

Design of 100KLD STP Using MBBR Technology at MITRC, Alwar

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Abstract

In the present world where fresh water scarcity is increasing rapidly it is our responsibility to retreat the wastewater and make it reusable for different purposes so that the fresh water demand could be reduced. The treated effluent can be reused in many ways like spraying the water in the fields, washing of automobiles present in the campus, gardening, irrigation in local village, etc. So there are various types of wastewater treatment process some of them which are ASP, MBBR, MBR, UASBR, SBR, Anaerobic Digestion, Electro-coagulation, Trickle-Bed Reactor, Ultra-Filtration and more. But most widely used are ASP, MBBR, and UASBR. This research paper deals with the MBBR Technology as the BOD, COD and TSS removal efficiency of MBBR Technology is much higher than other technologies because of the presence of small bio-media in the aeration tank which enhances the bacterial colonies in the bio-media hence the rate of decomposition of the sludge present in the chamber is increased. This process is often used in the existing ASP based process to increase its efficiency and recycling of the sludge is not required in this method.

This MBBR Technology is proposed for MITRC, Alwar, and Rajasthan. In the college campus presently no treatment of the wastewater is done and the effluent goes to the local drains from where it passes to the river. So, in this research paper a proposal of design of a 100KLD sewage treatment plant is made using MBBR technology.

Keywords: -MBBR, Reuse, BOD, COD, TSS

INTRODUCTION

The main focused of the paper is on M.B.B.R Technique. The MBBR system consists of an aeration tank with special plastic media where the growth of bacteria is reinforced. The carriers are made of a material with a density close to the density of water and are mixed in the tank by aeration mechanism. The mechanism doesn't require recycling of sludge. The MBBR system is generally added to the existing ASP to enhance the capacity of the system. In Membrane Bio Reactor (MBR) membrane processes like microfiltration and ultra-filtration are joined with a biological treatment process like ASP, and this process is now widely used in industrial and municipal wastewater treatment. The Sequential Batch Reactor (SBR) process treats wastewater after an output from anaerobic digestion which is promoted in batches and thereafter the aeration is provided through the mixture of wastewater and activated sludge which decreases the organic matter i.e. BOD and COD. Up flow Anaerobic Sludge Blanket Reactor (UASBR) process includes anaerobic digestion and produces methane in the

digester, the efficiency is very high in this process of treating domestic wastewater.

CONSIDERATIONS FOR THE DESIGN OF STP

1. Total no. of students in the college = 1500
2. Total no of students residing in hostel = 150
3. So in India average amount of water per person per day for students in hostels = 135L

Total water consumed by 150 students = $150 \times 135 = 20250L$

4. Water consumed by day scholars in various activities during the entire day = 20L(considered)

So, Total water consumed by (1500-150) students is equal to $1350 \times 20 = 27000L$

5. Water consumed by many other purposes by different staffs and other people = 5000L (considered)

6. So, total water demand for the college premises $20250+27000+5000 = 52250$
 $L = 52.25\text{KL}$

7. It is considered that 80% of the sewage is generated therefore total swage generated= $0.8*52.25 \text{ KL}= 41.8\text{KL}$

It is therefore assumed to design a STP of 45 KLD.

Following points are considered during the design of sewage treatment unit:

- The maximum waste water generation shall not exceed 5KLD.
- The proponent shall provide Sewage Treatment Plant (STP) of 45 KLD

capacity consisting of Inlet chamber, Bar Screen Chamber, MBBR Tank, PSF, ACF, Chlorination tank, etc.

- The treated wastewater shall be recycled for agricultural and gardening purposes. The excess treated wastewater is to be discharged into Public sewer line.
- All the units of the STP shall be impervious to prevent ground water pollution and the STP shall be operated in a closed circuit so as to avoid smell nuisance.

