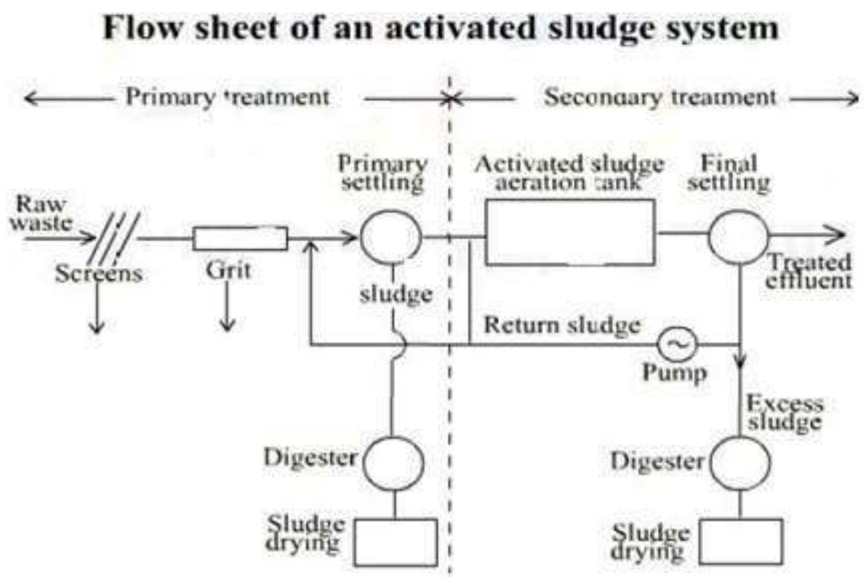
Activated Sludge Process:

The most common suspended growth process used for municipal wastewater treatment is the activated sludge process as shown in figure



Activated sludge plant involves:

1. Wastewater aeration in the presence of a microbial suspension,
2. Solid-liquid separation following aeration,
3. Discharge of clarified effluent,
4. Wasting of excess biomass, and return of remaining biomass to the aeration tank.

In activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and Part is oxidized to CO2 and water to derive energy. In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in t he form of a flocculent sludge i n settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

Activated Sludge Process Variables

The main variables of activated sludge process are the mixing regime, loading rate, and the flow scheme.

Mixing Regime

Generally two types of mixing regimes are of major interest in activated sludge process: plug flow and complete mixing.

In the first one, the regime is characterized by orderly flow of mixed liquor through the aeration tank with no element of mixed liquor overtaking or mixing with any other element. There may be lateral mixing of mixed liquor but there must be no mixing along the path of flow.

In complete mixing, the contents of aeration tank are well stirred and uniform throughout. Thus, at steady state the effluent from the aeration tank has the same composition as the aeration tank contents.

The type of mixing regime is very important as it affects

1. Oxygen transfer requirements in the aeration tank,
2. Susceptibility of biomass to shock loads,
3. Local environmental conditions in the aeration tank, and
4. The kinetics governing the treatment process.

Flow Scheme

The f low scheme involves:

1. The pattern of sewage addition
2. The pattern of sludge return to the aeration tank and
3. The pattern of aeration.

Sewage addition may be at a single point at the inlet end or it may be at several points along the aeration tank. The sludge return may be directly from the settling tank to the aeration tank or through a sludge reaeration tank. Aeration may be at a uniform rate or it may be varied from the head of the aeration tank to its end.

Sludge characteristics

By analyzing the different characteristics of the activated sludge or the sludge quality, plant operators are able to monitor how effective the treatment plant's process is. Efficient operation is ensured by keeping accurate, up-to-date records; routinely evaluating operating and laboratory data; and troubleshooting, to solve problems before they become serious.

Problem:

Design an oxidation pond for treating sewage from a hot climatic residential colony with 5000 persons contributing sewage at120 lit/capita/day. The 5 day BOD of sewage is 300mg/lit.

