

**Techno – Commercial comparison of wastewater treatment
technologies**

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For the award of degree of

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In

Environmental Science & Technology

Submitted by

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TO WHOM IT MAY CONCERN

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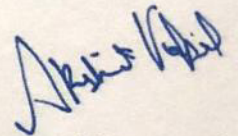
He was punctual and hard working. We wish him all success in his future endeavors.

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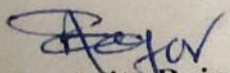
I hereby declare that the project work entitled “**Techno – commercial comparison of wastewater treatment technologies**” is an authentic record of my own work carried out at “**Eco Laboratories & Consultants Pvt. Ltd., Mohali**” as requirements of one year project internship for the award of M.tech in **Environmental Science & Technology**, Thapar Institute of Engineering and Technology, Patiala under the guidance of **Mr. Ankit Mohta and Dr. Anita Rajor**, During June 2017 to June 2018.



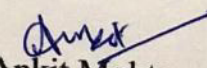
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Abstract

Wastewater treatment plants based on different technologies are in practice. Varied claims are being made on their performance efficiency as suitability. In most of the situations, these claims are made on the basis of evaluation of different plants. A technical and commercial basis for comparison of these plants has done. In this study an attempt was made to evaluate the performance of the treatment plants based on MBBR and MBR, operating under similar conditions. In the present study, the membrane bio reactor MBR is the promising technology for the biological treatment of domestic as well as the industrial wastewater. Interestingly, the technology has the considerable scope to reduce the operation and maintenance cost with better efficiency. The filtration based system is suitable for the treatment of domestic wastewater and proper solid liquid separation.

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1 Introduction

Water is an important part of our day to day lives and we require water mostly for all activities, human life is affected in all forms by water. Increasing population and development increases the demand of water every year and due to limited resources there comes shortage of clean water on our planet.

In the past we have been using water and then releasing the used water (wastewater) into the rivers, streams and oceans which is now affecting the source because it contains excessive nutrients, harmful bacteria/viruses and household chemicals that may contaminate the land and waters and threaten public health. This pollution to the source of water will give rise to many water borne diseases and harm aquatic life, so to prevent this and save our water resources we need some methods to properly treat wastewater. The treatment of waste water is considered to be very essential before discharging it to eco system [Gulhane et al., 2015]

In India there is a huge gap between the production of wastewater and treatment of wastewater, due to which adverse impact was observed in an ecosystem and fresh water availability. The discharging of wastewater into natural water bodies is increasing the pollution of natural resources and is the rising cause of many water borne diseases and problems. Wastewater with high levels of organic matter, total suspended solid (TSS) cause several problems such as oxygen depletion, toxicity and turbidity when discharged to the environment. It is therefore necessary to remove these substances from wastewater for reducing their harm to environment. To demolish these problems, treatment of wastewater is necessary. [Ravichandran et al., 2012]

After treating the wastewater, it can be reused in various activities such as irrigation (both agricultural and landscape), recharge of aquifers, industrial applications, dual-distribution systems for toilet flushing and other urban use. Reusing of wastewater became ecofriendly solution for conservation of water.

For implementation of methods to reduce, treat or reuse wastewater Authorities has set guidelines, which will be implied on all anthropogenic activities that generates wastewater. The Ministry of Environment and Forest has fixed norms to discharge the sewage effluents with following characteristics so as to avoid the adverse effects.

pH	6.5-9.0
BOD (Biological Oxygen Demand)	20 mg/L
TSS (Total Suspended Solids)	<50 mg/L

(Source- Moef 13 Oct 2017)

To achieve these above mentioned norms after treatment of wastewater, it is important to select most efficient and effective wastewater treatment process. In the selection of suitable waste water treatment technology, in-depth study is required. [Ravichandran et al., 2012]

Wastewater can be treated by chemical, biological or combination of both methods. The biological wastewater treatment methods are however widely used because of their suitability and merits over other methods. They are economically suitable in the developing countries which have low operation and maintenance cost with better efficiency than any other treatment methods. Biological processes are a cost-effective and environmentally sound alternative to the chemical treatment of wastewater.

Biological process is usually divided into anaerobic and aerobic processes, “Aerobic” refers to a process in which oxygen is present, while “anaerobic” describes a biological process in which oxygen is absent.

These processes are based upon suspended growth system and attached growth system. The suspended growth system (i.e., activated sludge process) is effective for organic carbon and nutrient removal in domestic waste water treatment plants. But there will be some problems of sludge settle ability, the need of large size of reactor and settling tanks for biomass recycling. Whereas attached growth biofilm processes proved to be reliable for organic carbon and nutrients removal without any of problems encountered in activated sludge process such as area requirement for the treatment units, recycling of biomass etc.

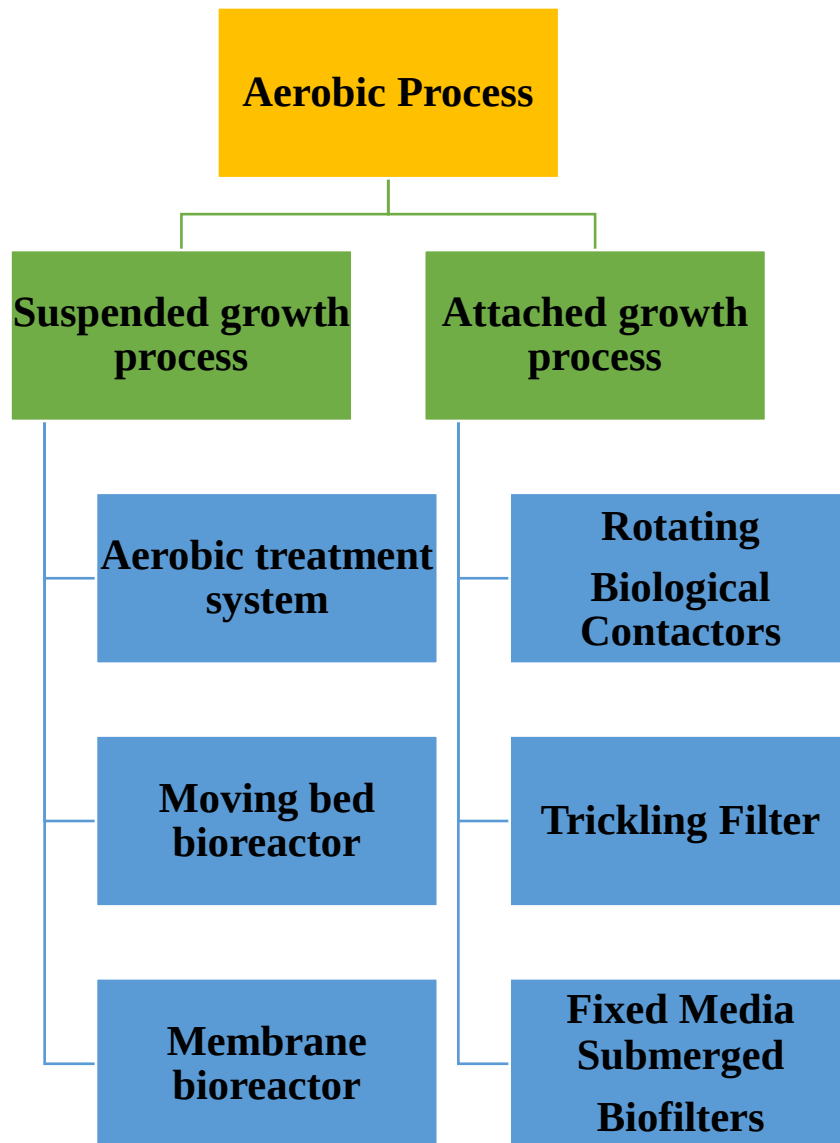


Figure 1-1 flowchart of treatment process

In this study it is more focused upon the real time commercial implementation of Biological treatment technology which depends upon Economical cost, Area required, Efficiency of Plant etc. Case study of two wastewater treatment plants with Moving Bed Biofilm reactor and Membrane Bioreactor technology is carried out.

1.1 Overview of waste water treatment technologies

Moving bed biofilm reactor (MBBR) process has been developed in Norway in the late 1980s and early 1990s. it is widely applied technology used to treat not only the domestic wastewater but also the industrial

wastewater, The process incorporates the better efficiency to treat the wastewater ranging from lower concentration to the higher concentration, The MBBR technique has various advantages over any other biological treatment methods used to treat wastewater. MBBR has the positive aspect of both the suspended growth and attached growth The MBBR technique has the combined advantage of both activated sludge processes and any other bio-film reactor. [Borkar et al., 2013]

In this process, carriers (media) are used for the adhesion of microbial bio-film on surface of carriers (media) which is responsible for the biodegradation of organic matter in wastewater. The continuous suspension of carriers (media) in reactor is maintained by providing the aeration system which introduces the fine or medium sized bubble into the reactor. The use of attached instead of suspended biomass allows the construction of very compact reactors and provides an easier separation of bio-solids from the treated effluent. The surface loading rate is responsible for the design of operational reactor. The MBBR system is characterized by low suspended solid content Different size and shape of carriers have different potential to form the bio-film It is proved that the bio-film process is reliable for the elimination of chemical oxygen demand (COD) as well as the nutrient removal. [Borkar et al., 2013]

Membrane bioreactor process is a suspended growth activated sludge system; combination of conventional biological wastewater treatment plant and membrane filtration. Filtration process in wastewater treatment is widely used as a tertiary treatment process as Ultra filtration, Nano Filtration etc. But in this technology it is primarily used with combination of activated sludge process to remove the sludge. The process is similar to typical wastewater treatment plant, the only difference is that separation of activated sludge is done by filtration instead of sedimentation.

