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Augmentation of Sewage Treatment Plant (STP), in the Vicinity of Gwalior (M.P.)

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***Abstract:** The increase in population of Gwalior city is observed as a result of the development of the modern societies. It is accompanied with the concern in water sector, which is a result of the increasing requirements for water supply and wastewater treatment. This situation justifies the evaluation of the system performance of existing sewage treatment plant (STP) that covers protection of water resources and its management.*

Poorly treated wastewater with high levels of pollutants caused by poor design, operation or maintenance of treatment systems, creates major environmental problems, when it is discharged into surface water or on land. Considering the above stated implications an attempt has been made to evaluate the performance of Sewage treatment plant (STP) near Morar area in Gwalior city having Plant capacity of 12 MLD.

To evaluate performance of sewage treatment plant (STP), Samples were collected after each units (Screening, Grit chamber & Facultative pond).

The performance efficiency of each units in treating the pollutants and overall performance of the plant has been estimated to know how efficiently the plant is working. The obtained results were very much useful to decide efficiency of STP. According to the analysis it is observed that sewage treatment plant is not working properly. Performance of treatment plant is also checked by design calculation of BOD removal for most critical season (i.e, in winter season).

Obtained results reveals that plant worked properly when operation of plant started i.e, in 2010 (Treated effluent BOD was 21.87mg/l). It is envisaged that sludge never been removed, which results in increase in the BOD value of effluent (BOD value in current scenario is 102.7mg/l).

In the study it is worked out that even by removing 90% of accumulated sludge, its treatment efficiency can not satisfy the standard norms of disposal of sewage in surface water (worked at treated effluent BOD value is 37mg/l>30mg/l). Therefore it is suggested that sludge removal is not a enough solution. Hence augmentation of treatment plant deemed to be necessary. In the present study augmentation is carried out for future population i.e, in 2040 (means after 20 years). In the suggested augmentation, it is proposed to divide existing stabilization pond in two ponds having 2/3rd and 1/3rd volume using an earthen embankment along the width.

The larger pond (receiving sewage from grit chamber) is converted in to aerated lagoon and second part having 1/3rd volume is used as settling cum maturation pond. It is proposed to provide 33 surface aerators each of 12HP to oxidized the organic material. Detention period of aerated lagoon worked out as 05 days. Maturation pond is suppose to remove sediments, suspended particles and pathogenic bacteria.

Thus treated waste water can be safely disposed off and effectively used for irrigation or some other purpose also as BOD of treated effluent using augmented proposal is approximately 20mg/l.

Keyword: Sewage treatment plant, Effluent BOD, Performance efficiency, Detention period

I. INTRODUCTION

Sewage treatment is the process of removing contaminants from industrial wastewater and municipal sewage. Its objective is to produce an environmentally safe fluid waste stream and a solid waste suitable for disposal or reuse.

The procedure for removing contaminants from the wastewater basically from the domestic sewage is called as sewage treatment. It has to undergo the chemical, physical and biological procedure to remove these contaminants and give out an environmentally safe treated effluent. This treated effluent is disposed off by suitable method. A semi-solid slurry called the sewage sludge is the by-product of the sewage treatment. This sludge is further processed before it becomes suitable for land application/disposal.

Sewage collected in municipal waste water system contains a wide variety of contaminants.

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Commonly found contaminants with their source and environmental significance are listed below.

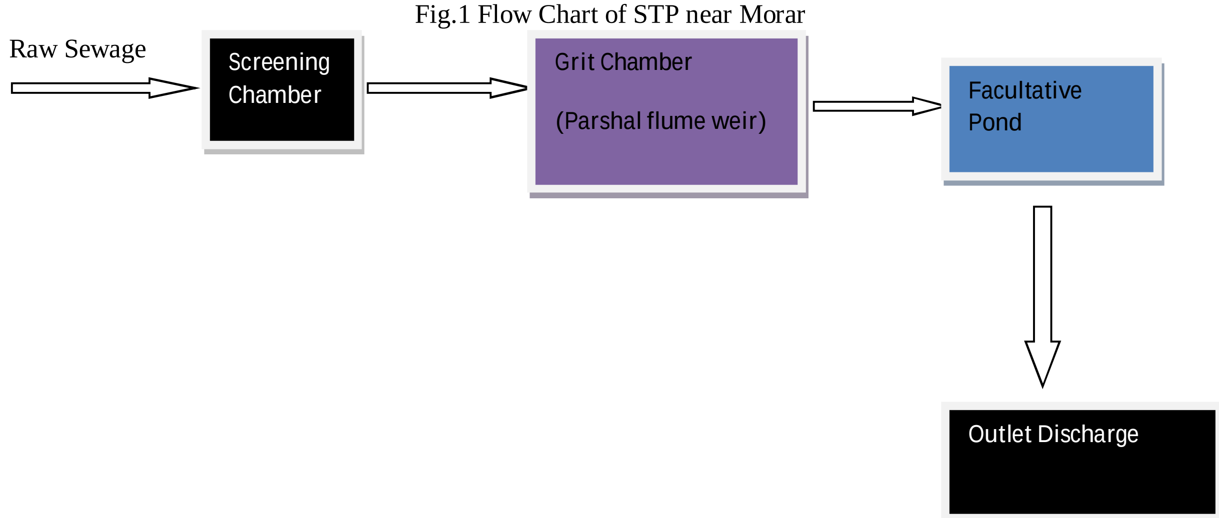
Table1: Important Waste Water Contaminants