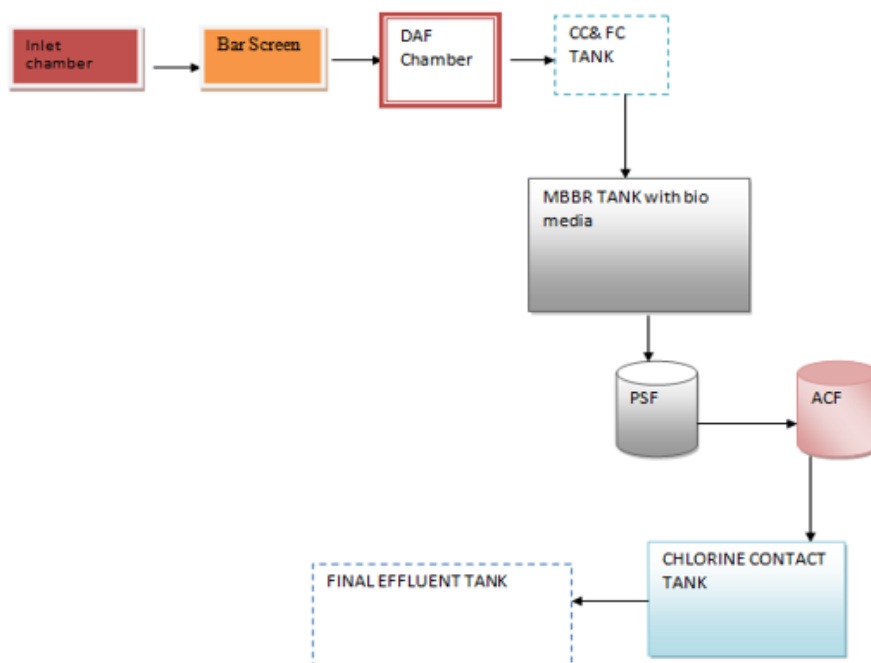


Figure:-1

- Treated effluents (i.e. outlet of STP) shall comply with inland surface water discharge standards.
- Self-scaling velocity should develop at every place and stage.
- The design of the treatment units should be economical, easy to maintenance and should offer flexibility in operation.

DESIGN CONSIDERATIONS

- Present Flow = 45KLD
- Maximum flow = considering 5KLD excess flow during high time (maximum)
- Ultimate flow including 5KLD future flow = $50/3600/24 = 0.000578\text{m}^3/\text{s}$
- Peak Factor = 2.25
- Peak flow-maximum = $50*2.25/24/3600 = 1.302 \times 10^{-3} \text{ m}^3/\text{s}$
- Peak flow- present = $45*2.25/24/3600 = 1.172 \times 10^{-3} \text{ m}^3/\text{s}$
- Average flow-present = $45/24/3600 = 0.00052\text{m}^3/\text{s}$
- Average inlet BOD = 200mg/l
- Average inlet COD = 300mg/l
- Average Inlet Suspended Solids = 400mg/l
- Average inlet Sulphate = 85mg/l
- Final BOD required = <5mg/l

DESIGN OF INLET CHAMBER

- Total No = 1
- Design flow = $1.302 \times 10^{-3} \text{ m}^3/\text{s}$
- Retention time considered = 60 sec
- Volume of tank = $60*1.302*10^{-3} = 0.07812\text{m}^3$
- Provide liquid depth = 0.5m
- Therefore, Area = $0.07812/0.5 = 0.15624\text{m}^2$
- Provide width = 0.4m
- So, length = $0.15624/0.4 = 0.391 = 0.4(\text{assumed})$
- Hence provide 1 No. of $0.4\text{m} \times 0.4\text{m} \times 0.5\text{m}$ LD + 0.2m F.B

DESIGN OF BAR SCREEN

A bar screen is a mechanical filter used to remove large objects, such as rags and plastics, from wastewater. It is part of the primary filtration flow and typically is the first, or preliminary, level of filtration, being installed at the influent to a wastewater treatment plant. They typically consist of a series of vertical steel bars spaced between 1 and 3 inches apart.

- Max Flow = 45 KLD
- Detention Time = 6.0 min
- Bar Screen Chamber Volume = $45*6/(60*24) = 0.1845 \text{ m}^3 = 0.2\text{m}^3$
- Let Side water depth (SWD) be 0.4 m
- BSC Size = 0.7 m x 0.7 m x 0.4 m