MBR's have proven quite effective in removing organic and inorganic contaminants as well as biological entities from wastewater. Advantages of the MBR include good control of biological activity, high quality effluent free of bacteria and pathogens, smaller plant size, and higher organic loading rates. [Cicek et al., 2003]

2 Literature Review

Wastewater treatment planning is a difficult task to accomplish. Due to many factors which should keep in mind before planning a treatment plant; Ecological conditions, budget, treatment efficiency power consumption, land requirement etc. there are three treatment units in every treatment plant Physical treatment, biological treatment and chemical treatment. Most important of all is biological treatment which degrades organic matter. In past when wastewater treatment technologies were at their research stage most common type of treatment plant consist of open aeration tanks in which wastewater is kept for some time for processing of natural degradation by bacteria which require large area and consumes time, now in the developing nation like India we need more advanced technologies to treat wastewater as already discussed due increasing quantity of wastewater. Different technologies are in practice but we need to choose the best suitable technology for fulfilling our needs and it is a challenging aspect to differentiate between wastewater technologies. Various studies have been carried out for comparison of different treatment technologies. [Koul et al., 2015]

2.1 Treatment Process

The wastewater produced can be organic or inorganic in nature or a combination of both. To remove organic and inorganic substance from the wastewater, various treatments like physical, chemical and biological treatment are used. The physical treatment methods remove settleable solids. Non biodegraded substances are removed by the chemical treatment. Biological processes are a cost effective and environmentally sound alternative to the chemical treatment of wastewater. The biological treatment such as trickling filters, oxidation pond, aerated lagoon, UASB and activated sludge process are used for organic removal. [Vaidhegi et al., 2016]

But there are many problems encountered in biological treatment such as sludge settle ability and requirement of large area for reactors and settling tanks and biomass recycling. Many number of technologies such as activated sludge process, sequencing batch reactor, trickling filter, UASB and rotating biological contactors are being used for treatment of wastewater. [Ingale et al., 2015]

Every wastewater treatment technology has its merits and demerits for example UASB was vastly used in wastewater treatment; up flow anaerobic sludge blanket is an anaerobic treatment, requires more time for processing and if the ratio of COD to BOD is too low then the process will not work. The methanogenic

bacteria reproduce slowly and they are very sensitive to toxic substances and the gas production during winter is low when compared to summer. Wastewater discharge from UASB has some organic substance. For removal of that substance, effluent needs to be treated using an aerobic process like activated sludge which is commonly preferred. In activated sludge process, recycling of sludge is used to maintain the reaction process and also large area is required. The composition of waste particularly contains high carbohydrates causes sludge bulking. Due to that poor settling will occur and high biomass will be lost with effluent. For that reasons, adopting new treatment or upgrading the existing treatment plant is essential. [Vaidhegi et al., 2016]

Below are two treatment technologies adopted to overcome the problems faced by above mentioned technologies:

The **Moving bed bio film reactor** is a process which combines the technologies of activated sludge processes and bio film processes. In that process, reduction of COD and BOD from the effluent is high without the loss of biomass. This technology uses media for microorganism attaching and the media are moving in water during operation. To compensate for lower performance, MBBR has a simple operational mode and it has high oxygen transfer efficiency. The land requirement is less and no recycling is required for that process.

The **Membrane Bio Reactor** technology, Biological treatment technologies have been utilized in wastewater reclamation for over a century. Out of the many different processes used, the activated sludge process has proven to be the most suitable. The implementation of membranes within the treatment process of a wastewater treatment plant was initially limited to tertiary treatment. High capital and operational costs as well as inadequate knowledge on membrane application in wastewater treatment were factors in limiting the use of this technology. However, with the introduction of less expensive and more effective membrane modules and the implementation of strict water discharge norms, membrane systems regained interest. [Cicek et al., 2003]

2.1.1 Moving Bed Biofilm Reactor

Moving Bed Biofilm Reactor (MBBR) is one of the promising technologies used for treatment of wastewater.

The MBBR incorporate benefits provided by both fixed film and suspended growth processes. The MBBR is reliable, innovative and cost effective treatment process for the wastewater. Moving bed biofilm reactor technology was invented in Norway before 25 years. The first MBBR facility became operational in 1990 in Lardnal, Norway. MBBR technology has since made significant penetration into the European market with an installed base of more than 300 MBBR systems. The idea behind the development of the Kaldnes MBBR process was to adopt the best features of the activated sludge process as well as those of the biofilter processes, without including the worst. Contrary to most biofilm reactors, the MBBR utilize the whole tank volume for biomass growth. It also has a very low head-loss. Contrary to the activated sludge reactor, it does not need any sludge recycle. 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 along with a water stream inside the reactor. [Borkar et al., 2013]

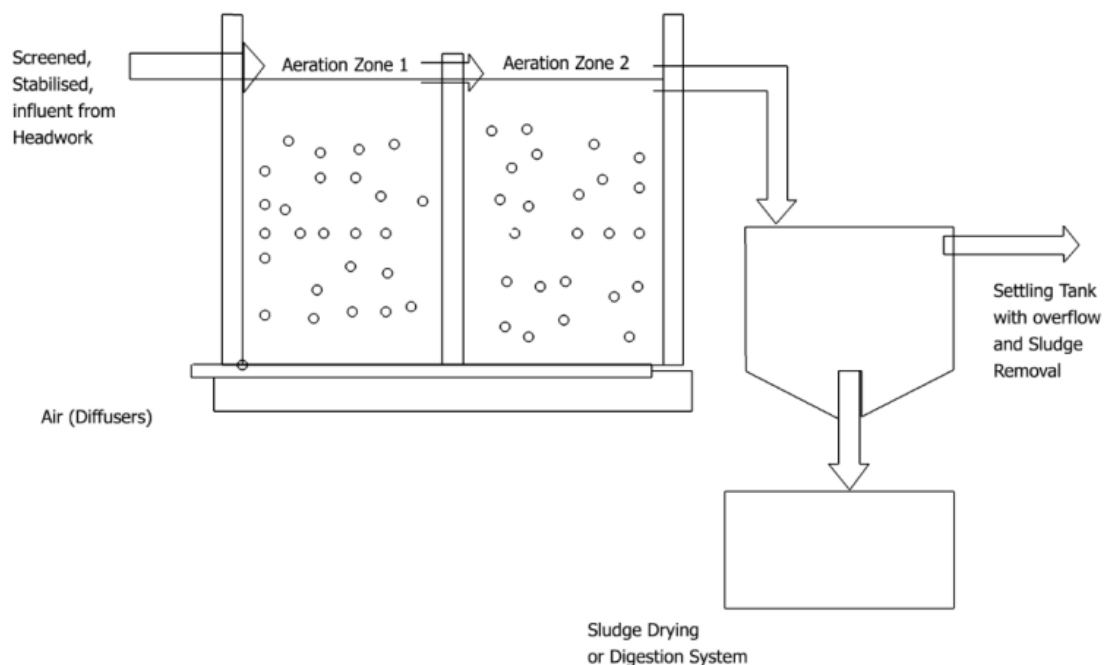


Figure 2-1 Schematic figure of MBBR process

The movement inside a reactor can be caused by aeration in an aerobic reactor and by a mechanical stirrer in an anaerobic or anoxic reactor. With MBBR technology, the biofilm that is created around each carrier element protects the bacteria cultures. This makes it much more stable under load variations and less sensitive to temperature or pH variations than conventional systems. Researchers have proven that MBBR

possesses have many excellent traits such as high biomass, high COD loading, strong tolerance to loading impact, relatively smaller reactor and no sludge bulking problem.¹

The process can either be used as a

- 1) Pre-treatment system ahead of an existing activated sludge system for increased organic matter removal
- 2) Stand-alone biological treatment process for BOD removal, nitrification and/or denitrification
- 3) A Retrofit of an existing activated sludge processes to help increase overall nitrification capacity of the existing system.

2.1.2 Membrane Bio Reactor

The MBR technology, for both municipal and industrial wastewater treatment, has rapid growth in recent years, boosted by need for more advanced wastewater treatment, more strict legalization and scares of fresh water resources. This technology is based on conventional activated sludge process, which involves the natural biodegradation of organics by bacteria in aerated conditions. Activated sludge further separate with the implementation of sedimentation process after the biological treatment process, the efficiency is usually limited by the difficulty in separation of suspended solids which affects the concentration of sludge, resulting in further treatment of sludge separately. Membrane bioreactors are an improvement to conventional Activated sludge process, where the traditional secondary clarifier is replaced by a membrane unit for the separation of treated water from the mixed solution in the bioreactor. The MBR's are now being used in advanced treatment plants because of its advantage over other technologies because of high quality effluent, less area requirement, lower sludge production, and improved nutrient removal. [Ivanoic et al., 2011]

The disadvantages associated with the MBR are mainly cost related. High capital costs due to expensive membrane units and high energy costs due to the need for a pressure gradient have characterized the system. Concentration polarization and other membrane fouling problems can lead to frequent cleaning of the membranes, which stop operation and require clean water and chemicals. Another drawback can be

¹ <http://www.sswm.info/category/step-nawatech/m1-nawatech-basics>

problematic waste activated-sludge disposal. Since the MBR retains all suspended solids and most soluble organic matter, waste activated sludge may exhibit poor filterability and settle ability properties.

Membrane bio reactor technology is based on biological treatment followed by membrane separation system consist of activated sludge process with the biomass separation stage by membranes. The membranes replace the settlement stage in conventional activated sludge systems and effectively improve the performance, the separation of biomass from treated wastewater using membranes provides good quality of effluent which can be further safely reused for irrigation purposes etc.

It allows very high biomass mixed liquor suspended solids (MLSS) concentration to be developed in the bioreactor without the detrimental effects usually happened with traditional settlement techniques. [Cicek et al., 2003]

3 Methodology

Case study of two wastewater treatment plants is carried out, with Moving bed biofilm reactor and Membrane bioreactor.

3.1 Wastewater treatment plant with MBBR Technology

Common effluent treatment plant with MBBR technology is installed at focal point, Derabassi for treatment of 2MLD of wastewater. The wastewater treatment plant is a combination of physio-chemical followed by aerobic biological treatment. The plant consisted of following primary and secondary treatment unit operations: collection tank, screen chamber, equalization tank, flash mixer tank, clari - flocculator, moving bed bio reactors, secondary clarifier, sludge sumps and treated water tank.

3.1.1 Process of treatment plant with MBBR Technology

The wastewater is collected in the Collection tank in the first stage of treatment plant. From collection tank wastewater effluent is further treated in screen chamber then continuously taken up into equalization tank to neutralize qualitative and quantitative irregularities from member industries.

