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Designing of Sewage Treatment Plant for Society Level By using Sequential Batch Reactor

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1. Abstract:

Sewage is waste come from houses, factories etc. as a result of laundry, using the bathroom and all soapy water. Rainwater entering drains and industries, also come under this category.

The major aim behind project is to treat sewage at society level. Here basically we take sewage from society and return the treated sewage in form of water so that the people of society can use that water for various purpose like washing cloth, vehicles, use in toilet, gardening and various purposes instead of drinking and cooking.

SEWAGE TREATMENT PLANT is a facility designed to receive the wastewater and treated it such a way to make it suitable for human consumption and a waste is used as manure after further treatment in fields for growing crops etc.

Keywords: Effluent, coagulation, chlorination etc.

2. INTRODUCTION:

Sewage basically contains 99% water and 1% solid waste for the treatment of these sewages we construct a sewage treatment plant (STP). The prior activity or work of STP is to treat the sewage that originate from home and in return provide a treated water that people use for various purposes.

Now-a-days many countries updated the tertiary treatment process of STP and make the water suitable for drinking and cooking also.

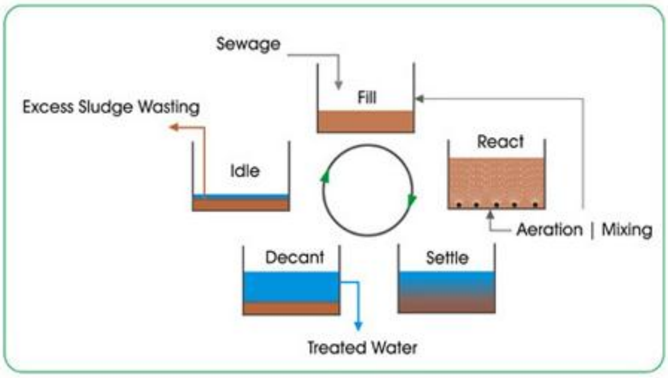

Fig-1: major Phases of the SBR operational cycle

Here we opt the Sequential Batch Reactor (SBR) technology for designing of our STP that is for Apartment Complex. As we aware of this very well that SBR technology gain proficiency over ASP and MBBR. It is eligible for treatment of both municipal and household waste. It contains less area and also required less amount of chamber than ASP and MBBR. As in SBR the three function that is Equalize, Aerate and Clarify the water are performed in single tank that is Aeration Tank. The activity of dumping of sewage are going to be more tough and also it polluted the natural soil as well as our environment and SBR technology proves a real technique which achieve lower effluent limits.

3. LITERATURE REVIEW:

Lamine (2007) completed investigation of treatment of grey water with help of SBR. HRTs which was noted was 0.6 no. of days what's more, load variety was for 2.5 no. of days. 90% of organic issue with COD removal can be accomplished by a viably SBR and can expel nutrients and do the biodegradation. The SVI noted was 100ml/g and that is exceptionally good. The execution of phosphorus removal was diminished. Concentration of ammonium noted was greater in system of HRT of 0.6 days while that was smaller influenced in system of HRT of 2.5.The situation of concentration as advancement is essential for HRT which is to be received by a load variety.

Moawada et. Al. (2009) researched the ability to treat municipal sewage with a combined method of aerobic and anaerobic treatment forms for example a flowing upward Anaerobic Sludge Blanket (UASB) trailed along aerobic SBR discharge sewage reasonable for supplying water to fields.

3 trials are tested, that comprises of 3-4 hours variety to HRT of USAB, 6-12 hours period variation of SBR which comprises of aeration cycle variety from 2-9 hours. The increment in hydraulic retention time of a SBR system was useful on Total Nitrogen extraction yet having no impact on Total Phosphorous just as extraction efficiencies of COD and BOD. COD shows removal efficiency as84%-89% and BOD shows removal efficiency as90-95.9% and TSS removal efficiency was 85 to 93.9% individually which inferred that utilization of SBR after UASB is a excellent innovation.

4. METHODOLOGY:

The main purpose of sewage treatment plant premise is to clean the sewage and supply that cleaned water to the people so that they can utilize that for completing their basic needs of water except cooking and drinking.

Here we design this system on Sequencing Batch Reactor, (SBR) technology which gains proficiency over(ASP) and(MBBR) in many aspects. SBR works on the concept of batch reactor that is in this multiple process done in single tank (aeration tank) in batch wise means one after other.

A remarkable difference between SBR and traditional activated sludge system with a continuous flow, is that in SBR Equalize, aerate and clarify the water are performed in single tank whereas in ASP individual tank is required for every process and functions. In this way SBR required less space and also economical than others.

