

Proposing Cost Effective Community Waste Water Treatment Plant

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ABSTRACT: Owing to enormous construction, unplanned sewage systems and maintenance costs, the management of wastewater in many urban centres of developing countries via a centralised wastewater management approach is very difficult often untreated water is directly discharged into adjacent natural water courses, causing a grave threat to both public health and aquatic environment.

We selected such an area Dubasipalya in Bengaluru, where water is discharged into nearby pond. In an effort to see that pond cleaner we planned to design a decentralised waste water treatment plant for the selected area. So that we can find out the installation possibility in that area, including economical aspect. Cost analysis helps us in comparing with other methods of treatment, so that we can select the cost effective treatment process.

We studied the existing decentralised wastewater treatment process to come up with the cost effective treatment plant. Quality Analysis of the sewage generated in the area was done. Medium quality sewage was generated in the area. Based on that we selected SBR as our secondary treatment method. Then design and cost analysis has been performed. Location of the treatment plant can be found out using contours. The designed treatment facility includes primary treatment unit, selection of secondary treatment unit and design of the unit.

Another angle we look at it is reuse of water. Water scarcity is growing concern in metropolitan cities. Since sewage generated in the area is of medium quality, we can reuse water for gardening, toilet flushing without much economical cost. Even though operational and maintenance cost is high, we can distribute the cost over the people who are benefited by the treatment plant. Government initiatives will help both people and government in a sense of managing water effectively and efficiently.

I. INTRODUCTION

The increasing population of urban area demands water and sanitary in huge quantity. However limited water resources have forced us to conserve and reuse the water for different activities. So now in many urban areas, local bodies made it mandatory to have decentralised waste water treatment in apartments. In 2004 to create awareness about the high pollution of waste water, the Karnataka State Pollution Control Board mandated that apartments having fifty or more homes, or generating 50 m³/day or more of sewage to install a good, robust, well designed treatment plant and reuse 100% of their wastewater, will result in installation of more than 2200 waste water treatment plants [1,2]. To avoid above mentioned disadvantages. We decided to come up with decentralised waste water treatment plant for a community. It will reduce burden on government money, solves water reuse up to some degree. It may cost people in community area, but due to that people will also reduces wasting water.

A centralized system commonly means a central treatment plant containing sewage collected in gravity sewers with pumping stations. Since 1970, a change in the conventional activated sludge process has made the rise of the sequencing batch reactor technology [3]. A decentralized system contains a common collection system and treatment facility or may be both. We decided to study the existing treatment process and to study the quality of waste water. Then going through the above things. We will propose a treatment plant, which will be a cost effective decentralised treatment plant. Then we will propose location for the plant in the selected area. The continuous flow-based biological wastewater treatment process, being a traditional process, has been facing severe challenges as the environmental discharge standards are getting stringent day by day [4].

Conventional onsite systems are those system where wastewater exits from home and goes through a septic tank before it was treated in a soil absorption field. These absorption fields can be pipe-in-rock trenches, may be chambers or beds. Although beds will not suit for large flows. The SBR is a technology which is nothing but a modification of the Activated Sludge Process (ASP) [5]. The state legislature has established an autonomous body in the city called 'Bengaluru Water Supply and Sewerage Board' (BWSSB) which is responsible to supply of potable water and to

collect, convey and treat the wastewater generated. It has been responsible for planning and running various sewage treatment plants in the city. Secondary or tertiary treated water are output of these Standard treatment plants. In present day scenario, SBR process is being used widely for biological treatment of wastewater from industries consisting of chemicals that are hard to treat, because of the good process control and design flexibility which is achieved by advanced technology [6].

II. STUDY AREA

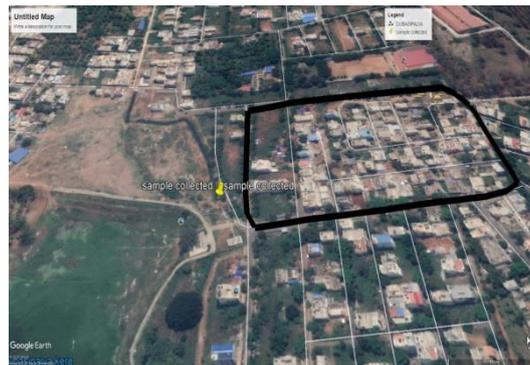


Fig. 1 Study area (source: Google earth)

Study area comprises of Bhairavanagar, Dubasipalya, Bengaluru in Karnataka, South India (Fig. 1). It lies between $12^{\circ} 93' 09.50''$ and $12^{\circ} 93' 25.25''$ North latitude and between $77^{\circ} 49' 2.94''$ and $77^{\circ} 49' 75.73''$ East longitude. Average annual temperature of 24.10°C . Bengaluru urban district has experienced rapid urbanization in recent years. So, Waste water generation increased rapidly without proper planning.

MOTIVATION

Today water is one of the most important mineral found in the earth. But pollution and scarcity of water have made it really unusable. And improper treatment of waste water in many areas made local pond, lake or river to get polluted. And made water bodies to die. And we are not getting fresh water from ponds or lakes due to pollution. And the solution for these problem is recycle and reuse of water and treat the waste water in efficient way.

In Dubasipalya there are nearly 371 houses, and average consumption of water is 135 LPCD and average daily supply of water is 202500 litres. And quantity of sewage generated is 162000 litres. But the waste water that is generated from these houses is not going to any treatment plants. But the waste water is directly flown into dubasipalya lake and the lake got completely polluted. And odour is generated from the storage of the sewage in the lake.

The treated water have excess of hardness and high total suspended solids, methyl orange alkalinity then acceptable limit. Therefore the waste water should be treated in order to stop pollution and scarcity.

So the main aim of the project is to propose a cost effective community waste water treatment plant in Dubasipalya to treat the waste water in an efficient way. And the treatment of waste water will be decentralized.

OBJECTIVES

The aim of this study is to propose a cost effective decentralised waste water treatment plant including cost analysis

The objectives of the study are milestones to achieve the aim of the study, which were as follows:

1. To study the existing process of waste water treatment for a community.
2. To conduct quality analysis of wastewater, then proposing efficient treatment plant.
3. To do cost analysis of different technologies and calculate cost for selected treatment plant.

