An Experimental Study on Design of Sewage Treatment Plant of 3-MLD using MBBR Technology in Kuppam Town

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Abstract— As per the norms of Central Pollution Control Board (CPCB) the waste water disposed from the community should not be directly released without proper treatment. For proper treatment of this type of water there should be a treatment plant needed. Since there is no sewage treatment plant in kuppam. This project deals with the study of waste water collected in kuppam surrounding area‟s and to design of sewage treatment plant for the same location. Kuppam has been developing place due to the steady increase in urban population, which in turn resulted in the increase of domestic sewage generated, but still there is no sewage treatment plant in kuppam location. So that it's required to construct a new sewage treatment plant with sufficient capacity of about 3-MLD to treat the generated sewage. Sewage water treatment and design plant it has a challenges to treat the excess of sludge and disposal of sludge. The treated water will be disposed to lakes and it can be used for domestic purposes.
The treated water will be disposed to lakes and it can be used for domestic purposes. The treatment is done by using the advanced technology named MBBR which consists of a polyethylene biofilm carriers for the removal of 244 BOD kg/day. Media of 208.28m^3 is provided. Disinfectant of hypo-chlorite is provided at Dosing rate 18.75 lph @ 10% conc.

Keywords: Central Pollution Control Board (CPCB), Domestic Sewage Treatment

I. INTRODUCTION

Sewage treatment plant is provided for treating all waste water generated due to domestic activities in the residential complex. This facility is installed not only for complying the legal requirement of pollution control board, but also to ensure that the treated water is utilized for gardening and flushing activities. Proper operation of STP helps us in conserving the precious and scarce natural resource i.e. "water". The treatment process / system is designed on the principle of Moving Bed Bio-reactor. The plant is designed to treat 3000 cum/day of sewage to the quality required for reuse as water for landscaping after the treatment.

II. LITERATURE REVIEW

S.No	Name	Research	Result
1	Rusten et al.	Small scale effluent treatment plants and hence the onset of the Moving Bed Biofilm Reactor systems.	The focus was directed to organic matter removal in MBBR systems while at present is used as complete treatment solutions The flexibility for future treatment capacity upgrades without requiring the constructions of additional reactors.
2	Odegaard	Unique design of biofilm carriers, in which the geometric shape, sizing and materials of the construction had been considered thoughtfully to maximize performance	This was a key distinction from the activated sludge method where treatment performance was directly associated to reactor volume. In the MBBR, surface area could be increased by planning carriers to have a high specific surface area or by adding greater quantity of carriers to a reactor volume. This therefore offers the flexibility for future treatment capacity upgrades without requiring the constructions of additional reactors.
3	Karamany	Investigated the performance of combined reactor model. For this purpose simulations comprising of both suspended growth biological reactor and attached growth biological reactor were constructed to envisage the effects.	The set-up had comprised of the RBC with fill and draw cups and diffused air. However, the fill and draw cups were intended for simulating the attached growth reactor, while the diffused air simulated the suspended growth reactor. This researcher, Karamany further investigated the rate of oxygen transfer applied to four (4) different configurations; three (3) were tested using tap water and the fourth set of experiment was made using primary treated wastewater.
4	Rodgers et al.	He presented an excellent review of four (4) types of moving medium biofilm reactors for the treatment of wastewater.	This study proved to be of great interest. Their review was however, based on published case studies and covers areas such as: rotating biological contactor (RBC), moving bed biofilm reactor (MBBR), vertically moving biofilm reactor (VMBR) and fluidized-bed reactor (FBR).

Table 1: Review of literature

III. MATERIALS USED

In this investigation materials used are

1) Sewage water collected from effluents of the Town.
2) Laboratory chemicals for testing of water.
3) Chlorine as disinfectant.
4) Lime to maintain pH value.
5) MBBR bio-film carrier.

IV. PROPERTIES OF SEWAGE WATER

S.No	PARAMETER	RESULT	PERMISSIBLE LIMITS
1	pH	8.4	6.5-8.0
2	BOD after 5 days @ 20^0c	218 mg/l	30-50 mg/l
3	COD	274 mg/l	85-150 mg/l
4	Oil & grease	2.6 mg/l	8-10 mg/l

Table 4.1: Properties of Sewage Water

V. DESIGN CRITERIA

A. Screening

Screening is the first unit operation used at wastewater treatment plants (WWTPs)[8]. Screening removes objects such as rags, paper, plastics, and metals to prevent damage and clogging of downstream equipment, piping, and appurtenances. Some modern wastewater treatment plants use both coarse screens and fine screens.

Capacity of plant Q = 3MLD = 3000m^3/day

= 0.0347m^3/sec.

