Proposed design of a sewage treatment plant for Tasgaon City

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Abstract: The sewage treatment plant is a key solution to pollution. This paper proposes the hybrid STP model with the combination of RO water purification and a biogas system. Water pollution is caused by sewage water disposal in water resources. The study elaborates on SBR technology in STP, a system with sequential multiple operations in one treatment tank. This system is less expensive and takes less area. The sewage in Tasgaon City is generated by residential, medical, institutional, commercial, and industrial waste with water. The proposed treatment is suitable for this type of problem. Direct wastewater disposal in Kapurwada Nallah causes environmental damage to water resources like rivers, lakes, or open land and soil. In this case, pollution affects living and non-living things in the area. This paper describes the STP design for Tasgaon City according to the sewage water quality and quantity with additional components which enhances the application-oriented approach.

Keywords: SBR technology, sewage water, characterization, organic load, pollution, composite sample.

I. Introduction:

Tasgaon City is a progressive city that has grown in all sectors. This city is situated in a region or area that has consistently faced water management problems. Many areas face water problems for farming. The groundwater level is also not sufficient. The water resources are already minimum and also the water which still used and disposed of has contaminants with toxic effects. The reason behind this problem is mainly the maximum sewage water is disposed of in Kapurvada Nallah. Many farmers are dependent on the Kapurvada Nallah for the water required for farming/agriculture. So, this polluted water causes the pollution of farming land and degradation of soil which directly affects agricultural products. These effects can be minimized with the help of various treatments on the wastewater before it is disposed of in water resources or on open land.

These various treatments have different types of categories according to the wastewater type and contents. We can reuse this water after treatment and also the treated byproduct from these treatments can be used as fertilizer in agriculture. The dry version of this byproduct will be used in boilers, in industries for heat energy generation.

Hence, there are several treatment technologies are present to treat sewage water. The SBR is the most suitable treatment technology present in the present day. Here adopted technology is SBR- Sequential Batch Bio-Reactor. This method of treatment is economical and also requires less area to install. The SBR treatment has more advantages over conventional sewage water treatments. Based on the results of water sample testing and comparison with MPCB standards, decided to propose a sewage treatment plant. In this paper, the SBR technology design is proposed with all component dimensions, and additional components are also discussed.

II. Principle of working and block diagram:

Water resource pollution (which is caused due to direct disposal of wastewater) is controlled by the installation of sewage treatment plants. In this SBR sewage treatment plant, multiple processes are carried out in one reactor. The steps of filling, aeration, reaction, settling of sludge, and decanting process are carried out within a single reactor with a batch pattern and the batches are repeated cyclically.

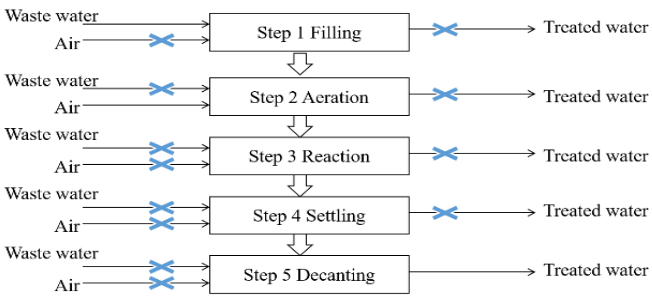

Fig. 1: Principle of working of SBR Technology

1. Types of components considered in plant: The stages in the treatment plant depend on the contaminants in sewage which will eliminate after treatment. The characterization of a water sample is carried out with the composite sample collection method and tested for physical, chemical, and biological parameters. Based on the contents in the water the SBR technology is adopted.

2. component size: For each stage size of the tanks depends on the amount of total sewage water flow and detention time at particular stages. The STP design was proposed according to water test results and the quantity of total discharge calculated.