III. METHODOLOGY

Proposing the cost effective decentralised waste water treatment plant with location for a selected community, located in Dubasipalya, Bengaluru. Disposal of waste water into a nearby lake has been found out. Quality analysis of waste water was done. From the quality analysis, parameters to be treated for reuse was taken.

Based on the parameters we selected the one technique among Membrane Bio Reactor(MBR), Anaerobic digestion system, biomass retention systems and Constructed Wetlands was selected. Based on the volume of waste water generated, Design was done. Cost comparison was done with centralised waste water treatment plant.

QUALITY ANALYSIS OF WASTE WATER

Quality analysis of waste water which is collected from the outfall of the sewer from the study area i.e., Dubasipalya. This will give the approach to the decentralized management system for the waste water treatment. The practical examinations are conducted on the waste water sample to have the proper system as per guidelines for wastewater analysis laid by Food and Agriculture Organization (FAO) and Bureau of Indian Standards (BIS) are mentioned.

Sl.No.	Parameters	Unit	Acceptable Limit	Test result
1	pH	-	6.5 - 8.5	7.5
2	Turbidity	NTU	<2	0.7
3	Total Chloride as Cl	mg/L	<250	149.0
4	Total Hardness as CaCO ₃	mg/L	<300	359.9
5	Calcium Hardness as CaCO ₃	mg/L	<80.10	161.7
6	Magnesium as Mg	mg/L	<24.28	48.1
7	Total dissolved solids	mg/L	<500	744.0
8	Total suspended solids	mg/L	<50 to 100	136.0
9	Total sulphate as SO ₄	mg/L	<400	55.8
10	Residual free Chlorine	mg/L	1	<0.2
11	Methyl Orange Alkalini as CaCO ₃	mg/L	<200	499.3
12	COD	mg/L	--	127.9
13	BOD(For 3 days at 27 °C)	mg/L	30	198

Table 1 Experimental results obtained and compared with Standards.

These are the some experiments we have conducted and the acceptable and our test results are shown in Table 1..The test results we got all are mostly in acceptable limits. But we have to treat other characteristics.



SELECTION OF SECONDARY TREATMENT SYSTEM

Here usual bacteria and some other microorganisms are made use of to clean water. Helps in controlling and purifying of water. Both aerobic and anaerobic biological processes are made use of to achieve the optimal removal of organic substances from wastewater

- Prevent flushing out of biomass from the system by proper controlling of flow.
- Make sure needed biomass within the system through Measurement of biomass concentration within the system and adjusting the recycling rate.

Currently there are several treatment options available and to seek out the foremost appropriate technology for the locality into account .

We determined that due to harshness of waste current within stream, it's essential to supply secondary treatment to treat all of effluent and it is ready for tertiary treatment. Within the following phase the pre-design stage was choosing a secondary treatment system. We have mentioned in Table2, our team selected sequential batch reactors as SBR empowered necessary treatment levels, features a moderate technique complicatedness, a moderate tolerance to variable flows and high aerial efficiency.

Table 2 Available options for secondary Treatment System

Secondary Treatment System	Base Level Treatment	Process Complexity	Enhanced Treatment	Tolerance to Variable Flows	Aerial Efficiency
Bio tower	30/30	Low	30/30 + Nitrification	Moderate	Moderate
Conventional Activated Sludge	30/30	High	Nitrification + Denitrification + Bio-P Removal	Low	Moderate
Conventional SBR	30/30	Moderate	Nitrification + Denitrification + Bio-P Removal	Moderate	High
Oxidation Ditch	30/30 + Nitrification	Moderate	Denitrification + Bio-P Removal	High	Low

SEQUENTIAL BATCH REACTOR

Sequential Batch Reactors (SBR) or successive cluster reactors are modern preparing tanks for efficient treatment of wastewater. SBR reactors treat squander water, for instance, sewage, or yield from anaerobic digesters or mechanical organic treatment offices in clumps. Oxygen is bubbled within the waste water, to scale back biochemical oxygen demand and chemical oxygen request to form reasonable for release into sewers or to be used ashore.

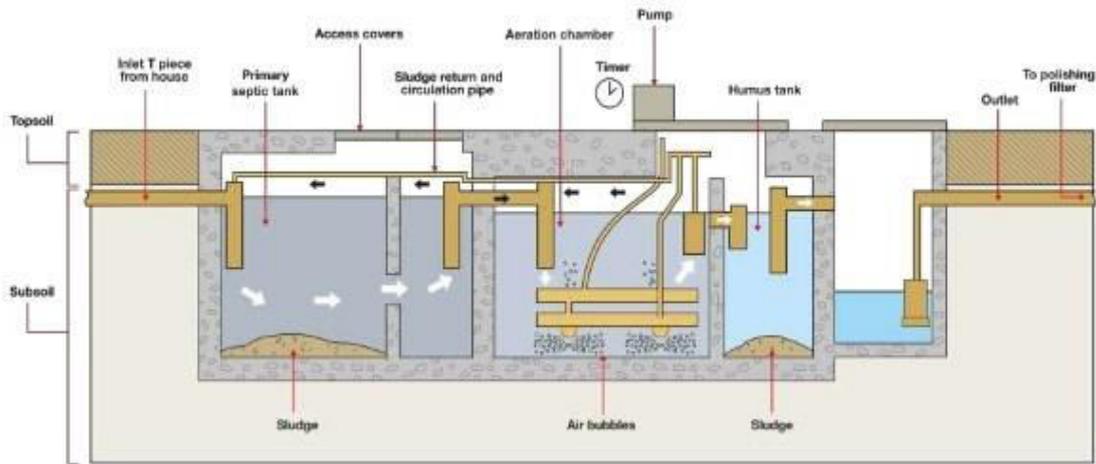


Fig. 2 Typical sequential batch reactor system

Consecutive clump reactors (SBR) or progressive bunch reactors are present day getting ready tanks for the effective treatment of wastewater. SBR reactors treat waste water, for example , sewage, or yield from anaerobic digesters or mechanical natural treatment workplaces in clusters. Oxygen is risen inside the waste water, to downsize biochemical oxygen request and concoction oxygen solicitation to frame sensible for discharge into sewers or to be utilized shoreward.

