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Design of Sewage Treatment Plant for Small Town

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Abstract: Sewage treatment is the technique for expelling contaminants from local and family sewage. This work introduced the design steps and calculation for each unit of the sewage treatment plant. The waste water that originates from homes and organizations as laundry waste, toilet waste and each one the foamy water that originates from washing dishes and in this way the preferences inside the kitchen is the thing that we call sewage or wastewater. This undertaking comprise the structure of the total parts of a sewage treatment plant from screening chamber, coarseness chamber, skimming tank, sedimentation tank, air circulation tank, auxiliary clarifier, sewer pipe line and slop drying beds for sewage. Design of sewage treatment is for the 15,000 populations and evaluated sewage of 1.624MLD. The proposed sewerage framework would serve to pick and move the sewage emerging from the present little town outfall for appropriate treatment and removal. This is capable accomplish the impact of dispensing with untreated or incompletely treated sewage releases to little city. This speaks to the most significant favourable position of the project, not solely in regards of water quality improvement inside the city yet in addition to the local climate inside the neighbourhoods by taking out unfortunate, foul and conceivably outwardly upsetting surface releases.
Keywords: Bed, Clarifier, Design, Drying, Plant, Quality, Sedimentation, Sewage,Sludge, Treatment, Waste

I. INTRODUCTION

Neatness is that the main point of sanitation. We need to keep up our body, food, home and apparel as perfect as could be expected under the circumstances. Our general condition ought to try and be kept up spotless and flawless. In a significant number of our activities, we use water in house, station, partnership and open spots. Cleaning of the yards, floors, vehicles, and heaps of materials are additionally done utilizing water. During completely these exercises, a lot of waste substances are taken far in arrangement or in suspension by water[6]. At the tip, it turns into a fluid containing wastewater. The dirty water that originates from homes and organizations as a result of clothing, utilizing the latrine, and each one the lathery water that originates from washing dishes and subsequently the preferences inside the kitchen is the thing that we call sewage or wastewater. Sewage treatment is that the technique for expelling contaminants from wastewater, fundamentally from family unit sewage. It incorporates physical, chemical and biological procedures to remove these contaminants and produce ecologically safe treated wastewater[1]. A side effect of sewage treatment is commonly a semisolid waste or slurry, considered sewage slop that get the chance to experience further treatment before being reasonable for removal or land application. As time passes, there will be populace increase that the govt. should give progressively usable water to society. Sewage treatment plant utilizes physical, chemical and natural procedures to wash down sewage to monitor the earth and open health [4].Present STP lessens the waste produces excrement and vitality and encourages us to remain our waterways, lakes clean. The sewage contamination causes unwanted changes and it influences the land, water and air or nature as a full. This work comprise the whole parts of a sewage treatment plant from screening chamber, grit chamber, skimming tank, sedimentation tank, air circulation tank, auxiliary clarifier, sewer pipe line and sludge drying beds for sewage[2].

II. METHODOLOGY

For the estimation of sewage water volume and sewage treatment plant design, the current populace of small community zone was evaluated. The populace of small community will be 15000. While figuring of sewage water generation it was expected that the normal sewage delivered by people is 1624 KLD and subsequently the all out sewage water volume created through plan populace was assessed 1.624 MLD. Following calculation refers from the design of sewage treatment plant IOSR Journal &Water treatment plant design, American Water Works Association American Society of Engineers, McGraw-Hill handbooks, 2005 [3,5].

III. OBJECTIVE

A. To design the sewage treatment units for the estimated sewage discharge.
B. To estimate the volume of sewage water generated by the society and different periods of the year.

IV. CALCULATION

A. Sewage Treatment Plant Capacity Calculation

Total sewage generated per day = Estimate population * 75 to 80% of LPCD * PF
LPCD = litre per capita (person) demand
Projected population of small town is = 15000
Water consumption = 15000*(90/100)*150
= 2025000LPCD = 2025KLD= 2.03MLD
Avg. Sewage generated = 80% of Supplied water = 0.80*2.03
= 1.624MLD = 1624KLD
Avg. Sewage per hour = 1624/2= 67.6m^3/hr
Peak factor (PF)– Ratio of maximum to average flows. It is observed to be dependent on contributory population.