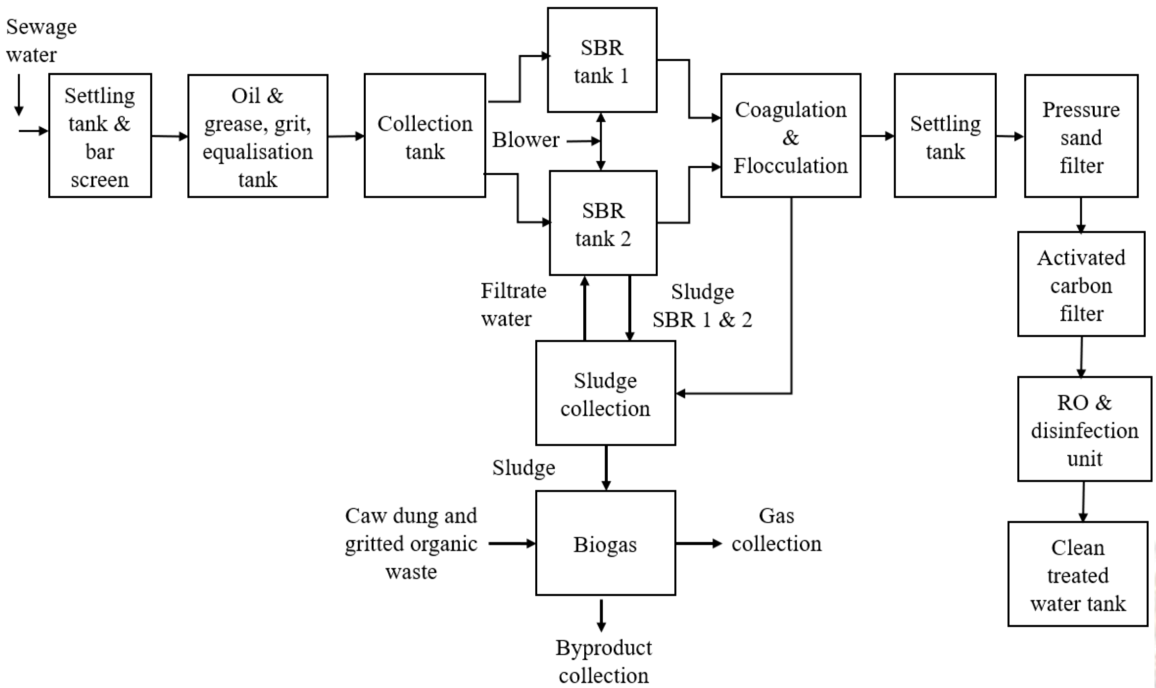

Fig. 2: Proposed STP design with components

Description:

Fig. 2 shows all the components proposed in the STP design. The design flow starts from sewage water collection and flows through the Bar screen to arrest all large and fine organic and inorganic materials. After the bar screen the water goes for oil & grease removal to collect grease, and oil, then passed into the grit chamber followed by an equalization tank to equalize water flow. Then sewage water came to the collection tank, followed by 2 SBR tanks. The collection tank provides the compatibility to pass the water according to batches in the SBR tank. From these SBR tanks, the 2 outputs are generated. One is treated water and another is sludge. The sludge was collected after reaction and decantation at each batch. Then the coagulation and flocculation processes are provided to arrest dissolved solids and the remaining output of this is settled at the settling tank. After this stage the disinfection is carried out and this output is given to the Filtration unit's sand filter and carbon filter. The above block diagram describes that the proposed design is a hybrid model or combination of STP, RO purification, and biogas systems. In this design, the additional components as the RO system and biogas system are to be designed later. At this stage, only primary and secondary stage components are designed with prefiltration and filtration units.

III. Design calculations and considerations:

1. Total sewage water discharge:

The design of STP according to capacity, considers the following points:

1) Amount of discharge of sewage water from sewer system; The amount of discharge of sewage water determined with the help of a) Actual and future population and b) Flow measurement techniques.

a) Actual and future population: The estimation of the future population using past and present populations is achieved by population forecasting. The Arithmetical increase method is suitable for calculating the average increase in population per 10 years calculated from precious population reports. This increase is added to the current population to find out the next decade.

Therefore, the population increases according to the time is with a constant rate. Thus, the population after the n^{th} decade will be $P_n = p + n \times c$. Where Pn is the population after 'n' decades and 'p' is the present population.

$$P = 37945\text{Nos.} \quad d = 4259\text{Nos. and } n = \frac{1}{10} \times (2051 - 2011) = 4\text{years}$$

The average increase in the decade = 4259Nos.

The population at the end of 2051 P_n = 54981Nos.

As per standard and municipal water irrigation department, Water demand per person per day = 135 lit/day

Total water demand at 2051 = 8.906×10^6 lit/day

Total Discharge = $8.906 \times 10^3\ m^3/day$ = 8.906 MLD

b) Flow measurement techniques: 'V' notch method:

$$\text{Discharge (Flow) } Q = 4.28 \times C_e \times \tan(\theta/2) \times (H + k)^{5/2}$$

Now for the present population of 2022, the discharge will be $Q_{present} = 1.7215 \times 10^{-6} \times 42630$

$= 0.07388745\ m^3/sec$

Hence for the future population of 2051, the discharge will be $Q_{present} = 1.7215 \times 10^{-6} \times 54981$

$= 0.09464979\ m^3/sec$

Discharge (Flow) Q = 0.09464979 ≅ 0.100 m^3/sec ≅ 0.1030 m^3/sec

Thus, from the above the discharge determined by population forecasting and actual discharge by the 'V' notch method are approximately match. So, the capacity of STP is designed accordingly.

