JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

COMPUTER AIDED DESIGN OPTIONS OF SEWAGE TREATMENT PLANT FOR NER PINGLAI VILLAGE

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Abstract: There are two fundamental reasons for treatment of wastewater viz., prevention of pollution and thereby protecting the environment, and protecting the public health by safe guarding water supplies and preventing the spread of water borne diseases. Proper design, construction together with good operation and maintenance are essential for Sewage treatment plant.

Computer aided design play vital role in designing and implementation of STP for particular data. While implementation such design verity of parameter such as chemical, physical and biological parameter play vital role. The Changes in any of the above parameters will change the design of STP. The Computer aided design of STP help in sizing the treatment units and improving the performance and capabilities with relevant input data.

The NerPinglai is a village in morshi taluka in Amravati district of Maharashtra state, India. The NerPinglai village has population of nearly 15015 as per population census 2011. This paper deals with alternative design options of STP applicable for NerPinglai village. The design of STP based on Activated sludge process (ASP) and sequential batch reactor (SBR) will be compared and best suitable design will be analyzed and compared based on various parameters by using spreadsheet.

IndexTerms - Wastewater, computer aided, STP, Activated sludge process (ASP), sequential batch reactor (SBR),

I. INTRODUCTION

Wastewater is the community's water supply after it has been contaminated by a variety of sources. During its use, water given to a community picks up a variety of chemicals and microbial flora, resulting in wastewater that has a polluting potential and poses a health and environmental risk. To commit this objective the wastewater usually requires some type of preparation or treatment before it is rendered fit for disposal or reuse.

The purpose of Sewage treatment plant is to separate inorganic particulates and to stabilize the decomposable organic matter present in waste water so as to produce an effluent and sludge which can be disposed of in the environment without causing health hazards or nuisance. Sewage treatment plants (STPs) allow removing contaminants in water to comply with water quality norms and regulations. A sequential combination of physical unit operations, chemical and biological unit processes is used to treat wastewater completely. Computer aided design help in sizing the treatment units and improving the performance and capabilities of the calculation speed with relevant input data. Dynamic modeling and simulation spreadsheet can help bridge the gap by performing computer-aided simulations of the sewage treatment process.

The NerPinglai is a village in morshi taluk in Amravati district of Maharashtra state, India. The NerPinglai village has population of nearly 15015 as per population census 2011. This paper deals with comparative computer aided design of sewage treatment plant with Activated sludge process (ASP) and sequential batch reactor (SBR) for NerPinglai by using spreadsheet. The paper will also discussed strategies to be adopted while designing a STP based on variable input parameters.

II. STUDY AREA

The NerPinglai is a village in morshi taluk in Amravati district of Maharashtra state, India. It belongs to Vidarbha region. It belongs to Amravati Division. It is located 43 KM towards North from District head quarters Amravati. 13 km from Morshi. The NerPinglai village has population of nearly 15015 as per population census 2011.

Fig.1:- Study Area of Nerpinglai

III. METHODOLOGY

NerPinglai has been a developing village due to steady increase in population, there will be more generation of domestic and municipal sewage. So there is a basic need of construction of sewage treatment plant with a view of sufficient capacity to treat the sewage. A sewage treatment plant is quite necessary to receive the domestic and household waste and thus removing the materials which harms for public health. Its objective is to produce an environmental safe fluid waste and solid waste suitable for disposal or reuse

3.1 Population Forecasting

The population will have to be estimated with due regard to all the factors governing the future growth and development of the project area in the industrial, commercial, educational, social, and administrative spheres. Special factors causing sudden immigration or influx of population should also be foreseen to the extent possible.

