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Ministry of Housing and Urban Affairs
Government of India

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एक कदम स्वच्छता की ओर

Swachh Bharat Mission – Urban 2.0

Ready Reckoner
on
Municipal Used Water Treatment Technologies
for
Medium and Small Towns

September 2022

Central Public Health and Environmental Engineering Organisation
(CPHEEO)

Ministry of Housing & Urban Affairs

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www.swachhbharaturban.gov.in www.cpheeo.gov.in

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Disclaimer

Ready Reckoner on Municipal Used Water Treatment Technologies for Medium and Small Towns is an advisory document aiming to guide ULBs in setting up suitable Used Water Management Facilities. This document contains information on size/ land area of facilities as well tentative costs based on data collected from ULBs as well technology providers. While implementing it, a more detailed understanding need to be developed, wherever needed, by setting up pilot plants in one or two cities and then taking up in others. The technologies included in this document is only few, on sample basis, which could be accessed, but it doesn't exclude similar other technologies and their modifications from implementation in field. All is needed is to examine its suitability for city through technical experts and testing pilots and then based on performance evaluation it can be taken up for implementation in other cities. The design sizes of various modular units of 1, 2 and 5 MLD plants can be suitably revised according to land available.

This document can be used for quick guidance of technology selection and DPRs preparation, however, while implementing, guidance of experts is important and 5 years O&M has to be integrated part of contract for assured performance.

मनोज जोशी
सचिव
Manoj Joshi
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Foreword

India is urbanizing fast and this pace is likely to continue for next several decades. Urban population, as per Census 2011, was around 38 crores, representing 31% of India's total population. This figure is estimated to go up to nearly 81 crores by 2050, comprising of 50% of India's population. This increase in population and consequent discharge of untreated domestic sewage is responsible for pollution of about 70% of surface water bodies.

To improve the environment and health & well-being of citizens, Ministry has accorded top priority to used water and faecal septage management through its Missions like AMRUT and SBM. To take the initiatives further, the second phase of Mission i.e., SBM-U 2.0 is focusing adequately on safe management of used water and faecal sludge in towns having population less than 1 lakh. To guide the States and ULBs in technical matters, thereof, CPHEEO, technical wing of Ministry, brings out requisite technical guidelines from time to time. The present **"Ready Reckoner on Municipal Used Water Treatment Technologies for Medium and Small Towns"** is another effort in this direction and will provide the requisite technical guidance to States & ULBs to expeditiously manage used water in cost effective manner leading to achievement of safe sanitation in all urban areas. It is presented in simple way to help decision makers also to identify and choose suitable used water treatment technology based on the local needs.

I congratulate CPHEEO and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH team in bringing out this comprehensive "**Ready Reckoner on Municipal Used Water Treatment Technologies for Medium and Small Towns**" at the appropriate time.

Manoj Joshi

(Manoj Joshi)

New Delhi
September 28th, 2022

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Preface

Since the launch of SBM-U in 2014, the journey of Urban India towards holistic sanitation has already achieved many milestones like ODF urban India, significant behaviour change in public and has become now a Jan Andolan. More importantly, we have not stopped at it and have taken up requisite steps to ensure sustainability in functionality of the constructed infrastructure, along with safe management of Used water. Hence was born the ODF+, ODF++ and Water+ protocols. Further, under SBM-U 2.0, the newly added component of "Used Water Management" aims that no untreated used water including faecal sludge is discharged into the open environment or water bodies,in the towns having population of less than 1 lakh.

To achieve this holistic sanitation, MoHUA is supporting the endeavourers of states/UTs particularly in off-site and on-site sanitation. I am delighted to see this "**Ready Reckoner on Municipal Used Water Treatment Technologies for Medium and Small Towns**" brought out by CPHEEO, which will not only be an excellent complement to the existing advisories but would greatly help in speedy selection in approach and technologies for safe management of Used Water.

I take this opportunity to congratulate the CPHEEO team for bringing out this Reckonercontaining planned approach of used water management in small cities/towns. The efforts put in by Dr. V.K. Chaurasia, Joint Adviser (PHEE), Shri Rohit Kakkar, Dy. Adviser, Shri Sathish Kumar S. – Assistant Adviser (PHE), and Shri Vipul Gulati and Shri Ashish Sharma, Consultants WASH Institute are well appreciated. I also acknowledge the efforts of various stakeholders including the technical experts and consultants from GIZ led by Ms. Monika Bahl who have contributed their time and energy in preparation of the document.

(**Roopa Mishra**)

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September 2022

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Abbreviations

AAOTS	Anaerobic-Aerobic On-site Treatment Systems
ABR	Anaerobic Baffle Reactor
ASP	Activated Sludge Process
AL	Aerated Lagoon
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AnPS	Anaerobic Packaged Septic Tank
Bcm	billion cubic meters
BOD	Biological Oxygen Demand
BOT	Build Operate and Transfer
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CWC	Central Water Commission
DTS	Decentralised Treatment System
EC	Electro Coagulation
EA	Extended Aeration
FAB	Fluidized Aerobic Bed Reactor
FMBR	Facultative Membrane Bioreactor
GLSS	Gas Liquid Sludge Separator
GoI	Government of India
HVAC	Heating, Ventilation, and Air Conditioning
INR	Indian Rupees
O & M	Operation and Maintenance
MBBR	Moving Bed Biofilm Reactor
MLD	Million Litres per Day
MoHUA	Ministry of Housing & Urban Affairs
MPN	Most Probable Number
OP	Oxidation Pond
SBM-U 2.0	Swachh Bharat Mission (Urban) 2.0
SBR	Sequencing Batch Reactors
SS	Suspended Solids
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids

TF	Trickling Filter
UASB	Up flow Anaerobic Sludge Blanket
WSP	Waste Stabilization Pond

Executive Summary

Government of India has launched the SBM-U 2.0 with the overall vision of creating "Garbage Free Cities". The newly added component **"**Used Water Management**"** aims that in the towns having population less than 1 lakh, as per census 2011, no untreated used water including faecal sludge is discharged into the water bodies or open environment. However, there exist several challenges in these towns like lack of financial resources, institutional capacity and technical know-how to plan, design, construct and operate these treatment facilities.

To overcome the technical challenges, there felt necessity for a Ready Reckoner on different Used Water Treatment options, that are suiting to smaller towns in Indian climatic conditions. This Ready Reckoner is prepared considering above said challenges and suggests more affordable sewage treatment options, that are low in CAPEX & OPEX, easy to implement and simple to operate & maintain, as compared to the cost intensive conventional treatment technologies being adopted indiscriminately.

The sewage treatment options suggested in this document are based on the extensive review of various documents, advisories, discussion with sector experts, studies of existing plants in India and other countries like Brazil which share similar climatic conditions. The views/ suggestions/ comments received on draft document from states/UTs/cities and from other sector partners including IITs are also considered and incorporated.

In this document, the sewage treatment technologies are divided into three categories, namely, nature-based technologies, mechanised technologies and combination of various treatment processes to get desired treatment standards. Nature-based and combination of various treatment processes have negligible OPEX and can be operated with even less skilled operators or many times with available personnel of ULBs. Apart from these Used Water treatment technologies, different technologies to treat diluted sewage/ grey water, in-situ treatment in drain (nallah) and community level treatment options etc. are also covered in the Reckoner. Guidance on options of Co-treatment of Septage at STPs is also provided. Some of these technologies provides good aesthetics and option for treating used water in decentralised manner depending on any piece of land easily available.

This Ready Reckoner contains Factsheets for each technology option depicting details like requirements of land, energy, capital cost, O&M cost, treatment efficiency, advantages and disadvantages etc. It also presents the flow charts, design components, typical design layouts, unit sizes and list of equipment etc. for modular 1, 2 and 5 MLD plants. These details will be helpful not only to practicing Engineers but also decision makers in understanding and opting right technology suiting to the needs of town. These details would be very helpful in quickly preparing

DPRs under Mission. Contents of Ready Reckoner are kept very objective, as great details about these technologies, are available in Manual on Sewerage and Sewage Treatment 2013.

Some of these technologies may require more land area as compared to energy intensive mechanised plant, but it would be recommended to acquire/purchase required piece of land in these smaller towns, which would help to treat more flows when town grows in future with upgradation of technologies. Moreover, investment in acquiring more land, at this stage, is an ever growing asset and can be monetised on need. Many states are financially supporting ULBs to acquire land to set up less suitable/mechanised treatment plants.

In the end, Ready Reckoner contains information on some operational plants to sensitise engineers and decision makers alike. While selecting a technology for treatment, a consideration to be made whether to go with simple and tested technologies, with due discipline in O&M in these smaller towns, or adopt high end technology without having commensurate end use of treated effluent, and allow ULBs to drain out its resources in O&M or sometime in such cases, bypass the treatment on defaulting payment of O&M/energy charges.

1 Introduction

1.1 Context

The Government of India (GoI) has recently launched Swachh Bharat Mission-Urban – 2.0, the second phase of SBM-U, on 1st October 2021 with the overall vision of creating "Garbage Free Cities". To achieve the vision, the prime objectives."i.e. Sustainable Sanitation and treatment of used water" and "Sustainable Solid Waste Management" are targeted to be achieved. The newly added component of "Used Water Management**"** aims that no untreated used water including faecal sludge is discharged into the open environment or water bodies, especially in the towns having population of less than 1 lakh.

The estimated sewage generation from urban centres in country is 72,386 MLD as of 2020-21.Againstthis, thereare1631 STPs (including proposed) having 36,668MLD capacity, however, the actual capacity utilization is 20,235 MLD i.e., just 27.9%. This clearly indicates that the existing approach to setup mechanised/highly skilled STPs often face operational problems on commissioning at ULB level, leading to discharge of untreated usedwater, thereby, polluting rivers, lakes, and water bodies. Further, due to lack of collection & conveyance network of sewage, and low number of house connections, the problem is further compounded, as only part of sewage generated from the households lead to STPs. At present, out of about 4,800 ULBs, only around 700 ULBs have partial or full sewer network.

To improve the water quality of rivers and lakes, there is an urgent need (i) to increase sewage treatment capacity including its optimum utilization and (ii) strengthening of sewage collection network with emphasis on house service connections.

1.2 Need for Ready Reckoner

Majority of the small and medium towns have no sewerage system. To improve sanitation in these towns, a customised approach will go a long way, which accounts for constraints of smaller ULBs like lack of financial resources, institutional capacity and technical know-how to construct and operate STPs. Keeping above in view, this Ready Reckoner is developed to provide guidance on STPs especially suiting to smaller ULB's, in warm climate of India. This will also be helpful in selection of suitable technology(ies) while preparing DPRs by State/UTs/ULBs.

1.3 Trends of adoption of Used Water Treatment technologies in India

As per CPCB Report 2021, various technologies are employed for treatment of domestic wastewater. It is observed that Sequential Batch Reactor (SBR) and Activated Sludge Process (ASP) are the most prevailing technology adopted by ULBs, especially in larger ones. Treatment technologies adopted in Indian cities in terms of treatment capacity is given at Figure 1. Type of treatment technologies adopted in Indian cities is categorized under Nature-Based/ Mechanized/ Combinations of more than one technologies are listed in **Table 1**.

Awareness about nature based STPs like anaerobic and aerobic systems has been increasing of late and hundreds of such nature based STPs are installed and successfully operating in various countries.

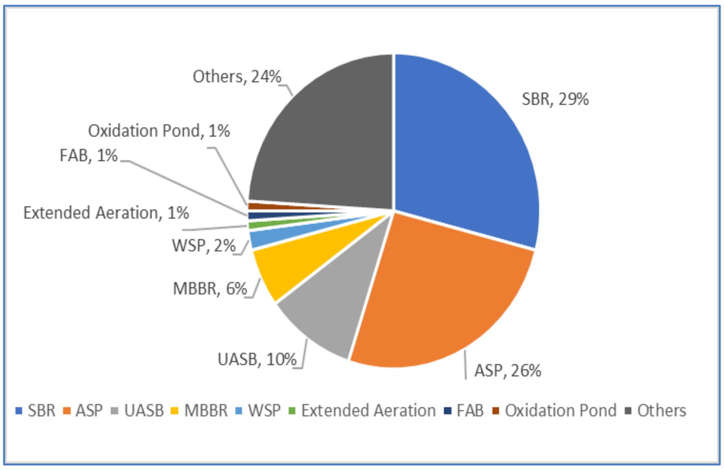


Figure 1: Treatment technologies adopted in India as per treatment capacity in MLD

Table 1:Treatment technologies adopted in Indian cities

	Nature based Treatment technologies		
1	Waste Stabilization Pond (WSP)	2	Root Zone/Constructed Wet Land

	Conventional/MechanizedTechnology		
1	Aerated Lagoon	5	Trickling Filter
2	Activated Sludge Process (ASP)	6	Moving Bed Biofilm Reactor (MBBR)
3	Extended Aeration (EA)	7	Up-flow Anaerobic Sludge Blanket (UASB)
4	Sequencing Batch Reactor (SBR)		

Combination of UASB/ABR technologies for higher rate of removal			
1	UASB/ABR + Polishing Pond	4	UASB/ABR + Activated Sludge Process
2	UASB/ABR + Land disposal	5	Decentralised Treatment System (DTS)
3	UASB/ABR + Trickling Filter		

1.4 Discharge standards for treated usedwater

Level of treatment, and therefore the adoption of treatment technology, should be governed by factors like receiving environment, available dilution level and end use of treated effluent. The lack of clarity on treated effluent standards in various ULBs and their perception on adopting of stringent treatment standards is probable the reason for going for more mechanized STPs having high CAPEX, OPEX and skilled maintenance. This approach of selection of treatment technology is often unsustainable given the weak financial base of ULBs, especially smaller ones.

Here, it is important to clarify that the 'general discharge standards 1986', were revised vide MoEF&CC notification dated 13th Oct 2017 in respect of few important parameters. Subsequently, Hon'ble NGT stayed the notification and directed MoEF&CC vide OA no.1069/2018 dated 30thApril 2019, to issue an appropriate Notification in the matter. But since the matter is subjudice and revised standards yet not notified by MoEF&CC, therefore, the 'general discharge standards 1986' still prevails except in those cases where CPCB/ SPCB enforced a more stringent set of standards. Some selected parameters of general discharge standards of 1986 ,those notified in Oct 2017 and the one directed by NGT in 2019, to incorporate in notification, are given in Table 2 below.

Table 2: Treated Usedwater Discharge Standards

S.no	Parameters	General norms 1986				MoEFCC Notification, October 2017**	NGT order 2019** (for Mega and metropolitan cities)
		Inland Surface water	Public sewers	Land irrigation	Marine coastal areas		
1	BOD [mg/L]	30	350	100	100	< 30 < 20 (metro cities)	<10
2	COD [mg/L]	250	–	–	250	Not more than 50 (for new STP design)	< 50
3	TSS [mg/L]	100	600	200	100 process water 10% of influent cooling water	< 100 < 50 (metro cities)[2]	< 20
4	TKN [mg/L]	100	–	–	100	Not more than 10 (for new STP design)	< 10
5	NH3-N [mg/L]	50	50	–	50	Not more than 5 (for new STP design)	–
6	Dissolved phosphorus [mg/L]	5	–	–	–	–	<1
7	Faecal coliform [MPN/100ml]	–	–	–	–	< 1000	Permissible < 230

Source: NGT 2019, MoEF&CC 1986, 2015 and 2019

1.5 International Experience- approach for Used Water treatment in Brazil and Germany

Two international experiences from Brazil and Germany are presented below intending to infuse confidence in ULBs on two aspects i.e. (i) for smaller towns having population less than 1 lakh, with similar warm climatic condition as of India, Brazil has adopted predominantly nature-based/ less mechanized used water treatment technologies to address the pollution problem and (ii) approach of Germany that shows to keep environment very clean, over a period of time, all usedwater has to be safely collected through sewer network and to be treated to tertiary treatment level.