S.No.	Contaminants	Source	Environmental significance
1	Suspended solids	Domestic use, Industrial waste	Cause sludge deposits and anaerobic condition in aquatic environment, reduces permeability of river bed.
2	Biodegradable organics	Domestic use, Industrial waste	Cause biological Degradation, D.O depletion
3	Pathogens	Domestic use, Industrial waste	Transmit communicable Disease
4	Nutrients	Domestic use, Industrial waste	Cause eutrophication
5	Refractory organics	Domestic use, Industrial waste	Cause taste and odour problems, causes health issues & detrimental to aquatic life.

II. MATERIALS AND METHODOLOGY

In present study performance evaluation of sewage treatment plant is carried out. The STP under consideration is situated near Morar area of Gwalior city. This STP consists of Coarse Screen, Grit Chamber and Stabilization pond. Flow chart of existing STP is mentioned in fig.1

Fig.1 Flow Chart of STP near Morar



Above mentioned treatment plant was commissioned during 2010. The project for this STP was prepared during 2005 for 15 years design period. Raw sewage is allowed to pass through screen chamber (Bar Screen) to remove coarse floating material from sewage. Then Screened sewage is treated in Grit Chamber with Parshall flume as velocity control device. Coarse inorganic impurities of specific gravity 2.5 and higher and size 2mm and higher are removed in Grit Chamber. Raw sewage containing soluble and suspended impurities are treated with stabilization pond/ facultative pond where removal of sediments and soluble BOD is done using bacterial-algae symbiosis. No disinfection or nutrient removal is practiced. Presently treated sewage from stabilization pond is used partially for irrigation purpose and unutilized sewage is discharged into Ghasmandi drain which finally joins morar river within 3-4Km reach. Hence in present scenario, the effluent shall satisfy the disposal norms for disposed by dilution. It is also envisaged that since the commissioning of plant, sludge removal is not being done. Following are the dimensions of various treatment units.

1) *Screen:* 2 no's of Screen chamber is provided with manually cleaned bar rack of medium size. Width of the each screen chamber is 1.6 m and depth is 2 m. The bars are rectangular sharp edged having clear spacing of 25 mm. and inclined at 60º with horizontal.
2) *Grit Chamber:* Grit chamber with parshal flume weir is a rectangular tank with 4.5 m x 10 m sides and 1.2 m depth.
3) *Stabilization Pond:* Stabilization pond is a rectangular pond having 655m length, 130m width and 1.6m depth.
4) *Pumps:* Plant has installed 08 pumps of 75 HP capacity and 02 pumps of 40 HP capacity to pump the raw sewage.

Under present scenario there is a need to evaluate performance of STP. After performance evaluation if it is observed that treated effluent is not satisfying disposal norms then some suitable augmentation of STP will be suggested to meet the effluent norms.

For performance evaluation of Morar STP and subsequently giving some suggestions for improvement/ augmentation. Following material and methods are used:

a) Determination of present population of area served and sewage contribution per capita.
b) Evaluation of performance of STP in present scenario of current population and available effective depth of facultative pond.
c) Performance is evaluated by determining concentration of important waste water parameters pH, TDS, TSS, BOD, COD, and Chloride in raw sewage and after other treatment units.
d) To compile concentrations of chemical parameters of sewage 4 set of samples are collected, each set of sample contains 6 numbers of sewage samples comprising of raw sewage and sewage, after Screening, after grit chamber and finally after facultative pond (i.e, treated effluent). Samples were collected using suitable procedure of sampling.
e) Each sample of sewage was analyzed on the same day (within 4 hours) in the laboratory for determination of below mentioned parameters and using mentioned methods.