Table.1:- Population Data

Year	Populations	Increase in Population	%Increase in population (r_n)
1981	10820	-	-
1991	12320	1500	13.86
2001	14583	2263	18.36
2011	15015	432	2.96
Total		4195	35.18

Population as calculated by geometrical increase method

Formula:-

$$P_n = P_o \text{ x} [1+(r/100)]^n$$

Where,

r = geometric mean % increase in population = $(r_1 x r_2 x r_3)^{1/3}$ = $(13.86 x 18.36 x 2.96)^{1/3}$

= 9.098%

The design period of the sewage treatment plant is 30 year therefore population should be required in year of 2051 i.e. $P_n = P_{2051}$

n = (2051-2011)/10 = 4

$P_n = P_{2051} = P_o \text{ x } [1+(r/100)]^n = 15015 \text{ x } [1+(9.098/100)]^4$

$P_n = P_{2051} = 21271.22$ say 21300

Estimated population by the year 2051 is 21271.22 numbers. For more safety side it can be round off up to 21300 numbers. And hence the design period will be increase by 1 year approximately.

3.2 Development of Software

Software based approach is adopted, where in the input data will be fill in the software which will be provide output in the form of output which will be applicable for two alternative design of sewage treatment plant mainly Activated sludge process (ASP) and sequential batch reactor (SBR). So as to the designer will be compare between two different biological operation units in order to achieve the optimized STP design.

3.3 Design of STP

This paper deals with design of sewage treatment plant for the population of NerPinglai village.

Population as calculated by geometrical increase method: 21300

Per capita demand =150 lpcd (Sewage generation 80% of per capita demand)

Sewage generation per capita=120 lpcd

Total sewage generation = 21300x120x10^{-6} =2.556 MLD

Approximately 4 MLD

Hence the design of sewage generated for knowing the quantity for the further proceedings revealed that the village of NerPinglai can produce 4 Million litres per day.

3.3.1 Input and Output Data

The input data will be filled in the software. The software will be provide the output regarding two alternative applicable foe the design based on two alternative namely,

1. Design based on Activated Sludge Process (ASP)
2. Design based on Sequential Batch Reactor (SBR)

INPUT DATA SHEET

Sr. No.	Description	Input Value	Unit
	PRIMARY INPUT DATA		
1	POPULATION (P)	21300	
2	PER CAPITA DEMAND (LPCD)	150	l/day
	SECONDARY INPUT DATA		
	DESIGN OF SCREEN CHAMBER		
1	SIZE OF BAR SCREEN CHMBER (L*B)	50	M
		0.006	M
2	INCLINATION OF BAR SCREEN CHAMBER(θ)	30	X^0
3	CLEAR SPACING BETWEEN BAR (S)	0.03	M
4	FREEBOARD (FB)	0.25	M
5	GROSS SURFACE AREA OF SCREEN CHAMBER (GSA)	0.83	%
	DESIGN OF GRIT CHAMBER		
1	MAXIMUM TEMPERATURE (T max)	20	ºC
2	MINIMUM TEMPERATURE (Tmin)	15	ºC
3	SMALLEST DIA. OF PARTICAL TO BE REMOVED (Ds)	0.02	cm
4	KINEMATIC VISCOSITY (ϒ)	0.0114	cm^2/s
5	WIDTH OF GRIT CHAMBER (Wg)	1.2	M
6	DEPTH OF GRIT CHMBER	1	M
7	CRITICAL VELOCITY (Vc)	0.2275	m/s
		22.75	cm/s
	DESIGN OF PRIMARY SETTLING TANK		
1	Suspended solid in wastewater (S)s	250	mg/l
2	BOD at 20 ºC of wastewater $(BOD)_5$	200	mg/l
3	Surface loading rate (SLR)		
	a) At daily average flow (SLR)avg	40	$m^3/m^2/d$
	b) At peak flow (SLR)peak	100	$m^3/m^2/d$
4	Detention time D.T	2	hr
5	Sp.gr . Of primary sludge $S_{(sludge)}$	1.03	
6	Dimension of hopper bottom tank		
	a_1	3	M
	b_1	2.5	M
	h_1	1	M
7	Flow through velocity through pipe (FVP)	0.3	m^3/min
	DESIGN OF AREATION TANK		
1	REMOVAL OF SUSPENDED SOLID IN PST $R_{(S.S)}$	0.6	%
2	BOD REMOVAL IN PST $R_{(BOD)}$	0.32	%
3	VOLATILE SUSPENDED SOLIDE (VSS)	0.8	%
4	GROWTH YEILD COEFF. (Y_1)	0.6	
5	MICRO-ORGANISUM DECAY COEFF. (K)	0.06	
6	MLSS	2500	mg/l

