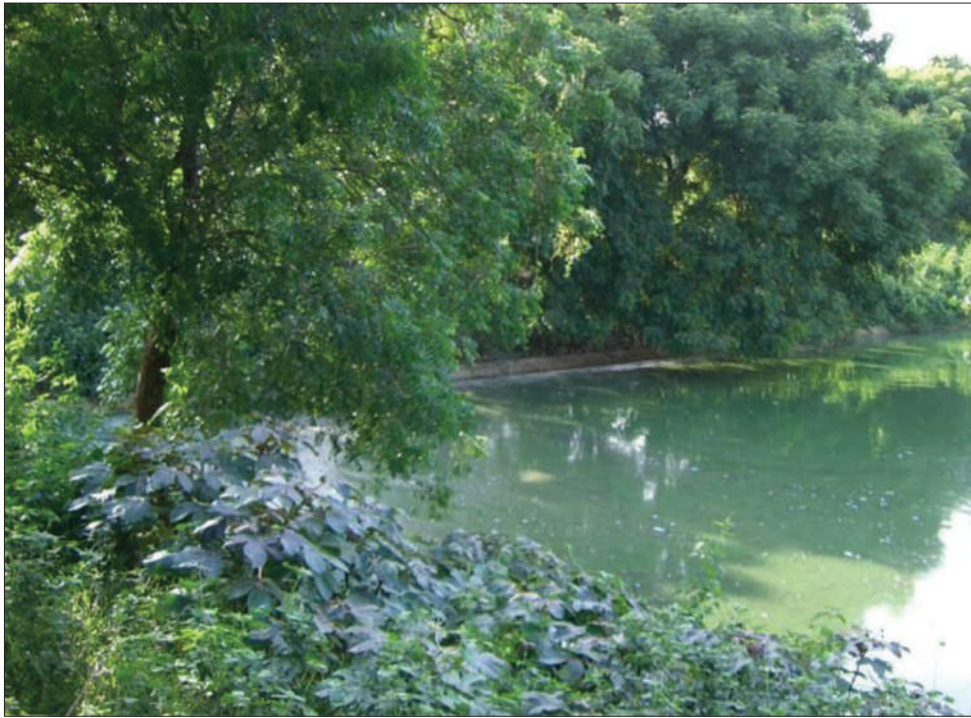


Figure 4.17 Over hanging Tree branches and the small area of the Lined bund may be seen

- This leads to the lagoon sewage running out on land and polluting the land and water in wells and streams.
- The hanging tree branches will be dropping leaves, which will support growth of mosquitoes.
- Manual scraping shall be done from the top of bund and not by persons entering the lagoon.
- In such cases, the branches shall be cut and the cut portions sealed with cow dung.

The biggest danger is if the bund gets broken and sewage escapes; it is very difficult to control

- Reconstructing the bund is also a problem when raw sewage keeps coming daily.
- Stopping the sewage escaping from the broken bund can be done by the following:
- Pack cement bags with mix of 90 % clay and 10% sewage and stack them one over the other.
- These have to be dumped to form a cofferdam inside the sewage spread.
- Thereafter, the reconstruction of the bund can be taken up easily.

4.9 ATTACHED GROWTH SYSTEMS

One of major attached growth systems adopted in sewage treatment lately is a “fixed film synthetic media filter”, which consists of synthetic media such as inclined corrugated media placed in cube sized packs and the inclinations changed to opposite directions in successive layers as shown in Figure 4.18 overleaf.

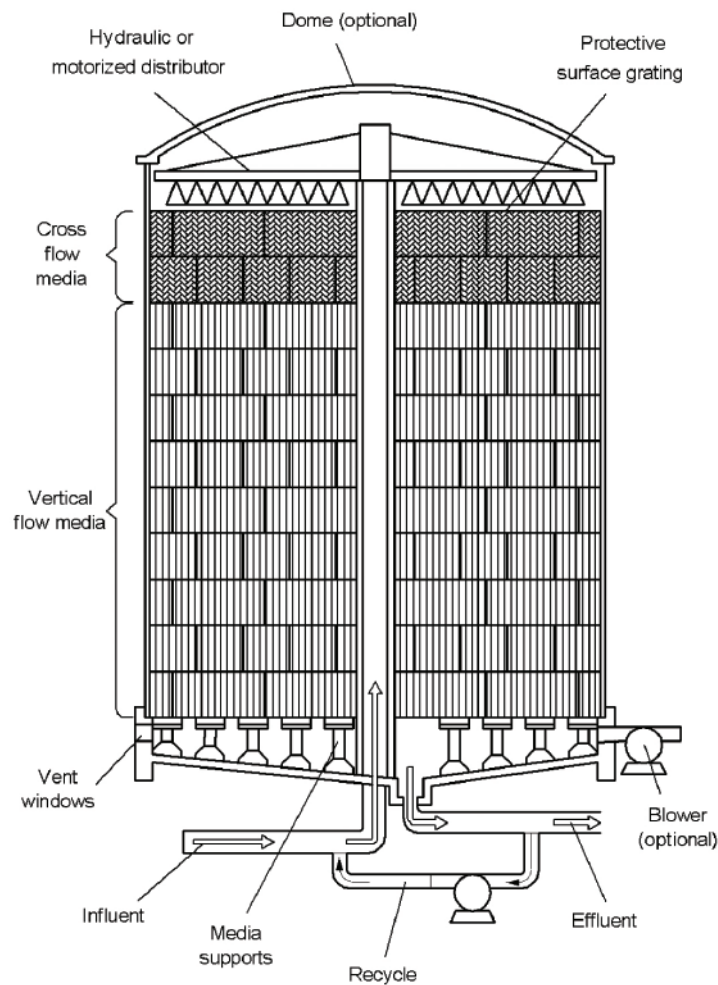


Figure 4.18 Fixed Film Synthetic Media Filters

Primary sedimentation is a pre-requirement in these applications. In Figure 4.18, the applied sewage is distributed from the top of the media pack by stationary or hydraulically driven reverse jet arms on opposite radii or rotated by a mechanical drive. The requirements to apply the sewage on the entire plan are to uniformly and simultaneously allow the gas exchange by releasing at the top and fresh air automatically forcing itself from the bottom.

The microbial films develop on the fixed media and bring about the metabolism as the sewage passes over them as a film. In due course of time, the thickness of the film increases and results in sloughing and getting carried away to secondary settling tanks. Recirculation of the treated effluent is sometimes practiced to the attached system so that the enzymes released by the microbes are returned to the reactor for solubilising the sewage organic matter. In all attached growth systems wastewater should be applied 24 x 7.

4.9.1 Operation

Many operating problems may be avoided by changing one or more of the following process control variables: distribution rates, and clarifier operation.

A. Distribution Rates

As a principal process control measure, operators can control the rates at which sewage and filter effluent are distributed to the filter media. Recirculation can serve several purposes, as follows:

- Reduce the strength of the sewage being applied to the filter.
- Increase the hydraulic load to reduce flies, snails, or other nuisances.
- Maintain distributor movement during low flows.
- Produce hydraulic shear to encourage solids sloughing and prevent ponding.
- Reseed the filter's microbial population.
- Provide uniform flow distribution.
- Prevent filters from drying out.

B. Clarifier Operation.

The manner in which secondary clarifiers are operated can significantly affect the filter performance. Although clarifier operation with fixed film reactors is not as critical as that with suspended-growth systems, operators must still pay close attention to final settling.

Sludge must be removed quickly from the final settling tank before gasification occurs or denitrification causes solids to rise. Use of the secondary clarifier as a principal means of thickening (rather than simply for solids settling) may not produce the best effluent quality, especially during summer months, when denitrification is likely to occur. The sludge blanket depth in the secondary clarifier should be limited to 0.3 to 0.6 m. Continuous pumping or intermittent pumping with automatic timer controls are used to accomplish solids wasting.

4.9.2 Maintenance

Planned maintenance will vary from plant to plant, depending on unique design features and equipment installed. Although this chapter cannot address all of these items, a summary of the most common and important maintenance tasks follows. The information provided in Table 4.3 overleaf is not equipment or plant-specific. Therefore, both the manufacturer's literature and engineer's operating instructions should be consulted and followed. The frequency of maintenance procedures depends on site specific conditions. However, until operating experience is gained, frequent plant inspections and maintenance should continue.

Maintenance schedules should consider the increased performance of fixed film synthetic media filters in warm weather months, which may reduce the effect of removing process units from service.

4.10 MOVING BED BIO REACTOR (MBBR)

4.10.1 Configuration

The moving bed biofilm reactor (MBBR) is based on the biofilm carrier elements. Several types of synthetic biofilm carrier elements have been developed for use in activated sludge process.

Table 4.3 Planned maintenance for fixed film synthetic media filters

Rotary Distributors
Observe the distributor daily. Make sure the rotation is smooth and that spray nozzles are not plugged.
Lubricate the main support bearings and any guide or stabilizing bearings according to the manufacturer’s instructions. Change lubricant periodically, typically twice a year. If the bearings are oil-lubricated, check the oil level, drain condensate weekly, and add oil as needed.
Time the rotational speed of the distributor at one or more flow rates. Record and file the results for future comparison. A change in speed at the same flow rate indicates bearing trouble.
Flush distributor arms monthly by opening end shear gates or blind flanges to remove debris. Drain the arms if idle during cold weather to prevent damage via freezing.
Clean orifices weekly with a high-pressure stream of water or with a hooked piece of wire.
Keep distributor arm vent pipes free of ice, grease, and solids. Clean in the same manner as the distributor arm orifices. Air pockets will form if the vents are plugged. Air pockets will cause uneven hydraulic loading in the filter, and non-uniform load and excessive wear of the distributor support bearing.
Make sure distributor arms are level. To maintain level, the vertical guy wire should be taken up during the summer and let out during the winter by adjusting the guy wire tie rods. Maintain arms in the correct horizontal orientation by adjusting horizontal tie rods.
Periodically check distributor seal and, if applicable, the influent pipe to distributor expansion joint for leaks. Replace as necessary. During replacement check seal plates for wear and replace if wear is excessive. Some seals should be kept submerged even if the filter is idle or their life will be severely shortened.
Remove ice from distributor arms. Ice build-up causes non-uniform loads and reduces main bearing life.
Paint the distributor as needed to guard against corrosion. Cover bearings when sand blasting to protect against contamination. Check oil by draining a little oil through a nylon stocking after sandblasting. Ground the distributor arms to protect bearings if welding on distributor and lock out the drive mechanism at the main electrical panel. Adjust secondary arm overflow weirs and pan test sewage distribution on filter as needed.
Fixed nozzle distributors
Observe spray pattern daily. Unplug block nozzles manually or by increasing hydraulic loading. Flush headers and laterals monthly by opening end plates. Adjust nozzle spring tension as needed.
Filter media
Observe condition of filter media surface daily. Remove leaves, large solids and plastics, grease balls, broken wood lath or plastic media, and other debris. If ponding is evident, find and eliminate the cause. Keep vent pipes open, and remove accumulated debris.

