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Analysis and Design of Sewage Treatment Plant: A Case Study Atnagore

G.Elangovan [1,*], V.M. Rajanandhini [2]

[1] *Assistant Professor & HOD, Department of Civil Engineering, University College of Engineering Thirukkuvalai, Nagapattinam,Pincode-610204, Tamil Nadu, India.*

[2] *Assistant Professor, Department of Civil Engineering, University College of Engineering Thirukkuvalai, Nagapattinam,Pincode-610204, Tamil Nadu, India.*

[*] *Corresponding Author E-mail: kgeln@rediffmail.com*

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ABSTRACT

The main objective of this study is to carry out to design of a sewage treatment plant for a Nagore and Nagore district, because it has been one of the developing pilgrimage places. Due to steady increase of increasing population, there will be more generation of domestic and municipal sewage. Sewage produces obnoxious smell which causes disease to all creatures. To avoid this problem, proper treatments is necessary before disposal to land by not throwing sewage directly to natural resources and reuse the treated water that ultimately reduces the overall demand of fresh water. Its objective is to produce an environmental safe fluid waste and solid waste suitable for disposal or reuse. In one day the total sewage generated was estimated 5 MLD considering the projected population of Nagore town for the next 30 years? Consequently this paper focuses on the sewage generation in the Nagore area based on the population and sewage treatment plant is designed accordingly. It is proposed to design the various components of sewage treatment plant considering the various standards and permissible limits of treated sewage water. The various components of sewage treatment plant are screening, grit chamber, primary sedimentation tank, biological reactor, secondary clarifier, activated sludge tank and drying beds.

Keywords: Design Approach, Sewage Treatment Plant,Sludge.

INTRODUCTION

Water plays an important role in the development of any activity in the world. Due to the growth of population, consumption of water resources is more and availability is less. So the demand for water is increasing. Sewage treatment is the process of removing contaminants from waste water, primarily from household sewage. Physical, chemical and biological processes are used to remove contaminants and produce treated wastewater that is safer for the environment. A by-product of sewage treatment is usually semi-solid waste or slurry called sewage sludge. The sludge has to undergo further treatment before being suitable for disposal or application to land. Sewage can be treated close to where the sewage is created, which may be called a decentralized system. The treatment process has a series of treating units which are categorized under primary treatment, secondary treatment and tertiary treatment. The primary treatment removes suspended & floating solids of 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 the first stage of sewage treatment.

The secondary treatment removes the dissolved organic matter that escapes primary treatment. Secondary treatment is typically performed by indigenous, water-borne micro-organisms in a managed habitat. It requires a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment.

Tertiary treatment is sometimes is defined as anything more than primary and secondary treatment in order to allow ejection into a highly sensitive or fragile ecosystem. Tertiary treatment can remove more than 99% of all the impurities from sewage, producing an effluent of almost drinking water quality. Treated water is sometimes disinfected chemically or physically prior to discharge into a stream, river or wetland.

2. LITERATURE REVIEW

Karrman, 2001 and Erbe et.al(2002) All things considered urban drainage system ought to be considered as a critical base in expelling both wastewater and water fromthe city that is rain water to anticipate unhygienic conditions and to maintain a strategic distance from damage and flooding.**Nuhoglu et.al(2004)** A point by point characterization of the approaching wastewater and an execution assessment was completed for the householdwastewater treatment plant of Erzincan City, Latin America.**Neethling and Gu(2006)** the procedure is more perplexing than anticipated by research center pure chemical tests, and that arrangement of and sorption to carbonates or hydroxides are vital factors. Actually, full-scale frameworks may perform superior to the 0.05 mg/L limit anticipated.**Murthy polasa et.al (2014)** reviewed about design of sewage treatment plant for gated community. In this project three types of treatment unit operations are conducted. Like physical, chemical and biological processes. By increasing the detention time of sewage in each treatment unit increases the efficiency of removal unwanted impurities. **Ramya et.al(2015)** reviewed on design of sewage treatment plant and characteristics of sewage. The growing environmental