2. Sewage water quality:

After analyzing the collected samples from different locations around the city, it is observed that some parameters show more value than MPCB permissible limits. The values of BOD are high for both samples which show a higher amount of organic matter. Also, oil and grease & chloride content for both samples are found below MPCB limits whereas suspended & T. D. S. are above MPCB standards. With these results, it is concluded that the sewage water from Tasgaon City has more heterogeneous characteristics and also shows above MPCB standards. Therefore, it is necessary to provide primary & secondary treatments on sewage water before releasing it into Kapurvada Nallah which ultimately reduces the pollution of the nallah.

3. Components of STP:

1) Settling tank and bar screen:

Settling tank: This is the first stage of the SBR plant with the settling tank. These tank and bar screen sizes are depending on the volume of sewage water and velocity of water & detention time.

The discharge (Q) = 0.1030 m^3/sec, assumed detention time = 06 min

The volume of receiving water in the tank, V = 0.1030 × 6 × 60 = 37.08 m^3

From the above volume capacity, the tank or chamber size is,

Tank size length=3.5m, width=3 m, hight=3.5 m.

Bar screen:

As per standard, the flow should not exceed more than 1m/sec.

Velocity through the screen at maximum flow = 0.8m/sec

The acceptable range of bar spacing is 1.5 cm to 3.5 cm

so considered spacing between. Bars is = 2.5 cm

Average discharge of sewage water,

Qaverage × Peak factor = 0.1030 × 3 = 0.309 m/sec

So, the vertical projected area of the screen is,

$$A = \frac{Q}{V} = \frac{0.309}{0.8} = 0.3863 m^2$$

The gross area of the screen,

Thickness=10mm, Width=25mm,

Clear spacing = 25mm

therefore, $A = 0.3863 \times \frac{(25+10)}{25} = 0.54\ m^2$

The screen is inclined at an angle of 60^0

Horizontal cross-sectional area of screen = Area / sin (60) = 0.54 / sin (60) = 0.624 m^2

Width of the screen = 3m

Width of the screen = (no. of bars × thickness) + (no. of openings × spacing)

3 = (n × 0.01) + (n + 1) × 0.025

3 = 0.01n + 0.025n 0.025

n = 3.025/0.035

No. of bars n = 86.42 ≅ 87

No. of openings = 88

Assuming depth as 3.9 including freeboard

The coarse screen is designed for size 3m × 3.9m

2) Oil & Grease, Grit chamber, and Equalization tank unit:

Tank volume calculations:

Hydraulic retention time (HRT) is generally taken as 6 to 8 hrs. Considered tank of 6 hrs of hydraulic retention time for a total of 3 compartments of grit chamber, oil & grease, and equalization tank respectively.

Qmaximum = 10 MLD so flow rate/hr

= 416.66 m^3/hr

Required chamber volume = 416.66 × 6 = 2499.96 ≅ 2500 m^3

Effective depth to be provided for 2500 m^3 volume,

The size of the chamber is Length = 15m, width = 14m, and height = 12m.

This tank is divided into 3 parts equally with a partition so that each process of Oil grease, Grit chamber, and equalization process takes place at ease.

1) For the grit chamber horizontal velocity of the water is maintained between 0.15 to 0.3 m/sec to settle the grit at the bottom also, the partition wall is provided to slow down the water speed. To settle the inorganic matter at the bottom slope is provided. In this chamber, the particles with a specific gravity of 2.65 & diameter greater than 0.2mm are settled & collected from the bottom.

2) For oil & grease two vertical baffle walls are provided in the tank, which divides it into three compartments. The vertical baffle

was do not touch the bed of the tank. At the top of the tank, the oil & grease are collected parodically.

3) Equalisation chamber air required:

This tank is divided into 3 parts equally so the length of only equalization tank is 5m

Tank volume = 5 ×14 ×12 = 840 m^3

As per standard for every 1 m^3 volume 0.5 m^3 air is required,

Air required = 0.5 × 840 = 420 m^3/hr

3) Collection tank:

Tank volume calculations:

Hydraulic retention time (HRT) is generally taken as 6 to 8 hrs

Considered collection tank of 6 hrs of hydraulic retention time. Hence, $Q_{maximum}$=10MLD,

so, flow rate/hr=10 ×10^3 m^3/day = 416.66 m^3/hr

Required chamber volume = 416.66 × 6 = 2499.96 ≅ 2500 m^3

Effective depth to be provided for 2500 m^3 volume,

Size of the chamber is, Length = 15m, width = 14m, height = 12m.;

