Design of Primary Sewage Treatment Plant for Cherpulassery Municipality

Sunaina K[1], Lubna C.H[2]

[1]*PG student, Dept of Civil Engineering, Malabar College of Engineering & Technology, Kerala, India*
[2]*Asst Professor, Dept of Civil Engineering, Malabar College of Engineering & Technology, Kerala, India*

Abstract - *Sewage is a major carrier of disease and toxins. The safe treatment of sewage is thus crucial to the health of any community. This project focuses on the primary treatment and management of sewage generated in cherpulassery municipality area and a sewage treatment plant was designed. A sewage treatment plant is quite necessary to receive the domestic and commercial waste and removes the materials which pose harm to the general public. Its objective is to produce an environmentally safe fluid waste stream (or treated effluent) and solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer). Cherpulassery Panchayath has been upgraded with Municipality status. The steady incremental increase in the city population results in an increase in domestic sewage generation. But still, now there is no treatment plant. So it is required to construct a Sewage Treatment Plant with sufficient capacity to treat the increased sewage. The mini-project deals with the design of the primary Sewage Treatment stage and its major components such as screening chamber, grit chamber, skimming tank & sedimentation tank. The project covers 2.5 km^2, 33 wards Cherpulassery Municipality for the next 30 years, and its increased population.*

Key Words: Pollution, Waste-water, Sewage, Population forecasting, Preliminary treatment, Primary Treatment

1. INTRODUCTION

Pollution in its broadest sense includes all changes that curtail natural utility and exert deleterious effects on life. The crisis triggered by the rapidly growing population and industrialization with the resultant degradation of the environment causes a grave threat to the quality of life. Degradation of water quality is the unfavorable alteration of the physical, chemical and biological properties of water that prevents domestic, commercial, industrial, agricultural, recreational and other beneficial uses of water. Sewage and sewage effluents are the major sources of water pollution. Sewage is mainly composed of human fecal material, domestic wastes including wash-water and industrial wastes. The growing environmental pollution needs for decontaminating wastewater result in the study of characterization of waste water, especially domestic sewage. In the past, domestic waste water treatment was mainly confined to organic carbon removal. Recently, increasing pollution in the waste water leads to developing and implementing new treatment techniques to control nitrogen and other priority pollutants.

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 modern living the heavy industrialization and increase of population increased the rate of water pollution. Therefore, the need for 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.

1.1. Need and benefit of domestic sewage treatment

Sewage treatment, or domestic wastewater treatment, is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove all the pathogens, that it may not pollute the receiving water and make it unsafe for use, to reduce the volume of sewage sludge, so that it can be easily disposed of. The cost of reclaimed water exceeds that of potable water in many regions of the world, where a freshwater supply is plentiful. However, reclaimed water is usually sold to citizens at a cheaper rate to encourage its use. As fresh water supplies become limited from distribution costs, increased population demands, or climate change reducing sources, the cost ratios will evolve also. Using reclaimed water for non-potable uses saves potable water for drinking, since less potable water will be used for non-potable uses.

It sometimes contains higher levels of nutrients such as nitrogen, phosphorus and oxygen which may somewhat help fertilize garden and agricultural plants when used for irrigation.

1.2. Wastewater reuse in India

In India, since wastewater is mainly untreated, it is used in the agricultural sector where the risks are considerably lower to using it in households or industry. It is mainly used for irrigation of Cereals, Vegetables, Flowers, Avenue trees and parks, Fodder crops, Aquaculture and Agroforestry. Considering the above facts the present study has been planned with the following objectives.

1.3. Objective Of the project

The objective of this project can be summarized as-

- Physical, chemical, and biological characterization of wastewater.
- To estimate the volume of sewage water to be generated during the next 30 years from Cherpulassery municipality area.
- To design the primary sewage treatment units for the estimated sewage discharge.

2. METHODOLOGY

Deals with design of primary sewage treatment plant for Cherpulassery Municipality, Kerala. Cherpulassery is located at 10° 52′ 45.48″ N, 76° 18′ 53.1″ E. It has an average elevation of 66 meters (217 feet) North region of Cherpulassery municipality is Thoothapuzha (Aliparamb Panchayath, Malappuram Dst). South region includes Chalavara and Thrikkadiri GramaPanchayaths. The west region includes Nellaya GramaPanchayath and the east part is Vellinezhi GramaPanchayath. The detailed description of the study area is given below.

The Municipality has a total area of 32.68 Sq Km which is divided into 33 wards. As of the 2011 India census, Cherpulassery had a population of 39919. Cherpulassery is one of the populated regions in Palakkad district. Males constitute 48% of the population and female's 52 %.The project covers the 2.5Sq Km, 17wards of cherpulassery municipality for next 30 years and its increased population. With regard to Cherpulassery almost the entire town and environment are plain and the general slope is from north to south. The town is situated at the altitude of 10°52'44.06"Nlatitude and 76°18'40.92" E longitude. The soil of the area is gravel, rocky and a large proportion of sand and gravel. All the aspects of cherpulassery, palakkad climate and topography, its population growth rate is to be considered while designing the project.

