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Design of Sewage Treatment Plant for a Gated Community

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***Abstract*-The main objective of this study is to carry out design of a Sewage Treatment Plant for a Gated Community. The sewage released from each source (63 lots + 1 shopping mall) located in the Gated Community is grouped together and the total discharge is calculated. For the calculated discharge the Sewage Treatment Plant is designed by adopting biological treatment method. It includes physical, chemical, and biological processes to remove floating material, suspended solids and dissolved organic matter. The designs are drawn using AUTOCAD 2010 software. By this design it can be said that the minimal changes in Detention time can give better results in treating sewage designed for small scaled purposes.**

Keywords -Discharge, floating material, suspended solids, dissolved organic matter, Detention Time.

I. INTRODUCTION

A liquid waste of domestic or Industrial Origin which is “Foul” in nature and consists of 99.9% water is called sewage. A Sewage Treatment Plant treats the sewage coming from various sources and brings it to the acceptable levels of impurity and then it is disposed. Sometimes the results meet the characteristics of normal drinking water and their mineral value. The Treatment process has a series of treating units which are categorized under primary (mechanical) treatment, secondary (biological) treatment and tertiary (disinfection) treatment.

The primary treatment removes gross, suspended & floating solids from raw sewage. It includes Screening to trap solid objects and Sedimentation by gravity to remove Suspended Solids. This level is sometimes referred to as “Mechanical Treatment” although chemicals are often used to accelerate the Sedimentation process. Primary Treatment can reduce the BOD of the incoming Wastewater by 20-30% and the Total Suspended Solids by some 50-60%. Primary Treatment is usually the first stage of Wastewater Treatment.

The secondary treatment removes the dissolved organic matter that escapes Primary Treatment. This is achieved by microbes consuming the organic matter as food & converting it to Carbon Dioxide, water & energy for their own growth & reproduction. This Biological process is then followed by additional Settling tanks i.e., Secondary Sedimentation Tank, to remove more of the Suspended Solids.

The tertiary treatment is an additional treatment beyond Secondary. Tertiary Treatment can remove more than 99% of all the impurities from Sewage, producing an effluent of almost drinking water quality. .Disinfection, typically with chlorine can be the final step before discharge of effluent [1, 2].

II. TYPES OF TREATING UNIT OPERATIONS

The different types of Unit operations involved in this study are show in table 1, table 2 and table 3.

Table 1. Physical unit operations

Screen Chamber	Removal of coarse and readily settle able solids from the waste water by screens.
Grit Chamber	To separate out the grit, gravel, sand etc. from the sewage of size 2mm or large with flow velocity (0.2-0.3) m/sec.

Table 2. Chemical unit operations

Sedimentation Tank	To remove impurities by the action of the natural forces i.e., by gravitational force or with the addition of chemicals called as coagulants.

Table 3. Biological Unit Operation

Activated Sludge process	Removal of digested Organic matter in the presence of oxygen and is known as Aerobic Process.

A. Count of Treating Units

The number of treatment units used in this design in order to achieve the maximum efficiency are listed below in table 4.

Table 4. Count of treating units.

Sr No.	ITEM	No. OF UNITS
1	Screen Chamber	1
2	Grit Chamber	1
3	Collection Tank	1
4	Intermediate sump	1
5	Aeration Tank	2
6	Chlorine contact Tank	1
7	Intermediate Sump	2

B. Basic Data

The basic data considered for designing the sewage treatment plant is wastewater quantity which has a Design flow rate inm^3 /day and the characteristics of the raw sewage considered for designing the STP are as given below in table 5.

Table 5.Characteristics of raw sewage

Sr. No.	**Parameter**	**Concentration**
1	pH	6.5-8.5
2	TSS	150-200
3	BOD (5 day at 20 ^{0}C)	250 – 300
4	COD	400-450

*All parameters except pH expressed as mg/l

The expected characteristics of the treated wastewater on adopting the scheme of treatment given under item 1.1 are as given below in table 6 [3].