Table 4.2: Methods used for the analysis

S.No.	Parameters	Method adopted
1	pH value	Potentiometric method
2	TDS	Gravimetric method
3	TSS	Gravimetric method
4	BOD	Titrimetric method
5	COD	Closed Reflux method
6	Chloride	Argentometric method

f) On the basis of characterization the performance of STP is evaluated in present scenario.
g) BOD removal efficiency is also mathematically calculated after 90% removal of sludge that has accumulated in the pond since the commissioning of the pond. Suitable design guide lines/ design parameters are used to work out efficiency of BOD removal as mentioned in literature.
h) If the BOD removal of STP after removal of sludge is not found to be satisfactory then some suitable augmentation strategy will be suggested.
i) If augmentation is found necessary, then proposal for augmented treatment plant will be given for 20 years design period i.e, to meet the requirements of expected population in 2040.

III. OBSERVATIONS AND RESULTS

Table 5.1: Analysis of the pH value

Date	Raw	Screening		Grit Chamber		Facultative pond	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
2 Dec 2019	7.61	7.61	7.61	7.61	7.59	7.59	7.49
18 DEC 2019	7.62	7.62	7.61	7.61	7.57	7.57	7.45
8 Jan 2020	7.53	7.53	7.52	7.52	7.47	7.47	7.34
23 Jan 2020	7.54	7.54	7.54	7.54	7.51	7.51	7.40
7 Feb 2020	7.5	7.5	7.51	7.51	7.48	7.48	7.37
21 Feb 2020	7.68	7.68	7.63	7.63	7.56	7.56	7.41`

Table 5.2 : Analysis of Total Suspended Solids (TSS) value (in mg/l)

Date	Raw	Screening		Grit Chamber		Facultative pond	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
2 Dec 2019	761	761	717	717	453	453	301
18 DEC 2019	767	767	719	719	451	451	305
8 Jan 2020	759	759	713	713	467	467	309
23 Jan 2020	741	741	707	707	471	471	318
7 Feb 2020	738	738	698	698	441	441	301
21 Feb 2020	746	746	694	694	461	461	308

Table 5.3 : Analysis of Total Dissolved Solids (TDS) value (in mg/l)

Date	Raw	Screening		Grit Chamber		Facultative pond	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
2 Dec 2019	1635	1635	1635	1635	1635	1635	1218
18 DEC 2019	1613	1613	1613	1613	1613	1613	1225
8 Jan 2020	1611	1611	1611	1611	1611	1611	1211
23 Jan 2020	1601	1601	1601	1601	1601	1601	1199
7 Feb 2020	1634	1634	1634	1634	1634	1634	1198
21 Feb 2020	1614	1614	1614	1614	1614	1614	1167

Table 5.4 : Analysis of Biochemical Oxygen Demand (BOD) Value (in mg/l)

Date	Raw	Screening		Grit Chamber		Facultative pond	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
2 Dec 2019	245.8	245.8	241.8	241.8	215.1	215.1	94.1
18 DEC 2019	241.2	241.2	233.2	233.2	211.4	211.4	96.2
8 Jan 2020	234.5	234.5	230.5	230.5	214.2	214.2	82.4
23 Jan 2020	239.1	239.1	231.1	231.1	209.6	209.6	86.2
7 Feb 2020	240.7	240.7	232.7	232.7	210.5	210.5	92.1
21 Feb 2020	260.3	260.3	253.3	253.3	220.8	220.8	104.9

Table 5.5: Analysis of Chemical Oxygen Demand (COD) value (in mg/l)

Date	Raw	Screening		Grit Chamber		Facultative pond	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
2 Dec 2019	298.2	298.2	298.2	298.2	265.2	265.2	110.4
18 DEC 2019	301.1	301.1	301.1	301.1	268.7	268.7	107.3
8 Jan 2020	296.7	296.7	296.7	296.7	266.6	266.6	112.2
23 Jan 2020	292.4	292.4	292.4	292.4	258.1	258.1	101.3
7 Feb 2020	289.1	289.1	289.1	289.1	269	269	112.3
21 Feb 2020	311.1	311.1	311.1	311.1	264.26	264.26	105.22

Table 5.6: Analysis of Chloride value (in mg/l)

Date	Raw	Screening		Grit Chamber		Facultative pond	
		Influent	Effluent	Influent	Effluent	Influent	Effluent
2 Dec 2019	138.2	138.2	138.2	138.2	131.3	131.3	112.5
18 DEC 2019	134.4	134.4	134.4	134.4	130.6	130.6	112.1
8 Jan 2020	129.2	129.2	129.2	129.2	127	127	102.6
23 Jan 2020	112.8	112.8	112.8	112.8	110.1	110.1	92.3
7 Feb 2020	141.3	141.3	141.3	141.3	136.3	136.3	119.1
21 Feb 2020	140.9	140.9	140.9	140.9	134.5	134.5	115.4