Given data

Population of residential colony = 5000

Sewage /capita/day =120 lit

5Day BOD of sewage=300 mg/lit=300x10^{-6} Kg/lit

Solution

Quantity of sewage treated/ day= 5000x120

=600000 liters

=60000/10^{6}

=0.6 Million Liters

The BOD content/ day = 0.6x300

=180Kg

Assuming the organic loading in pond as 300Kg/hectare

Surface area required = $\frac{\text{BOD content per day}}{\text{Organic loading}}$

= 180/300= 0.6 hec

=0.6x10000= 6000m^2

Surface area required= 6000m^2

Assuming the length of tank twice the width L=2b

2bxb=6000

b=55m

L=2x55=110m

Assuming effective depth as 1.2m

Volume= 110x55x1.2 = 7260m^3

Detention time= $\frac{\text{Volume}}{\text{Sewage flow per day}}$

=7260/0.6x1000

Detention time = 12 days

Hence use an oxidation pond with length 110m, width 55m , overall depth1.2+1=2.2m and the detention period of 12 days.

Design of inlet and outlet

Assuming the average velocity of sewage as 0.9m/sec and daily flow for 8 hours only

$$\text{Discharge} = \frac{\text{Quantity of sewage per day}}{\text{Daily flow in hrs}}$$

$= 600\ m^3 / 8 \times 60 \times 60\ sec$

Discharge= $0.0208\ m^3/sec$

$Q = AV$

$0.0208 = A \times 0.9$

$A = 0.023 m^2$

Inlet pipe diameter $A = \pi d^2/4$

$0.023 = \pi d^2/4$

d= 0.172m=17.2cm

Diameter of outlet pipe may be taken as 1.5 times the inlet diameter

= 1.5x0.172=0.25m

Diameter of outlet pipe=25cm.

Extended Aeration Treatment System:

It is an innovative activated sludge process using extended retention of biological solids to create an extremely stable, easily operated system. The capabilities of this unique technology far exceed ordinary extended aeration treatment. The process maximizes the stability of the operating environment and provides high efficiency treatment. The design ensures the lowest cost construction and guarantees operational simplicity. The system utilizes a longer sludge age than other aerobic systems. Sludge age, also known as SRT (Solids Retention Time) or MCRT (Mean Cell Residence Time), defines the operating characteristics of any aerobic biological treatment system. A longer sludge age dramatically lowers effluent BOD and ammonia levels, especially in colder climates.

The systems long sludge age process produces BOD levels of less than 10 mg/L and complete nitrification (less than 1 mg/L ammonia). Minor modifications to the system will extend its capabilities to denitrification and biological phosphorus removal.

System Construction

A major advantage of this system is its low installed cost. Most systems require costly in-ground concrete basins for the activated sludge portion of the process. This system can be installed in earthen basins, either lined or unlined. The fine bubble diffusers require no mounting to basin floors or associated anchors and leveling. These diffusers are suspended from the Bio-Flex floating aeration chains. The only concrete structural work required is for the simple internal clarifier(s) and blower/control buildings.

Aeration System Components

The ability to mix large basin volumes using minimal energy is a function of the unique BioFlex moving aeration chains and the attached BioFuser fine bubble diffuser assemblies. The gentle, controlled, back and forth motion of the chains and diffusers distributes the oxygen transfer and mixing energy evenly throughout the basin area. No additional airflow is required to maintain mixing.

Membrane Bioreactors:

The technologies most commonly used for per-forming secondary treatment of municipal wastewater rely on microorganisms suspended in the wastewater to treat it. Although these technologies work well in many situations, they have several drawbacks, including the difficulty of growing the right types of microorganisms and the physical requirement of a large site.

The use of microfiltration membrane bioreactors (MBRs), a technology that has become increasingly used in the past 10 years, overcomes many of the limitations of conventional systems. These systems have the advantage of combining a suspended growth biological reactor with solids removal via filtration.

The membranes can be designed for and operated in small spaces and with high removal efficiency of contaminants such as nitrogen, phosphorus, bacteria, bio-chemical oxygen demand, and total suspended solids.