Design flow velocity = 0.3m/sec.

c/s area of screen A = Q/V. since (Q=AV)

= 0.0347/0.3

= 0.1157m^2

c/s area is increased by 50% to compensate for the clogging of screens

= 0.1157x1.5

= 0.1735 ~ 0.18m^2

B. Screen Dimensions

Assuming depth of screen d = 1m.

Area = b x d

b = A/d = 0.18/1

= 0.18m.

Width of the screen , b = 0.18m.

Gap between bars = 10mm.

Thickness of bar = 5mm.

Total number of bars =

$$\frac{width\ of\ the\ screen}{thickness\ of\ screen + gap\ between\ two\ bars} = \frac{180}{10+5}$$

Therefore total number of bars =12

C. Equalization Tank:

The Objective of the Collection Tank is to receive the waste from the various sources, to hold the same and to even out the 'variations in flow and quality'.

Storage capacity = 1MLD = 1000m^3(volume)

Assumed length of the tank 'l' = 20m.

Breadth of the tank 'b' = 15m.

Depth of the tank d = volume / area

$$= \frac{1000}{20X15} = 3.33m$$

Assume free board = 0.2m

Depth 'd'=3.53m~3.6m .

Detention period = 7-8hrs .

The equalization tank should be large enough to hold the maximum difference between the inflow and the outflow. In our example, the maximum difference is 150-60=90 m3. Therefore, the equalization tank must be larger than 90 m3 (otherwise it will overflow).

D. MBBR Tank – Moving Bed Bio-Reactor:

The moving bed bio reactor (MBBR) technology is proposed to reduce the effluent BOD to required level for discharge and reuse. The soluble BOD is converted to biomass and the solids get removed subsequently in the settling/clarifier tank after being settled at the bottom of settling/clarifier tank. The proposed treatment has been designed for MBBR technology based on the following.

BOD: 300 mg/l

COD: 400 mg/l

Flow: 3000 kld

Total BOD load: 300 kg/day

BOD removal : 95 %

BOD out : 15 mg/l

Tank Volume = [Qc x Q x Y x (BODin-BODout)]/[X x (1+KdxQc)] (As per CPHEEO manual)

Where:

– Qc – Sludge age (10-25 days as per CPHEEO manual)
– Q – Daily Flow (3000 m3/day)
– Y – Yield Coefficient (0.6)
– X – MLSS to be maintained (3000 mg/ltr as per CPHEEO manual)
– Kd – Decay coefficient (0.06)

Tank Volume required = (25x3000x0.6x285)/(3000x2.5) = 1710 m^3

Tank Volume provided = 1810 m3 (adopting HRT of 4 hours)

Tank length provided = 12 m.

Tank breadth provided = 12 m.

Depth provided = 3.4 m.

Number of tanks = 4 no's.

Surface area of MBBR media = 350 m2/m3 (as per manufacturer)

Media BOD loading rate = 10 gram BOD per m2 per day (as per manufacturer)

BOD handled by tank volume = 1810 X 0.30 (adopting organic volumetric loading rate as 0.3 kg BOD per m3 per day as per CPHEEO guidelines) = 543 kg/day

Balance BOD to be handled = 300-543= 243kg/day

MBBR Media required = (BOD x Flow)/(area x BOD loading rate) = (99 X 1000)/350x10 = 208.28 m3

Therefore Media provided = 208.28 m3.

E. Secondary Clarifier:

The main objective of the Clarifier tank is to separate water and sludge and help in achieving a high underflow suspended solids concentration for recirculation purpose. The clarifier Tank should operate on a continuous basis.

This design is used for large STPs only. A typical tank is shown below. As shown, the tank is cylindrical, with bottom that slopes toward the center, with very little slope.

Flow rate : 3000 m^3 /day = 125 m^3 /hr

Average overflow rate : 1.041 m^3 / m^2 /hrs (Ref CPHEEO manual)
Area of cross section : 125/1.041 = 120.076 m^2
Size of the clarifier tank required: 12.37m diameter X 3.0 m.
Size of the clarifier tank provided: 12.5m diameter X 3.0 m.
Area of the clarifier tank provided: 368.15 m^3.

