Analysis and Design of Sewage Treatment Plant: Imphal City Manipur

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Abstract- *A sewage treatment plant is very much important in order to receive the domestic an household waste and thus removing all the materials detrimental to public health. Its main objective is to produce environment safe fluid and solid waste that is feasible for disposal or reuse.*

The aim is to design a sewage treatment plant for Imphal city of Manipur by studying, analyzing and estimating the population data for the next twelve decade and performing of analysis and design based on this data. The location of the plant is to be established in Lamphelpat, Imphal, next to Imphal sewage treatment plant. Here detailed study has been carried out on the population growth and analysis is done for peak flow. Based on this, the primary, secondary and tertiary treatment units have been designed. The project cover the various dimensions of components in order to cover the entire population.

Since, Imphal holds a population of 3.36 million currently as per 2019 estimation and is still growing, thus this project has a scope to cater to the needs of the locality, as an urgent necessity is seen for the construction of a separate sewage treatment plant to serve various environment issues of the city. By the execution of this project the entire sewage of the city can be treated effectively and efficiently upto the year 2049.

Keywords- Area, Dis-charge, Indian Standards, Kinematic velocity, Reynolds Number, Settling velocity, Sewage Treatment Plant.

I. INTRODUCTION

Sewage treatment is the process of removing contaminants from municipal wastewater, containing mainly household sewage plus some industrial wastewater. Physical, chemical, and biological processes are used to remove contaminants and produce treated wastewater (or treated effluent) that is safe enough for release into the environment. A by-product of sewage treatment is a semi-solid waste or slurry, called sewage sludge. The sludge has to undergo further treatment before being suitable for disposal or application to land.

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 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 maybe called a De-Centralized system. The treatment process has a series of treating unit which are categorized under primary treatment secondary treatment and tertiary treatment.

II. OBJECTIVES

The main objective of this study is carried out to design a sewage treatment plant for Imphal city Manipur, To Study, Analyse and Estimate the Population data for the decades 2029,2039,2049 using Arithmetic population estimation method.To Analysis and design Sewage treatment plant in order to meet the expected demand as per estimation upto the year 2049.

III. METHODOLOGY

The following methodology has been used in this project as stated below :-

- To analyse the population study and estimate the population for the next decades ie: year 2029,2039,2049.
- To determine the peak flow for the sewage generated..
- To design the sewage treatment plant and analyse the primary , secondary and tertiary treatment processes for the plant.
- To generate expected results and further discussion.

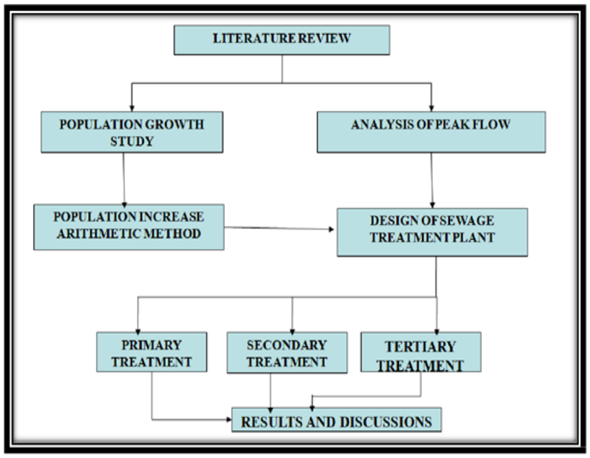

Figure 1. Methodology flow chart of the project.

IV. PLANNING

The location of plant is to be established in Lamphelpat, Imphal ,next to Imphal Sewage treatment plant , at the specified location detailsLamphelpat, Imphal is a city in Manipur with Longitude: 24.828481, Latitude : 93.919386. The Plant is to be constructed at 24°49'42.5"N 93°55'09.8"E. The city receives an Average precipitation of 97.2ppm, with an average elevation of 786m.The Average Daily Temperature is 21 Celsius.

Figure 2. Study Area for the Project

V. POPULATION ANALYSIS.

The Population of the Imphal city has been found to be as follows in Table 1.

Table 1. Population year wise

Year	Population(inmillions)	Increase(in millions)
1999	2.3	
2001	2.3	
2009	2.6	0.3
2011	2.85	
2014	2.90	
2015	2.94	0.75
2016	2.97	
2017	3.21	
2018	3.27	
2019	3.35	x=0.525

Population estimation has been done using Arithmetic estimation method .

