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DESIGN OF SEWAGE TREATMENT PLANT AT MEDICITY HOSPITAL

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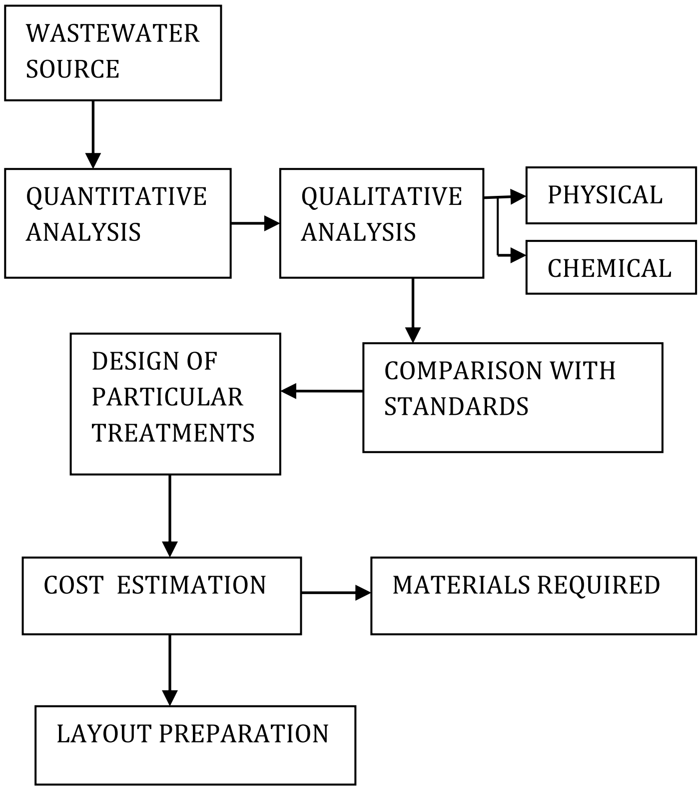
Abstract - *In hospitals where the demand for water is huge, it is highly feasible to adopt a system of waste water recycling for purposes like toilet flushing, gardening/agriculture and for maintenance of landscape, since these are usages with low physical contact. Among the available technologies for waste water treatment, MBBR based sewage treatment is most suitable. This paper demonstrates the detailed procedure for the design of a MBBR based sewage treatment plant of 650 KLD capacity for MEDICITY Hospital Thiruvalla. The present study comprises the study on quality of domestic waste water and industrial waste water. The study includes characterization tests for pH value, acidity, alkalinity, chloride, turbidity & BOD etc. Depending upon the values of these parameters, calculations are done for designing the different units of a Sewage Treatment Plant at Medicity Hospital .*

Key Words: Biological Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids , Moving Bed Biofilm Reactor.

1. INTRODUCTION

Hospital wastewater contains pathogenic agents and hazardous compounds; so, it will cause many risks on environmental and human health. Hospitals consume large volume of water per day for different purposes and also generate large volumes of wastewater that need to be treated. There are many units which generate waste water such as patient wards & administration units, kitchen /canteen & laundry, operating units & ICUs, radiology & dialysis section, laboratories. The main function of waste water treatment plant is to protect environment and human health from excessive overloading of various pollutants. Moving Bed Bio-film Reactor (MBBR) is gaining importance around the world. It is a leading technology in waste water treatment as this system can operate at smaller footprints and give higher removal efficiency. It is compact, efficient and effective option for domestic waste water treatment. In properly designed MBBR, the whole reactor volume is active, with no dead space or short circuiting. MBBR is an aerobic attached biological growth process. It does not require primary clarifier and sludge recirculation. Raw sewage, after screening and de-gritting, is fed to the biological reactor. In the reactor, floating plastic media is provided which remains in suspension. Biological mass is generated on the surface of the media. Attached biological mass consumes organic matter for their metabolism. Excess biological mass leaves the surface of media and it is settled in clarifier.

2. METHODOLOGY



3. LOCATION OVERVIEW

Medicity Hospital is also known as Pushpagiri College of Dental Science & Pharmacy. The overall campus is about

16 acres. It is situated in one of the most important cultural regions of South Kerala. It is located 4kms from Thiruvalla on the Main Central Road (Kollam-Theni Highway Perumthuruthy). Its Latitude is $9^0$24'45.7"N & longitude is $76^0$33'20.7"E.

