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RESEARCH ARTICLE

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DESIGN OF EFFLUENT WASTE WATER TREATMENT PROCESS WITH PIPING SYSTEMS

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ABSTRACT

A study was conducted of primary treatment and management of sewage generated in area around NALLAGONDA and sewage treatment plant was designed with piping systems as per ASME standards. It was concluded from the study that in next 20 years the predicted population will be 35,000 and estimated sewage will be 5.2 MLD. The various components of designing primary sewage treatment plant are by screening chamber, grit chamber, sedimentation tank, skimming tank sludge drying bed and active sludge tank were designed considering the various standards and permissible limits of treated sewage water. The receiving chamber of dimension 5m x 3m x 2m, the coarse screen of dimension 1m x 5 m, Grit chamber of dimension 5m x 3.5m x 1m, Primary sedimentation tank with diameter of 5m and depth 3m, trickling filter of diameter 15m and depth 3m, aeration tank of dimensions16m x 8m x 4m and sludge dry bed of dimensions 14m x 8m will effectively treat the sewage water at primary stage by keeping the sewage quality within the permissible limits. First and foremost we should be caring for our environment and for our own health . If it is not properly cleaned, water can carry disease. Because we live, work and play so close to water, harmful bacteria have to be removed to make water safe. And after the treatment processes the treated water is supplied for irrigation of crops and remaining sludge is used as manure to make soil more fertile . And thus this also decreases the usage of ground water and water can be saved.

1. INTRODUCTION

Treatment of Sewage

The treatment of sewage consists of many complex functions. The degree of treatment depends upon the characteristics of the raw inlet sewage as well as the required effluent characteristics.

Treatment processes are often classified as:

(i) Preliminary treatment
(ii) Primary treatment
(iii) Secondary treatment
(iv) Tertiary treatment.

Preliminary Treatment

Preliminary treatment consists solely in separating the floating materials like tree branches, papers, pieces of rags, wood etc. and heavy settable inorganic solids. It helps in removal of oils and greases and reduces the BOD by 15% to 30%. The processes under this are-

- Screening – to remove floating papers, rags, clothes.
- Grit chamber – to remove grit and sand.
- Skimming tank – to remove oils and greases.

Primary Treatment (Mechanical)

Primary treatment consists in removing of large suspended and floating particles of organic solids. It is usually accomplished by sedimentation in settling basins. The liquid effluent from the primary treatment often contains a large amount of suspended organic material and has a high BOD (about 60% of original).This is sometimes referred as "mechanical treatment"

Secondary Treatment(Biological)

In the secondary treatment processes the effluent from primary treatment is treated through biological decomposition of organic matter carried out either by aerobic or anaerobic conditions. this is sometimes referred as "Biological treatment"

Aerobic Biological Units

(i) Filters (intermittent sand filters, trickling filters)

(ii) Activated Sludge Plant (feed of active sludge, secondary settling tank and aeration tank)

(iii) Oxidation ponds and Aerated lagoons.

Anaerobic Biological Units

(i) Anaerobic lagoons

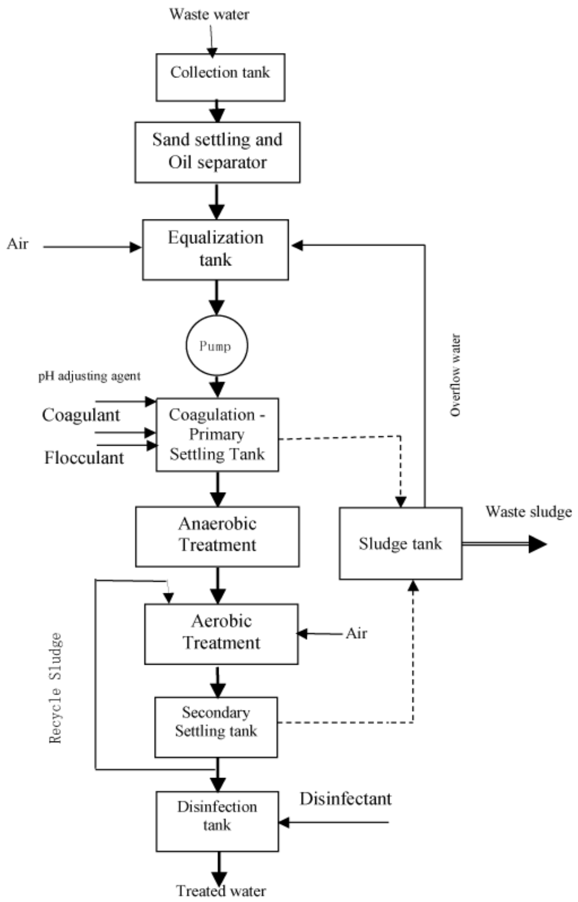
(ii) Septic tanks

(iii) Inhoff tanks.

The effluent from the secondary treatment contains a little BOD (5% to 10% of original) and may contain several milligrams per liter of DO.