Using Arithmetic mean method $P_n = P_o + n\bar{x}$

For 2029, after 1 decade P2029=P2019 + 1(0.525)

=3.35 + 0.525

=3.875 M

For 2039, after 2 decades P2039=P2029 + 2(0.525)

=3.875 + 2(0.525)

=4.925 M

For 2049, after 3 decades P2049=P2039 + 3(0.525)

=4.925 + 3(0.525)

=6.5 M

Estimated population for arithmetic increase method,

P2029=3.875 M

P2039 = 4.925 M

P2049=6.5 M.

VI. RESULTSANDDISCUSSIONS

DESIGN

The project includes the design of various components that are essential for a good working for a sewage treatment plant.this includes design of presidentation tank ,raw water tank , cascade aerator , sedimatary tank ,floc chamber , inlet and outlet valve design ,rapid gravity filter.

Design of pre-sedimentation tank

We shall design to remove particles up to 0.1mm size and adopt following parameters

General parameters:

Overflow rate=20 – 80 m^2/m^2/day

Minimum side water depth=2.5 m

Detention time=0.5 – 3 hrs

Side slopes (for non mechanical cleansing)
=10 % from sides towards centre line
Longitudinal slope=1 % in rectangular tank
Ratio of length and breadth=3:1 to 5:1
Settling velocity=to ensure removal of minimum size of particle of 0.1 mm.

Hydraulic design

i) Dimensions of the tank

Assuming water required by year 2069 = 6.5MLD= 18 ×1000×24
= 271m^3/hr
= 275 m^3/hr
Since pumping is considered for 16 hrs,

The discharge coming into the pre-sedimentation tank = (275 × 24)

Hence provide a tank of size 25.2 m ×8.4 m × 3 m providing a free board of 0.5 Hence a tank of 25.2 × 8.4 × 3.5 m

Loading on tank/ overflow rate
Q = (412.5×24)
A (25.2×8.4)= 46.76 m3/m2/day - (4.1)=412.5 m3/hr
Assuming water loss in de-sludging=2%
Design average flow=(412.5 ×100)(100−2)
=420.9 m^3/hr
Assuming detention period=1.5 hrs
Effective storage of sedimentation tank
=(420.91 × 1.5) × 631.4 m^3/hr
Assume effective depth=3 m
Area of tank required 631.37/3=210 m^2
Assume L : B=3:1
3B × B=210.
B=8.4 m=3 × 8.4=25.2 m

ii) **Settlement Velocity (Vs) by method of Stoke's Law**
Hence,

a) Size of particle (d) = 0.10 mm
b) Specific gravity (Ss) = 2.65
c) Kinematic viscocity of 20 degree C'V' = 1.01×0.000001 m^2/sec^2
d) Value of g = 9.81 m/sec^2
V = 9.81 ×(S -1)d^2 - (4.2)
s 18 s V= 0.0089 m3/s
Reynold's number (R) = Vsd
v= (8.9×0.001×0.1×0.001)
(1.01×0.000001)= 0.88 < 1

Hence the flow is laminar and stoke's law is applicable(4.3)

iii) **Settlement velocity(Vs) by the method of discharge entering the tank and tank dimensions**

a) Discharge entering the basin (Q) = 412.5 m^3 /hr
= 6.87 m^3 /min
= 0.11 m^3 /sec
b) Depth of water in tank (H) = 3 m
c) Width of basin (B) = 8.4 m
d) Length of tank (L) = 25.2 m
Horizontal flow velocity is given as (V) = QH
= (0.11)(8.4×25.2)
= 5.196×10-4 m /sec
= 0.031 m /min
Settling velocity Vs = (0.11×3) (25.21)
= 0.013 m /min= 2.16 m /sec

Thus, particle having settling velocity greater than or equal to 9.73 × 0.001m/sec shall settle in the tank of above mentioned dimensions

iv) **Time period required for particles to settle in the tank**

As in above calculation, a particle of size 0.1 mm shall settle in the tank if settling velocity is greater than equal to 8.9×0.001m /sec

Since we assumed the water depth = 3 m
Time required to settle down this depth = t1= 3
8.9×10−3sec= 337.078 sec= 0.0936 hrs

Since the horizontal velocity of flow is 0.051m/s and the length of tank is 41.49m, time taken is as = 882.76 sec= 14.71hrs

Thus, the time required by water to flow from inlet to the outlet is more than the time required by partile size 0.1m settledown.

Hence all the particle of size 0.1mm, having a settling velocity greater than or equal to 8.9×0.001 m/sec shall be retaining in sedimentation tank, longitudinal slope of 1 in 50 is being provided and slope of 1 in 30 is being provided towards the longitudinal centre line.