Whereas Brazil case is useful in guiding our ULBs of < 1 lakh population on affordable and sustainable Used water technology adoption, to begin with, even in smaller towns, the feat that Germany has achieved, in last 40-50 years, with concerted efforts to address used water related pollution, would guide that how our ULBs should start planning and implementing for Used water management for India@100. Now most of the municipalities in Germany are responsible for creation and management of wastewater treatment facilities.Although, Indian towns will aspire to reach to this level in coming 20-30 years or so, but, given the present financial and skill base with ULBs, it is important to learn from Brazilian experience and incrementally, based on end use, used water can be treated up to tertiary level as Germany has done.

Predominance of nature based STPs in Brazil

Brazil is in many ways comparable to India in terms of economy, demographics, and warm climatic conditions. There are a total of 5,570 towns in Brazil, and out of these around 95% towns have population less than one lakh. Therefore, the vast majority of ULBs in Brazil are small to medium-sized. Around 1,900 (34%) ULBs have STPs. The total number of STPs in Brazil is estimated to be around 2,800 plants. A survey conducted in 2015 by National Water Agency of Brazil on 2,187 STPs highlighted the following:

i. The treatment configurations most widely adopted in terms of number of treatment plants are, in this order: Anaerobic Pond followed by Facultative Pond, UASB, ASP, Ponds followed by Maturation Ponds, Septic Tanks followed by Anaerobic Filter.

ii. In terms of groupings of treatment systems, it is observed that:

   a. Ponds and UASB reactors alone/or followed by any form of post-treatment, dominate in terms of number of treatments plants representing almost 80% of 2,187 STPs.

   b. UASB reactors alone/or followed by any form of post-treatment, ASP and different combinations of ponds, treat the largest number of inhabitants representing 95% of the total population equivalent surveyed.

iii. Different sewage treatment configurations are being used in Brazil. The most traditional system involves stabilization ponds, which are present in large numbers of populations up to around 20,000 inhabitants. Variants of the ASP have been used for many population ranges, covering small, medium, and large cities.

iv. UASB reactors represent the main trend for all population ranges, especially when they are followed by a post-treatment stage. Several post-treatment options for UASB effluent are available, with a special mention to trickling filters, which are being implemented in many locations, especially when land availability is not large.

Different sewage treatment technologies adopted in Brazil is given in Figure 2.

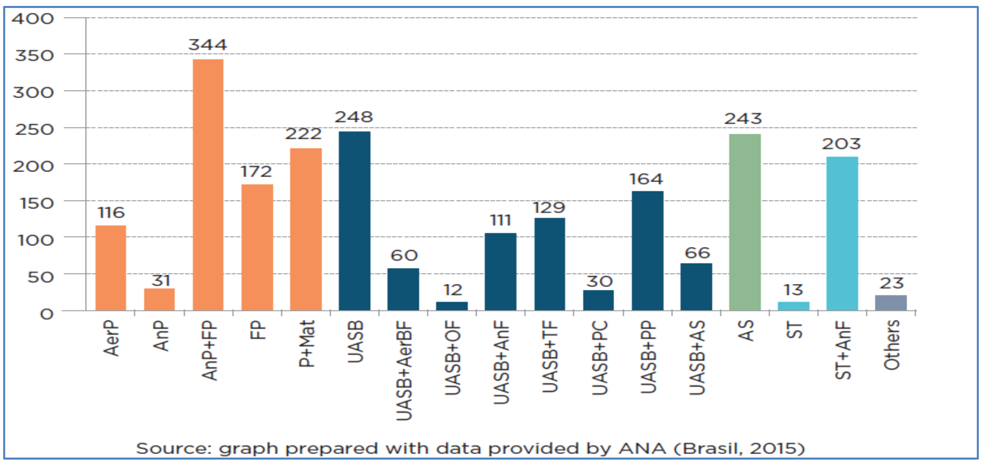


Figure 2: Technology wise distribution of number of STPs in Brazil (n=2,187)

Further, the distribution of number of Wastewater Treatment plant (WWTP) range, are given in the figure 3 below, which shows that the nature based system can be provided in the towns having population as low as 5000.

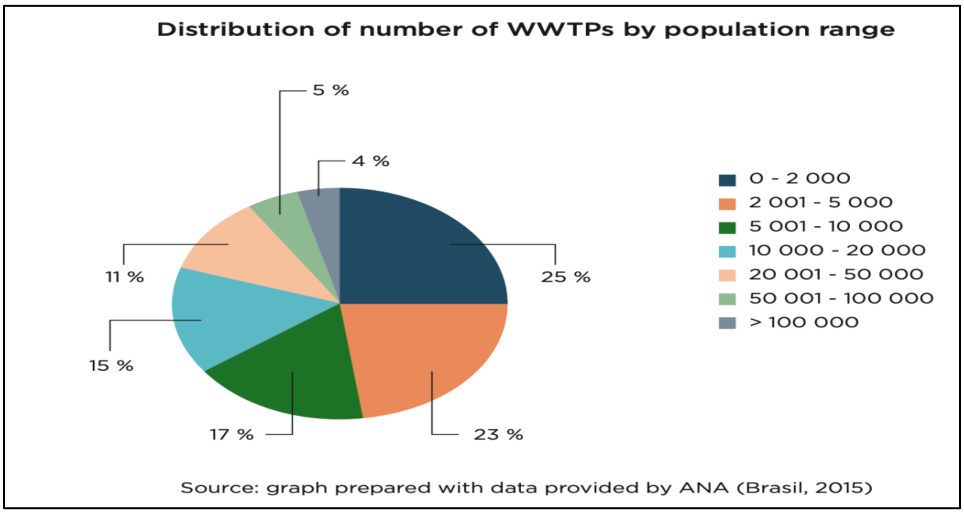


Figure 3: Percentage of WWTPs (2800 Nos.) per population range in Brazil

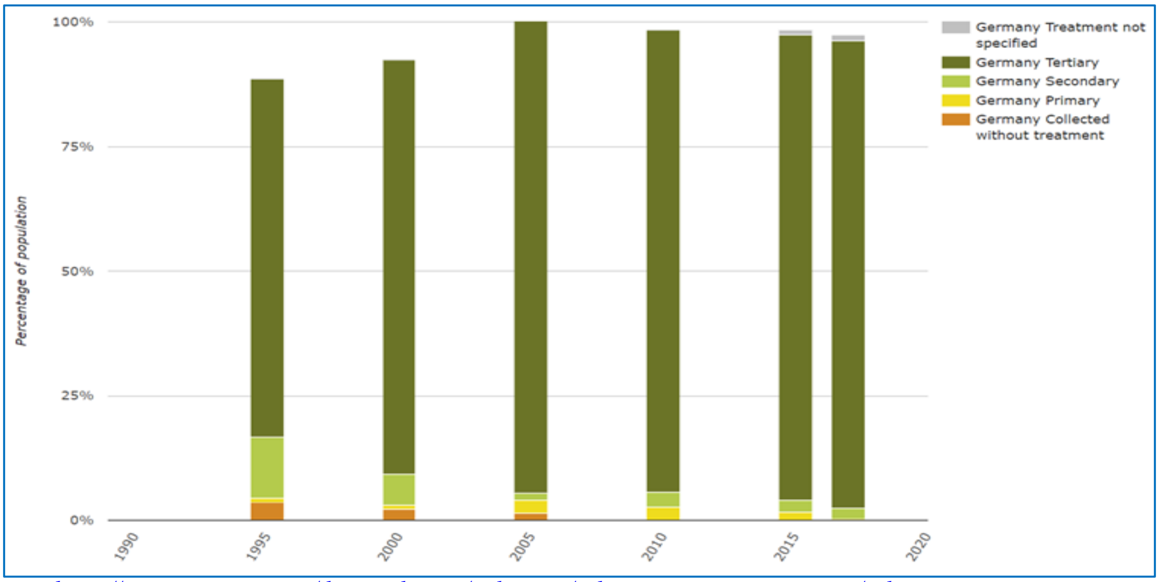
This approach enlightens that opportunity available under SBM-U 2.0 for treatment of Used Water need to be availed now even by smaller towns and let's not leave planning and implementation of UWM in these towns till they become Class I or Million Plus. This is important for cost effective and ease of implementation of such systems on one hand and for behaviour change towards it from very beginning on other hand.

However, in large 10% towns (class I and above) accounting for 75% of urban population, considering factors like land cost, financial health of ULB, end use of treated Used water etc. mechanised STPs may be preferred on lines guided in CPHEEO manual of 2013 in detail.

Status of Treatment Infrastructure in Germany[1]

More than 95 percent of the German population (8 Crore inhabitants) are linked to the public sewage system (2004). Wastewater is treated in more than 10,000 sewage treatment plants. In general, municipalities are responsible for wastewater treatment facilities. There are, however, also privately owned sewage treatment plants in industry. Around 94 lakh ML of wastewater are treated annually in public wastewater treatment facilities. During 1990 to 2017, Germany has moved from 72% of tertiary treatment systems to 94% of the tertiary treatment systems as shown in **Figure 4**.

[1]Source: https://www.bmu.de/en/topics/water-resources-waste/water-management/wastewater/sewage-treatment-plant



Source: https://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment/urban-waste-water-treatment-assessment-5

Figure 4: Change in urban wastewater treatment in Germany from 1990 to 2017

Almost 100 percent of the wastewater is treated in sewage works with three purification stages[2].

1. **Primary stage**: Mechanical processes (adsorption, filtration, stripping) with grill, sand filtration, primary sedimentation tank
2. **Secondary treatment stage**: Microbiological processes, decomposition of organic components (aerobic & anaerobic), elimination of organic Nitrogen & Phosphorus
3. **Tertiary treatment stage**: Abiotic-chemical processes (oxidation, precipitation) to further eliminate Phosphorus and nitrogen.

Once smaller ULBs are provided with Used Water treatment facilities, depending on need and end use up-gradation of treatment technology can be taken up with closed sewer networks to achieve high level of hygiene and improved public health.

1.6 A brief about Sewage Treatment Processes

The objective of wastewater treatment is to separate various pollutants from water. There are a large variety of treatment techniques designed to remove pollutants from wastewater. The CPHEEO Manual on Sewerage and Sewage Treatment Systems (2013) discusses in detail the different types of treatment technologies including decentralized wastewater treatment technologies along with their design considerations and operating requirements. A significant classification categorising the type of treatment is as below.

[2]Source: https://www.ecologic.eu/sites/default/files/event/2017/prasentation_evenlyn_water_management_in_germany_and_waste_water_treatment.pdf

i. **Primary treatment:** the purpose of primary treatment is to settle materials by gravity, removing floating objects and reduce the pollution to ease secondary treatment. Primary treatment aims to reduce the Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) in the wastewater. It essentially consists of removing the suspended solids present in the wastewater through physical sedimentation or coarse screening methods. Primary treatment system consists of bar screen, grit chamber and primary settling tank has been suggested for all technologies except for Extended aeration where Primary Settling Tank (PST) is absent.

ii. **Secondary treatment:** Secondary process is stage where major biological reaction occurs. The microbes present in the activated sludge degrade the organic pollutants that exerts the biochemical oxygen demand resulting in the treatment of wastewater. The various technologies are described in the later sections 2.2

iii. **Disinfection:** The last stage in the wastewater treatment process is disinfection. The process ensures the elimination of E-Coli and other microbes to permissible level. Disinfection using chlorine is a common practice. It shall be provided for all the technologies mentioned in the Ready Reckoner document. Ozone and Ultra Violet (UV) radiation can also be used for disinfection but these methods of disinfection are not in common use

iv. Depending on need, Tertiary treatment process after Secondary process can be used to remove Phosphorous and Nitrogen etc. It can be further treated using Ultrafiltration and Reverse Osmosis techniques to meet industry process requirements.

The classification of common wastewater treatment process according to their level of advancement is summarized in the **Table 2** below.

Table 3: Classification of common wastewater treatment processes

Primary	Secondary	Disinfection
Bar or bow screen	Waste Stabilization Ponds	Chlorine disinfection
Grit removal	Aerated Lagoon (AL)	Ozone
Parshall Flume	Root Zone Technology (RZT)	Ultra Violet (UV) radiation
Primary Settling Tank	Activated Sludge Process (ASP)	
	Extended Aeration (EA)	
	Sequential Batch Reactor (SBR)	
	Trickling Filter (TF)	
	Moving Bed Biofilm Reactor (MBBR)	
	Up-flow Anaerobic Sludge Blanket Reactor (UASB)	

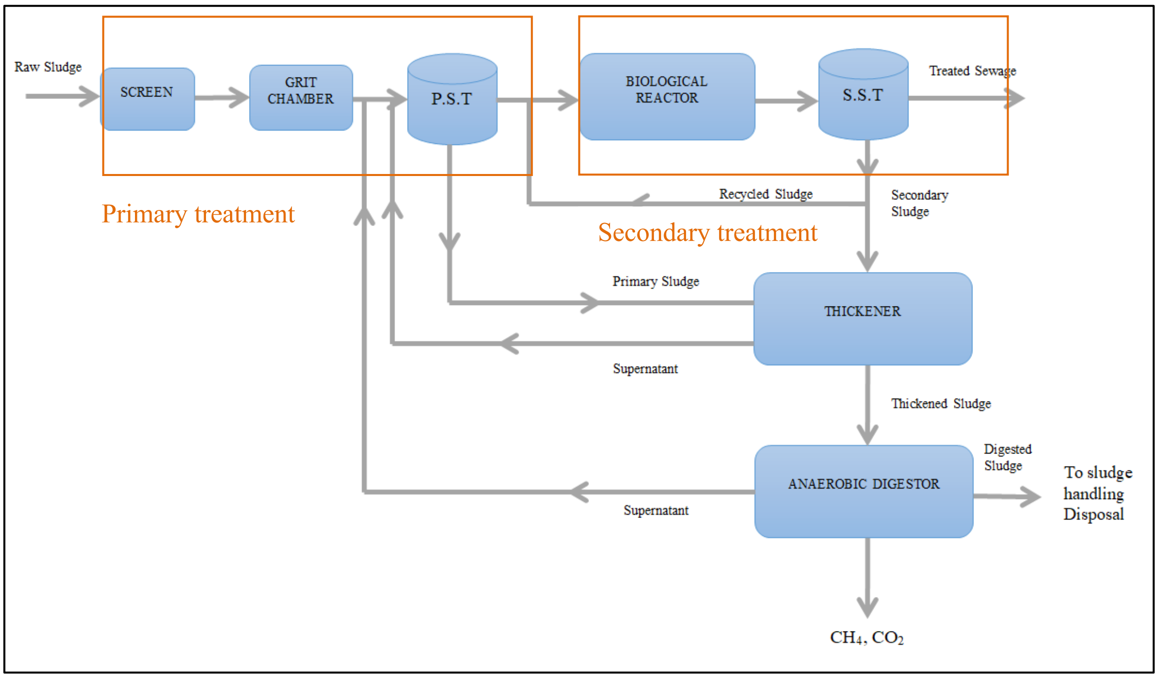
Source: Adapted from Water Pollution Control - A Guide to the Use of Water Quality Management Principles, WHO/UNEP

The sizing of primary treatment and disinfection units described in the Ready Reckoner will be common for all the treatment options described in section 2.2

Further, the treatment processes can be classified as mechanised & non-mechanised. Mechanised system involves pumps, blowers, skilled resource, and electric motors. The non-mechanised wastewater treatment are nature-based systems involving primary, secondary, and tertiary treatments require almost negligible energy, chemical and low skilled resource. However, depending on technology opted, since the biological processes are not intensified by mechanical equipment, in some cases relatively large land areas are required to provide sufficient retention time to allow for a high degree of contaminant removal. This makes it suitable for relatively smaller towns. Further, the land acquired at this stage for sewage treatment can accommodate larger volume of sewage for treatment at later stage, when the town grows.