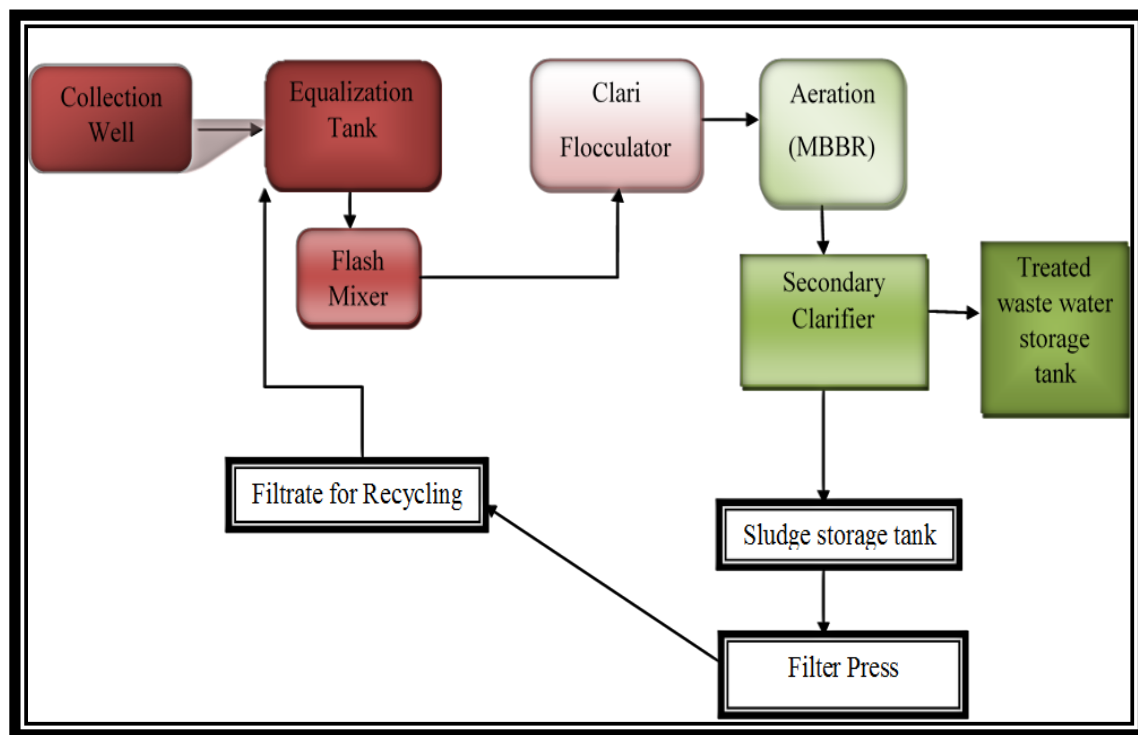


Figure 3-1 Layout of treatment plant with MBBR technology

Poly- aluminium chloride is used as a coagulating agent. Lime is used to adjust pH and alkalinity in coagulation. Waste water effluent is then contacted with coagulants in flash mixer tank. Coagulated mass enters primary clari flocculator where it is flocculated with the help of slow speed stirrer and settles along with some inorganics. Nutrients, urea and phosphoric acid (H_3PO_4) are added to the effluent before biological treatment, the clear supernatant flows into MBBR reactors for biological treatment. After aerobic treatment, the effluent enters secondary clarifier for biomass removal then the treated wastewater is further require a anti bacterial treatment with hypo dosing and then enters to a storage tank. Flowchart diagram of treatment is shown in figure 3.1.

3.1.2 Plant Description of wastewater treatment plant with MBBR technology

Collection Tank is equipped with two pumps to lift the raw wastewater effluent to the Equalization tank. (Fig. 3.2)



Figure 3-2 Collection Tank

Screen Chamber: - Screening is a mechanical filter used to remove large objects, such as rags plastics, from wastewater screening of raw effluent before discharging it to equalization tank. (Fig. 3.3)



Figure 3-3 Screen Chambers

Equalization Tank: - Effluent from the collection tank comes to the equalization tank. The main function is to collect the incoming raw effluent that comes at widely fluctuating rates and position to the rest of the ETP at steady flow rate. During the peak hours ETP comes at high flow rate. The equalization tank stores this effluent and lets it out during the non peak time when there is little incoming effluent. In this ETP initial aeration is provided in this tank to improve the oxygen content through submerged aeration by installing a grid of air diffusers, pattern of the diffuser grid can be seen in Fig. 3.4



Figure 3-4 Top view of equalization tank with initial aeration process

Flash Mixer Tank: - In the case of the flocculation process, the rapid mixer is specifically designed to disperse so they enhance flocculation by optimizing the strength, size and weight of the flocs. Rapid

mixers are used to violently agitate the water with the chemicals for a short period of time before being released into the Clari - Flocculator. (Fig. 3.5)



Figure 3-5 Flash mixing tank

Clariflocculator: - Clariflocculator is a combination of flocculation and clarification in a single tank. It has two concentric tanks where inner tank serves as a flocculation basin and the outer tank serves as a clarifier. (Fig. 3.6)



Figure 3-6 Side view of clariflocculator

In the clariflocculator, the water enters the flocculator, where the flocculating paddles enhance flocculation of the feed solids. As heavy particles settle to the bottom, the liquid flows radially upward in the clarifier zone. The clarified liquid is discharged over a peripheral weir into the peripheral launder. The deposited sludge is raked to the bottom near the central weir from where it is routed to the sludge chamber and discharged. (fig. 3.7)



Figure 3-7 Top view of Clariflocculator

Aeration Process: - In this MBBR technology is used as Biological Treatment, Moving bed bio reactors are advanced version of aeration in which surface area is increased by providing media for attached growth process.



Figure 3-8 Side view of MBBR reactor



Figure 3-9 Top View of MBBR tank

Secondary clarifier: - After biological treatment the treated effluent is further processed in the secondary clarifier for the removal of Biomass this is the last stage of secondary treatment process.



Figure 3-10 Side view of Secondary clarifier

Filter Press: -



Figure 3-11 Filter Press

3.2 Wastewater Treatment Plant with MBR technology

Sewage treatment plant is installed for treatment of 200 KLD of wastewater with Membrane Bioreactors.

It includes biological treatment with moving bed bioreactors then followed by membrane bioreactor for separation of solids

Layout of treatment plant includes collection chamber, coarse bar screen, fine bar screen, grit removal tank, anoxic tank, MBBR tanks, MBR tank, hypo dosing units and then treated wastewater tank.

3.2.1 Process of treatment plant with MBR technology

The wastewater is collected in the collection tank in the first stage of treatment plant. From collection tank wastewater is further treated with screening which consist of coarse bar screen then followed by fine bar screen then grit removal chamber.

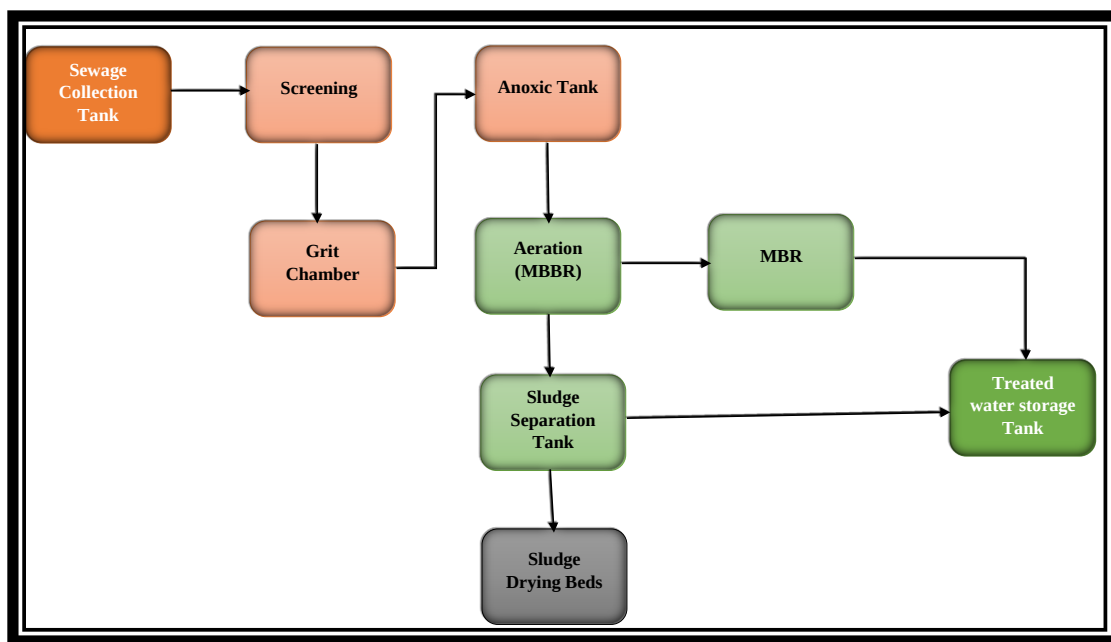


Figure 3-12 layout of treatment plant with MBR technology

For more efficiency of the treatment plant denitrification is done in anoxic tank after that wastewater is treated biologically in moving bed bio reactor tanks which had the initial aeration to the wastewater, then it followed to two supplies one goes to membrane bioreactor which separated the solid and other goes to sludge separation Tank after MBBR's. Then the treated wastewater is further require anti-bacterial treatment with Hypo dosing and then enters to a storage tank, the treated wastewater is reused in irrigation to all plantation and trees nearby the treatment plant. (Fig. 3.12)

3.2.2 Plant Description of wastewater treatment plant with MBR technology

Sewage collection Tank is equipped with two pumps to lift the sewage to screen bar chambers and is covered with a net to prevent the debris or leaves mix with the sewage as shown in fig. 3.13.



Figure 3-13 Sewage collection chamber

Screening, initial removal of heavy debris from sewage is required for proper working of treatment plant. This plant is equipped with coarse screen bar chamber followed by fine screen bar chamber.



Figure 3-14 Coarse screen chamber



Figure 3-15 Fine screen chamber

Coarse screen bar are screens which have minimum spacing of 20mm between each bar and is inclined to 45° to provide more efficiency and require less maintenance.

Fine screens have minimum spacing of 10 mm between each bar and is inclined to 45 to provide better results.

Grit Chamber, after screening the sewage flows towards the Grit chamber, heavy settleable solids are separated in this process. This is a small tank which is designed to slow down the sewage for settling of heavy solids before treating the wastewater biologically.



Figure 3-16 Side view of grit chamber

Simply adding bacteria to a wastewater plant does not guarantee to achieve the targeted task of denitrification. To encourage their growth, it is essential to first establish an anoxic environment, and then introduce a mixer that has been optimized specifically for the process. **Anoxic tank** is required to create an anoxic condition when the bacteria utilize the nitrates instead of oxygen and converts that into nitrogen and releases in the atmosphere this reduces the nitrates present in the sewage, which further helps in improving the overall efficiency of biological treatment.

Agitator is installed in the Anoxic tank for mixing the sewage as shown in Fig 3.17.