4. QUANTITATIVE ANALYSIS

4.1 POPULATION FORECASTING

Population forecasting method used here is Geometric increase method. Present population is about 950 and population before 10 years was 725. Then design population after 30 years P_t,

$P_t = P_o . e^{kt} = 950 \times e^{(3/100)x30} = 2336.6 \sim 2340$

4.2 CALCULATION OF SEWAGE GENERATION

Ultimate design period = 30 years

Forecasted population after 30 years = 2340

Per capita water supply = 340 lpcd

Avg. water supply per day = 2340 x 340 = 0.795 MLD

Avg. sewage generation per day = 80% of supplied water

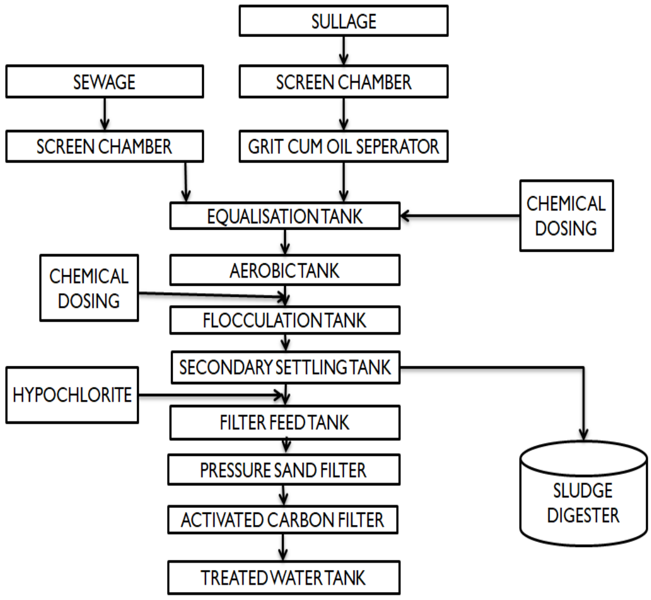
= 0.8 x 0.795 ~ 0.65 MLD

5. QUALITATIVE ANALYSIS

Characteristics of wastewater like pH, chlorine, BOD, COD, Suspended solids are found out and results are,

Sl.no	Parameters	Unit	Wastewater
1.	pH	-	6.8-7.5
2.	Suspended Solids	mg/l	480
3.	BOD	mg/l	350
4.	COD	mg/l	520
5.	Oil & Grease	mg/l	5

6. DESIGN OF SEWAGE TREATMENT PLANT



6.1 DESIGN DATA

For various requirements in the hospital, the total quantity of water is estimated to be 795 KLD. Assuming that 80 % of the water supplied would be converted into sewage and sullage , the quantity of waste water was estimated as 650 KLD.

Total waste Water Generated = 650 KLD , Quantity of sewage (40%) =260 KLD , Quantity of sullage (60%) = 390 KLD

6.2 DESIGN OF RECEIVING CHAMBER

6.2.1 Sewage receiving chamber

Quantity of sewage = 260KLD = 6.31×10^{-3}cumecs

Detention time = 60 sec

Volume required = flow x detention time = $0.38 m^3$

Provide, depth =1m

Area = volume / depth = $0.38 m^2$

Provide, Length : breadth = 2:1

Size of receiving chamber= 0.9m x 0.44m x 1m

6.2.2 Sullage receiving chamber

Quantity of sullage = 390 KLD = 9.48×10^{-3} cumecs

Volume required = 0.57m^3

Provide, depth = 1m

Area = volume / depth = 0.57 m^2

Size of receiving chamber = 1.07m x 0.53m x 1m

6.3 DESIGN OF SCREEN CHAMBER

The process enables removal of coarse particles from the stream that may clog pipes and cause operational disruptions in downstream unit processes.

6.3.1 Sewage screen chamber

Assume velocity of flow through screen, V = 0.8 m/sec

Net area screen opening required = (6.31 x 10^{-3}) / 0.8

= 7.88 x 10^{-3} m^2

Screen with MS bars of size 10 x 50 mm is to be used

Let clear spacing of 20mm be provided

Efficiency coefficient of bars = 0.67

Gross area of screen openings = (7.88 x 10^{-3}) / 0.67

= 0.0118 m^2

Assume screen bars are placed at 45° to the horizontal

Area of screen = 0.0118/ sin45 = 0.0167 m2

If 20 bars are provided, no.of openings will be 21

Gross width of screen and screen channel = 0.62m

Depth of flow in screen channel= 0.0167 / 0.62 = 0.027m

Assume top of the screen to be 0.3m above the highest flow level and a free board of 0.3m.