The sewage treatment process includesvariety of knotty functions and itsscope of treatment mainly decided by its initial nature of influents ofuntested sewage as well as required nature of the effluents. The various treatment methods of STP are:

Primary Treatment: In this type of treatment large sized suspended solids of organic nature are removed. It this mainly Screening tank and Oil and Grease tank come.

Secondary Treatment: The effluent that came out from primary treatment can be further treated out through biological degradation of organic matter. This biological decomposition is performed in two different ways, aerobically and an-aerobically. In this usually collection tank and aeration tank came.

Tertiary Treatment: This is the final step in sewage treatment process in this we obtained a treated water in the treated water tank and the residue remain moved towards a sludge holding tank.

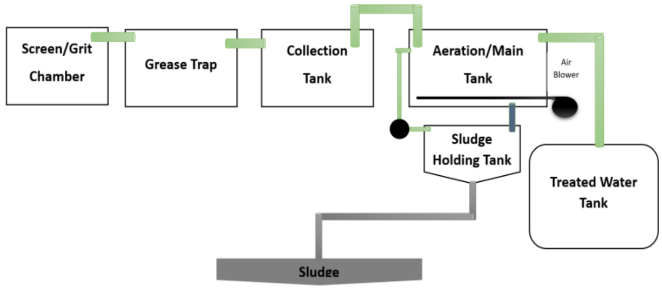

Fig- 2: Flow Diagram of STP

5. POINT TO BE EXAMINE FOR DESIGN OF STP:

a) The generated sewage is at most 80 KLD.

b) The water we obtained after treatment should be used in toilets, washing clothes, vehicles, house and used in small field and garden of apartment, almost most of the work except drinking and cooking.

c) Based on plandesign a sewage treatment plant of 100 KLD capacity which contains tank or chamber named as bar screen chamber, oil and grease tank, collection tank, aeration chamber, treatment chamber and residue(sludge) holding tank.

d) Constructing of STPs done in such a way that it should be far from crowded area in order to avoid inconvenience due to bad odour of sewage.

e) Here we design a small capacity STPs and also for few numbers of people in order to clean the sewage day by day which reduces extra hold on untreated sewage and free from spreading of various diseases.

f) Capability of treatment of sewage by STPs is such a way that it full fill everyday requirement of water of people so that the dependency of people on groundwater is reduces.

g) As all sewage moved on STP plant so it also reduces environment pollution at very large extent.

h) All the treated unit that are design should be economical and easy to clean and maintain it.

6. DESIGN OF SEWAGE TREATMENT PLANT:

6.1. Some important components of projects:

Table-1: The silent components of the project layout are described below:

Project's Type	Society Level
Water source	Underground water
No. of people	500-600
Water consumption in KLD	72 KLD
Quantity of sewage in KLD	64 KLD
Proposed sewage with design details	80KLD

6.2. Water consumption details- [2]

Requirement of water is dependent on the rules of NBC. The quantity of water required for the proposed project is assessed to be about 72 KLD during the activity stage.

The required water is =120×600

= 72000 litre/day

Assume 80% of total supplied water become sewage,

The amount of sewage generated = 72000×0.8

= 57600 litre/day

Take a detention time as 24 hours,

The quantity(capacity) of sewage produced during this period

= 57600× $\left(\frac{24}{24}\right)$

=57600 litres

Now the sludge is deposited at the rate of40 litres/capita/year: and,assume the interval of cleanseis 3 months,

The sludge deposited volume is

= 40 × 600 × $\left(\frac{1}{4}\right)$

= 6000 lit.

Full capacity of the tank is,

= capacity of sewage + capacity of sludge

= 57600 + 6000

= 63600 litres

Sewage quantity = 63.6 KLD

STP proposal with design details is **80 KLD.**

6.3. Design wastewater quantity and quality:

The Primary and Secondary Treatment units are designed for 80 KLD flow.

Table-2: Theraw effluents and treated effluents quality as per norms. [2]

Expected Parameter	Influents	Treated water
Average BOD	250-300 mg/litre	<10 mg/litre
Average COD	400-650 mg/litre	<250 mg/litre
Total suspended solids	250-300 mg/litre	<20 mg/litre

6.4. Design of screen chamber and receiving bar:

Discharge = 80 KLD= 0.00093 m^3/sec

Assume detention time = 6 minute

Volume of receiving chamber

V = 0.00093(60 × 60) = 0.335 m^3

Chamber size = 1.085m × 0.5m × 1.75m

6.5. Design of coarse screen:

Velocity through screen at maximum flow is assumed to be 0.45 m/sec.

