5.3 OXIDATION POND

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.

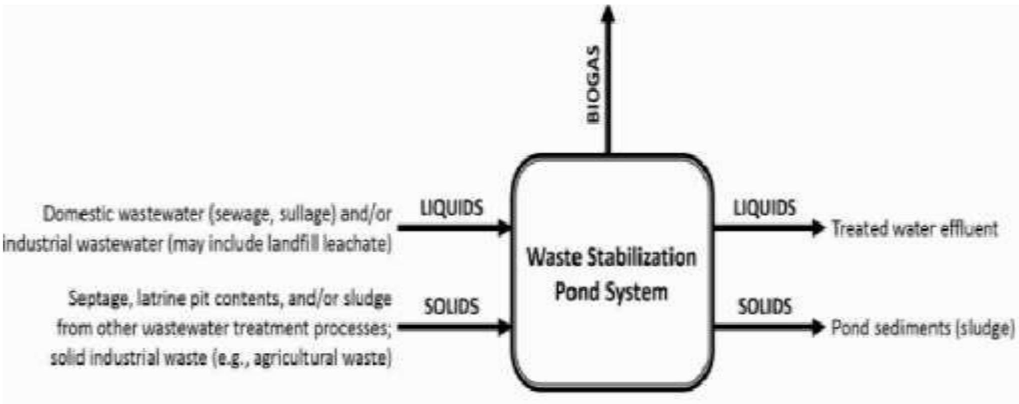
WSPs may receive untreated wastewater that has gone through preliminary treatment (e.g. screening and grit removal), or they may receive secondary effluent from some other treatment process, such as anaerobic reactors, activated sludge, or trickling filters.

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.

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.

<u>Given data</u>

Population of residential colony = 5000

Sewage /capita/day =120 lit

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

<u>Solution</u>

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

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

$$= 600 \text{ m}^3 / 8\text{x}60\text{x}60 \text{ sec}$$

$$\text{Discharge} = 0.0208 \text{ m}^3/\text{sec}$$

$$Q = AV$$

$$0.0208 = A\text{x}0.9$$

$$A = 0.023\text{m}^2$$

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

$$0.023 = \pi d^2/4$$

$$d = 0.172\text{m} = 17.2\text{cm}$$

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

$$= 1.5\text{x}0.172 = 0.25\text{m}$$

Diameter of outlet pipe=25cm.

OXYGEN SAG CURVE AND ITS IMPORTANCE:

In a running polluted stream exposed to the atmosphere, the deoxygenation as well as there-oxygenation goes hand in hand. If de-oxygenation is more rapid than the reoxygenation, an oxygen deficit results. (Note; if the D.O content becomes zero, anaerobic conditions will no longer be maintained and putrefaction will set in) The amount of resultant oxygen deficit can be obtained by algebraically adding the de-oxygenation and re-oxygenation curves. The resultant curve so obtained is called the oxygen sag curve or the oxygen deficit curve. From this curve the oxygen deficit (D) and oxygen balance (i.e 100-D) percent in a steam after a certain lapse of time, can be found out.

It can also be seen that when the de-oxygenation rate exceeds the reoxygenation rate, the oxygen sag curve shows increasing deficit of oxygen, but when both the rate becomes equal, the critical point is reached, and then finally when the rate of de-oxygenation falls below that of re-oxygenation, the oxygen deficit goes on decreasing till becoming zero.

DEOXYGENATION AND REAERATION:

In the polluted stream, the D.O content goes on reducing due to decomposition of volatile organic matter. The rate of deoxygenation depends upon the amount of the organic matter remaining to be oxidisied at he given time as well as on the temperature of reaction. In order to counter- balance the consumption of DO due to de-oxygenation, atmosphere supplies oxygen to the water, and the process is called re-oxygenation. The rate at which the oxygen is supplied by the atmosphere depends.

1. The depth of the receiving water

2. The condition of the body of water

3. The saturation deficit or the oxygen deficit

4. The temperature of water

5.3.1 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.

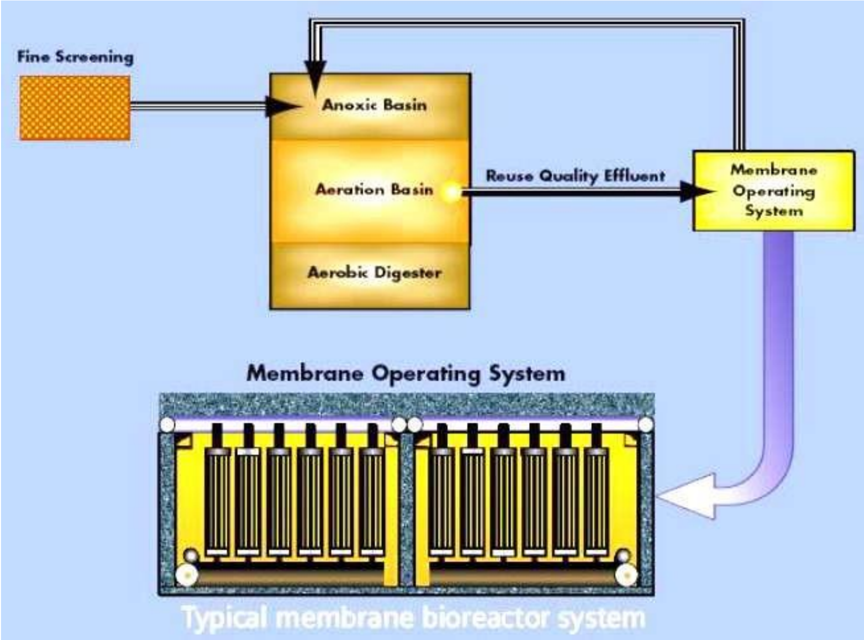
The membrane filtration system in effect can replace the secondary clarifier and sand filters in a typical activated sludge treatment system. Membrane filtration allows a higher biomass concentration to be maintained, thereby allowing smaller bioreactors to be used.