Store extra plastic media out of sunlight to prevent damage via ultraviolet rays. Observe media for settling. After they are installed, media settle because of their own weight and the weight of the bio film and water attached to its surface. Settling should be uniform and should stabilize after a few weeks. Total settling is typically less than 0.3 m for random plastic media, less for plastic sheet media, and nearly zero for rock. If settling is non-uniform or excessive, remove some of the media for inspection.
Observe media for hydraulic erosion, particularly in regions where reversing jets hit the media.
Under drains
Flush out periodically if possible. Remove debris from the effluent channels.
Media containment structure
Maintain spray against inside wall of filter to prevent filter fly infestation and to prevent ice build-up in winter.
Practice good housekeeping. Keep fibreglass, concrete, or steel outside walls clean and painted, if applicable. Keep grass around structures cut, and remove weeds and tall shrubs to help prevent filter fly and other insect infestations. Remember, using insecticides around treatment units may have adverse effects on water quality or biological treatment units.
Filter pumps
Check packing or mechanical seals for leakage daily. Adjust or replace as needed. Lubricate pump and motor bearings as per manufacturer's instructions. Keep pump motor as clean and dry as possible. Periodically check shaft sleeves, wearing rings, and impellers for wear; repair or replace as needed. Perform maintenance of speed reducer, coupling, and other appurtenant equipment maintenance according to manufacturer's instructions.
Secondary clarifier
Lubricate drive motor bearings, speed-reducing gear, drive chains, work and spur gears, and the main support bearing for the solids-collection equipment according to the manufacturer's instructions. Flush scum troughs and grease wells daily. Maintain solids withdrawal equipment. Clean effluent wells and baffles at least weekly. Paint or otherwise protect equipment from corrosion as needed.
Appurtenant equipment
Maintain piping, valves, forced draft blowers, and other appurtenant equipment according to the manufacturer's instructions.

Source: WEF, 2008

These biofilm carrier elements may be suspended in the activated sludge mixed liquor in the aeration tank by air from the diffusers in aerobic reactors and by means of propeller mixers in anaerobic and anoxic reactors. The carrier elements are retained by suitably sized sieves or plates. These processes are intended to enhance the activated sludge process by providing a greater biomass concentration in the aeration tank and thus offer the potential to reduce the basin size requirements. They have also been used to improve the volumetric nitrification rates and to accomplish the denitrification in aeration tanks by having anoxic zones within the biofilm depth. Because of the complexity of the process and issues related to understanding the biofilm area and activity, the process design is empirical and based on prior pilot-plant or limited full-scale results.

The typical diagram of MBBR is shown in Figure 4.19.

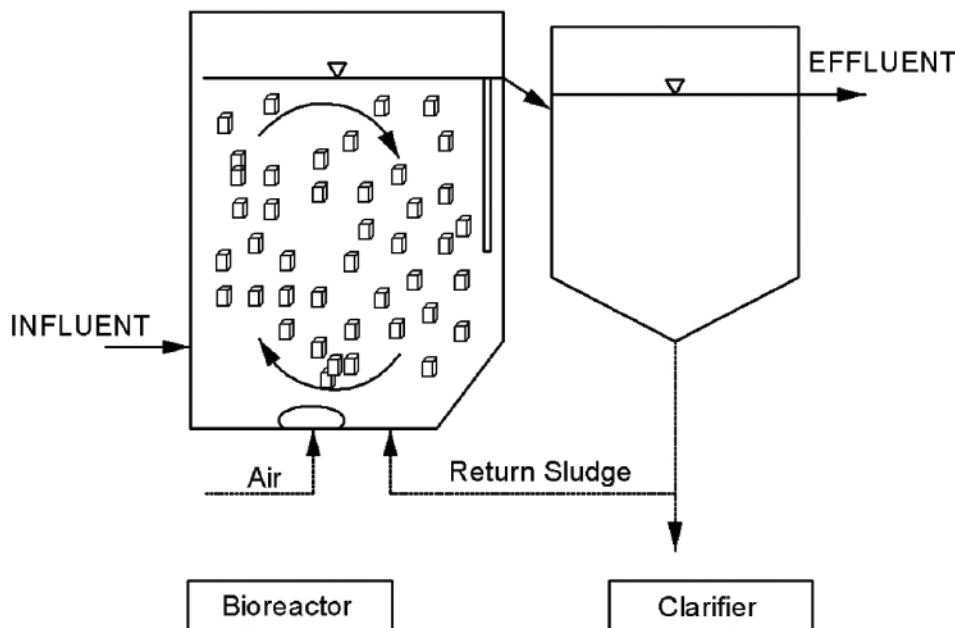


Figure 4.19: Moving bed bioreactor

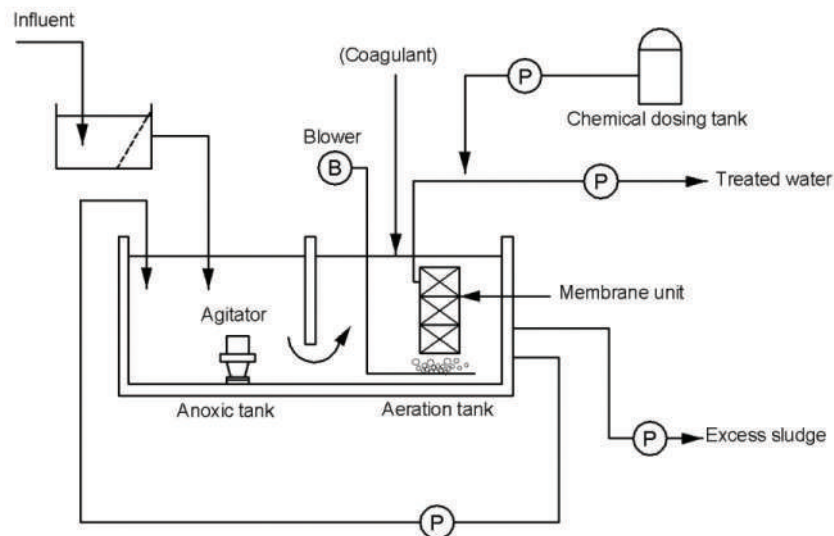
4.10.2 Operation and Maintenance

There are now more than 10 different variations of the process in which a biofilm carrier material of various types is suspended in the aeration tank of the activated sludge process.

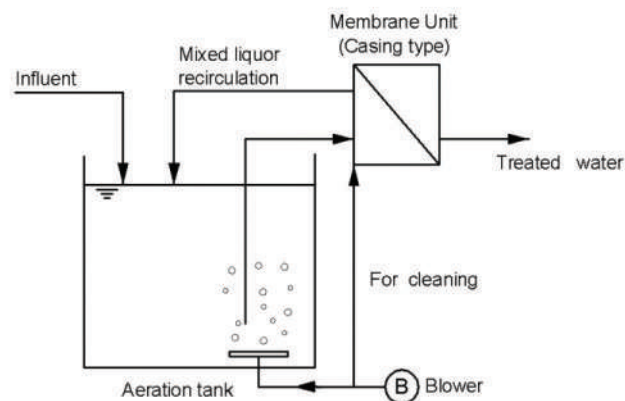
Differently varied processes have their own characteristics and require specific O&M. Therefore, operators should have thorough knowledge on their systems and implement daily O&M according to the manufacturers' instruction manuals. Refer to Part-A 5.18.13 MBBR for system description on the varieties of MBBR.

4.11 MEMBRANE BIO REACTOR (MBR)

The membrane bioreactor (MBR) process is a combination of activated sludge process and membrane separation process. Low-pressure membranes (ultra-filtration or microfiltration) are commonly used. Membranes can be submerged in the biological reactor or located in a separate stage or compartment and are used for liquid-solid separation instead of settling process as in Figure 4.20 overleaf. Basically, primary sedimentation tank, final sedimentation tank and disinfection facility are not installed in this process. The reaction tanks comprise an anoxic tank and an aerobic tank, and the membrane modules are immersed in the aerobic tank. Pre-treated, screened influent enters the membrane bioreactor, where biodegradation takes place. The mixed liquor is withdrawn by water head difference or suction pump through membrane modules in a reaction tank, being filtered and separated into solid and liquid. Surfaces of the membrane are continuously washed down during operation by the mixed flow of air and liquid generated by air diffuser set at the bottom of the reaction tank. Permeate from the membranes constitutes the treated effluent.



(a) Immersed membrane system



(b) External membrane system

Source: JSWA

Figure 4.20 Configuration of membrane bioreactor system

4.11.1 Operation

All MBR systems require some degree of suction or pumping to force the water flowing through the membrane. One type of membrane systems uses a pressurized system to push the water through the membranes. The major systems used in MBRs draw a vacuum through the membranes so that the water outside is at ambient pressure. The advantage of the vacuum is that it is gentler to the membranes; the advantage of the pressure is that throughput can be controlled. Both systems also include techniques for continually cleaning the system to maintain membrane life and keep the system operational for as long as possible.

All the principal membrane systems used in MBRs use an air scour technique to reduce build-up of material on the membranes. This is done by blowing air around the membranes out of the manifolds.

The permeate from an MBR has low levels of suspended solids, as also levels of bacteria, BOD, nitrogen, and phosphorus. Disinfection is easy and may not even be required, depending on discharge standards.

The solids retained by the membrane are recycled to the biological reactor and build up in the system. As in conventional biological systems, periodic sludge wasting eliminates sludge build-up and controls the SRT within the MBR system. The waste sludge from MBR goes through standard solids-handling technologies for thickening, dewatering, and ultimate disposal. Chemical addition increases the ability of solids to settle. As more MBR facilities are built and operated, a more definitive understanding of the characteristics of the resulting sludge will be achieved. However, experience to date indicates that conventional sludge processing unit operations are also applicable to the waste sludge from MBR.

