**OPTIONS AVAILABLE TO TREAT MUNICIPAL SEWAGE-**
**BRIEF DETAILS OF PROCESES**
**(Abstracted from Wastewater Treatment for Pollution Control and Reuse, by Soli J Arceivala & Shyam R Asolekar)**

## A. Conventional Activated Sludge :

The raw wastewater undergoes screening, grit removal, and primary settling before aeration. The wastewater is then aerated and the mixed liquor from the aeration tank is settled to give a clear supernatant which may be disinfected and discharged or treated further depending on the intended end-use. Sludge withdrawn from the final settling tank is called the activated (or aerated and full of micro-organisms) sludge. It is recycled to the aeration tank, while a small fraction is wasted in order to keep the system in steady state. The fraction wasted is generally mixed with the primary sludge, thickened and digested anaerobically, before being dewatered.

Typical performance characteristics:
(Based on water supply rate of 185 lpcd)

| | |
|---|---|
| BOD removal, % 85-92 | Nutrient removal, % N 30-40 |
| Coliform removal, % 60-90 | Nutrient removal, % P 30-45 |
| Land requirement based on population equivalent 54g /cap-d: | 0.20-0.25 $m^2$/person |
| Process power requirement* | 12-15 kWh/person-year |
| Sludge handling | First digested then dried on beds or use mechanical devices |
| Equipment requirement (excluding screening and grit removal which are required in all cases). | Aerators, recycle pumps, scrapers, thickeners, digesters, dryers, gas equipment. |
| Operational characteristics | Skilled operation required |
| Effect of population | Considerable |
| Considerable equipment and skilled operation required, especially if gas collection and usage involved. | |
| Considered mainly for large sized plants. | |
| Note: *Based on aerator capacity of 2 g $O_2$ / Kwh at standard conditions (zero DO and plain water at $20^0$ C) and 75% of standard value delivered at field conditions. | |

## B. Extended Aeration or Aerated Lagoons:

Extended Aeration systems are simpler in construction and operation and are entirely aerobic, since the primary settling of wastewater and the anaerobic digestion of sludge are omitted. The wastewater is brought directly to the aeration basin after screening and grit removal. Aeration is now done for an extended period of time, thus mineralizing the sludge solids sufficiently so that they can be dewatered on open beds without any prior digestion. This helps in improving efficiency and in simplifying the whole operation. But the power requirement is higher than that of activated sludge system. Hence the operation cost of this system is higher. This can be reduced somewhat by encouraging denitrification concurrently with nitrification in the aeration tank.

**Typical performance characteristics:**

**(Based on water supply rate of 185 lpcd)**

| | |
|---|---|
| BOD removal, % 95-98 | Nutrient removal, % N 15-30 |
| Coliform removal, % 60-90 | Nutrient removal, % P 10-20 |
| Land requirement based on population equivalent 54g /cap-d: | 0.15-0.20 $m^2$/person |
| Process power requirement* | 16-19 kWh/person-year |
| Sludge handling | No digestion, dried on beds or use mechanical dewatering devices |
| Equipment requirement (excluding screening and grit removal which are required in all cases). | Aerators, recycle pumps, scrapers (for large settlers). |
| Operational characteristics | Simpler than activated sludge. |
| Effect of population | Relatively little. |
| BOD removal highest; effluent nitrified; relatively high power requirement. | |
| Favoured for small and medium sized plants. | |
| Note: *Based on aerator capacity of 2 g $O_2$ / Kwh at standard conditions (zero DO and plain water at $20^0$ C) and 75% of standard value delivered at field conditions. | |

## C. Oxidation Ditch:

An oxidation Ditch is basically an extended aeration system of a modified activated sludge process. Therefore it is designed and operated on the same basic principles of activated sludge process. A motor (i.e. an aerator) is provided across the ditch with flow through velocity of 0.3 to 0.6 m/s. Intensive or extended aeration produces a very clear effluent as biological solids produced are destroyed completely by endogenous respiration and separate sludge handling is not required.

Normally, raw wastewater is applied to the reactor only after screening and grit removal. Therefore, the system does not require a PST and expensive sludge handling and disposal facilities..

## D. Facultative Aerated Lagoons:

In this method power input per unit volume is sufficient only for diffusing the required amount of oxygen into liquid, but not for maintaining all the solids in suspension. Some substrate tends to settle down and undergo aenarobic decomposition at the bottom. It is capable of giving 70-90 % BOD removal.