The mechanised and nature based secondary technologies broadly work on aerobic (ASP) & anaerobic (UASB, Anaerobic filter etc.) degradation principles. The choice between aerobic and anaerobic technologies must be considered mainly with the fact that added complexity of the oxygen supply that is in need for aerobic technologies and its higher O&M cost.

Unit processes in aerobic and anaerobic treatment processes are shown in Figure 5& Figure 6 below.



PST: Primary settling tank, SST: Secondary settling tank

Figure 5: Unit operations in aerobic mechanized biochemical sewage treatment process

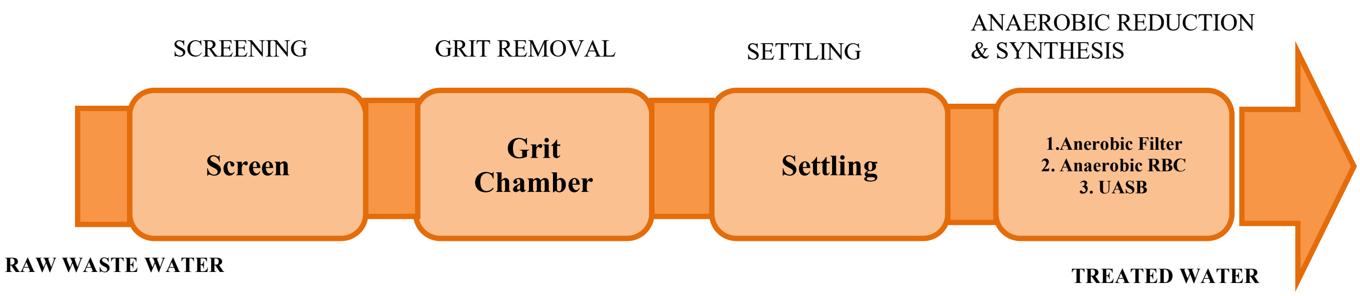


Figure 6: Process flow of conventional anaerobic sewage treatment

2 Sewage Treatment Technologies

Sewage Treatment Technologies, suitable for small and medium towns, can be broadly classified into three categories, namely, nature-based treatment technologies, conventional or mechanised treatment technologies and combination of the two. The factsheet, photograph, typical layout, process diagram and design sizes for various components for modular 1, 2 & 5 MLD STPs are given in subsequent paragraphs. The representative influent quality parameters in respect of BOD, COD and TSS are considered250 mg/l,425mg/l and 375 mg/l respectively as per CPHEEO Manual. The Ready Reckoner considers the technologies meant to comply with treated effluent standards notified by MoEF&CC.

2.1 Nature Based Technologies

Nature Based Systems are biological treatment systems that require no or very low electrical energy instead they rely on entirely natural factors such as sunlight, temperature, filtration, adsorption, biodegradation, sedimentation etc, to treat wastewater[3]. NBS include waste stabilisation pond, Root zone technologies etc. These are characterised by low dependence on fossil energy, mechanical equipment's and chemicals. Two technologies are described under section below.

2.1.1 Waste Stabilization Pond

Waste stabilization ponds are open, flow-through earthen basins specifically designed and constructed to treat sewage. They provide comparatively long detention periods extending from 7-10 days[4] depending on the type of pond. The soluble and fine particulate BOD is aerobically stabilized by bacteria that grow dispersed in the liquid medium, while the BOD in suspension tends to settle, being converted anaerobically by bacteria at the bottom of the pond. The ponds can be used individually or linked in a series for improved treatment.

[3]Source: IWA Online-Nature based solutions for wastewater treatment

[4]https://sswm.info/factsheet/waste-stabilisation-ponds

I. The Factsheet of Waste Stabilization Pond is given below.

Table 4: Fact Sheet - WSP

Waste Stabilization Pond (WSP)		
1.	**Process and units**	• There are two basic types of waste stabilization ponds, and these are normally connected in series to provide a two- or three-stage treatment process as mentioned below: • **Anaerobic ponds:** Comparatively small and deep (3–4 m) as there is no need for aeration. They receive raw sewage, which is treated by anaerobic bacteria, while sludge that builds up in the bottom of the pond is digested by anaerobic micro-organisms. • **Facultative ponds:** Shallower (1.5–2 m) with a larger surface area than anaerobic ponds. They consist of an aerobic zone close to the surface and a deeper, anaerobic zone. • The treatment units of WSP are shown in the figure 8.
2.	**Land Requirement**	0.5 – 1.0 Ha/ MLD installed capacity [10,000 Sq.m.] [100m x 100m]
3.	**Energy Requirement[5]**	Negligible
3.	**Capital Cost**	INR 30 to 60lakh/MLD (depends on whether earthened or bricklined)
4.	**O&M Cost**	INR 0.6 to 2.5 lakh/year/MLD Installed capacity. The cost substantially varies with different type of WSP i.e., lined, unlined and as per geographical location.
5.	**Effluent Quality**	• BOD: 15-50 mg/l • Suspended solids (SS): 75 to 125 mg/l • BOD removal efficiency: 80-95%, COD: 85-90%, TSS: 80-95%
6.	**Advantage**	• Simple to construct, operate and maintain • Low O&Mcost • Extremely robust and can withstand hydraulic and organic shock loads
7.	**Disadvantage**	• Large land requirement • High cost of lining • Likelihood of odour nuisance and mosquito
8.	**O&M**	• **Start-up Procedures –** Pond systems should preferably be commissioned at the beginning of the hot season to establish as quickly as possible the necessary microbial populations to effect waste stabilization. • **Routine Maintenance –**Desludging once in two years orwhen it is accumulated to the desired height. Weeds and floating materials should be removed • **Process Control –** Ensure the sludge accumulation does not exceed 30% of the total liquid depth or the design depth of sludge. • **Records –** Daily tests of Flow, SS, and monthly tests of DO.
9.	**Plant examples**	• Fatehgarh: 2.7 MLD (1993) • Punjab: Bhucho: 3 MLD (2012) and Goniana: 3 MLD (2012) • Mandapal, Talcher: 2 MLD (2018)
10.	**Sludge generated[6]**	• 32 T /year for 1MLD
11.	**Suitability**	• Suitable for all location and weather condition with temperature above 20°C. If the required temperature is low appropriate change can be made in the design of the treatment system. • WSP is very much suitable for smaller towns having population less than 20,000 due to its robustness and less O&M cost and low skill maintenance. Land acquired at this stage would be capable to manage increased sewage flow through upgradation of technology when town grows in coming decades.

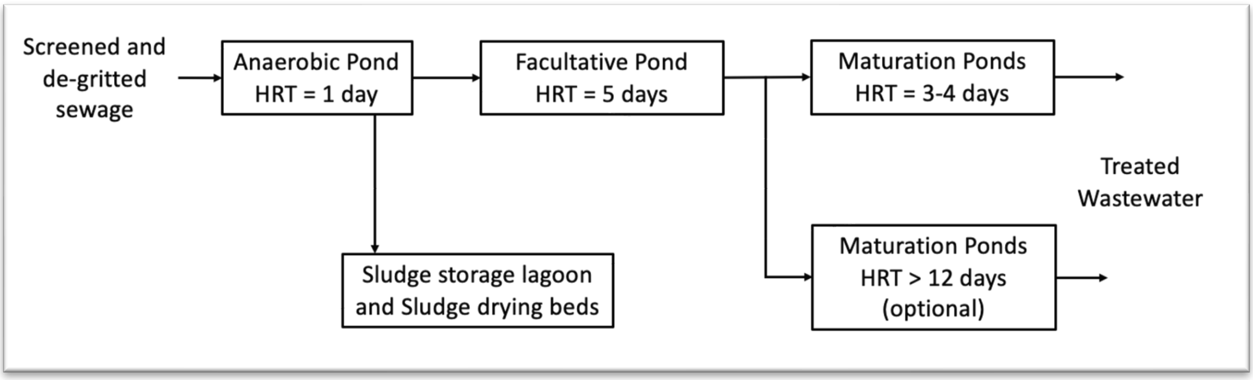
[5] On-site and Off-site Sewage management practices,2020
[6] Source: Wastewater Treatment: Concepts and Design Approach by GL Karia, RA Christian

II. The photographs of Waste Stabilisation Pond are given below

Figure 7: Photographs of 3.0 MLD WSP technology based STP at Goniana, Punjab

III. The process diagram of WSP is given below.

The below image Figure 8 shows the schematic diagram of a waste stabilization pond with Anaerobic and Facultative Pond



Note: Maturation pond can be replaced by disinfection unit to save land, after suitable modification in facultative pond.

Figure 8: WSP – Process

Source: https://xtremeindia.com/services/stp/

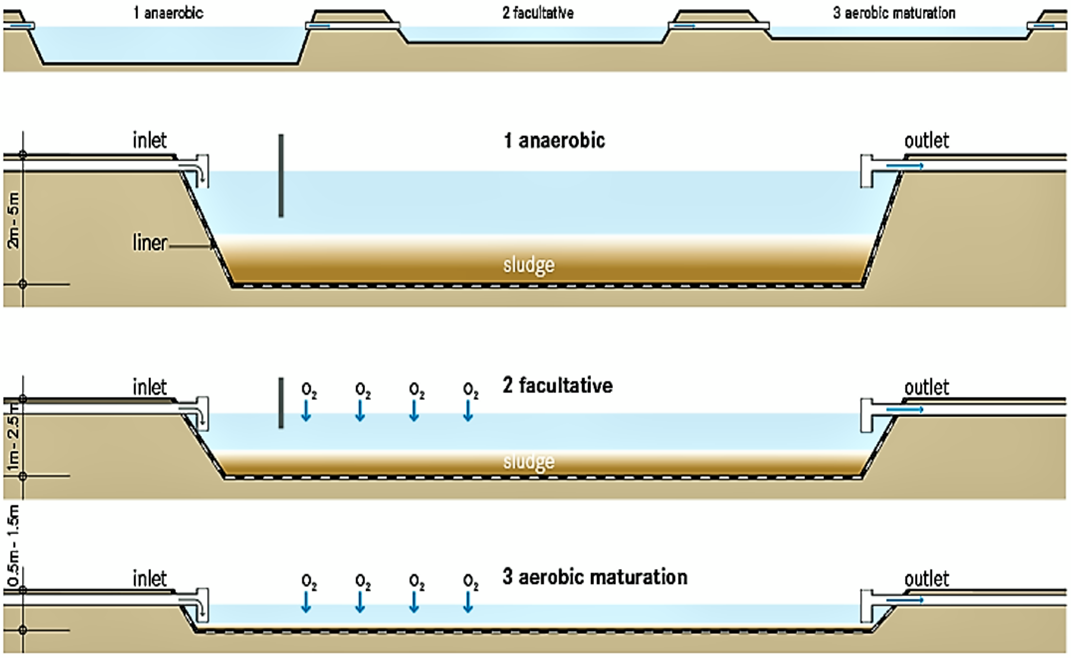


Figure 9: Schematic Diagram of the Cross-Section on of a Waste Stabilization on Pond

Source: SSWM, Waste Stabilisation Pond-Factsheet[7]

IV. The typical layout of WSP is given below

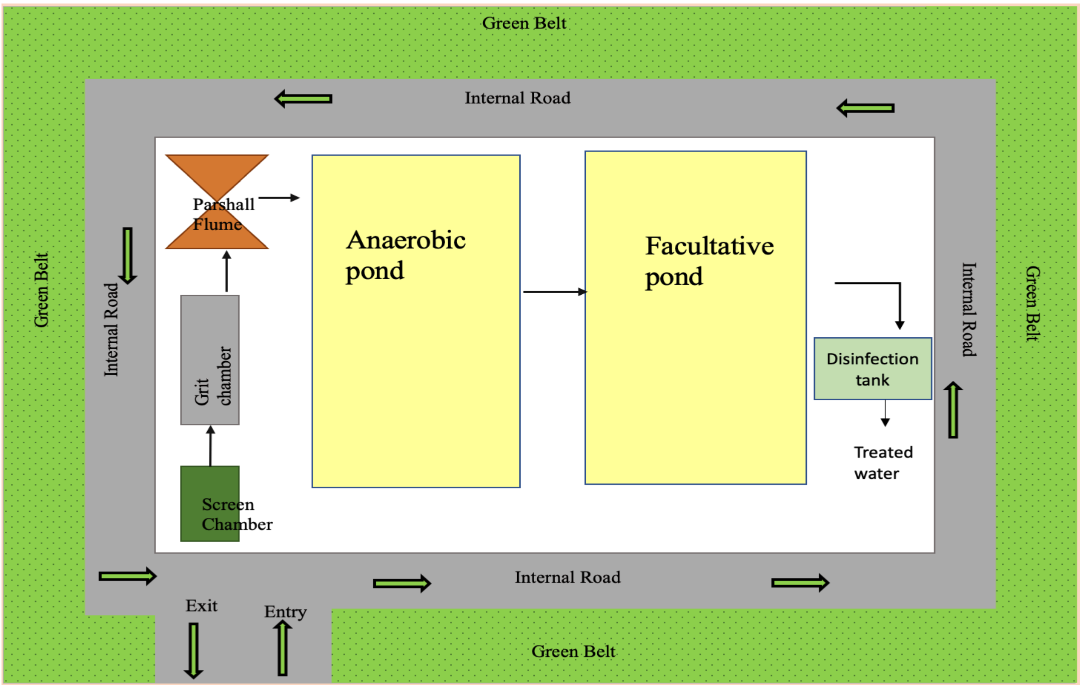


Figure 10: Typical Layout for WSP plant

V. The unit sizes for different capacities for WSP may vary based as indicated below:

[7] https://sswm.info/factsheet/waste-stabilisation-ponds

Table 5: Design inputs for 1, 2 and 5 MLD for WSP

	1 MLD	2 MLD	5 MLD
LIST OF STRUCTURES*	**(L X B X D)**	**(L X B X D)**	**(L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
Facultative pond (m)	62.00 x 124.00 x 2.20	87.00x174.00x2.20	140.00 x 280.00x2.20
Anaerobic Pond (m)	13.50 x 27.00 x (3.50+0.50 FB)	19.00 x 38.00 x (3.50 +0.50 FB)	30 x 60 x (3.5+0.5FB)
*(BOD removal = 2XT-20)**L** = Length, **B** = Breadth, **D** = Depth, **FB** =Free Board* ** The dimension can be re-oriented according to the available space*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing

STP is designed for a minimum average temperature of 15°C

2.1.2 Root Zone or Constructed Wetland

They are also known as constructed wetlands or Planted gravel filter or Horizontal Gravel Filter, based on the flow pattern of wastewater. The Root zone process functions according to the laws of Nature. To effectively purify domestic wastewater, Root Zone encompasses the life interactions of various species of bacteria, the roots of the reed plants, soil, air, sun and water. Constructed wetlands represent an alternative treatment system to conventional treatment systems such as activated sludge process.