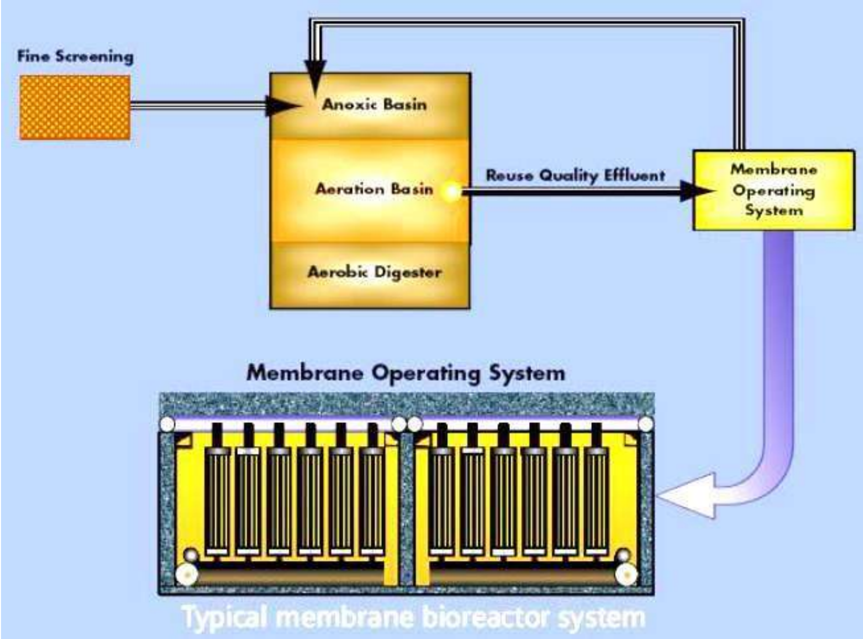
The membrane filtration system in effect can replace the secondary clarifier and sand filters in a typical activated sludge treatment system. Membrane filtration allows a higher biomass concentration to be maintained, thereby allowing smaller bioreactors to be used.

Applicability

For new installations, the use of MBR systems allows for higher wastewater flow or improved treatment performance in a smaller space than a conventional design, i.e., a facility using secondary clarifiers and sand filters.

Historically, membranes have been used for smaller-flow systems due to the high capital cost of the equipment and high operation and maintenance (O&M) costs. Today however, they are receiving increased use in larger systems. MBR systems are also well suited for some industrial and commercial applications.

Although MBR systems provide operational flexibility with respect to flow rates, as well as the ability to readily add or subtract units as conditions dictate, that flexibility has limits. Membranes typically require that the water surface be maintained above a minimum elevation so that the membranes remain wet during operation.



Membrane Care

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

- Good screening of larger 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.

Advantages and disadvantages

The advantages of MBR systems over conventional biological systems include better effluent quality, smaller space requirements, and ease of automation.

Specifically, MBRs operate at higher volumetric loading rates which result in lower hydraulic retention times. The low retention times mean that less space is required compared to a conventional system.

The primary disadvantage of MBR systems is the typically higher capital and operating costs than conventional systems for the same through-put.

O&M costs include membrane cleaning and fouling control, and eventual membrane re-placement. Energy costs are also higher because of the need for air scouring to control bacterial growth on the membranes.

Sequencing Batch Reactors (SBR):

The sequencing batch reactor is a fill and draw activated sludge system for waste water treatment. In this system, wastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged. Equalization, aeration, and clarification can all be achieved using a single batch reactor. To optimize the performance of the system, two or more batch reactors are used in a predetermined sequence of operations.

SBR systems have been successfully used to treat both municipal and industrial wastewater. They are uniquely suited for wastewater treatment applications characterized by low or intermittent flow conditions.

An SBR serves as an equalization basin when the vessel is filling with wastewater, enabling the system to tolerate peak flows or peak loads in the influent and to equalize them in the batch reactor. In many conventional activated sludge systems, separate equalization is needed to protect the biological system from peak flows, which may wash out the biomass, or peak loads, which may upset the treatment process.

