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# Proposed Wastewater Treatment Plant Design of Harihar City

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***Abstract :*** **The harihar city is located right bank of Tungabhadra River in Davangeredistrict. The existing facility with capacity of 8.8 MLD in 20 acre land on downstream side of the city. Ultimate design period is 2054 years and 1, 19,611 population with generation of 16.5 MLD wastewater. The proposed design has considered all applicable environmental, chemical and civil aspects. The proposed design includes treatment units are Receiving Chamber, Screening, Grit Chamber, Fine Screen, Skimming tank Primary Sedimentation Tank, Aeration Tank, Secondary Sedimentation tank, Stabilization tank, Sludge drying beds and Sewer pipe lines. Considered usage of Rice bran in aeration tank to decrease the bulking of Sludge volume index.**

***Keywords: Wastewater Treatment Units, Harihar, Tungabhadra River, Incremental Increase method, Environmental impact assessment,***

## 1. INTRODUCTION

Harihar city located on right bank side of the river Tungabhadra at Davanagere district. The existing facility of wastewater treatment plant are Screening, Grit chamber and waste stabilization ponds with capacity of 8.8 MLD unable to treat the chemical characteristics of the wastewater effectively and the treated effluents is discharging to Tungabhadra river. So that required to construct Physical, Chemical and Biological treatment units to save the natural water source river Tungabhadra. The project deals with the design and civil estimation of the proposed wastewater treatment plant.

### *A. Scope and Objective*

The project covers the current 7.77 sq.km of area with 31 wards of harihar city by forecasted year 2054 and population of 1, 19,611.

The objective of the project is to estimate the volume of domestic wastewater generation of Harihar city for forecasted year 2054. To design a proposed wastewater treatment plant by considering all negative and positive impacts on surrounding environment. And to reduce the contamination of river Tungabhadra by Harihar City wastewater.

## II MATERIALS AND METHODOLOGY

### *A. Back Ground:*

Harihar city is located on the right bank of the Tungabhadra River with at 14o 42' northern latitude and 75o 08' eastern longitude in Davanagere District . The existing treatment facility is located near Kirloskar Institute of Advance Management Studies, 20 acres of area north side from the city (Towards Harapanahalli). The existing treatment facilities includes 3 wastewater interception and diversions with screening and grit chamber such are in 1) Gowdegeri, 2) Matha, 3) Near Kirloskar Company and one is the wastewater treatment plant which is located near Kirloskar Institute of Advance Management Studies, capacity of 8.84 MLD with 7 number of waste stabilization pond technology, inlet and outlet arrangements, wet well, screen chamber.

### *B. Wastewater*

The wastewater sample has collected near Gowdegeri interception and diversion drainage. The sample has collected morning at 9.00 am with new sterilized 2 litres can. The pH range found 5.

### *C. Wastewater Treatment*

The wastewater treatment consists of many complex functions. The degree if treatment depends upon the characteristics of the raw inlet of wastewater as well as the required effluent characteristics.

Treatment processes are classified as:

i) Preliminary Treatment
ii) Primary Treatment
iii) Secondary Treatment
iv) Tertiary Treatment
v)

*i) Preliminary Treatment*

Preliminary wastewater treatment is the removal of solely of separating the floating materials (like dead animals, tree branches, papers, pieces of rags, wood etc.) and the heavy settle able inorganic solids. It also helps in removing the oils and greases, etc. from the wastewater. This treatment reduces the BOD of the wastewater, by about 15 to 30%.

