

# DESIGNING A CENTRALISED SEWAGE AND SULLAGE COLLECTION SYSTEM FOR VILLUPURAM MUNICIPALITY

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**ABSTRACT:** Water that has been used for domestic purpose is also called as waste water. The water when let into environment causes adverse effects on the surrounding and humans, hence to avoid the peril caused by sewage the water is treated and let into natural sources are used for industrial purpose. Treatment of water comprises of three parts 1.collection 2.Treatment 3.Disposal.The collection process is the first and the major step in the process of treatment. The population forecasting is done with proper care and the number of people residing in particular environment is calculated based on the analytical methods. After computing the total number of population next step is to calculate the total sewage quantity released by the locality under study. Based on the quantity of sewage let by a particular locality the pipelines are designed as per the norms. The stoneware pipes are generally used for the transportation of the sewage. The plant has some major parts such as primary clarifier, secondary clarifier, digestion tank, chlorine tank. Thus the construction of treatment plant is fussy process that takes a lot of time for designing and construction. The pipeline design takes the majority of time in the set up. The hereby select locality forecast the population in the locality by the through the surveying and indulge in designing the sewer network with main sewer and branch sewer. Pumping stations are set up when the requirement of lift manholes rises. Pumping main must be end point of sewer network. We are intended in designing sewer network and functional design of treatment unit.

**Keywords:** Sewage, Sullage, clarifier, Sewer network

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## I. INTRODUCTION

### GENERAL

Villupuram is a Selection grade municipality and the District headquarters for Villupuram district. The town is spread over an area of 33.13 sq.km. It is the largest urban centre in the district and is about 170 km south of Chennai. The town lies at 11°57' Northern latitude and 79°3' Eastern longitude. Villupuram is located on one of the major transportation corridors of the state i.e. between Chennai and Madurai. The Railway line from Chennai to Trichy and the

National Highway NH45 and 45A pass through this town. Villupuram is a Railway junction and a transportation nodal centre with metre gauge railway line to Pondicherry, Cuddalore and Katpadi. It is the gateway to the southern part of Tamil Nadu, and a commercial centre dealing with agriculture and food products largely meant for its hinterland.

Villupuram Municipality is the urban local body responsible for the provision, operation and maintenance, and delivery of various civic services within its administrative jurisdiction in the town. The population of the town is 140714 persons as per the 2011 Census. The total number of property assessments of the municipality is 16,878, of which 14,112 are domestic, 2763 non-domestic and 3 are Industrial. The total length of roads in the town is 183.17 km. The municipality is divided into 42 wards. The town is served by a protected water supply system designed to supply 3.25 crore liters per day from a source 12 km away in South Pennaiar River basin. This had been commissioned in 1970.

Villupuram does not have an underground sewerage system for scientific and systematic collection, transmission, treatment and disposal of sewage generated in the town. As a result, the sewage finds its way into open storm water drains and ultimately discharging into the low-lying areas, posing large-scale pollution of the surrounding environment (sub-soil water, water bodies, soil, etc.) besides creating unhygienic conditions and breeding ground for mosquitoes and flies. The sewage and sullage flows along the road margins and finds its way into almost all the water bodies located within the municipal limits. This creates a lot of nuisance and unhealthy conditions to the public. Villupuram Municipality intends to implement an underground sewerage scheme.

## **II. OBJECTIVE**

The objective of a detailed project report for the Villupuram underground sewerage scheme covers technical, environmental and social aspects. The design of proposed sewerage system including sewer lines, transmission mains, sewage treatment plant. Main objectives are;

- To study the existing drainage system of the town along with the detailed drawings available in the municipality with a view to examine the feasibility of providing underground sewerage scheme.
- To prepare detailed designs of proposed sewerage system for a design period of 35 years including sewer lines, transmission mains, sewage treatment plant.