4.11.2 Maintenance

The key to the cost-effectiveness of an MBR system is membrane life. If membrane life gets curtailed such that frequent replacement is required, costs will increase significantly. Membrane life can be increased in the following ways:

Good screening of solids before the membranes to protect the membranes from physical damage.

Throughput rates that are not excessive, i.e., that do not push the system to the limits of the design. Low rates reduce the amount of material that is forced into the membrane, and thereby reduce the amount that has to be removed by cleaners or that will cause eventual membrane deterioration.

Mild cleaners/cleaning solutions most often used with MBRs include regular bleach (sodium) and citric acid, which are regularly used. The cleaning should be in accordance with manufacturer's recommended maintenance protocols.

4.12 UP FLOW ANAEROBIC SLUDGE BLANKET REACTOR (UASB)

The Up flow Anaerobic Sludge Blanket reactor (UASB) maintains a high concentration of biomass through formation of highly settleable microbial aggregates. The sewage flows upwards through a layer of sludge. Separation between gas-solid-liquid takes place at the top of the reactor phase. Any biomass leaving the reaction zone is directly recirculated from the settling zone. The process is suitable for both soluble wastes and those containing particulate matter. The process has been used for treatment of municipal sewage at few locations and hence performance data and experience available presently are limited. The Up flow Anaerobic Sludge Blanket reactor (UASB) is shown in Figure 4.21 overleaf.

4.12.1 Plant Commissioning and Operation

Two to three months are needed to build up a satisfactory sludge blanket without the addition of "seed" sludge from a working UASB. A shorter time is sufficient, if seeding is done.

During the start-up period, COD removal in the UASB gradually improves as sludge accumulation occurs. This may be called the sludge accumulation phase.

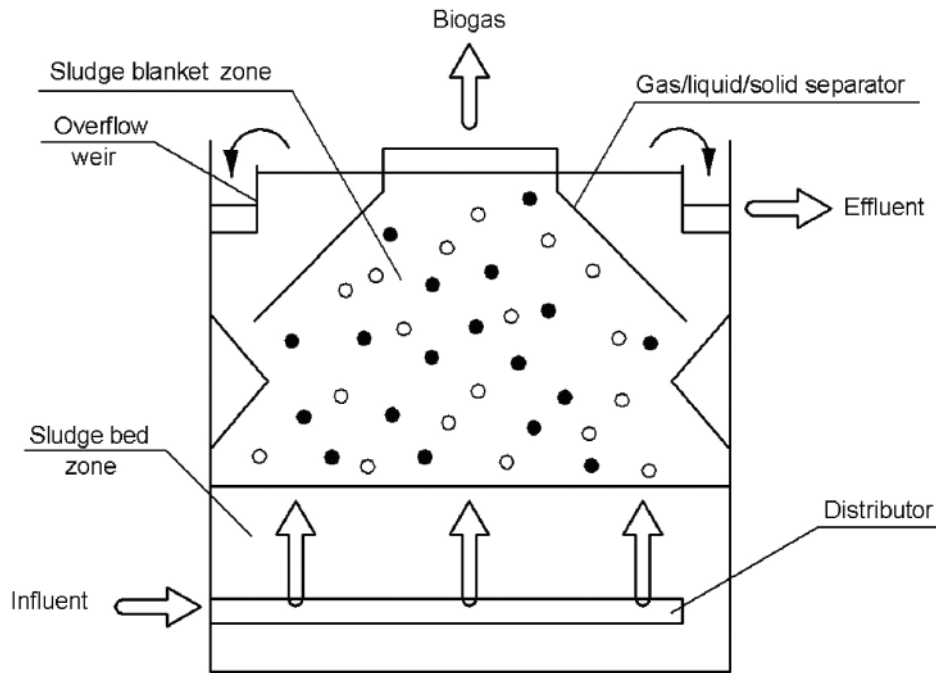


Figure 4.21 Schematic diagram of an Up flow Anaerobic Sludge Blanket Reactor

The end of the sludge accumulation phase is indicated by sludge washout. At this time, the reactor is shut down to improve the quality of the sludge. This may be called the sludge improvement phase. After sludge improvement, blanket formation starts. Once the blanket is formed, again some surplus sludge washout could occur and to stabilise the stable operation, the excess sludge needs to be removed periodically. The excess sludge so removed can be sent directly for sludge treatment.

The sludge in the UASB is tested for pH, volatile fatty acids (VFA), alkalinity, COD and SS. If the pH reduces while VFA increases, the sewage should not be allowed into the UASB until the pH and VFA stabilise. Daily operation of the UASB requires minimum attention. No special instrumentation is necessary for control, especially where gas conversion to electric power is not practiced. As stated, surplus sludge is easy to dry over an open sand bed. The reactor may need to be emptied completely once in five years, while any floating material (scum) accumulated inside the gas collector channels may have to be removed every two years to ensure free flow of gas.

4.12.2 Daily Operation and Maintenance of UASB

A. Cleaning of Effluent Gutters

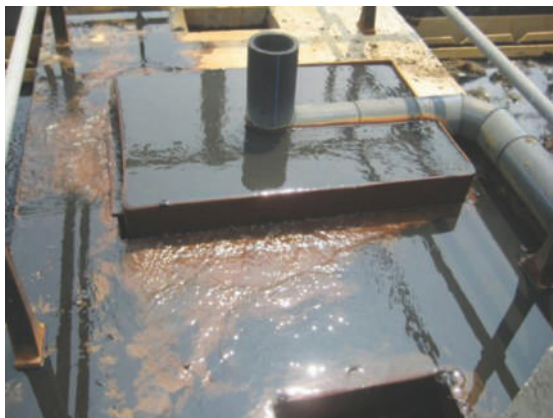
All V-notches must be cleaned in order to maintain the uniform withdrawal of UASB effluent coming out of each V-notch. The irregular flow from each V-notch results in the escape of more solids washout. Similarly, blocking of the V-notches of the effluent gutters will lead to uneven distribution of sewage in the reactor. Therefore, the effluent gutters have to be inspected on a regular basis to remove any material blocking and even the outflow over the V-notches in the gutters. The regular maintenance involves cleaning of V-notches with a broom three times a day and removing sludge with a brush or with a water jet once a day as in Figure 4.22 overleaf.



Figure 4.22 Cleaning of effluent gutters

B. Unclogging Feeder Pipes

The feeder pipes should be checked regularly for clogging. Flexible iron rods can be used for this purpose. A submersible pump can be used to unclog the feeder pipes as in Figure 4.23.



Submersible pump



Cleaning of feed pipes by submersible pumps Clean feed pipes (equal flow distribution)

Source: PWSSB

Figure 4.23 Cleaning of Feed Inlet Pipes

The appropriate valve can be closed and the treated sewage can be pumped through the clogged feeder pipe and this will unclog the feeder pipe. The valve can be opened after the feeder pipe is free of the blockage. Compressed air if available at the location can also be used to unclog the feeder pipe. An air lift pump can also be used for this purpose. These feeder pipes are generally clogged due to rags and floating material. It is necessary to provide a fine screen or extra prevention at the screen to capture floating material at the pre-treatment unit itself.

C. Removal of Floating Mat

Floating mat must be removed from the top of the surface of reactor with a rake. The removed material should be disposed at the dumping site.

D. Check of Leakage of Biogas

The gas collectors should be checked for leakage. Leakage is easily detected by applying soap solution to the piping. This should be done on a regular basis. If the gas collectors are leaking, the valve at the end of one bay in the gas leak should be first closed and then repaired as soon as possible.

Regular maintenance includes opening of hatch boxes and removing floating layer inside the gas collectors.

E. Scrubbing of Biogas

Waste at the Top of UASB Reactor

The risk of the corrosion of dual fuel engine parts, as biogas contains H_2S , can be minimised if biogas can be scrubbed before using it as fuel for dual fuel gas engines.

F. Check for Sludge Withdrawal Ports

The ports of the sludge withdrawal must be free from any clogging which reduces the chances of checking of sludge height in reactor. The feeder pipes should be checked regularly for clogging. Flexible synthetic rods can serve the purpose. A submersible pump can be used to unclog the feeder pipes.

G. Methanogenic Activity

Successful operation of a UASB reactor depends upon maintaining a satisfactory balance between methane and acidogenic bacteria. The methane formers are susceptible to changes in environmental conditions such as pH, temperature etc. The methanogenic activity must be analysed monthly. The testing can be outsourced.

H. Proper Sludge Wasting

Sludge must be removed or transferred from the UASB reactor occasionally based on the sludge yield or concentration of TSS or VSS. Higher sludge withdrawal points to a poor performance of the reactor in terms of treatment.

I. Biogas Analysis

The biogas analysis is used largely at STP where information on fuel value of gas is important. In addition, knowledge of gas composition can be of considerable help in the control of digestion units. Sudden changes in gas composition can signal a change either in the operation of the treatment unit or in the amount or composition of incoming sewage. Such changes can thus be used as a warning sign to suggest the need for closer observation and control of treatment unit. The testing can be outsourced.

J. Hydrogen Sulfide Determination

The determination of hydrogen sulphide will continue to be an important consideration wherever gas is used for fuel in gas engines, particularly in areas where the sulphate content of sewage is very high.

K. Sludge Pumping Station Maintenance

After every sludge withdrawal operation, clean the pipeline by opening the top flushing valve until all the sludge in the pipeline is washed out. The sump has to be cleaned with water.

Never keep the sludge in the sump, it may damage the pumps. Before getting into the sumps for any maintenance, keep the top cover open for an hour before anybody gets in so that any accumulated biogas will vent to the atmosphere. Keep the valve chamber dry and valves clean. Check the electrical components regularly.

L. Biogas Holder Operation and Maintenance

The biogas produced in the reactors is taken in the common Fibre Glass Reinforced Plastic (FRP) pipes to the biogas holder. The biogas before being sent to the gas holder has to pass through a moisture trap. The gas coming to the gas holder is measured through gas flow meters connected to FRP pipe after the moisture trap

The biogas before going to the holder is branched off. One branch is taken to the flaring system, the other to the biogas engine. Before going to the engine, the gas is measured from the flow meter provided on pipeline going to the engine. Sluice valves are provided on the lines to isolate the flow, which is manually operated.