Preliminary operations are:

• Screening - removal of debris and rags.
• Grit - removal for the elimination of coarse suspended matter
• Floatation / skimming - removal of oil and grease.

ii) Primary Treatment
In primary treatment, a portion of the suspended solids and organic matter is removed from the wastewater. The liquid effluent from primary treatment, often contains a large amount of suspended organic materials, and has a high BOD (about 60% of original). The organic solids, which are separated out in the sedimentation tanks (in primary treatment), are often stabilized by anaerobic decomposition in a digestion tank or are incinerated. The residue is used for landfills or as a soil conditioner. The principal function of primary treatment is to act as a precursor to secondary treatment.

iii) Secondary Treatment
Secondary treatment involves further treatment of the effluent, coming from the primary sedimentation tank and is directed principally towards the removal of biodegradable organics and suspended solids through biological decomposition of organic matter, either under aerobic or anaerobic conditions.

Aerobic Biological Units
i) Filters (Intermittent sand filters, trickling filters)
ii) Activated Sludge Plant (Feed of active sludge, secondary settling tank and aeration tank)
iii) Oxidation ponds and Aerated lagoons.

Aerobic Biological Units

i) Anaerobic Biological Units
ii) Septic Tanks
iii) Imhoff tanks

vi) Tertiary Treatment
The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality before it is discharged to the receiving environment are sea, river, lake, ground etc.,. More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process and it is also called as "effluent polishing".

### *D. Location of Treatment Plant*
The following points are considered during the design of wastewater treatment plant in existing site:

- All the treatment units are to be located in the order of sequence, so that wastewater from one process should directly go to other process.
- If possible all the plant should be located at such elevation that wastewater can flow from one plant into next under its forces of gravity only.
- All the treatment units should be arranged in such a way that minimum area is required it will also ensure economy in its cost.
- Sufficient area should be occupied for future extension.
- Considered all the possible impacts from the wastewater treatment plant unit during constructional and operational phase of plant.

### *E. Environmental Impact Assessment*
The study has carried out by considering all the possible causes from construction phase and operational phases.

i)Construction Phase
During the construction phase of wastewater treatment plant there few major, medium, low impacts will occur nearby environment like ground water

a. Ground Water

*Impacts:*
1. The excavation works will significantly disturb the aquifer level due to the lower elevation of the city and its effects nearby formers wells.
2. During rainy the rainwater will mixed with some waste materials and percolates to ground water table. There will be a medium impact for ground water.

*Mitigation measures:*
1. The negative impacts on the ground water must controlled effectively by avoiding or minimizing disturbance of the groundwater quality.
2. The safe drainage system, soil erosion and conservation must be prevented during excavation.
3. Regular waste disposal has to be taken care. Proper handling, storage and disposal of construction waste to be done without causing harm to ground water quality.

b. Surface Water Quality:

The proposed area of the wastewater treatment plant is near to the Tungabhadra River around 1 km. so it is very much needs to take control measures to pollute the surface water quality.

*Impacts:*
1. Probability of river water pollution due to increased surface runoff and soil erosion during excavation. May cause medium impact for Tungabhadra River quality.
2. Medium impact expected untreated wastewater treatment from the accommodation facilities into the Tungabhadra River water and improper solid waste management

*Mitigation measures:*
1. The effective waste management must be plan during construction for handling, storage and disposal of construction waste in a safe manner.
2. Minimize the earth work and excavation activities during rainy season. (From June to October) to control the polluted water runoff and to avoid the surface soil erosion.
3. Use impermeable surfaces while refilling of fuels and oils to arrest the leakage.

c. Noise and Dust:

Around 1 to 1.2 Km there are 2 city extension area's a) Harlapura b) Vijayanagar and also there is small village Guttur 2 km away from the proposed site.

*Impacts:*

1. There will be significant emission of dust and noise during construction phase. It creates lower impacts for nearby extension area's and villagers.
2. The dust will cause medium effect to cultivated lands, chances of reduce the crop yield.
3. Noise creates nuisance to the residents.

