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Design of Primary Sewage Treatment Plant

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Abstract

A study was conducted for the primary treatment and management of sewage generated in residential area and a sewage treatment plant was designed. The total sewage generated in one day was estimated by considering the projected population for the next 30 years. The various components of primary sewage treatment plant viz. screening chamber, grit chamber, skimming tank, sedimentation tank, active sludge tank and sludge drying bed were designed considering the various standards and permissible limits of treated sewage water. It was concluded from the study that in next 30 years of the sewage estimated by considering population. The receiving chamber and the coarse screen and Grit chamber and Primary sedimentation tank and trickling filter and the aeration tank and sludge dry bed will be designed effectively to treat the sewage water at primary stage keeping the sewage quality within the permissible limits. Generally, sewage create nuisance in atmosphere so that treatment plant was designed. The main concept of sewage treatment plant is to reduce the strength of sewage by decreasing the oxygen content before going to disposal of waste. It was recommended that the treated water will be supplied for irrigating the crops on Research Farm and the remaining sludge after treatment will be used as manure on Farm. The use of treated water will reduce the ground water use and additionally the treated sludge will be very useful for increasing the fertility of soil.

Keywords: *Sewage treatment plant, Laboratory Equipment's, Treatment Plant*

INTRODUCTION

More than two billion people worldwide lives in regions facing water scarcity. Water scarcity already affects every continent and more than 40 percent of the people on our planet. By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be living under water stressed conditions. Global water use has been growing at more than twice the rate of population growth in the last century. About 1.1 billion people do not have access to adequate water to meet their most basic needs. Around 1.2 billion people, or almost one-fifth of the world population, live in areas of physical water scarcity, and 500 million people are approaching this situation (FAO,2003). Agriculture is the number-one user of water worldwide, accounting for about 69% of all freshwater withdrawn from lakes, rivers and aquifers. The daily drinking water requirement per person is 2-4 litres, but it takes 2000 to 5000 litres of water to produce one-person daily food.

India demand for water is growing at an alarming rate. India is surrounded by water bodies on the three sides, yet we face water shortage every year. The per capita water availability in India was 3450cu.m in 1951. By 2025 the annual per capita availability of water is expected to rise drastically from the current 1800cu.m per person to 1200 – 1500 cum

Sewage

Sewage is a dilute mixture of the various types of wastes from the residential, public and industrial places. The sewage pollutant causes undesirable changes and it affects the land, water and air or the environment as a whole. In the modern living the heavy industrialization and increase of population increased the rate of water pollution. Therefore, the need of water pollution control has drawn the attention of the concerned department. The characteristics and composition of sewage mainly depend on this source. The main Source of water pollution is industrial wastes coming from the industrial area and big industries contain grease, oil, chemical, highly odorous substances, explosives, etc. The main industries which contribute to the Indian rivers pollution are oil and soap, pulp-paper, sugar and distilleries, chemical, textile, steel mills, pharmaceuticals, tanneries, oil refineries and various other miscellaneous industries. The other source is domestic sewage which also contains oils, human excreta, decomposed kitchen wastes, soapy water etc.

OBJECTIVES OF THE STUDY

1. To estimate the volume of sewage water generated during the different periods from catchment areas of the city.
2. To estimate the volume of sewage water to be generated during the next 30 years from catchment areas of the city.
3. To design the primary sewage treatment units for the estimated sewage discharge.

LAYOUT OF TREATMENT PLANT

The following point should be kept in mind while giving layout of any sewage treatment plant:

- All the plant should be located in the order of sequence, so that sewage from one process should directly go to other process.
- If possible, all the plant should be located at such elevation that sewage can flow from one plant into next under its force of gravity only.
- All the treatment units should be arranged in such a way that minimum area is required it will also ensure economy in its cost.
- Sufficient area should be occupied for future extension.
- Staff quarter and office also should be provided near the treatment plant, so that operators can watch the plant easily.
- The site of treatment plant should be very neat and give very good appearance.
- Bypass and overflow weir should be provided to cut out of operation any unit when required.

Design considerations

Following points are considered during the design of sewage treatment unit:

The design period should be taken between 25 to 30 years.

- The design should not be done on the hourly sewage flow basis, but the average domestic flow basis.
- Instead of providing one big unit for each treatment more than two numbers small units should provided, which will provide in operation as well as no stoppage during maintenance and repair of the plant.
- Overflow weirs and the bypasses should be provided to cut the particular operation if desired.
- Self cleaning velocity should develop at every place and stage.
- The design of the treatment units should be economical; easy in maintenance should offer flexibility in operation.

RESULTS AND DISCUSSIONS

This chapter deals with the various results on design of primary sewage treatment plant for catchment area of the city in Hyderabad. The detail descriptions of the results are given as under.