This procedure is closely resembling the enacted muck process, however the successive clump reactor (SBR) comprises of 5 phases: Screened fill, React, Settle, Empty/Recycle, Rest/inert. Influent waste ordinarily leaves through screens and coarseness expulsion before the SBR procedure. Wastewater at this point joins an incompletely packed reactor, containing biomass, that is adapted to waste constituents all through leaving before cycles. When reactor is full, it carries on sort of standard actuated ooze framework, in any case, while not perpetual inflowing or emanating stream. The air circulation and mix is hindered when natural responses are completed, the biomass settles, and along these lines rewarded supernatant is vacated. Overabundance biomass are frequently evacuated whenever all through the cycle. Visit squandering brings about carrying the mass size connection of inflowing substrate to biomass almost steady from cycle to cycle. Nonstop stream frameworks hold the mass extent connection of inflowing substrate to biomass consistent by modifying come enacted slime flowrates normally as inflowing flowrates, attributes, and subsidence tank undercurrent fixations change. at the point when the SBR, the "cluster" of waste could stream inside the endeavor bowl any place the waste flowrate to additional unit prepared is controlled at a decided rate. At times the waste is separated to ask deter additional solids at that point cleaned. When the vessel is loading up with profluent , facultative the framework to endure top streams or pinnacle masses inside the inflowing and to even out them inside the cluster reactor. In numerous traditional enacted slop frameworks, separate evening out is required to monitor the natural framework from top streams, which may clean out the biomass, or pinnacle masses, which may diminish the treatment technique productivity. In most conventional initiated muck emanating treatment plants essential clarifires square measure utilized before the natural framework. In any case, essential clarifires could even be indicated by the SBR maker if the general suspended solids (TSS) and BOD unit very 400 to 500 mg/L.

SITE LOCATION AND LAYOUT

Very significant rules for area is, a location which may use gravity the greatest sum as conceivable to diminish the multifaceted nature of plan and development stage. The group scanned for a site inside the examination region. With



the exponential development of the populace comes a development and extension of the private locale , the group glanced at the Bengaluru water framework and Sewage Board (BWSSB) site which had a stock of designated decentralized treatment plant locations and chose a site inside the examination territory which had the entirety of the predefined traits. As far as treatment level, the group scanned for a base auxiliary treatment of 30/30 mg/L of BOD₅ and absolute suspended solids (TSS).

GENERALDESIGNCRITERIA

To design the treatment plant, we have to find out amount of flow, design period using the standards we have studied.

DISCHARGE STANDARDS

We know that United States gave rigid guidelines in case of effluent quality of a discharge leaving a wastewater treatment plant, So we concluded to obey these guidelines when designing the most treatment units of the plant. Table 3 summarizes the guidelines set by the NPDES that ought to be followed for secondary treatment plants.

Table 3 CPCB Standards

Parameter	Avg. Monthly Limit	Avg. Weekly Limit
TSS	30 mg/L	45 mg/L
BOD5	30 mg/L	45 mg/L
TSS & BOD5 removal (concentration)	>85%	N/A
pH	Within 6.0-9.0 at all times	

For this project, the appropriate values wont to guide the planning were the typical monthly limits for BOD5 and TSS. Therefore, these limits shall be mentioned as 30/30.

SERVICE POPULATION

Treatment systems must be designed for increasing population, we took estimation up to next 20 years. Population was helpful to work out the everyday discharge that the treatment plant would like to treat. And moreover, As the plant we are designing is used for just treating selected area, the entire population within that location is calculated, then a percentage of change applied. Relevant values of the estimation for this project are indicated in Table 4

Table 4 Population Estimation for 20 years

Parameters	Value
Number of Houses	371
Mean Household Size	4.0 (census 2011)
Total Present Population	1500
Population Annual Growth	1.1%
Projected population (20 years)	1867

The population change was found through borrowing the all-around growth of city and referring that same percentage to Dubasipalya.



BASE FLOW RATE

When the design population estimation was done, base flow rate for the selected community region was computed. Table 5 shows the values utilized for computation.

Table 5 Base Flow Rate

Parameters	Value
Service Population	1867
Wastewater Production (Per Capita)	150 L/D
Base Flow Rate	2,80,050LD

Water consumption per person assumed to be 150 LPCD (this figure is assumed for superior grade community) (LPCD-Litres Per Capita Demand)

Total quantity of water consumed = 1867 X 150 = 2,80,050litres

Assuming 80% of water is converted into waste water, we have

Total quantity of sewage generated = 2,80,050 X 0.8 = 2,24,040 litres = 0.22 MLD

Daily peak flow = 1.8 X Average flow = 2 X 0.85 X 106 = 1.36 MLD

PEAKING FACTOR

The usage of electricity and water usage will be high during certain times of the day. And this fact applicable for wastewater. Since many of us are following an equivalent daily schedules. And there are many treatment plants which receive the above average sewage at certain hours. This rate of increase in flow are often accounted for with use of a peaking factor.

There are a spread of peaking factor calculations, all based upon the planning population, and that they all give quite similar values. For this project, peak hourly demand was used. Its form is noted in Equation 1

$$\begin{aligned}
 \text{Daily peak flow} &= 1.8 \times \text{Average flow} && \text{Equation(3.1)} \\
 &= 2 \times 0.22 \times 10^6 \\
 &= 0.44 \text{ MLD}
 \end{aligned}$$

BAR SCREEN CHAMBER

Peak flow was assumed to be 0.44 MLD.

$$\begin{aligned}
 \text{Peak flow} &= 0.44 \text{ MLD} = 440 \text{ m}^3 \\
 &= \frac{440}{(24 \times 60 \times 60)} = 0.0050 \text{ m}^3 / \text{sec}
 \end{aligned}$$

Assuming the velocity through the screens = 0.8 m/sec

$$\therefore \text{Required net area of screen bar} = \frac{0.0050}{0.8} = 0.00625 \text{ m}^2$$

Let us use rectangular steel bars in the screen section having 10 mm width and let us place 20 mm clear spacing, gross area is at:

$$\text{Screen gross area} = \frac{0.00625 \times 6}{5} = 0.0075 \text{ m}^2$$

Let us assume that screen bars are inclined at 60° to the horizontal, we have :

$$\begin{aligned}
 \text{Total gross screen area:} \\
 &= \frac{0.0075}{\frac{\sqrt{3}}{2}} = 0.0086 \text{ m}^2 \approx 0.09 \text{ m}^2
 \end{aligned}$$

Operation and maintenance considerations are:

- 1)The bar screen should be examined and polished at regular times.
- 2)Make sure not to allow solids to overspill or come out of the screen
- 3)Make sure that large gaps do not get formed because of corrosion in screens
- 4)The corroded bar screens must be replaced then and there.