Table 5.7 : Removal efficiency of effluent of each units

S.No.	Parameter		Units	Sewage Treatment Units		
				Screening	Grit Chamber	Facultative pond
1	pH	Influent	-	7.58	7.57	7.53
		Effluent	-	7.57	7.53	7.41
		Removal Efficiency	%	0.13	0.53	1.60
2	TDS	Influent	mg/l	2318	2318	2318
		Effluent	mg/l	2318	2318	1803
		Removal Efficiency	%	0.00	0.00	22.20
3	TSS	Influent	mg/l	752	708	457.3
		Effluent	mg/l	708	457.3	307
		Removal Efficiency	%	5.85	35.4	32.86
4	BOD	Influent	-	243.6	243.6	224.1
		Effluent	-	243.6	224.1	92.65
		Removal Efficiency	%	0.00	8.00	58.60
5	COD	Influent	mg/l	298.1	298.1	265.31
		Effluent	mg/l	298.1	265.31	106.12
		Removal Efficiency	%	0.00	11.00	60.00
6	Chloride	Influent	mg/l	132.8	132.8	128.3
		Effluent	mg/l	132.8	128.3	109
		Removal Efficiency	%	0.00	3.40	15.04

According to this analysis it is observed that plant is not working properly under present scenario. Efficiency of existing treatment is also worked out as per design guide lines to cross verify the results obtained.

A. Calculation for BOD Removal under Present Scenario

Population of Morar area (in 2010) = 89,600 (FROM MP GOVT. SITES)
WATER DEMAND = 135lpcd, CONVERSION FACTOR = 0.8
Discharge (Q) = 89,600×135×0.8 = (9.7×10^6) L/d. ≈ 9.7MLD
Influent BOD entering in the existing STP = 213.6 mg/l.
Applied BOD5 (at 20⁰C) value (in Kg/d) = 213.6×9.7 = 2071.92Kg/d
Dimension of the pond (in m.) = 655(L)×130(B)×1.6(D)
Volume of the tank = (655×130×1.6) ⇒ 1,36,240 m^3
Detention time (T) = V/Q ⇒ (1,36,240 m^3) /(9700 m^3/d) ⇒ T = 14.04 days ≈ 14 days.

B. Calculating Ultimate BOD

Yo = (Y) / (1-10^(-Kd× t)) ⇒ Yo= (213.6mg/l) / (1-10^(-0.1/d×5d)) ⇒ Yo= 312.4mg/l (taking Kd=0.1/d at base 10)

C. Calculation of mean temperature of Gwalior.

1) At Winter Season

Min. avg. temperature of Gwalior in January month (i.e, in winter season) = 7⁰C.
Max. avg. temperature of Gwalior in January month (i.e, in winter season) = 25⁰C.
Avg. temperature of Gwalior in winter season = 16⁰C.

2) At Summer Season

Min. avg. temperature of Gwalior in June month (i.e, in summer season) = 26⁰C.
Max avg. temperature of Gwalior in June month (i.e, in summer season) = 42⁰C.
Mean temperature of Gwalior in summer season = 34⁰C.
(from source of times of india sites)
Thus winter season is a most critical season from the point of view of Sewage treatment.
Mean temp. of Gwalior city in winter season = 16⁰C
KD 16⁰C = [KD20⁰C (1.047)^(T-20)] ⇒ KD 16⁰C = 0.1×(1.047^(16-20)) ⇒ 0.083
Detention time of the tank = 14days
BOD removed after 14 days (Y) = Y0[1-10^(-KD×T)] ⇒ Y = 312.4 [1-10^(-0.083×14)] ⇒ 290.53mg/l
BOD of effluent after 14 days = 312.4-290.53 ⇒ 21.87mg/l ≈ 20mg/l.
(Ok, performance is satisfactory when plant was commissioned.)
Which is just equal to 20mg/l, and is permissible for surface water (as per IS 2296-1992)
Since the commissioning of the plant (2010), accumulated sludge has never been removed. This has resulted in to accumulation of huge amount of sludge at the bottom of the pond resulting in to reduce effective depth thereby the detention time of sewage is likely to get reduced considerably. This reduced detention time will cause higher BOD of treated effluent. Following is the calculation for expected value of effluent BOD during present scenario.
Calculation of BOD removal in present scenario-
Present population = 1,12,000 (in 2020)
Discharge = (1,12,000×135×0.8) ⇒ Q = 12.09×10^6 L/d ≈ 12MLD
Sludge accumulation rate = 0.07 m^3/c/y. (FROM SOURCE OF CPHEEO MANUAL)
Total Sludge accumulated =(0.07 × avg. population × no. of years) ⇒ 0.07×[(1,12,000+89,600)/2] ×10 ⇒ 70,560m^3
Accumulated sludge depth = V/A ⇒ (70,560 m^3/85,150 m^2) = 0.8m.
Remaining effective depth of pond = (1.6-0.8) ⇒ 0.8m.
Effective detention period (T) = V/Q ⇒ T = (85,150m^2×0.8m/12,000 m^3/d) = 5.7d
In present scenario BOD removed can be worked out as (at 20⁰C)
Y = Y0[1-10^(-Kd×t)] ⇒ Y = 312.4[1-10^(-0.083×5.7)] = 209.3 mg/l
BOD of effluent after 5.7 days detention period = 312.4-209.3 ⇒ 103.1 mg/l.
Which is more than 20 mg/l (permissible value of BOD of treated effluent for disposal in surface water as per IS 2296-1992)
Hence it is not permissible for disposal in surface water source. (by Dilution)

