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Case Study Based Comparison of Popular Wastewater Treatment Technologies in Present Scenario

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ABSTRACT: Wastewater treatment is a process used to convert wastewater, which is highly polluting into an effluent that can be either returned to the water cycle with minimal environmental issues or reused safely. There are various technologies used in the treatment of wastewater in the present times. The best technology can be selected for a particular place based on various parameters like space requirement, initial cost of the plant, operation and maintenance cost, power requirement, quantity and quality sludge produced etc. The paper aims to establish comparative analysis of three popular wastewater treatment techniques based on literature reviewed and the site study done for each case. The main technologies studied are as : (i) Moving Bed biological Reactor(MBBR), (i) Sequencing Batch Reactor(SBR), (iii) Soil Bio Technology(SBT).

Keywords: Wastewater treatment, SBR, MBBR, SBT.

I. TECHNIQUES FOR WASTEWATER TREATMENT

A. Sequencing Batch Reactor (SBR)

The Sequencing Batch Reactor (SBR) is an activated sludge process designed to operate under non-steady state conditions. The SBR operates in a true batch mode with aeration and sludge settlement both occurring in the same tank.

The SBR is distinguished from conventional continuous-flow, activated sludge system as SBR tank carries out the functions of equalization, aeration and sedimentation in a time sequence rather than in the conventional space sequence of continuous-flow systems. In addition, the SBR system can be designed with the ability to treat a wide range of influent volumes whereas the continuous system is based upon a fixed influent flow rate.The SBR processes save more than 60% of the cost required for conventional activated sludge process in operating cost and also achieve high effluent quality in a very short cycle time (Ramasamy *et al.,* 1993). The complete process takes place in a single reactor, within which all biological treatment steps taking place sequentially. Noadditional settling unit / secondary clarifier is required.The complete biological operation is divided into cycles. Each cycle is of 3 – 5 hours duration, during which all treatment steps take place (Irvine *et al*., 1989).

A basic cycle comprises of

(i) **Anoxic fill:** The influent wastewater is distributed throughout the settled sludge through the influent distribution manifold to provide good contact between the microorganisms and the substrate.

(ii) **Aerated fill:** Mixed liquor is drawn through the manifold, mixed with the influent flow in the motive liquid pump, and discharged, as motive liquid, to the jet aerator. Nitrification and denitrification occurs at the beginning of this stage.

(iii) **React:** During this period aeration continues until complete biodegradation of BOD and nitrogen is achieved.

(iv) **Settle:** Aeration is discontinued at this stage and solids separation takes place leaving clear treated effluent above the sludge blanket.

(v) **Decant:** This period is characterized by the withdrawal of treated effluent from approximately two feet below the surface of the mixed liquor by the floating solids excluding decanter.

(vi) **Idle:** The time in this stage can be used to waste sludge or perform backwashing of the jet aerator. The wasted sludge is pumped to an anaerobic digester to reduce the volume of the sludge to be discarded.

Site visit of SBR plant was done in Sector 54, Noida. The capacity of plant was 25 MLD. The plant flow characteristics were as follows:

Table 1: Flow characteristics of SBR Plant.

Capacity Of Plant	25 MLD	**Inlet COD**	350-450 mg/L
Residual Chlorine	2.5 ppm	**Outlet COD**	<50 mg/L
Inlet BOD	250-300 mg/L		
Outlet BOD	<10 mg/L		

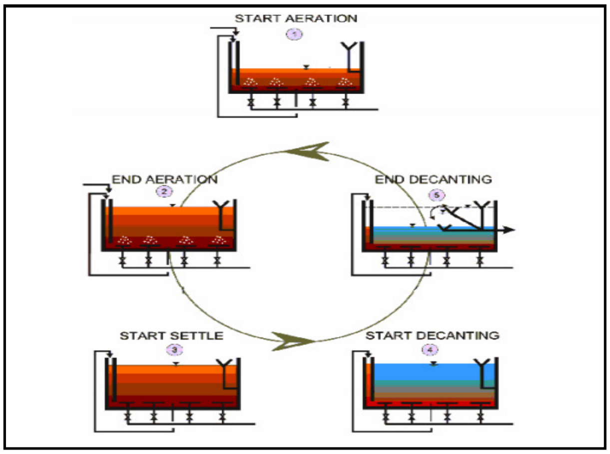

Fig. 1. Operation Cycle of SBR.