Table 1: Details of the design parameters of the primary sewage treatment plant

S. NO.	Design parameter	Value
1	Design during period	30 years
2	Estimated population by the year 2042	23000 adults
3	Average flow	30MLD
4	Average flow velocity	0.347cum/sec
5	peak flow	0.781 cum/sec
6	Dimension of receiving chamber	Length=12m
		Width=3.6m
8	Dimension of Corse screen	Length=8.2m
		Width=0.9m
		Depth=0.6m
9	Dimension of inlet chamber	Length=3.1m
		Width=2.4
10	Dimension of aeration tank	Length=117m
		Width=70m
		Depth=3.8m
11	Dimension of sludge drying beds	Length= 23.3m
		Width=13.7m
		Depth= 0.6m

Receiving Chamber

Table 2: Details of receiving chamber for primary sewage treatment plant

S. NO.	Design parameter	Value
1	Average flow in receiving chamber	0.347cum/sec
2	Detention time	120sec
3	Required volume of receiving chamber	30.24
4	Surface area of the receiving chamber	2.52m2
5	Depth of receiving chamber	0.7m
6	Length of receiving chamber	12m
7	Width of receiving chamber	3.6m

For the design of receiving chamber of the primary sewage treatment plant the influent volume has been estimated as 0.347cum/sec with an assumed detention period of 2min and 0.7m depth. The planned cross-section of the designed chamber is given in figure. The detention period for receiving chamber was calculated 120 seconds.

The volume of sewage water required at receiving chamber was estimated 30.24cum. The ratio of depth and width is taken as 0.7 : 3.6 The design dimensions of receiving chamber to carry the required volume was calculated width of the chamber is 3.6m, length of the chamber 12 m and the depth was 0.7m with total cross-section area of 2.52m2 . A free board of 0.3 m was provided for the safety purpose to avoid the overflow.

Coarse Screen

For the designing of Coarse Screen, no. of opening of coarse screen was estimated as the formula given and accordingly the width and depth of channel to carry the sewage discharge paring through the design coarse screen was estimated 0.9m and 0.6 m respectively,0.3 m free board was proceeded for safety factor. The coarse screen is made of steel bares at 60 inclinations to horizontal with 20mm opening between the bars. The steel bares size 20mm x 10 mm was recommended for the coarse screen. The maximum allowable velocity was considered 0.2-0.3 m/sec for the average sewage flow through the coarse screen. The detailed result is and the head losses occurring due to the coarse screen and sewage movement through the channel was also estimated and given in Table: 3.

Table 3: Details of coarse screen for primary sewage treatment plant

S. No.	Design parameter	Value
1	Peak flow through coarse screen	0.781cum/sec
2	Velocity through the screen	0.3 m / sec
3	Clear opening area	3.905
4	Clear opening between bars	0.02 m
5	No. of clear opening in Coarse Screen	0.02m
6	Width of channel for coarse screen	0.9 m
7	Depth of channel for coarse screen	0.6m
8	Head loss through the screen	0.013m

Inlet Chamber

For the design of Grit Chamber to carry the sewage passing through the coarse screen the dimension of the grit chamber was designed as discussed and result are shown in Table 4. The specific gravity of sewage water screened through coarse screen was assumed 2.65and the detention period was considered 180sec respectively for design of grit chamber. It was also suggested that in order to maintain the grit chamber efficient, periodically two chambers should be used. The detailed result of the dimension of grit chamber and the Aerated volume of inlet chamber was also estimated and given in Table 4.

Aeration Tank

For the designing of Aeration tank, the estimation of efficiency in the activated plant, dimension of the tank, volume of aeration tank, BOD of inlet, BOD of outlet was designed and the result are shown in Table 5. The F/M ratio was assumed as 0.4. The liquid depth of the tank as 0.6 m and the width to depth ratio was assumed as 70:3.8 and the capacity of pump 20HP. The detention time is 24 hours and sludge formation is 0.3m.

Table 4: Detail of inlet chamber for primary sewage treatment plant

S. No.	Design parameter	Value
1	Peak flow of sewage in grit chamber	0.781cum /sec
2	Detention period	180 sec.
3	Aerated volume of one grit chamber	70.29
4	Depth of grit chamber	0.4 m
5	Width of grit chamber	2.4 m
6	Length of grit chamber	3.1 m

Table 5: Details of aeration tank for primary sewage treatment plant

S. No.	Design parameter	Value
1	Average volume flow in aeration tank	31122cum
2	BOD in inlet (Y0)	215.56mg/l
3	BOD at outlet (YE)	6mg / l
4	BOD removed in activated plant	209.56 mg / l
5	F/M ratio	0.4
6	Required Volume of the tank	31122cum
7	Depth of aeration tank	3.8 m
8	Length of aeration tank	117 m
9	Width of aeration tank	70 m

Sludge Drying Beds

For the designing of the Sludge Drying Bed, estimation of volume of sludge, no of cycle per year and dimension of beds was designed and the result are shown in Table 6. The number of dry have been taken as 12. The solid content present in the sludge was assumed as 2% and the drying period of the sludge was assumed to be done in 7days and each cum 500kgs.