- Screen is made out of MS Flat of Size 10mm x 50mm (10mm facing the flow)
- Clear spacing between bars = 20mm
Inclination of bars with horizontal = 60° (For Manual Cleaning)
- $Q_{\max} = 1.172 \times 10^{-3} \text{ m}^3/\text{s}$
- Assume, Shape of bar = M.S. Flats
Size 10mm x 50 mm
- Clear spacing between the bars = 20 mm.
- Inclination of bars = 80 deg.
- Assume avg. Velocity to sewer = 0.8 m/sec
- At peak flow, net inclined area required is as follows $1.172 \times 10^{-3} / 0.8 = 1.465 \times 10^{-3} \text{ sq. m}$
- Gross inclined area = $1.465 \times 10^{-3} \times 0.4 = 5.86 \times 10^{-4} \text{ sq. m}$
- Gross vertical area required = $5.86 \times 10^{-4} \times \sin 80^\circ = 5.77 \times 10^{-4} \text{ sq. m}$
- Provide submergence depth = 0.1 m
- Width of channel = $5.77 \times 10^{-4} / 0.1 = 5.77 \times 10^{-3} \text{ m} \approx 30 \text{ mm}$
- Provide 20 bars of 10 mm x 50 mm at 20 mm clear spacing.
- Screen chamber will be 60 cm wide.
- Bar Screen Chamber Size = 1.0 m x 1.0m x 1.50 m

Dissolved air flotation (DAF) chamber will act as a clarifier and will remove the suspended matter such as oil and solids. The removal will be achieved by dissolving air in the wastewater under pressure and then releasing the air at atmospheric pressure in the flotation tank basin. The released air forms tiny bubbles which adhere to the suspended matter causing the suspended matter to float to the surface of the water where it may be removed by a skimming device.

Providing Coagulation and Flocculation Chamber

Coagulation-flocculation process is a water treatment system in wastewater treatment, coagulation flocculation involves the addition of polymers that clump the small, destabilized particles together into larger aggregates so that they can be more easily separated from the water. Coagulation is a chemical process that involves neutralization of charge whereas flocculation is a physical process and does not involve neutralization of charge. The coagulation-flocculation process will be used as a preliminary step between other wastewater treatment processes. Iron and Aluminum salts are the most widely used coagulants but salts of other metals such as titanium and

Providing DAF Chamber

zirconium have been found to be highly effective as well.

MBBR TANK WITH BIO MEDIA

- Flow in cum = 50KLD
- Inlet BOD = 200mg/l
- Outlet BOD in ppm = 5mg/l
- Surface area loading rate (SALR) for BOD is equal to
 $7.5- 25 \text{ g/m}^2 \cdot \text{d}$
- Surface area loading rate (SALR) for BOD considered is equal to $15 \text{ g/m}^2 \cdot \text{d}$
- BOD to be removed in aeration = 195mg/l
- BOD load in g/day = $50 \cdot 195 = 9750 \text{ g/day}$
- Area required = $\text{BOD load/SALR} = 9750/15 = 650 \text{ m}^2$
- Effective Surface Area of Carrier Element is $500 \text{ m}^2/\text{m}^3$ (considering Bio-media type K3)
- Percent Media Fill = 67%
- Volume of Media = $650/500 = 1.3 \text{ m}^3$
- Volume of tank = $1.3/(67/100) = 2 \text{ m}^3$
- Let us consider depth of the tank = 0.5m
- Therefore, Area of the tank = $2/0.5 = 4 \text{ m}^2$
- Consider width of the tank be 2m
- So, the length of the channel = $4/2 = 2 \text{ m}$
- Therefore, Provide a MBBR tank of $2\text{m} \cdot 2\text{m} \cdot 0.5\text{m} + 0.2 \text{ m FB (Free Board)}$

DESIGN OF AIR BLOWER IN MBBR TANK

An air blower is a mechanical device for moving air or other gases. The terms "blower" and "squirrel cage fan", (because it looks like a hamster wheel), are frequently used as synonyms. These fans increase the speed and volume of an air stream with the rotating impellers.

- Total Volume of the MBBR Chamber = 2 m^3
- Oxygen required in decomposition of 1Kg BOD = 0.9Kg
- BOD at inlet = $50 \cdot 200 = 10000 \text{ gm} = 10 \text{ Kg}$
- BOD at outlet = $50 \cdot 5 = 250 \text{ gm} = 0.25 \text{ Kg}$
- Total BOD removal = $10 - 0.25 = 9.75 \text{ Kg}$
- Oxygen required under field condition = $9.75 \cdot 0.9 = 8.775 \text{ Kg/day}$
- Residual DO in aeration tank = 1.5mg/l
- So, Oxygen in aeration Tank for DO per day = $2 \cdot 1.5/1000 = 3 \cdot 10^{-3} \text{ Kg} = 3 \text{ gm}$
- Total Oxygen needed = $8.775 + 0.003 = 8.778 \text{ Kg/day}$
- Specific weight of air in summer at $37^\circ\text{C} = 1.14 \text{ Kg/m}^3$
- Specific weight of air in winter at $27^\circ\text{C} = 1.18 \text{ Kg/m}^3$