B. Soil Bio Technology

SBT is a wastewater treatment process, which is based on a bio-conversion process where fundamental reactions of nature; namelyrespiration, photosynthesis and mineral weathering take place in a media housing micro and macro organisms which bring about the desired purification. SBT is an oxygen supplying biological engine and so the process can treat all types of water – domestic, municipal and industrial.It can be used for heavy metal removal, hospital waste, and industrial wastewater processing and air purification. It is highly versatile. (www.cleanindiajournal.com/soil_biotechnology_for_sewage_treatment).Soil Biotechnology harnesses the bioenergy in organic matter by combining the elements of a productive soil ecosystem to unlock plant nutrients from minerals, fix atmospheric nitrogen and produce metabolites that are used by plants and thus, avoid wasteful dissipation of the carbon energy. Presence of select aerobic bacteria and mineral additives prevent foul odour in the process. Since SBT treats water for reuse and not for disposal, SBT is recommended for apartments and communities in cities for solving apartment water problem. (www.commonfloor.com/guide/soil-biotechnology-for-sewage-treatment).

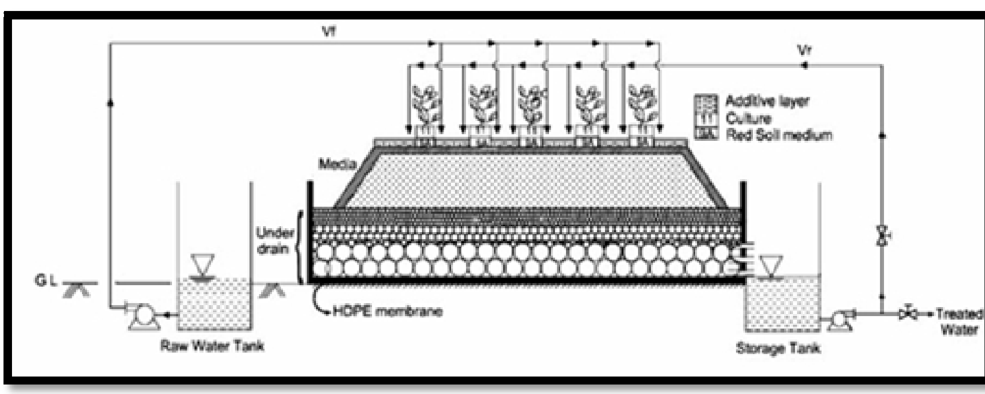

Fig. 2. Layout of SBT.

SBT plants are built of natural minerals, constructed media, proprietary, culture, additives and plantation with absolutely no moving parts.All this gives the plant a serene look and makes it easy to run with virtually no maintenance. Site visit of soil biotechnology plant was done at JIEM, Jaipur.

C. Moving Bed Biological Reactor (MBBR)

The MBBR is a two (anoxic) or three (aerobic) phase system with free- moving plastic biofilm carrier which requires energy (i.e., mechanical mixing or aeration) to enable uniform distribution throughout the tank. These systems can be used for municipal and industrial wastewater treatment (Feng *et al.,* 2009). The process includes a submerged biofilm reactor and liquid solids separation unit.

The components include several process configurations and effluent water quality standards for processes like carbon oxidation, nitrification, and denitrification.

Table 2: Flow characteristics of Soil Biotechnology Plant.

Plant Capacity 15 Kld	
Inlet BOD 60.5 Mg/L	Outlet BOD 11.5 Mg/L
Inlet COD 463.6 Mg/L	Outlet COD 78.2 Mg/L
Total Suspended Solids in Influent 219 Mg /L	Total Suspended Solids In Outlet 61.5 Mg /L
Dissolved Oxygen 1.8 Mg/L	Dissolved Oxygen 5.4 Mg/L

MBBR is a highly effective biological treatment process that was developed on the basis of conventional activated sludge process and bio-filter process. It is a completely mixed and continuously operated biofilm reactor, where the biomass is grown on small carrier elements that have a little lighter density than water and are kept in movement on the top of influent (Lee *et al.,* 2006).

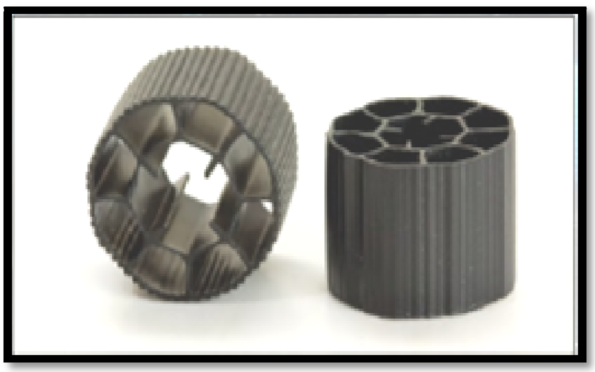

Fig. 3. Media used in MBBR treatment.

Table 3: Flow characteristics of MBBR plant.

Plant Capacity 30 MLD	
Inlet BOD 215-245 Mg/L	Outlet BOD <30 Mg/L
Inlet TSS 415-580 Mg/L	Outlet TSS < 50mg/L
Inlet COD 350 -450 Mg/L	Outlet COD <150mg/L

Movement is ensured by aeration or stirrer. The high biofilm surface area in MBBR is achieved by adding biofilm carries with a high surface area at high volumetric filling fractions, usually up to 2/3 of the reactor volume (Odegaard *et al.,* 1994). Site visit to MBBR plant was done at Loni Ghaziabad, U.P.. The plant characterstics are summarized in Table 3.