APPLICABILITY

SBRs are typically used at flow rates of 5 MGD or less. The more sophisticated operation required at larger SBR plants tends to discourage the use of these plants for large flow rates. As these systems have a relatively small footprint, they are useful for areas where the available land is limited.

In addition, cycles within the system can be easily modified for nutrient removal in the future, if it becomes necessary. This makes SBRs extremely flexible to adapt to regulatory changes for effluent parameters such as nutrient removal. SBRs are also very cost effective if treatment beyond biological treatment is required, such as filtration.

ADVANTAGES AND DISADVANTAGES

Some advantages and disadvantages of SBRs are listed below:

Advantages:

a) Equalization, primary clarification (in most cases), biological treatment, and secondary clarification can be achieved in a single reactor vessel.

b) Operating flexibility and control.

c) Minimal footprint.

d) Potential capital cost savings by eliminating clarifiers and other equipment.

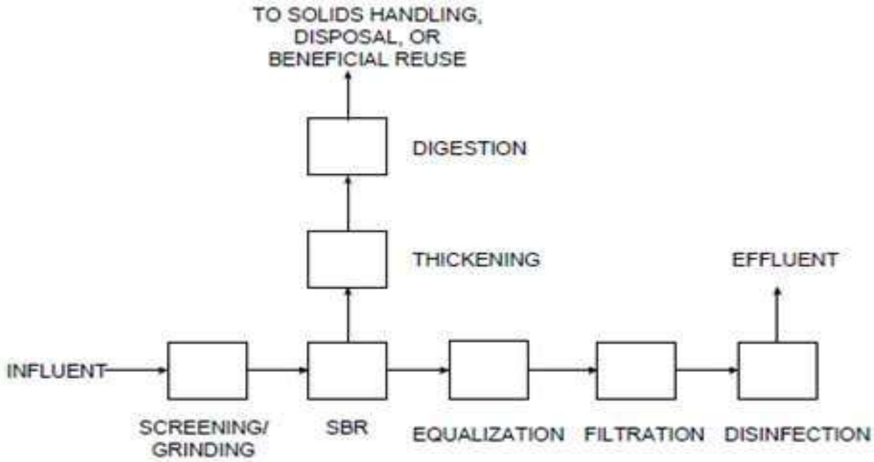
Disadvantages

a) A higher level of sophistication is required (compared to conventional systems), especially for larger systems, of timing units and controls.

b) Higher level of maintenance (compared to conventional systems) associated with more sophisticated controls, automated switches, and automated valves.

c) Potential of discharging floating or settled sludge during the DRAW or decant phase with some SBR configurations.

d)Potential plugging of aeration devices during selected operating cycles, depending on the aeration system used by the manufacturer.



Process flow diagram for a typical SBR

Construction

Construction of SBR systems can typically require a smaller footprint than conventional activated sludge systems because the SBR often eliminates the need for primary clarifiers. The SBR never requires secondary clarifiers. The size of the SBR tanks themselves will be site specific, however the SBR system is advantageous if space is limited at the proposed site.

Tank and Equipment Description

The SBR system consists of a tank, aeration and mixing equipment, a decanter, and a control system. The central features of the SBR system include the control unit and the automatic switches and valves that sequence and time the different operations. SBR manufacturers should be consulted for recommendations on tanks and equipment.

It is typical to use a complete SBR system recommended and supplied by a single SBR manufacturer. It is possible, however, for an engineer to design an SBR system, as all required tanks, equipment, and controls are available through different manufacturers. This is not typical of SBR installation because of the level of sophistication of the instrumentation and controls associated with these systems.

The SBR tank is typically constructed with steel or concrete. For industrial applications, steel tanks coated for corrosion control are most common while concrete tanks are the most common for municipal treatment of domestic wastewater.

For mixing and aeration, jet aeration systems are typical as they allow mixing either with or without aeration, but other aeration and mixing systems are also used. Positive displacement blowers are typically used for SBR design to handle wastewater level variations in the reactor.