2.1. DESIGN OF SEWAGE TREATMENT UNIT

Sewage contains various types of impurities and disease bacteria. This sewage is disposed of by dilution or on land after its collection and conveyance. If the sewage is directly disposed of, it will be acted upon the natural forces, which will convert it into harmful substances. The natural forces of purification cannot purify any amount of sewage within specified time. If the quantity of sewage is more, then receiving water will become polluted or the land will become sewage sick. Under such circumstances it becomes essential to do some treatment of the sewage, so that it can be accepted by the land or receiving water without any objection.

2.1.1. POINT CONSIDERED IN DESIGN:

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 plus the maximum industrial flow on the yearly record basis.
- Instead of providing one big unit for each treatment more than two numbers small units should be 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.

2.2. DESIGN PERIOD

A sewerage scheme involves the laying of underground sewer pipes and construction of costly treatment units, which cannot be replaced or increased in their capacities easily or conveniently at a later date. In order to avoid such complications, the future expansions of the hotel's and residential area, consequent increase in the sewage quantity should be forecasted to serve the community satisfactorily for a reasonable year. The future period for which the provision is made in designing the capacities of various components of the sewerage is known as design period. This sewage treatment plant is designed for 30 years. The treatment plant is normally designed to meet the requirement over a 30 year period after its completion. The time lag between the design and completion should not normally exceed 2-3 years. Care should be taken that the plant is not considerably under loaded in the initial stages, particularly the sedimentation tank. The ultimate design period should be 30 year to that extent sufficient accommodation should be provided for all the units necessary to cater to the needs of the ultimate population. In some cases, it may be necessary to combine a number of sewage systems with a common sewage treatment plant.

2.3. POPULATION FORECASTING

Design of water supply and sanitation scheme is based on the projected population of a particular city, estimated for the design period. In this project adopting incremental increase method and it is suitable for an average size town under normal conditions where the growth rate is found to be in increasing order.

TABLE .1. Details of Population forecast

Year	Population	Incremental	Incremental
1991	23462		
2001	30730	7268	
2011	39919	9189	1921
Average		X=8228.5	Y=1921

P_n= Po +n* X+ {n(n+1)/2}
Base period as 2020 ,
P_{2020}=39919+.9x 8228.5+{(.9x1.9/2)x1921}
P_{2020}= 48967.105
Intermediate period as 2035
P_{2035}=39919+2.4x8228.5+ {2.4(2.4+1)/2)x1921}
= 67505.08.
Ultimate design period as 2050,
P_{2050}= 39919+3.9 x 8228.5 + { 3.9(3.9+1)/2}x 1921
P_{2050}=90365.305

At design period of 30 years the forecasted population of the cherpulassery municipality is 91000

2.4. CALCULATION OF SEWAGE GENERATION

Quantity of wastewater is related to water consumption. The relationship between water demand and wastewater flow varies from city to city. Wastewater flow is usually from 50 to 100% of the water demand. Accurate wastewater determination comes from past gauging (measurements) records.

Ultimate design period = 30 years
Forecasted population at 2050 = 91000
Per Capita Water Supply = 135 lpcd
Avg. water supply per day = 91000. x 135
= 12199316.2 ≈ 12000000
= 12.2 MLD
Avg. sewage generation per day = 80% of supplied water
= 0.8 x 12.2
= 9.76 MLD
Maximum flow = 3 x 9.76 = 29.28 MLD ∼30 MLD
In cumec,
Avg. sewage generation per day = .1154cumec (1**ML/d**= 0.011574074074074 m3/s.)
Avg. discharge = .1154cumec
Max. discharge = 3 x avg

Discharge = 3 x .113 = 0.3462 cumec

2.5. DESIGN OF RECEIVING CHAMBER

Receiving chamber is the structure to receive the raw sewage collected through the underground sewage system from the city. It is a rectangular shape tank constructed at the entrance of the sewage treatment plant. The main sewer pipe is directly connected with this tank.
Design flow= 0.3462 cumec
Detention time = 60sec
Volume required = Flow x detention time
= 0.3462 x 60
=20.772m^3
Provide depth = 3m
Area of receiving chamber =v/d
Where, A = Area (m^2)
V = Volume, (m^3)
d = Depth,(m)
A =19.8/3 = 6.924 m^2
Length: breadth = 2:1
Area = L x B = 2B x B= $2B^2$
7 = 2 x B^2
B = 1.9m ∼ 2m
L = 3.8m
CHECK: Volume Designed = 3.8 x 1.9 x 3 = 21.66 m^3, Vreq = 19.8m^3
Vdes > Vreq
Receiving Chamber is designed for the size of 3.8 x 1.9 x (3 + 0.5(FB))

2.6. DESIGN OF COARSE SCREEN

The coarse screens essentially consist of steel bars or flat placed 30° to 60° inclination to the horizontal. The openings between bars are 50mm or above. These racks are placed in the screen chamber provided in the way of the sewer line. The width of the rack channel should be sufficient so that self-cleaning velocity should be available and a bypass channel should be provided to prevent the overtopping. The bypass channel is provided with a vertical bar screen. A well-drained trough is provided to store the impurities while cleaning the rack. These racks are cleaned mechanically.