Tertiary Treatment

The purpose and the use of tertiary treatment is to provide a final treatment stage to raise the effluent quality before it is discharged to the receiving environment (sea, river, lake, ground, etc.). Tertiary treatment can remove more than 99 percent of all the impurities from sewage, producing an effluent of almost drinking-water quality. More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also known as "effluent polishing".



CALCULATION FOR DESIGN OF PRIMARY SEWAGE TREATMENT PLANT

Calculation of effluent waste Generation

Total population in apartments = 30,000 person

Residential area = 5,000 person

Water supply per capita – Apartments' = 200 l/h/d

Residential area = 300 l/h/d

Sewage generation per day = 80% of supplied water

Per capita sewage water –

Apartment's = 180 l/h/d

Residential area = 250 l/h/d

Total sewage generation per day

Apartments – 180 x 30,000 = 5400000 l/d

Residential area – 250 x 5000 = 1250000 l/d.

Total amount of sewage – 5400000 + 1250000 = 4150000 = 3.6 MLD In cumec,

Average discharge = 0.052 cumec

Maximum discharge = 3 x avg. discharge

3 x 0.052 = 0.156cumces

Design of Receiving Chamber

Design flow = 0.156 cumec

Detention time = 60 sec

Volume required = 0.156 x 60

Vrqd = 9.36 m^3

Provide depth = 1 m

Area = 9.36m^3

Take ratio of length : breadth = 2 : 1

L x B = 2B x B = 2 m^2 = 9.36 m^2

B^2= 4.68

B = 2.84 m

Say 3m

L = 3.28 m

Say 4m

Design of Grit Chamber

Peak flow of sewage = 0.156 m^3/s

Assume average detention period = 180s

Aerated volume = 0.156 x 180

=28.08 = 28 m^3

In order to drain the channel periodically for routine cleaning and maintenance two chambers are used.

Therefore volume of one aerated chamber = 28/ 2

= 14 m^3

Assume depth of 1.5m and width to depth ratio 2:1

Width of channel = 1.5x 2 = 3 m

Length of channel = 14 / 3

= 4.66 m

Say 5m

Increase the length by about 30% to account for inlet and outlet Provided length = 5+1.5 = 6.5 m

Design of Coarse Screen

Peak discharge of sewage flow = 0.156 m^3/s

Assume the velocity at average flow is not allowed to exceed 0.8 m/s

The net area screen opening required = 0.156 / 0.8

= 0.195 m^2

Clear opening between bars = 30 mm = 0.03m

Size of the bars = 70 mm x 10 mm

Assume width of the channel = 0.5m

The screen bars are placed at 60° to the horizontal.

Velocity through screen at peak flow = 1.8m/s

Clear area = 0.195 / 1.8 x sin 60

= 0.153 m^2

No of clear openings = 0.153 / 0.03 = 5.11 = 5 Nos.

Width of channel = (4 x 30) + (5 x 10)

= 170mm = 0.17m

Provided width of the channel = 0.3m

Depth of channel = 0.153 / 0.3

= 0.51m

Design of Skimming Tank

The surface area required for the tank A = 7.38 x 10^{-3} x q / Vr

q = 0.153 x 60 x 60 x 24

= 13219.2 m^3/ day

Vr = 0.35 m / min

0.35 x 60 x 24

504 m / day

A = 7.38 x10^{-3} x 13219.2 / 504

= 0.193m^2

Provide the depth of the skimming tank is 1m The length breadth ratio is 1.5: 1

L = 1.5B A = 1.5 m^2

0.189 = 1.5 m^2

B = 0.355 m L = 0.532 m

Design of Primary Sedimentation Tank

Max. Quantity sewage = 5.2 MLD

Surface loading = Q /$\frac{\Pi}{4}$ m^2

= 30,000 m^2/ / day

Detention period = 2hr

Volume of sewage =

$$\frac{Maximum\ quantity\ of\ sewage}{detention\ period\ x\ 24} x1000$$

= 108.3m^3

Provide effective depth = 3m

Surface area = volume / depth = 108.3 / 3 =36.1 m^2

Diameter of the tank $\frac{\Pi}{4} d^2$

= 36.1

d = 6.03m

say 6m

Primary sedimentation tank is designed for the dimension of 8m dia and 2m depth with free board of 0.5m extra depth.

Design of Rotary Distribution

Peak flow per day = 0. 156 m^3/s

Assume that the velocity at central column of the distributor = 2 m/s

The dia. of central column (D)

$$\sqrt{\frac{0.156}{2} * \frac{4}{\pi}} m^2$$

D = 0.35 m

Check for Velocity at Average Flow

The velocity through the column at average flow, as it should not be less than 1 m/sec

Discharge through average flow = 0. 156 m^3 /s

Velocity at average flow –

$$\sqrt{\frac{0.156}{\frac{\pi}{4}*(0.35^2)}}$$

V = 1.27 m/sec

1.27 m/sec > 1 m/sec hence , the dia. central column is 0.35m

Design of Arms

We use the rotary reaction spray type distributer with 4 arms .