Table 6. Characteristics of treated wastewater

Sr.No.	**Parameter**	**Concentration**	
1	pH	6.5-8.0	6.5 - 8.0
2	TSS	$\leq$ 80	$\leq$ 10
3	BOD(3 days at 27^0 C)	$\leq$ 30	$\leq$ 15
4	COD	$\leq$ 175	$\leq$ 150

*All parameters except pH expressed as mg/ltr

C. Calculations

The Gated community consists of 63 lots and 1 groceries shopping mall. A rough estimation of 5 persons per lot and 6 persons operating the shopping mall is made. If the gated community is GHMC (Greater Hyderabad Municipal Corporation) approved then it receives 162 lpcd [4, 5].

Total Population: (63x5) + (1x6) = 321 (approximately 330)

Total Water Demand: (162 lpcd) x (330)

= 52002 l/day

= 52 cumecs

From the calculated Water Demand, only (75-80)% gets converted into sewage.

Total Sewage Discharge (Q):80% of 52 cumecs

Therefore, (Q) = 41.6 cumecs

III. DESIGN OF SEWAGE TREATMENT PLANT

The design of Sewage Treatment Plant is categorized into three (3) Stages:

A. DESIGN I (Primary Treatment Units)

The series of treating units in the Primary Treatment are screen chamber, grit chamber and Primary Sedimentation Tank. From the calculated discharge volumes of each treating unit is found by the help of Detention time. General detention times of Treating Units are shown in table 7.

Table 7. Detention times of treating units

Sr. No.	**Treating Tank**	**Detention Time**
1	Grit Chamber	<1 min
2	Primary Sedimentation Tank	2-4 hrs
3	Aeration Tank	4-8 hrs
4	Secondary Sedimentation Tank	2-4 hrs
5	Chlorine Tank	10-20 mins

For better results, detention time is multiplied by 2.5 and the volumes are manipulated. The formula used for calculation**:** D = (V/Q)

Where, D = Detention Time; V = Volume; Q = Discharge

After manipulations the cross sectional dimensions of different treating units are given in AUTOCAD drawings.

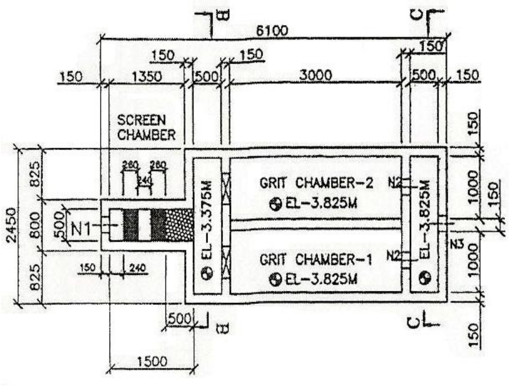

Figure 1. Top view of screen chamber and Grit chamber (all dimensions are in mm)

The top view of Screen chamber & Grit Chamber is shown in figure 1. The sewage is initially passed through the Screen Chamber which consists of two Screens, fine screen and the coarse screen. The effluent of Screen chamber enters into the Grit chamber which has a detention time generally less than 1 min. But, as the design of sewage treatment plant is for a gated community with very less sewage discharge the detention time is multiplied by multiplication factor 2.5 for getting optimum dimensions of grit chamber. However the detention time of screen chamber is negligible. The design of screen chamber is done by taking the standard dimensions of screen bars (MS flats 25 X 3 mm). Spacing of 3mm is adopted between two adjacent bars. The angle to which the screen bars are inclines is 45^0.The side view of screen and grit chamber is shown in figure 2

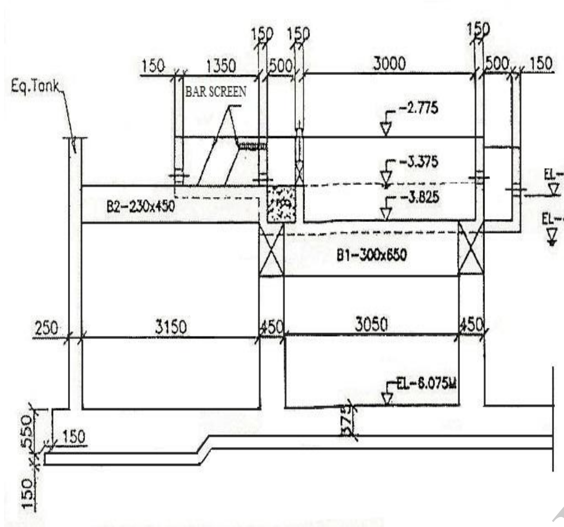

Figure 2.The side view of the Screen & Grit Chamber

The effluent from Grit Chambers enters into Primary sedimentation tank with Detention time of 2-4 hrs. Here, the efficiency in removal of settle able impurities is 60-65%.

