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Comparative Study of Various Wastewater Treatment Technologies

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Abstract: ***Huge amount of wastewater emerging from various sources like industries, household works, commercial works etc is produced in our country on daily basis. The amount of wastewater produced is increasing day by day due to increase in industrialization and the increasing population of our country. This wastewater is discharged into water bodies after full or partial treatment causing water pollution problems. Thus, this pollution must be controlled by adequately treating the wastewater before it is discharged into the water bodies. Many treatment methods have come into existence like aerated lagoons, oxidation ponds, activated sludge etc. Moving bed biofilm reactor (MBBR), Membrane bioreactor (MBR) and Sequencing batch reactor (SBR) are also one of the latest treatment methods of the wastewater. This paper aims on the study of the MBBR, MBR and SBR methods in which conclusion of the research paper will be helpful to environmentalist / designers to decide the suitable treatment strategy among these according to situations prevailing on site. All the considered wastewater treatment process are used to remove contaminants from wastewater and convert it into an almost non-polluted effluent that can be returned to the water cycle with a minimum impact on the environment, or can be directly reused/recycled. The latter is called water reclamation because treated wastewater can be used for other purposes. The treatment process takes place in a wastewater treatment plant (WWTP), often said to be a Water Resource Recovery Facility (WRRF) or a Sewage Treatment Plant (STP).***

I. INTRODUCTION

Due to increase in the urbanization the amount of wastewater released into the environment has grown to a significant amount which should be treated up to adequate extent as it is causing significant negative impact on human life, wild life and aquatic life. The treatment of wastewater is carried out at a common place known as the wastewater treatment plant. These plants are helpful in removing contaminants from the wastewater.

The wastewater has to undergo the physical, chemical and biological procedure to remove the contaminants from it and give out an environmentally friendly safe treated effluent. Apart from various conventional treatment units like ASP, TF, RBC, USAB, stabilization pond etc various types of new technologies being used for the treatment of wastewater in modern treatment plant namely –

A. Moving Bed biofilm Reactor (MBBR)

This is the type of aerobic treatment in which small circular ring like structures called Carriers are introduced into the reactor in appropriate quantity. These Carriers are made up of various materials which have density close to the density of water (generally high density polythene).These carrier media are placed in a reactor and are operating in a fixed continuous motion in it and the process of aeration is also carried out simultaneously with the help of the aerators provided on the bottom of the reactor.

This technology provides a cost effective treatment with requirement of very less maintenance, produces lower sludge, show better respond to load fluctuations and also does not require the recycling of the sludge.

Such reactors can be arranged in series based on BOD load of waste water. This is a leading edge technology for wastewater treatment which is based on aerobic biofilm principle which provides all the advantages of the activated sludge system and fillers.

This reactor can have any shape and size for fulfilling different discharge requirements and varying load requirements. This reactor can be used both for aerobic and anaerobic process.

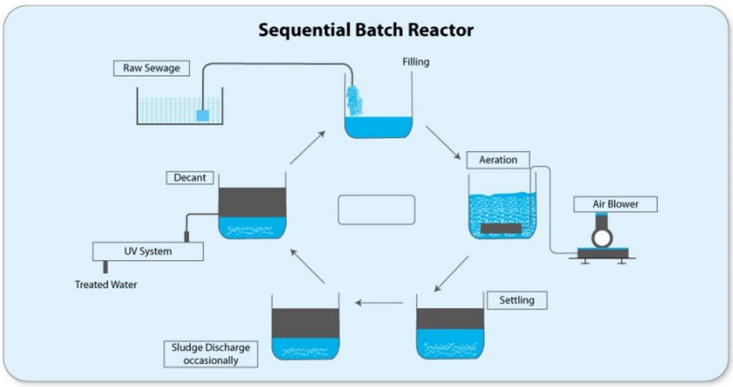
View of the carrier media is shown in Figure 1

B. Sequencing Batch Reactor (SBR)

It is a modification of the conventional activated sludge process which is designed to operate under non steady state conditions. This differs from activated sludge plants because it combines all of the treatment steps including the functions like equalization, aeration, sedimentation and decantation in a time sequence in a single tank or basin. In addition to this SBR can be used for the treatment of wide range of effluent discharge.

The main advantage that SBR system provides over other process is that this process saves up to 60% of the operating cost required for the conventional Activated sludge process and also operating in less time provides a higher effluent quality. The complete biological treatment is divided into cycles. Each cycle is of 3-5 hours duration.

Figure 2 shows operating stages of SBR.



A basic cycle comprises of –

1) *Fill:* In this phase the basin receives influent wastewater. Food (organic matter) is provided to the microbes in the activated sludge which creates an environment for the biochemical reactions to take place.