Tablei
Contributory Population & Peak Factor

CONTRIBUTRY POPULATION	PEAK FACTOR
Up to 20,000	3
Above 20,000 to 50,000	2.5
Above 50,000 to 750,000	2.25
Above 750,000	2.o

Peak Factor = 3
Design flow capacity = 67.6*3
= 203m^3/hr
= 0.0563m^3/sec.

B. Design Of Screen Chamber

2 No's screen chambers/channels shall be provided as per sound engineering practice.
The flow from the inlet chamber to screen chamber shall be Q_{max} = 0.0563m^3/sec.
Assumptions
Shape of bar = MS Flats
Size = 10mm*50mm (10mm facing flow)
Clear spacing between the bars = 20mm
Inclination of bars with horizontal = 80 degree (cleaning manually)
Assuming velocity normal to screen = 0.8m/sec.
At peak flow, net inclined area required = 0.0563/0.8
= 0.070375sqm
Gross vertical area required = 0.1055625*sin80.
= 0.10395795sqm
Provide submerge depth = 0.3m
Width of channel = vertical area required / submerge depth = 0.34652m
Check velocity in duct = 0.034652/0.3*0.3
= 0.0346m/sec
Provide 20 bars of 10mm*50mm*20mm clear spacing
Screen chamber shall be 60 cm width

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C. Design of grit chamber

Flow from screen channels shall be taken into grit chamber, provided in duplicate 2 no C.I gates, one each at inlet and outlet are provided for each grit chamber.

Design Flow = (peak flow * avg. sewage generated)/ grit chamber quantity

= 2.43MLD (OR) 2430$m3$ /day

To account for turbulence and short circuiting, reduce the surface loading to about 800 $m3$ /sq. m/ day.

Area required = Design flow / Surface Loading = 3.0375sqm

Detention time= 60sec.

Volume = (2430*60) / (24*3600) = 1.687m^3

Liquid depth = $Volume / Area$ = 0.5553m.

Size of the grit chamber = 1.70 * [0.5553+0.6]

1.7 x 1.533

Diameter ← → Depth

D. Check for Horizontal Velocity

Cross sectional area of grit chamber = 1.7*0.5553 = 0.9440sqm

Velocity = 1624/ (1.7*0.5553*24*3600)

= 0.0199m/sec. = 1.991cm/sec < 18cm/sec.

Grit generation assumed = 0.05m^3 per 1000m^3 of sewage flow. Even though the grit is continuously raked, still grit storage is provided for avg. Flow.

Storage volume required = (1624*8*0.05) / (24*1000) = 0.027 m^3

Grit storage area = $(\pi/4)$*1.7 2 = 2.27 m^2

Grit storage depth = 0.027/2.27 = 0.011 m

Total liquid depth = 0.5553 + 0.008 = 0.561 = 0.6m

Provides grit chamber of size = 1.7*(0.6 + 0.6)

= 1.7m * 1.2m

Out flow from grit chamber shall be carried to the aeration tank through a 600mm wide RCC channel provided with fine bar screen (manually operated).

E. Design of Primary Sedimentation Tank

Detention time = 2hr.

Volume of sewage = max.Quantity of sewage/ (detention time * 24) = 33.8 m^3

Provide depth = 2m.

Surface area = Volume/Depth = 16.916sqm

Surface area = $(\pi/4) * d^2$ = 16.916

d = 4.640m = 5m

F. Design of Skimming Tank

Surface Area of the TankA = 6.22 *10^{-3} * q / V_r m^2

Where –q = rate of flow sewage in = 1624.8m^3/day

V_r = minimum rising velocity of the oily material to be removed in m/min

Provide the depth of the skimming tank is 0.5m

The length breadth ratio is 1.5:1

A = 6.22 *10^{-3} * 1624.8/0.5

A =20.2m^2

G. Design of aeration tank

No. of tanks = 2

Avg. Flow to each tank Q = 1.624MLD/ No. of tanks = 0.812MLD = 812m^3/day

Assuming Total BOD entering STP = 295mg/L

Assuming that negligible BOD is removed in screening and grit chamber (since it mainly removes inorganic solids).The BOD of sewage coming to aeration tank= $Y_0 = 295mg/L$

BOD Left in the effluent= Y_E= $20mg/L$

BOD removed in aeration plant = 295 – 20 = 275mg/L

Volume of aeration tank can be designed by assuming a suitable values of Mixed liquid suspended solid = XT =3000mg/L (Between 3000 – 3500mg/L)

'θc '(or F/M ratio) = 0.15 (Between 0.18 – 0.10)

F/M = Q/V = Y_0/XT

V = 665.38m^3

Aeration tank dimensions; Let us adopt an aeration tank of liquid depth (D) 3.5m, 9m width (B) then; length of the tank = V/ B * D

= 21.12m = 22m

Therefore, Volume provided= 22*9*3.5 = 693m^3

1) Check For aeration period

t = (V/Q)*24hr

t = 20.048hr = 20hrs

2) Check for volumetric loading

= Q. Y_0/V gm of BOD5/m^3 volume of tank.