B. Design II (Secondary Treatment Unit)

The secondary treatment unit is the biological activity that takes place in order to reduce the digested organic matter. The methodology adopted for this treatment plant is "Activated Sludge Process". The Activated Sludge Process consists of Aeration Rank (Aerobic), Secondary Sedimentation Tank and Sludge Digester (Anaerobic) [6].

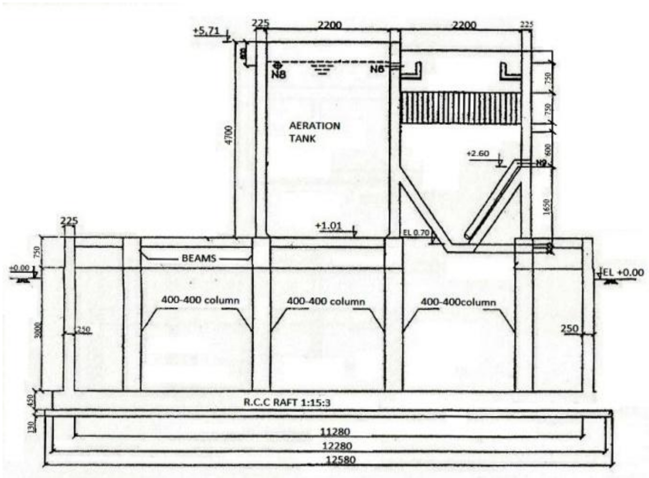

Figure 3: The dimensions of Aeration Tank

The detention time of aeration tank is 4-8 hrs. This is an aerobic process as we supply oxygen which serves as energy for the growth of microbe's reproduction. After the aeration process the effluent of Aeration tank enters into Secondary Sedimentation tank which fallows the same principle of settlement by natural forces. The efficiency is calculated and found to be 85%. The effluent of Secondary Sedimentation Tank then enters the Sludge Digester which takes place in the absence of oxygen and known to be as anaerobic process. Adopted Parameters are F/M Ratio: 0.4-0.3, Sludge Age: 5 to 15 days and efficiency: 85-95 %.

For proper seeding and start-up of aerobic treatment process fresh cow dung up to 10% of volume of aeration tank is mixed with 80% fresh water and the balance 10% volume of aeration tank is filled with clarified wastewater. The contents are aerated for 20hrs. After that continues aeration for 20hrs it is stopped for 3hrs and the mixture is allowed to settle and decant 10% of supernatant. About 10% of volume of aeration tank id made up and filled with fresh clarified wastewater. The process of aeration is repeated for 20 hrs and again kept idle for 3 hrs after continues process of aeration. This method is repeated till a constant percent of reduction in BOD is noticed. On reaching 80% BOD removal, the wastewater flow into aeration tank is increased by 20% of volume of tank. Process of aeration is repeated and again at the stage of removal of 80% of BOD 40% by volume of tank is filled with wastewater. This process is repeated continuously and after the wastewater increased by 60% of volume of tank over flow from aeration tank is allowed from which the effluent enters in to the Secondary clarifier.

The entire sludge collected in the secondary clarifier should be recycled to aeration tank and this is a cyclic process till the desired concentration of MLSS is build up in the aeration tank. When MLSS concentration in aeration tank reaches the desired value, full load of wastewater is fed to the aeration tank.

C.Design III: Tertiary Treatment Unit

As the study is related to Gated community we can either adopt the process of Chlorination or UV rays for disinfection. As Ultraviolet rays method is very costly and chlorination being well known disinfection treatment method which gives good results instantaneously and also provides residual effect for future contamination, chlorination is preferred over Ultraviolet rays method. The chlorine dosage is generally kept between 1-2 ppm with a contact time of about (10-20) min. The efficiency is about 99.9%.