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Following steps are suggested to resolve the issue.

a) Remove 90% of accumulated sludge of the stabilization pond and find efficiency of BOD removed.

b) If in step1 treatment efficiency is not adequate, then suggest some suitable augmentation scheme considering 20 years design period, i.e. for population in 2040.

Step1 Because sludge accumulated in 10 years is very high (0.8m), hence remaining effective depth of pond is 0.8m. If 90% sludge is removed then the BOD of effluent is worked out as follows:

Volume of the sludge removed = 0.9×70,560 (90% of total sludge volume accumulated) ⇒ 63504m^3

Depth of sludge removed = V/A ⇒ 63504 m^3/85150 m^2 = 0.72m

Remaining depth of the pond = 0.8+0.72 ⇒ 1.52m

After sludge removing detention time of the pond = (85,150 m^2×1.52m) /(12000) ⇒ 10.8days

BOD removing after detention period 10.8 days (Y) = Y0[1-10^(-Kd×t)] ⇒ Y = 312.4 [1-10^(-0.083×10.8)] = 274.9mg/l

BOD of effluent after 10.8 days detention period = 312.4 - 274.9 ⇒ 37.5 mg/l

(i.e Treated effluent BOD > 20 mg/l permissible value for disposal in surface water as per IS 2296-1992)

As per first stage calculation it is suggested that sludge removal is not a adequate solution. So we need augmentation of treatment plant.

Step2 When augmentation is carried out, we have to spend considerable expenditure. Therefore it is suggested to augment the treatment plant for future population in 2040 (20 years after). If we provide other plants like (Trickling filter, ASP, Oxidation ditch etc.) it will be very costly, but if we provide some mechanical aerators in this pond (design as aerated lagoon) it will be cheaper than others and may satisfy all the disposal norms and existing infrastructure can be used effectively.

D. Augmentation of the Plant by Designing as Aerated Lagoon for 20 Years Design Period (Year 2040)

Present population of area served = 1,12,000

Population of area forecasted for 20 years (by average increase method) =1,12,000+(2.5×1,12,000×20/100) ⇒ 1,68,000 (since population growth rate of Gwalior is approx. 2.5%) (from the source of mp govt. sites of past 50 years data record.)

Sewage Discharge after 20 years design period (Q) = 1,68,000×135×0.8 ⇒ 18.14×10^6 L/d ≈ 18 MLD

1) Design of Grit Chamber for Additional Discharge.

Sewage discharge (Q) = 18MLD

But 12MLD flow is treated by existing grit chamber, in new chamber balance sewage discharged is treated as 18-12=6 MLD.

Design grit chamber for maximum discharge i.e, 6MLD×2 = 12MLD (Considering Peak factor as 2).

Thus new chamber is designed for 12MLD design discharge.

Flow through velocity (Vh) = 0.20m/s (assumed) (range between 0.15m/s-0.3m/s as per CPHEEO manual)

Settling velocity (Vs) = 0.025m/s (assumed) (because for particle size 0.2mm, Vs=0.025m/s)

Plane area of grit chamber (B×H) = 12MLD (Q) / 0.2 m/s (Vh) ⇒ 12000 (m^3/d) / (0.2×24×3600) (m/d) = 0.7m^2

Assume depth (H) = 0.8m, (provide 0.3m as free board), Width (B) = 0.88m ≈ 0.9 m

Area (L×B) = 12MLD(Q) / 0.025mps(Vs) ⇒ 12000(m^3/d) / (0.025×24×3600) (m/d) = 5.6 m^2

Length of the chamber (L) = 6.3m. (Providing 20% additional length for inlet and outlet turbulence.)

Total length of the chamber (L) = 6.3×1.2 ⇒ 7.56m ≈ 8m. (ranges between 3-25m.), (L×B×H = 8m×0.9m×1.1m)

Detention period of the chamber = (6.3×0.9×0.8) / (12000) ⇒ 33sec (ranges between 30-60sec.)