4) SBR reactor:

Organic load = 10 ×10^3× (210 − 10) × 10^{-3}= 2000 kg/day. For the two tanks with half size, this organic load is divided into two parts. The organic load for each tank is 1000 kg/day

Aeration time:

Aeration time is depending on various parameters like volume present in the tank, F/M ratio, total oxygen required, solids in water, total cycle time for each batch, etc.

for SBR technology F/M ratio shifts from as high as 0.30 to as low as 0.10

so, consider 0.20 for design calculations, for a mechanical aeration system for 1kg organic load the requirement of unit oxygen varies between 1.0 to 2.0kg O2/kg. Assuming for each tank total oxygen required as 1000 kg of O2/kg of BOD extracted = 1000 × 2 = 2000kg/day

Mixed liquor suspended solids (MLSS) = 1893 mg/lit

Hydraulic retention time = $\frac{(\text{BOD mg/lit})}{(\text{MLSS} \times \text{F/M})} = \frac{(2000)}{(0.2 \times 1893)}$ = 5.283 hrs ≅ 5.3 hrs.

Assuming 50% decantation, the cycle time is,

Cycle time T_c = 5.3 (aeration) +0.5 (decantation) + 0.5 (settling) = 6.3 hrs ≅ 6 hrs

Hence designed for 4 batches a day = 24hrs/4 = 6hrs.

SBR reactor tank design:

The design of the tank depends on the total flow of the sewage water in the tank for each batch.

Design flow = 10 ×10^3 m^3/day

BOD = 210 mg/lit

Volume of SBR tank = $\frac{(\text{Q} \times \text{BOD})}{(\text{MLSS} \times \text{F/M})} = \frac{(10 \times 10^3 \times 210)}{(1893 \times 0.2)}$

As already calculated the retention time = $\frac{(\text{BOD mg/lit})}{(\text{MLSS} \times \text{F/M})}$ = 6hrs

so, consider flow in terms of m^3/hr = 416.66 m^3/hr

Volume of SBR tank = 416.66 m^3/hr × 6hrs = 2499 m^3 = 2500 m^3

This volume is divided into two tanks of each

V = 2500 /2 = 1250 m^3

Hence the size of 2 tanks each of, length = 11m, width = 10m, height = 11m

Collectively considered each reactor of volume 1250m^3 effective volume + freeboard Size = 11 × 10 × 11(SWD) + 0.5m F.B. =1265 m^3

SWD considered approximately = 11m,

Plan area = 1250/11 = 113.65 m^2

Oxygen required for each SBR reactor: 1.5×BOD load=1.5×2000/4=750 kg/batch

So, 4 batches should be completed in 24 hours & each batch should have 6Hr time

Oxygen to be supplied = 750/6 = 125 kg/Hr

Assuming oxygen transfer efficiency of 35% per meter depth of water column

Total SWD of reactor = 11.5 m

Overall efficiency = 11.5 × 3.5 = 40.5%

Oxygen to be supplied = 125/0.405 = 308.642 kg/Hr

Air to be supplied = $\frac{(\text{Oxygen required})}{(\text{Air required} \times \frac{W}{W}\% \text{ of Oxygen in air})} = \frac{(308.642)}{(0.23 \times 1.4)}$ = 958.52 ≅ 960 m^3/hr

Total air required = Air for 2 SBR reactors = 960×2 = 1920 m^3/hr

Assuming 80% of efficiency for the blower = 1920/0.8 = 2400 m^3/hr

Considered blower with a capacity of 2400 m^3/hr

Bio-culture and micro-organisms growth:

In this stage, the bio-culture and biomass are mixed with wastewater and aerated. The effective activated sludge process depends on aeration, the F/M ratio, and the bio-culture environment present at that stage. The bio-culture is the most important factor for the healthy growth of the organisms, these organisms are responsible for the degradation of organic matter present in sewage water. The bio-culture maintains the ratio of BOD, Nitrogen, and phosphorous. Cow dunk is used for BOD, Uria is used for Nitrogen, and Dag is used for phosphorous ratio respectively. In many cases, some pre-prepared bio-cultures are used for better performance and also, and this stage prevents fog formation.