Actual detention time in sedimentation tank = (41.49×13.89×3)
(1147.95)= 1.496 hrs
v) Check against Scow of departed particle Scow Velocity (Vd)
Vd = 0.13 m / sec

To avoid Scow , the flow velocity should not exceed Vd hence, horizontal flow velocity is 0.047 m/sec which is less than scow velocity Vd,

Hence design is OK. As per IS 1172:1993 Code of basic requirements for water supply, drainage and sanitation.

Design of Raw Water Tank

Considering a Raw water storage tank of 8 hrs detention period is proposed to be provided so that the water coming from the main at the rate of 1.5 x Average discharge due to 16 hrs pumping can be stored in it for 8 hrs.

Water tank shall maintain a continuous flow in filtration plant for 24hrs Water required for 20 yrs = 6.5 MLD
Taking 8.05 how detention period capacity of tank= (6.5×8)
Hence, provide a tank of 43×16.9×3 mor 43×17×4m (considering free space)

Design of Cascade Aerator

Water required for 2049 = 6.5MLD=2.16ML=2160 m^3
Provide water depth=3 m
Plan area of the tank=2160/3 = 720m^2
Assume L:B ratio as 2.5:1
2.5B × B=720
B=16.97
L=2.5B=42.42 m or 43 m
Average water requirement Q = (6.5×0.000001) (24×3600×1000)m^3/sec
Width of weir proposed For broad aestedweir , Q=0.0752 m^3/sec
H=0.099 m=9.98 cm or 10 cm
So a total depth of 10cm shall be flowing over the weir.

Six steps of 1m size shall be provided on which water shall be flowing down the outlet chamber. At the outside of the outlet chamber, one side wall has been kept 200mm below the top surface of the tank , so as to provide excess flow of water towards alum mixing chamber. 4 pipes of 250mm dia have been provided at the outlab aerator to the alum mixing chamber. Enough discharge of water will flow through these pipes. The outflow shall take place when the outlet of alum mixing chamber dogged. All the masonry walls shall be plastered with wall thickness as 1m.

Alum dose

The dose of alum varies from 15 to 20mg/l of water but actual dose is to be ascertained by experiments in the laboratory from time to time. The optimum coagulation occurs when PH value of water is between 6 to 8. Floc alum makes the water acidic, the alum design tank will be lined with rubber or preferably polyethene tanks shall be used. Here we shall be see tanks of over 3000L capacity. Now assuming the peal alum dose to be 20mg/l and normal dose be 30% of that,we get,

Alum required for 20mg/l = (10 1000× 800 × 106 × 1)/1000
= 160 kg/d.
Only 30% of 160kg shall be used in normal condition.Thus for most of the year, the alum to be used will be 32kg/day.

Design of Sedimantry Tank

General provision
Overflow rate = 15 - 30 $m^3/d/m^2$
Minimum side water depth = 25 m Detention period for coagulate water = 2 – 4 hrs . Using loading = 200 $m^2/d/m^2$
Side slope for non mechanical cleaning = 10% fiber sides towards the longitudinal central lines.
Longitudinal slope = 1% in case of rectangular tank
Rate of length & width = 3:1 & 5:1
Settling velocity = to cross removal of minimum side peak of 0.02min
Detention time to flocculation chamber = 10 – 30 min
Skimming weir = to check the surface of outlet to reduce the load on the filter
Horizontal flow velocity = 0.15 - 0.9 m/min Hydraulic design of purposed Sedimentation tank cum flocculation
i) **Dimension of the tank-**

water required by year- 2048=18 MLD=750 m^3/hr
Water lost in desalination=2%
Power average flow = (750 × 100)/1002 1002= 365.30 m3/hr.
Assume a total detention period of 2 to 6 hrs
Effective stress of sedimentation tank=765.3 × 2.6
=1789.78
Assume effective depth (h)=3 m
Area of tank required (A) = 1789.78/3 = 663.26 m^2
Hence use a tank of size 80 m × 9.8 m × 3.5 m.

Table 2. Details of various layers of the ground STP

Size(mm)	2	5	10	20	40
Depth(cm)	9.2	21.3	30.5	40	49
Increments(cm)	9.2	12.1	9.2	9.5	9