= 345.65gm/m^3

= 0.345kg/m^3 (It should lie between 0.2-0.4)

3) Check for return sludge ratio (RSR)

RSR= $QR/Q = XT/$ [$10^6/SVI - XT$]

Using sludge volume index (SVI) = 100m/gm [between 50-150 m/gm]

= 0.43 [Should be between 0.5 - 1.0]

So taking SVI = 120ml/gm

$QR/R = XT/$ [10^6/120 – 3000]

= 0.56

4) Check for SRT(Solids retention time)

$V. XT = [\alpha y. (Y_0 - Y_E).\theta c]/KE.\theta c .t.1$

Where,

αy = 1.0

Ke = 0.06d^{-1}

= [1 * 812 (295−20) θC]/1+0.06 θC

=θC = 19.275days

The adopted tank size is thus ok. Hence, adopt an aeration tank having an overall 22m * 9m * (3.5+0.6)m. Overall depth, width 0.6m of free board. The outlet weir shall be adjustable type. The effluent from the aeration tank will be taken to the final clarifiers.

H. Design of flocculation (Slow Mixing)

Design parameter

Detention time = 20-30min.

Depth of the tank = 2-4m

Total area of paddles = 10 – 25% of the vertical cross section area of the tank.

Velocity of tip of blades V = 0.3 – 0.4m/sec.

Velocity of water at tip of blades V = 25% of above V_{in} m/sec.

Rotational sped of impeller = greater than 100RPM

Velocity gradient * time = 2 to 6*10^4 for alum coagulant

Peripheral speed of paddle = 0.2 to 0.6m/sec.
Inlet flow = 67.6 m^3/hr (67.6/60 = 1.126m^3/min.)
Volume of flocculator = detention time * inlet flow
Volume of flocculator = (30min.*1.126m^3/min.)
= 33.78 ~ 34m^3
And water depth (D_h) = 2.0 to 2.5m
Area of flocculator = volume/ depth ⇨ 34/2.5m
= 13.6m
Dia. of flocculator = $\sqrt{4/\pi.\text{Area}}$
= 4.159m

1) Power required for agitator or mixing unit

Power spent = μ * G * volume of tank
= 36watt
Velocity of water tip of blades = 0.25*0.3
= 0.075m/s
Area of blades A_p of impeller = ½(C_d * density * A_p* (v-v)^3
36 = ½[1.8 * 997 * A_p * (0.3-0.075)^3]
A_p= 3.5m^2
Ratio of area paddles to cross section area of flocculation.
= $A_p/\pi D_h$
= 3.5/π * 3.6 * 2.5 0.123
= 12.3%
This is acceptable as it is within the limits of 10-25%.

I. Design of flash mixer (Rapid Mixing)

Parameter
Detention time = 20-60sec.
Ratio of tank height to dia. = 1 to 3:1
Ratio of impeller to tank diameter ($r_{n)}$ = 0.2 to 0.4:1
Rotation speed of impeller = 100RPM
Velocity gradient, G = greater than 300persec.
Inlet flow = 67.6m^3/hr = (67.6/3600 = 0.018 m^3/sec.)
Volume of flash mixer = detention time * inlet flow
Volume of flash mixer tank = 30 sec * 0.018m^3/sec.= 0.54m^3
If ratio of tank height to dia. = 1.5:1(1.3Dis height & D is dia.)
Volume of tank = height of tank * area tank
Volume of tank = 1.5D * π/4D^2
= 0.42m^3
Diameterof the tank, D = 0.42m (provided 1m)

1) Power required for agitator or mixing unit

Power spent = μ * G * volume of tank
= 10^{-3} * 1.0087 * 600^2 * 0.42
= 152.5 watt
Power per unit flow of water = 152.5/67.6
= 2.255watt
Diameter of impeller = 0.4 * dia. of tank = 0.4 * 1 = 0.4