EQUALIZATION TANK

Equalization tanks are the structures designed for the provision of steady influent flow to the further processes by maintaining high flow differences. Aeration and mixing is needed in equalization tanks for the prevention of the raw sewage water from becoming septic and to maintain suspension in solids because of the additional retention time.



Design details are as follows:

Peak flow rate = $0.0050 \text{ m}^3/\text{sec}$

Assume detention/aeration time = 1 hour

The quantity of sewage to be treated in 1 hour is:

$= 0.0050 \times 60 \times 60 = 18 \text{ m}^3/\text{hr}$

Capacity of the tank = 18 m^3

Assuming depth of tank = 3 m

\therefore Area of tank $= \frac{18}{3} = 6 \text{ m}^2$

Provide a square tank.

\therefore Length = breadth = $\sqrt{6}$

$= 2.44 \text{ m}$

$\approx 2.5 \text{ m}$

\therefore Required Dimensions of tank = $2.5 \times 2.5 \times 3.5 \text{ m}$

Air supply required:

Assume that $0.03 \text{ m}^3/\text{min}$ per m length may be adequate.

Air required = $0.03 \times 2.5 = 0.075 \text{ m}^3/\text{min}$

Operation and maintenance considerations includes,

1) Mixing of air must be done continuously.

2) Should be made sure that the air flow or mixing is unvarying over the entire tank. The equalization tank must be kept nearly empty before the peak flow hours, or else, it may overflow..

3) Clogged diffusers must be checked and cleaned up at regular breaks.

4) Settled muck/ sediments must be manually evacuated at least once in a year.

SEDIMENTATION TANK

Sedimentation tank or settling tank or a clarifier. It is a important material of a modern system of sewage treatment. There is chance for suspended particles to get settle out of wastewater because it flows slowly in the tank, in a sedimentation tank. This, thereby provides some degree of purification.

Design details:

Flow rate = $0.0050 \text{ m}^3/\text{sec}$

Assume Detention time = 2 hours

Sewage quantity that can be treated in 2 hours

$= 0.0050 \times 60 \times 60 \times 2 = 36 \text{ m}^3/2 \text{ hours}$

Capacity of tank = 36 m^3

Assume,

depth of tank = 3 m

Area of tank = $36/3 = 12 \text{ m}^2$

$\frac{\pi d^2}{4} = 12$

$d = \sqrt{\left(\frac{12 \times 4}{\pi}\right)}$

$= 3.90 \text{ m} \approx 4 \text{ m}$

Provide a free board = 0.3 m

Sludge zone = 0.5 m

Bed slope = 1 in 50

Dimensions of tank = $4 \text{ m} \times 3.8 \text{ m}$ [where 4m is diameter and 3.8 m is depth]

Operation and maintenance considerations are, there is no need of operation and maintenance if the sedimentation tank is properly engineered, designed and constructed. The unmechanized settling tanks, i.e., hopper-bottom are often called as zero- maintenance structures. But some parts of the mechanical rake just like the gearbox, motor, etc., demand only routine maintenance. The unmechanized settling tanks, i.e., hopper-bottom are often called as zero- maintenance structures.

The rubber scrapers cleaning the ground of the tank should be checked and repaired if required, probably every couple of years. The unmechanized settling tanks, i.e., hopper-bottom are often called as zero- maintenance structures.

SEQUENCING BATCH REACTOR

Design details of SBR:

Flow = 440 m³/day

To find out SBR operating cycle:

Let, Fill = t_F , React/ aerate = t_A , Settle = t_S , Decant = t_D

Total cycle time = T_c

Provide minimum 2 tanks because of that if one tank acquires the fill period t_f , the upcoming cycles will occur in the other tank, i.e.,

t_A , t_S and t_D . Therefore,

$t_F = t_A + t_S + t_D$ equation (3.2)

Assume:

$t_A = 2$ hours

$t_S = 30$ minutes

$t_D = 30$ minutes

from equation 3.2

$\therefore t_F = 2 + 0.5 + 0.5 = 3$ hours

Therefore, Total cycle time, $T_c = t_F + t_A + t_S + t_D$
= 6 hours

Number of cycles per tank per day = (24 hrs/day)/(6 hrs/cycle) = 4 cycles/day/tank

Total number of cycles/day = 2 tanks \times 4 cycles/day
= 8 cycles/day

Fill volume/cycle = (440 m³/day)/(8 cycles/day) = 55 m³/fill

The Sequencing Batch Reactor naturally eradicates the necessity for individual primary and secondary clarifiers in most systems, which decreases operations and maintenance necessities. Return Activated Sludge (RAS) pumps needn't be added. Anoxic basins, anoxic zone mixers, toxic basin aeration equipment, toxic basins and internal MLSS nitrate-nitrogen recirculation pumps could also be necessary in conventional biological nutrient removal systems.

With the SBR, this will be achieved in one reactor using aeration-mixing equipment, which will reduce operation and maintenance necessities which may rather be required for clarifiers and pumps.

PRESSURE SAND FILTER

This equipment contains quite one layer of sand with a spread especially size and gravity. These Filters are designed to eliminate turbidity and suspended matter that's present within the influent water with least pressure drop. These Filters are designed to suit the method needs.

This equipment is employed as a after secondary treatment unit to hold the trace amount of solids which will get away from the clarifier and will usually take up to 50 mg/l of solids in a cost-effective method. This PSF is importantly a pressure vessel which is occupied with graded materials which are gravel and sand. Water that is purified using Pressure Sand Filter will be treated subsequent stages within the Sewage Treatment Plant system.

Design criteria includes an efficient regular filtration rate is 12 m³/m²/hour for design. That is cross-sectional area of filter, and maximum filters utilized in Sewage Treatment Plant purposes are designed on an equivalent principle.