2) Justification of Augmentation.

Area of the stabilization pond = 85,150m^2 & Depth of the pond = 1.6m, Volume of the pond = 1,36,240 m^3,

Sewage Discharge (Q) = 18 MLD.

Since there is no recycling that's why Hydraulic retention time (HRT) (ϴ) = V/Q ⇒ 1,36,240m^3 / 18000m^3/d = 7.5 days.

Since range of HRT for aerated lagoon is in between 3-6 days, hence we provide 5 days retention time.

volume of the lagoon (V) = ϴ×Q ⇒ 5×18000 = 90,000m^3, Length of the pond (L) = V/(B×D) ⇒ 90,000/(130×1.6) = 433 m.

Thus we can provide aerated lagoon of size 433m (L) & 130m (B) & 1.6m (D).

And remaining volume (1,36,240-90,000 = 46,240m^3) of pond is used as a settlement pond cum maturation pond for sludge settling and removal of pathogens algae and nutrients with detention period is 2.5 days approximately.

E. Design of Aerated lagoon

Volume of the lagoon(V) = 90,000m³, Surface area of lagoon (A) = 433×130 ⇒ 56,290m²

1) Compute Wastewater Temperature.

Tw = (As × f × Ta + Q × Ti)/(As × f + Q)

Where, Tw = Lagoon wastewater temperature ºC, As = Surface area, m² (56,290 m²),

Ta = Mean monthly temp. (in summer 34ºC & in winter 16ºC),

Ti = Influent wastewater temp. ºC (24ºC in summer and 18ºC in winter)

Q = Wastewater flow rate, m³/d (18MLD), f = Proportionality factor (assume 0.5)

a) Wastewater temperature in summer,

Tws = [(56,290×0.5×34)+(18000×24)]/[56,290×0.5+18000] ⇒ 29.5ºC

b) Wastewater temperature in winter,

Tww = [(56290×0.5×16)+(18000×18)]/[56,290×0.5+18000] ⇒ 16.78ºC

2) Compute effluent BOD in Aerated Lagoon

We can determine it by using following equation

S = [Ks×(1+Kd×ϴ)]/[(YK-Kd)×ϴ-1] (source from Metcalf and Eddy book)

Ks = Substrate conversion factor half velocity constant = 90mg/l (for domestic sewage). (range between 25-100)

Kd = Endogenous decay coefficient = 0.08/d, (range between 0.06 to 0.15), Y = Yield coefficient = 0.4, (range between 0.4-0.8)

K = Maximum substrate utilization rate constant = 4 /d, (ranges between 2-10)

S = [90×(1+0.08×5)] / [(0.4×4-0.08)×5-1] ⇒ 19.09mg/l ≈ 19 mg/l

3) Compute the Concentration of Biological sludge (MLVSS) Produced in the Reactor

From VX = [Y×(Si-S)Qo×ϴ]/(1+Kd×ϴ)), (V = Q × ϴ)

X = [Y×(Si-S)] / (1+Kd×ϴ) ⇒ X = 0.4×(213.6-19)/(1+0.08×5) = 55.6 mg/l

4) Compute Oxygen Requirement

Neglecting the oxygen required for nitrification, the oxygen needed to stabilize only carbonaceous organic compounds is determined as under.

First calculate the mass of ultimate BOD utilized per day,

BODu (O_2 equalized) = (Qo×(So-S)/f) ⇒ 18×10^6 L/d × (213.6-19)(mg/l) / 0.68 ⇒ 5151.2 Kg/d

(Where f = factor for converting BOD5 to BOD ultimate ≈ 0.68)

Now, compute oxygen required/d

O_2 required/d = (Mass of O_2 equalized) – 1.42 × (Mass of Biomass wasted)

O_2 (Kg/d) = 5104.6 - 1.42 (Q×X)) ⇒ 5151.2 – 1.42 (18×10^6) L/d × 55.6 (mg/l)) ⇒ 3730 Kg/d

5) Compute the Power Required for Supplying Desired Oxygen each Day

Surface aerator power requirement for winter and field operating conditions is computed by the following relation:

Nf = N0×[βCs(temp, alt)-CL]/Cs × (1.02)^(T-20)×α

Where, Nf = Oxygen transfer rate at field condition (Kg O_2/HP-h)

N0 = Oxygen transfer rate at standard conditions and Zero dissolved oxygen in tap water (Kg O_2/HP-h), (assume 1.7)

β = Salinity correction factor (assume 1), α = Correction factor for oxygen transfer for wastewater (0.95)

CL = Oxygen concentration to be maintained in the aeration tank during operation. (1ppm)

Cs = Oxygen concentration in tap water at 20ºC. (9.2ppm), T = Operating temperature, ºC (16.78ºC).