Pollution need for decontaminating water results in the study of characterization of waste water especially domestic sewage. The waste water leads to developing and implementing new treatment techniques to control nitrogen and other priority pollutants. **Pramodsambhajipatil et.al(2016)** studied on design of sewage treatment plant for dhule city . Some treatment units are designed like screens, grit chamber, storage tank, settling tank, aeration tank and skimming tank. The effluent can also be used for artificial recharge of ground water, flushing, foam control, fire protection, lawn sprinkling. **Chakarbhushan et.al (2017)** reviewed about design of sewage treatment plant for lohegaon village, Pune. This project studied that social and environmental pollution issue due to sewage is disposed in some part of village and directly sewage drain in open land. It is used for recharging sub surface water level at lohegaon and used for irrigation purpose. **Aswathy et.al (2017)** studied on analysis and design of sewage treatment plant of apartment in Chennai. This project is studied that domestic and commercial waste and removes the material with possess harm from generated public. To produce an environmental sewage fluid waste stream and solid waste suitable from disposal of use.

3. STUDY AREA

Nagore is a town in the Nagapattinam district, TamilNadu, India. It is located approximately 12 km to the south of Karaikal (a province of Pondicherry) and 5 km to the north of Nagapattinam. Thiruvarur, Mayiladuthurai, Muthupet, Athirampattinam, are nearby towns.

This paper deals with design of sewage treatment plant for the population of Nagore district. The latitude of town is 108167(1040’0.120”N), longitude of Nagore is 798500(7950’60.000”E) and altitude of Nagore 1m.This is a small town along the shore of the

Bay of Bengal. The festival season in Nagore occurs during month of May. In Tamil Nadu Nagore Dhargah is not only the Islamic religious center but also common religious gathering point by which many hundreds of thousands of devotees attend to get the peerless spiritual empathy which can cause gathering to deliver more amount of SEWAGE, which could be harmful, if left untreated.

Fig 1. *Study Area of Nagore*

4. METHODOLOGY

Nagore district has been a developing place due to steady increase in population, there will be more generation of domestic and municipal sewage. So there is a basic need of construction of sewage treatment plant with a view of sufficient capacity to treat the sewage. A sewage treatment plant is quite necessary to receive the domestic and household waste and thus removing the materials which harms for public health. Its objective is to produce an environmental safe fluid waste and solid waste suitable for disposal or reuse

5. SEWAGE DISPOSAL

The disposal of treated sewage into land or water body is called as sewage disposal. This can be done by several methods,

- Dilution –disposal in water bodies.
- Treated sewage /Effluent irrigation-disposal on land.

a. Dilution

The disposal of treated sewage / effluent by discharging it into water courses such as streams, rivers or large body of water such as lake, sea is called as dilution.

b. Treated Sewage / Effluent Irrigation

When the effluent is evenly spread on the surface of land it is effluent irrigation. The water of sewage percolates on the ground and the suspended solids are partly acted upon by the bacteria and are partly oxidized by exposure to atmospheric actions of heat, light and air.

While considering the characteristics of Nagore Corporation it is preferred that *Effluent Irrigation* i.e. land disposal for the following reasons.

- Nagore Corporation is a coastal city. Nagore have a perennial river it makes possible for dilution.
- The sewage Treatment Plant is designed according to Indian Standards which produces effluent having lesser hazardous characteristics than the standards of land disposing.

It is an alternative source of water for irrigation and it contains the manure and some amount of NPK compounds.