PERFORMANCE

The performance of SBRs is typically comparable to conventional activated sludge systems and depends on system design and site specific criteria. Depending on their mode of operation, SBRs can achieve good BOD and nutrient removal. For SBRs, the BOD removal efficiency is generally 85 to 95 percent.

SBR manufacturers will typically provide a process guarantee to produce an effluent of less than:

i) 10 mg/L BOD

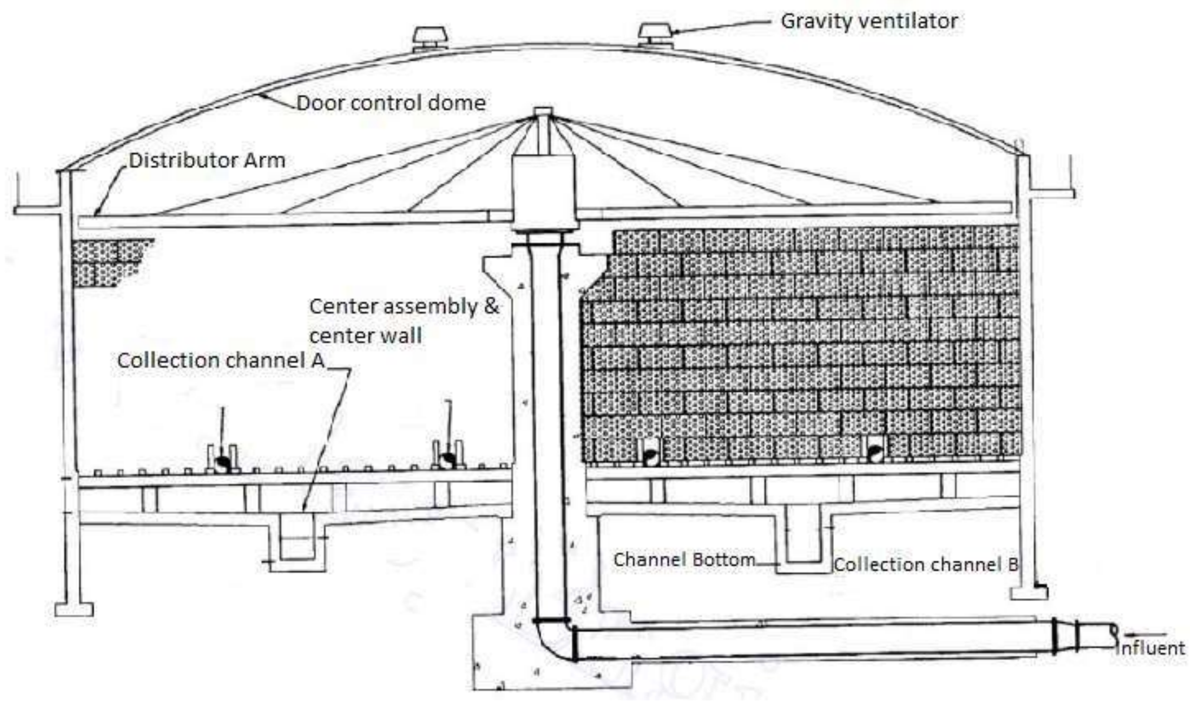
ii) 10 mg/L TSS

Trickling Filters:

Trickling filter is an attached growth process i.e. process in which microorganisms responsible for treatment are attached to an inert packing material. Packing material used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials.

Process Description

1. The wastewater in trickling filter is distributed over the top area of a vessel containing non-submerged packing material.
2. Air circulation in the void space, by either natural draft or blowers, provides oxygen for the microorganisms growing as an attached biofilm.
3. During operation the organic material present in the wastewater is metabolized by the biomass attached to the medium. The biological slime grows in thickness as the organic matter abstracted from t he f lowing wastewater is synthesized into new cellular material.
4. The thickness of the aerobic layer is limited by the depth of penetration of oxygen into the microbial layer.
5. The micro-organisms near the medium face enter the endogenous phase as the substrate is metabolised before it can reach the micro-organisms near the medium face as a result of increased thickness of the slim layer and lose their ability to cling to the media surface. The liquid then washes the slime of the medium and a new slime layer starts to grow. This phenomenon of losing the slime layer is called sloughing.
6. The sloughed off film and treated wastewater are collected by an under drainage which also allows circulation of air through filter. The collected liquid is passed to a settling tank used for solid- liquid separation.