Assume the velocity at average flow is not allowed to exceed 0.8 m/s
Maximum Flow = 30 MLD = 0.3462 m3 /sec
Shape of bars = M.S Bars
Size of bars =10x50mm^2 (10mm facing flow)
Clear spacing = 30mm (6-40mm for medium screens)
Velocity of flow = 0.8m/s (0.6-0.9m/s)

Hence, net submerged area of screen openings=0.3462/0.8 =0.433m^2
Gross vertical area required = 0.433sin60 =0.374m^2
Providing a depth of 0.3m
Width of channel = 0.374 /0.3 =1.25m
The velocity of flow in screen chamber = 0.3462/(0.3×1.25) =0.925m/s
which is greater than 0.42m/s (self-cleansing velocity) with spacing of 30mm or 0.03m
No. of bars required = 1.25/ (0.03+0.01) = 32bars
Actual width of screens = 32x0.04 =1.28m
Actual depth of sewage flow = 0.374/1.28 = 0.292m ∼0.3m
Providing a free board of 0.5m
Total depth of screen = 0.3+0.5 =0.8m

Hence, **size of screen = 1.3m x 0.8m**

2.7.DESIGN OF GRIT CHAMBER

To prevent scouring of already deposited particles the magnitude of 'v' should not exceed critical horizontal velocity V_C, and the above equation becomes The critical velocity, Vc,can be given by the following equation (RaoandDutta,2007):-
where, β= constant
= 0.04 for uni granular sand
= 0.06 for non-uniform sticky material
f = Darcy –Weisbach friction factor = 0.03 for gritty matter
g = Gravitational acceleration,
Gs = Specific gravity of the particle to be removed (2.65 for sand), and
d = Diameter of the particle, m
Vc = 0.228m/s (0.17 - 0.26 m/s)
The grit chambers are designed to remove the smallest particle of size 0.2 mm with specific gravity around 2.65. For these particles, using the above expression the critical velocity comes out to be Vc = 0.228 m/s
Keeping horizontal velocity 0.2m/s (<0.228m/s) to prevent scouring and detention time 60 sec (vary from 40-60s)
To lower the velocity, hydraulic structures like Sutro weir and Parshal flume should be provided.
Length of grit chamber = velocity of flow x detention time
=0.2x60
=12m
Volume of grit chamber = discharge x detention time
=0.3462 x 60
=20.772m^3
Cross-sectional area of flow = Volume/Length
= 20.772/12
=1.731m^2
Providing width of grit chamber = 3m
Depth of of grit chamber = 1.731/3
=0.58m
Now assuming grit generation = 0.05m^3 per 1000m^3 of sewage
Even though grit is continuously raked, still 8hrs grit storage is provided for avg. flow
Storage volume required =30,000x8x0.05/(24x1000)
=0.5mm^3
Thus grit storage depth = 0.5/1.731
= 0.288m ∼0.3m
Also providing free board = 0.5m
Total depth of grit chamber = 0.5+0.3+0.58
= 1.38m
~1.5m

Hence, Size of grit chamber = 12mx3mx1.5m

2.8. DESIGN OF SKIMMING TANK

Detention time = 3 to 5 minutes
Compressed air required = 300 to 6000m3 per million litres
Surface area required = A = 0.00622 (q /Vr)

Where,
q=Rate of flow of sewage in m/day
Vr = Minimum rising velocity of greasy material to be removed in m/minute
=0.25 m/minute in most cases.
A = (0.00622x 30,000)/.25
= 746.4**m^2**
Providing a square tank
Side of tank = 27m

Hence provide a **skimming tank of size =27x27m^2**

Actual area of tank = 27x 27
=729m^2

2.9. PRIMARY SEDIMENTATION TANK

Primary sedimentation tank is the settling tank constructed next to skimming tank to remove the organic solids which are too heavy to be removed i.e. the particles having lesser size of 0.2 mm and specific gravity of 2.65.

Continuous flow tank is to be provided
Detention time = 2hrs (1-2hrs)
Quantity of sewage treated in 2hrs
V = 30,000x2/24
= 2500m^3
Now, assuming that the low velocity through the tank is 0.3m/minute .
The length of the tank required = Velocity of low x Detention period
=0.3x(2x60)m.