I. The **factsheet for Root Zone** based STP is given below.

Table 6: Fact Sheet-Root zone

		Root Zone
1.	**Process and units**	• Constructed filtration systems planted with wetland vegetation like cattails (Typha species), reeds (Phragmites species), bulrushes (Scirpus species), sedges (Carex species), Canna indica etc. with defined filter material and direction of wastewater flow • It is based on slow filtration of pre-treated wastewater • The filter environment must fulfil the pre-defined requirements in terms of hydraulic conductivity and load of wastewater by pollution, flow rate, frost penetration, or the possibility to bind phosphorus and heavy metals • The treatment units of Root Zone process are shown in the figure 11.
2.	**Land Requirement**	0.6 – 1.5 Ha/ML
3.	**Capital Cost**	Rs 30-150Lakh per MLD[8] The per MLD cost varies depending on capacity and geographical location.
4.	**O&M Cost**	Rs 1.2 - 3 Lakh per MLD per Annum
5.	**Advantage**	• Construction does not need expensive materials

[8]Based on the cost of STPs implemented in Himachal Pradesh

		• Operation and maintenance of the system is easy • Process does not require fossil fuels and chemicals for treatment. • Besides purification, facility can be used for fish cultivation, production of biomass, agriculture, recreation, flora and fauna conservation and water supply for different purposes
6.	**Disadvantage**	• Land availability is a constraint. • Optimizations of parameters become difficult when different wastewater get mixed together • Regular harvesting of the biomass and removal of dead plant material is essential to maintain consistent performance
7.	**O&M**	• Substrate - Clean the substrate and replace if necessary for proper functioning of system. Check clogging of the substrate. • Inlet - Remove end caps from inlet pipe and distribution network and flush out and clean thoroughly to remove slimes and blockages • Outlet - Clean and remove plants around outlet pipe to provide access and guard against blockages. • Vegetation - Harvest vegetation and replant if necessary • Primary treatment - Check sludge levels in primary treatment and de-sludge as necessary to maintain treatment performance and avoid sludge drift into wetland.
8.	**City/plant examples**	Kalyan Dombivali Municipal Corporation(Manda Titwala) – 2 MLD Hyderabad- Kanhasanthivanam-1.2 MLD Dharmshala, H.P.- 180 KLD
9.	**Sludge generated**	Minimal to be cleaned filter once in 10 year or when clogged
10.	**Suitability**	Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

II. The process flow diagram for Rootzone based STP is given below.

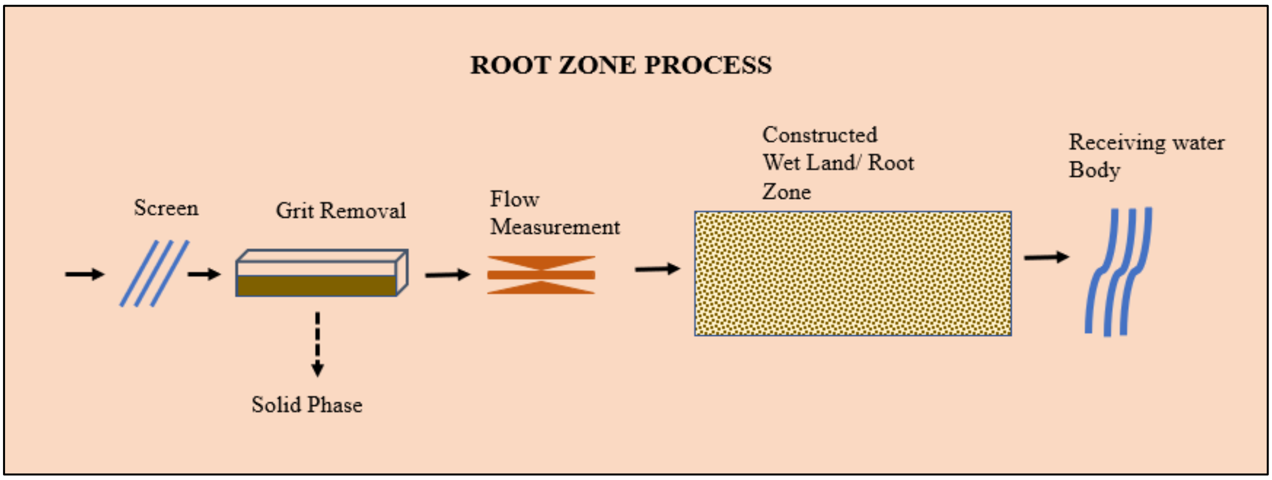


Figure 11: Root zone– Process

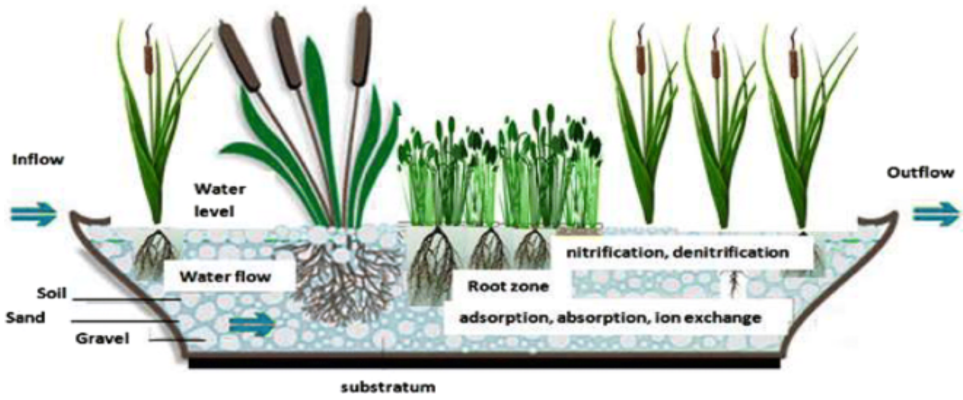


Figure 12 : Root zone–schematic cross section

III. The photograph of Root Zone based STP is given below

Figure 13: Photo of Root Zone technology based STP (180 KLD STP at Dharamshala, H.P.)

IV. Typical Layout of Root Zone based STP is given below.

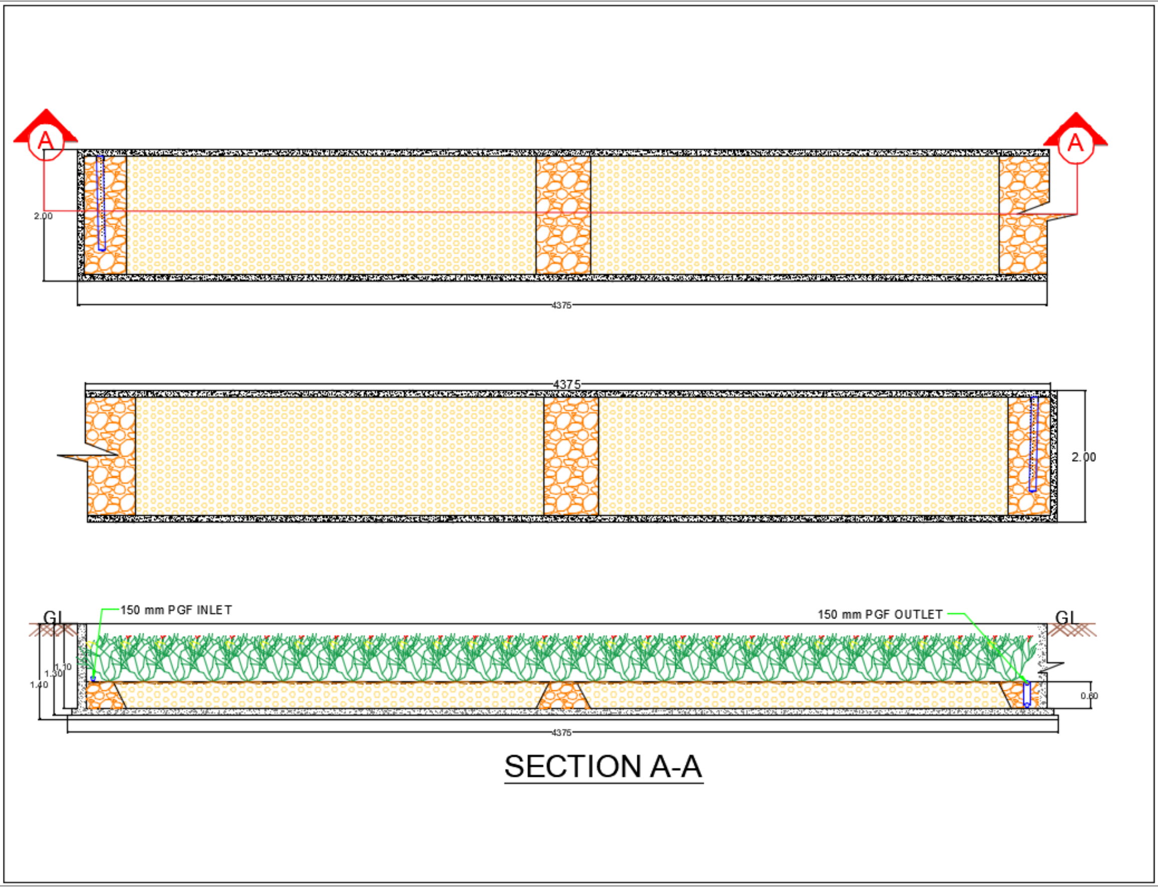


Figure 14 Typical layout for Root Zone System

V. The **Unit sizes of different capacities of Planted Gravel Filter** are in Table 7.

Table 7: Design inputs for 1, 2 and 5 MLD of Planted Gravel Filter

	1 MLD	**2 MLD**	**5 MLD**
LIST OF STRUCTURES	(L X B X D)	(L X B X D)	(L X B X D)
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
Planted Gravel Filter	30.00 x 40.00 x (0.80 + 0.30 FB) 4 Nos	30.00 x 75.00 x (0.80 + 0.30 FB) 8 Nos	30.00 x 95.00 x (0.80 + 0.30 FB) 16 Nos
Tertiary Treatment			
Disinfection tank (m)	5.60 x 5.60 x (1.50 + 0.5 FB)	8.90 x 7.00 x (1.50 + 0.50 FB)	10.90 x 8.70 x(1.50 +0.50 FB)
Sludge Treatment			

***L** = Length, **B** = Breadth, **D** = Depth **FB** = Free Board* ** The dimension can be re-oriented according to the available space.*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10x10mm bar, 25mm spacing	10x10mm bar, 25mm spacing
Flow measurement devices	1(W)	1(W)	1(W)
W = Working, S = Standby			

2.2 Mechanised Treatment Technologies

Mechanised treatment technologies, such as ASP, Extended aeration, MBBR etc., achieve treatment by creating an artificial environment using chemicals, tanks, pumps and other components to eliminate the contaminants. These systems require less land but are more expensive as they are energy-intensive and require external reagents. Such systems are described in this Reckoner as below.

2.2.1 Aerated Lagoon

Aerated lagoons are of two principal types depending on how the microbial mass of solids in the system is handled. Facultative Aerated Lagoons are those in which some solids may leave with the effluent stream, and some settle down in the lagoon since aeration power input is just enough for oxygenation and not for keeping all solids in suspension. As the lower part of such lagoons may be anoxic or anaerobic while the upper layers are aerobic, the term facultative is used.

While, Aerobic Lagoons, on the other hand, are fully aerobic from top to bottom as the aeration power input is sufficiently high to keep all the solids in suspension besides meeting the oxygenation needs of the system.

I. Factsheet for Aerated lagoon is given below.

Table 8: Fact Sheet –Aerated Lagoon

Aerated Lagoon Technology Options- Wastewater Treatment [Grey + Black Water; Septic Tank Effluent], Secondary Treatment		
1.	**Process and units**	• Lagoons are generally rectangular, though it is not particularly essential. Natural land contours may be followed to the extent possible to save on earthwork. • Lagoon units may be built with different length-width ratios and arrangement of internal baffles to promote desired mixing conditions. • Lagoons may also be provided as two or three stage systems with the subsequent units placed at a lower level than the first if desired. • The treatment units of Aerated Lagoon are shown in the figure 15.
2.	**Land Requirement**	• 0.27- 0.4 Ha/ MLD installed capacity [4000 Sq.m.] [80mx50m]
3.	**Energy Requirement**	• 15-20 kWh/ML treated

3.	**Capital Cost**	• INR 40 to 60lakh/MLD capacity[9]
4.	**O&M Cost**	• INR 1.5to 3.0 lakh/year/MLD Installed capacity
5.	**Effluent Quality**	• BOD: 25-30mg/l; COD: 40-65mg/l • SS: 40-150 mg/l • BOD removal efficiency: 80-90%; COD: 85-90%, TSS: 95%
6.	**Advantage of FAL[10]**	• Relatively simple construction, O&M • Lower land requirements than the facultative and anaerobic-facultative pond systems • Satisfactory resistance to load variations
7.	**Disadvantage of FAL[11]**	• Land requirements still high • Relatively high energy requirements • Need for periodic (some years interval) removal of sludge from aerated pond
8.	**City/ plant examples[12]**	• Sadalaga, Chikkodi (Karnataka): AL 3.72 MLD (2018) and 15 MLD (2004) • Ramanagara, Karnataka City Municipal Council (CMC) (2014) – 7.5 MLD • Puri (Odisha): AL 15 MLD (2014)
9.	**Sludge generated[13]**	• 70 T /year for 1MLD
10.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

II. Process flow diagram for Aerated lagoon is given below.

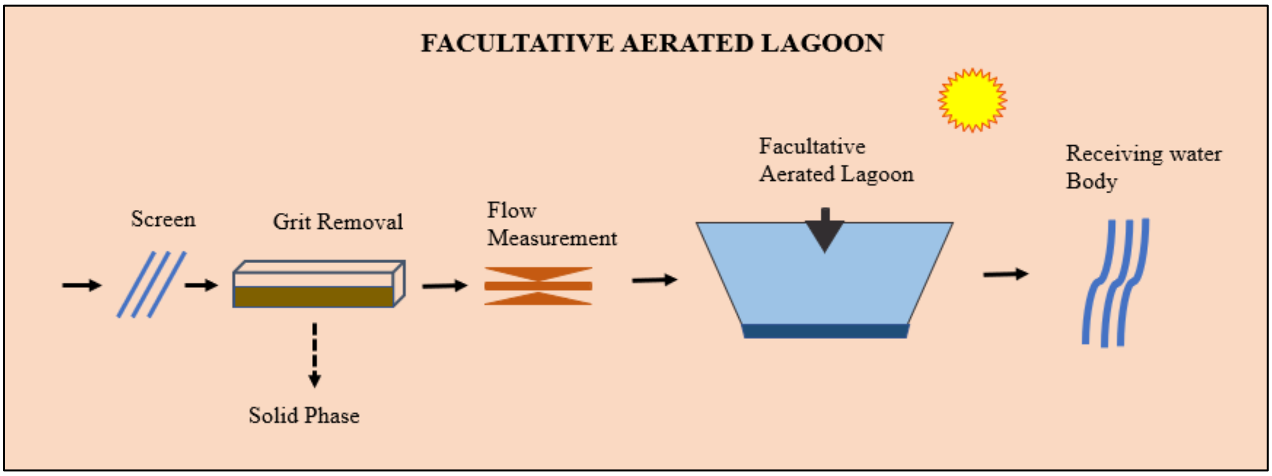


Figure 15: Flowsheet of Facultative Aerated Lagoon

[9]Compendium of sewage treatment technologies, 2006 (Considering current increment by 10% 27.5lakh/MLD)
[10]Source: Biological Wastewater Treatment in Warm Climate Regions, Volume – I, IWA (2006)
[11]Source: Biological Wastewater Treatment in Warm Climate Regions, Volume – I, IWA (2006)
[12]Source: CPCB Inventory (2021)
[13]Source: Wastewater Treatment: Concepts and Design Approach by GL Karia, RA Christian