During the fill phase mixing and aeration can be varied, according to which fill operation is classified as –

a) *Static Fill:* In this phase no mixing and aeration is adopted while the influent wastewater is entering the tank.
b) *Mixed Fill:* In this scenario mechanical mixers are active but the aerators remain off during filling operation.
c) *Aerated Fill:* In this phase both the aerators and the mechanical mixing units are active during filling operation.

2) *React:* In this phase reduction of the organic matter present in the wastewater take place as there is no waste water entering the basin and the mechanical mixers and the aerations units are working simultaneously. During this stage there is no addition of wastewater in reactor and the organic loadings in the basin.
3) *Settle:* During this phase, sludge is allowed to settle under quiescent conditions. No flow enters the basin and no aeration and mixing is carried out. The settling of the flocculent mass is done under flocculent zone/ hindered zone settling.
4) *Decant:* During this phase a decanter is used to remove the clear supernatant which is formed after satisfactory settling of suspended organic matters. Once, the settle phase is completed signal is send to the decanter to start the opening of the effluent discharge valve. Floating or fixed decanters are used to take out treated clear wastewater from top layer without disturbing the settled sewage.
5) *Idle:* This step occurs between the settle and decant phase during which a small amount of activated sludge is pumped out present at the bottom of the basin to maintain suitable F/M ratio to ensure satisfactory performance of the system.

Treated effluent can be disinfected and further treated for getting higher quality standards of wastewater to meet specific requirements, if any.

C. Membrane Biofilm (MBR)

This process is the combination of the microfiltration and the ultrafiltration. This process uses membranes for the solid – liquid separation. A membrane is simply a two-dimensional material used to separate components of fluids usually on the basis of their relative size or electrical charge. In this process the separated components remain chemically unchanged. This method provides a very high quality of treated effluent.

MBR are distinguished into two types-

1) *Internal:* In this type of MBR unit the membranes are immersed or integrated in the bioreactor.
2) *External:* In this type of MBR unit the membranes are separate units.

This method is preferred over the conventional ASP. In fact, it is one of the most important innovations in the wastewater treatment, as it overcomes most of the drawbacks of the ASP. A MBR is a hybrid of the conventional biological treatment system and the physical liquid –solid separation using membrane filtration.

This method does not require the need for the secondary clarification because of the inclusion of the membranes.

However, the major drawback of the system includes higher energy cost and replacement cost due to fouling of the membrane.

Membrane fouling reduces the membrane performance and its life span and increases head loss. MBR can treat up to 48 million of wastewater per day.

Figure 3 shows a view of MBR unit

Figure 3: Membranes in MBR

II. LITERATURE REVIEW

1) MANJU MINHAS and SHEFALI BAKSHI (2017) performed case study based comparison of popular wastewater treatment technologies in present scenario and concluded that among the three wastewater treatment methods i.e. MBBR,SBR and SBT (soil bio technology) the SBT is the technology for the future. This technology has an edge over other treatment techniques. The advantages of SBT compared to other technologies include cost effectiveness, odourless operation of the plant, skilled manpower is not required, no use of chemicals etc.
2) ANKIT B. PINJARKAR, RUSHIKESH D. JAGTAP, CHAITANYA K. SOLANKE and HITESH H. MEHTA (2017) studied the Moving bed biofilm reactor and concluded that The moving bed bio film reactor has established itself as a well proven, robust and compact reactor for waste water treatment. The efficiency of the reactor has been demonstrated in many process combinations, both for BOD-removal and nutrient removal. It has been used for small as well as large plants. The load of BOD-COD has been reduced considerably by use of this technology. The basic advantage of the process as compared to activated sludge reactors is its compactness and no need for sludge return. The advantage over other bio-film processes is its flexibility. One can use almost any reactor shape and choose different operating loads in a given reactor volume, simply by varying volume of carrier filling. Even though it has been focused on municipal waste water applications. In this paper, it is mentioned that the reactor has been used also for industrial waste water, particular for the food industry and the pulp and paper industry. Tests area so being performed on anaerobic waste water treatment as well as drinking water treatment.
3) RAHUL RANGARI, DIWAKAR AMANE, SAURABH KELZARKAR and SNEHA BAMBARDE (2020) studied the a review on utilization of sequencing batch reactor technology for wastewater treatment plant and concluded that SBR has wide applicability for treating domestic wastewater. SBR is efficient biological treatment for domestic wastewater when it is assessed on the basis of variations in operating parameters like flow, BOD etc.
4) STACY SCOTT studied the Application of membrane bioreactor technology to wastewater treatment and reuse and concluded that the application of MBR technology is rapidly expanding with new installation occurring every year. MBR technology is highly suitable for the reclamation of wastewater due to the ability to produce nearly drinking water quality standard. The effluent produced can be reused within industrial processes or discharged to surface waters without degrading streams and rivers.