*Mitigation measures:*

1. Spraying the water on vehicle moment road and during excavation will reduce the dust generation.
2. Decrease the vehicles moment as far as possible to control the noise and dust
3. By covering the crops of farmers will reduce the dust effects on plants.

ii) Operation Phase

Constructing a wastewater treatment plant in a city will have significant positive impact to environment. In other words a plant have significant impact to surface water and ground water quality and improve the public health of the city and also socio-economic development of the project area.

a. Ground Water Quality

*Impacts:*

1. Ground water pollution due to leakage of the wastewater treatment units and effluent leakage of the units for sludge production.
2. During drying process of sludge on the drying beds, there is high possibility of ground water pollution due to infiltration of drying bed leachate. This leachate effect large negative impact ground water because the sludge may content dangerous substances.
3. The treatment plant may pollute the nearby tube wells cause the health problems for residents.

*Mitigation measures:*

1. The operation of the wastewater treatment plant will have large positive impact on the quality of ground water, as there will be no direct discharge of wastewater into surface water body.
2. Proposed measures must ensure mitigation of the large negative impacts on the ground water.

b. Tungabhadra River water Quality (Surface Water)

*Impacts:*

1. Due to the strong connection of surface water on ground water possible chance of lower negative impact due to leakage of leachate from the wastewater treatment plant.
2. If the plant is not worked properly as it is designed for.
3. If the failure of the treatment units will discharge wastewater without effective treatment on to Tungabhadra river.

*Mitigation measures:*

1. Plan the proper drainage system for leachate discharge from the sludge drying beds.
2. Frequent monitoring and inspection of WWTP to arrest the leakages of units and to control the working condition of units.
3. The proper working system of WWTP will prevent the large negative impacts on river Tungabhadra.

c. Public Health

*Impacts:*

1. Local public will get work during construction and operational phases of wastewater treatment plant. It will improve the economic condition of the city slightly.
2. In spite of that there is medium impact on WWTP workers during sludge removal and cleaning of treatment units.

*Mitigation measures:*

1. City municipal must ensure the treatment plant workers must be trained for applying safety measures during cleaning and inspection. Addition to that city municipal must provide adequate clothing, tools and safety equipment to them

d. Nuisance (Noise, Odour and Vermin)

*Impacts:*

1. The generation of noise will be less during operational, the noise from only pumps and motors. These will create nuisance only for very closures such as for brick factories.
2. Probability of mosquito breeding place in aeration tank, sludge drying beds and channels during summer season.
3. There is low level of odour impact for nearby farmers and brick factories. And also chances of odour to residents like Old Harlapura, AK Colony and Vijaynagar during winter.

*Mitigation measures:*

1. During the summer months some bio-enzymes or pest controls will be used for suppressing the mosquito breeding and insect breeding.
2. Frequent removal of sludge, grease and oil traps to be done. It helps to reduce the impact of odour and vermin formation at plant.
3. Since the residents are not closure to wastewater treatment plant chance of odour impacts are negligible.

e. Soil

*Impacts:*

1. When unsatisfactorily treated effluents are released for the plant, these might contaminate soil.
2. If the sludge, grease and oil waste are not properly handled and managed at site can cause the contamination of nearby soil and create unsightly condition.

*Mitigation measures:*

1. The treatment plant staff must be well trained for waste management like greases, sludge and oil to avoid soil pollution.
2. Periodic test will be done to assure the quality of wastewater treatment plant effluent to avoid partially treated effluent to reach the soil.

f. Flora

*Impacts:*

1. During the construction will affect medium on flora.
2. Operational phase of wastewater treatment plant, the discharged effluent will effect to flora only if the plant not working properly

*Mitigation measures:*

1. Ensure that, the wastewater treatment plan operate properly. Effective wastewater treatment plant management must be carried.

g. Fauna

*Impacts:*

1. Effluent of treatment plant will have lower impact on the soil microorganisms, particularly beyond the immediate vicinity of the wastewater treatment plant.
2. In dry season, the plant effluent can become a water source for the birds.

*Mitigations measures:*

1. Tree planation at site by using wastewater effluents
2. Effective management of wastewater treatment plant units will avoid the improper treatment of effluents.

## *F.Population Forecasting*

There are 9 standard methods available for calculation of population forecasting. Here used a simpler and commonly used incremental increase method for population forecasting for future 4 decades.