**III. DESIGN****POPULATION DESIGN**

METHOD	YEARS			
	2021	2031	2041	2051
ARITHMETIC INCREASE METHOD	158219	175724	274712	210734
GEOMETRIC INCREASE METHOD	172262	210883	258163	316044
INCREMENTAL INCREASE METHOD	165708	198189	238161	285620
DECREASING RATE OF GROWTH METHOD	200233	274712	362878	460826

Hence the population of zone 1 and 2 were calculated based on the number of wards in each zone. The total population of zone 1 = 3, 33,408 and total population of zone 2 = 1, 27,418

**DESIGN OF SEWER PIPE LINE****DESIGN OF SEWER PIPE LINE ZONE-1****DATA:**

Total population in zone 1 = 3, 33,408

Average sewage produced =  $0.07313 \text{ m}^3/\text{sec}$

At maximum flow sewage runs 70% full dia of pipe

**CALCULATION:**

$$d/D = 0.7$$

$$0.7 = (1/2) \times \left(1 - \frac{\cos \theta}{2}\right)$$

$$1.4 = \left(1 - \frac{\cos \theta}{2}\right) \cos (\theta / 2) = -0.4$$

$$(\theta/2) = -66.42$$

$$\theta = -132.84$$

$$\theta = \frac{360}{132.84} = 227.16$$

$$A = ax \left[ \frac{\theta}{360} + \frac{\sin \theta}{2\theta} \right]$$

$$A = \frac{3.14 \times D^2}{4} \times 0.748$$

$$A = 0.578 \times D^2$$

$$r = R \times \left( 1 - \frac{360 \sin \theta}{2\pi\theta} \right)$$

$$r = \left( \frac{D}{4} \right) \times \left( 1 - \frac{360 \sin 227.16}{2 \times \pi \times 227.16} \right)$$

$$= 0.2963 \times D$$

Using

$$Q = AxV$$

$$= Ax \left( \frac{1}{n} \right) \times (r^{2/3}) \times (S^{1/2})$$

$$n = 0.013, S = 1 \text{ in } 2500, Q = 0.07313 \text{ m}^3/\text{sec}$$

$$0.07313 = 0.578 \times D^2 \times \frac{1}{0.013} \times (0.2963D)^{2/3} \times \left( \frac{1}{2500} \right)^{1/2}$$

$$0.07313 = 0.4014 \times D^{8/3}$$

$$D = \left( \frac{0.07313}{0.4014} \right)^{3/8}$$

$$= 530 \text{ mm}$$

#### CHECK FOR SELF-CLEANSING VELOCITY

$$V = \left( \frac{1}{n} \right) \times (r^{2/3}) \times (S^{1/2})$$

$$r = 0.2963 \times 0.53$$

$$= 0.15704$$

$$= \left( \frac{1}{0.013} \right) \times \left( (0.15704)^{2/3} \right) \times \left( \left( \frac{1}{2500} \right)^{1/2} \right)$$

$$= 0.448 \text{ m/sec}$$

$$0.448 \text{ m/sec} > 0.375 \text{ m/sec}$$

The dimensions of sewer pipe for zone 2 was calculated by the same method and its diameter is 385mm

## DESIGN OF TREATMENT PLANT

### SCREEN CHAMBER ZONE-1

#### DATA:

Sewage contribution	= 115 LPCD
Total ultimate population	= 333408 nos
Peak factor	= 2.25
Ultimate average flow	= 443.77 lps
Ultimate peak flow	= 998.48 lps

#### CACULATION:

a) Determination of area

$$\text{For average flow} \quad A = \frac{0.444}{0.3} = 1.48 \text{ m}^2$$

$$\text{For peak flow} \quad A = \frac{0.998}{0.75} = 1.33 \text{ m}^2$$

$$\text{Provide net submerged area} = 1.48 \text{ m}^2$$

$$\text{Provide gross submerged area} = 1.5 \text{ m}^2$$

$$\text{Area X} = 1.5 \times \sin 30 = 0.75 \text{ m}^2$$

#### CHECK FOR VELOCITY

$$V = \frac{0.998}{0.75} = 1.331 \text{ m/s} > 0.375 \text{ m/s}$$

$$\text{Provide area of } 0.75 \text{ m}^2$$

#### DIMENSIONS

Number of bars = 30

$$\text{Width} = 31 \times \frac{30}{1000} + 0.01 \times 30 = 1.23 \text{ m}$$

$$\text{Liquid depth for average flow} = \frac{0.75}{1.23} = 0.61 \text{ m}$$

Size of screen 1.23m x 1m

$$V = \frac{1}{n} X (R)^{2/3} X (S)^{1/2}$$

$$1.331 = \frac{1}{0.013} X (0.381)^{2/3} X (S)^{(1/2)}$$

$$S = 1:710$$

### HEAD LOSS

$$H_L = \beta X \left(\frac{W}{B}\right)^{4/3} X h_v \sin \emptyset$$

$$= 25.25 \text{ mm} < 150 \text{ mm}$$

Similarly, the calculation was carried out for zone 2 and the dimensions of screen chamber for zone 2 is