III. COMPARITIVE STUDY

A comparative study was carried out of all the three methods discussed above on the basis of design of these systems and the results are shown in the form of the table.

The results are shown for a 100 MLD plant

Parameters of comparison	MBBR	SBR	MBR
Total area requirement (Acres)	12–14 (secondary + tertiary)	13-15 (secondary + tertiary)	6-8 (secondary + tertiary)
Capital cost of the plant (crores)	67.5 – 68.0 (till secondary treatment)	74.5 – 75.0 (till secondary treatment)	79.5-80.0 (till secondary treatment)
Supervision required	2-3 persons	3-5 persons	1-2 persons
Replacement of the parts	10 -15 years replacement of carrier media	10-15 years life of decanters	4-6 years replacement of membranes
Power cost	4-5 crores (per annum)	90 lakhs- 1.5 crores (per annum)	6.5 – 7 crores (per annum)
BOD, mg/l of treated effluent	< 20-30	<5	<3-<5
COD , mg/l of treated effluent	<250	<100	<100
TSS , mg/l	<100	<10	<5
TKN and P mg/l	Not treatable	<10-<2	Not treatable
Annual operating and maintenance cost	6-12 crores (per annum)	8-10 crores (per annum)	14-15 crores (per annum)

A general comparison of MBBR, SBR & MBR is mentioned below-

PARAMETERS OF COMPARISON	MBBR	SBR	MBR
1. LAND REQUIREMENT	Moderate 93% of SBR	High Considering 100%	Very less 53% of SBR
2. LAND COST	Medium	Highest	Lowest
3. ENERGY RECOVERY	Poor	Poor	Poor
4. CAPITAL COST	Medium cost 85% OF MBR	High cost (DECANTERS) 93% of MBR	Potential high cost (MEMBRANES) considering 100%
5. OPERATING AND MAINTENANCE COST	Medium 80% of MBR	High cost of maintenance 66.6% of MBR	High cost of maintenance Considering 100%

6. PERIODIC EQUIPMENT REPLACEMENT TIME	10-15 years (media)	15 year replacement (decanters)	Membrane replacement from 4-6 years
7. POWER COST	Medium 71.4% of MBR	High 21.4% of MBR	Highest Considering 100%
8. SKILLED PERSONAL COST	Operation is simple	Cycle time management needs skilled supervision	Needs higher skills
9. CHEMICAL COST	Only disinfection (low)	Only disinfection (low)	Various chemicals for membrane cleaning + disinfection (high)
10. ELECTROMECHANICAL COST	Medium	High	Highest
11. CIVIL CONSTRUCTION COST	Highest	Medium	Medium
12. GLOBAL WARMING POTENTIAL	Less	High	High
13. POWER REQUIREMENT	Less	High	Very high
14. COMPLEXITY	Relatively simple process	Less complex but cycle time adds complexity	Very complex
15. TERTIARY TREATMENT	Required	Required	Not required
16. MAN POWER	Lower	Medium	Very few but skilled
17. ABILITY TO HANDLE VARYING FLOWRATE	Yes	Yes	Yes
18. USE OF SLUDGE	Manure	Disposed to landfill otherwise used as compost	Very less sludge (requires treatment)
19. USES OF TREATED WATER	Irrigation	Irrigation	For other better purpose like groundwater recharge
20. PERFORMANCE RELIABILITY	Reliable with controlled cycle time	Reliable	Highly reliable
21.EASE OF UPGRADATION	Easy	Easy	Difficult
22. EASE OF OPERATION AND MAINTENANCE	Poor	Good	Poor

23. MATURITY OF TECHNOLOGY	Matured	Matured	Latest
24. COST AND FREQUENCY OF SERVICE	Moderate	Moderate	High
25. POWER GENERATION	Nil	Nil	Nil
26. EFFLUENT QUALITY	Moderate	Moderate	High
27. COLIFORM REMOVAL	High	High	Very high
28. NITRIFICATION – DENITRIFICATION	Average	Good	Poor
29. FLY ODOUR NUISANCE	Medium	High	Less
30. PHOSPHOROUS REMOVAL	Poor	Very good	Poor
31. APPLICABILITY ON BASIS OF SCALE	Large scale	Large scale	Small scale (suitable for industrial use)
32. APPLICABLE FOR INDUSTRIES	Yes, space requirement more + less skilled labour	No, space requirement more + skilled labour	Yes, skilled labour+ less space + high cost
33. BOD of treated effluent in mg/l	< 20-30	<5	<3-<5
34. COD	<250	<100	<100