Operation and maintenance considerations are, in this system operations essentially contains an extended filtration run, then a brief backwash arrangement will be there. This filter requires backwash when the pressure developed drop through the filter surpasses 0.5 kg/cm². Nevertheless, it is an honest method to backwash just one occasion during a shift, no matter the important quantity of pressure toll. Usually 5 to 10 minute backwash would characteristically get rid of the filter of all gathered silt.

ACTIVATED CARBON FILTER

This method of Carbon filtering is done by purifying, which certainly will use a bed of activated charcoal to dismantle pollutants and contaminations, with the help of chemical adsorption. Active charcoal carbon purifiers are effectively operational at eliminating chlorine, which will use a bed made of activated charcoal to eliminate pollutants and contaminations matter like Volatile Organic Compounds (VOCs), sediment, odour, colour and taste from the water.

SLUDGE DIGESTER

Design details includes:

Assuming sewage contains 300 mg of settleable solids/ litre,

Flow = 0.44 MLD

Mass of suspended solids in 0.44 MLD of sewage



$$= \frac{300 \times 0.44 \times 10^6}{10^6} = 132 \text{ kg/day}$$

Let us assume, fresh sludge has maximum concentration that is 95% , we have

5 kg dry solids will bring = 100 kg wet sludge

$$\therefore 132 \text{ kg dry solids will bring} = \frac{100}{5} \times 132$$

$$= 2640 \text{ kg wet sludge per day}$$

Assuming specific gravity of digested sludge at 85% maximum concentration,

$$V_2 = V_1 \left[\frac{100 - P_1}{100 - P_2} \right] \tag{equation(3.3)}$$

From equation 3.3

$$V_2 = 3 \left[\frac{100 - 95}{100 - 85} \right] = 1 \text{ m}^3/\text{day}$$

Assuming that the period of digestion is 30 days, total capacity of the digestion tank required is:

$$\text{Capacity} = \left[V_1 - (V_1 - V_2) \frac{2}{3} \right] t \tag{equation(3.4)}$$

From equation 3.4

$$= \left[3 - (3 - 1) \frac{2}{3} \right] 30$$

$$= 50 \text{ m}^3 \approx 51 \text{ m}^3$$

Providing a depth of 3m,

$$\text{Area} = 51/3 = 17 \text{ m}^2$$

$$\therefore \text{Diameter of tank} = \sqrt{\frac{4 \times 17}{\pi}} = 4.65 \text{ m} \approx 4.7 \text{ m}$$

Hence, we will procure a sludge digestion tank that is cylindrical which is 3m deep and 4.7 m dia, with an additional hoppers bottom that consists 1:1 slope so that the collection of digested sludge is easier.

SLUDGE DRYING BEDS

This is a usual method utilized to dewater the sludge through purification and evaporation. Punctured pipes located at the bottommost of the bed are utilized to drain seepage water or purify. A decrease of around 35% or less in moisture content is likely after drying.

Sludge drying beds are needed to allow extra sludge which is withdrawn from the method to make it dry so that it become less complicated to handle. Drying of sludge depends on the underground drainage process and also on sunshine. Generated liquid in the underdrains must be resent to the STP for the further treatment.

Design details are as follows:

$$\text{Volume of wet sludge} = 3 \text{ m}^3/\text{day}$$

Let it be spread in 22.5 cm thick layer (20 to 30 cm) on under-drained sand beds, then:

$$\text{Required area of beds} = \frac{3}{0.225} = 13.33 \text{ m}^2/\text{day}$$

In Indian tropical circumstances, beds may be drained out in 10 days, therefore let us take 2 weeks as the time of drying,

$$= \frac{52 \text{ weeks}}{2 \text{ weeks}} = 26 \text{ times in a year}$$

$$\therefore \text{Bed Area} = \frac{13.33 \times 365}{26} = 187.13 \text{ m}^2 \approx 200 \text{ m}^2$$

Let us provide 100% space for repairs in the storage, resting of beds etc.,

$$\text{Total area of beds required} = 2 \times 200 = 400 \text{ m}^2$$

Now, using 15 x 30 m sized beds, we have the number of beds required:

$$= \frac{400}{15 \times 30} = 0.88$$

Let us provide 1 bed,

$$\text{Then, area of each bed} = \frac{400}{1} = 400 \text{ m}^2$$

Let width of bed = 20 m

$$\therefore \text{Length of bed} = 20 \text{ m}$$

Operation and maintenance consideration of sludge treatment varies from one country to another country because of differences in energy costs and operating circumstances. Sludge drying through conventional method is just too easy, but it requires skilled/trained labours are required to oversee operation and maintenance of the system and also

functioning. System like this don't need electricity. Also, the O & M comprises control of system, function of sludge, desludging therefore, the supervision of the secondary treatments for dried sludge.

PURPOSE OF COST ANALYSIS

Lack of detailed cost information on small-scale STPs. Even though we can adopt any of the available technologies, cost, maintenance and operation matters. Detailed cost analysis and comparison is not available. There is no understanding of total cost it may cost us for next 10-20 years. In that direction we need this study.

Identify financially-driven reasons for why STPs fail. If we reduce the failures which cost us more, we can easily reduce the total financial cost over the span of its useful period. In that direction we will study some technologies, which reduces failures and requires less maintenance.

Options for de-centralized STPs at community scale. We will try to find out is there any of technology in development stage which may cost us less and also we also try to get the information of existing technologies used in different community water treatment plants and its efficiency.

FACTORS THAT DETERMINE COST OF A STP

Quality of components we make use of in treatment plant and collection of sewerage matters most. Based on the design period, we should use better components at cheap rates. Best way is to call tender, so that we can get materials at cheap rates.

Design Specifications: Capacity, component ratings. Based on volume of waste water to be treated, type of living standard of people in the given community it changes.

Climate in the given area matters, as climate is a factor in quantity of water used by the people. In extreme climates usage of water will be more.

In most of the DEWATS in final stage effluent is discharged to soil absorption system. Based on the type of soil, treatment level of wastewater can be increased or decreased in earlier stages. Fine texture soils have higher surface compared to coarse texture soils because of chemical reactivity. Soil chemical properties also matters as they can adsorb anions.

Degree of automation and human labour required to see upon operations determines extra cost.