Types of Filters

Trickling filters are classified as high rate or low rate, based on the organic and hydraulic loading applied to the unit.

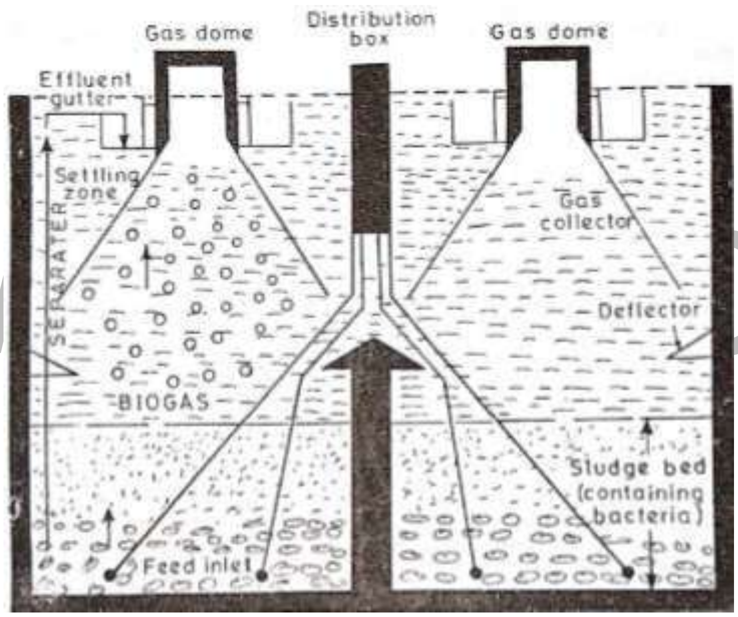
S.No	Design Feature	Low Rate Filter	High Rate Filter
1.	Hydraulic loading, $m^3/m^2.d$	1 - 4	10 - 40
2.	Organic loading,kg BOD / m^3.d	0.08 - 0.32	0.32 - 1.0
3.	Depth, m.	1.8 - 3.0	0.9 - 2.5
4.	Recirculation ratio	0	0.5 - 3.0 (domestic wastewater) upto 8 for strong industrial wastewater.

1. The hydraulic loading rate is the total flow including recirculation applied on unit area of the filter in a day, while the organic loading rate is the 5 day 20°C BOD, excluding the BOD of the recircular, applied per unit volume in a day.
2. Recirculation is generally not adopted in low rate filters.
3. A well operated low rate trickling filter in combination with secondary settling tank may remove 75 t o 90% BOD and produce highly nitrified effluent It is suitable for treatment of low t o medium strength domestic wastewaters.
4. The high rate trickling filter, single stage or two stage are recommended for medium to relatively high strength domestic and industrial wastewater. The BOD removal efficiency is around 7 5t o 90% but the effluent is only partially nitrified.
5. Single stage unit consists of a primary settling tank filter, secondary settling tank and facilities for recirculation of the effluent. Two stage filters consist of two filters in series with a primary settling tank, an intermediate settling tank which may be omitted in certain cases and a final settling tank.

UASB (Upflow Anaerobic Sludge Blanket) Reactor:

The UASB reactor maintains a high concentration of biomass through the formation of highly settle able microbial sludge aggregate. The waste water flows upwards through a layer of very active sludge to cause anaerobic digestion of organics of the waste water at the top of the reactor, these phase separation between gas-solid-liquid takes place any biomass leaving the reaction zone is directly recirculated from the settling g zone. The process is suitable for both soluble waste waters as well as waste water containing particulate matter.