- Area = 0.3 m<sup>2</sup>
- Size of the screen 1.23mX0.75m
- S = 1:900

### GRIT CHAMBER

#### GRIT CHAMBER ZONE-1

##### DATA:

Average flow = 443.772 lps

Peak factor = 2.25

Ultimate average flow = 998.5 lps

$$\text{Surface loading rate} = 2.25 \text{ m}^2/100\text{m}^3/\text{hr}$$

**CALCULATION:**

Surface area

$$\frac{2.25}{100} = \frac{X}{382.5 \times 2.25}$$

$$X = 50.55\text{m}^2$$

Assume settling velocity = 0.3m/s

$$c/s \text{ area} = \frac{0.9985}{0.3} = 3.33\text{m}^2$$

Detention time = 60 sec

$$\text{Velocity} = \frac{d}{t}$$

$$\text{Length of tank} = 0.3 \times 60 = 18\text{m}$$

Surface area = length X width

$$50.55 = 18 \times W$$

$$W = 2.81\text{m}$$

$$\text{Liquid depth} = \frac{3.33}{2.81} = 1.2\text{m}$$

Cleaning period once in 3 days 60m<sup>3</sup>/million m<sup>3</sup> of waste water

$$\text{Grit accumulation} = \frac{60}{10^6} \times (998.5 \times 2.25) \times (3 \times 24)$$

$$V = 9.71\text{m}^3$$

$$\text{Depth} = 0.3 + 0.2 + 1.2 = 1.7\text{m}$$

Similarly, the calculation was carried out for zone 2 and the dimensions of grit chamber for zone 2 is

- Length = 18m
- Width = 1.1m
- Depth = 1.7m

## PRIMARY SETTLING TANK

### PRIMARY SETTLING TANK ZONE-1

#### CALCULATION:

$$\text{Quantity of sewage produced} = 38.35 \text{ MLD} = 38.35 \times 10^6 \text{ L / Day}$$

$$\text{Assume detention period} = 2 \text{ hours}$$

$$\text{Volume} = \text{Quantity of sewage produced / treated during detention period}$$

$$\begin{aligned} &= \frac{14.66 \times 10^6 \times 2}{1000 \times 24} \\ &= 3195.8 \text{ m}^3 \text{ say } 3196 \text{ m}^3 \end{aligned}$$

$$\text{Capacity of tank} = 3196 \text{ m}^3$$

#### STEP 2

$$\text{Assume surface loading rate} = 40000 \text{ l / m}^2 / \text{ day}$$

$$\text{Surface loading rate} = \frac{Q}{B \times L}$$

$$\text{Surface area} = \frac{14.66 \times 10^6}{40000}$$

$$= 958.75 \text{ m}^2 \text{ say } 959 \text{ m}^2$$

#### STEP 3

Since it is circular tank

$$\text{Surface area} = \frac{\pi d^2}{4}$$

$$\frac{\pi d^2}{4} = 959$$

$$d = 35 \text{ m}$$

$$\text{effective depth} = \frac{3196}{959}$$

$$= 3.4 \text{ m}$$

$$\text{Total depth} = \text{effective depth} + \text{free board}$$

$$= 3.4 + 0.3$$

$$= 3.7 \text{ m say } 4\text{m}$$

Dimensions of tank = 35 m diameter and 4m depth

Similarly, the calculation was carried out for zone 2 and the dimensions of primary settling tank for zone 2 is

- Capacity = 1222 m<sup>3</sup>
- Diameter = 22m
- Depth = 4m

## **ACTIVATED SLUDGE PROCESS**

### **ACTIVATED SLUDGE PROCESS ZONE-1**

#### **DATA:**

Population = 333408

Sewage contribution = 115 lpcd

Settled sewage BOD<sub>5</sub> = 200mg/l

Effluent BOD<sub>5</sub> required, S = 20mg/l

#### **CALCULATION:**

Assume any other data suitability

$$\text{Efficiency of system} = \left(\frac{200-20}{200}\right) \times 100$$

$$= 90\%$$

Volume of aeration tank

$$F/M = \left(\frac{Q \times S_0}{V \times X}\right)$$

Assume  $F/M = 0.25$

$$X = \text{MLSS} = 3000\text{mg/l}$$

$$\text{Assume } \frac{\text{MLVSS}}{\text{MLSS}} = 0.8$$

$$\text{MLVSS} = 2400\text{mg/l}$$

$$V = \frac{333408 \times 115 \times 200}{0.25 \times 2400}$$

$$= 12780.64 \text{ m}^3$$

$$\text{Hydraulic Retention Time } t = \frac{V}{Q}$$

$$= \frac{12780.64}{38341.92}$$

$$= 0.333\text{days}$$

$$= 8\text{hours}$$

Conventional ASP (4-8 Hours)