Figure 3-17 Anoxic tank



Figure 3-18 Top View of anoxic tank

Bioreactor tanks are advanced version of activated sludge process to reduce the overall area of plant by increasing the surface area with addition of media. This is biological treatment unit in which biodegradation of organics takes place in aerobic condition, aeration is provided at the bottom of the tank with installation of air diffusers connected to air blowers. The aeration also helps in mixing of the sewage.

In this treatment plant two Bioreactor tanks are provided for better efficiency of the plant as shown in Fig. 3.19



Figure 3-19 Top view of bioreactor tank 1

MBR Tank, after biological treatment in bioreactor tanks the separation of solid and liquid is done in MBR tank, which includes a membrane filter attached with membrane suction pump which helps in extract the liquid and further forwards it to chemical dosing tanks for disinfection.



Figure 3-20 Top view of MBR Tank



Figure 3-21 Side view of MBR tank

Sludge separation tank is a structure used to manage and dispose off the sludge. Increase the concentration of sludge by providing a hopper at the bottom of the structure, the heavy sludge is collected at the bottom by gravity and is further disposed to sludge drying beds.



Figure 3-22 Top view of Sludge separation Tank

Sludge separation Tank is provided for the uninterrupted working of treatment plant in case of maintenance of MBR tank. So the sewage after MBBR is transferred to MBR and Sludge separation tank.

After the MBR tank and Sludge separation tank the wastewater is further treated with disinfectants such as Citric dosing for removal of Hardness and anti bacterial treatment with Hypo dosing.

Then the wastewater flows to a **Treated water storage tank** from where it is reused for irrigation purposes.



Figure 3-23 treated water storage tank

Sludge drying beds:-



Figure 3-24 sludge drying beds

3.3 Design Calculations

3.3.1 Design calculations of wastewater treatment plant with MBBR technology

3.3.1.1 Bar Screen Design

Formula used for calculations:

(a) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(b) Calculation for design flow in m³/sec

$$\text{Design Flow (m}^3\text{/sec)} = \frac{\text{Design Flow (m}^3\text{/hour)}}{3600 \text{ (sec)}}$$

(c) Calculation for volume required

$$\text{Volume (m}^3\text{)} = \text{flow rate (m}^3\text{/sec)} \times \text{Detention time (sec)}$$

(d) Calculation for Width (m)

$$\text{Width (m)} = \text{Volume (m}^3\text{)} / \text{Length (m)} \times \text{Depth (m)}$$

<u>Sr. No.</u>	<u>Screen Chamber</u>	<u>Units</u>	
1.	Design Flow	m ³ /Day	2000
2.	Design Flow	m ³ /hour	83.33
3.	Design Flow	m ³ /sec	0.02
4.	Detention Time	sec	20
5.	Volume required	m ³	0.40
6.	Provided first dimension (depth)	m	0.5
7.	Provided second dimension (length)	m	1.4
8.	Calculated third dimension (width)	m	0.66
9.	Provided width	m	0.7
10.	Velocity at Peak Flow	m/sec	0.8
11.	Clear Spacing	mm	10
12.	Dimensions of Screen Chamber	m	1.4x0.7x 0.5d
13.	Provided Volume	m ³	0.49

3.3.1.2 Equalization tank

Formula used for calculations:

(a) Calculation for peak flow

$$\text{Peak Flow (m}^3/\text{Day)} = \text{Design flow (m}^3/\text{Day)} \times \text{Peak factor}$$

(b) Calculation for Detention time (sec)

$$\text{Detention time (sec)} = \text{Detention time (min)} \times 60$$

(c) Calculation for Area (m²)

$$\text{Area (m}^2\text{)} = \frac{\text{Volume (m}^3\text{)}}{\text{Depth (m)}}$$

(d) Calculation for diameter(m)

$$(\text{Diameter})^2 = \frac{\text{Area of circle (m}^2\text{)} \times 4}{3.14}$$

<u>Sr. No.</u>	<u>Equalization Cum Collection Tank</u>	<u>Units</u>	
1.	Design Flow	m ³ /Day	2000
2.	Peak Factor		2.5
3.	Peak Flow	m ³ /Day	5000
4.	Design Flow	m ³ /hour	250.00
5.	Detention Time	Min	240
6.	Detention Time	Sec	14400
7.	Volume Required	m ³	1000.00
8.	Provided Depth	M	5.5
9.	Calculated Area		181.81
10.	Calculated Diameter	m	15.2
11.	Provided Diameter	m	15.2
12.	Circular tank dimensions		15.2 x 5.5

* Tank is designed to hold 4 hours of average flow

3.3.1.3 Moving bed biofilm reactor

Formula used for calculations:

(a) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(b) Calculation for BOD to be treated in mg/l

$$\text{BOD to be treated (mg/l)} = \text{Maximum BOD} - \text{BOD removed at primary treatment}$$

(c) Total organic loading to be treated in kg/day

$$\text{Organic loading (kg/day)} = \text{Design flow (m}^3\text{/Day)} \times \text{BOD (mg/l)}$$

(d) Loading rate for sewage in kg/day/m³

$$\text{Loading rate} = \text{Considered } 1.5/100 \text{ (m}^2\text{) of media}^2$$

(e) Volume of media required in m³

$$\text{Volume of media (m}^3\text{)} = \text{Organic load (kg/day)} / \text{Loading rate (kg/day/m}^3\text{)}$$

(f) Volume of reactor tanks in m³

$$\text{Vol. of reactor tanks (m}^3\text{)} = \text{Volume of media (m}^3\text{)} \times 3$$

(g) Calculation for Area (m²)

$$\text{Area (m}^2\text{)} = \frac{\text{Volume (m}^3\text{)}}{\text{Depth (m)}}$$

(h) Calculation for diameter(m)

$$(\text{Diameter})^2 = \frac{\text{Area of circle (m}^2\text{)} \times 4}{3.14}$$

² Guidelines for Water Quality Management by CPCB

Sr. No.	Moving bed biofilm reactor	Units	
1.	Design Flow	m ³ /Day	2000
2.	Design Flow	m ³ /hour	83.33
3.	No of Units	Nos	2
4.	Max incoming BOD	mg/ltr	750
5.	BOD removal at primary Treatment	%	5
6.	BOD removal at primary Treatment	mg/ltr	37.5
7.	BOD at Inlet	mg/ltr	712.5
8.	BOD at Outlet	mg/ltr	30
9.	Net BOD to be Treated	mg/ltr	682.5
10.	Total Organic Load to be treated	kg/Day	1365
11.	Calculation of Media		
12.	Surface area of Media considered		500
13.	Loading Rate for Sewage Waste	kg/Day/m ³	7.5
14.	Volume of Media required	m ³	182.00
15.	Volume of Media Provided	m ³	180
16.	Size of Reactor Tank		
17.	Volume Required for reactors	m ³	540
18.	Quantity	Nos	2
19.	Vol. Required for One Reactor	m ³	270
20.	Provided depth	M	5.5
21.	Area of tank		49.1
22.	Calculated diameter of the tank		7.9
23.	Provided diameter of the tank		8.0

24.	Dimensions of Circular Tank		8 dia x 5.5
25.	Air Requirement		As per guidelines for water quality management by CPCB
26.	Required Oxygen Rate	kg/kg BOD	1
27.	Total Organic Load	kg/Day	1365
28.	Required Oxygen / Unit	kg/Day	1365
29.	Correction Factor		0.8
30.	Required Oxygen with Corr. Factor	kg/Day	1092
31.	Oxygen Concentration in air	%	23.2
32.	Theoretical Air Requirement	kg/Day	4706.90
33.	Density of Air	kg/ m ³	1.20
34.	Theoretical Air Requirement	m ³ /Day	3922.41
35.	Standard Oxygen Tfr Efficiency	%	15
36.	Field Capacity	-	0.95
37.	Actual Air Requirment	m ³ /Day	30764.03
38.	Actual Air Requirment	m ³ /hr	1281.83
39.	Blower Capacity Provided	m ³ /hr	1160
40.	Pressure of Air Blower	kg/cm ²	0.35

3.3.2 Design calculations of wastewater treatment plant with MBR technology

3.3.2.1 Bar Screen design

Formula used for calculations:

(a) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(b) Calculation for design flow in m³/sec

$$\text{Design Flow (m}^3\text{/sec)} = \frac{\text{Design Flow (m}^3\text{/hour)}}{3600 \text{ (sec)}}$$

(c) Calculation for volume required

$$\text{Volume (m}^3\text{)} = \text{flow rate (m}^3\text{/sec)} \times \text{Detention time (sec)}$$

(d) Calculation for Width (m)

$$\text{Width (m)} = \text{Volume (m}^3\text{)} / \text{Length (m)} \times \text{Depth (m)}$$

<u>Sr. No.</u>	<u>Coarse Screen Chamber</u>	<u>Units</u>	<u>-</u>
1.	Design Flow	m ³ /Day	200
2.	Design Flow	m ³ /hour	8.33
3.	Detention Time	min	1
4.	Detention Time	sec	60
5.	volume required	m ³	0.14
6.	Provided Depth	m	0.75
7.	Provided Length	m	1
8.	Calculated Width	m	0.19
9.	Provided Width	m	0.5
10.	Velocity at Peak Flow	m/sec	0.8

11.	Clear Spacing	mm	20
12.	Dimensions of Screen Chamber	m	1 x 0.5 x 0.75
13.	Provided Volume	m³	0.375

Source – The STP guide by Karnataka state pollution control board

<u>Sr. No.</u>	<u>Fine Screen Chamber</u>	<u>Units</u>	
1.	Design Flow	m ³ /Day	200
2.	Design Flow	m ³ /hour	8.33
3.	Detention Time	min	1
4.	Detention Time	sec	60
5.	volume required	m ³	0.14
6.	Provided Depth	m	0.75
7.	Provided Length	m	1
8.	Calculated Width	m	0.19
9.	Provided Width	m	0.5
10.	Velocity at Peak Flow	m/sec	0.8
11.	Clear Spacing	mm	10
12.	Dimensions of Screen Chamber	m	1 x 0.5 x 0.75
13.	Provided Volume	m³	0.375

3.3.2.2 Grit removal chamber design

Formula used for calculations:

(a) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(b) Calculation for design flow in m³/sec

$$\text{Design Flow (m}^3\text{/sec)} = \frac{\text{Design Flow (m}^3\text{/hour)}}{3600 \text{ (sec)}}$$

(c) Calculation for volume required

$$\text{Volume (m}^3\text{)} = \text{flow rate (m}^3\text{/sec)} \times \text{Detention time (sec)}$$

(d) Calculation for Width (m)

$$\text{Width (m)} = \frac{\text{Volume (m}^3\text{)}}{\text{Length (m)} \times \text{Depth (m)}}$$