F. Tertiary Treatment Section

1) Clarified Water Tank:

a) Objective:
To collect the clarified water from the secondary clarifier tank and to disinfect the water before taking the water for Tertiary Treatment

The purpose of the Clarified water tank is to collect the clarified water overflowing from the clarifier tank and disinfect the same before filtration and adsorption. The disinfection process requires a contact time of at least 30 minutes (as per CPHEEO manual).
Average Daily Flow : 3000 m3/day
Though 30 minutes HRT is sufficient, we need to provide 3 – 5 hours HRT on the average flow for clarified water tank (Feed tank to the filtration system). This is to ensure the complete disinfection and to store the biologically treated sewage for continuous feeding to the filtration system without frequent ON / OFF operation of the filter feed pumps.
Recommended HRT : 3 – 5 hrs
Tank Volume provided: 600 m3
HRT provided : 5 hours

2) Hypo-Chlorite Preparation and Dosing System

The hypo dosing system comprises of a hypo preparation tank, in which a dilute solution of hypo solution is prepared. The solution is dosed into the Clarified Water Tank with help of a dosing pump.
Concentration of Hypo available: 5-10% (commercial grade)
Dosage Recommended: 15 ppm (Ref Metcalf eddy)
Total flow rate: 3000 m3/day = 125 m3/hr
Dosing rate required : (Flow Rate X Dosage)/Conc.: (125 X 15 X 1000)/100000 (For 10 % Concentration Hypo)
Dosing rate required : 18.75 lph @ 10% conc.
Quantity of Hypo required: 18.75 lph x 24 hours = 450 ltr/day
Hypo Dosing Pump required: 60 – 70 lph
Hypo Dosing Tank required : 1500 lts
Contact time for max. Disinfection: 30 minutes

VI. FILTER MEDIA & SLUDGE HANDLING

A. Pressure Sand Filter

The purpose of passing the clarified water through the Pressure sand filter is to remove the residual suspended solids from it. The PSF is operated for 20 hours a day.

The operation of the PSF has two phases/cycles – the Normal operation/Filtration phase and the Backwash phase. Fig 6.1 shows the layout of PSF.

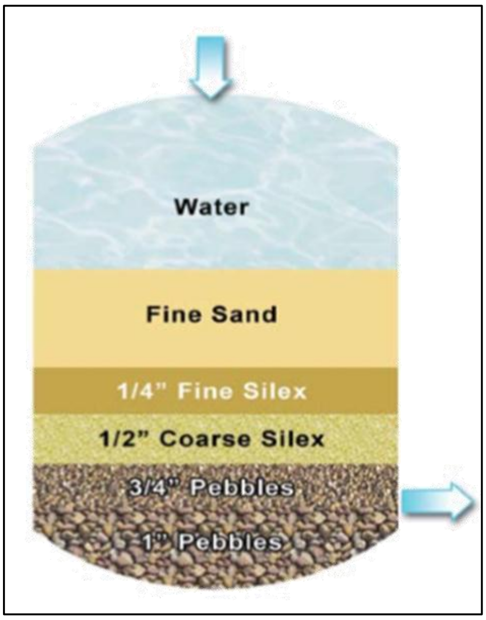

Fig. 6.1: Pressure Sand Filter

1) Working:

The upper layers of the sand perform the actual filtration function. The gravel layers merely provide physical support to the upper sand layers.

The sand used in the PSF is not ordinary construction sand: It has particle size in a specific range, and is specially sieved for this purpose.

Think of a sand filter as a 3D ("in depth") filter, as compared to planar filters like a tea bag or tea strainer. Here, the filtration occurs along the entire depth of the sand layer. The solid particles in the water get entrapped and enmeshed in the spaces between the sand particles.

Gradually, the space between sand particles gets filled with incoming solids. This blocks the passage of water through the sand layer. As a result, the pressure at the outlet drops rapidly21, and wastes the pumping power, and reduces the throughput of the filter.

When the pressure drops beyond a limit, the sand is cleaned by backwashing of the filter (backflushing) with water, in which water is passed in the reverse direction (from outlet to inlet). This process agitates, fluidizes and expands the sand bed. The backwash water carries away the lighter pollutant solid particles as backwash waste. Table 6.1 shows the filter media details.
Daily Flow rate : 3000 m3/day
The total treated effluent (3000 m3/day) has to be filtered within 20 hours a day.
Average Flow rate : 3000/20=150 m3/hr
Filtration rate : 45 m3/hr/m2.
Area of cross section of the filter : 150 / 45 = 3.33 m2
Size of the Dual Media Filter required: 2060 mm dia
Size of the Dual Media Filter provided: 2100 mm dia
Height of the Pressure Sand Filter provided: 2000 mm HOS
Operating pressure : 3.5 kg/cm2
Design Pressure : 5.5 kg/cm2

S.No	Media	Size	Height
1	Aggregate	2"- 4"	Dish end height
2	Pebbles	1½" - 1"	200
3	Pebbles	1" – ¾"	150

4	Pebbles	¾" – ½"	100
5	Pebbles	½" – ¼"	100
6	Crushed Gravel	¼" – 1/16"	100
7	Coarse Sand	12/14	700
8	Fine Sand	16/31	200

Table 6.1: Filter media details:

B. Activated Carbon Filter:

The purpose of passing the clarified water through the Activated carbon filter is to remove the residual amount of organics, odour, colour, etc to the extent possible. The ACF is operated for 20 hours a day, during which the filtration process is completed. The outlet from the ACF is the final treated water that will be stored in the filtered water tank for discharge or reuse. Fig 6.2 shows the layout of activated carbon filter.