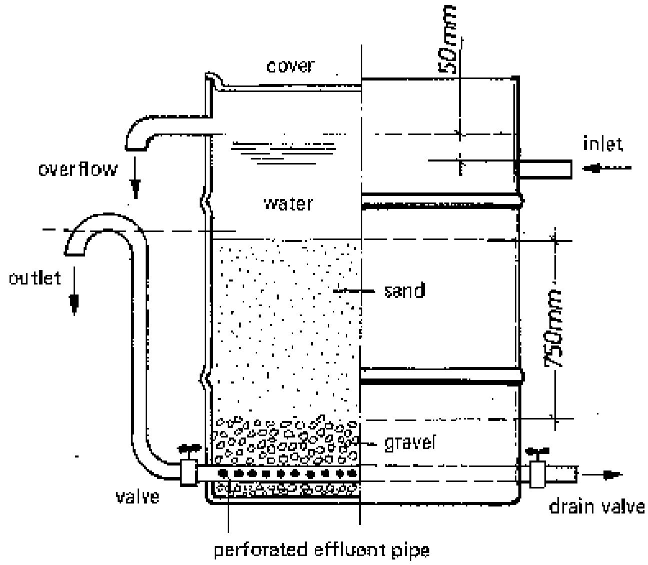

Figure 3. Rapid Gravity Filter Diagram

The rapid sand filter is a type of filter used in water purification and is commonly used in municipal drinking facilities as a part of multiple stage treatment..

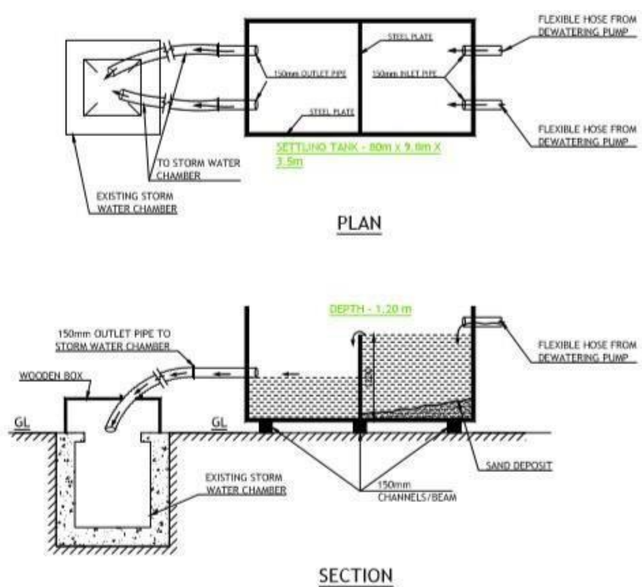

Figure 4. Sedimentation tank

Sedimentation tank is component of modern system of water supply or waste water treatment. A sedimentation tank allows suspended particles to settle out of water or wastewater as it flows slowly through the tank.

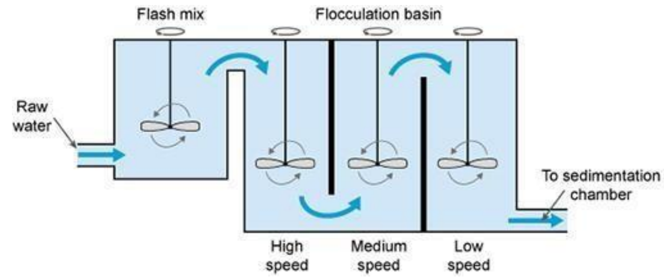

Figure 5. Floc chamber

The coagulant encourages colloidal material in water to join together into small aggregates or flocs which helps to further remove the impurities.

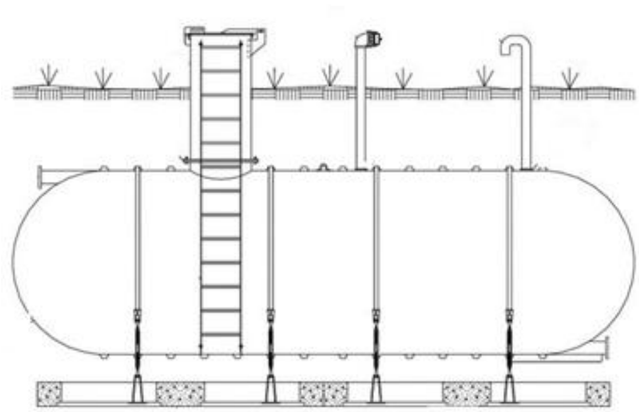
Figure 6. Raw Water Tank

Raw water tank is used to store raw water found in the environment that has not been treated and does not have any of its minerals, ions ,particles ,bacteria or ,parasites removed.

VII. CONCLUSION

The experiment ha s been in proper manner and following conclusions has been made:

- The project deals with design parameters of sewage treatment plant and the demand expected of the sewage to be treated .
- The design has been done for a predicted population of 30 years up to the year 2049.
- Although the project and the data helps in design of sewage treatment plant in future, The plant is designed perfectly to meet the needs and demand of about 6.5M population with a very large time period .
- The treated sewage water is further used for irrigation , fire protection and toilet flushing purpose in commercial and industrial buildings and if it is sufficiently clean it can be used for ground water recharge.

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