Total depth of screen channel = 0.027 + 0.3 +FB = 0.627m

Size of screen chamber = 1.24 x 0.62 x 0.63m

6.3.2 Sullage screen chamber

Net area screen opening required = (9.48 x 10^{-3}) / 0.8 = 0.012 m^2

Depth of flow in screen channel = 0.025 / 0.62 = 0.04m

Assume top of the screen to be 0.3m above the highest flow level and a free board of 0.3m.

Total depth of screen channel = 0.04 + 0.3 +FB = 0.64m
Size of screen chamber = 1.24m x 0.62m x 0.64m

6.4 DESIGN OF GRIT CHAMBER

The screened Sullage approaches the Grit and Oil Trap. In this chamber a series of baffles are provided which enable the settlement of grit particles at the bottom and the separation of the oil in the stream at the top. The final oil and grit free stream is directed to the equalization tank.

Maximum waste water flow, Q = 9.48 x 10^{-3} cumec

Horizontal flow grit chamber are designed to maintain a velocity of around 0.2m/s.

Horizontal flow velocity, vh = 0.2m/s

Area required = (9.48 x 10^{-3})/0.2= 0.05m^2

Assuming depth of 0.5m

Width of chamber = 0.5m

Settling velocity ,Vs = 0.016 to 0.022 m/s = 0.02m/s

Detention time =0.5/0.02 = 25 sec

Length of tank = 0.2 x 25 = 5m

Depth = 0.5+ FB = 0.8m

Size of Grit chamber = 5m x 0.5m x 0.8m

6.5 DESIGN OF EQUALIZATION TANK

An equalization tank is provided for receiving the pre-treated waste water. The equalization tank will have the capacity to cope with peak flow conditions. The waste water from the equalization tank is then pumped to aeration tank.
Two pumps are provided one duty and other standby.

Average sewage generation per day = 650 m^3/day

Assume detention period as 2 hours

Capacity of the tank =(650x2)/24 =54.16m^3

Assuming the depth of liquid in the tank as 4.5 m and freeboard as 0.5 m

Total depth = 5 m

Total surface area of tank = 54.16/5 = 10.83 m^2

Providing one unit of equalization tank, the surface area of the tank = 10.83 m

Assuming Length : Breadth ratio as 2:1

Size of equalization tank = 4.65m x 2.32 m x 5 m.

6.6 DESIGN OF AERATION TANK

Average flow = 0.65 MLD = 650 x10^3 l/day

BOD at inlet = 350 mg/l

Total applied BOD = 350 × 650×10^3 = 227.5 kg/day

BOD loading rate = 3 kg/m^3/day

Volume of aeration tank =227.5/3 = 76 m^3

Assuming the media filling factor = 0.5

Media volume = 76 x 0.5 = 38 m^3

Assume square section of 3m height

Area of aeration tank =76/3 = 25 m

Required number of tanks = 2

Thus, Area of each tank = 12.5 m^2

Size of aeration tank =6.25m x 2m x 3m

6.7 BLOWER AIR REQUIREMENT IN MBBR TANK

BOD loading = 227.5 kg/day

Oxygen uptake ratio = 1.25 kg of oxygen /kg of BOD

Oxygen required for 227.5 kg of BOD = 284.375 kg
Percentage of oxygen in air = 21% = 0.21

Weight of oxygen required = 284.375 / 0.21= 1354.16 kg
Density of air = 1.225 kg/m^3

Volume of air = 1354.16 / 1.225 = 1105.43 m^3/day

Quantity of air required= 1105.43 / 0.075= 14739.15 m^3 / day

Factor of safety = 50%

Quantity of air required = 14739.15 x 0.5= 7369.57 m^3/ day

Volume of air required per hour = 7369.57/24= 307.06 m^3/hr

Total volume = 53.94 + 4.489 = 58.43 m^3

Volume of air required = 1.5 x 58.43 = 87.645 m^3/hr

Total air required = 307.06 + 87.645 ~ 400 m^3/hr

Capacity of blower = 400m^3/hr

6.8 DESIGN OF FLOCCULATION TANK

A mild dose of coagulants and flocculants is dosed into the flocculation tank. The addition of these chemicals will aid in the formation of large flocs consisting of the bio-sludge flowing in from the MBBR.
Average hourly flow = 27.08/60=0.45 m^3/min
Detention time ranges between 10 to 30 minutes.

Let us take detention time =10 minutes

Volume of flocculation tank = 10 x 0.45 = 4.5m^3

Assume depth of flocculation tank as 1.5m and length of flocculation tank = breadth of flocculation tank.