Table 6: Details of sludge drying bed for primary sewage treatment plant

S. NO.	Design parameter	Value
1	Sludge applied to the dry bed	12.56 kg /day
2	Specific gravity	2.65
3	Volume of dry sludge	6280kg/day
4	Number of cycles in one year	46
5	Drying Period of each cycle	7day
6	Area of bed required	492.6
7	No. of dry bed	12
8	Area of each bed	100
9	Depth of Spreading layer per cycle	0.6 m
10	Length of dry bed	23.3m
11	Width of dry bed	13.7m
12	Sludge applied to wet bed	122cum/day

LABORATORY REPORTS

P^H^

Acids ($PH < 7$)

- Bases (PH>7)
- Neutral (PH=7)

Acids: Two types of acids they are following types

Strong acid:

Ex: HNO_3, HCL etc.

HCL $\rightarrow H^{+} + CL^{-}$

Weak acid:

Ex: Acetic acid (CH_3COOH)

$CH_3COOH \rightarrow CH3COO^{-} + H^{+}$

Bases: Two types of bases they are following types

Strong bases:

Ex: NaOH

NaOH$\rightarrow Na^{+} + OH^{-}$

Weak bases:

Ex: NH_4OH

NH

$_4$OH $\rightarrow NH4^{+} + OH^{-}$

Inlet = 7.1mg/litre

Outlet = 7.7mg/litre

Mineral water = 7mg/litre

Bore water = 6.5mg/litre

Manjira water = 7mg/litre

Figure 14: P^H meter

DO (Dissolved oxygen)

Inlet = 0.38mg/litre

Outlet = 2.91mg/litre

Mineral water = 5.33mg/litre

Bore water = 2.86mg/litre

Manjeera water = 4.55mg/litre

Figure 15: DO meter

BOD (Biochemical oxygen demand)

Inlet BOD:

Initial DO = 4.10 mg/litre

Final DO = 0.5mg/litre

BOD = (4.10 – 0.5)/0.0167

= 215.56 mg/litre

Outlet BOD:

Initial DO = 4.11 mg/litre

Final DO = 3.11mg/litre

BOD = (4.11– 3.11)/0.167

= 6mg/litre

COD (Chemical oxygen demand)

COD is defined as the mg of oxygen consumed per litre.

- First take 10ml vials (3 numbers)
- Two reagents

(1) Acid reagents:

Contents: H_2SO_4, $AgSO_4$ etc.

(2) Digestion solution:

Contents: H_2SO_4, HgSO4, $K_2Cr_2O_7$ and H_2O

Figure16: Spectro Photometer

TSS (Total suspended solids)

Spectro photo meter is used.

Range: 25-750mg/litre

Inlet = 383mg/litre

Outlet = 90mg/litre

Mineral water = <25mg/litre

Distilled water = 14mg/litre

Manjira water = <25mg/litre

Alkalinity

Formula:

Burette reading/Taken sample ×1000

Inlet sample:

Alkalinity = 14/50 ×1000

= 280mg/litre

Outlet sample:

Alkalinity = 14.3/50 ×1000

= 286mg/litre

Distilled water:

Alkalinity =1.0/50 × 1000 = 20mg/litre

Mineral water:

Alkalinity = 1.5/50 × 1000= 30mg/litre

Temperature

Inlet =29.5

Outlet = 28.5

Mineral water = 28.3

Bore water = 29.5

Manjira water = 27.3

Sulphides

Range: 0.020-1.50mg/litre

Inlet =1.45mg/litre

Outlet = 0.15mg/litre

Distilled water = 0.12mg/litre

Sulphates:

Range: 25 –300mg/litre

Inlet =320mg/litre

Outlet = 207mg/litre

Distilled water = 0mg/litre

Figure 17: Distilled water

CONCLUSION

Sewage water treatment consists of applying technology to improve or upgrade the quality of waste water. Usually this improvement involves collecting the waste water in the central segregated location and subjecting the waste water to various treatment process. Most often, since large volume of waste water involved, treatment process carried out on a continuous flowing of waste water rather than a bath or a series of periodic treatment process.

While most wastewater treatment processing are continuous flow, certain operation such as storage of sludge, are usually handled as periodic bath operations.

The objective of sewage treatment plant is to produce a disposal effluent without causing harm to the surrounding environment and prevent pollution.

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