<u>Sr. No.</u>	<u>Grit Removal Chamber</u>	<u>Units</u>	<u>-</u>
1.	Design Flow	m ³ /Day	200
2.	Design Flow	m ³ /hour	8.33
3.	Detention Time	min	5
4.	Detention Time	sec	300
5.	Volume Required	m ³	0.69
6.	Provided Depth	m	0.75
7.	Provided Length	m	4.75
8.	Calculated Width	m	0.19
9.	Provided Width	m	0.5
10.	Dimensions of O&G chamber	m	4.75 x 0.5 x 0.75
11.	Provided Volume	m³	1.78125

3.3.2.3 Anoxic tank design

Formula used for calculations:

(a) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(b) Calculation for design flow in m³/sec

$$\text{Design Flow (m}^3\text{/sec)} = \frac{\text{Design Flow (m}^3\text{/hour)}}{3600 \text{ (sec)}}$$

(c) Calculation for volume required

$$\text{Volume (m}^3\text{)} = \text{flow rate (m}^3\text{/sec)} \times \text{Detention time (sec)}$$

(d) Calculation for Width (m)

$$\text{Width (m)} = \frac{\text{Volume (m}^3\text{)}}{\text{Length (m)} \times \text{Depth (m)}}$$

<u>Sr. No.</u>	<u>Anoxic Tank</u>	<u>Units</u>	<u>-</u>
1.	Design Flow	m ³ /Day	200
2.	Design Flow	m ³ /hour	8.33
3.	Detention Time	min	20
4.	Detention Time	sec	1200
5.	Volume Required	m ³	2.78
6.	Provided SWD	m	1.5
7.	Provided Length	m	1.5
8.	Calculated Width	m	1.23
9.	Provided Width	m	1.5
10.	Dimensions of Equalization Tank	m	1.5 x 1.5 x 1.5
11.	Provided Volume	m³	3.375

3.3.2.4 Bio Reactor design

Formula used for calculations:

(g) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(h) Calculation for BOD to be treated in mg/l

$$\text{BOD to be treated (mg/l)} = \text{Maximum BOD} - \text{BOD removed at primary treatment}$$

(i) Total organic loading to be treated in kg/day

$$\text{Organic loading (kg/day)} = \text{Design flow (m}^3\text{/Day)} \times \text{BOD (mg/l)}$$

(j) Loading rate for sewage in kg/day/m³

$$\text{Loading rate} = \text{Considered } 1.5/100 \text{ (m}^2\text{) of media}^3$$

(k) Volume of media required in m³

$$\text{Volume of media (m}^3\text{)} = \text{Organic load (kg/day)} / \text{Loading rate (kg/day/m}^3\text{)}$$

(l) Volume of reactor tanks in m³

$$\text{Vol. of reactor tanks (m}^3\text{)} = \text{Volume of media (m}^3\text{)} \times 3$$

(i) Calculation for Area (m²)

$$\text{Area (m}^2\text{)} = \frac{\text{Volume (m}^3\text{)}}{\text{Depth (m)}}$$

(j) Calculation for diameter(m)

$$(\text{Diameter})^2 = \frac{\text{Area of circle (m}^2\text{)} \times 4}{3.14}$$

³ Guidelines for Water Quality Management by CPCB

<u>Sr. No.</u>	<u>Bio Reactor</u>	<u>Units</u>	-
1.	Design Average Flow	m ³ /Day	200
2.	Design Flow	m ³ /hour	10.00
3.	No of Units	Nos	2
4.	Max incoming BOD	mg/ltr	250
5.	BOD removal at primary Treatment	%	5
6.	BOD removal at primary Treatment	mg/ltr	12.5
7.	BOD at Inlet	mg/ltr	237.5
8.	BOD at Outlet	mg/ltr	20
9.	Net BOD to be Treated	mg/ltr	217.5
10.	Total Organic Load to be treated	kg/Day	43.5
11.	Calculation of Media		
12.	Surface area of Media considered		500
13.	Area considered of media for design		400
14.	Loading Rate for Sewage Waste	kg/Day/m ³	6
15.	Volume of Media required	m ³	7.25
16.	Volume of Media Provided	m ³	11
17.	Size of Reactor Tank		
18.	Volume Required for reactors	m ³	33
19.	Quantity	Nos	2
20.	Vol. Required for One Reactor	m ³	16.5
21.	Provided Depth	m	3.5
22.	Provided Length	m	2.45
23.	Calculated Width	m	1.92
24.	Provided Width	m	2
25.	Dimensions		2.45 x 2 x 3.5
26.	Vol. Calculated for One Reactor		16.5
27.	<u>Air Requirement</u>		

28.	Required Oxygen Rate	kg/kg BOD	1.2
29.	Total Organic Load	kg/Day	43.5
30.	Required Oxygen / Unit	kg/Day	52.2
31.	Correction Factor		0.56
32.	Required Oxygen with Corr. Factor	kg/Day	29.232
33.	Oxygen Concentration		23.2
34.	Theoretical Air Requirement	kg/Day	126.00
35.	Density of Air		1.20
36.	Theoretical Air Requirement	m ³ /Day	105.00
37.	Standard Oxygen Tfr Efficiency	%	15
38.	Field Capacity		0.85
39.	Actual Air Requirement	m ³ /Day	823.53
40.	Actual Air Requirement	m ³ /hr	34.31
41.	Diameter of diffuser	mm	63
42.	Capacity of Diffuser	m ³ /hr/m	8
43.	Required No. of Diffusers		4.3
44.	No. of Diffusers to be Provided		7
45.	Blower Capacity Provided	m ³ /hr	56
46.	Pressure of Air Blower	kg/cm ²	0.35

3.3.2.5 Membrane bioreactor tank design

Formula used for calculations:

(a) Calculation for design flow in m³/hour

$$\text{Design Flow (m}^3\text{/hour)} = \frac{\text{Design flow (m}^3\text{/Day)}}{\text{No. of operating hour}}$$

(b) Calculation for design flow in m³/sec

$$\text{Design Flow (m}^3\text{/sec)} = \frac{\text{Design Flow (m}^3\text{/hour)}}{3600 \text{ (sec)}}$$

(c) Calculation for volume required

$$\text{Volume (m}^3\text{)} = \text{flow rate (m}^3\text{/sec)} \times \text{Detention time (sec)}$$

(d) Calculation for Width (m)

$$\text{Width (m)} = \frac{\text{Volume (m}^3\text{)}}{\text{Length (m)} \times \text{Depth (m)}}$$

<u>Sr. No.</u>	<u>MBR Tank</u>	<u>Units</u>	-
1.	Design Flow	m ³ /Day	200
2.	Maximum Hourly Flow	m ³ /Hour	8.33
3.	Detention Time	hour	2.00
4.	Volume Required	m ³	16.67
5.	Provided depth	m	3.4
6.	Provided length	m	2
7.	calculated width	m	2.45
8.	Provided width	m	2.5
9.	Dimensions		2 x 2.5 x 3.4
10.	Volume Provided	m ³	17

3.4 Sampling and analytical techniques

The experimental method for the work includes a lab research conducted in ECO Laboratories & Consultants Pvt. Ltd.

The samples were analyzed using the Standard Methods (APHA/IS). The primary parameters including pH, Total dissolved solids (TDS), Total suspended solids (TSS), Biological oxygen demand (BOD), Chemical oxygen demand (COD), Oil & Grease were analyzed.

As a part of the case study, Samples were taken from Inlet (raw) and Outlet (treated) of Treatment plant.

Composite sampling was collected for time interval of every two hours in working day of Eight hours, Composite sampling is made up of smaller sub samples, Samples were time-related composites, which are made up of sub samples of equal volume (1 litre) taken at specific time intervals.



Figure 3-25 Sampling of Wastewater in 2Ltr Plastic Bottle

3.4.1 Analytical technique

Analysis of various parameters and procedure adopted are giving in table.

<u>Sr. no.</u>	<u>Parameters</u>	<u>Analysis Method</u>
1.	pH	pH Meter (APHA-22 nd Ed 2012 – 4500B)
2.	TDS	Gravimetric Method (APHA-22 nd Ed 2012 – 2540C)
3.	TSS	Gravimetric Method (APHA-22 nd Ed 2012 – 2540D)
4.	COD	Open Reflux Method (APHA-22 nd Ed 2012 – 5220B)
5.	BOD	3 Day BOD @ 27°C (IS:3025 (P-44)-1993 R-1999 Ad. 1)
6.	Total Hardness	Titration Method
7.	Alkalinity	Titration Method
8.	Electric Conductivity	Conductivity Meter

4 Results & Discussion

4.1 Characterization of MBBR plant samples

4.1.1 Test results on Day 1

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	7.01	7.62	-
2.	BOD (3 days 27° C)	mg/l	82	17	79
3.	COD	mg/l	236	56	76
4.	Total Dissolved Solids	mg/l	947	1406	-48
5.	Total Suspended Solids	mg/l	350	50	85

4.1.2 Test results on Day 2

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.9	7.81	-
2.	BOD (3 days 27° C)	mg/l	80	18	77
3.	COD	mg/l	228	52	77
4.	Total Dissolved Solids	mg/l	930	1394	-49
5.	Total Suspended Solids	mg/l	355	60	83

4.1.3 Test results on Day 3

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	7.21	7.81	-
2.	BOD (3 days 27° C)	mg/l	70	17	75
3.	COD	mg/l	234	58	75

4.	Total Dissolved Solids	mg/l	924	1386	-50
5.	Total Suspended Solids	mg/l	340	45	86

4.1.4 Test results on Day 4

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.9	7.81	-
2.	BOD (3 days 27° C)	mg/l	73	20	72
3.	COD	mg/l	245	64	73
4.	Total Dissolved Solids	mg/l	981	1430	-45.7
5.	Total Suspended Solids	mg/l	340	45	86

4.1.5 Test results on Day 5

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.9	7.82	-
2.	BOD (3 days 27° C)	mg/l	72	17.4	75
3.	COD	mg/l	240	58	75
4.	Total Dissolved Solids	mg/l	954	1429	-49.7
5.	Total Suspended Solids	mg/l	365	55	84

4.1.6 Test results on Day 6

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	7.13	7.58	-
2.	BOD (3 days 27° C)	mg/l	71	16	77
3.	COD	mg/l	236	52	77

4.	Total Dissolved Solids	mg/l	935	1350	-44.3
5.	Total Suspended Solids	mg/l	355	60	83

4.1.7 Test results on Day 7

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	7.18	7.68	-
2.	BOD (3 days 27° C)	mg/l	68	17	75
3.	COD	mg/l	238	58	75
4.	Total Dissolved Solids	mg/l	938	1423	-51.7
5.	Total Suspended Solids	mg/l	370	65	82

4.2 Characterization of wastewater

4.2.1 pH

The hydrogen ion concentration expressed as pH, is a valuable parameter in the operation of biological units. The pH of the fresh sewage is slightly more than the water supplied to the community. However, decomposition of organic matter may lower the pH, while the presence of industrial wastewater may produce extreme fluctuations. The variation of pH from inlet of treatment plant to the outlet is shown in the Fig. 4.1 as below, the pH is in between the safe range of 6.5 to 8. The variation was observed in Inlet from 6.9 to 7.01. Initially it increased from 7.6 to 7.8 which was almost linear up till 5th day. On 6th day it decreases and again it increased. This decrease in pH may be due to more decomposition.