Fig. 6.2: Activated Carbon Filter

1) Working

This filter uses the adsorption action of activated carbon. Activated carbon is typically manufactured from coconut shell or charcoal, the "activation" process creating a highly porous material with a very large surface area. Organic pollutant molecules are physically adsorbed and held fast within the catacomb-like porous structure of the activated carbon. Granular activated carbon is typically used for this purpose.

The water filtered by the Pressure Sand Filter enters the Activated Carbon Filter. Unlike in the case of the sand filter, trapped molecules in the carbon cannot be backwashed and got rid of. Hence, activated carbon in the filter has a finite capacity to adsorb and hold the pollutants, after which the carbon is said to be exhausted. The exhausted material is removed from the filter and disposed of Fresh activated carbon is charged in the filter.

Daily Flow rate : 3000 m3/day
The total treated effluent (3000 m3/day) has to be filtered within 20 hours a day.
Average Flow rate : 3000/20=150 m3/hr
Filtration rate : 45 m3/hr/m2.
Area of cross section of the filter : 150 / 45 = 3.33 m2
Size of the Dual Media Filter required : 2060 mm dia
Size of the Dual Media Filter provided : 2100 mm dia
Height of the Pressure Sand Filter provided: 2000 mm HOS
Operating pressure : 3.5 kg/cm2
Design Pressure : 5.5 kg/cm2

S.No	Media	Size	Height
1	Aggregate	2"- 4"	Dish end height
2	Pebbles	1½" - 1"	200
3	Pebbles	1" – ¾"	150
4	Pebbles	¾" – ½"	100
5	Pebbles	½" – ¼"	100
6	Crushed Gravel	¼" – 1/16"	100
7	Coarse Sand	12/14	200
8	Fine Sand	granular	700

Table 6.2: Filter media details:

C. Sludge Holding Tank

The main objective of the Sludge holding tank is to store the excess sludge from the biological system and to feed it to the Mechanical sludge dewatering unit – Filter Press

D. Filter Press Feed Pumps

The main objective of this pump is to feed the filter press or decanter centrifuge from the sludge holding tank for dewatering purpose.

E. Sludge Dewatering Using Filter Press or Decanter Centrifuge

The main objective of using a filter press or decanter centrifuge is to dewater the excess sludge stores in the sludge holding tank. The sludge cakes produced by the filter press or decanter centrifuge is collected in a hand trolley and disposed of manually. The water removed from the sludge is taken back to the equalization tank by gravity.

F. Air Calculation for Air Blower

1) Diffused Aeration System in MBBR Tanks

Average Flow rate : 3000 m3/day (125 m3/hr) @ 300 mg/l
Average BOD load : 125 m3/hr X 0.30 kg/m3 : 37.5 kg/hr
Oxygen required : 2.0 Kg of oxygen / kg of BOD load .
Oxygen required : 2.0 X 37.5 = 75.0 kg of Oxygen/hr .
Air Required for MBBR tanks:

$$\frac{75.0 \text{ kg of Oxygen /hr}}{1.2 * x\,0.232 ** x\,0.65 *** x\,0.95 **** x\,0.30 *****}$$

Note :
* = Density of Air
** = Percentage of Oxygen in Air by weight
*** = Alpha factor
**** = Beta factor
***** = Oxygen transfer efficiency at the respective tank depth
Air Required for MBBR tanks : 1454.23 m3/hr .

VII. CONCLUSION

Based on the Study, the following conclusions can be drawn.

- The COD removal efficiency of WWTP was found to be 80.0%.
- The BOD5 removal efficiency of WWTP was found to be 90%.
- The Total solid removal efficiency of WWTP was found to be 95%.

The current results suggest that the treated effluent is complying with the standard values and can be used for irrigation. The treated effluent water is found to meet the effluent discharge standards. In order to further improve the performance of the ETP, the following action plans are recommended. The above study recommended to following action plan for the resource recovery to make ETP sustainable for conservation of energy and water.

Based on results, we can conclude that the Treated Wastewater is used for Eco-plantation.

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