Facultative type aerated lagoons have been more commonly used the world over because of simplicity in operation and minimum need of machinery. Much less land is required compared to oxidation pond. This can also be used for upgrading overloaded oxidation ponds.

**Typical performance characteristics:**
**(Based on water supply rate of 185 lpcd)**

| | |
|---|---|
| BOD removal, % 75-85 | Nutrient removal, % N Nil |
| Coliform removal, % 60-90 | Nutrient removal, % P Nil |
| Land requirement based on population equivalent 54g /cap-d: | 0.30-0.40 $m^2$/person |
| Process power requirement* | 12-15 kWh/person-year |
| Sludge handling | Manual desludging in 5-10 years. |
| Equipment requirement (excluding screening and grit removal which are required in all cases). | Aerators only. |
| Operational characteristics | Simple. |
| Effect of population | Slight. |
| Power requirement similar to activated sludge but construction and operation very simple; easy to enlarge or relocate if necessary. | |
| Note: *Based on aerator capacity of 2 g $O_2$ / Kwh at standard conditions (zero DO and plain water at $20^0$ C) and 75% of standard value delivered at field conditions. | |

## E. Upflow Anaerobic Sludge Blanket (UASB)

Upflow Anaerobic Sludge Blanket (UASB) is like a large septic tank standing on its head. Like septic tank it needs no power to operate. Yet it is more efficient in removal of organic matters than a septic tank, and gives usable biogas. Main components required will be;

1. Screening and degritting
2. Main UASB reactor (having a sludge blanket and settlers)
3. Gas collection and handling
4. Sludge drying beds
5. Post treatment facility (optional, depending on discharge standards)

In the UASB process, the whole waste (not just the sludge) is passed through the anaerobic reactor in an upflow mode, with hydraulic retention time (HRT) of only about 8-10 hours at average flow. No prior sedimentation is required. The anaerobic unit does not need to be filled with any stones or other media; the upflowing sewage itself forms millions of small 'granules or particles which are held in suspension and provide a large surface area on which organic matter can attach and undergo biodegradation. A high solid retention time (SRT) of 30-50 or more days occurs within the unit. No mixers or aerators are required, thus conserving energy and giving very low operating costs.

Gas produced can be collected and used if desired. Anaerobic systems function satisfactorily when temperature inside the reactor is above 18- 20 degree C. Thus in most part of India temperature is no problem.

Excess sludge is removed from time to time through a separate pipe and sent to a simple sand bed for drying. The nutrients, nitrogen and phosphorus are not removed but are, in fact conserved in the process and, to that extent, make the use of effluent for irrigation more valuable.

**Typical performance characteristics:**

**(Based on water supply rate of 185 lpcd)**

## F. TRICKLING FILTERS

A trickling or percolating filter is form of a packed-bed, fixed-film reactor used in waste treatment. Biological degradation occurs in a manner similar to that in the activated sludge process except that the filter is a system in which the bio-film (corresponding to MLSS in activated sludge) is fixed on a solid medium (stones or plastic). Stone media are placed in a bed about 2 m deep while the wastewater is dosed over it and air is allowed to flow past it within the voids in the media bed. No aeration is necessary, but with some deep bed designs, forced ventilation has been practised.

Although the contact time between the percolating wastewater and the bio-film is of the order of a few minutes to about an hour, much BOD removal is accomplished since it is transferred to the bio-film where the oxidation and synthesis of new cells occur and the end-products are washed back into the wastewater. Synthesis leads to growth of the bio-film thickness which eventually sloughs (peels) off and is washed out of the bed by the flowing wastewater. The bio-microbial composition varies with the depth of the filter, the nature of the waste, and the season of the year.

The trickling filter has been considered more rugged in operation and easier to maintain than activated sludge plants. This is partly because attached growth systems can, on the whole, have a much larger mass of biological solids than the corresponding mass of MLSS in suspended growth systems, and the growths are not easily destroyed or washed out of the system by incoming slugs (fluctuations) in the quality of the wastewater. Alongwith domestic sewage, the presence of considerable concentrations of toxic substances like cyanide, phenols, and formaldehyde can also be tolerated and treated.

Trickling filters are classified into low and high rate filters depending on the organic and hydraulic loads placed on them.

Low rate filters are best used for serving small communities or single households wherein simple and sturdy operation is desired. They need no mechanical equipment except a simple tipping trough or dosing siphon. Re-circulation of flow is not practised. Thus, pumping is not required.