In case of outlet pH decreases on 1st day from 7.62 to 6.9 on 2nd day which again increases to 7.81 on 3rd day and decreased 7.3 on 4th day and more or less on 5th day. After that it increases linearly

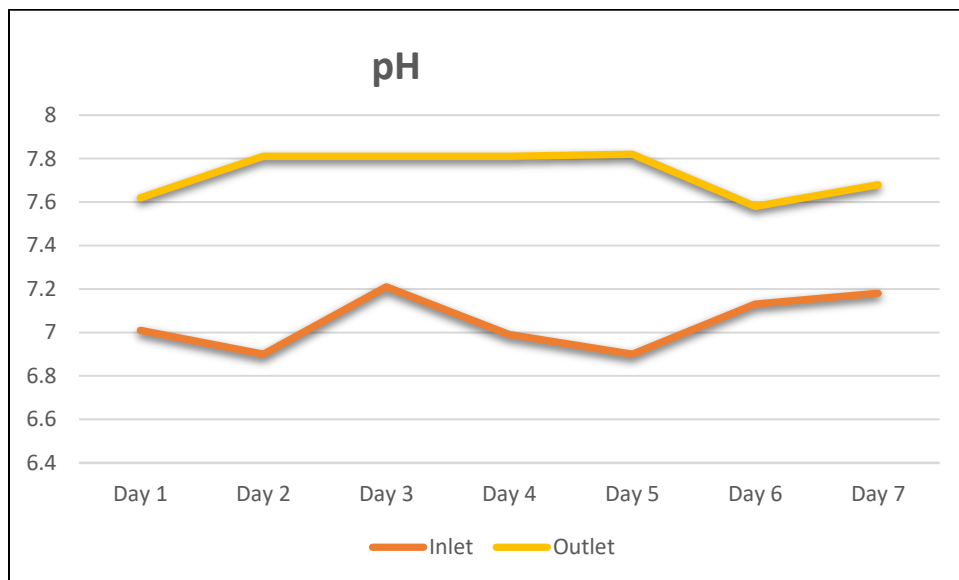


Figure 4-1 Graphical representation of pH

4.2.2 Total Suspended solids

Though sewage contains only about 0.1 percent solids, the rest being water, still the nuisance caused by the solids cannot be overlooked, as these solids are highly putrescible and therefore need proper disposal. It can be seen that TSS at the inlet of the treatment plant is high and after every treatment process it keeps on decreasing and is low at the treatment plant outlet which represents that the treatment plant is working properly and the TSS at the discharge point is under permissible limits. (Fig. 4.2) The fluctuation in TSS in inlet sample is not very high but almost linear throughout sampling time. It ranges from 340 to 370 where as in outlet also it is linear and ranges from 45 to 65 which showed good degradation of waste in MBBR technology. The percent decrease in suspended solids observed 95 to 96%. These results indicate that this technique is good for degradation of organic matter present in sewage.

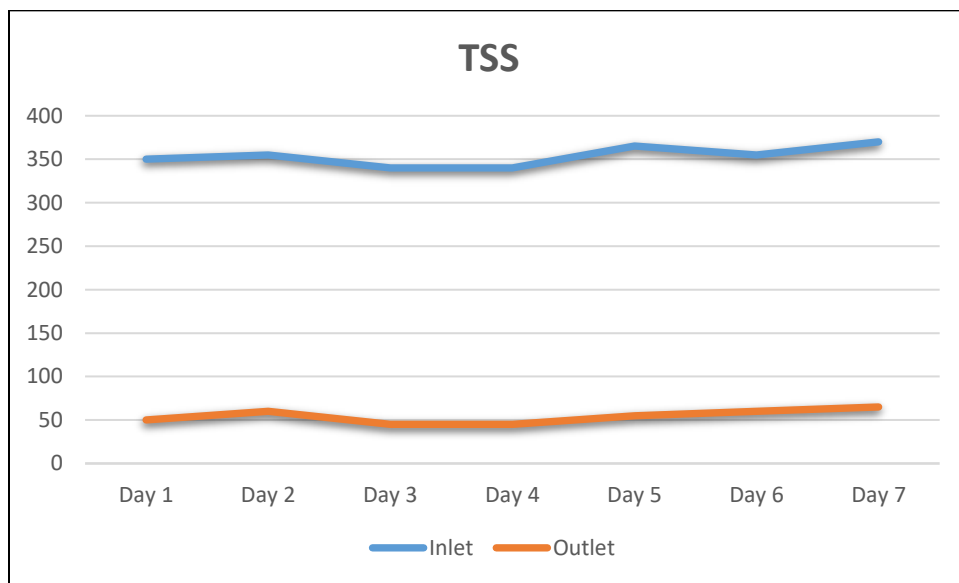


Figure 4-2 Graphical representation of TSS

4.2.3 Total dissolved Solids

In the process of treatment the TDS can be differentiated and due to the additions of chemicals TDS can increase in the course of treatment, which can be seen in Fig. 4.3 below that the TDS at the Inlet is lower than the TDS at the outlet because of the addition of number of chemicals in the chemical treatment of wastewater. The initial TDS ranges between 924 mg/l to 987 mg/l there is not much difference found in 7 day sampling; it means TDS is almost linear throughout the experiment. As discussed above the TDS increased due to addition of chemicals it ranges between 1350 mg/l to 1430 mg/l with addition of alum, lime, poly aluminium chloride and sodium hypochlorite which contributes 30 – 31% increase in TDS but from fig no.4.2 it is shown that degradation process is quite well and plant is working properly.

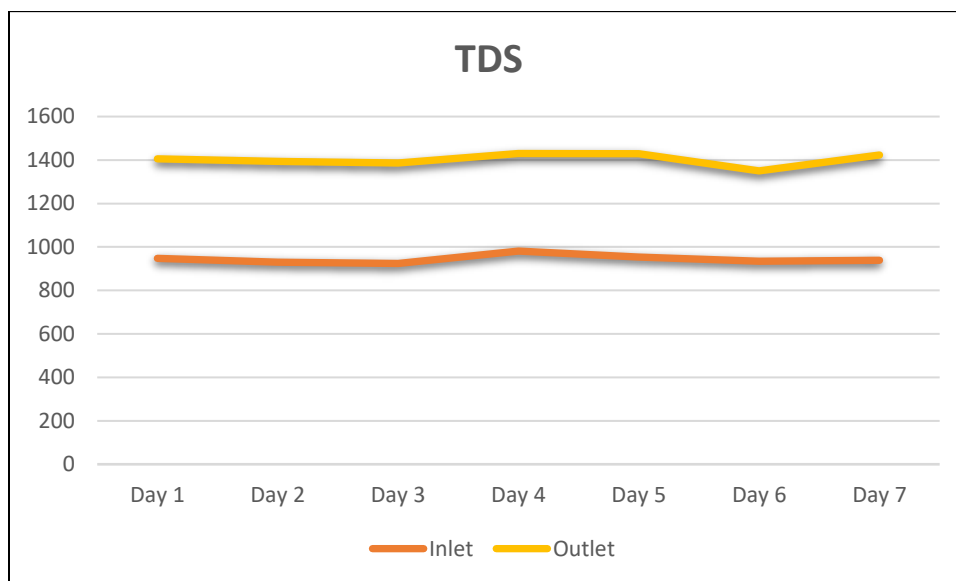


Figure 4-3 Graphical representation of TDS

4.2.4 Biological Oxygen Demand

The BOD of the sewage is the amount of oxygen required for the biochemical decomposition of biodegradable organic matter under aerobic conditions. The oxygen consumed in the process is related to the amount of decomposable organic matter. This is a parameter which needs to be considered before discharging in the streams as it will deplete oxygen for aquatic life. In this study the decrease in the BOD can be seen from inlet to the outlet of the treatment plant and this shows the proper working of the Treatment plant. (Fig. 4.4) The initial BOD ranges between 68 mg/l to 82 mg/l and is linear in all sampling days and after the treatment the outlet BOD ranges between 16 mg/l to 20mg/l which is within permissible limits and BOD removal efficiency of the plant is 72 – 82%.

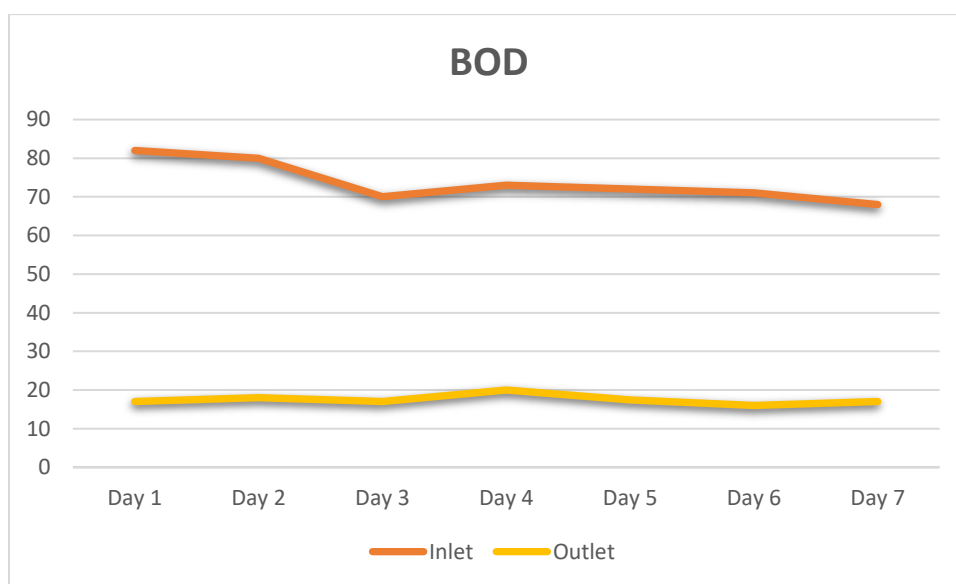


Figure 4-4 Graphical representation of BOD

4.2.5 Chemical Oxygen Demand

The COD gives the measure of the oxygen required for chemical oxidation. It does not differentiate between biological oxidisable and non oxidisable material. In this study the decrease in COD can be seen from inlet to the outlet of the treatment plant and this shows the proper working of the treatment plant. The maximum COD in the inlet was found 245 mg/l on 4th day of sampling which was reduced to 64 mg/l this result indicate that degradation process is efficient. The overall COD ranges in between 245 mg/l to 226 mg/l it means less fluctuation was found in the COD where as in case of COD outlet it ranges between 52 mg/l to 64 mg/l. the reduction of COD results found 72 – 81% which is good indication for the efficiency of treatment plant.