Location of area where DEWATS to be provided matters. Whether it's a city prime area or a village area. And whether it's located in plain area or a slope area also matters. Location is in underground or basement, based on this cost varies.

IV. LIFECYCLE COST OF STPS

CAPITAL COSTS

Civil construction and tanks. Construction bears a great financial cost compared to other expenses. Construction also depends on design period, capacity required. Construction should be done in a efficient way, at lower cost high construction strength should be achieved.

Electro-mechanical components: Pumps, Blower etc. Another important cost factor, Operation and maintenance depends mainly on electro-mechanical components quality and efficiency and Fig 3 shows the capital cost for different technologies.

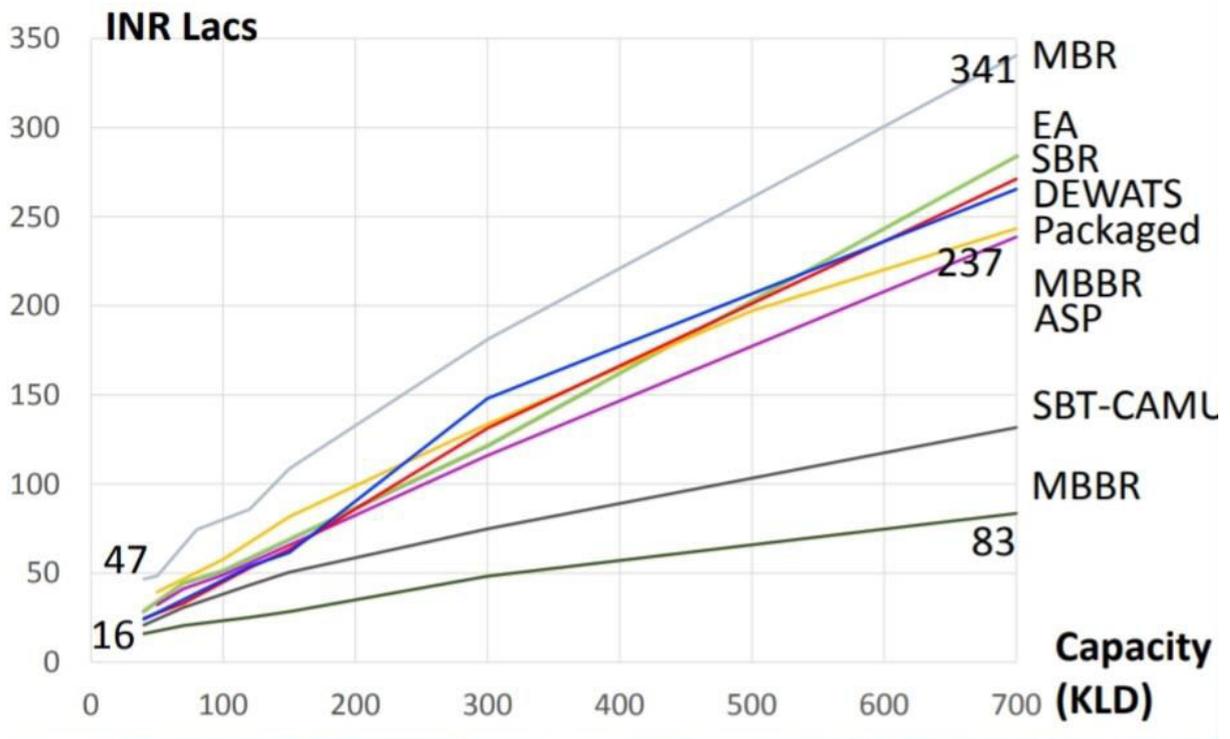


Fig 3 Capital Costs for different technologies *Source(www.eawag.ch)*

OPERATION & MAINTENANCE COSTS

Skilled labours are important factor, without them DEWATS is a failure. If labours are hired on permanent basis and appointing them to many DEWATS at a time can reduce much cost in this regard.

Continuous flow of electricity must be ensured, so as to maintain plant in a good order.

Chemicals required and materials required must be supplied in time to the plant. Care should taken care of this.

Maintenance around the plant is also necessary. Cleanliness of the plant is also necessary to avoid any unnecessary odour and fig 4 shows the operation and maintenance cost for different technologies.

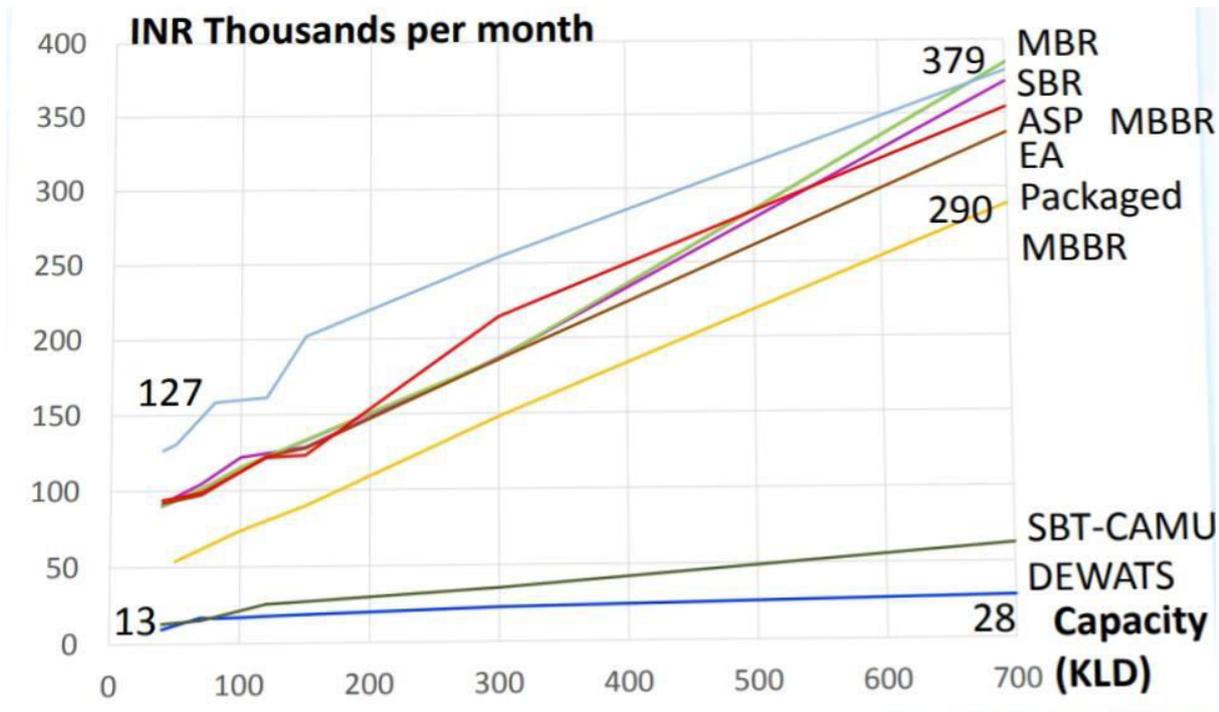


Fig 4 Operations and maintenance cost for different technologies Source(www.eawag.ch)