In case of sudden reduction in dome levels, the reactor FRP dome connector and its connection to the gas pipe header should be checked with soap water for any leakage of gas. This is one of the reasons for having a gas holder level trap.

The typical UASB preventive maintenance check list is mentioned below.

- Date and time
- Check and clean weir levels of division boxes
- Clean-up- feed inlet points
- Cleaning of V-notches
- Removal of sludge from effluent gutter by water jet or brush

- Removal of floating layer on the top of reactor
- Cleaning and scrubbing of effluent channels
- Check gas pipes for leakage
- Leakage greasing of spindle of sludge valves
- Cleaning of sludge sump

4.12.3 Routine Maintenance

4.12.3.1 Quarterly Maintenance

- The spindles of the valves have to be greased every three months.
- The glands and packing of the valves have to be checked every three months and replaced, if necessary.

4.12.3.2 Annual Maintenance

The reactor should be emptied after the first year of full operation to check the complete feeder and sludge withdrawal systems, especially the valves and the internal pipes for any accumulation of debris, sludge etc.

- A first check of the complete system including valves and holes should be made after one year, or earlier when required. Routine check can be established on the basis of the first inspection observation.
- The effluent gutters should be checked for levelling and alignment once a year. Each gutter should be horizontally levelled and all gutters in one reactor should be at the same level.
- Electrical wiring should be checked every year.
- Corrosion of electrical connections should be corrected every year.
- The cement structures should be checked yearly and repaired when necessary.
- The sludge filtrate water pumps should be maintained.

4.12.3.3 Five-Yearly Maintenance

Every five years, the following maintenance should be carried out.

- Each reactor should be alternately put out of operation.
- Clean the inside concrete surface.
- Apply new coating of epoxy to the concrete surface.
- Check quality of feed inlet pipes and replace when necessary.
- Check fixing of the feed inlet pipes, both at the distribution boxes and at the bottom.
- Change corroded fixing material when necessary.

- Check position of PVC sheets.
- Check the fixing-material of the PVC sheets and replace when necessary.
- Check the quality of gas collectors and carry out repairs where necessary.

4.12.4 Decision Schemes for Sludge Removal

The removal of sludge is subject to a number of choices such as

- How much sludge should be removed and
- From where should it be removed, etc.

4.12.5 Shut-Down and Standstill

At shutdown of the plant, the sludge will settle at the bottom of the reactor. The biological activity of the sludge decreases slowly during standstill. Care should be taken to ensure that the sludge is not exposed to aerobic conditions. This might occur, for instance, when the reactor is flushed with clean water for prolonged periods.

At shutdown of the plant, the gas production will decrease. At a prolonged period of plant standstill, the pressure in the gas collection system can drop and air may enter into the system. In this situation, internal parts of the gas flare, the gas metre and the pressure/vacuum release valves that normally are not in contact with the atmospheric air may start to corrode. These parts have to be protected, for instance by greasing.

If the water level in the tank is lowered during shutdown, the limited capacity of the vacuum release valves should be kept in mind. It is possible that imploding of the gas collectors may occur due to fast withdrawal of the reactor contents. At lowering of the water level in the reactor, it is advised to open the manholes on the top of the gas collectors. Only after re-establishing the maximum water level, the manholes can be closed and sealed.

In general, any type of work on the gas collectors requires the opening of the manholes as the explosive mixture of air and methane can develop in or around the gas collectors. When it is necessary to enter the reactor while sludge is present, it should be realised that methane is being formed continuously. A proper ventilation of the reactor is necessary. Very strict rules concerning open fire, spark emission, etc., should be followed. When entering the reactor plant, personnel should wear respiration equipment. Measurement of explosion risk and hydrogen sulphide concentration should be taken frequently when repair work is carried out.

4.12.6 Operational Cautions

- Do not get upon the UASB unless you have a gas mask, safety shoes, goggles and helmets.
- Do not carry any ignitable matters on your person.
- Once you reach the walking platform at top, check the H₂S by hand held meter.
- Unless it registers safety, immediately climb down the UASB.

- Once all the above mentioned issues are ensured, proceed to check any overflows of sewage and if so, stop the UASB.
- Check for corrosion at least once in 6 months and get it rectified.

4.12.7 Final Polishing Unit (FPU)

Not much maintenance is required for this unit. The algal growth needs to be maintained, and the dead algae floating on the top of water surface has to be periodically removed. The baffles provided at the outlet unit have to be cleaned regularly. Keep the floating material away from the unit. See that dead algae do not pass out into the pond. Sewage flow should be maintained to avoid development of anaerobic/septic conditions. These ponds should be de-sludged/de-silted regularly depending on the depth of sludge accumulation. A record of maintenance should be maintained.

4.12.8 Duckweed Pond

The bund sides shall not be grown over by weeds. Figure 4.17 illustrates the same.

4.13 WASTE STABILIZATION POND (WSP)

Waste stabilization ponds are open, flow-through earthen basins specifically designed and constructed to treat sewage. They provide comparatively long detention periods extending from a few days to several days.

There are three principal types of WSP:

- Anaerobic,
- Facultative, and
- Maturation ponds.

Anaerobic ponds and facultative ponds are designed for BOD removal, and maturation ponds are designed for faecal bacteria removal. These three types of WSP can also be arranged in a series – first an anaerobic pond, then a facultative pond, and finally (if needed to achieve the required faecal coliform removal) followed by one or more maturation ponds.

Apart from the above three types, there is another type of WSP called aerobic pond, which are seldom used. When used, follow the same procedures as in facultative ponds.

4.13.1 Start-up Procedures

Pond systems should preferably be commissioned at the beginning of the hot season so as to establish as quickly as possible the necessary microbial populations to effect waste stabilization. Prior to commissioning, all ponds must be free from vegetation. Facultative ponds should be commissioned before anaerobic ponds: this avoids odour release when anaerobic pond discharges into an empty facultative pond. It is best to fill facultative and maturation ponds with freshwater from a river, lake or well; water from public water supply is prohibited.

The developments of the algal and heterotrophic bacterial populations are gradual. Alternatively, facultative ponds should be filled with raw sewage and left for three to four weeks to allow the microbial population to develop; a small amount of odour release is inevitable during the period.

4.13.2 Routine Maintenance

The maintenance requirements of ponds are very simple, but they must be carried out regularly. Otherwise, there will be serious odour, fly and mosquito nuisance.

Maintenance requirements and responsibilities must therefore be clearly defined at the design stage so as to avoid problems later. Routine maintenance tasks are as follows:

- Removal of screenings and grit from the inlet works.
- Cutting the grass on the embankments and removing it so that it does not fall into the pond (this is necessary to prevent the formation of mosquito-breeding habitats; the use of slow-growing grass minimizes this task).
- Removal of floating scum and floating macrophytes, such as Lemna, from the surface of facultative and maturation ponds (this is required to maximize photosynthesis and surface re-aeration and prevent fly and mosquito breeding).
- Spraying the scum on anaerobic ponds (which should not be removed as it aids the treatment process), as necessary, with clean water or pond effluent, or a suitable biodegradable larvicide, to prevent fly breeding.
- Anaerobic ponds, during times of low pH produce odour. In such cases addition of NaOH or lime to raise the pH to above 7 is recommended to eliminate the odour caused due to H_2S . However, addition of NaOH will produce less sludge as compared to lime which produces more sludge.
- Repair of any damage to the embankments caused by rodents, rabbits or other animals.
- Repair of any damage to external fences and gates.

Additional precautions and practices are described below:

- The scum has a tendency to form at the corners of the ponds and supports mosquito growth.
- In anaerobic ponds, during times of low pH, odour is produced. In such occasions, addition of sodium hydroxide is required to raise the pH to 7. The advantage of sodium hydroxide is that it produces less sludge. In case, production of sludge is not a concern then lime can be added to raise the pH to 7. Once the pH is raised to 7, odour can be eliminated.
- In anaerobic ponds, low pH produces odours. In such cases addition of NaOH produces less sludge, or lime can be added to raise the pH to 7 to eliminate odour caused by H_2S .
- The scum need not be taken out of the ponds.
- What is needed is breaking the surface of the scum by a light long pole while standing at the bank.

- This releases the gases that are supporting the scum layer and automatically the mat sinks back.
- These are dealt with like any other organic matter, which are stabilized by the organisms of the pond.
- Fish shall not be allowed to breed in these.
- The precautions involved in manually operating the scum removal must be adopted.
- Sometimes sludge removal would become necessary.
- The thumb rule will be to verify the depth of sludge and de-sludge once it is about 30 % of depth.

4.13.3 De-Sludging

The biggest challenge to an operator in the management of pond systems is to identify when a pond requires de-sludging, and to carry it out safely without giving rise to environmental problems. These issues are addressed in this section so as to help the operator develop adequate confidence in this task.

4.13.3.1 When to De-Sludge

When raw sewage without grit removal is admitted to the pond, a general rule of thumb to calculate the grit accumulation is 0.5 meters depth for a ten year period. Similarly, the accumulation of sludge can be taken as 0.7 meters for a ten year period. Generally, the pond has to be de-sludged when the combined depth of this grit and sludge exceeds 30 % of the designed liquid depth of the pond. However, the “as constructed drawing” may not be available sometimes. Hence, it becomes necessary to physically measure the total depth of the pond from the top of the bund to the floor, the free board and the depth of accumulated sludge. The procedure will be needed, in general after 10 years or when the BOD removal is getting reduced drastically or when black sludge is constantly overflowing in the treated sewage from the pond.

4.13.3.1.1 Preparatory for the Measurement

In order to do the actual measurements in the pond, manual and mechanical methods as also remote instrumentation can be used. In the manual method, the minimum requirements are a clear sunny day with no rains, broad daylight, working between 9 AM and 3 PM only, fire service personnel available at site, minimum of three able bodied persons on a good water tight row boat with a set of extra spare oars, number of people on the boat not to exceed 50 % of the safe carrying capacity of the boat, life vests for all those on board, the boat doubly checked for water tightness, an experienced boatman and oxygen masks for all on board. In the mechanical method, a long arm boom crane which can reach at least one third of the sides from the bund, an apparatus to hold tightly a dip pipe (described later) and an experienced operator. In the instrumentation method, the same crane as above, but equipped with an ultra sound sensor mounted on the end of the boom arm with transmission of the readings by a modem to a personal computer nearby.