III. Typical Layout for Aerated lagoon is given below.

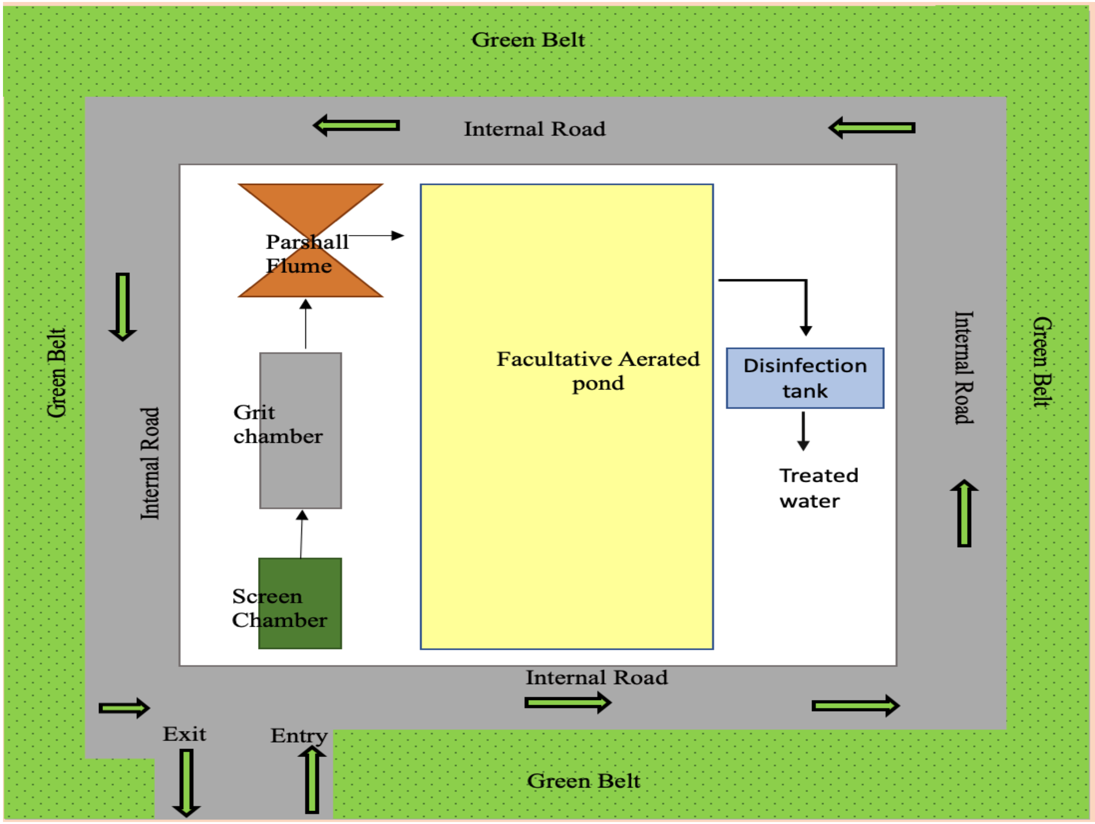


Figure 16: Typical Layout for Aerated Lagoon

IV. The unit sizes for different capacities of Aerated Lagoon based STP may vary based as indicated below Table 9:

Table 9: Design inputs for 1, 2 and 5 MLD Aerated Lagoon

	1 MLD	2 MLD	3 MLD
LIST OF STRUCTURES*	**(L X B X D)**	**(L X B X D)**	**(L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m) with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
Facultative aerated pond (m)	100.00 x 12.50 x (4.00 +0.5 FB)	(136 × 34 ×3.5+0.5 FB)- 2 no's	(212 × 53 × 3.50+0.50 FB)- 2 no's
***L** = Length, **B** = Breadth, **D** = Depth, **FB** = Free Board* ** The dimension can be re-oriented according to the available space*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing

Sludge pump	0.75kW,2900rpm (For desludging)- 2 no	0.75kW,2900rpm (For desludging)- 2 no	0.75kW,2900rpm (For desludging)- 2 no
Aerators	10HP	7.5 HP (4 no)	7.5 HP (4 no)
			***W** = Working, **S** = Standby*

2.2.2 Activated Sludge Process

In principle all ASPs consist of three main components: an aeration tank, which serves as bio reactor; a settling tank ("final clarifier") for separation of activated sludge solids and treated wastewater; a return activated sludge (RAS) equipment to transfer settled activated sludge from the clarifier to the influent of the aeration tank. The oxygen supply is done by mechanical aerators or by diffused air. The solids are smashed during this process. The sewage is bubbled, and the sewage liquor is discharged into a chamber with activated sludge. The live bacteria will sink to the bottom of the tank, while dead bacteria float to the surface

I. The **Factsheet of ASP based STP** is in Table 10.

Table 10:Fact Sheet for Activated Sludge Process

Activated Sludge Process (ASP)		
1.	**Process and units**	• Sewage and return activated sludge (RAS) enter together or separately into the reactor and leave as mixed liquor. → This mixed liquor flows into the clarifier where it can settle and the treated effluent separates from the activated sludge. • The settled activated sludge is recycled to the aeration tank and a portion wasted out of the system as waste activated sludge (WAS). • The treatment units of ASP are shown in the figure 18.
2.	**Land Requirement**	0.15 - 0.25 Ha/ MLD installed capacity [2500sqm/MLD] [50*50]
3.	**Energy Requirement**	180 to 225 kWh/ML treated [225 units/ML]
3.	**Capital Cost**	INR 80- 170 lakh/MLD (55 % as civil cost & remaining 45% as electrical & mechanical cost)
4.	**O&M Cost****	INR 6to 10lakh/year/MLD Installed capacity (INR 12.5 lakh/ MLD as per SBM Advisory CPHEEO (2020))
5.	**Effluent Quality**	• BOD: 20-30 mg/l • Suspended solids (SS): 20-5'0 mg/l; BOD removal efficiency: 75 -90%; TSS: 95%
6.	**Advantages**	• Less land requirement and Low installation cost in comparison to mechanized treatment systems
7.	**Disadvantages**	• Difficulty in sludge removal and disposal. • High operational costs
8.	**O&M**	• Equipment – The whole unit should be thoroughly inspected once a year. • Abnormal Operation: Activity of the bacteria is varied based on seasonal temperature variations which requires the operator to gradually adjust aeration rates, return sludge rates and wasting rates. • Records – Activated sludge operation should include recording of flow rates of sewage and return sludge, DO, MLSS, MLVSS, biota, SRT, air, BOD, COD and nitrates in both influent and effluent. *Refer Part B – Section 4.7.2 of CPHEEO manual 2013 for more details*
9.	**Plant examples[14]**	• Bangalore Urban, Yelahanka: 10 MLD (year 2003) • Nellore (at Janardhan Reddy Colony): 5 MLD (Year 2019) • Nashik (at Panchak): 7.5 MLD (Year 2004)
10.	**Sludge generated[15]**	• 108 T /year for 1MLD

[14]Source: CPCB Inventory (2021)
[15] Source: Wastewater Treatment: Concepts and Design Approach by GL Karia, RA Christian

11.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.
	** Higher cost is for treatment plant including sludge treatment like anaerobic digestion or for small capacity plants without sludge treatment.	

II. The **Photographs of ASP based STP** of a plant is given below


Figure 17: ASP – Photographs

III. The **Process diagram of ASP based STP** is given below.

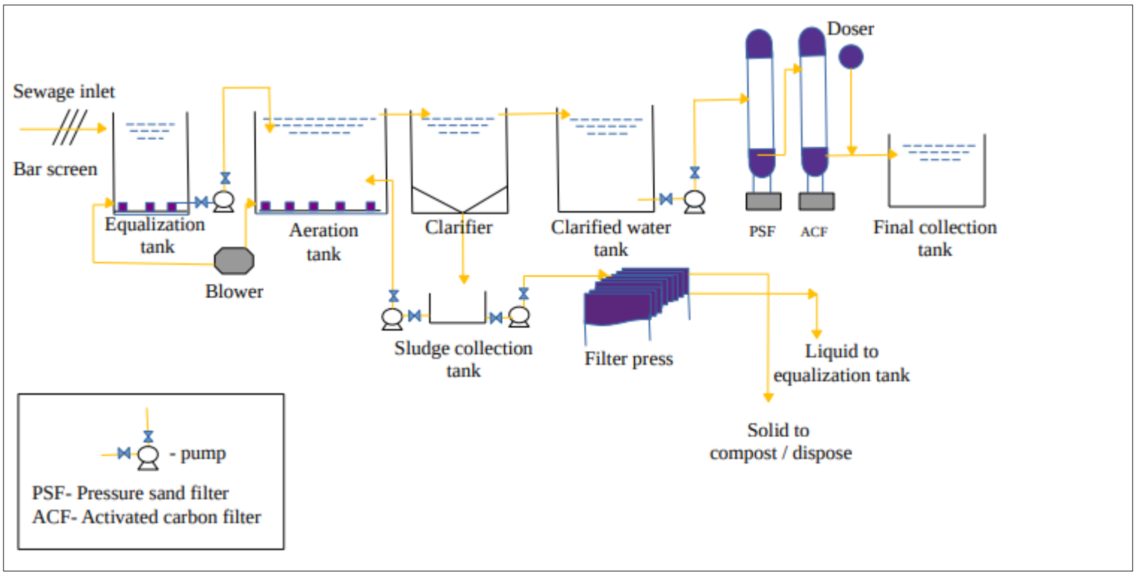


Figure 18:Common process in ASP

IV. The **Typical layout of ASP based STP** is given below.

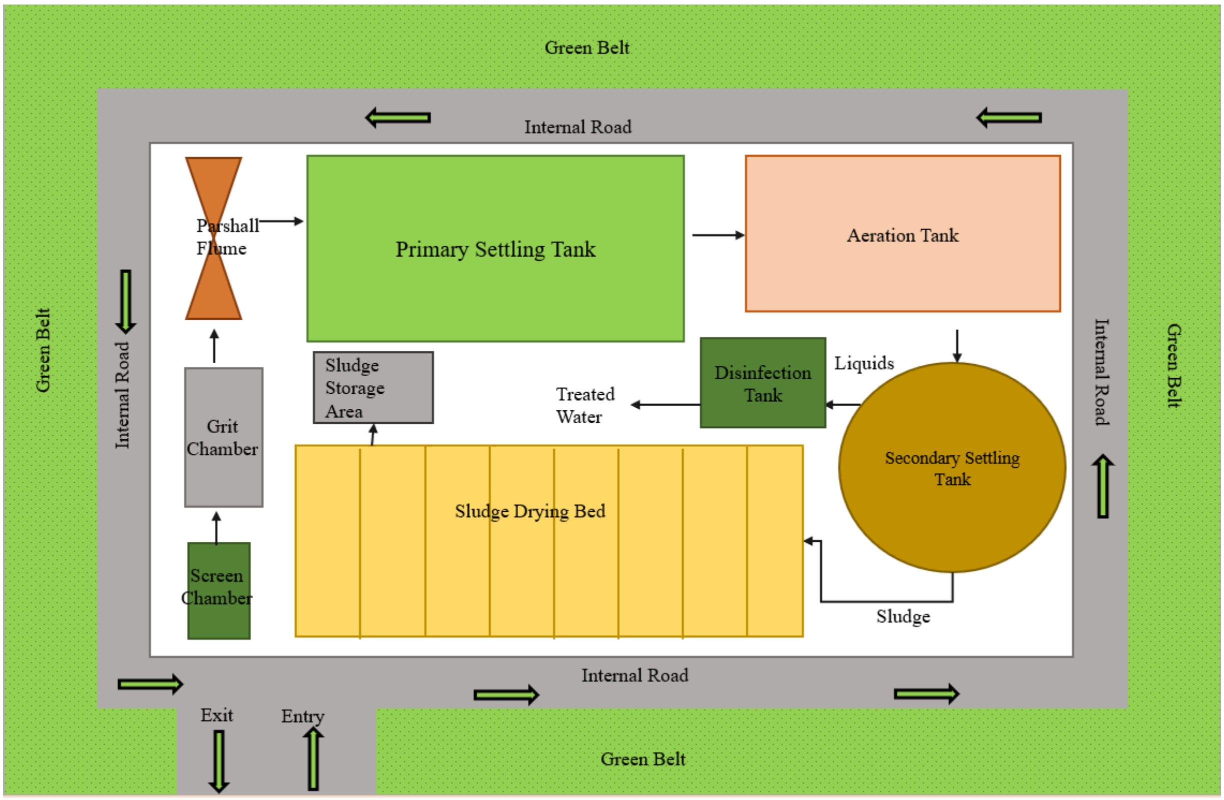


Figure 19: Typical Design Layout for ASP plant

V. The **Unit sizes of different capacities of ASP based STP** is in Table11.

Table 11: Design sizes for different unit for 1, 2 and 5 MLD of ASP

	1 MLD	**2 MLD**	**5 MLD**
LIST OF STRUCTURES	(L X B X D)	(L X B X D)	(L X B X D)
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Primary settling tank(m)	11.00 x4.00 x 3.00	15.90 x 5.30 x 3.00	25.20 x8.40 x 3.00
Secondary Treatment			
Aeration tank	5.00 x10.00x (4.50 +0.5 FB)(No.1)	6.50x13.00x(5.00 +0.50FB) (No.1)	10.00x20.00x(5.00+0.50 FB) (No.1)
Secondary settling tank	8m dia, 2.7m depth	8m dia, 2.7m depth	8m dia, 2.7m depth
Tertiary Treatment			

Disinfection tank (m)	5.60 x 5.60 x 1.50 + 0.5 FB	8.90 X 7.00 X 1.50 + 0.50 FB	10.90 X 8.70 X 1.50 +0.50 FB
Sludge Treatment			
***Sludge drying bed*	25 x5 x0.2 m, 18 no's	25 x 5 x 0.2m, 34no's	25 x5 x0.2 m, 81 no's
***L** = Length, **B** = Breadth, **D** = Depth **FB** = Free Board* ** The dimension can be re-oriented according to the available space.*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10x10mm bar, 25mm spacing	10x10mm bar, 25mm spacing
Return sludge pump	1(W) + 1(S)	1(W) + 1(S)	1(W) + 1(S)
Flow measurement devices	1(W)	1(W)	1(W)
Sewage Transfer Pump	1(W) + 1(S)	1(W) + 1(S)	1(W) + 1(S)
Blower	250m3/hr	450m3/hr	1100 m3/hr
Chlorination Dosing System	1	1	1
Aerator	2 no's of 20 HP + 1 standby	2 no's of 20 HP + 1 standby	2 no's of 20 HP + 1 standby
W = Working, S = Standby			

2.2.3 Extended Aeration

Process: The extended aeration process is one of the modifications of the ASP. It is complete mix system and provides biological treatment for the removal of biodegradable organic wastes under aerobic conditions. Air may be supplied by mechanical or diffused aeration to provide the oxygen required to sustain the aerobic biological process. Mixing must be provided by aeration to maintain the microbial organisms in contact with the dissolved organics.