OUTPUT DATA SHEET

Sr. No.	Description	Output Value	Unit
I	DESIGN OF SCREEN CHAMBER		
1	Width of screen chamber	0.53164209	M
2	Number of opening	18	Nos
3	Number of bar	17	Nos
4	Actual width of screen	0.642	M
5	Velocity of flow of screen	0.085748792	m/s
6	Diameter of sewer	0.35442806	M
7	Liquid depth	0.185060074	M
8	Theoretical depth	0.435060074	M
9	Head loss when half clogged	0.004544014	M
10	Slope from Manning formula	2.162E-05	M
II	DESIGN OF GRIT CHAMBER		
1	Depth of grit chamber	0.162545788	M
2	Total depth of the chamber	0.412545788	M
3	Theoretical length	1.528095729	M
4	Overall length of grit chamber	1.986524447	M
i	DESIGN OF CONTRAL DEVICE FOR GRIT CHAMBER TRAPEZOIDAL SECTION		
1	Actual top width of grit chamber	1.8	M
2	Depth in control section	1	M
3	width in control section	0.016696968	M
4	Depth of flow in section	1.786628312	M
III	DESIGN OF PRIMARY SETTLING TANK		
1	Diameter of PST	12	M
2	Volume of PST	333.3333333	m^3
3	Depth of PST	3.333333333	M
4	Check for weir loading	106.1571125	m^3/m^2-d
5	Check for surface rate	100	m^3/m^2-d
i	DESIGN OF HOPPER BOTTOM		
1	Volume of hopper bottom	7.583333333	m^3
2	Depth of water slope	1	M
3	Overall depth of PST	5.583333333	M
ii	CALCULATION OF DIAMETER OF CENTER PIPE		
1	Cross sectional area of pipe	0.023148148	m^2
2	Diameter of pipe	0.171720956	M
IV	DESIGN OF AREATION TANK		
1	Length of aeration tank	25.21495736	M
2	Cross-sectional area of each tank	39.744	m^2
3	Actual air requirement	36309.5386	m^3/day
4	Tank volume	2004.286531	m^3
5	no of tank	2	Nos

7	MEAN CELL RESIDENCE $(\theta)_C$	10	days
	DESIGN OF SEQUENCING BATCH REACTOR		
1	BOD_{in} =	300	mg/l
2	BOD_{out} =	10	mg/l
3	F/M =	0.2	
4	MLSS in the reactor =	4000	mg/l
5	total number of basin provide =	4	Nos
A	**Design of tank aeration tank**		
i	Assume side water depth [SWD]=	3	M
ii	Assume width of tank =	3	M
B	**design of anoxic zone**		
i	providing SWD of =	3	M
ii	width of anoxic tank	3	M
iii	total influent TKN (ammonical-N + Organic-N) =	40	mg/l
iv	Total effluent ammonical-N, assumed =	2	mg/l
C	**Design of Decant tank**		
i	providing holding capacity of	4	hour
ii	SWD =	3	M
iii	and width of tank =	3	M
	DESIGN OF DRYING BED		

1	SOLIDE IN DIGESTED SLUDGE FROM AREATION TANK =	57	g/c/d
2	WIDTH OF BED (b)	8	m
3	LENGTH OF BED (l)	30	m
4	Sp.Gr.of sludge S(sludge)	1.025	