Cs(temp, alt.) = Oxygen saturation concentration for tap water at field temperature and altitude(ppm).

Oxygen saturation concentration at 16.78ºC = 9.75 & Altitude of Gwalior is 211m thus correction factor (f) = 0.92

Cs(temp., alt.) = 0.92×9.75 ⇒ 8.97ppm

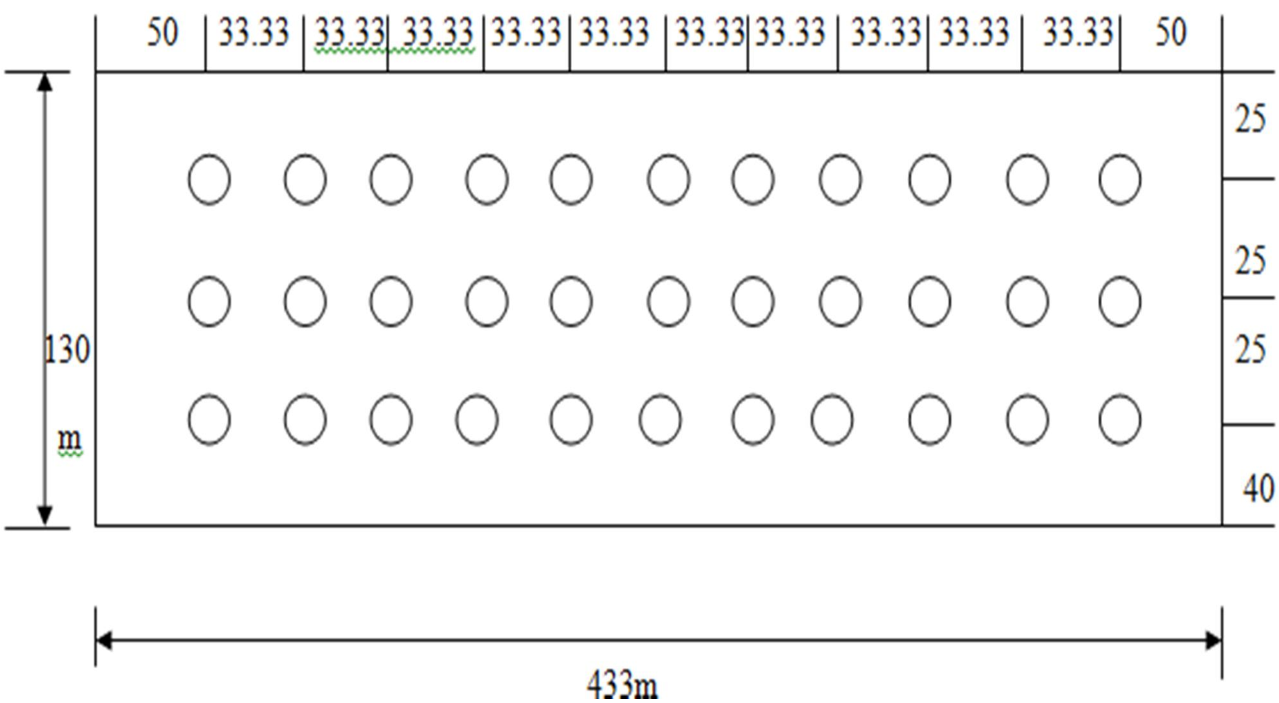
Nf = 1.7×[(1×8.97-1)/(9.2)] × 1.02^(-3.22)×0.95 ⇒ 1.32Kg/HP-h.

Thus total O2 required to stabilize the organic compounds are 3730 Kg/d.

But some quantity of oxygen will be generated by algae-bacteria symbiosis process, already. The oxygen generated in symbiosis process is as:
Area of the lagoon = 56,290m² or 5.6hact.
BOD loading rate for 26º latitude (at Gwalior) = 213Kg/hact./d
Oxygen amount generated by photosynthesis process = 213×5.6 ⇒ 1192.8Kg/d
Remaining air requirement/d by aerators = 3730-1192.8 ⇒ 2537.2 Kg/d

6) Now Quantity of Air Required
Volume of air required = (Mass of oxygen needed)/ (air density × percentage of O_2 in air)
=2537.2 / (1.216 × 0.21) ⇒ 9935.77 Kg/d = 414 Kg/hr
Quantity of air required = 414×1.216 ⇒ 503.4 Kg/hr