2) Dimension of agitator or mixing unit

Dimension of flat bed and impeller
Dia. of impeller = 0.4m
Velocity of tip of impeller, V_r = 2πr_n/60m/s

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= 2 * 3.14 * 0.2 * 120 / 60
= 2.512m/s
Area of blades $A_p$of impeller = ½(C_d * density * A_p* V_r^3)
(C_d = 1.8 drag force coefficient)
152.5 = ½ x (1.8 * 1000 * A_p* 1.256^3)
A_p= 0.025m^2
Thus provided 4 blades of size 0.1 * 0.025m
= 0.025m

J. Design of Secondary Clarifier
No. of clarifiers = 1 no.
Avg. Flow = 1624 KLD = 1624m^3/day
Recirculated flow, say 50% = 812m^3/day
Total inflow = 1624 + 812 = 2436m^3/day
Provide hydraulic detention time = 2hrs
Volume of tank = 2436*2/24 = 203m^3
Assume liquid depth = 3.5m Area = 203/3.5M = 58m^2
Surface loading rate of avg. flow = 15m^3/m^2/day
Surface area to be provided = 1624/15 = 108.26m^2 = 108.26m^2
(Provide area greater of two i.e. 108.26m^2)
Dia. of circular tank (d); = $\sqrt{108.24*4/\pi}$
= 11.74 m = 12m
Actual area provided = 85m^2
Check for weir loading;
Avg. flow = 1624m^3/day
Weir loading = 1624/(π*12)
= 43.077m^3/day/m [as it is less than 185 m3 /day/m]
Provide per day solid loading = 77
Check for solids loading:
Recirculated flow = 812m^3/day
Avg. flow = 1624m^3/day
MLSS solids inflow = 3000mg/L
Total solids inflow = (1624 + 812) * 3
= 7308kg/day Solids loading
= 7308/77
= 94.90kg/day/m^2
Provide a clarifier a 10m dia. having liquid depth as 3.5m Hopper slope shall be 1 in 12.

K. Design of Sludge Drying Beds
Sludge applied for drying beds 100kg/MLD
Sludge applied = 125kg/day
Specific gravity = 1.015
Solid contents = 1.5%
Volume of sludge = 125 1.5 % *11000*1.015 = 8.2m3/day
Considering monsoon Total no of cycle in 1yr. = 33
Period of each cycle = 365/33 = 11days.
Volume of sludge = 8.2*11 = 90.2m^3
Spreading a layer of 0.3m/cycle
Area of beds required = 90.2/0.3

A = 300.67
Provide 4 beds of 1.2m * 7m thus providing = 300.67m^2 area.

L. Design of Sewer Pipeline

A sewer consists of collection of sewage water from the source, carrying it or transporting it to the treatment plant and finally distributing the treated water among the use. Separate sewer system is used for transporting the sewage material. A Separate is facility that the Sewer System is the sewerage system in which the domestic sewage isn't carried with the storm water within the rain season. Shape of sewer design was considered.

X-Cross section area –A = $\pi/4D_2$
Wetted perimeter –P = πD
Hydraulic mean depth (HMD)R = A/P = D/4
Now pipe is running half full, thenA =$\pi D^2/8$
Diameter of sewer pipe –Q = A * V
0.812 = $\pi D^2/8*$1.8
D = 0.422m
Slope of sewer pipe –By Manning's formula –V = $1/nR^{2/3}S^{1/2}$
V = 1.8 m/s
n= 0.013
R = 0.42
$1.8 = 1/0.013(0.42)^{2/3}S^{1/2}$
$S^{1/2} = 1.8*0.013/(0.42)^{2/3}$
S = 0.00176
Slope = 1 in 556

V. CONCLUSION

This work was attempted to design sewage treatment plant with some specific information. The grit chamber, sedimentation tanks are designed and at that point the mean residence time, volume of air circulation tank, hydraulic retention time, f/m proportion, f/m ratio, return sludge stream rate, sludge production and oxygen necessity are determined, at last the theoretical aspects of grit chamber, waste sludge and biological phosphorus removal are covered. A few assumption are made during plant designing, the arguing is to diminish these assumption however many as could reasonably be expected to acquire the more exact and dependable outcomes. The sewage produce in one day is 1.624 MLD. The proposed sewerage system would serve to gather and move the sewage emerging from the small town outfall for proper treatment and removal. This would accomplish the impact of wiping out untreated or halfway treated sewage releases to small town. This speaks to the significant benefit of the project, not just in the regard of water quality improvement to the town yet in addition to the nearby condition in the local locations by wiping out undesirable, foul and conceivably outwardly terrible surface releases. The treated water are provided for crop irrigation and furthermore the rest of the sludge after treatment will be utilized as farm manure. Sewage treatment plant design is influenced by the population density, populace growth and time of broadcasting. The last objective of sewage water treatment is that the security of the environment during a way similar with general well being and financial concerns.