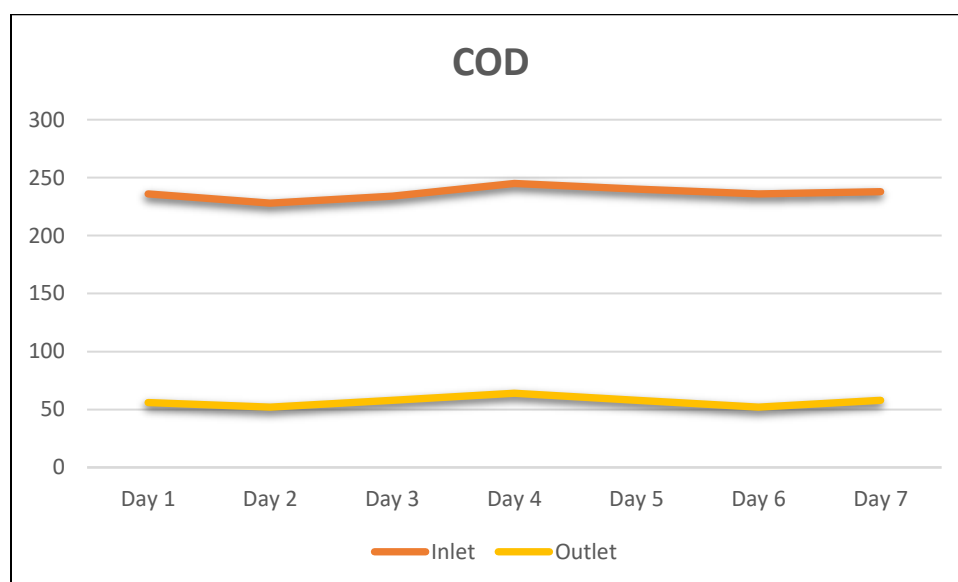


Figure 4-5 Graphical representation of COD

4.3 Characterization of MBR plant samples

4.3.1 Test results on Day 1

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.72	7.81	-
2.	BOD (3 days 27° C)	mg/l	148	4.6	96
3.	COD	mg/l	380	27.5	92
4.	Total Dissolved Solids	mg/l	745	780	-4.61
5.	Total Suspended Solids	mg/l	188	8	95

4.3.2 Test results on Day 2

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.7	7.79	-

2.	BOD (3 days 27° C)	mg/l	148	4.8	96
3.	COD	mg/l	390	27.8	92
4.	Total Dissolved Solids	mg/l	732	774	-5.73
5.	Total Suspended Solids	mg/l	192	7	96

4.3.3 Test results on Day 3

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.65	7.75	-
2.	BOD (3 days 27° C)	mg/l	133	4.7	96
3.	COD	mg/l	382	27	92
4.	Total Dissolved Solids	mg/l	744	780	-4.83
5.	Total Suspended Solids	mg/l	178	9	94

4.3.4 Test results on Day 4

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.61	7.85	-
2.	BOD (3 days 27° C)	mg/l	146	4.8	96
3.	COD	mg/l	385	27.6	92
4.	Total Dissolved Solids	mg/l	732	775	-5.87
5.	Total Suspended Solids	mg/l	190	9	95

4.3.5 Test results on Day 5

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.68	7.9	-
2.	BOD (3 days 27° C)	mg/l	140	4.6	96
3.	COD	mg/l	380	27.5	92
4.	Total Dissolved Solids	mg/l	740	770	-4.05
5.	Total Suspended Solids	mg/l	185	8	98

4.3.6 Test results on Day 6

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.65	7.8	-
2.	BOD (3 days 27° C)	mg/l	150	4.7	96

3.	COD	mg/l	376	278	26
4.	Total Dissolved Solids	mg/l	730	762	-4.3
5.	Total Suspended Solids	mg/l	190	8	95

4.3.7 Test results on Day 7

S. NO.	TEST PARAMETERS	UNITS	INLET	OUTLET	% REMOVAL
1.	pH	-	6.72	7.75	-
2.	BOD (3 days 27° C)	mg/l	150	4.7	96
3.	COD	mg/l	386	272	29
4.	Total Dissolved Solids	mg/l	734	768	-4.63
5.	Total Suspended Solids	mg/l	195	9	95

4.4 Characterization of wastewater

4.4.1 pH

In all sampling days pH was observed in the range of 6.61 to 6.72 in the inlet sample which was almost same as shown in fig. 4.6. the pH was varying in between 6.65 to 6.85 in outlet sample. This little increase in pH may be due to addition of chemicals which can increase the pH.

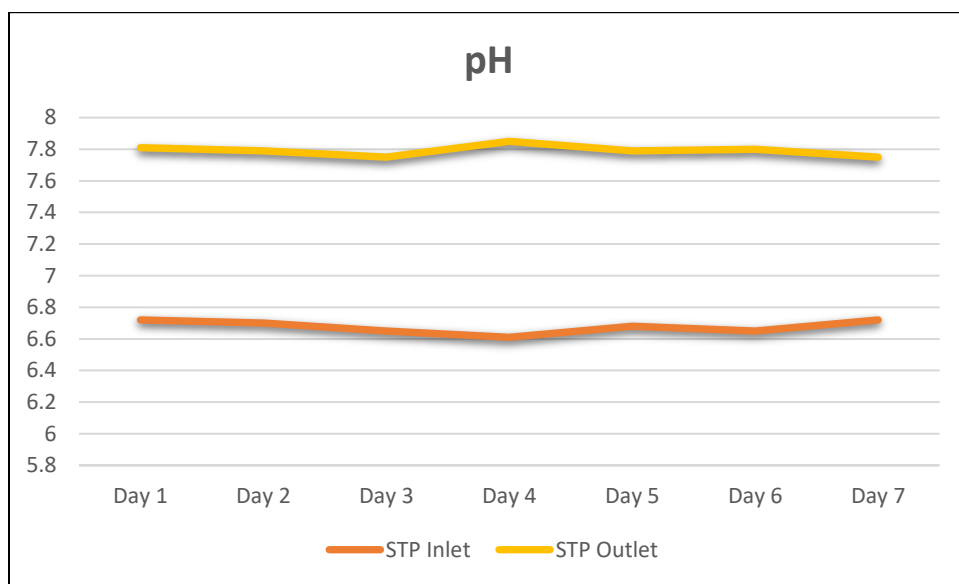


Figure 4-6 Graphical representation of pH

4.4.2 Total Suspended solids

The TSS are the suspended solids which are in the form of organics and are reduced to a permissible limit after the treatment, change in Inlet and Outlet of wastewater is shown in Fig. 4.7. the separation suspended solids in MBR technology is quite efficient and percentage removal of suspended solids is 93 – 96% which is very good reduction and showed better efficiency of the plant. The initial TSS found ranges between 185 mg/l to 192 mg/l which reduced to 8 mg/l to 7 mg/l.

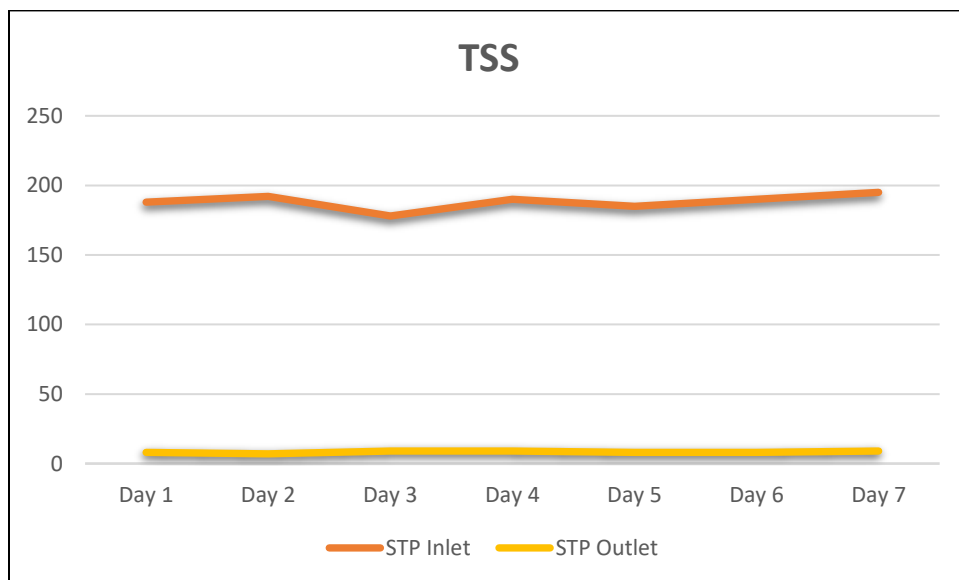


Figure 4-7 Graphical representation of TSS

4.4.3 Total dissolved Solids

In the process of treatment the TDS can be differentiated and due to the additions of chemicals TDS can increase in the course of treatment, which can be seen in Fig. 4.8 that the TDS at the Inlet is lower than the TDS at the outlet because of the addition of number of chemicals in the chemical treatment of wastewater. The total dissolved solids range initially 740 mg/l to 732 mg/l and as already discussed due to addition of chemicals the results showed an increase in outlet TDS ranging from 760 mg/l to 780 mg/l.