4.13.3.1.2 The Dip Tube

This is a light weight tube of strong aluminium and about 30 mm inner diameter and with striations lightly carved as lines all over its outer length. The length of the tube must be at least the depth of the pond plus a minimum of two meters. A white fluffy “terry” towel is wrapped around the tube three times for a length equal to the depth of the pond plus 0.5 m and securely tied using good nylon thread as a spiral at interval of 30 cm between the windings and finally tied securely in a knot at the top side. At the bottom end, separate thread must be tied and knotted to hold the towel in place. Once this is done, check the towel for tightness before using it.

4.13.3.2 The white towel test

The test uses the dip tube and is used to understand the depth of the sludge, Malan (1964). The dip tube wrapped with the white towel is lowered vertically into the pond until it reaches the pond bottom and held there for about 10 to 15 minutes and it is then slowly withdrawn. The depth of the sludge layer is clearly visible since some of the blackish sludge particles will have been entrapped in the towel material and this can be measured. The length of wetness of the towel will indicate the liquid depth. A demonstration is shown in Figure 4.24.



Source: Duncan Mara, 2004

Figure 4.24 The White Towel test

The sludge depth should be measured at various points throughout the pond, away from the embankments, and its mean depth calculated. Duncan Mara (2004).

In order to do this test, the boat as described earlier can be used by staying close to the sides of the bund at about 3 to 5 m only.

It is not necessary to measure at the pond center because normally, the sludge settles uniformly over the entire plan area of the pond.

Alternatively, if the crane with boom is available, the dip tube can be securely tied to the free end of the boom which can be positioned at chosen locations and the dip tube gently lowered till it comes to rest and the same can be taken out of the bund and measured.

This is a type of remote measurement. Do not send any person on the boom arm.

4.13.3.3 De-Sludge Procedure

- Repeat the above depth measurements slowly without hurry. Always do this in clear non-rainy weather. Make sure you have at least four readings, which are fairly close.
- Once the sludge depth is thus measured, consult the chemist for any tendency of efficiency drop in the pond for BOD removal. If the chemist feels that there is a steady decline and efficiency is going down, consult the plant superintendent.
- As a rule of thumb, if the liquid height is less than 1.2 meters in a facultative or anaerobic pond, it is time for de-sludging. Take the decision jointly and never by yourself.
- The best method of de-sludging is to take one pond out of operation during the beginning of summer and pump out the water portion to the other ponds. Thereafter, it normally takes two months for a sludge depth of about 2 meters to dry out.
- Deploy manpower equipped with oxygen mask to gently turn the dried sludge upside down uniformly over the whole area so that drying is hastened. Never use a machine during this operation as methane may get released.
- Once this is completed and the sludge is dried, deploy a suitable earthmoving equipment and evacuate the sludge over the bund and on to the ground on the earth side of the bund.
- The sludge can be heaped into a pile by manual labourers who should wash their hands thoroughly with soap after finishing their work.

4.13.3.4 Special cautions for anaerobic pond / maturation pond

All the points listed earlier in aerated lagoon and facultative ponds apply here also except that the depth of sludge before de-sludging will be according to the original design.

The boat ride to measure the sludge depth shall not be used in these ponds. Instead, the white towel test shall be conducted and a long boom crane shall be used without making any person stand at the end of the boom.

4.13.4 Process Control

There is nothing much to control in the process of purification of sewage in WSP except making sure that the sludge accumulation does not exceed 30% of the total liquid depth or the design depth of sludge.

4.13.5 Record Keeping

4.13.5.1 Records necessary for Anaerobic Pond

- Daily tests and records will be the flow and SS.
- Monthly tests shall be the BOD after filtering through Whatman 42 filter paper and pH.

4.13.5.2 Records necessary for Facultative Pond

- Daily tests and records will be the flow and SS.
- Weekly tests will be identification of organisms as per “Standard Methods” drawings.
- Monthly tests shall be the BOD after filtering through Whatman 42 filter paper and pH.

4.13.5.3 Records necessary for Maturation Pond

- Daily tests and records will be the flow and SS.
- Monthly tests shall be the BOD after filtering through Whatman 42 filter paper and pH.
- Yearly test of faecal and total coliforms at peak summer and peak monsoon shall be conducted.

4.14 FARM FORESTRY

Please hand over the O&M work to the local forestry department who are competent in this.

4.15 FISH POND

Fish ponds otherwise referred to as pisciculture cannot be looked upon as a method of stand-alone sewage treatment.

However, treated / diluted sewage if used for pisciculture on the lines of the on-going East Kolkata wetlands, this needs to be strictly monitored by

- Department of Health (DOH)
- Department of Environment (DOE)
- State Pollution Control Board (SPCB)

More important is public hearing and acceptance.

4.16 SECONDARY SEDIMENTATION TANK

The terms settling tank, sedimentation tank and clarifiers are synonymous and mean the same. A typical plant may have clarifiers located at two different points.

The one that immediately follows the bar screen, comminutor, or grit channel is called the primary sedimentation tank or primary clarifier, merely because it is the first sedimentation tank in the plant.

The other, which follows other types of treatment units, is called the secondary sedimentation tank or the final sedimentation tank or secondary clarifier. The two types of sedimentation tanks operate almost exactly the same way. The function of a primary clarifier is to remove settleable and floatable solids. The reason for having a secondary sedimentation tank is that other types of treatment following the primary sedimentation tank convert more solids to the settleable form, and they have to be removed from the treated sewage. Because of the need to remove these additional solids, the secondary clarifier is considered part of these other types of processes.

The main difference between primary and secondary sedimentation tanks is in the density of the sludge handled. Primary sludge is usually denser than secondary sludge. Effluent from a secondary clarifier is normally clearer than primary effluent.

Solids that settle to the bottom of a sedimentation tank are usually scraped to one end (in rectangular clarifiers) or to the middle (in circular clarifiers), into a sump. From the sump, the solids are pumped to the sludge handling or sludge disposal system. Systems vary from plant to plant and include sludge digestion, vacuum filtration, filter presses, incineration, land disposal, lagoons and burial.

Disposal of skimmed solids varies from plant to plant.

Skimmed solids may be buried with material cleaned off the bar screen, or pumped to the digester.

Even though pumping of skimmed solids to a digester is not considered good practice because skimming can cause operational problems in digesters, it is a common practice.

4.16.1 Operation

Of all the different types of clarifiers that an operator must regulate, secondary clarifiers in the ASP are the most critical and require the following attention from the operator.

- Levels of sludge blanket in the clarifier
- Concentration of suspended solids in the clarifier effluent
- Control and pacing of return sludge flows
- Concentration of dissolved oxygen (DO) in the clarifier effluent
- Level of pH
- Concentration of RAS

4.16.2 Maintenance

Annually, during periods of low flow, each clarifier should be shut down for inspection, routine maintenance, and any necessary repairs. Even though the clarifier and all equipment are working properly, an annual inspection helps to prevent serious problems and failures in the future when the STP may break down.

During normal operations, the operator should schedule the following daily activities:

A. Inspection

Make several daily inspections with a “stop, look, listen, and think” routine.

B. Cleanup

Using water under pressure, wash off accumulations of solid particles, grease, slime, and other material from walkways, handrails, and all other exposed parts of the structure and equipment.

C. Lubrication

Grease all moving equipment according to manufacturer’s specifications and check oil levels in motors where appropriate.

4.17 ADVANCED TREATMENT

Advanced sewage treatment processes typically are used to further reduce the concentrations of suspended solids, nutrients (nitrogen or phosphorus) and soluble organic chemicals in secondary treatment effluent. These processes may be physical, chemical, biological, or a combination of these processes.

4.17.1 Sand Filtration

Sand filters have influent and effluent distribution systems consisting of pipes and fittings. Head loss is a measure of solids trapped in the filter. As the filter becomes full with trapped solids, the efficiency of the filtration process falls off, and the filter must be backwashed. Filters are back washed by reversing the flow so that the solids in the media are dislodged and can exit the filter and sometimes air is dispersed into the sand bed to scour the media.

Sand filters can be automatically backwashed when the differential pressure exceeds a pre-set limit or when a timer starts the backwash cycle.

4.17.2 Multimedia Filtration

A multimedia filter operates with the finer, denser media at the bottom and the coarser, less dense media at the top. A common arrangement is as follows.

- Top: Anthracite
- Middle: Sand
- Bottom: Garnet

These media can be used alone, such as in sand filtration, or in a multimedia combination. Some mixing of these layers occurs and is anticipated. During filtration, the removal of the suspended solids is accomplished by a complex process involving one or more mechanisms, such as:

- Straining,
- Sedimentation,
- Interception,
- Impaction, and
- Adsorption.

The size of the medium is the principal characteristic that affects the filtration operation. If the medium is too small, much of the driving force will be wasted in overcoming the frictional resistance of the filter bed. If the medium is too large, small particles will travel through the bed, preventing optimum filtration. As same as “sand filtration”, back wash is required to keep adequate filtration efficiency.

4.17.3 Membrane Filtration (MF, UF, NF, RO)

The membrane filtration is used for polishing water for specific uses like industry process water, or for aquifer infiltration. In India, membrane filtration as in Figure 4.25 is used in the water and sewage sectors.