Discharge per arms(Q)-

Q = $\frac{0.156}{4}$

Q = 0.039 m^3/s

Dia. of filter used = 30 m

So

Arm length =15m

Design of Aeration Tank

Design flow = 5.2 MLD

Average flow of tank = 3800m^3

BOD in inlet = 1 x 200

(20% BOD removed at grit chamber)

Y_O = 200mg/l

BOD at outlet Y_E= 20 mg / l

BOD removed in activated plant = 200 – 20

= 180 mg / l

Minimum efficiency required in the activated plant = 180 /200

= 90 %

aeration process can remove 85 – 90% Hence it is OK

MLSS (Xt) = 3000 mg/l F/M ratio = 0.4

Volume the tank required (v)

$= \frac{Q*Y}{F*XT}$

$= \frac{3800*200}{0.4*3000}$

= 633.3m^3

Assume the liquid depth of the tank as 5 m The width to depth ratio as 2:1

Width = 10 m

Length of tank

L x B x D = 633.3

L =$\frac{633.3}{B*D}$

=$\frac{633.3}{10*5}$

= 12.6 m

Check for Aeration Period / HRT

Hydraulic retention time (HRT) -

t = $\frac{V*24}{Q}$

= $\frac{633.3*24}{3800}$

= 3.9 hrs

Since it lies between 3 – 6 hrs it is OK

Check for Volumetric Loading

Volumetric loading

= $\frac{Q*Y}{V}$

= $\frac{3800*200}{633.3}$

= 1200m^3 g/

= 1.2m^3 kg/

Since it is lies between 1.0 – 1.3, it is OK.

Capacity Aerator

BOD applied of tank = 200 mg/l

Average flow of tank = 3800 m^3 day

BOD removed in tank = 3800 x 0.200

760 kg / day

= $\frac{760}{24}$ kg / hr

31.6 kg / hr

Oxygen requirement = 1 kg / kg of BOD applied Peck oxygen demand = 125%

Oxygen transfer capacity of the aeration of the standard condition

0.9 kg /kWh

1.41 kg / HP / hr

Oxygen transfer capacity aerators at field condition

= 0.9 x 1.41

= 1.269 kh / HP / hr

Oxygen to be in a tank = 1.0 x 24 x 1.25 = 30 kg /hr

HP of aerators required

$\frac{30}{1.269}$

23.64 HP

24 HP

Design of Sludge Drying Beds

Sludge applied to drying bed at the rate of 150kg / MLD Sludge applied = 400 kg/day

Specific gravity = 1.015 Solid content = 2%

Volume of sludge = $\frac{\text{Sludge applied}}{\text{Solid content xSpecific gravity x 1000}}$

= $\frac{400}{0.02*1.015*1000}$ m^3

= 19.70 / day

weather condition the beds get dried out about 8 day Number of cycle in one year = $\frac{365}{8}$

= 45.62

Say 46 cycles

Period of each cycle = 8 days

Volume of sludge per cycle = 19.70 x 10 = $197.0m^3$

Spreading a layer of 0.3m per cycle,

Area of bed required = 197.0/0.3 = $656.8m^2$

Say $650m^2$

Provide 6 nos of bed,

Area of each bed = 100 m^2

Dimension of each bed 12.5m x 8m are designed.

Design of Sewer

X-Cross section area –

A = $\frac{\Pi}{4}D^2$

Wetted perimeter –

P = πD

Hydraulic mean depth (HMD)

R = $\frac{A}{P}$ = $\frac{D}{4}$

Now pipe is running half full, then A = $\frac{\Pi D^2}{8}$

Diameter of sewer pipe - Q= A x V

0.156 = $\frac{\Pi D^2}{8}$ x 1.2

D = 0.57m

Slope of sewer pipe – By Manning's formula -

$V = \frac{1}{N} R^{2/3} S^{1/2}$

V = 1.2 m/s n= 0.013

R = 0.42 1.2 = $\frac{1}{0.013}(0.42)^{2/3}S^{1/2}$

$S^{1/2} = \frac{1.2*0.013}{(0.42)^{2/3}}$

S = 0.0278

Slope = 1 in 556

2. CONCLUSION

In the study for the primary treatment and management of sewage generated in the Apartments and residential area has been developed. The total sewage generated in one day is 5.2ML. hence the effluent treated water will be useful for irrigation. and the sludge which is remained after treatment will be used as manure in farming and also increases the fertility of soil . This usage of treated water will reduce the ground water usage increasing the fertility of soil. Important units of the scheme have been designed for a specific case are:-

1. The design of primary sewage treatment is for the predicted population of 35,000 and estimated sewage of 5.2 MLD.
2. The dimension of receiving chamber is 4m x 3m x 1.5m.
3. The dimension of screen is 0.5m x 5m
4. The dimension of grit chamber with aeration is 5m x 3m x 1.5m
5. The dimension of the primary sedimentation tank is diameter of 6m and depth 3m
6. The dimension of the aeration tank is 12.6m x 10m x 5m
7. The dimension of sludge dry bed is 12.5m x 8m

The construction of the effluent treatment plant will prevent the direct disposal in to rivers and the use of treated water will reduce the surface water and ground water contamination.

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