Table 1. *Salient Details of Sewage*

Sl.No	Characteristics	Effluent from the plant	Tolerance limit as per IS:3307-1986
1	PH	5.5-9.0	5.5-9.0
2	BOD	≤20mg/l	100mg/l
3	Suspended Solids	≤30mg/l	200mg/l
4	Oil & Grease	≤10mg/l	10mg/l
5	Chlorides	≤1000mg/l	600mg/l
6	Sulphate	≤250mg/l	1000mg/l

The effluent to be disposed in Land Effluent Irrigation method and it is done by consisting Ridge and Furrow in the disposal land. Here the land is first ploughed up to 45cm, then leveled and divided into plots and sub-plots. Then each sub-plate is enclosed by small dykes. Now ridges and furrows are formed in each sub-plot. The sewage is allowed to flow in furrows, whereas crops are grown on ridges. After an interval of 8-10 days the sewage can be again applied depending on the crops requirement and the nature of the soils.

Population Forecasting

The population will have to be estimated with due regard to all the factors governing the future growth and development of the project area in the industrial, commercial, educational, social, and administrative spheres. Special factors causing sudden immigration or influx of population should also be foreseen to the extent possible.

Table 2. *Population Data*

Year	Population	Increase in Population	%Increase in population
1961	16311	-	-
1971	17946	1635	10.02%
1981	22860	4914	27.28%
1991	23870	1010	4.41%
2001	25708	1838	7.75%
2011	28380	2672	10.39%
Total		**12069**	**59.19%**

Population as calculated by geometrical increase method

Formula used:

$$P_n = P\,(1 + (G/100))$$

Where,

P- Population at present

G- Average percentage of growth of ‘n’

Decades

Average percentage=(10.02+27.28+4.41+7.75+10.39+59.19)/6=11.98%

Table 3. Expected Population Data

Year	Expected population
2021	28380+28380 x (11.98/100) = 31780
2031	31780+31780 x (11.98/100) = 35587
2041	35587+35587 x (11.98/100) = 39850
2051	39850+39850 x (11.98/100) = 44624

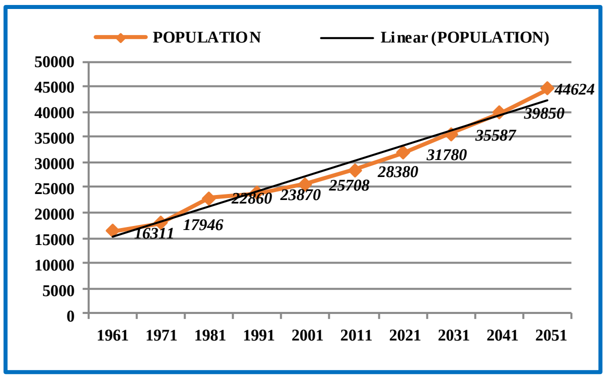


Fig2. *Graphical Representation of Population Forecast*

7. Design of Treatment Units

This paper deals with design of sewage treatment plant for the population of Nagore district.

Population as calculated by geometrical increase method : 44624

Per capita demand =135 lpcd

(Sewage generation 80% of per capita demand)

Sewage generation per capita=108 lpcd

Total sewage generation = 44624x1 =4.8 MLD

Approximately 5 MLD

Hence the design of sewage generated for knowing the quantity for the further proceedings revealed that the town of NAGORE can produce 5 Million litres per day.

Design of screen chamber:

Average flow =5MLD

Peak factor =2.25

Peak flow =0.13 m^3 /s

Screen bar size =10mm (As per NIT)

Screen opening =25mm (As per CPHEEO

Area provided =0.16m^2

Provided depth of flow =0.45m

Width of the screen channel =0.35m
No.of openings =14 Nos.
No.of bars =13 Nos.
Width ofthe screen channel=480mm
Provided width of the Screen Channel=600mm
Approach velocity in the channel for averageultimate flow=0.29m/s
Net area of flow of screen=0.216m^2
Velocity through screen at average Present flow =0.08/0.216 = 0.37m/s

HENCE OKs

Number of screen channel =1

Provided vertical depth =1.6m
Manual screen installed 60^o
With horizontal projected length=1.6cos60^o=0.8m
Platform provided =1.6m
Free board =0.3m
Tank size provided **(1 Nos of 1.6mx0.6mx0.45m)**