If the land is quite hilly and rocky, a non-mechanized low-rate trickling filter arrangement may become a viable alternative to other waste treatment methods which may then be difficult and expensive to construct. Low-rate trickling filters may also merit strong consideration for medium-sized communities perched on hilltops. The trickling filter could extend all the way from the hilltop to the foot of the hill or as far down as is necessary for providing the required stone volume (with no re-circulation). The energy conservation needs of today demand that the low-rate trickling filter be favourably considered in case, where both hydraulic head and filter stone are available to provide a 'natural' solution as described in the above case.

High-rate filters are more commonly used for municipal sewage treatment as they are preferred for larger flows. They involve more mechanization due to pre and post-filtration settling, continuous sludge withdrawal, recirculation pumping, etc. The excess sludge also needs further treatment.

In the case of stone media, the filter depth is generally restricted to 3 m only, so as not to impede free ventilation.

**Typical performance characteristics:**

**(Based on water supply rate of 185 lpcd)**

| | |
|---|---|
| BOD removal, % 80-90 | Nutrient removal, % N 15-20 |
| Coliform removal, % 60-90 | Nutrient removal, % P 10-20 |
| Land requirement based on population equivalent 54g /cap-d: | 0.20-0.30 $m^2$/person |
| Process power requirement* | 7-11 kWh/person-year |
| Sludge handling | First digest then dried on beds or use mechanical devices |
| Equipment requirement (excluding screening and grit removal which are required in all cases). | Trickling filter arms, recycle pumps, sludge scrapers, thickeners, digesters, gas equipment. |
| Operational characteristics | Skilled operation required. |
| Effect of population | Considerable |
| Considerable equipment and skilled operation required, especially if gas collection and usage involved. | |
| Often been preferred in India for large sized plants owing to lower power requirement compared to activated sludge. | |
| Note: *Based on aerator capacity of 2 g $O_2$ / Kwh at standard conditions (zero DO and plain water at $20^0$ C) and 75% of standard value delivered at field conditions. | |

## G. CONTACT STABILIZATION PROCESS

The contact stabilization process is yet another modification of the activated sludge process in which one takes advantage of the fact that substrate removal occurs in two stages. In the first stage ( lasting 0.5 to 1.0 hour), the colloidal and dissolved organics present in the wastewater are rapidly adsorbed on activated sludge solids. In the second stage (lasting 3 to 6 hours), the adsorbed organics are stabilized. In the processes seen so far, both these steps occurred in the same unit. However, in the contact stabilization process, the two steps, are separated or functionalized. The first step occurs in what is called the 'contact' tank and the second one in the 'stabilization' tank.

The functionalization helps to reduce the overall volumetric requirement of tanks as compared with activated sludge system though the oxygen requirement remains practically the same because the organics to be oxidized remain the same in both cases. An MLSS concentration upto 3,000 mg/L is maintained in the contact unit, while it may even go up to 10,000 mg/L in the stabilization unit. The surplus sludge is withdrawn for further treatment either in an aerobic digester (for smaller plants) or in an anaerobjc digester (for larger plants). As regards the efficiency of performance, the contact process is somewhat similar to the conventional activated sludge process, but requires less reactor volumes.

The contact stabilization process generally lends itself well to the treatment of domestic and municipal wastewaters.

Existing conventional activated sludge plants have sometimes been converted into contact stabilization plants capable of handling nearly double the original flow without any major additions to the overall tank capacities. This is possible because, for example, if a conventional plant receives a flow Q cum/hr and its aeration time is 6 hours, the aeration tank volume is 6Q.Now, for a contact stabilization plant, if the required contact time is 1 hour and the stabilization time is 4 hours based on a return flow of 0.5hrs, the total tank volume required is (Q x 1 hr) + (0.5Q x 4hrs) = 3 hours. Thus, double the flow can be accommodated by converting from the conventional to the contact process.

## H. SEQUENCING BATCH REACTORS (SBR)

### The Process

Although the process is based on the well-known activated sludge extended aeration principle, it has now undergone further simplification due to the adoption of the sequencing batch reactor (SBR) configuration in which the aeration tank serves the double purpose of aeration and settling in the same tank, one after the other, batchwise, in sequence.