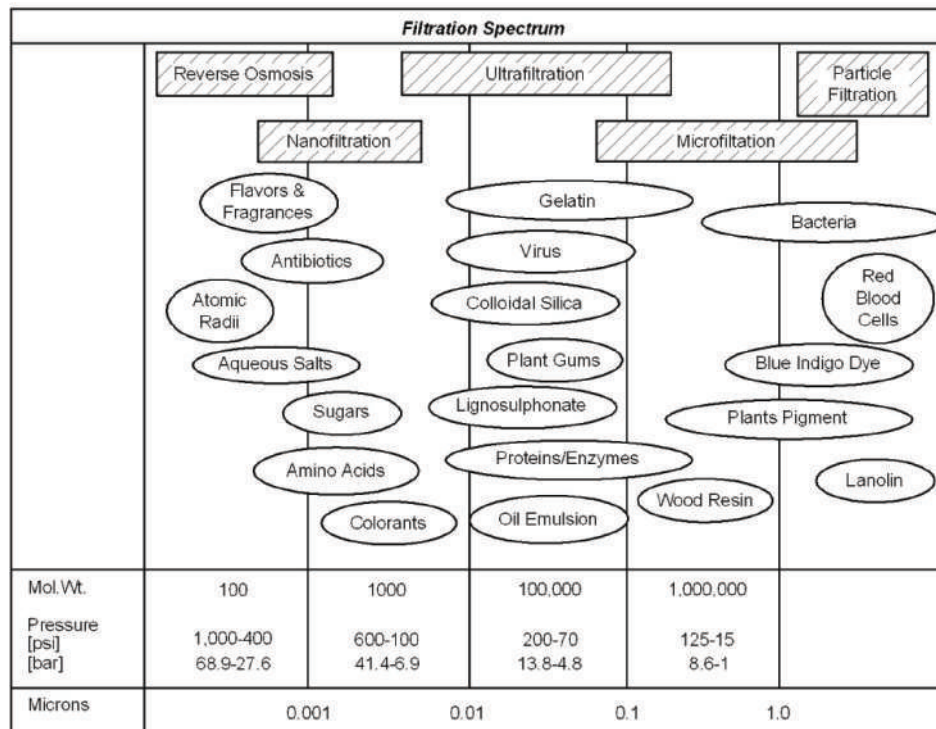


Figure 4.25 Filtration spectrum

MF – Microfiltration membranes are porous membranes with pore sizes between 0.1 and 1 micron (1 micron=one thousandth of a millimeter). They allow almost all dissolved solids to get through and retain only solids particles over the pore size.

UF – Ultra filtration membranes are asymmetric or composite membranes with pore sizes between 0.005 and 0.05 micron. They allow almost mineral salts and organic molecules to get through and retain only macromolecules

NF – Nano filtration membranes are with pore sizes 0.001 micron. They retain multivalent ions and organic solutes that are larger than 0.001 micron.

RO – Reverse osmosis membranes are dense skin, asymmetric or composite membranes that let water get through and rejects almost all the salts.

4.17.4 Operation and Maintenance

A. Operational Unit Processes

All membrane filtration systems have associated operational unit processes that are essential for maintaining and optimizing system performance and therefore critical to the implementation of the technology.

The unit processes include backwashing, chemical cleaning, and integrity testing.

For the purposes of this discussion, pre-treatment and post-treatment are also considered operational unit processes associated with membrane filtration.

Each of these processes and its role in the operation of a membrane filtration system are described in the following sections. Although not every membrane filtration system utilizes all of these processes, they utilize each process to a certain degree.

B. Pre-treatment

Pre-treatment is typically applied to the feed water prior to entering the membrane system in order to minimize membrane fouling, but in some cases may be used to address other water quality concerns or treatment objectives. Pre-treatment is most often utilized to remove foulants, optimize recovery and system productivity, and extend membrane life. It may be used to prevent physical damage to the membranes.

Different types of pre-treatment can be used in conjunction with any membrane filtration system, as determined by site-specific conditions and treatment objectives.

Pilot testing can be used to compare different pre-treatment options, optimize them and / or demonstrate pre-treatment performance.

Various methods of pre-treatment for membrane filtration systems are discussed in the following sub-sections.

C. Pre-filtration

Pre-filtration, including screening or coarse filtration is common membrane filtration systems that are designed to remove large particles and debris. Pre-filtration can either be applied to the membrane filtration system as a whole or to each membrane unit separately. The particular pore size associated with the pre-filtration process (where applicable) varies depending on the type of membrane filtration system and the feed water quality. For example, although hollow fibre microfiltration (MF) and ultrafiltration (UF) systems are designed specifically to remove suspended solids, large particulate matter can damage or plug the membrane's fibres.

Because spirally wound nanofiltration (NF) and reverse osmosis (RO) utilize non-porous semi permeable membranes and are almost exclusively designed in a spiral-wound configuration for municipal water treatment applications, these systems must utilize much finer pre-filtration in order to minimize exposure of the membranes to particulate matter of any size.

A summary of the typical pre-filtration requirements associated with the various types of membrane filtration is presented in Table 4.4.

Table 4.4 Typical membrane system pre-filtration requirements

Membrane System		Pre-filtration Requirements	
Classification	Configuration	Size (µm)	Type(s)
Membrane Cartridge Filtration (MCF)*	Cartridge	300 - 3,000	Strainers; Bag Filters
Microfiltration (MF) / Ultra filtration (UF)	Hollow-Fibre, Inside-Out	100 - 300	Strainers; Bag Filters
	Hollow-Fibre, Outside-In	300 - 3,000	Strainers; Bag Filters
Nanofiltration (NF) / Reverse Osmosis (RO)	Spiral-Wound	5 - 20	Cartridge Filters

* Pre-filtration is not necessarily required for MCF systems

Source: WEF, 2008

D. Backwashing

The backwash process for membrane filtration systems is similar in principle to that for conventional media filters and is designed to remove contaminants accumulated on the membrane surface. Each membrane unit is backwashed separately and in a staggered pattern so as to minimize the number of units in simultaneous backwash at any given time. During a backwash cycle, the direction of flow is reversed for a period ranging from about thirty seconds to three minutes.

The force and direction of the flow dislodge the contaminants at the membrane surface and washout accumulated solids through the discharge line.

Membrane filtration systems are generally backwashed more frequently than conventional media filters, with intervals of approximately 15 to 60 minutes between backwash events. Typically, the membrane backwash process reduces system productivity in the range of 5 to 10 % due to the volume of filtrate used during the backwash operation.

Backwashing is conducted periodically according to manufacturer's specifications and site-specific considerations. Although more frequent backwashing allows for higher fluxes during filtration, this benefit is counterbalanced by the decrease in system productivity. In general, a backwash cycle is triggered when a performance-based benchmark is exceeded, such as a threshold for operating time, volumetric throughput, increase in trans-membrane pressure (TMP), and/or flux decline. Ideally, the backwash process restores the TMP to its baseline (i.e., clean) level; however, most membranes exhibit a gradual increase in the TMP that is observed after each backwash, indicating the accumulation of foulants that cannot be removed by the backwash process alone. These foulants are addressed through chemical cleaning.

Because the design of spiral-wound membranes generally does not permit reverse flow, NF and RO membrane systems are not backwashed. For these systems, membrane fouling is controlled primarily with chemical cleaning, as well as through flux control and cross flow velocity. The inability of spiral-wound membranes to be backwashed is one reason that NF and RO membranes are seldom applied to directly treat water with high turbidity and/or suspended solids.

E. Chemical Cleaning

Chemical cleaning is another means of controlling membrane fouling, particularly for those foulants such as inorganic scaling and some forms of organic and bio-fouling that are not removed via the backwash process. As with backwashing, chemical cleaning is conducted for each membrane unit separately and is typically staggered to minimize the number of units undergoing cleaning at any time. While chemical cleaning is conducted on both MF/UF and NF/RO systems, because non-porous, semi-permeable membranes cannot be backwashed, chemical cleaning represents the primary means of removing foulants in NF/RO systems. Although cleaning intervals may vary widely on a system-by-system basis, the gradual accumulation of foulants makes eventual chemical cleaning virtually inevitable. Membrane cartridge filters are an exception, however, in that cartridge filters are usually designed to be disposable and thus are typically not subject to chemical cleaning.

As with backwashing, the goal of chemical cleaning is to restore the TMP of the system to its baseline (i.e., clean) level. Any foulant that is removed by either the backwash or chemical cleaning process is known as reversible fouling. Over time, membrane processes will also typically experience some degree of irreversible fouling which cannot be removed through either chemical cleaning or backwashing.

Irreversible fouling occurs virtually in all membrane systems, albeit over a wide range of rates, and eventually necessitates membrane replacement. A summary of chemical cleaning is given in Table 4.5 overleaf.

Table 4.5 Chemical cleaning agents

Category	Chemicals Commonly Used	Typical Target Contaminant(s)
Acid	Citric Acid (C ₆ H ₈ O ₇) Hydrochloric Acid (HCl)	Inorganic scale
Base	Caustic (NaOH)	Organics
Oxidants / Disinfectants	Sodium Hypochlorite (NaOCl) Chlorine (Cl ₂) Gas Hydrogen Peroxide (H ₂ O ₂)	Organics Biofilms
Surfactants	Various	Organics Inert particles

Source: WEF, 2008

4.17.5 Integrated Nutrient Removal

4.17.5.1 Nutrient Removal

Sewage may contain high levels of the nutrients nitrogen and phosphorus. Excessive release of these nutrients to the environment can lead to a build-up of nutrients, called eutrophication, which can in turn encourage the overgrowth of weeds, algae and cyanobacteria (blue-green algae). This may cause an algal bloom, and a rapid growth in the population of algae. The algae numbers are unsustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of oxygen in the water that most or all of the species die, which creates more organic matter for the bacteria to decompose. In addition to causing de-oxygenation, some algal species produce toxins that contaminate drinking water supplies.

Different treatment processes are required to remove nitrogen and phosphorus.

4.17.5.2 Nitrogen Removal

Nitrogen is removed through the biological oxidation of nitrogen from ammonia to nitrate (nitrification), followed by de-nitrification, i.e., the reduction of nitrate to nitrogen gas. Nitrogen gas is released into the atmosphere and is thus removed from the sewage.

Nitrification itself is a two-step aerobic process, each step facilitated by a different type of bacteria.

The oxidation of ammonia (NH₃) to nitrite (NO₂) is most often facilitated by *Nitrosomonas* spp. (nitroso referring to the formation of a nitroso functional group). Nitrite oxidation to nitrate (NO₃), though traditionally believed to be facilitated by *Nitrobacter* spp. (nitro referring the formation of a nitro functional group), is now known to be facilitated in the environment almost exclusively by *Nitrospira* spp.