The large scale adoption of this technique for treating municipal waste waters is comparatively of recent origin .This reactor consists of an Up flowing treatment tank, provided with a feed inlet distribution system at the tank bottom. A gas solid-liquid separator (GSS) device is provided at the top to help provide a quiescent zone at the top of the reactor.



The wastewaters enter the tank from the bottom and flows upward through the sludge bed. The sludge bed develops micro-organisms capable of Flourishing in an oxygen deficient environment. The sludge bed (blanket) traps the suspended organics of the up moving wastewater. The suspended solids trapped in the sludge bed are degraded by the producing methane and CO 2(ie, biogas, which is a mixture of 65-70% methane, and 30-35% CO_2.The biogas produce of during the anaerobic decomposition reducing the BOD and suspended solids of the wastewater. The methane or biogas is collected at the top of the tank in a gas collector from Where it can be withdraw n for use as a by-product, while the water sludge mixture is made to enter a setting tank where the sludge mixture is made to enter a setting tank where the sludge settles down and f lows back in to the bottom of the reactor.

The sludge will show good settling properties after an initial start up period, followed by granulation forming a sludge blanket or sludge bed in the lower part of the reactor. Retention of the bacteria contacting sludge in the reactor is one of the most important features of the UASB process. The bacteria in the sludge continue to perform their function of treating the incoming effluent. The continuous bacterial presence and activity enables retention time in the reactor to be reduced to about 6-8 hours, as compared to at least 30 hrs that is required in conventional sewage treatment systems. The treated effluent is collected in gutters, and discharged out of the reactor. The sludge is periodically shifted in to the drying beds to be used as a soil enriches, The methane generated can be used as a gas for domestic or industrial use it may also be used for generation of electricity for running the plant, after the approximated hydration and cleaning. This process can be reactivated even after the plant remains shut down for days or months, or after power breakdowns and interruptions in wastewater supply Like other high rate anaerobic systems.

The various advantages offered by UASB systems are

The space requirement of the system is quite comparable to that of an Activated sludge ie, about 0.5 acres per MLD, as compared to 2.5 acres per MLD required for oxidation ponds, and 1.5 acres for Aerated lagoons.

The capital cost investment of such a plan it s about Rs.20 lakh/MLD as compared oabout Rs.35 lakh/MLD for an Activated sludge plant, Rs.75 lakh/MLD for oxidation ponds and Rs.15lakh/MLD f or Aerated lagoons.

The system requires lesser and simpler electromagnetic parts as compared to the ones required in an Activated sludge plant, leading to lower operation and Maintenance cost.

Electricity consumption in this system , like all anaerobic systems is quite low, and the system is quite capable of withstanding long power failures.

The sludge Production system is low, and the produced sludge is having quick dewatering characteristics.

The system enables quicker sludge digestion, as compared to the conventional digestors.

Biogas is produced in the system as a by-product, which can be used to produce electricity to run the system.

Waste Stabilization Ponds:

Waste stabilization ponds (WSPs) are sanitation technologies that consist of open basins that use natural processes to treat domestic wastewater, septage, and sludge, as well as animal or industrial wastes. They can be used in centralized or semi-centralized sewerage systems, they can also be used to treat fecal sludge from onsite dry sanitation systems, or as onsite water-based sanitation systems serving a single building or home. The most common types of WSPs are anaerobic ponds, facultative ponds, maturation or polishing ponds, aerated ponds, and high-rate algal ponds (HRAPs)

Some pathogen removal is accomplished in anaerobic, facultative, aerated ponds and HRAPs, even though their primary function is to remove and stabilize organic matter. The primary function of maturation and polishing ponds however, is to remove and inactivate pathogens.

WSP systems require large areas of open land, making them ideal in smaller towns and rural settings, though they are used successfully in many urban environments as well, often in combination with other sanitation technologies. One of the biggest advantages of WSPs is that they are easy and inexpensive to operate and maintain, and generally do not rely on mechanized equipment or expensive material.