Design of Grit Chamber:
Peak flow sewage =0.13m^3/s
Assume average detention period=180 Seconds
Aerated volume =(0.13X180)
=23.4m^3*say***24m^3**
In order to drain the channel periodically for routine cleaning and maintenance one chamber is used.Therefore volume of one aerated chamber=23.4m^3
Assume depth of 2m &width to depth ratio ***2:1***
Width of the channel=2mX2m
Breadth =4m
Length of the channel=V/(B×D)=24/ (4X2)=3m
Increase the length by about 20% to account for inlet &outlet Provide length=3 ×1.2=3.6m
Hence the size provided is, **(3.6m ×4m ×2m)**

Design Primary Sedimentation Tank
Design flow =5MLD
Design over flow rate of primary settling lies between 35 to 50 m^3/m^2/day *(As per CPHEEO)*
Design of over flow rate =43m^3/m^2/day
Consider clarifier depth=4.40m
Area required = 5000/43=116.27m^2say 117m^2
Volume of clarifier=117×4.40=515m^3
Hydraulic retention time (HRT)=2.5 hr
Diameter=12.5m
Providedtank size**(12.5m diaX4.40m)**

Aeration Tank

Aeration tank is the mixing and diffusing structure in the activated sludge plant. These are rectangular in shape having the dimensions ranging 3 to 4.5 m deep, 4 to 6 m wide and 20 to 200m length. Air is introducing continuously to the tank.
No.of. aeration tank = 1
Design flow = 5MLD

Average flow of tank = 5000m^3
BOD inlet (Y_o) = 240mg/l
BOD outlet (YE) = 20mg/l
BOD removed in activated plant = (YO-YE)
= (240-20)
= 220mg/l
Percent of BOD removed in activate Plant = (220/240) × 100 = 91.7%
(Since the adopt extended aeration process can be removed 85-92%)
Hence it is ok.
MLSS (Xt) = 2400mg/l
F/M ratio = 0.4
Volume of the tank = (Q/F/M)×(YO/XT) = 1145m^3
(The liquid depth of the tank as 3m and width to depth ratio as 2m)
Width of the tank = 3×2
B = 6m
Length of the tank = V/ (B×D)= 1145/ (6×3) = 63.61m (Approximately 64m)
Volume provided = 64 ×6×3 = 1152m^3

Check for aeration period / HRT:
Hydraulics retention time (HRT) required
Formulae used = (V×24)/Q
= (1152X24)/5000 = 5.52hrs
Since it's lies between 3 to 6 hours (As per CPHEEO)
It is hence ok.
Check for volumetric loading:
Formulae used = Q×(YO/V)
= 5000×(240/1152) = 1042g/m^3 = 1.042kg/m^3
Since between 1.0 to 1.2kg/m3
(As per CPHEEEO)
Hence it is ok.

Check to SRT (ϴc):
Formulae used = Ay×Q×(YO- YE)×ϴc+(KE×ϴc)
Where,
KE = 0.06 Constant for municipal sewage
ϴc = Solids Retention time(SRT)
YO = 240mg/l
YE = 20mg/l
V = 1152m3
Xt = 2400mg/l
Q = 5000m3
Ay = 0.5 Constant
1152×2400 = 0.5× (5000× (240-20) ×ϴc+ (0.06×ϴc)
ϴc = 5.96days
Its lies between 5 to 8 days
(As per CPHEEO) The design is ok.
Aeration tank size provided 64m (L) ×6m (B) ×3m (D)
Design Of Secondary Clarifier
Design flow=5MLD
Over flow rate secondary settling=15to25 m^3/m^2/day(As per CPHEEO)
Design of over flow rate =20m^3/m^2/day