- Oxygen content in air = 21%
- Air required in m³/day in summer =
Total Oxygen needed per day/sp.
Weight/% oxygen = $8.778/1.14/0.21 = 36.66\text{m}^3/\text{day}$
- Air required in m³/day in winter =
Total Oxygen needed per day/sp.
Weight/% oxygen = $8.778/1.18/0.21 = 35.42\text{m}^3/\text{day}$
- Safety factor = 1.3
- Transfer efficiency Maximum value = 0.881(FINE BUBBLE AERATOR)
- Air required in m³/day in summer including safety factor = $36.66*1.3/0.881 = 54.1\text{ m}^3/\text{day}$
- Air required in m³/day in winter including safety factor = $35.42*1.3/0.881 = 52.27\text{ m}^3/\text{day}$
- Highest value chosen for design = $54.1\text{m}^3/\text{day}$
- Air needed in hours = $54.1/24 = 2.25\text{m}^3/\text{hr}$

Hence, Provide 2 blowers with 1 stand by

DESIGN OF PRESSURE SAND FILTER

The Pressure sand filter consists of a multiple layer of sand with a variety in size and specific gravity. These Filters are designed to remove turbidity and suspended particles present in the feed water with minimum pressure drop. For

downward flowing devices the fluid can flow under pressure or by gravity alone.

- Let us consider the HRT of the Activated Carbon Filter is 20 min
- Total flow/day = 45m^3
- So, the total volume of the PSF will be $20*45/(60*24) = 0.625\text{m}^3$
- Providing 1 filters, therefore volume of the filter = $.625\text{m}^3$
- Considering height of the filter be 0.5m
- Volume = $\pi*r^2*h$, $0.625 = \pi*r^2*0.5$, therefore, $r = 0.631\text{m}$, so diameter of the filter will be 1.26m
- Hence provide one filter in cylindrical shape each of 3m (height)*6.66m (dia.) + 0.5m FB
- The backwashing and rinse process will be done simultaneously with the air blower 1 time per shift.

DESIGN OF ACTIVATED CARBON FILTER

Carbon filtering is a method of filtering that uses a bed of activated carbon to remove contaminants and impurities, using chemical adsorption. Each particle/granule of carbon provides a large surface area/pore structure, allowing contaminants the maximum possible exposure to the active sites within the filter media. Activated carbon works via a process called adsorption, whereby pollutant

molecules in the fluid to be treated are trapped inside the pore structure of the carbon substrate.

- Let us consider the HRT of the Activated Carbon Filter = 20 minutes
- Total flow/day = 45m³
- So, the total volume of the ACF will be $20 \times 45 / (60 \times 24) = 0.625 \text{m}^3$
- Providing 1 filters, therefore volume of the filter = 0.625m³
- Considering height of the filter be 0.5m
- Volume = $\pi \times r^2 \times h$, $0.625 = \pi \times r^2 \times 0.5$, therefore, $r = 0.631 \text{m}$, so diameter of the filter will be 1.26m
- Hence provide one filter in cylindrical shape each of 3m (height)*6.66m (dia.) + 0.5m FB
- The backwashing and rinse process will be done simultaneously with the air blower 1 time per shift.

DESIGN OF CHLORINATION CHAMBER

- Detention time = 30 min(assumed)
- Volume = $45 \times 30 / (\text{BOD load in Kg after the tertiary treatment i.e. 5ppm}) = 45 \times 30 / (5 \times 45) / 24 = 0.25 \text{m}^3$
- Provide depth = 0.25m
- Therefore Area of the chamber = $0.25 / 0.25 = 1 \text{m}^2$
- Provide length and width of the chamber 1m*1m

- Hence provide chlorination chamber of 1m*1m*0.25m with 0.1m FB (Free Board)

CONCLUSION

The potential reuse of the treated can be done in effective and innovative ways because the final results will be of very good quality which lies under the PCB norms which are very good for reuse in irrigation, gardening, and washing of automobiles available in the campus of MITRC.

To maximize the output we need to make full use of the system so we need to make the use of biogas generation from the SLUDGE DRYING BED, "GENBACHER GAS ENGINES - TYPE 3" can be used in the STP to generate electricity and reduce the power cost of the STP.

To reduce the foul smell from the entire STP we need to spray the "GOLDEN DECOMPOSER" that is prepared by "ASHA JYOTI EnviTech".

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