<u>Applicability</u>

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 required, 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 replacement. Energy costs are also higher because of the need for air scouring to control bacterial growth on the membranes.

5.3.2 SELF PURIFICATION TREATMENTS

Self purification of natural streams:

When the waste water or the effluents discharged in to a natural stream, the organic matter is broken by bacteria to ammonia, nitrate, sulphate, carbon dioxide etc In this process of oxidation, the DO content of natural water is utilized. Due to this, deficiency of DO is created. As the excess organic matter is stabilized, the normal cycle will be restabilised in a process known as self purification where in the oxygen is replenished by its reaeration by wind.

Water quality standards are often based upon maintenance of some minimum dissolved oxygen concentration which will protect the natural cycle in the stream while taking advantage of its natural assimilative capacity.

Actions involved in the self purification are physical, chemical and biological in nature

1. Dilution

2. Dispersion due to currents

3. Sedimentation

4. Oxidation

5. Reduction

6. Temperature

7. Sunlight

1. Dilution

When waste water is discharged in to the receiving water, dilution takes place due to which the concentration of organic matter is reduced and the potential nuisance of sewage is also reduced. When the dilution ratio is high, large quantities of DO are always available which will reduce the chances of putrefication and pollutional effect. Aerobic condition will always exist because of dilution.

2. Dispersion due to currents

Self purification of stream largely depends on currents which will readily disperse the wastewater in the stream preventing locally the high concentration of pollutants. High velocity improves reaeration which reduces the concentration of pollutants. High velocity improves reaeration which reduces the time of recovery, though length of stream affected by waste water is increased.

3. Sedimentation
If the stream velocity is lesser than the scour velocity of particles, sedimentation of the particles will take place which will have two effects,

a. The suspended particles will contribute largely to oxygen demand which will be removed by settling and hence water quality to the downstream will be increased.

b. Due to settled solids, Anaerobic decomposition may take place.

4. Oxidation

The organic matter present in the waste water by aerobic bacteria utilizing DO of the natural water, This process prevails till complete oxidation of organic matter. The stream which is capable of absorbing more oxygen rapidly through reaeration etc. and purify heavily polluted water in a short time.

5. Reduction
The reduction occurs in the streams due to hydrolysis of the organic matter biologically or chemically.Anaerobic bacteria split the organic matter in to liquids and gases thus paving way for their ultimate stabilization by oxidation.

6. Temperature
At low temperature the activities of bacteria is slow and hence rate of decomposition will also be slow though DO will be more because of increased solubility of oxygen in water. At higher temperature, however the self purification takes lesser time though t he quality of DO will be less.

7. Sunlight

It helps certain microorganisms to absorb co2 and give out oxygen, though assisting in self purification. Sunlight act as a disinfectant and stimulate the growth of algae which produce oxygen during day light but utilize oxygen at night hence wherever there is algal growth, the water may be supersaturated in DO during daylight hours though anaerobic condition exist in it.

Self Purification Process:

When sewage is discharges into a natural body of water, the receiving water gets polluted due to waste products, present in sewage effluents. But the conditions do not remain so for ever, because the natural process of purification such as dilution, sedimentation, oxidation-reduction in sunlight, etc, go on acting upon the pollution elements, and bring back the water in to its original condition. The automatic purification of polluted water, in due course is called the self purification phenomenon. However if the self purification is not achieved successfully due to either too much of pollution discharge in to it or due to other causes, the river water itself will get polluted, which in turn, may also pollute the sea where the river outfalls.

Factors influencing self purification process:

1. Temperature

2. Turbulence

3. Hydrography such as the velocity and surface expanse of the river stream.

4. Rate of reaeration etc.

Temperature:

Besides affecting the dilution and sedimentation rates, the temperature also affects the rate of biological and chemical activities, which are enhanced at high temperatures and depressed at lower temperatures. The dissolved oxygen content of water, which is very essential for maintaining aquatic life and anaerobic conditions (so as to avoid the anaerobic decomposition and subsequent nuisance caused by the eruption of foul odors) is also influenced by temperature. At higher temperature the capacity to maintain the D.O concentration is low.

Turbulence:

while the rate of biological and chemical activities are high, causing thereby rapid depletion of D.O this is likely to lead to anaerobic conditions, when the pollution due to putrescible organic matter is heavy. The turbulence in the body of water helps in breaking the surface of the stream of lakes, and helps in rapid re-aeration from the atmosphere. Thus it helps in maintaining aerobic conditions in the river stream, and in keeping it clean. Too much of turbulence, however is not desirable, because it cannot be at the bottom sediment increases the turbidity and retards algae growth, which is useful in reaeration process. Wind and under current in lakes and oceans cause turbulences which affect their self-purification.

The hydrography:
Affects the velocity and surface expanse of the river stream, High velocities cause turbulence and rapid reaeration, while large surface expanse(for the same cubic contents) will also have the same effects.

Dissolved oxygen:

The large amount of dissolved oxygen present in water, the better and earlier the self purification will occur. The amount and type of organic matter and biological growth present in water will also affect the rate of purification. Algae which absorbs carbon dioxide and gives out oxygen, is thus very helpful in the self purification process.

The rate of Reaeration:

The rate at which the D.O deficiency is replenished, will considerably govern the self purification process. The greater is the rate, the quicker will be self-purification, and there will be no chances of development of anaerobic conditions.