5) Sludge collection tank:

The discharge of sewage water Q = 10 $\times 10^3$ m^3/day ≅ 0.1157 m^3/sec

C1 = 200 mg/l, C2 = 1893 mg/l, M_{sludge} = Mass of sludge produced

$Mass_{in} = Mass_{out}$ + accumulation

$QC1 + QC2 = QC_{out} + M_{sludge}$

M_{sludge} = Q (C1+C2+C3-Cout)

= 10 $\times 10^3$ m^3/day × (210+1893+8620-10) mg/l

After some adjustments in units, the quantity of sludge is

M_{sludge} = 107.13 $\times 10^6$ g/day = 107.13 × 10^3 kg/day = 107.13 m^3/day ≅ 107m^3/day = 4.458 m^3/hr

Detention period for sludge collection tank Td = 24hrs = 1 day

Volume V = Td × Msludge = 24hrs×4.458 m^3/hr = 107 m^3

Volume of tank V = V1+V2, Here V1 is the volume of the cylindrical part of the tank and V2 is the conical part of the tank. So as per volume considerations,

For the sludge tank considered the bottom part as conical and upper part is cylindrical. So, Volume of Sludge tank V = V1+V2, Here V1 is the volume of cylindrical part of the tank and V2 is the conical part of the tank. So as per volume considerations, cylindrical part dimensions are,

Diameter D = 8m i.e., radius r = 4m and

Height H1 = 2m thus, V1 = 100.5 m^3

For conical part dimensions are,

Diameter D = 8m i.e., radius r= 4m and

Height H2 = 1m thus, V2 = 16.755 m^3

So, from the above dimensions the total volume achieved is,

V=V1+V2=117.3 m^3 suitable for volume V=107 m^3

6) Prefiltration process:

A) Coagulation (Flash mixing):

The coagulation stage consists of a flash mixer with rapid mixing of water to be treated and coagulant chemicals. Standard detention time for coagulation is 30 to 60secs is sufficient. Here 60secs detention period is considered.

The standard ratio of tank height to diameter=3:1, H=3D

The rotational speed of the impeller should be > 100rpm hence considered as 150rpm

Flow=10MLD=10 $\times 10^3$ m^3/day =0.11574 m^3/sec

Volume of the Flash mixer = 0.11574 × 60 sec = 6.942 ≅7 m^3

Volume = height × Area of the tank

$7 = 3D \times (\pi/4) D^2$

$D^3 = (7\times4) / (3\pi)$

D = 1.437 m ≅ 1.5m

D = 1.5m therefore H = 3D = 4.5m

Overall volume for these dimensions V = 7.95 m^3

Power required for agitator at flash mixer:

For this stage Temporal mean velocity gradient (G) >300/sec, G = $\sqrt{(P/\mu V)}$, Here assume G = 400/sec,

Where, μ= Absolute viscosity (N-sec/m^2)

= 1.0087×10^{-3} N-sec/m^2

P = Power and V = volume

Power spent P = $G^2 \times \mu \times V$

= $400^2 \times 1.0087\times10^{-3}\times7$

= 1129.744 ≅1130 watt

P = 1130/7.95 = 142.15 watt/m^3

P = 1130/416.66 = 2.712 watt/m^3/hr

Dimensions of flat blades of impeller:

Diameter of the impeller = 0.4 × Dia. of tank = 0.6m

The tangential velocity of the tip of the impeller = Impeller velocity × Impeller periphery/60

= 150 × (μ×0.6)/60 m/sec

= 4.71 m/sec

Relative velocity = Vr = 0.75×Tangential velocity = 3.53 m/sec

Area of blades Ap of impeller:

Power spent $P = (1/2)\ Cd \times \varrho \times Ap \times V_r$

Where, Cd = 1.8 = Coefficient of drag for flat blades

ϱ = Density of water kg/ m^3

A_p = Area of plates or blades m^2

V_r = Relative velocity m/sec

Area of impeller blade $Ap = 2 \times P / (Cd \times \varrho \times Ap \times V_r^3) = 0.0286 \cong 0.03\ m^2$

Assuming for 2 blades, Area for each blade = Ap/2 = 0.015 m^2

Dosing of coagulant:

The coagulant considered is poly-aluminum chloride. The amount of dosing is depended upon the dissolved solids present in the output of secondary treatment. The jar test is performed on treated water from secondary treatment. The results are satisfactory for 40 ppm of PAC dosing. So, for the total volume of 7m^3, the PAC dosing of 28 grams is considered.

B) Flocculation:

The flocculation stage consists of a mixer with slow mixing of water and flocculant chemicals.

Standard detention time for flocculation is 20 to 40min is sufficient. Here 30min detention period is considered.