$$\text{Check for Volumetric Loading} = \frac{38341.92 \times 200}{12780.64}$$

$$= 600\text{mg/l}$$

$$= 0.6\text{Kg/m}^3/\text{d}$$

(Conventional value 0.3 to 0.7 Kg/m<sup>3</sup>/d)

### TANK DIMENSIONS:

Let the diameter of tank is 65m

$$\text{Total length of tank} = \frac{\text{Volume}}{\text{Area}}$$

$$= \frac{12780.64}{3318.31}$$

$$= 3.9\text{m say } 4\text{m}$$

Hence provide 4m depth of the tank

Similarly, the calculation was carried out for zone 2 and the dimensions of Activated Sludge Process for zone 2 is

- Volume = 4885 m<sup>3</sup>
- Diameter = 46 m
- Depth = 3m

### SECONDARY SETTLING TANK

#### SECONDARY SETTLING TANK: ZONE-1

##### DATA:

Average flow = 38350 m<sup>3</sup>/day

Surface loading rate = 20 m<sup>3</sup>/d/m<sup>2</sup>

Assume other data suitably

##### CALCULATION:

##### Step-1

$$\text{Surface area required} = \frac{Q}{\text{surface loading rate}} = \frac{38350}{20}$$

$$= 1917.5 \text{ m}^2$$

### Step-2

Adopting a solids loading of  $125\text{kg/day/m}^2$  for MLSS of  $2000 \text{ mg/l}$

$$\begin{aligned} \text{Surface area required} &= \frac{3835 \times 2000}{1000} \times \frac{1}{125} \\ &= 613.6 \text{ m}^2 \text{ say } 614 \text{ m}^2 \end{aligned}$$

The higher surface area of  $1917.5 \text{ m}^2$  is adopted

### Step-3

Adopting a circular tank

$$\text{Diameter} = \sqrt{\frac{1917.5 \times 4}{3.14}} = 49.4 \text{ m say } 50 \text{ m}$$

Similarly, the calculation was carried out for zone 2 and the dimensions of secondary settling tank for zone 2 is

- Diameter = 31m

## SLUDGE DRYING BED

### SLUDGE DRYING BED ZONE-1

#### DATA:

In order to design sludge drying beds, the quantity of excess waste sludge will be calculated by

The Volume of aeration tank is  $12780.64 \text{ m}^3$

#### CALCULATION:

Sludge age in days  $Q_c = 5 \text{ days}$

Mixed liquor suspended solid  $X_t = 2000 \text{ mg/l}$

$$Q_c = \frac{V * X_t}{Q_w * X_R}$$

$$Q_C * X_R = \frac{4885 * 2000}{5}$$

$$= \frac{5112256}{1000}$$

$$= 5112.256 \text{ Kg/day}$$

For 10 Kg/m<sup>3</sup> suspended solids concentrating in secondary sludge

$$\text{Excess secondary sludge volume} = \frac{5112.256}{10}$$

$$= 511.2256 \text{ m}^3/\text{day}$$

This secondary sludge volume of 511.2256 m<sup>3</sup>/day shall be taken to sludge drying beds along with the primary sludge

Similarly, the calculation was carried out for zone 2 and the capacity of sludge drying bed for zone 2 is

- Secondary sludge volume of 511.2256 m<sup>3</sup>/day shall be taken to sludge drying beds along with the primary sludge

#### IV. CONCLUSION

The newly added areas in villupuram municipality are highly polluted due to the absence of sewer line. These areas have low gradient level and highly congested streets. Due to this inconvenience TWAD BOARD has not laid sewer line properly in this area.

Peoples residing in this place are highly affected in both health and environment aspects because of the absence of sewer line. To overcome this problem we proposed an underground sewerage system by following steps

- Census (population and existing water resources)
- Street wise levelling
- Design of sewer line network
- To design sewage treatment plant

➤ Estimation of sewer line network and sewage treatment plant

Sewer pipe lines have been designed for a design period of 35 years, for the zones 1 & 2. Sewage treatment plant has also been designed separately and the selected objective was completed successfully.

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