V	DESIGN OF SEQUENCING BATCH REACTOR		
i	design of aeration tank		
1	aeration period =	18	Hr
2	so the cycle time =	19	Hr
3	volume of tank =	375	m^3
4	total depth=	3.5	M
5	width of tank =	3	M
6	length of tank =	54.3	M
7	HRT for the basin	9	Hr
8	hence designed for batches a day =	1	Nos
ii	design of anoxic zone [for removal of nitrogen (TKN) by denitrification]		
1	providing SWD of =	3	M
2	width of anoxic tank	3	M
3	length of anoxic tank compartment =	6	M
iii	oxygen requirement for SBR reactor		
1	total oxygen required for process =	700.675	Kg/d
iv	Design of Decant tank		
1	providing holding capacity of	4	Hr
2	SWD =	3	M
3	and width of tank =	3	M
4	length of tank is =	18.6	M

VI	DESIGN OF DRYING BED		
1	Bed area	4431.465	m^2
2	Per capita area	0.20805	m^2
3	No. of bed	19	Nos
4	Volume of digested sludge	17	m^3/d
5	Depth of application sludge	0.136074561	m

IV. RESULT

This paper deal with the design and analysis of sewage treatment plant for the population of **Nerpinglai Village.** The Nerpinglai village is located at 21.1841^0 N latitude and 77.9824^0 E longitudes. The location of sewage treatment plant should be nearer to the point where sewage is disposed.

Finally,

The design consideration and parameters for the sewage treatment plant are given below:-

- The design period should be **30 year**
- Estimate population by the **year 2051 is 21300 number**

4.1 Basic Treatment Units

4.1.1 Screen Chamber

Provide the screen chamber of 0.54 M x 0.44 M x + 0.25 M FB. The inclination bar screen chamber is 30° and the clear spacing between bar is 30 mm. provide number of opening 18 numbers and number of bar 17 numbers

4.1.2 Grit Chamber

Provide the grit chamber of 2 M x 1.2 M + 0.45 M [including free board of 0.25M]. For the proper functioning of the grit chamber, providing a control device for grit chamber of trapezoidal section at a outlet having size of 1.8 M x 1 M

4.1.3 Primary Settling Tank

Provide a primary settling tank (PST) of diameter 12 M and depth of 3.5 M + 0.25 M FB. Also provide the bottom hopper of PST having volume of 7.59 M^3 and depth of water slope 1 M. the overall depth of PST is 5.59 M

4.1.4 Drying Bed

The volume of digested sludge in Drying Bed is 17 M^3/d. The Bed area in a Drying Bed is 4431.456 M^2 and per capita area is 0.21 M^2. The number of bed is Drying Bed is 19 numbers and depth of application sludge is 0.14 M.

4.2 Main Treatment Units

4.2.1 Option 1 - Activated Sludge Process

Provide two number of aeration tank having a cross section area of each tank is 39.75 M^2 and the length of each tank aeration tank is 25.5 M. The actual air required for each tank is 36309.54 M^3/day

4.2.2Option 2 - Sequencing Batch Reactor

Provide four number of aeration basin having dimensions 54.3 M x 3 M x 3.5 M [including FB = 0.5M, Vol. = 375 M^3] also size of anoxic tank is 6 M x 3 M x 3 M [including FB=0.5 M] and size of decant tank is 18.6 M x 3 M x 3 M [including FB=0.5 M] with holding capacity of 4 hours. The total oxygen requirement for SBR reactor is 700.675 Kg/d

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V. CONCLUSION

Since, Nerpinglai Village lacks an adequate sewage treatment facility. So Construction of a sewage treatment facility is necessary. The plant is designed perfectly to meet the further expansion for the next 30 year [upto the year 2051] in accordance with cpheeo manual provisions. The plant is designed perfectly to meet the needs and approximate 21300 populations.

The treated sewage water is further used for other purpose such as irrigation work, industrial and commercial work and if it is sufficiently clean, it can be discharge on land or nearer water body. As per result obtained in the form of Output data sheet, the volume of Activated Sludge Process (ASP) and Sequential Batch Reactor (SBR) are 1002.15 M^3 for each tank and 375 M^3 for each tank respectively. It is clearly seen that the SBR required less land as compare to ASP. SBR is a modern biological process which is give good effluent quality and more BOD removal than the ASP

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