Td = 30 min, Td = Volume/Flow = V/Q

The standard ratio of height to diameter=3:1, H=3D

The rotational speed of the impeller should be≥ 5rpm hence considered as 10rpm

Flow =10MLD $=10 \times 10^3\ m^3$/day = 6.944 m^3/min

= 0.11574 m^3/sec

The volume of flocculation = D.T. × Inlet flow

$= 30 \times 6.944 m^3 = 208 m^3$

Volume = height × Area of the tank

$208m = 3D \times (\pi/4)\ D^2$

$D^3 = (208 \times 4)/(3\pi) = 88.2779$

D = 4.453 m ≅ 4.5m therefore

H = 3D = 13.3579 ≅ 13.5m

Overall volume for these dimensions V = 214.7 m^3

Power required for agitator at flocculation:

For this stage Temporal mean velocity gradient (G) = 10 to 75/sec or more,

$G = \sqrt{(P/\mu V)}$, Here assume G = 60/sec,

here, μ = Absolute viscosity (N-sec/m^2) = 1.0087×10^{-3} N-sec/ m^2,

P = Power and V = volume

Power spent $P = G^2 \times \mu \times V$

$= 75^2 \times 1.0087 \times 10^{-}3 \times 208$

= 1180.179 ≅1180 watt

P = 1180/ 214.7 = 5.496 watt/m^3

P = 1180/416.66 = 2.832 watt/ m^3/hr

Dimensions of flat blades of impeller:

Diameter of the impeller =0.4×Dia. of tank=1.8 m

The tangential velocity of the tip of the impeller = Impeller velocity × Impeller periphery/60

$= 10 \times (\pi \times 1.8)/60$ m/sec

= 0.9423 m/sec

Relative velocity = Vr = 0.75×Tangential velocity = 0.71 m/sec

Area of paddles Ap of impeller:

Power spent $P = (1/2)\ Cd \times \varrho \times Ap \times V_r^3$

Cd = 1.8 = Coefficient of drag for the flat area of paddles

ϱ = Density of water kg/m^3

Ap = Area of paddles m^2

Vr = Relative velocity m/sec

Area of the paddles of the impeller $Ap = 2 \times P / (Cd \times \varrho \times Ap \times V_r^3) = 3.671 \cong 3.7$

Cross-sectional area of tank $A = (\pi/4)\ D^2 = 15.90\ m^2$

The area of paddles should be 10 to 25% of the cross-sectional area of the tank

The ratio of the area of paddles to the cross-sectional area is 3.7 % of the cross-sectional area of the tank so, providing 4 paddles with 6 flat blades on each paddle or impeller

Area of each blade = 3.7/ (6×4) = 0.1541m^2 = 0.154 m^2= 1540 cm^2

The dimension of each rectangular blade on each paddle is = 154cm×10cm

Dosing of flocculant:

Here Poly-electrolyte polymer is the flocculant under consideration. The amount of dosage is determined by the amount of dissolved solid in the output of secondary treatment. Water that has undergone secondary treatment is used for the jar test. The outcomes are acceptable for Poly-electrolyte polymer dosage at 2ppm. Thus, the polymer dosage of 400 grams is taken into account for the entire volume of 208m^3.

7) Settling tank:

In designing this tank detention period as per the CPHEEO manual is ranges between 1.65 to 4 hrs. So considered as 4hrs. And Surface overflow ranges between 50 to 60 m^3/m^2day, assumed, Surface overflow rate = 60 m^3/m^2day

Discharge rate Q = 10×10^3 m^3/day

= 416.66 m^3//hr

Volume of tank = Td×Q = 4×416.66

= 1666.64 ≅ 1667 m^3

SOR = Q/A so, A= Q/SOR = (10×10^3 m^3/day) / (60 m^3/m^2day) =166.66≅167 m^2

For circular tank design Area = $(\pi/4)\ D^2$ So, Diameter(D) = 14.58 ≅ 15m

Volume=Area×Depth,

therefore Depth (H) = Q/A =1667/167 = 9.98 ≅ 10m

Therefore, Dimensions of tank D = 15m, H = 10m

8) Pump calculations:

The pumps are required for sewage water transfer from one stage to the next stage. The pump power or capacity is calculated with respect to the static head and density of the sewage water or sludge transferred. Here the sewage water is transferred through the pumps at certain heads. The sewage water transfer requires appropriate pumps with motors having compatible power (P) to achieve a certain static head (H).

Power calculation

Pump power P = $(\varrho \times g \times H \times Q)/\eta$

Here,

ϱ = Density of sewage water (kg/m^3)

= 1 to 1.03 g/cm^3

g =Gravitational acceleration constant = 9.8 m/sec^2

H = Head (combination of static suction head(H_1) and discharge head(H_2))

Q = Flow rate of the pump, to match the flow of sewage water=0.1157m^3/sec

Ƞ = Efficiency of the pump, considered 75%

The media transferred through the pump is sewage water and sludge. The density of both sewage water and sludge varies from time to time. Here for the calculation, the average density of sewage water is considered 1030kg/m^3, and the density of sludge is considered ≤1400 kg/m^3

1) Pump for sewage water transfer from equalization tank to collection tank:

Here the media is sewage water which is equalized. Hence,

Pump power P = $(\varrho \times g \times H \times Q)/\eta$

$H = H_1 + H_2$= 12m+12m = 24m

Power required to transfer the sewage water,

P = 1030×9.8×24×0.1157/0.75 = 37372watt = 37.372kW = 49.83Hp

Power consumed depends on the efficiency of the pump

2) Pump for sewage water transfer from collection tank to 2 SBR tanks:

These SBR tanks require flow according to their batches. Here the media is sewage water. Hence,

Pump power P = $(\varrho \times g \times H \times Q)/\eta$

$H = H_1 + H_2$= 12m+11.5m = 23.5m

Power required to transfer the sewage water,

P=1030×9.8×23.5×0.1157/0.75 = 36593watt = 36.593kW = 48.75Hp

3) Pump for treated water transfer from 2 SBR tanks to flash mixer:

Here the media is treated water. Hence,

Pump power P = $(\varrho \times g \times H \times Q)/\eta$

$H = H_1 + H_2$= 10.5m+10m = 20.5m

Power required to transfer the sewage water,

P=1000×9.8×20.5×0.1157/0.75 = 30992watt = 30.992kW = 41.3Hp

4) Pump for sewage water transfer from Flocculator to settling tank:

Here the media is treated water. Hence,

Pump power P = $(\varrho \times g \times H \times Q)/\eta$

$H = H_1 + H_2$= 9m+10m = 19m

Power required to transfer the sewage water,

P=1000×9.8×19×0.1157/0.75 = 28724watt = 28.724kW = 38.3Hp

5) Pumps for sludge transfer from 2 SBR tanks to sludge tank:
Here the media is sludge with water. Hence,

Pump power P = (ϱ×g×H×Q)/η

$H = H_1 + H_2 = 11.5m+3m = 14.5m$

Power required to transfer the sewage water,

P=1030×9.8×14.5×0.1157/0.75 = 22578.9watt = 22.58kW = 30.11Hp

6) Pumps for sludge transfer from the sludge tank to the slurry mixture tank:
Here the media is sludge. Hence,

Pump power P = (ϱ×g×H×Q)/η

$H = H_1 + H_2 = 3m+2m = 5m$

Power is required to transfer the sewage water,

P=1400×9.8×5×0.1157/0.75 = 10582.7watt = 10.583kW = 14.11Hp

9) Disinfection unit:

The following factors are considered for the chlorination process for best results.

1) The time period for an effective disinfection process Chlorine dosing time should be 20min. The considered time for chlorination dosing is 20min.

2) After the disinfection process there is a need for filtration to minimize the residue contents of chlorination.

3) pH level of the water while chlorine dosing should be 5 to 8.5. but in this case for 5 pH or less pH, if we try to contact chlorination there is the chance of oxidation and corrosion action on the pipeline. Here considered maintain the pH at 6.5 to 8.

4) The chlorine dosing range is 0.2 ppm to 2 ppm. Here considered 2ppm dosing for adequate disinfection.

Chlorine disinfection calculation:

Here, Flow of the water = 10MLD = 416.66 m^3/hr, Time = 23hrs, Chorine dosing mg/l = 2ppm = 2mg/l
Chlorine % in provided chemical NaOCl = 10%
Dosing pump capacity = 4LPH
Total chlorine dosing = Flow × Time × chlorine dosing × 10%

= 416.66 m^3/hr × 23hrs × 2mg/l × 0.1

= 1916.64gm = 1916.64 ml

= 1917ml ≅ 1.9litter

Total Dosing water = (Time × LPH) = 23×4 = 92litter
Total 92lit dosing chlorine water = 90.1lit water + 1.9lit NaOCl = 92lit

10) Pressure sand filter and Activated carbon filter:

For designing of sand filter, for cylindrical shape need to know the diameter & height for calculation of these both dimensions we require flow(Q) & surface overflow rate (SOR)
Flow (Q) = 10MLD
Assuming the cleaning period is 30min