I. The **Factsheet of EA based STP** is given in Table 12.

Table 12: Fact Sheet - Extended Aeration

Extended Aeration (EA)		
1.	**Process and units**	• This is a modification of the activated-sludge process using long aeration periods to promote aerobic digestion of the biological mass by endogenous respiration. • The treatment units of EA are shown in the figure 22.
2.	**Land Requirement**	0.15 - 0.25 Ha/ MLD installed capacity [25000 sq.m.] [50mx50m]
3.	**Energy Requirement**	180 to 225 kWh/ML treated [225 units/ML]
3.	**Capital Cost**	INR 90 to 200 lakh/MLD capacity excluding civil cost
4.	**O&M Cost**	INR 7to 12lakh/year/MLD Installed capacity
5.	**Effluent Quality**	• BOD: 20-30 mg/l • Suspended solids (SS): 50-100 mg/l BOD removal efficiency: 75 -90% COD: 85-90%, TSS: 95%
6.	**Advantage**	• Variant with Highest BOD removal efficiency • Consistent Nitrification

7.	**Disadvantage**	• Increased energy consumption compared to ASP • Skilled operators required • High investment and operational costs
8.	**O&M**	• **Operation of Aeration Equipment -** Aeration equipment should be operated continuously 24x7, non-stop • **Abnormal Operation -** As the temperature changes from season to season, activity of the organism's speeds or slows down. This requires the operator to gradually adjust aeration rates, return sludge rates and wasting rates. • **Maintenance -** Items requiring attention include – plant cleanliness, aeration equipment, air lift pumps, scum skimmer, etc. *Refer Part B, CPHEEO Manual, Chapter 14 – Section 4.7.3 for more details.*
9.	**Plant examples[16]**	• Bangalore Urban, K& C Valley: 30 MLD (2005) • Pimpri Chinchwad (Chikhaliphase I): 16 MLD (1987) • Mangalore(panchady) 8.75 MLD (2011)
10.	**Sludge generated[17]**	• 96 T /year for 1MLD
11.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

II. The **aerial view of an EA based STP** of a typical plant is given below.

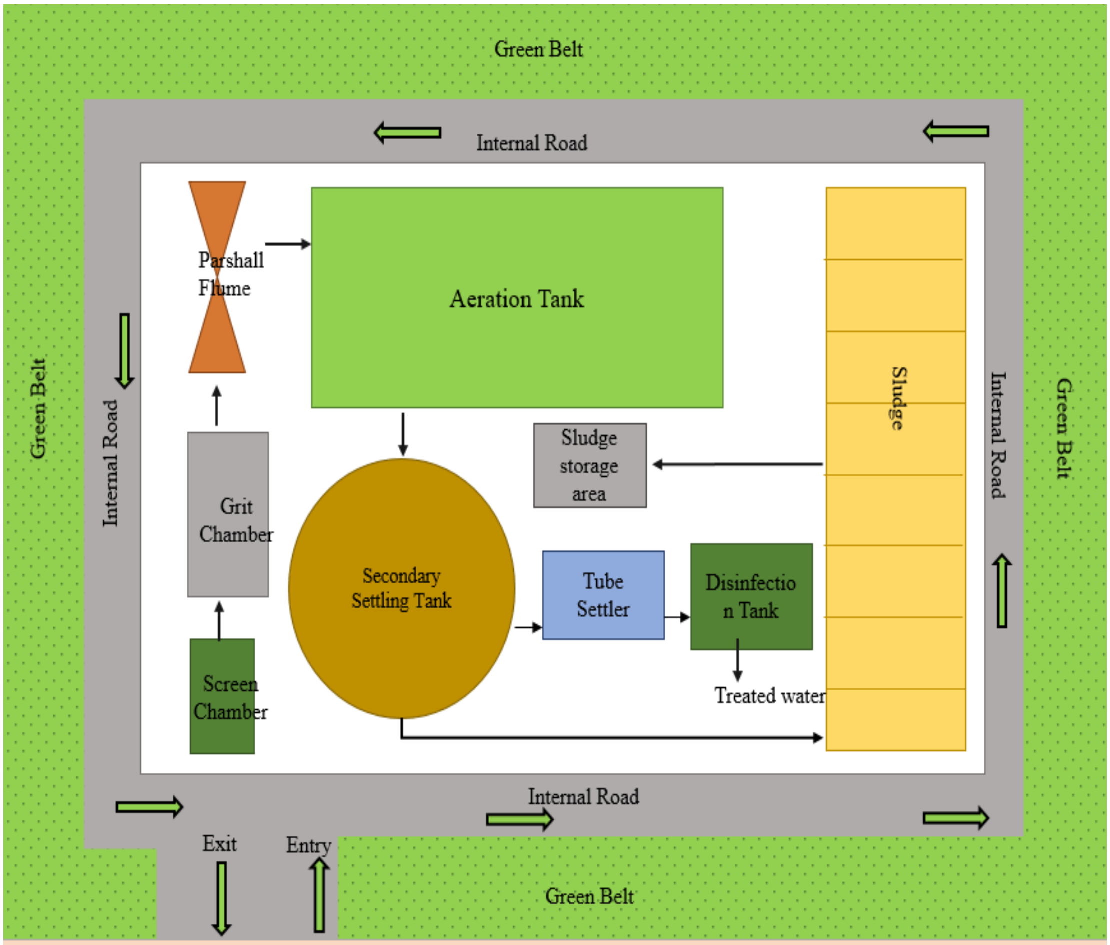
Figure 20:Photographs of Extended Aeration based STP

[16]Source: CPCB Inventory (2021)

[17] Source:Wastewater Treatment: Concepts and Design Approach By GL Karia, RA Christian

III. The **typical layout of EA based STP** is given below.

Figure 21: Typical layout of Extended Aeration Process



IV. The **process diagram of EA based STP** is given below(Refer Figure 22).

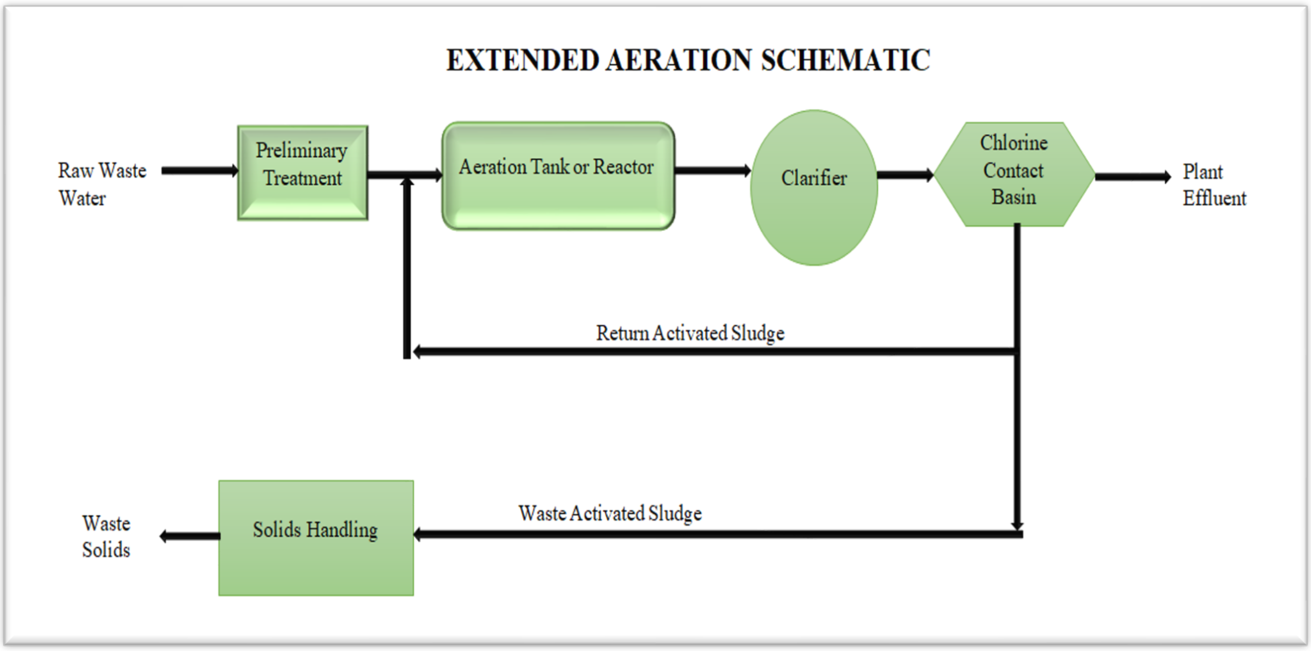


Figure 22: EAP Process

V. The **unit sizes for different capacities of EA based STP** is given below Table 13.

Table 13: Design sizes of different units for 1, 2 and 5 MLD of EAP

LIST OF STRUCTURES*	**1 MLD (L X B X D)**	**2 MLD (L X B X D)**	**5 MLD (L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
Aeration tank	18.00 x9.00 x5.00+0.5 FB	26.00x13.00x5.00 +0.50 FB	40.00x20.00x5.00 + 0.50 FB
Secondary settling tank	10.50Dia x 3.20+0.50FB	14.00 Diax3.20 + 0.50FB	24.00 Diax3.00 +0.50 FB
Tube Settler	3.60 x 3.60x 3.20 + 0.50 FB	5.00x5.00x3.20 + 0.50 FB	7.50x7.50x3.20 +0.50 FB
Tertiary Treatment			
Disinfection tank (m)	5.60 x 5.60 x 1.50 + 0.5 FB	8.90 X 7.00 X 1.50 + 0.50 FB	10.90 X 8.70 X 1.50 +0.50 FB
Sludge Treatment			
***Sludge drying bed*	28.00 x 6.00, 6Nos	38.00 x 6.00, 6 Nos	42.00 x 6.00, 10Nos
***L** = Length, **B** = Breadth, **D** = Depth, FB= Free Board* ** The dimension can be re-oriented according to the available space*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar screen	10 x 10mm bar,25 mm spacing	10 x 10mm bar,25 mm spacing	15 x 10mm bar,25 mm spacing
Blower with motor	2(w) + 1(s)	2(w) + 1(s)	2(w) + 1(s)
Return pump	1(w) + 1(s)	1(w) + 1(s)	1(w) + 1(s)
Flow meter	3	3	3
Sewage transfer pump	1(w) + 1(s)	1(w) + 1(s)	1(w) + 1(s)
Aerator	3 no's of 20 HP + 1 standby	3 no's of 20 HP + 1 standby	3 no's of 20 HP + 1 standby
Chlorine dosing pump	1	1	1
***W** = Working, **S** = Standby*			

2.2.4 Sequencing Batch Reactors

The Sequencing Batch Reactor (SBR) is an Activated Sludge Process designed to operate under non steady state conditions. An SBR operates in a true batch mode with aeration and sludge settlement both occurring in the same tank. Thewastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged. They suitable for treatment applications characterized by low or intermittent flow conditions. These systems have a relatively small footprint, they are useful for areas where the available land is limited.

I. The **Factsheet of SBR technology based STP** is given in Table 14.

Table 14: Fact Sheet – SBR

	Sequential Batch Reactors (SBR)	
1.	**Process and units**	• In SBR operations, the cycle processes Fill-react, React, Settle and Decant are controlled by time intervals to achieve the objectives of the operation. • Each process is associated with reactor conditions (turbulent/quiescent, aerobic/anaerobic) that promote selected changes in the chemical and physical nature of the sewage. • These changes lead ultimately to a fully treated effluent. • The treatment units of SBR are shown in the figure 24.
2.	**Land Requirement**	0.10– 0.15 Ha/ MLD installed capacity [1500 sq.m.] [39mx38m]
3.	**Energy Requirement**	150 to 200 kWh/ML treated [200 unit/ML]
3.	**Capital Cost**	INR 150 to 300 lakh/MLD capacity
4.	**O&M Cost**	INR 10 to 20 lakh/year/MLD Installed capacity
5.	**Effluent Quality**	• BOD< 5 mg/l • Total Suspended Solids (TSS)< 10 mg/l BOD removal efficiency: 75 -90%; COD: 85-90%, TSS: 95%
6.	**Advantage**	• High BOD removal efficiency • Low land requirement • High degree of coliform removal
7.	**Disadvantage**	• Moderate/low area required for operation • Comparatively high energy consumption • Highly skilled operators needed
8.	**O&M**	• The precaution needed is to make sure that power supply is available continuously. • Process Control – SBR has inbuilt process control. Depending on the BOD load, it adjusts the DO supply. • Records – The limited parameters as per the design requirements and the flow rate and cycle times.
9.	**Plant examples[18]**	• Bangalore Urban, Halasuru: 2 MLD (year 2018) • Daman: 4.21 MLD (2018) • Bhiwani (Chiriya Road Charkhi Dadri Bhiwani): 5 MLD (year 2013)
10.	**Sludge generated[19]**	• 92 T /year for 1MLD
11.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

[18]Source: CPCB Inventory (2021)
[19] Source:Wastewater Treatment: Concepts and Design Approach By GL Karia, RA Christian