Table 1: Characteristics of Raw Wastewater

| Sl No | Parameter | Raw wastewater | Environmental Protection Act 1986 Effluent Standard on Inland Surface water |
|---|---|---|---|
| 1 | pH | 5 | 5.5 - 9 |
| 2 | $BOD_5$ | 320 mg / l | 30 mg/l |
| 3 | TSS | 469.5 mg/ l | 30 mg / l |
| 4 | COD | 550 | 250 mg / l |
| 5 | Oil and grease | 42.31 mg/ l | 10mg / l |



## *G.Receiving Chamber*

Q = A x v

A = V / depth

Q = Wastewater flow

v = Velocity in m / sec

## H.Screening

Q = A / v

The gross area of the screen needed = Gross area required / sin $60^0$

NO. Of spacing = Gross area needed / Clear spacing of one bar

Aerated Volume = Peak Flow x Detention Time

Volume of one Chamber Va = V / 2

## J.Fine Screen

The gross area of the screen needed = Gross area required / sin $60^0$

NO. Of spacing = Gross area needed / Clear spacing of one bar

V = Volume of the tank

A = Area of the tank

L = Length of the tank

B = Breadth of the tank

Width of the channel = (No. of spacing x distance of the each spacing in mm) + (No.of bars x size of the bars in mm)

Depth of channel = Gross area needed / width of the channel

## I. Grit Chamber

Width to depth ratio 2:1

Width of the channel = (No. of spacing x distance of the each spacing in mm) + (No.of bars x size of the bars in mm)

*K. Skimming Tank*

$A = 0.00622 \times q / v_r$

Add chlorine gas 2 mg / l of sewage

q = Rate of flow of sewage in Cum / day

$v_r$= Minimum rising velocity of greasy material to be removeed in m/ miniute

Length breadth rationn 1.5 : 1

L. Primary Sedimentation Tank

Volume of the tank V= Q x DT

Surface area required = V / D

Surface area the tank = Total flow / surface loading rate

Consider the greater area out of two calculated

Area of tank $A = \pi d^2 / 4$

*M. Aeration Tank*

Assume 20 % BOD removal at grit chamber

Volume required for tank $V = QxY_o / F/M \times X_t$

$F/M = Q \times Y_o / V \times Xt$

MLSS: $X_t$ = Mixed liqiud suspended soilds

$Y_0$ = BOD inlet

$Y_E$ = BOD outlet

F / M = Food to Micro-organisms

$\alpha_y$ = 0.5 constant for municiple sewage with respect to MLSS

Xt = 3000 mg/l Ke = 0.06 $d^{-1}$ constant for municiple sewage

I) Check for detention period / HRT

Time t = V / Q x 24

II) Check for volumetric loading

Volumetric loading = Q x Yo / V

III) Check for return sludge ratio

Return activated sludge = $Q_R / Q = Xt / (10^6 / S.V.I - Xt)$

Where S.V.I. = Sludge Volume Index

$Q_R$= Sludge recirculation rate

IV) Check for S.R.T. (ɵc) :

$V. Xt = \alpha_y . Q (Yo - Y_E) ɵ_c / 1 + Ke.ɵ_c$

V) Aerators Calculation :

Oxygen to be applied in each tank =Avg. Flow x Peak Oxgen Demand

HP of aerators required = Oxygen to be applied in each tank / Oxgen transfer capacity aerators

VI) Utilization of Rice Bran

Quantity of rice bran = Rice bran in mg per liter x Quantity of wastewater flow

N. Secondary Sedimentation Tank

Total flow = Avereage flow + Recirculation ratio

Area A = Volume / liquid depth

Assume circular tank $A = \pi d^2 / 4$

Volume of the tank V = Total flow x DT

I) Check for weir loading :

Length = $\pi$ x d  d = diameter of the secodnary sedimentation tank

II) Check for solid loading rate

STABILIZATION TANK :