Operating Schedule

The aeration system consists of floating aerators (or diffused aeration) which work for a few hours after which they are switched off, together with the inflow, for an hour or so during which period the tank acts like a quiescent settling tank, allowing the MLSS to settle down. The relatively clear liquid from the approximately upper one-third of the tank is then decanted off either through a telescopic outlet or a floating arm or by merely providing an outlet pipe at the lowest level proposed to be reached after withdrawing the supernatant. (The latter arrangement can be adopted for the sake of simplification but may not give as clear an effluent as the other types of outlets would do). When decantation or withdrawal is complete, the outlet valve is closed and raw sewage inflow re-started. The aeration system is now switched on again and the settled MLSS immediately gets picked up in circulation. In this manner, the cycle of aeration, settling, decantation, refilling and re-aeration goes on again and again.

### Nitrification-Denitrification

Some nitrification generally occurs during aeration. The nitrified wastewater undergoes denitrification if the start of re-aeration is delayed and anoxic conditions are allowed to develop in the tank. Already, during the quiescent settling period, when there is no aeration, the dissolved oxygen (DO) level gradually decreases owing to bacterial respiration. If the DO is completely used up, the facultative organisms start breaking down the nitrate molecules into nitrogen gas and oxygen. The nitrogen goes into the atmosphere while oxygen is used to meet the respirational needs of the organisms. Eventually, when the nitrates are exhausted, the sulfates are broken down and this emits obnoxious sulfides. Thus, the anoxic period should be such that only denitrification occurs in it and the sulfates are not touched. The anoxic period required for denitrification is usually the 1.0 to 1.3 hours.

However, when the effluent is to be reused for gardening or horticulture, nitrogen should, in fact, be retained in the system and hence, an additional anoxic period after decantation does not need to be provided.

**Advantages of SBRs**

SBRs ensure economy of construction because no separate settling tank and no recycle sump, pumps or piping are required. Besides simplifying construction, its operation is more stable. As the aeration tank becomes the settling tank, it has a large surface area and can comfortably accommodate peak flows that may come in the morning hours. This also eliminates the danger of exceeding the settling tank's overflow capacity at such times. SBRs is responding better to shock loads. The difficulties caused by rising sludge, filamentous sludge and carry-over of solids are also obviated by the use of SBRs. Aeration equipment and control valves can be sequenced to operate as required, by using timer switches.

Excess sludge is removed from the bottom of the aeration tank, directly dried on open sand beds or wherever possible, and then sent back to the original sewer system downstream of the intake point.

**Performance**

The performance of SBRs has generally remained very satisfactory and stable wherein power is available on a continuous basis. The overall BOD removal efficiency is generally higher than 95 per cent for municipal wastewater, which is typical for extended aeration systems.

**I. Stabilization Ponds (Oxidation Pond):**

Stabilization Ponds are open, flow-through earthen basins specially designed and constructed to treat sewage and biodegradable industrial waste. These are broadly classified as a) Aerobic b) Anaerobic and c) Facultative.

The facultative pond functions aerobically at the surface while anaerobioc conditions prevail at the bottom. The aerobic layer acts as a good check against odour evolution from the pond. The treatment effected by this type of pond is comparable to that of conventional secondary treatment processes. The facultative pond is hence best suited and most commonly used for treatment of sewage.

**Typical performance characteristics:**

| | |
|---|---|
| BOD removal, % 75-85 | Nutrient removal, % N 40-50 |
| Coliform removal, % 60-99.9 | Nutrient removal, % P 20-60 |
| Helminth removal, | yes |
| Land requirement based on population equivalent 54g /cap-d: | 1.0-2.8 $m^2$/person (excluding post treatment) |
| Process power requirement* | Nil |
| Sludge handling | Manual desludging in 5-10 years. |
| Equipment requirement (excluding screening and grit removal which are required in all cases). | Nil. |
| Operational characteristics | Simplest. |
| Effect of population | Slight. |
| Simplest treatment method and nil power requirement but advantage may be offset by high land requirement which may be unavailable or expensive near urban areas. | |

There are standards to meet with for disposal of treated effluent. Main criteria of BOD and COD (mg/l) are given below.

| **Mode of Disposal** | **COD** | **BOD** | **SUSPENDED SOLIDS** |
|---|---|---|---|
| Inland surface water | 250 | 30 | 100 |
| Public sewer | | 350 | 600 |
| Land for irrigation | | 100 | 200 |
| Marine costal areas | 250 | 100 | |
| | | | |

From all the above details it is obvious that treatment method should be decided keeping in mind the quality of sewage, end use of treated water, point of disposal, financial capacity of local body, etc.

**Note:** For further details the book mentioned above can be reffered.