Bar spacing(clear) = 2.2 cm

Average discharge of wastewater = 0.00093 m^3/sec

Peak discharge = $Q_{average}$ × Peak factor = 0.00093 × 3 = 0.0028 m^3/sec

At average flow velocity should notexceed to 0.45 m/sec,

Screen's vertical projected area is = $\frac{Q}{V}$ = $\frac{0.0028}{0.45}$ = 0.006222 m^2 = 6222.22mm^2

Assume-

Diameter of screen = 1cm = 10mm, Width of screen = 1.9 cm = 19 mm, Clear spacing = 2.2 cm = 22mm. [5]

No. of openings = 15, No. of bars = 15 – 1 = 14, No. of ends bars/ plates = 2

So, Total number of bars = 16

Total gross width = 0.5m

Assume, depth or height = 0.8, screen inclined at 60°

Dimension of screen is: Length = 1m, Width = 0.5m.

6.6. Designing of oil and grease tank:

Discharge = 240 m^3/day

V_r = rising velocity removed oily material should not exceed = 0.12m/min (assume).

A = $\frac{240\frac{m^3}{day}}{0.12\ m/min}$ = $1.4m^2$

Provide depth of tank is 2m, the ratio of length and width is 3:2

Length = 3m, Width = 1m, Height = 2m + 0.25(free board) = 2.25m

Dimension of oil and grease tank = 3m × 1m × 2.25m

6.7. Designing of collection tank:

Design flow (Discharge) = 80 KLD

For collection tank taking a peak factor as 1. [2]

Sewage collection in 1 day = $80m^3$/day × 1 day = $80m^3$.

Depth of tank = 4 m (assume),

Area = $\frac{80}{4}$ = 20 m^2

The length and width ratio = 3:2

Length = 5.5 m, width = 3.65 m, Height = 4 m.

Dimension of collection tank = 5.5m × 3.65m × 4m

Collection tank air required = $0.5m^3$ of air/m^3 for tank volume if more than 2 hrs of retention time is to be accumulate = 0.5× 80 = $40m^3$/Hr [8]

6.8. Design of aeration tank:

6.8.1. Estimation of Aeration Time:

Firstly, we calculate Aeration Cycle Time:

Here Organic load:

$80m^3 \times (300 - 10) \times 10^3 = 23.2kg$/day.

Now calculate aeration time,

F/M ratio of SBR shifts from maximum as 0.3 to minimum of 0.10. [1]

Range of F/M ratio: 0.1-0.3(For SBR)

Estimation of 0.2 for design calculation.

Acquire ratio of F/M as 0.2

Total oxygen required(assume) as 23.2 kg of O_2/kg of BOD extracted: 23.2× 2 = 46.4kg/day.

MLSS in reactor = 4000mg/L. HRT (Hydraulic retention time) = $\frac{BOD\left(\frac{mg}{l}\right)}{MLSS\times\frac{F}{M}}$ = $\frac{46.6}{0.2\times4000}$ (Assume 50% decantation)

= 1.74 Hours (say 2 Hours).

Then the cycle time = 1.74(Aeration) + 0.75(Decantation) + 0.75(Settling) = 3.24 Hours (say 4 Hours)

So, we design for 3 batches in one day (on working time of 12 hr)

6.8.2. Tank Design: [7][8]

Discharge = $80m^3$/day, BOD = 300mg/lit.

Tank volume = $\frac{Q \times BOD}{MLSS \times\frac{F}{M}}$ = $\frac{80\times300}{0.2\times4000}$ = $30m^3$

Sludge accumulation provided is 30% and total provided tank volume is $39m^3 \approx 40m^3$

Assumed depth of tank is 3m

Plan area = $\frac{40}{3}$ = $13.33m^2$

Reactor provided of $40m^3$ effective volume + Free board, Tank size: 4m × 3.5m × 3.0(SWD) + 0.25m FB.

6.8.3. Requirement Of Oxygen for Aeration Tank:

Required Oxygen = 1.5 × load of BOD

= 1.5 ×$\frac{29}{4}$ = 10.875 Kg/Batch = $\frac{10.875}{4}$ = 2.719 Kg/Hr.

Assume transfer efficiency of Oxygen is 3.5% per meter depth of water column.

Reactor's total SWD = 3.0 m, Overall efficiency = 3.0 × 3.5 = 10.50%, Oxygen to be supplied = $\frac{2.719}{0.105}$ = 25.89 Kg/Hr.

Supplied air = Required Oxygen/ (Air density × W/W % of oxygen in air) = $\frac{25.89}{0.23 \times 1.4}$

= 80.41m^3/Hr.

6.8.4. Total Oxygen Required:

Overall required air = Collection tank air + Aeration tank air = 80 + 80.41

= 160.41m^3/Hr.