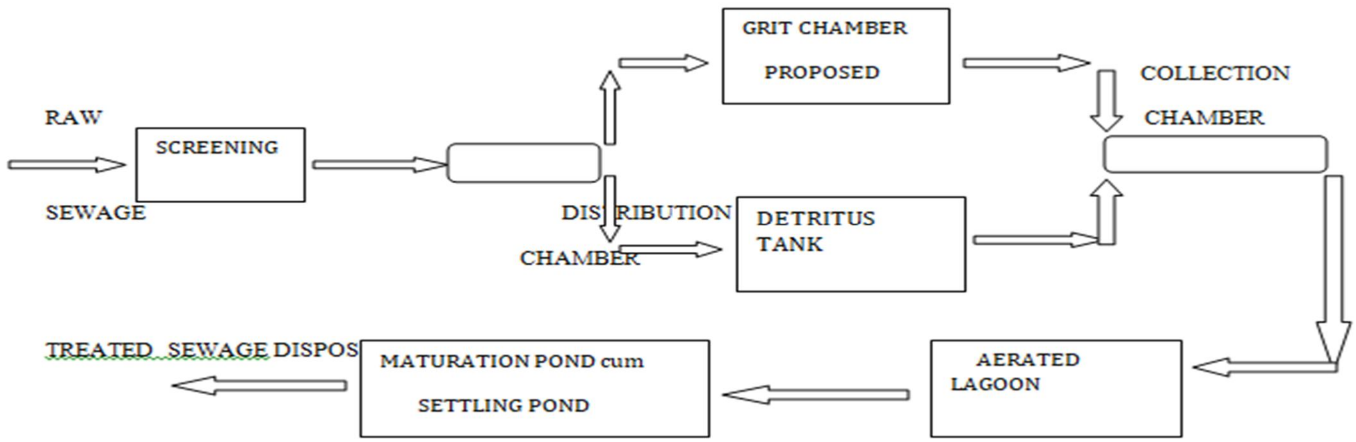
7) Power Required By Aerators To Supply Air
Total power required to supply 503.4 Kg of O_2/hr = 503.4 / 1.32 ⇒ 381.4 HP.
So, 33 aerators each of 12HP at a rate of 1.32Kg oxygen/ HP-h, will supply O_2/h = 33×12×1.32
= 522.72 Kg of O_2/h.



F. Check for Oxygen Requirements
(Oxygen requirements /d)/(BOD removed in Kg/d)
2597.5/(1,68,000×135×0.8(213.6-20.76)) = 0.75 Kg of BOD (range between 0.7-1.4 as per CPHEEO manual).

G. Design Maturation Pond
Main function of maturation pond is to destruct the pathogens algae and remove nutrients. Some degree of BOD removal is also done in such pond.
Volume of the Maturation pond = 46,240m³
Length of the maturation pond = (655-433) = 222m, Width (B) = 130m, Depth (D) = 1.6m.
Detention period of the Maturation pond = 2.5 days.

Flow chart of proposed augmented S.T.P.



IV. CONCLUSIONS AND SUGGESTIONS

On the basis of performance evaluation, following is concluded and suggested.

A. Stabilization pond in current scenario is not performing satisfactory as effluent BOD recorded is 103.1mg/l, which is more than 100mg/l for disposal by irrigation practices.
B. The demand of treated effluent as irrigation water is decreasing gradually as with time more agricultural land is being diverted for other uses.
C. Treated effluent is not being used completely for irrigation. Some part of treated effluent is being discharged in Ghasmandi drain which joins river morar within 3-4 km reach.
D. Particularly during rainy season there is no demand of treated effluent for irrigation use.
E. In the light of above, treated effluent shall satisfy the effluent standards for disposal by dilution. Thus augmentation is required.
F. It is also concluded that if 90% of accumulated sludge is removed from facultative pond, quality of treated effluent (BOD 37.5mg/l) is not meeting disposal standards.
G. Further, in future due to increase in population, effluent BOD is likely to increase.
H. Thus, some major augmentation work is required to be executed. For augmentation, design period (future population) shall be considered while proposing augmented scheme. The design period considered is 20 year.
I. In the augmented proposal, it is proposed to convert 2/3rd part of present facultative pond as aerated lagoon and remaining 1/3rd part as maturation/ settling pond, by providing a separation/ partition embankment wall at 2/3rd distance along length from inlet.
J. It is also proposed to provide suitable numbers of aerators to meet balanced requirement of oxygen (deducting available photosynthesis yield). Flag stone pitching on inner slope is also recommended to avoid erosion of slope due to agitation created by surface aerators.
K. Proposed treatment strategy can bring down the BOD of treated effluent below 20mg/l (disposal standard) and will remove pathogens and suspended solids also for satisfactory performance of treatment.

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