Size of flocculation tank =1.73m x 1.73m x 1.5m

6.9 DESIGN OF SECONDARY SETTLING TANK

The waste water from the flocculation tank along with biologically stabilized solids and chemically precipitated sludge will flow by gravity to the secondary settling tank.

Average flow = 650/24= 27.08 m^3/hr

Surface flows rate = 13 m^3/hr/m^2

Surface area = 27.08/13 = 2.083 m^2

Assume depth ,D = 3 m

Assuming Length : Breadth ratio as 2:1

Size of secondary settling tank =2.04m x 1.02m x 3m

6.10 CHLORINE DOSAGE

Assuming a chlorine dosage of 30 ppm

Amount of chlorine required to disinfect 27083.33 litre/hr = 27083.33 x 30 = 812500 mg /hr

Amount of chlorine solution required= 812500 mg /hr = 812500/150000 = 5.41 litres/hr

Chlorine dosage per day = 5.41 x 24= 129.84 litres/day

6.11 DESIGN OF FILTER FEED TANK

Average hourly flow rate =650/24 = 27.08 m^3/hr

Retention time = 3 hr

Volume of filter feed tank = 27.08 x 3= 81.24 m^3

Assuming Height = 3m and a square plan

Area required =81.24/3 =27.08m^2

Assuming L:B =1:1

Size of filter feed tank =5.20m x 5.20m x 3m

6.12 DESIGN OF PRESSURE SAND FILTER

The media in the filter contains fine grain sand that serves to trap any small particles that might have escaped removal in the settling tank.
Average hourly flow = 650 / 24= 27.08 m^3/hr

Loading rate = less than 12 m^3/m^2/hr

Assume loading rate = 11 m^3/m^2/hr

Area = 27.08/11 = 2.461m^2

Size of Pressure Sand Filter = 1.8mØ x 2.25m height

6.13 DESIGN OF ACTIVATED CARBON FILTER

The media in the filter contains granular activated carbon that serves to remove chemical compounds in the effluent by adsorption. Colour causing and odour forming compounds are removed in this stage.
Average hourly flow = 27.08 m^3/hr

Assume loading rate = 11 m^3/m^2/hr

Area = 27.08/11 = 2.461m^2

Size of Activated Carbon Filter = 1.8mØ x 2.25m height

6.14 DESIGN OF TREATED WATER TANK

Average hourly flow rate= 27.08 m^3/hr

Retention time = 3 hr

Volume of Treated water tank= 27.08 x 3 = 81.24 m^3

Assuming, Height = 3m

Area required= 81.24/3 = 27.08m^2

Assuming L:B =1:1

Size of treated water tank =5.20m x 5.20m x 3m

6.15 DESIGN OF SLUDGE DIGESTION TANK

The sludge from the settling tank is pumped to a sludge digester.
Average flow = 0.650 MLD

Assume Total Suspended Solids in raw sewage = 300 mg/L

Total suspended solids = 0.65 x 300 = 195 kg/day

Assume 65% solids are removed in settling tank

Mass of solids removed in settling tank = (65/100) x 195

= 126.75 kg/day

Assume that fresh sludge has a moisture content of 95%

i.e., 5 kg of dry solids make 100 kg of wet sludge.

Thus, mass of wet sludge made by 126.75kg of solids = (100/5)x 126.75=2535 kg/day

Assuming the specific gravity of wet sludge as 1.02

Density of sludge = 1.02 x 1000= 1020 kg/m^3

Volume of raw sludge produced per day, V_1 =2535/1020

= 2.485 m^3/day

Assume moisture content of digested sludge as 85% volume of digested sludge (V_2) = 2.485 x (100-95)/(100-85) = 0.828 m^3/day

Assuming the digestion period as 30 days.

Capacity of required digestion tank= 2.485-$\frac{2}{3}$ (2.485-0.83)}x 30= 41.418 m^3

Providing 4m depth of cylindrical digestion tank

Cross sectional area of tank = 41.418/4= 10.354 m^2

Diameter of tank ,d = 3.63 m

Hence provide a cylindrical sludge digestion tank 4m deep and 3.63m diameter , with an additional hoppered bottom of 1:1 slope for collection of digested

7. CONCLUSIONS

Since, hospital wastewater consists of various potentially hazardous components that will cause many risks on human and environment by polluting surface and ground water. Hence, hospital sewage treatment is very much required. Through this paper, the detailed procedure for the design of a MBBR based sewage treatment plant of 650 KLD capacity for an hospital campus is demonstrated. It is hoped that this would act as a reference for the designers as well as the stakeholders in hospitals to adopt this or similar technologies.

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