Assume blower efficiency as 85 % = $\frac{160.41}{0.85}$

= 188.72 m^3/Hr

Compression factor (assume) = 1.5

Total Volume is $\frac{188.72}{1.5}$ = 125.81m^3/Hr.

Provided blower capacity is 150m^3/Hr factor of safety is considered.

6.9. Designing of Treated Water Tank-

Discharge = 80 m^3/day

There are three batches completed in one day and the decantation time is 0.75 Hr. [4]

Hence $\frac{80}{3} m^3$ = 26.67 m^3 ≈ 30 m^3

Assume depth of tank = 2m

So, area of plane of tank = $\frac{30}{2}$ = 15m^2

Then length of the tank = 5m and width of tank is 3m.

The block warrior provided at the distance of 1 meter.

So, the number of warriors = 4

Size of Tank: 5m × 3m × 2m + 0.25m FB.

5.10. Design of sludge holding tank:

Average flow of sewage = 80 KLD = 0.08 MLD

Total suspended solid = 300 mg/l, Volatile suspended solid = 250 mg/l, Moisture content digested sludge = 87%, Assume 65% removal done in primary settling tank, Fresh sludge has water content of 95%.

Mass of suspended solids = $\frac{300 \times 0.08 \times 10^6}{10^6}$ = 24kg/day

65% solids are removed by primary settling tank = 24 × $\left(\frac{65}{100}\right)$ = 15.6 kg/day

Fresh sludge contains 95% water content

Dry solid of 5 kg make = 100 kg of wet sludge

15.6kg of dry solid that generated = $\left(\frac{100}{5}\right)$ × 15.6 = 312 kg/day

Assume specific gravity of wet sludge as = 1.02 i.e.,Density = 1020 kg/m^3

The volume (V_1) of raw sludge produced = $\frac{312}{1020}$ = 0.305 m^3/day

The volume of digested sludge [6]

$$V_2 = V_1 \left(\frac{100 - P_1}{100 - P_2}\right)$$

$P_1 = 95\%, P_2 = 87\%, V_2 = 0.0117 m^3/day$

Assume digested period as 30 days, capacity of digested tank required = 5.39m^3

Provided depth of 1.5m of cylinder digested tank.

Area = $\frac{5.39}{1.5}$ = 3.59m^3, diameter of tank (d) = 2.13.

The digestion tank is cylindrical shape having:

Depth = 1.5m, Diameter = 2.13m with hopper of 1.1 slope

5.11. Pumps: [9]

A. Two transfer pumps are providing one is used in working and another is put for emergency case,
Capacity: 5.0 KLH @ 15 m head, Type: Centrifugal pumps

Solid handling capacity: up to 10 mm
Purpose:For pumping the sewage from collection tank to aeration tank.

B. One pump is used for transferring sludge.
Capacity: 3 KLH/hr @ 15m head, Type: Centrifugal pumps

Solid handling capacity: up to 25 mm
Purpose: For pumping sludge from the aeration tank to the sludge holding tank.

C. Two Filter feed pumps are required.
Capacity: 5.0 KLH @ 30m head, Type: Centrifugal pumps

Solid handling capacity: up to 5mm
Purpose: For pumping the treated effluent from the aeration tank to treated water tank.

7. CONCLUSION:

80 KLD sewage treatment plant is designed for the treatment of waste generated by an apartment. Here we implemented a sequential batch reactor (SBR) technology which gain a proficiency over ASP and MBBR in many aspects. SBR oxidize the(BOD),that denitrify the reduced total nitrogen to a permissible limit and nitrify the ammonia. Water that derived from treated water tank is then chlorinated so that it can be used for various purposes like washing clothes, vehicle, used in toilets, gardening and for other use except cooking, bathing and drinking. Many countries treated the sewage up to drinking level and India is still working on upgrading their technology.

The remaining solid sludge residue is sends to sludge holding tank which can be used as manure in fields.

Table-3: Treatment unit and its sizes

S. No.	Name of unit	Size in m
1	Coarse screen filter press	16 bars with 22mm clear spacing, plate size of 1m × 0.5m
2	Bar screen chamber	$1.085m \times 0.5m \times 1.75m$
3	Oil and Grease tank	$3m \times 1m \times 2.25m$
4	Collection tank	$5.5m \times 3.65m \times 4m$
5	Aeration tank	$4m \times 3.5m \times 3.0m + 0.25m\ FB.$
6	Treated water tank	$5m \times 3m \times 2m + 0.25m\ FB$
7	Sludge holding tank	Depth = 1.5m, dia. = 2.13m, hopper slope = 1.1

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