In one day, we have to clean the sand filter that means for 30min the normal filtration of the sand filter will stop & for 30min we have to do the cleaning of the sand filter (backwashing). During this cleaning, extra water will be used. So, the water will be treated at 4% extra
Assume 4% of water is used in cleaning
Qactual = 1.04 Q = 1.04 × 10 ×10^3 m^3/day

$$= \frac{(1.04 \times 10 \times 10^3)}{(23.5)}$$

= 442.55 m^3/day

Assume ROF 12 m^3/m^2/hr as per the standard from the CPHEEO manual

ROF = Q/A,

Area A = Q/ROF = 442.55/12 = 36.879m^2
Now we have to calculate no of units. This area is divided into N number of filtration units.
Number of units = $1.22 \times \sqrt{Q} = 1.22 \times \sqrt{10}$ = 3.8579 ≅ 4 units
Area for 1 unit = Area/No of units = 36.879/4 = 9.219 m^2 ≅ 9m^2
For cylindrical area A = $\frac{\pi d^2}{4}$ So,

$$d^2 = \frac{(2\times9)}{(3.14)} = 11.45, \; d = 3.385 \cong 4m$$

From the diameter we can assume the height (H) 1.2 to 1.5 of diameter d,

H = 1.5 × d = 1.5 × 4 = 6m ≅ 6000mm

d = 4000mm = 4m = 157.48 inches

H = 6000mm = 6m = 236.22 inches

Therefore, the same dimensions are considered for 4 units of each Pressure sand filter and Activated carbon filter. Also, the media in each filter unit is the same volume calculated as follows,

Sand and Carbon media quantity calculations:

For sand or carbon filter has two medias

1. Supporting media (pebbles & gravels)
2. Media bed (sand/carbon)

Pressure sand filter and Carbon filter:

Considered diameter = 4m ≅ 4000mm, H = 6m

The volume of the cylindrical shell

$V = \pi r^2 h = \pi (2^2) \times 6 = 75.398\ m^3 \cong 75.4\ m^3$

For the calculation of the total water capacity of the filter,

q_w = volume × density of water = 75.4 × 1000

Total water quantity (q_w) = 75400 litter

For sand & other media calculation

Total volume of filter = 75.4 m^3

The total volume of media in the filter should be 60% of the total filter volume

V_{total} = 60% of the total volume = 75.4 × 0.6 = 45.24 m^3

Now total media volume is divided into 2 parts

1. Media bed (sand/carbon) = 60%
2. Supporting bed (pebbles & granules) = 40%

$V_{media\ bed} = 45.24\ m^3 \times 0.6 = 27.14 m^3$

$V_{supporting\ bed} = 45.24 \times 0.4 = 18.1\ m^3$

As per standards, For the quantity of supporting layer (bed) is made up of gravels & pebbles

Density of pebbles = 1880 kg/m^3 ≅ 1900 kg/ m^3

Density of gravels = 1680 kg/m^3 ≅ 1700 kg/ m^3

Average of densities = 3600/2 = 1800 kg/ m^3

Average of densities = 3600/2 = 1800 kg/ m^3

Quantity of supporting bed (pebbles & gravels) = Vsupporting × 1800 kg/ m^3 = 18.1×1800 = 32580kg

Density of sand ≅ 1500 kg/ m^3

Quantity of media bed (sand) =Vmedia×1500kg/ m^3

= 27.14 × 1500

= 40710kg

Total bed quantity = 32580 + 40710 = 73290 ≅ 73300kg

The same calculations for dimensions and media volume calculation are considered for activated carbon filter but only change in density of carbon material in calculations.

IV.Results and Conclusion:

The Capacity of the SBR treatment plant is suggested 10MLD. The sewage Treatment Plant treats the generated wastewater with Sequencing Batch Reactor (SBR) technology, which is the modified form of the activated sludge treatment method, which will be used to carry out the treatment. To treat the wastewater in batches, an SBR is equipped with 2 sequencing batch reactors. SBR will nitrify the ammonia, oxidize the biological oxygen demand (BOD), and denitrify the lowered total nitrogen to a tolerable level. Chlorine is used to first disinfect the water processed from the Sequencing Batch Reactor tank because this prevents the growth of parasites, microscopic organisms, and green growth (diverted from the reactor) in the sand filter. The coagulation and flocculation arrest the dissolved solids. After that, it is run through both tertiary filters to get rid of the colour and other remaining solids if any. The further design to be extended for drinking application with RO purification system and biogas system is also designed in the future, which will give the application-oriented result outputs.

Sr. No.	Component name	Dimensions
1	1) Settling tank 2) Bar screen	3.5m×3 m×3.5m, 3m×3.9m
2	1) Oil & Grease 2) Grit chamber 3) Equalization tank	5m×14m×12m, 5m×14m×12m, 5m×14m×12m
3	Collection tank	15m×14m×12m.
4	SBR reactor tank×2	11m×10m×11m
5	Sludge collection tank	8m Dia.× 3m
6	1) Coagulator/Flash mixer 2) Flocculator	1.5m Dia.×4.5m 4.5m Dia.×13.5m
7	Settling tank	15m Dia. × 10m
8	1) Pressure sand filter 2) Activated carbon filter	4m Dia. × 6m, 4m Dia. × 6m

Table 1: Dimensions of STP components

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