Waste stabilization ponds (WSPs) are open basins enclosed by earthen embankments, and sometimes fully or partially lined with concrete or synthetic geofabrics. They employ natural processes to treat domestic wastewater, septage, and sludge, as well as animal or industrial wastes. They can be used in centralized or semi-centralized sewerage systems, serving cities or towns; they can also be used as onsite systems serving a single entity (e.g., highway rest area, community center, etc.)

Inputs and Outputs for Waste Stabilization Ponds:

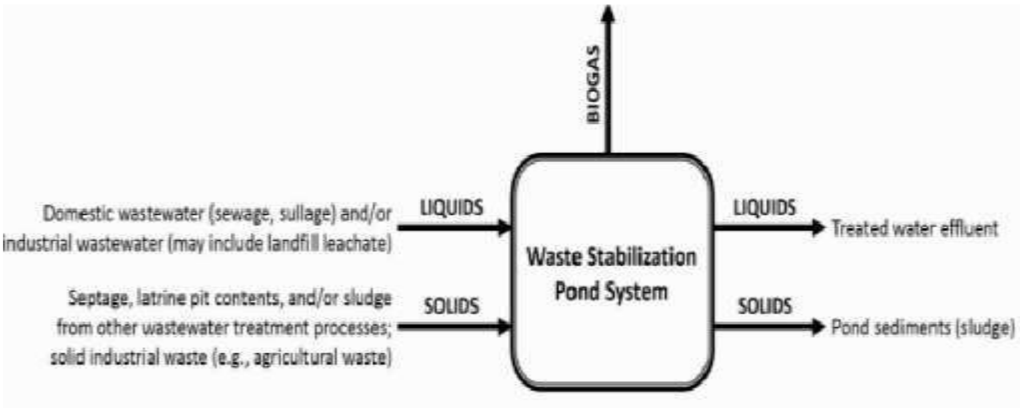
WSPs can be used to treat a variety of water and waste streams, thus the inputs may include wastewater, septage, latrine pit contents, and/or sludge from other wastewater treatment processes.

WSPs may receive untreated wastewater that has gone through preliminary treatment (e.g. screening and grit removal), or they may receive secondary effluent from some other treatment process, such as anaerobic reactors, activated sludge, or trickling filters. The outputs from WSP systems include the treated effluent (liquid), sludge/sediments (solids), and biogas. The treated liquid effluent from WSPs is often continuously discharged; however, operators of some systems (especially in colder climates) may stop discharging for months at a time, allowing the ponds to fill up and discharging once the temperature gets warmer (this extra retention time makes up for the slower rate of treatment during colder months).

Sludge removed from WSPs is contaminated with pathogens and needs to be safely managed (to prevent exposure) or treated (to reduce the concentration of pathogens). Refer to the chapter on Sludge Management.

Factors Affecting Pathogens in Waste Stabilization Ponds:

Different factors affect different types of pathogens in different ways. The most important factor for the removal of viral and bacterial pathogens is sunlight exposure, although other factors such as temperature, dissolved oxygen and pH are also important. Sedimentation, hydraulic efficiency, sunlight exposure, and physical chemical factors (including temperature and pH) are all important factors for the removal of protozoan pathogens, though sedimentation is perhaps the most important.



Typical inputs and outputs from waste stabilization pond systems

Sedimentation

WSP systems have hydraulic retention times on the order of days, weeks, or even months, which allows large, dense particles to settle. Sedimentation is more effective in WSPs with less turbulence. Ponds should be designed to maintain quiescent conditions that approach laminar flow.

The size and density of pathogens and particles determines their settling velocities. Bacteria and viruses will not settle in WSPs unless they are attached to larger, denser particles. Only a small percentage of viruses attach to WSP particles, and they mostly attach to particles that are too small to settle.

Physical-Chemical and Microbiological Factors

The most important physical-chemical factors for pathogen inactivation are pH, temperature and dissolved oxygen in the presence of dissolved organic matter. Most bacterial pathogens are vulnerable to high pH.