= 36m
Cross-sectional area of the tank required = Capacity of the tank/Length of the tank
= 2500/36
= 70m^2
Assuming the water depth in the tank (ie. effective depth of tank) = 5.5m

The width of the tank required =Area of cross–section / Depth

= 70/5.5
= 13m

Since the tank is provided with mechanical cleaning arrangement, no space at bottom is required for a sludge zone.

Now, assuming free-board of 0.5 m
The overall depth of the tank = 5+0.5 = 5.5m=6 m.
Hence, a rectangular sedimentation tank with an overall size of 36 x13 x6 m^3 can be used.

3. Result

For the estimation of sewage water volume used for design of primary sewage treatment plants the present population of Cherpulassery municipality was estimated. The present population was found 49000 for estimation of the population after 30 years the future planning of cherpulassery municipality expansion plan was considered and it was assumed that by the year 2050, the population of the peoples in the cherpulassery municipality will be 91,000 .The design discharge was estimated as described in Article 3.11 and the results are given in Table.. While calculating sewage water generation it was assumed that the average sewage produced per day is 9.76 MLD and hence the Maximum flow of sewage volume generated through design population was estimated 30MLD.

TABLE 4.6. Details of the design parameters of the primary sewage treatment plant

SL NO	Design parameter	Value
1	Design period	30 years
2	Estimated population by the year 2050	91000
3	Average wastewater discharge per day	9.76MLD
4	Maximum discharge in cumec	.3462 cumec
5	Dimensions of Receiving chamber	Length - 3.8m Width – 1.9m Depth – 3m
6	Dimension of Coarse screen	Free board – 0.5 m Width - 1,28 Depth – 0.8m
7	Dimension of Grit chamber	Free board – 0.5m Length - 12m
8	Dimension of Skimming tank	Width – 3m Depth – 1.5m
9	Dimension of Primary sedimentation tank	size - 27m x 27m Length – 36m width 13m
		Depth – 6m Free board – 0.5m

4. CONCLUSIONS

A successful technical project involves integration of various fields. This is an attempt to combine several aspects of environmental, biological and chemical and civil engineering. Since, in cherpulassery municipality, there is no proper treatment plant for sewage, it is necessary to construct a Sewage Treatment Plant. The plant is designed perfectly to meet the future expansion for the next 30 years in accordance with Indian Code provisions. This project gives the design of the preliminary & primary components of a Sewage Treatment Plant from receiving chamber, screening chamber, grit chamber, skimming tank and sedimentation tank for sewage.

REFERENCES

[1] Sagar M Gawande et al ,characteristics study of wastewater in gandhiglaj, International Journal of Current Research,Vol.7, Issue, 02, Page.12408-12410M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] N. Benit et al (2015), Physicochemical properties of wastewater collected from different sewage sources ,-International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 11.page 691 - 696K. Elissa, "Title of paper if known," unpublished.

[3] Jayashree Dhote et al (2012),Review on wastewater treatment technologies,International Journal of Engineering Research & Technology, Vol. 1 Issue 5,Page 1 - 10

[4] Rajat Palya et al (2018), Design of a sewage treatment plant for a locality in bhopal to recycle the liquid waste, international journal of engineering sciences & research technology,Vol 7, page 193 - 199.

[5] A Venkatarakis P. kokkihos et al(2016),Investigate the impact on the quality of life when living close to a municipal wastewater treatment plant,Journal of environmental & public health,,Vol. 4 ,Pages 8

[6] Kamal K et al (2012), municipal wastewater treatment,International journal of current research, Vol 10

[7] A. Mohamed Mansoor et al (2018),Planning and Designing of Wastewater Treatment Plant in Kumbakonam,International Research Journal of Advanced Engineering and Science, Volume 3, Issue 1, Page 180-183

[8] Hallvard Odeggard et al (2002),Wastewater sludge as a resource: Sludge disposal strategies and corresponding treatment technologies aimed at sustainable handling of wastewater sludge,International journal of current research, Vol 46,Page 295 - 303.

[9] Garg s.K. , 1976 : environmental engineering - Khanna publisher, (2010 edition)

[10] IS: 3025 (part 10) – 1984 methods of sampling and test(physical and chemical) for water and wastewater, part 10 - turbidity.

[11] IS: 3025 (part 15) – 1984, methods of sampling and testphysical and chemical) for water and wastewater, part 15 - total residue (total solids —dissolved and suspended).

[12] IS: 3025 (part 22) – 1986, methods of sampling and test(physical and chemical) for water and wastewater, part 22 – acidity

[13] IS: 3025 (part 32) - 1988, methods of sampling and test physical and chemical) for water and wastewater, part 32 - chloride (first revision).