Area required =5000/20=250m^2
Check overflow rate @ peak Flow=20×2.25=45m^3/m^2/day
Solids loading rate=70 to 140kg/m^2/day(As per CPHEEO Table 12.1)
Solid loading rate for calculated Area=250/45=5.55kg/m^2/day
Consider clarified depth=3.85m
Volume of clarifier=962.5m^3
Diameter provided, $A=(\pi/4)\times d^2$

$250=(\pi/4)\times d^2$

D =17.90m *say* 18m

Hence the **secondary** clarifier tank size is**18m (dia) ×3.85(SWD)**

8. RESULT AND DISCUSSION

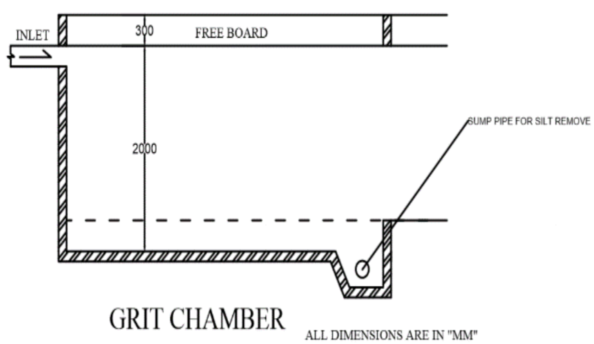
This deals with the Analysis and Design of sewage treatment plant for the population of Nagore. The Nagore district is located at (1040’0.120”N), latitude and (7950’60.000”E) longitude. The location of sewage treatment plant should be nearer to the point where sewage is disposed finally.

The designed considerations and parameters for the sewage treatment plant are given below:

- The design period should be 30 years
- Estimated population by the year 2051 is 44624 numbers

a) ***Screens***: generally the standard parameters of screens are width should be in between 6mm to 20mm, depth should be in between 30mm to 80mm, dia of bars should be in between 6mm to 12mm and the spacing between the bars should be in between 6mm to 40mm. After designing the screens obtained values are width is 0.6m, depth is 0.4m, dia of bars is 6mm, and spacing of bars is 36mm.

Grit Chamber: generally the standard parameters of grit chamber are length should be in between 7.5m to 20m, width should be in between 1m to 7m, depth should be in between 1m to 5m.



(C)Primary Sedimentation Tank: generally the standard parameters of sedimentation tank are length should be maximum up to 90m, width should be maximum 30m, depth should be minimum 2m, and free board should be 0.6(max). After designing the sedimentation tank obtained values 12.5m dia x 4.40m

(D) Aeration Tank: generally the standard parameters of aeration tank are length should be in between 30m to 100m, width should be in between 5m to 10m, and depth should be in between 3m to 4.5m. After designing the aeration tank obtained values are length is 64m, width is 6m, and depth is 3m.

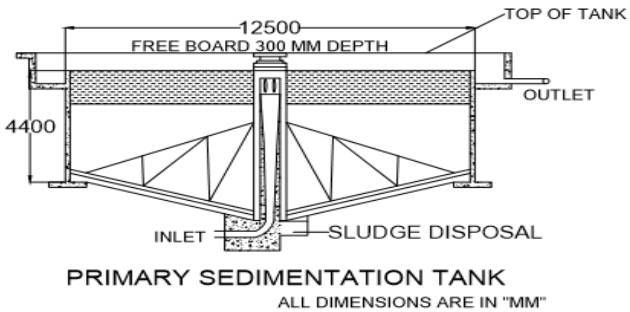


Fig 4. *Primary sedimentation tank*

Conclusion

Since there is no proper treatment plant for sewage in Nagore Municipal Corporation, it is necessary to construct a Sewage Treatment plant. The plant is designed perfectly to meet the future expansion for the next 30 years (upto the year 2051) in accordance with Indian Codal provisions. The plant is designed perfectly to meet the needs and demands of appropriate *44624* population with a very large time period.

The treated sewage water is further used for the irrigation, fire protection, and toilet flushing in public, commercial and industrial buildings and if it is sufficiently clean, it can be used for ground water recharge.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.

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