II. COMPARISON OF TREATMENT TECHNIQUES

A comparison of various parameters related to the about mentioned treatment techniques has been done on the basis of site visits and detailed study on the technologies. The observations are tabulated in Table 4.

Table 4: Comparative Analysis of Treatment Techniques.

S. No.	FACTORS OF COMPAR-ISON	MBBR	SBR	SBT
1	Type of process (BOD reduction)	BOD reduction takes place aerobically. Fixed film process. Organic matter is brought in contact with bacteria attached to plastic media, which is in suspension. Excess sludge is sloughed off automatically, and separated in the clarifier. No sludge recycle is required.	BOD reduction takes place aerobically. Suspended growth process. Improvised Activated Sludge Process. The organic matter is brought in contact with bacteria in suspension.	BOD reduction takes place. Aerobically, no excess sludge is generated in the process.
2.	Process variables	No sludge volume index / recycle need be checked. System is self-sustaining. Excess biomass automatically gets wasted off. MLSS levels up-to 12,000mg/l are easily achieved.	Need to maintain certain level of MLSS, sludge volume index like activated sludge process. MLSS levels up-to 5000 mg/l are possible. Higher levels hinder settling and results in poor performance	Population of microorganisms, type of plants used, reactor bed configuration, time for the start of the process.

S. No.	FACTORS OF COMPAR-ISON	MBBR	SBR	SBT
3	Area required	Very small area required as compared to SBR, ASP, UASB, RBC.	Area required is higher than MBBR but less then ASP.	Very less area is required.
4	Power requirement	Power requirement is low.	Power required is more than MBBR.	Less power is consumed in the process. Only power is used for operating the pump.
5	Moving parts	No moving part in biological process.	Moving parts in biological process. Decanter mechanism is mechanically activated and hence needs continuous maintenance. Without decanter, SBR does not function at all. Very high level of instrumentation is required.	No moving parts are there.
6	Operation and maintenance	No scum formation in the process and less moving parts in the system. Hence very low maintenance. Therefore the manpower cost is low.	The entire plant operation is cyclic in nature and controlled by PLC only. The process requires very high level of instrumentation and sequencing operation.	No operation and maintenance is required. Once the process is started it continues and the performance of the plant increases as the time progresses.
7	Excess sludge control	The excess sludge wasting is from secondary clarifier, which is like any other ASP system and hence simple.	Excess sludge must be removed with manual intervention. Any higher withdrawal will result inSBR operating at lower efficiency. Hence control of process becomes very sensitive and instrument dependent.	No excess sludge is generated.
8	Sludge properties	Sludge is fully digested. Hence, it can be dewatered directly without any further treatment.	Sludge is active. Hence, anaerobic(or aerobic) digester is a must, for complete destruction of biomass. This increases plant cost and operator attention.	No sludge is produced in the process.
9	Amount of excess sludge	Sludge age is very high, and hence sludge production is about 0.1 – 0.15kg / kg of BOD destroyed, hence very small amount of excess sludge is generated.	Sludge age is low hence sludge production is about 0.3 – 0.6 kg /kg BOD destroyed. Which means that the amount of excess sludge generated is about 200 to 400% higher than MBBR. This requires large sludge handling system.	Nil.

S. No.	FACTORS OF COMPAR-ISON	MBBR	SBR	SBT
10	Expandability	High as higher loads can be accepted with extra media filling. Modular construction is possible.	Very low as higher loads cannot be accepted. However, Modular construction is possible.	Higher loads not accepted.
11	Usage of treated effluent	No further treatment required for gardening and horticulture.	Treated effluent can be used for low end purposes such as construction, floor washing, etc. For gardening or higher end uses, chlorination and filtration are a must.	Treated effluent is used for horticulture , gardening ,etc.
12	Size wise suitability of process	Suitable for analysis, no limitation.	Suitable for any size, no limitation. Larger sizes demand much higher space.	Suitable for colleges, schools,airports etc.

III. CONCLUSION

Based on the study, it can be concluded that Soil Biotechnology is the technology for the future. It has an edge over other treatment techniques. The advantages of SBT as compared to other technologies are listed below:

- Cost effective.
- High efficiency in removing BOD and COD.
- Efficient pathogen removal.
- Odorless operation of the plant.
- Environment friendly technology.
- Maintains good aesthetic quality-green gardens.
- Skilled manpower is not required.
- No use of chemicals.

Thus, more focus should be given to SBT to make it a primary treatment technique for all types of wastewater owing to its large number of advantages. It is one of the most feasible solutions for urban wastewater management and can be employed at apartments and institutions.

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