De-nitrification requires anoxic conditions to encourage the appropriate biological communities to form. It is facilitated by a wide diversity of bacteria. Sand filters, lagoons and reed beds can all be used to reduce nitrogen, but the activated sludge process (if designed well) can do the job the most easily. Since de-nitrification is the reduction of nitrate to nitrogen gas, an electron donor is needed. This can be, depending on the sewage, organic matter (from faeces), sulphide, or an added donor like methanol. Sometimes the conversion of toxic ammonia to nitrate alone is referred to as tertiary treatment. Many sewage treatment plants use axial flow pumps to transfer the nitrified mixed liquor from the aeration zone to the anoxic zone for de-nitrification. These pumps are often referred to as Internal Mixed Liquor Recycle (IMLR) pumps. A schematic is shown in Figure 4.26.

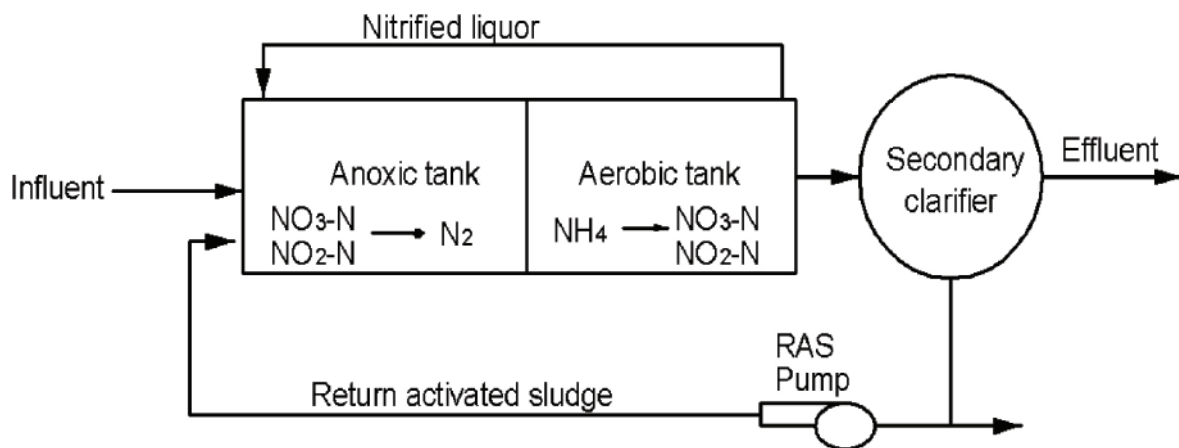


Figure 4.26 Configuration of Recycled Nitrification/De-nitrification Process

4.17.5.2.1 Process Control

Operators of biological nitrogen removal (BNR) facilities need more process-control knowledge than those of conventional treatment facilities to keep them operating smoothly. The key operating parameters for a BNR facility typically include:

A. SRT

SRT is the key to understanding whether the BNR process has enough time to function effectively. When evaluating SRT, operators should answer such questions as:

- Is the SRT long enough to establish nitrification?
- How much sludge should be wasted to maintain a desired SRT?
- Can the SRT be increased by maintaining a higher MLSS?

B. F/M Ratio

F/M ratio is a good indicator of how well selector reactors will promote the growth of floc-forming bacteria. When the F/M ratio is high, floc-forming bacteria have a competitive advantage over filamentous bacteria. Selector loading also helps ensure that nuisance bacteria will not cause operating problems. The selector cells should be arranged so BOD is taken up rapidly.

C. HRT (Hydraulic Retention Time)

Although not used in daily BNR operations, HRT indicates whether the plant is operating within a normal contact time. Nitrifying facilities, such as conventional activated sludge and A2O (Anaerobic, Anoxic, and Oxidic process), typically have an HRT between 5 and 15 hours.

D. Oxygen Levels

When a conventional activated sludge system is converted into a BNR facility, its dissolved oxygen requirements typically increase, requiring changes in the aeration equipment or diffuser layout.

E. Alkalinity and pH Control

For every 1 mg of ammonia-nitrogen oxidized to nitrate, 7.14 mg of alkalinity is consumed. Likewise, for every 1 mg of nitrate reduced to nitrogen gas, 3.57 mg of alkalinity is recovered.

F. ORP (Oxidation–Reduction Potential).

Automated control systems for the internal anoxic mixing process measure the ORP so they can detect nitrate depletion in the mixed liquor. This variable indirectly measures nitrate availability in an aqueous media, although there is no direct correlation between any specific ORP value and nitrate concentration.

ORP measures the net electron activity of all oxidation–reduction reactions occurring in sewage. It is affected by temperature, pH, biological activity, and the system's chemical constituents, but its response pattern to changes in a solution's oxidative state is reproducible in a specific system.

In continuous-flow suspended-growth systems, the control system's ORP breakpoints must be constantly reviewed and revised. In batch systems (e.g., SBR or cyclic aeration systems), however, a characteristic “knee” (change in ORP values) indicates when the system is changing from an oxidized state to a reduced one.

G. Recycle Flows

For sewage facilities with either ammonia and/or nitrate limitations, it will be necessary to adjust recycle flows (typically RAS flow) to achieve operational goals.

H. Secondary Clarification

It is essential that the secondary clarifier be able to do both, separate biological solids from the treated effluent and, concentrate the solids without a build-up of sludge within the clarifier. Parameters of concern with clarification are the hydraulic loading rate (HLR) and the solids loading rate (SLR).

4.17.5.3 Phosphorus Removal

Phosphorus removal is important as it is a limiting nutrient for algae growth in many fresh water systems. It is also particularly essential for water reuse systems where high phosphorus concentrations may lead to fouling of downstream equipment such as reverse osmosis.

Phosphorus removal in excess of metabolic requirements can be achieved by using enhanced biological phosphorus removal (EBPR) or chemical addition.

In the EBPR process, specific bacteria, called Polyphosphate Accumulating Organisms (PAOs), are selectively enriched and accumulate large quantities of phosphorus within their cells (up to 20 % of their mass). When the biomass enriched in these bacteria is separated from the treated water, these biosolids (sludge) have a high fertilizer value.

The EBPR process consists of anaerobic and aerobic zones. By definition, the anaerobic zone contains no usable dissolved oxygen or nitrate. In this zone, PAOs do not grow, but consume and convert readily available organic material (i.e., VFAs) to energy-rich carbon polymers called poly-hydroxyalkanoates (PHA). The energy required for this reaction is generated through breakdown of the stored polyphosphate (poly-P) molecules, which results in phosphorus release and an increase in the bulk liquid soluble phosphorus concentration in the anaerobic stage. Magnesium and potassium ions are concurrently released to the anaerobic medium with phosphate. In addition, a substantial amount of reducing power is required PAOs to produce PHA. The breakdown of glycogen, another form of internal carbon storage, generates the reducing power.

Phosphorus removal can also be achieved by chemical precipitation, usually with salts of iron (e.g. ferric chloride), aluminium (e.g. alum), or lime. This may lead to chemical sludge production as hydroxides precipitate and the added chemicals can be expensive. Chemical phosphorus removal requires significantly smaller equipment footprint than biological removal, is easier to operate and is often more reliable than biological phosphorus removal. Another method for phosphorus removal is the use of granular laterite. Once removed, phosphorus, in the form of a phosphate-rich sludge, may be stored in a land fill or resold for use in fertilizers.

4.18 DISINFECTION FACILITY

Disinfection of sewage from STP is required to decrease the disease risks associated with the discharge of treated sewage containing human pathogens (disease causing organisms) into receiving waters. These microorganisms are present in large numbers in the treated sewage.

The chlorine gas is controlled, metered, introduced into a stream of injector water and then conducted as a solution to the point of application.

The primary advantage of vacuum operation is safety. If a failure or breakage occurs in the vacuum system, the chlorinator either stops the flow of chlorine into the equipment or allows air to enter the vacuum system rather than allowing chlorine to escape into the surrounding atmosphere. In case the chlorine inlet shutoff fails, a vent-valve discharges the incoming gas to the outside of the chlorinator building.

The operating vacuum is provided by a hydraulic injector. The injector operating water absorbs the chlorine gas and the resultant chlorine solution is conveyed to a chlorine diffuser through corrosion resistant conduit. A vacuum chlorinator also includes a vacuum regulating valve to dampen fluctuations and allow smooth operation. Vacuum relief prevents excessive vacuum within the equipment. Chlorine gas flows from the chlorine container to the gas inlet.

After entering the chlorinator, the gas passes through spring-loaded pressure regulating valve, which maintains the proper operating pressure. A rotameter is used to indicate the rate of gas flow. The rate is controlled by V-notch variable orifice. The gas then moves to the injector where it dissolves in water and leaves the chlorinator as a chlorine solution (HOCl) ready for application.

4.18.1 Operational Variables

The process-control variables associated with chlorination systems are:

A. Detention (Contact) Time

The chlorine solution is best injected into the effluent via a diffuser or, preferably, a flash mixer. Otherwise, some of the chlorine gas could come out of solution un-dissolved (stratification). This would reduce the efficiency of disinfection and increase its costs.

Typically, depending on the STPs discharge standards of the state or regional regulatory requirements, chlorine detention time should range from 30 to 60 minutes at the average daily flow (ADF) and should equal or exceed 15 minutes at peak flows. Such detention times allow a safety factor for possible hydraulic inefficiency of the contact chamber, thus maximizing pathogen inactivation.

B. Chlorine Residual

Depending on the effluent-disposal method (receiving-water discharge or reclaimed-water reuse) the permit may require a chlorine residual in the contact chamber effluent. The three types of chlorine residuals are; combined, free and total. Free and total residuals are typically monitored.

The combined residual consists of chloramines and chloro-organic compounds that are formed by the reaction of chlorine with ammonia and organic compounds in the secondary or tertiary effluent. Each milligram per litre of ammonia consumes 10 mg/L of chlorine. The chlorine dose that satisfies the ammonia's chlorine demand is called the breakpoint. Note that the combined residual decreases slightly as the chloramines and chloro-organic compounds are oxidized at a narrow range of chlorine doses of less than the breakpoint. The breakpoint chlorination curve is shown in Figure 4.27 overleaf.

C. Indicator Bacteria Results

Regardless of the chlorine residual method employed enough chlorine solution must be injected into the effluent to sufficiently destroy or inactivate the indicator bacteria that signal the likely presence of pathogens. The primary objective of chlorination is to destroy pathogenic organisms; however, the coliform bacteria often used as indicators are not pathogenic. The indicator bacteria inactivation concept works because coliform and other indicator bacteria are much easier to detect than pathogens and more difficult to destroy than most pathogens, except possibly viruses. Testing directly for pathogens is complex and costly. If the coliform count has been sufficiently reduced through disinfection, it indicates a reduction in pathogen.