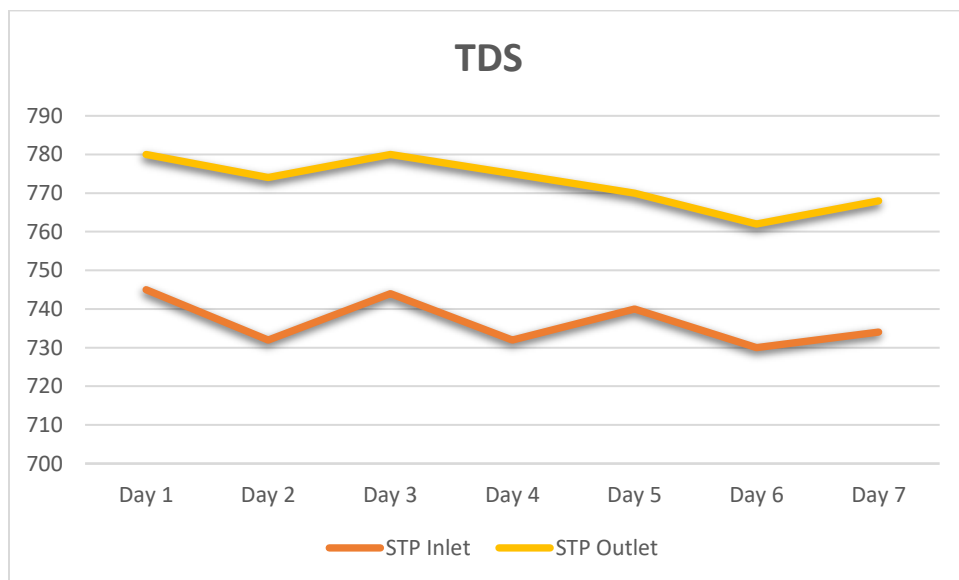


Figure 4-8 Graphical representation of TDS

4.4.4 Biological Oxygen Demand

BOD is an important parameter to treat before using the treated water for irrigation or disposing off. In MBR maximum BOD reduction is achieved as seen in the Fig. 4.9. The initial BOD ranges from 133 mg/l to 150 mg/l and after treatment the outlet BOD is between 4.6 mg/l to 4.8 mg/l the BOD removal efficiency is 95 – 96 % which indicated the process working nicely and degradation of organic matter takes place.

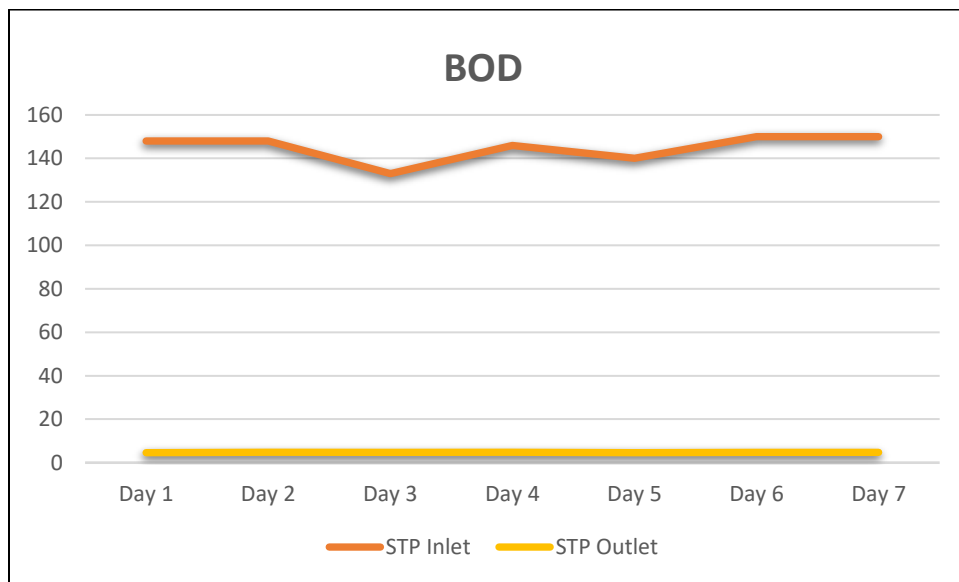


Figure 4-9 Graphical representation of BOD

4.4.5 Chemical Oxygen Demand

The Variation of COD represents the proper working of treatment plant, the reduction is shown in the Fig.4.10. the same observation was found in COD as in BOD. There is 92 – 93% COD removal after treatment. The degradation found in COD also showed the good working and efficiency of treatment plant.

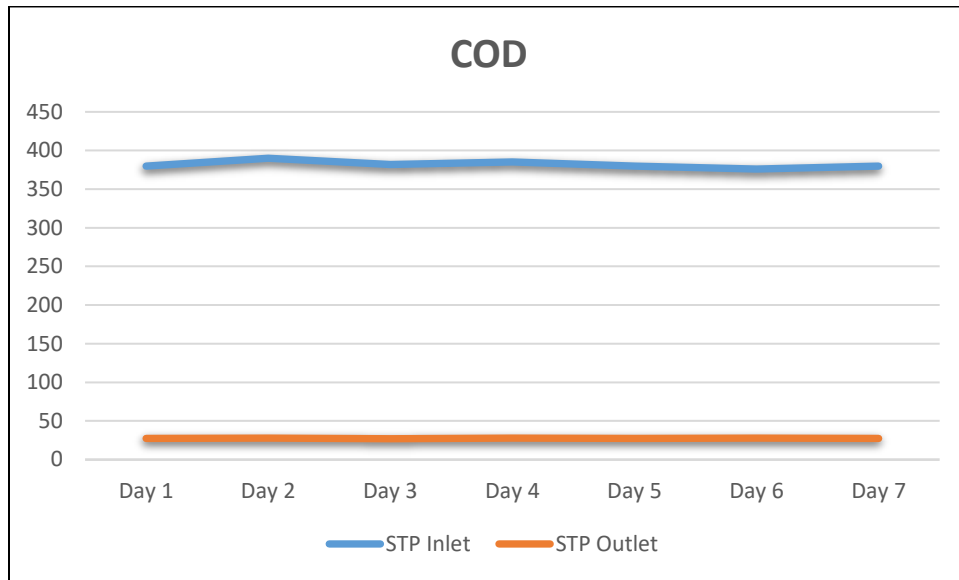


Figure 4-10 Graphical representation of COD

4.5 Percentage Removal efficiency Comparison



Figure 4-11 Bar chart comparison of Removal efficiency

4.6 Comparison

A comparison of various parameters related to the above mentioned treatment techniques has been done on the basis of site visits and detailed study on the technologies.

Sr. No.	Factors of Comparison	MBBR	MBR
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. Organic matter is degraded aerobically with bacteria and after that the solids are separated via Membranes.
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 3,000mg/l – 4,000mg/l are easily achieved.	MBR can be designed up to MLSS 9,000 mg/l. System requires proper cleaning and backwashing regularly.
3.	Area required	Very small area required as compared to SBR, ASP, UASB, RBC.	Less area is required as compared with MBBR
4.	Power requirement	Power requirement is Low	Membrane Suction pumps and Membrane backwashing Pumps are used and require more power than MBBR
5.	Moving parts	No moving part in biological process.	Membranes are used for separation.

6.	Operation and maintenance	less moving parts in the system. Hence very low maintenance. Therefore the manpower cost is low.	Requires proper maintenance, backwashing of membranes and hence require skilled operator.
7.	Excess sludge control	Excess sludge wasting is from secondary clarifier, which is like any other ASP system and hence simple.	Sludge is further treated in sludge separation units for better efficiency.
8.	Sludge properties	Sludge is fully digested. Hence, it can be dewatered directly without any further treatment.	Sludge is fully dewatered after membrane separation
9.	Expandability	High as higher loads can be accepted with extra media filling. Modular construction is possible.	Low as it require installation of Membranes as per the expansion.
10.	Usage of treated effluent	No further treatment required for gardening and horticulture.	Effluent quality achieved is better than MBBR and can be reused for Irrigation and after further treatment with anti bacterial can be used for construction & floor washing
11.	Size wise suitability of process	Suitable for any size, no limitation. Require larger area for big Plants.	Suitable for any size, no limitation.

4.7 Cost Comparison

Sr. No.	Components	Units	Cost (Rupees) of MBBR	Cost (Rupees) of MBR
1.	Unit Capital Cost including Land	Crores per MLD	3.17	2.94
2.	Cost of Civil Works	Crores per MLD	0.97	0.93
3.	Cost of Mechanical Equipment	Crores per MLD	0.86	1.54
4.	Capital Cost	Crores per MLD	1.7	2.4
5.	Annual Power Cost	Crores per MLD	0.019	0.031
6.	Annual O & M Cost	Crores per MLD	0.6	0.8

5 Conclusion

While there are similarities between MBR and MBBR both are forms of the activated sludge process, there is one fundamental difference – the method of separating the liquid from the solid waste. MBBR technology relies on gravity settling, while MBR technology uses membranes as a physical barrier for separation. On the surface this may seem like a subtle difference, however, by using a physical barrier for separation, MBR technology provides numerous advantages.

Based on the study it can be concluded that both the technologies are highly advanced and are result of years of research and development over conventional technologies. Results obtained from 7 day sampling of treatment plants are satisfactory and showed that both the technologies are capable of achieving desired values and provide good quality effluent which can be reused in irrigation.

- One of the benefits of MBR technology over MBBR is that an MBR plant can be set up about one third the land area required for an MBBR. So when comparing the cost of the two technologies it is very important to consider the extra cost of the land needed for MBBR. Given that land is at a premium in India, this factor is an important variable into its final costing. The compact design of an MBR system greatly minimizes land acquisition and construction costs. The reason for an MBR having a smaller footprint is its ability to operate at high biomass concentrations (MLSS). A typical MBR design will operate at an MLSS of 9,000 mg/l, while a typical MBBR design will have an MLSS in the range of 3,000 mg/l. This difference in biomass concentration leads to much smaller process basins for MBR technology, and results in the MBR system having an overall plant footprint 50 – 70% smaller than an MBBR system.
- In terms of reduction levels and achieving the desired norms by authorities it can be observed that MBR has better removal efficiency than MBBR and it is designed to reduce BOD levels to less than 5mg/l and reduce COD levels to less than 100mg/l which therefore can be a future proof technology and produces results 75% lesser than norms by authorities.
- In terms of Cost MBBR is cost efficient then MBR, the initial cost of treatment plant with MBR technology is quite more because of the higher costing membranes and use of chemicals for regular cleaning of membranes in backwashing this makes MBBR more economical.

Future Scope of these wastewater treatment technologies is that due to increase in population and cost of land we require treatment plant which require less area and have efficient results. Even if in future the authorities revise the discharge limits the wastewater treatment plant should compete to the futuristic norms.

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