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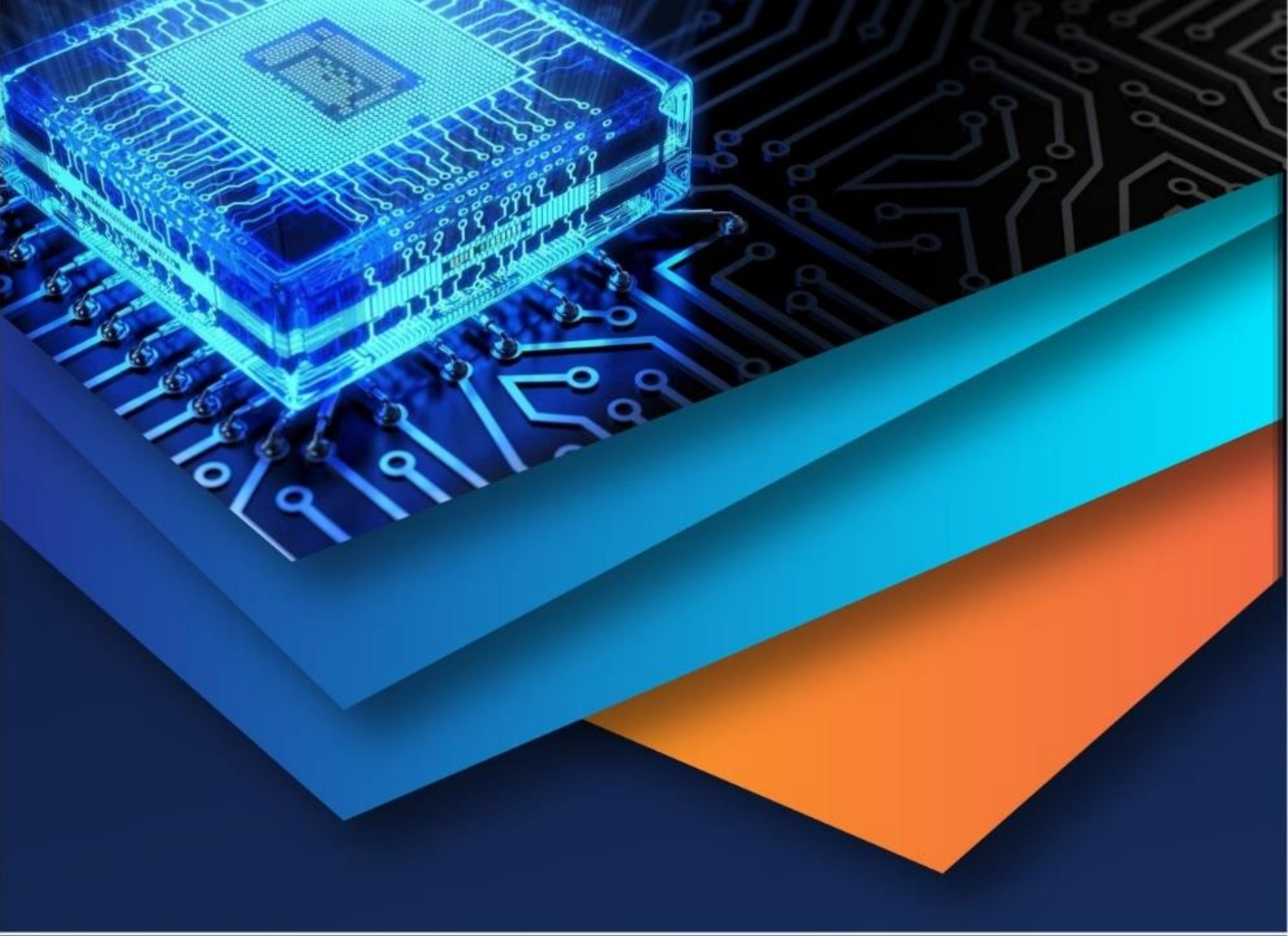

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