II. The **photograph of SBR technology based STP** is given below.

Figure 23: SBR based STP

III. The **process diagram of SBR technology based STP** is given below.

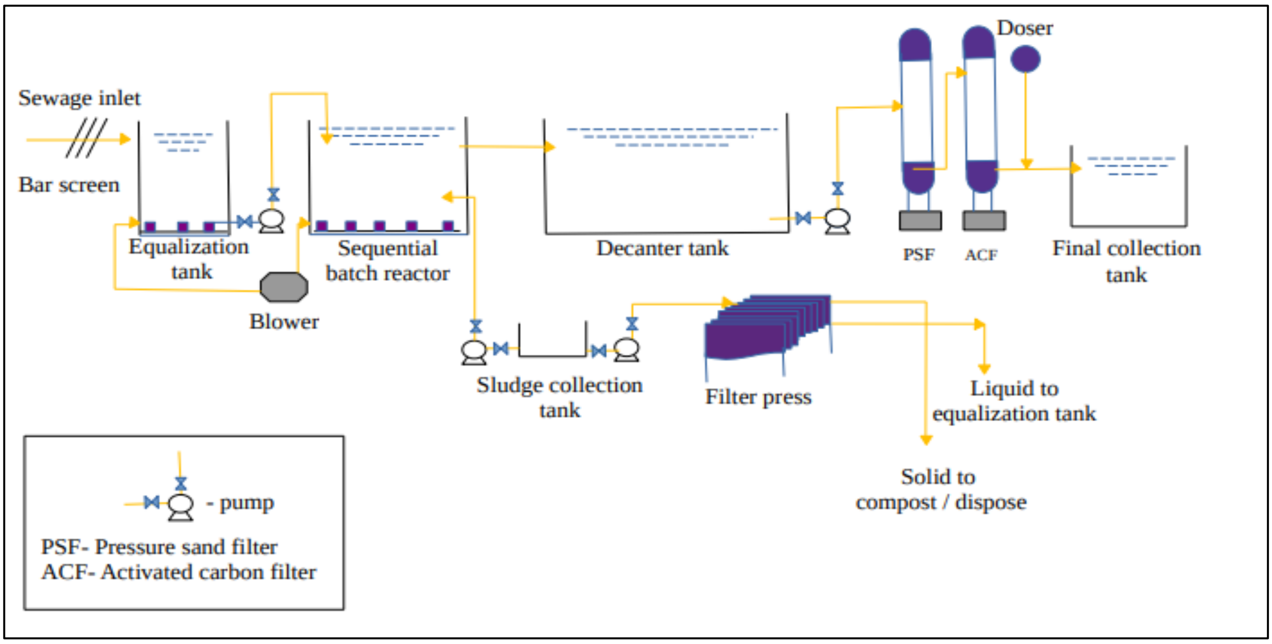


Figure 24: SBR -Process

IV. The **typical layout of SBR technology based STP** is given below.

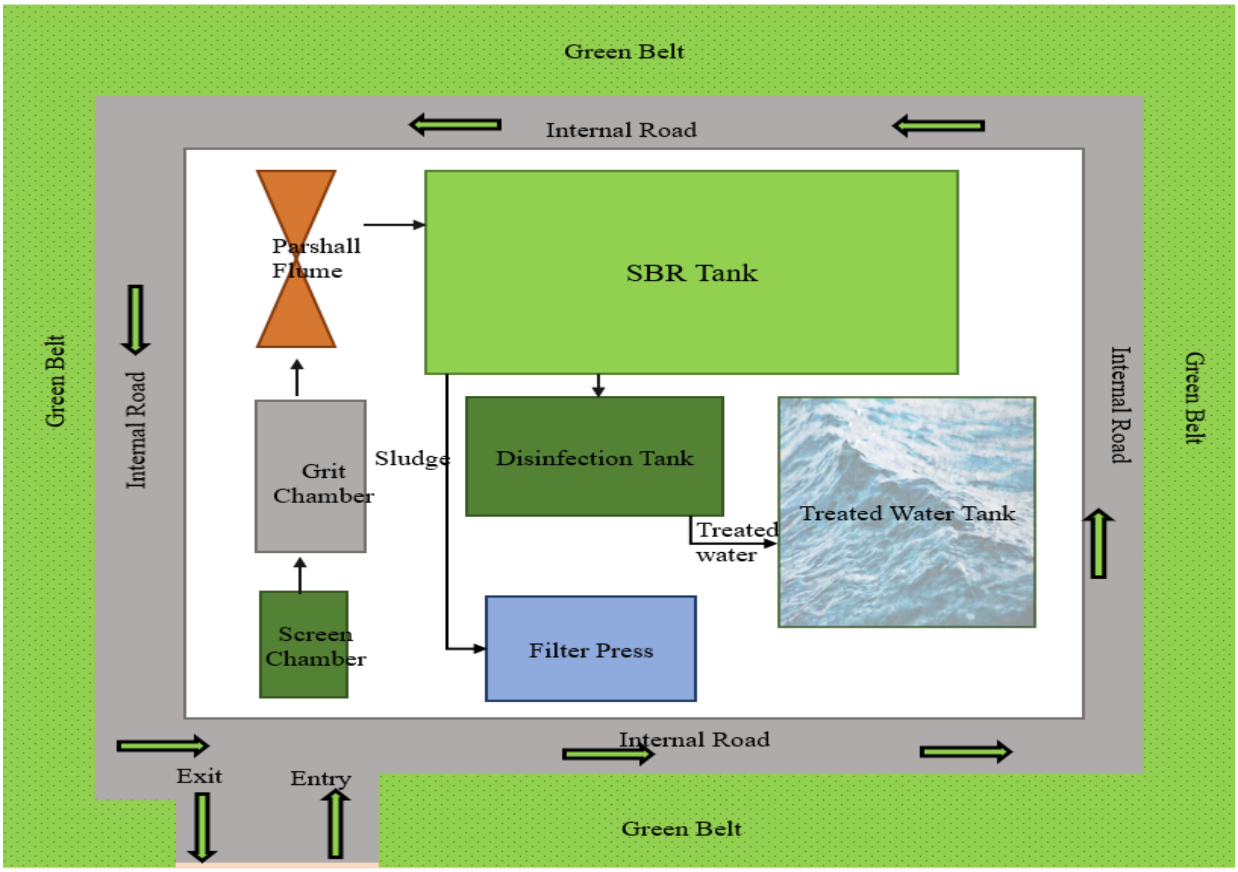


Figure 25: SBR – Typical Layout for SBR plant

V. The **unit sizes for different capacities of SBR technology based STP** is given in Table 15.

Table 15: Design sizes for SBR

LIST OF STRUCTURES*	**1 MLD (L X B X D)**	**2 MLD (L X B X D)**	**5 MLD (L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x(0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 +0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
SBR Tanks (m)	9 x 8.2 x 5 (2nos)	14 x 10.8 x 5 (2nos)	14x 27 x 5 (2nos)
Tertiary Treatment			
Disinfection tank (m)	5.60 x 5.60 x (1.50 + 0.5 FB)	8.90 X 7.00 X (1.50 + 0.50 FB)	10.90 X 8.70 X(1.50+0.50 FB)
***Sludge Drying Beds*	28.00 x 6.00, 6 Nos	38.00 x 6.00, 6 Nos	42.00 x 6.00, 10 Nos

Treated water tank	7.5 x 7.5 x 5 m	7.5 x 7.5 x 5 m	7.5 x 7.5 x 5 m
***L** = Length, **B** = Breadth, **D** = Depth, **FB** = Free Board * The dimension can be re-oriented according to the available space*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing
Blower with motor	2(**w**) + 1(**s**)	2(**w**) + 1(**s**)	2(**w**) + 1(**s**)
Sewage transfer pump	1(**w**) + 1(**s**)	1(**w**) + 1(**s**)	1(**w**) + 1(**s**)
Parshall Flume	1	1	1
Chlorination dosing system,	1	1	1
Decanters	1	1	1
***W** = Working, **S** = Standby*			

2.2.5 Trickling Filter

The Trickling Filters can treat domestic blackwater or brown water, greywater, or any other biodegradable effluent. Trickling filters can be built in almost all environments, but special adaptations for cold climates are required. Compared to other technologies like waste stabilization pond, trickling filters are compact, although they are still best suited for peri-urban or large rural settlements.

I. The **Factsheet of Trickling Filter based STP** is given in Table 16.

Table 16: Fact Sheet –Trickling Filter

Trickling Filter		
1.	**Process and units**	• A trickling filter consists of a shallow bed filled with natural or synthetic media. It is aerobic attached growth process. • Wastewater is applied on the surface by means of rotating arms. Biofilm that develops over the media removes the organics present in the wastewater. • A portion of the clarified wastewater is recirculated. Organic matter is adsorbed on the slime layer, and it is degraded by the aerobic microorganisms present in the slime. • The treatment units of TF are shown in the figure 27.
2.	**Land Requirement**	0.25– 0.50 Ha/ MLD installed capacity [5000 sq. m.] [72mx70m]]
3.	**Energy Requirement**	150-180kWh/ML treated [180units/ML]
3.	**Capital Cost**	INR 50 to 80 lakh/MLD capacity
4.	**O&M Cost**	INR 2-5 lakh/year/MLD
5.	**Effluent Quality**	• BOD 25-30 mg/l • BOD removal:75-90%; COD: 85-90%, TSS: 95%
6.	**Advantages**	• Low energy requirement compared to ASP • Low land requirement • Simple mechanical equipment
7.	**Disadvantage**	• To improve effluent quality, a settling tank can be provided,

		• Sensitivity to low temperatures,
8.	**City/ plant examples**[20]	• Bangalore Urban V valley, 10 MLD, two stage TF (2009) • Nagpur, Sonegaon NIT, 0.3 MLD, Phytorid bed TF (2019)
9.	**Sludge generated**[21]	• 88 T /year for 1MLD
10.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

II. The **photograph of Trickling Filter based STP** is given below(Refer Figure 26).

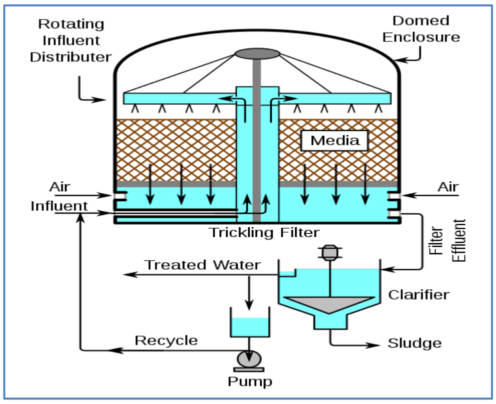


Figure 26: Trickling filter

III. The **process diagram of Trickling Filter based STP** is given below.

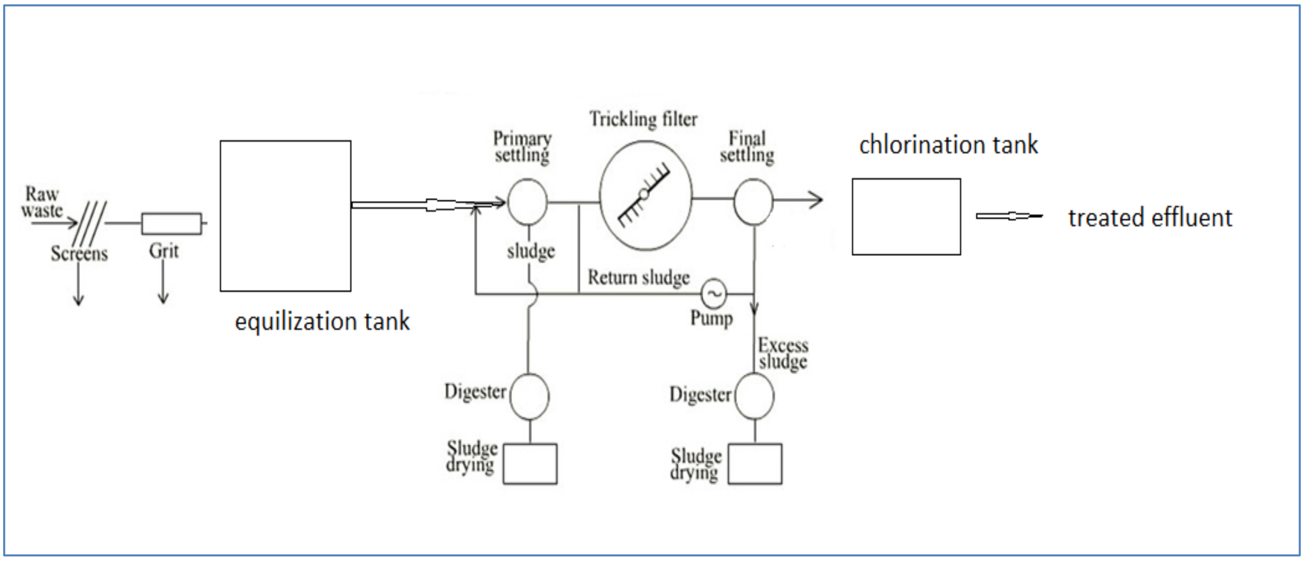


Figure 27: General layout of a STP with TF

[20]Source: CPCB Inventory (2021)

[21] Source:Wastewater Treatment: Concepts and Design Approach By GL Karia, RA Christian

IV. The **typical layout of Trickling Filter based STP** is given below.

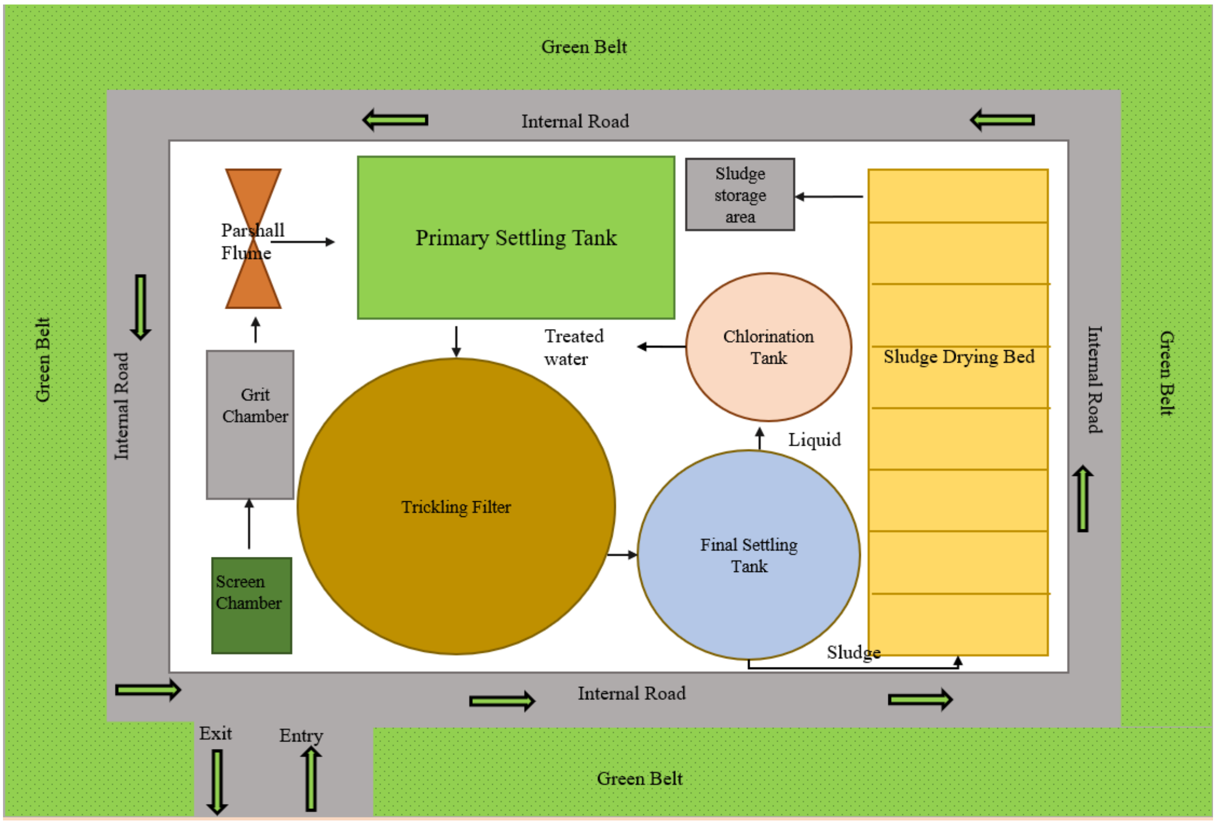


Figure 28: Layout for 1 MLD STP with trickling filter

Figure 29: 10 MLD STP with trickling filter at Kalyani West Bengal

V. The **unit sizes for different capacities of Trickling Filter based STP** is given in Table 17.

Table 17: Design sizes of different units for1, 2 ad 5 MLD for Trickling Filter

LIST OF STRUCTURES*	**1 MLD (L X B X D)**	**2 MLD (L X B X D)**	**5 MLD (L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x 0.4 + 0.3 FB	5.0 x 0.60 x 0.50 + 0.30 FB	7.0 x 0.8 x 0.7 +0.30 FB
Parshall Flume (m)	3.80 x 0.15 x 0.22 + 0.30 FB	3.80x 0.15 x 0.35 + 0.30 FB	3.80 x 0.15(throat) x 0.54 +0.30 FB
Primary settling tank(m)	11.00 x4.00 x 3.00	15.90 x 5.30 x 3.00	25.20 x8.40 x 3.00
Secondary Treatment			
Trickling filter	18.00m Dia x 2.20+0.50m 2 Nos	26.00Dia x2.20+0.50m FB 2 No	40.00Dia x 2.20 +0.50m FB 2 nos
Tertiary Treatment			
Chlorination tank (m)	6.52 dia, 3 depth	10 dia, 2 depth	14.57 dia, 2 depth
Sludge Treatment			
***Sludge drying bed*	28.00 x 6.00 6 Nos	38.00 x 6.00 6 Nos	42.00 x 6.00 10 Nos
__L__ = Length, __B__ = Breadth, __D__ = Depth ** The dimension can be re-oriented according to the available space*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing
Recirculation pump	1(**w**) + 1(**s**)	1(**w**) + 1(**s**)	1(**w**) + 1(**s**)
Sludge transfer pump	1(**w**) + 1(**s**)	1(**w**) + 1(**s**)	1(**w**) + 1(**s**)
Air blower	2(**w**) + 1(**s**)	2(**w**) + 1(**s**)	2(**w**) + 1(**s**)
Chlorination dosing pump	1	1	1
***W** = Working, **S** = Standby*			

2.2.6 Moving Bed Biofilm Reactor

MBBR is a highly effective biological water treatment process which is based on a combination of biofilm media and conventional activated sludge processes .Moving Bed Biofilm reactor (MBBR) processes improve reliability, simplify operation, and require less space than other traditional wastewater treatment systems like ASP and is tolerant of both load swings and temporary load deprivation.