Volume of tank V = Qr x DT

Total return flow Qr

O. Sludge drying bed

Load to the secondary sedimentaion tank = Total feed suspended solids - Total outlet suspended solids

Area of bed required = Volume of sludge per cycle / depth of spreading layer

Sludge applied = Q x Load to the secondary sedimentaion tank

Volume of sludge = Sludge applied / Solid content x 1000 x specific gravity

Voulme of sludge per cycle = Volume of sludge x period of each cycle

P.Design of Sewer Pipe Line

Hydraulic Radius R = A / P = $\pi$ $d^2$ / 8 / $\pi$ d

R = d / 4

Discharge through pipe line Q = A x v

Cross section area of sewer pipe line A = $\pi$ $d^2$ / 4
Cross section area of sewer line has calculated by considering the lines are running half full

A = $\pi$ $d^2$ / 8

Manning's Formula: v = 1 / n $R^{2/3}$ $S^{1/2}$
Where, n = Manning's Constant assume for CC sewer = 0.013
R = Hydraulic Radius
S = Slope

Wetted Perimeter P = $\pi$ d

## III RESULTS AND DISCUSSIONS

Table 2: Population of Forecasted years

| Sl No. | Year of Forecasted | Forecasted Population in Numbers |
|---|---|---|
| 1 | 2014 | 80,499 |
| 2 | 2024 | 90,277 |
| 3 | 2034 | 1,00,055 |
| 4 | 2044 | 1,09,883 |
| 5 | 2054 | 1,19,611 |

At a design of 2054 years the forecasted population of the harihar city is 1, 19,611
The design of wastewater treatment is for the period of 2054 and the estimated quantity of wastewater 16.5 MLD

1. The dimension of receiving chamber is 5.0 x 2.5 x 3.5 m, Earth work excavation 64.232 Cubic meter, PCC 3.472 Cubic meter and RCC walls 17.01
2. The dimension of Screen chamber width 1.3 m and depth 1.0 m
3. The dimension of grit chamber with aeration is 6.66 x 3.6 x 2.55 m. Earth work excavation 167.06
4. Cubic meter, PCC 12.30 Cubic meter and RCC 33.231 Cubic meter
5. The dimension of fine screen width 3.2 m and depth 1.3 m
6. The dimension of skimming chamber 1.2 x 0.80 x 3.50 m. Earth work 9.12 Cubic meter, PCC 0.50 Cubic meter and RCC 1.70 Cubic meter
7. The dimension of primary sedimentation tank diameter 24 m and depth 4.0 m. Earth work excavation 1757.70 Cubic meter, PCC 95.010 Cubic meter and RCC 81.106 Cubic meter
8. The dimension of Aeration tank 87 x 6 x 3 m. Earth work excavation 3700 Cubic meter, PCC 231.264 cubic meter and RCC 81.106 Cubic meter
9. The dimension of secondary sedimentation tank 29 diameter 4 m depth. Earth work excavation 2888.70 Cubic meter, PCC 137.57 cubic meter and RCC 111.60 Cubic meter

10. The dimension of sludge drying beds 30 x 23 x 0.35 m (16 number of beds). Earth work excavation 2888.70 Cubic meter, PCC 137.57 cubic meter and RCC 111.60 Cubic meter

## CONCLUSION

The technical project involves integration of various fields. This report has combined all the aspects of environmental, chemical, biological and civil engineering. The plant is designed to meet future expansion for the next 40 (2054) years, population of 1, 19,611. This project consist the design of the complete components of a wastewater treatment plant from receiving chamber, screening chamber, grit chamber, fine screen, primary sedimentation tank, secondary sedimentation tank, activated sludge tank and sludge drying beds and sewers systems with civil estimation.

The construction of Wastewater treatment plant will prevent the direct disposal of wastewater from Harihar city into Tungabhadra River and the usage of treated water will reduce the surface and ground water contamination.

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