4.4.3 CAPITAL MAINTENANCE COSTS

The costs that occur for maintenance of wastewater treatment plants usually can take up to 15–25 % of the operation costs that occur totally. Hence, the organization and technique of maintenance activities play crucial role for the DEWATS. The life cycle cost for different technologies shown in fig 5.

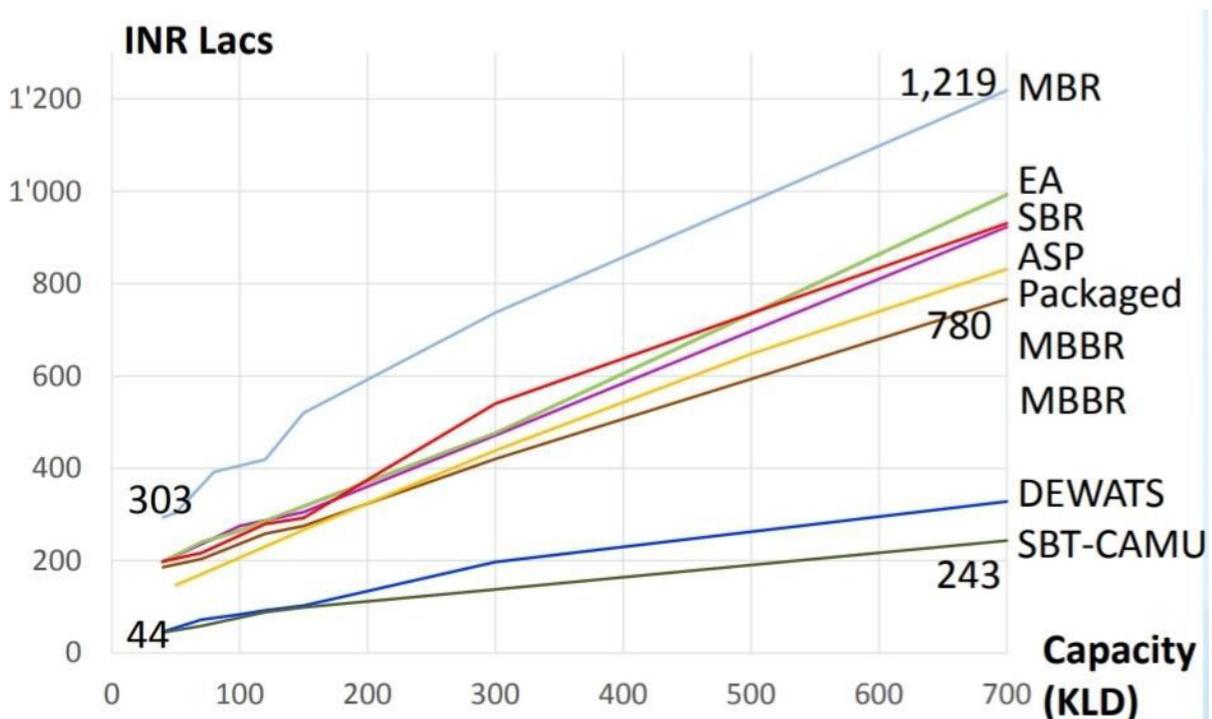


Fig 5 Life Cycle Costs for different technologies Source(www.eawag.ch)

4.5 CONSTRUCTION COST

To start the cost estimation of this project, the group divided project into a structure which declared essential tasks that required to be completed for different phases of design and construction. Project structure was divided into 5 categories. Total Cost of Capital, Electro-mechanical cost, Civil Cost, Annual O & M Cost, Electricity Cost. Those values are in Table 6, with the categories mentioned above. To get costs and of tasks, we took some formulas from research papers, then arrived at formulas to calculate cost.

Table 6 Construction Cost

Details	Formula	Cost (INR)
Total Capital Cost	$2445x-0.33$	328.04
Electro-Mechanical Cost	$1806x-0.38$	178.83
Civil Cost	$721.7x-0.38$	71.42
Annual O & M Cost	$61359x-0.49$	3108
Electricity Cost	$4476x-0.23$	1103.81

Table 7 Net worth Investment per MLD of the STPs

S No	Parameter	Unit	SBR
1	Land Area used	acres/MLD	0.12
2	Capital Cost	crores/MLD	0.7
3	Biogas Generation	m ³ /d	-
4	Annual Power Cost	crores/MLD	0.0312
5	Annual O&M cost (including recurring, chemical, manpower costs, etc.)	crores/MLD	0.6
6	Total Annual O&M cost	crores/MLD	0.63
7	Average Land cost (per acre)	Crores	11
8	Cost of Land	crores/MLD	1.32
9	Unit Capital cost including land	crores/MLD	2.02
10	Annual Interest	Percent	12
11	Economic Life	Years	30



12	Capital Recovery Factor (CRF)		0.124
13	Total Annual cost	crores/MLD	0.88
14	Present Discount Factor		8.06
15	Net Present Worth of Investment Cost	crores/MLD	7.09

Source(www.ijirae.com)

As we can see from the above, it takes around 7 crores per MLD. It is a cost for one year, but if we take the use of treatment plant over the years then cost per MLD goes on reducing.

4.6 COST COMPARISON

Even though all technologies working way is almost similar, efficiency differs. Cost required for each technology differs. Let’s take a look at comparison in efficiency as well as cost among different technologies. Table 8 represents cost comparison.