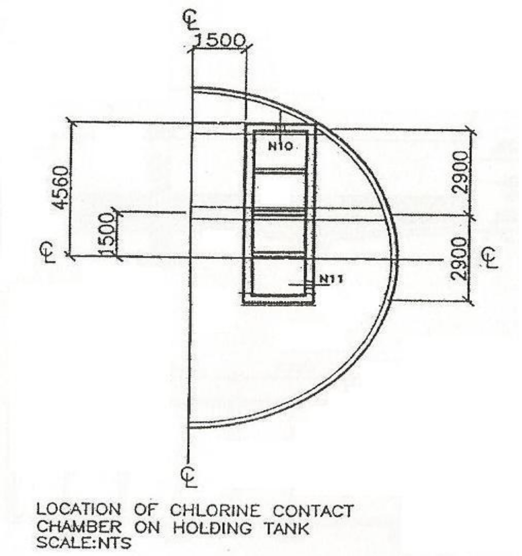

Figure 4: chlorine tank

IV. DETAILS OF OTHER WORKS

The various units mainly include mechanical works in sewage treatment plant. Details of Mechanical works are shown in Table 8

Table 8. Details of Mechanical works

UNIT	**No.OF UNITS**	**TYPE**	**MOC**
SCREENS	2	MS flats 25 X 3 mm	MSEP
GATES	2	Rising spindle type	MSEP
AERATION GRID FOR SUMP	1	Piping network with header and laterals	PVC
PUMPS	2	HEAD: (10-25) m	PVC
BLOWERS	2	Twin lobe rotary type.	MOC
FEED PUMPS	2	Head: (35 -100) m	PVC

*MOC: Material of Choice

V. REMOVAL EFFICIENCY DATA

The removal efficiency of SS, BOD, COD, pH after each treatment are shown in table 9

Table 9. Removal efficiency data

Item	After Primary	After Secondary	After Tertiary
SS	70%	80%	95%
BOD	15%	90%	95%
COD	20%	61%	95%
pH	6.5-8%	6.5-8	95%

VI. SCHEDULE OF PARAMETERS TO BE TESTED

It is necessary to have the observation reports of parameters like Flow, pH, SS, COD, BOD for the efficient functioning of a treatment plant. The details of the parameters to be tested are given in Table 10.

Table 10. Details of the Parameters to be tested.

S.No	PARAMETERS TO BE TESTED	FREQUENCY OF TESTING
1	Flow	Hourly
2	pH	Hourly
3	SS	3 Hours
4	COD	Twice a Day
5	BOD	Once a week

VII. CONCLUSION

The Removal Efficiency data from Table (9) satisfies the efficiency required by each treating unit in order to treat the Sewage coming from sources in Gated Community and meet the acceptable quality of Sewage for the disposal after treating. By increasing the detention time of sewage in each treating unit increases the efficiency of removal of unwanted impurities and this type of design suits well for small scaled purposes like Gated community, Educational Institutions, Hospitals etc.

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REFERENCES

[1] B.C.Punmia, Arun Kumar Jain & Ashok Kumar Jain, *Environmental Engineering Volume-II (Wastewater)*,Laxmi Publications Pvt Ltd, 1998 edition, pp 256-259.
[2] G.S.Birdie&J.S.Birdie, *Water Supply and Sanitary Engineering*, Jain book depot, *9th*edition.
[3] Metcalf & Eddy, *Wastewater Engineering* Fourth Edition, McGraw Hill Inc., 1972.
[4] Ashton, John; Ubido, Janet *The Healthy City and the Ecological Idea* Journal of the Society for the Social History of Medicine, pp 173–181, 2013.
[5] David Hill, *Sewage Plant Undergoes Dramatic Society of Transformation*, Journal byAmerican Society of Civil Engineers, *2013.*
[6] Tilley, David F. (2011), *Aerobic Wastewater Treatment Processes*; IWA Publications, 2013.