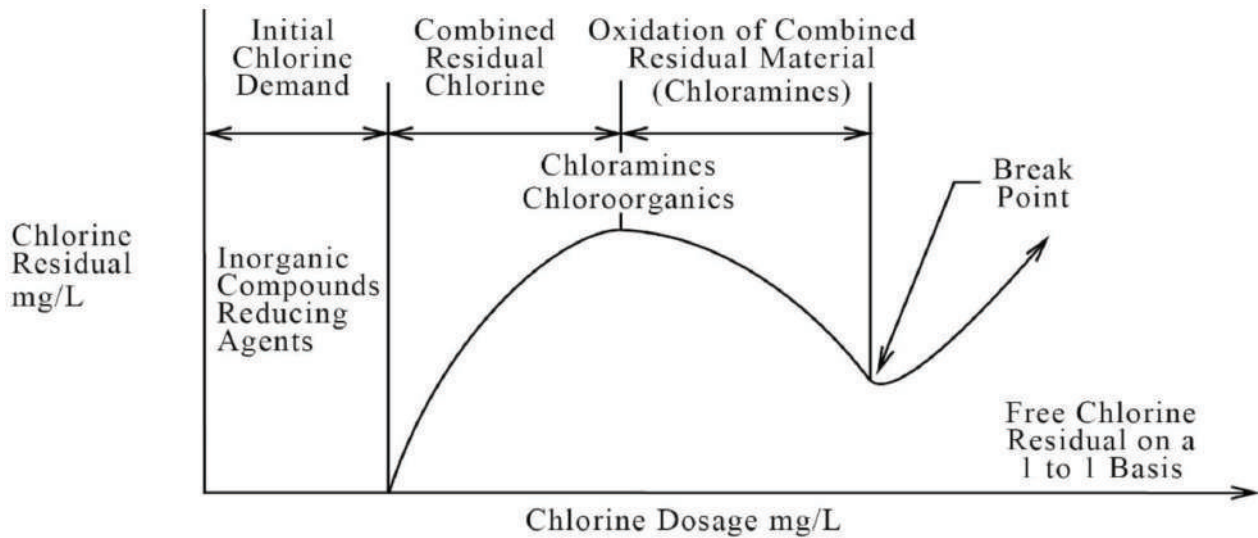


Figure 4 - 27 Breakpoint Chlorination Curve

4.18.2 Operational Hazards

A. Chlorine Hazards

Chlorine is a gas, 2.5 times heavier than air, toxic, and corrosive in moist atmospheres. Dry chlorine gas can be safely handled in steel containers and piping, but with moisture it must be handled in corrosion-resisting materials such as silver, glass, teflon, and certain other plastics.

Chlorine gas at container pressure should never be piped in silver, glass, teflon, or any other plastic material.

Even in dry atmospheres, the gas is very irritating to the mucous membranes of the nose, to the throat, and to the lungs; a very small percentage in the air causes severe coughing. Heavy exposure can be fatal.

B. Warning

When entering a room that may contain chlorine gas, open the door slightly and check for the smell of chlorine. Never go into a room containing chlorine gas with harmful concentrations in the air without a self-contained air supply, protective clothing and helpers.

Help may be obtained from the chlorine supplier and your local fire department.

4.18.3 Maintenance

Routine operations and troubleshooting. Table 4.6 (overleaf) lists routine operational checks of chlorination equipment and remedies if these checks indicate potential problems.

Table 4.6 Routine operational checklist and troubleshooting guide for chlorination system

Items	What to check	Potential problems	Corrective actions
Record scale reading	Usage	Degrading effluent increases chlorine demand (nitrite demand increases use)	Monitor dose and demand. Adjust process to improve effluent quality.
		Low scale weight, chlorine about to run out	Replace container or cylinder before scale reaches zero to prevent sediment from entering system.*
Chlorine lines, valves, and unions	Erratic reading	Scale not tared out properly	If necessary, retare or calibrate scale.
	Presence of chlorine leaks	Personal injury (potential death), evacuation logistics, and corrosion of nearby equipment and electronics	Work with a trained assistant, wear SCBAs (Self-Contained Breathing Apparatus), and follow all appropriate safety procedures when closing container or cylinder main valve and evacuating chlorination pipe network. Repair all leaks immediately; they will only get worse. Notify the emergency response teams if required.
	Iced container or cylinder	Chlorination rate too high	Reduce chlorination rate, or manifold containers or cylinders together. If an evaporator is being used, be certain liquid chlorine is being withdrawn from the container's bottom valve.
Solution lines	Leaks	Chlorine evaporating	Repair all leaks immediately. Evacuate chlorine network and repair PVC pipes. Follow all appropriate safety procedures when working with any chlorine leak.
System gauges	Gauges	Chlorination system downtime	Correct all potential problems immediately.
	Main manifold pressure	Could break rupture disk?	If necessary, evacuate network and replace rupture disk. Check all network valves for correct positioning.

(*) This will prevent sediment in the container from entering the chlorination network and possibly damaging the process equipment.

Source: WEF, 2008

4.19 OPERATION & MAINTENANCE OF DEWATS AND JOHKASOU

The package treatment plants like DEWATS and Johkasou also have to be maintained as per the vendors of these systems.

4.20 PREVENTIVE MAINTENANCE

Preventive Maintenance addresses the civil, mechanical, electrical, instrumentation and automation aspects. In respect of civil works, follow the local rules, regulations and guidelines of the local Public Works Department (PWD). These procedures are mostly annual. It will be better to hand over such maintenance to the PWD and remit the costs to that department. In respect of mechanical equipment, it is better to enter into a contract with the contractor who has built the STP to do this as per the directions of the equipment suppliers and retain the equipment supplier to check and certify the work. In respect of the electrical installations, it is better to entrust this work to the local Electricity Department, similar to civil works. In respect of instrumentation and automation, similarly, entrust the work to the contractor who supplied and erected these and retain a third party agency to certify the proper completion of the work. The following checklist as in Table 4.7 is an example of a preventive maintenance programme for activated-sludge facilities. When developing a site-specific schedule, consult the service manuals that were provided with each piece of equipment.

Table 4.7 An example of a Preventive Maintenance Programme for
Activated-Sludge facilities Checklist

Activated-sludge system preventive maintenance (typical)	Daily	Weekly	Monthly	Quarterly	Biannual	Annual	Comments
Aeration blower							
Maintain proper motor lubricant level		•					
Lubricate motor roller bearings							1.5 months
Check for abnormal noises and vibration				•			
Check that air filters are in place and not clogged				•			
Check motor bearing rise temperature				•			
Check motor for voltage and frequency variations				•			
Check that all covers are in place and secure				•			
Rotate blower operation				•			
Lubricate motor ball bearings				•			
Check that electrical connections are tight				•			
Check wiring integrity				•			
Lubricate motor sleeve bearing					•		or 2000 hours
Inspect and clean rotor ends, windings, and blades					•		
Check that electrical connections are tight and corrosion is absent					•		
Change blower bearing oil						•	
Re-lubricate after checking flexible couplings							As needed

Activated-sludge system preventive maintenance (typical)	Daily	Weekly	Monthly	Quarterly	Biannual	Annual	Comments
Oxygen dissolution system							
Lubricate motor					•		
Change gear drive oil					•		
Lubricate flex coupling						•	or 2500 hours
Inspect gear tooth pattern wear, shaft and bearing end play alignment, bolting, and seal condition						•	
Fine bubble diffusers							
Check biological reactor surface pattern	•						
Check air mains for leaks	•						
Check and record operating pressure and airflow	•						
Purge water moisture from distribution piping			•				
Bump diffuser system			•				
Drain biological reactor						•	
Remove excess solids that may accumulate						•	
Clean diffusers						•	
Check that retaining rings are in place and tight						•	
Check that fixed and expansion joint retaining rings are tight						•	
Secondary clarifier							
Remove trash and debris	•						
Test torque-control line switches		•					
Test torque overload alarm		•					
Verify torque scale pointer moves		•					
Check drive unit for accumulated condensation		•					
Check drive oil level and quality		•					
Check drive overload response controls						•	
Inspect the entire mechanism above and below the water line						•	
Inspect and tighten all nuts and bolts							Regular interval
Inspect lubrication for torque-overload protection device, per manufacturer's instructions							e.g., 18 months or 500 cycles
Return activated sludge pumps (centrifugal)							
Lubricate pump bearings							or 2000 hours
Lubricate motor bearings				•			
Waste activated sludge pumps (centrifugal)							
Lubricate pump bearings							or 2000 hours
Lubricate motor bearings				•			

Source: WEF, 2008

4.21 TROUBLESHOOTING

Refer to Appendix B.4.1.

4.22 RECORD KEEPING

The importance of maintaining adequate O&M records cannot be overemphasized. The purpose of recording data is to track operational information that will identify and duplicate optimum operating conditions. Records of the volume and concentration of waste sludge fed to the digester and volume and concentration of digested solids removed from the digester should be kept. Additional information that needs to be maintained, include DO concentration and pH. Keep a monthly report form. In plants where the aeration system capacity is marginally adequate in providing desirable DO concentration in the digester, record DO concentration data on a trend chart.

If chemicals are added to the digester for pH or odour control, record the type and amount of chemicals added. If mechanical aerators are used, record the power usage. In the case of diffused-air systems, air flow records may be of interest. If airflow meters are not available, records of power consumption may be useful. Experimenting with the aeration system often leads to significant savings in power costs.

A record of instrument performance and repairs allow O&M personnel to properly evaluate an instrument's effectiveness and determine if the instrument meets the objectives used to justify its purchase and installation.

As a minimum, the following basic information should be maintained for each instrument in the STP:

- Plant equipment identification number
- Model number and serial number
- Type
- Dates placed into and removed from service
- Reasons for removal
- Location when installed
- Calibration data and procedures
- Hours required to perform maintenance
- Cost of replacement parts
- O&M manual references and their locations
- Apparatus failure history

4.23 SUMMARY

Appendices to this manual provide troubleshooting lists for possible problems in STPs. Operators should check their operational problems in the troubleshooting lists so that they can take prompt measures to solve the problem.