IV. CONCLUSIONS

Based on the above study, it is concluded that MBBR is the best suitable method. It has an edge over other treatment techniques. The advantages of MBBR compared to other treatment methods are listed down below-

A. It is perfect wastewater solution for space constraints.
B. It does not require skilled labour as it is easy to be operated by the semi experienced plant operators.
C. Lesser maintenance is required.
D. Resistant to shock loadings.
E. It works quickly with low hydraulic retention time.
F. Complete solids removal
G. Enhanced process stability
H. Health accommodating
I. Has a D.O (dissolved oxygen meter) that allows the control of the amount of dissolved oxygen injected into the waste stream.
J. No media clogging

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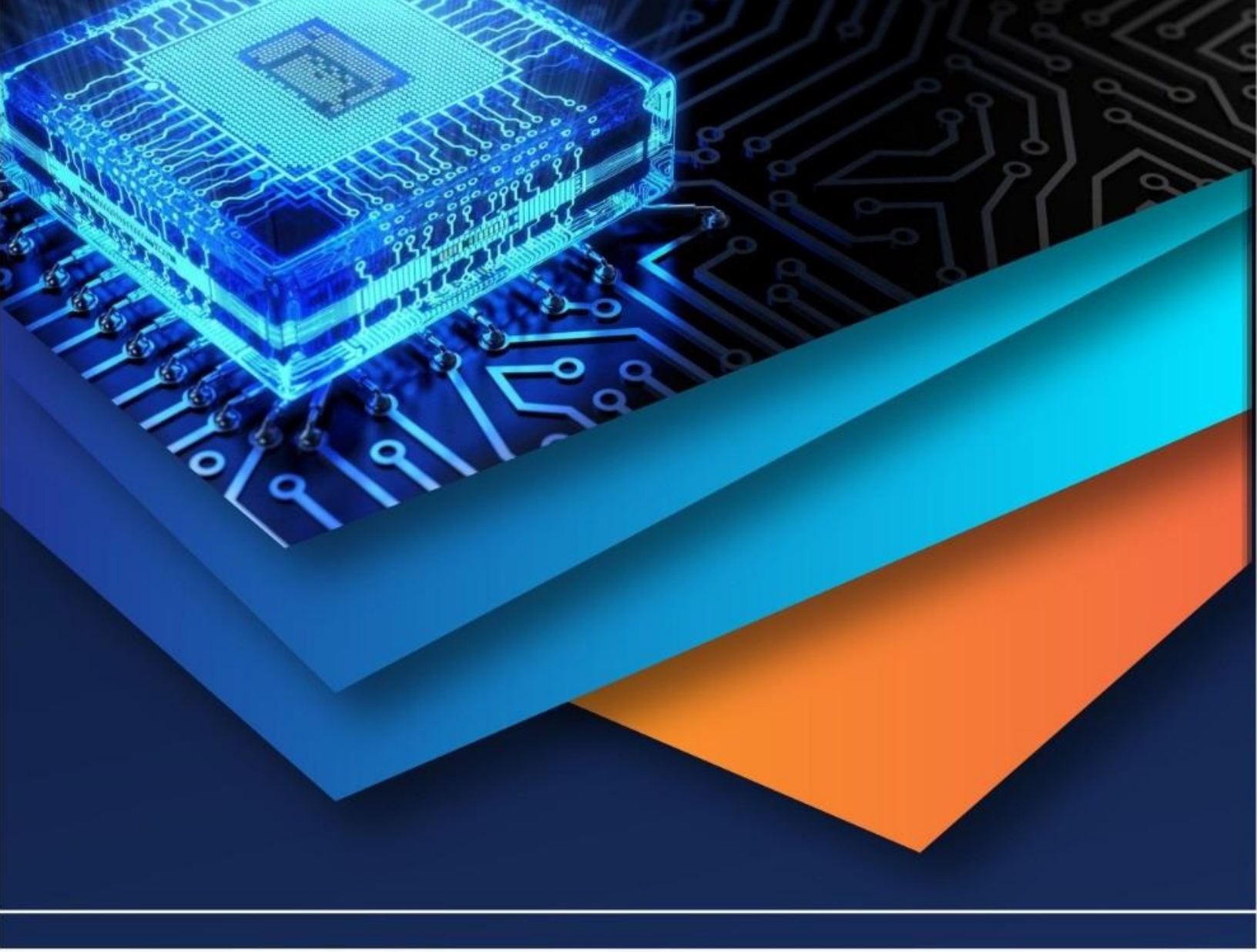

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