Table 8 Cost Comparison

Process	Effluent Quality	Coliforms removal	Nitrification-Denitrification	Phosphorous removal	Process Reliability	Land Use	Ease of Operation	Ease of Maintenance	Energy Recovery	Electrical Demand	Capital Cost	Track Record	Typical Capacity Range, MLD
EA	VG	G	P	P	VG	A	VG	VG	P	P	G	G	SF
ASP	G	G	P	P	VG	G	G	G	VG	A	A	VG	AF
MBBR	VG	VG	P	P	G	VG	P	A	P	A	G	P	SF
MBR	VG	VG	P	P	G	VG	P	P	P	P	P	P	SF
SBR	VG	VG	VG	VG	G	VG	G	G	P	A	A	G	AF
UASB + ASP	G	G	P	P	G	G	A	VG	G	A	A	G	AF
CW	P	P	P	P	P	P	A	P	P	VG	G	P	AF
WSP	A	P	P	P	P	P	A	VG	P	VG	G	A	AF

Abbreviations-

EA-Extended Aeration; ASP-Activated Sludge; MBBR-Moving Bed Biofilm Reactor; MBR-Membrane Bio Reactor; SBR-Sequencing Batch Reactor; UASB-Up flow Anaerobic Sludge Blanket; CW-Constructed Wetlands; WSP-Waste Stabilization Pond; VG-Very Good; G-Good; A-Average; P-Poor.



As we can observe from the above analysed table, every technology has one or the other advantages and disadvantages. In a way while adopting suitable technology, we should also look at other aspects like available area, benefits earned from bio-methane and electrical energy generation. In that context for our Project SBR seems suitable. Also we can see it is efficient.

4.7 COST DISTRIBUTION

It may cost us more money for decentralised waste water treatment plant, but if we use some government incentives and distribute overall cost to per house on monthly basis we can afford it easily. Cost distribution shown in fig 6.

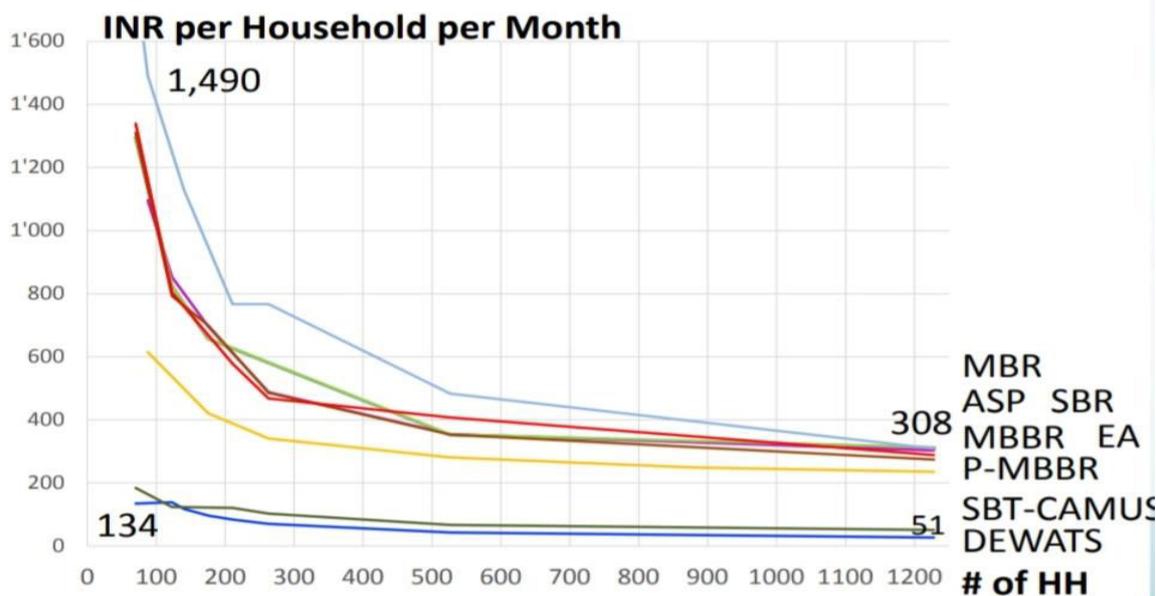


Fig 6 Cost Distribution Source(www.eawag.ch)

V. CONCLUSIONS

The main objective is to propose cost effective decentralized waste water treatment plant including suitable location by using GIS software for a selected community.

From the study conclusions below are drawn:

- Several methods are used to collect and treat waste water. In most of the cases Grey water and Black water are collected separately and treated separately so as to minimise cost. Selection of method of treatment depends on the area of location too. Operation and maintenance of treatment plant should be taken care of.
- Through quality analysis we came to know that medium sewage is generated in the study area. We got BOD⁵ 198 mg/l and Total Suspended Solids 136mg/l
- From the point of efficiency and level of sewage we selected SBR as our secondary treatment process. In Sequential batch reactor oxygen will enter through a combination of wastewater and activated sludge so that the organic matter can be reduced. The treated sewage may be acceptable for release into water surface or possibly for use on land.
- The design process and the biological treatment technologies adopted in a such a way that should be running on lower cost. And the design process should allow optimum utilization of capital. In comparing the all the above available technologies, the method of using Sequential batch reactor was found to be optimal for the treatment of the wastewater generated in the study area by analysing the test results
- Through cost analysis also, it is observed that the waste water treatment process by SBR will operate in less cost in comparison to other methods and it is more efficient.

5.2 FUTURESCOPE

- The optimal design of SBR systems with different process kinetics that has not been completely addressed in previous research and studies requires some attention and there is scope in this context.
- Until Secondary treatment level we carried out project. Installing tertiary treatment is a challenge from both operational and economical point of view.
- Using the data in the project, actual community plant can be built and can be explored for further enhancement.
- Pre-programmed controlled strategies need to gain more popularity. Introducing real time control strategies may enable the process to attain better robustness and dependability. This will help in enhancing the energy efficiency and shall also help increase the application areas of the SBR technologies.
- In addition to the biogas production and its usage as fuel in the kitchens, the food wastes generated could be added to the system for the purpose of generation of more biofuel hence achieving energy positivity.

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