I. The **Factsheet of MBBR based STP** is given in Table 18.

Table 18:Fact Sheet - MBBR

MBBR		
1.	**Process and units**	• It is modern water treatment technology and process • It's a combination of activated sludge process (suspended growth) and attached growth process (media). • It uses simple floating media, which are carriers for attached growth of biofilms. Biofilm carrier movement is caused by the agitation of air bubbles. • This compact treatment system is effective in removal of BOD as well as nitrogen and phosphorus while facilitating effective solids separation. • The treatment units of MBBR are shown in the figure 30.
2.	**Land Requirement**	0.04 - 0.05 Ha/ MLD installed capacity i.e. [500 sq.m. for 1 MLD i.e., 25mX20m]
3.	**Energy Requirement**	200 to 250 kWh/ML treated [250 units for 1 ML]
3.	**Capital Cost**	INR 170 to 230[22] lakh/MLD capacity
4.	**O&M Cost**	INR 8-12 lakh/year/MLD Installed capacity
5.	**Effluent Quality**	• BOD< 10 mg/l; COD< 50 mg/l • TSS < 20 mg/l; BOD removal efficiency: 80-90% COD: 85-90%, TSS: 95%
6.	**Advantage**	• Smaller footprint compared to conventional treatment • Resistant to shock loads • Work quickly with Low Hydraulic retention time
7.	**Disadvantage**	• High operating cost due to large power requirements • Skilled manpower requirement • Reduce nutrient removal
8.	**O&M**	• **Equipment -** The electro-mechanical components such as blowers, aerators and pumps need to be checked on weekly basis. • The overhauling of the needs to be done on annual basis for detailed check up to avoid major break down. • **Records -** operation should include recording of flow rates of sewage and return sludge, DO, MLSS, BOD, COD (Chemical Oxygen Demand).
9.	**City/ plant examples[23]**	• Sonepat: Kharkhoda 4.5 MLD (2013), Gohana 3 MLD (2015) • Ambala: total 12 STPs with capacity ranging from 0.25 MLD to 6 MLD
10.	**Sludge generated[24]**	• 96 T /year for 1MLD
11.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

[22]Source: SBM Advisory, CPHEEO (2020)
[23]Source: CPCB Inventory (2021)
[24]Source: Wastewater Treatment: Concepts and Design Approach By GL Karia, RA Christian

II. The **photograph of MBBR based STP** is given below.

Figure 30 MBBR technology based 5 MLD STP at Uttrakhand

III. The **Process diagram of MBBR based STP** is given below.

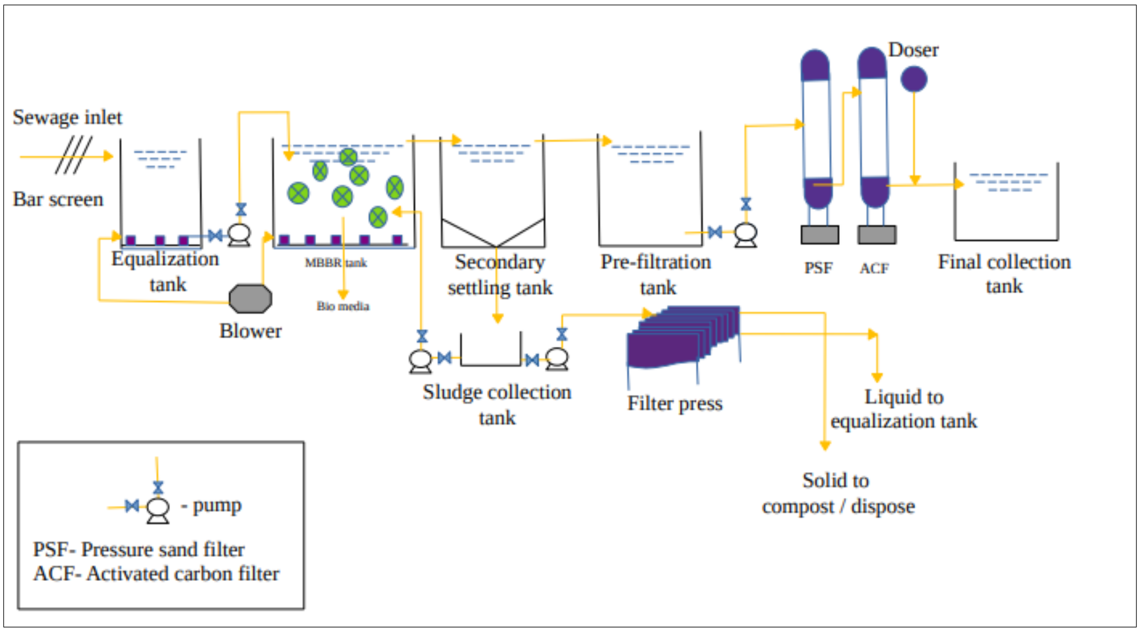


Figure 31: MBBR – Process

IV. The **Typical layout of MBBR based STP** is given below

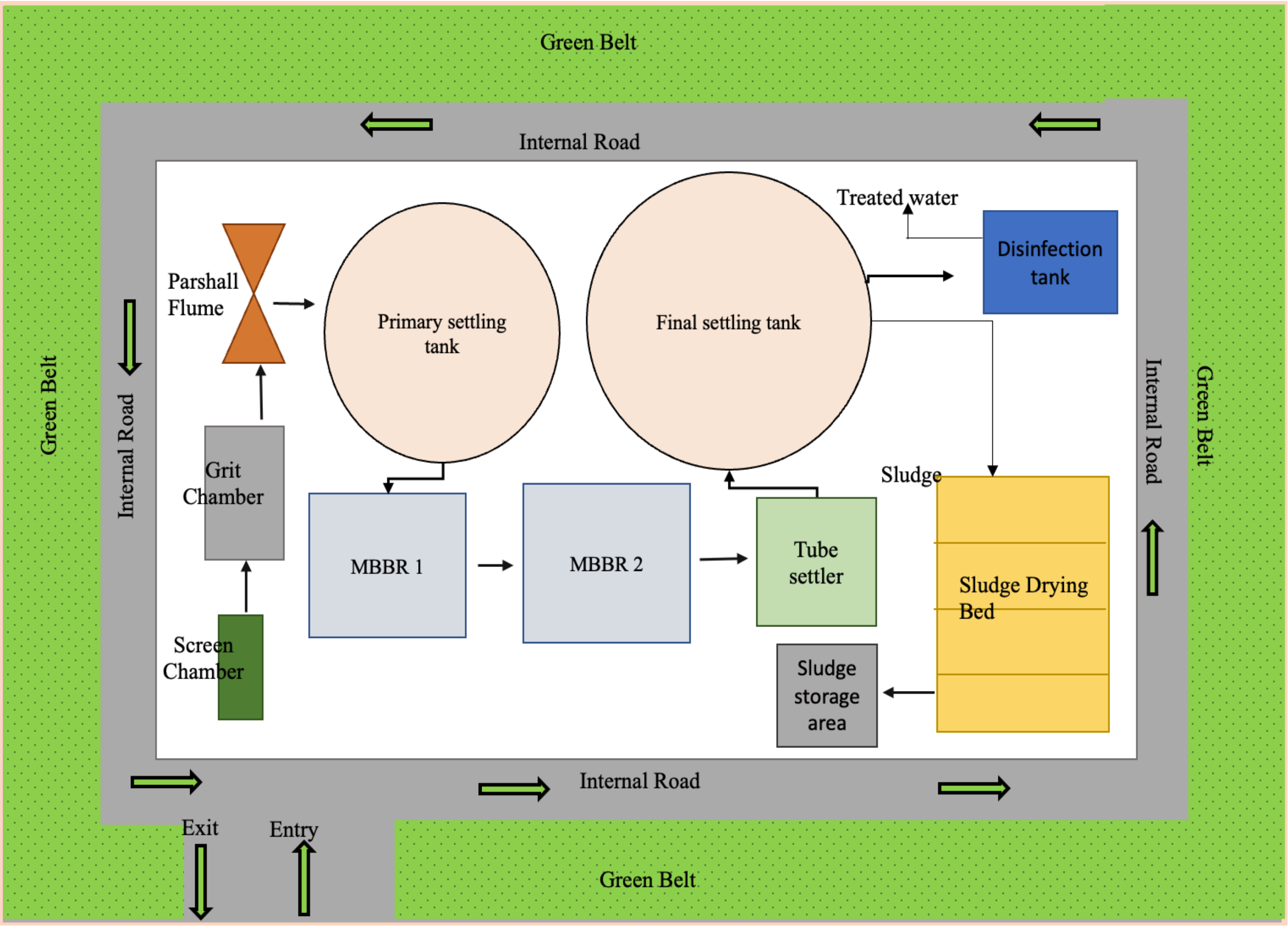


Figure 32: Typical Layout for MBBR Plant

V. The **Unit sizes of different capacities of MBBR based STP** is Table 19.

Table 19: Typical Design sizes of different units for 1, 2 and 5 MLD MBBR plant

	1 MLD	**2 MLD**	**5 MLD**
LIST OF STRUCTURES	(L X B X D)	(L X B X D)	(L X B X D)
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x 0.4 + 0.3 FB	5.0 x 0.60 x 0.50 + 0.30 FB	7.0 x 0.8 x 0.7 +0.30 FB
Parshall Flume (m)	3.80 x 0.15 x 0.22 + 0.30 FB	3.80x 0.15 x 0.35 + 0.30 FB	3.80 x 0.15(throat) x 0.54 +0.30 FB
Secondary Treatment			
Primary Settling Tank(m)	6.50 Diax 3.00 + 0.50 FB	9.00 Dia x 3.20 +0.50 FB	14.00 Dia x 3.20 + 0.50 FB
MBBR Reactor 1(m)	4.00 x 4.50 x 4.50 +0.50 FB	4.50 X 7.30 x (4.50 +0.50 FB)	4.80 x 11.30x(4.50+0.50 FB) 2.80 x 9.10 x (4.50 +0.50

MBBR Reactor 2(m)	4.00 x4.00 x 4.50 +0.50m (HRT-4.5HR)	2.50 X 5.80 X (4.50 +0.50 FB)	FB)
Secondary Settling Tank Or *Tube settler*	8.00 Dia x (3.00 +0.50FB) 3.60 x 3.60x (3.20 + 0.50 FB)	12.00m Dia x (3.20 +0.50m FB) 5.00x5.00x(3.20 + 0.50 FB)	18.00 Dia x (3.20m+0.50 FB) 7.50x7.50x(3.20 +0.50 FB)
Sludge Treatment			
***Sludge Drying Bed*	25 x 5 x 0.16 m, 18Nos	25 x5 x3 m, 3 no's	25 x 5 x 3 m, 3 no's
***L** = Length, **B** = Breadth, **D** = Depth,**FB**= Free Board* ** The dimension can be re-oriented according to the available space.*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar Screen	10 x 10 mm bar, 25 mm spacing	10 x 10 mm bar, 25 mm spacing	10 x 10 mm bar, 25 mm spacing
Blower with Motor Coarse Bubble diffuser 1(W) + 1(S)	Capacity 450 m3/hr	Capacity 900 m3/hr	Capacity 2200 m3/hr
Media for MBBR Tank 1	Carrier specific surface area, 500m2/m3	Carrier specific surface area, 500m2/m3	Carrier specific surface area, 500m2/m3
Media for MBBR Tank 2	Carrier specific surface area, 500m2/m3	Carrier specific surface area, 500m2/m3	Carrier specific surface area, 500m2/m3
Chlorination Dosing pump	1	1	1
Recirculation pump	1	1	1
Dosing Pump		1	1
***W** = Working , **S** = Standby*			

2.2.7 Up flow Anaerobic Sludge Blanket

Up flow Anaerobic Sludge Blanket also popularly known as UASB is a methane-producing digester, which is based on an anaerobic process. In UASB reactor, the sewage flows upwards through a layer of sludge. At the top of the reactor, phase separation between gas-solid-liquid takes place. Any biomass leaving the reaction zone is directly recirculated from the settling zone. Appropriate tertiary treatment which mentioned in Table 2 should be given as a polishing system after the secondary treatment, with approved disinfectant technology in order to make pathogen free treated water. As mentioned, the UASB is a methane producing digester, which has a global warming potential 28 times greater than carbon dioxide, it has to be managed properly. Methane can be trapped and stored which can be used as biofuel or for generating electricity and simplest and common method is combusted before letting out into the air.

I. ***Factsheet about technology*** *is given in Table 20 below.*

Table 20Fact Sheet - UASB

UASB		
1.	**Process and units**	• Wastewater flows upwards through the blanket and is processed by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants. Provision of feed inlet pipe in a UASB reactor such a way that 1 feed inlet/sqm area of UASB subject to minimum of 1 feed inlet pipe for 2 sqm of floor area of UASB • The treatment units of UASB are shown in the figure 34.
2.	**Land Requirement**	0.2 - 0.3 Ha/ MLD installed capacity i.e. [3000 Sq.m./MLD] or [60mx50m]
3.	**Energy Requirement**	10 to 15 kWh/ML treated
3.	**Capital Cost**	INR 40- 60 lakh/ MLD
4.	**O&M Cost**	INR 2.0 - 3.5 lakh/ year/ MLD
5.	**Effluent Quality**	• BOD:70-100 mg/l • TSS: 75-100 mg/l • BOD removal efficiency: 50 -70%; TSS: 95%, COD: 85-90%
6.	**Advantages**[25]	• Low land and energy consumption • Low construction and operational costs • Production of methane, a highly calorific fuel gas
7.	**Disadvantages**[26]	• Longer start-up period. • Post treatment required to achieve surface water discharge quality. • Efficient working only between the temperature 15° to 35° c
8.	**City/ plant examples**[27]	• Mirzapur 14 MLD (1994) • Panipat (Jattal Road): 10 MLD (2000) • Karoli(Karauli): 5 MLD (2018)
9.	**Combination of Treatment processes to achieve surface water discharge quality**	• UASB + Aerated biofilter • UASB + Overland flow (land disposal) • UASB + Anaerobic filter • UASB + Trickling filter • UASB + Physical-chemical treatment • UASB + Polishing Pond (facultative or maturation) • UASB + Activated sludge
10.	**Sludge generated**[28]	• 80 T /year for 1MLD
11.	**Suitability**	Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

[25]Source: Biological Wastewater Treatment in Warm Climate Regions, Volume – I, IWA (2006)
[26]Source: Biological Wastewater Treatment in Warm Climate Regions, Volume – I, IWA (2006)
[27]Source: CPCB Inventory (2021)
[28] Source : Reference , Sl No: 14

II. Photograph of UASB is given below .

Figure 33: Photograph of 14 MLD UASB technology based STP at Mirzapur, Uttar Pradesh

III. The process diagram of UASB is given below.

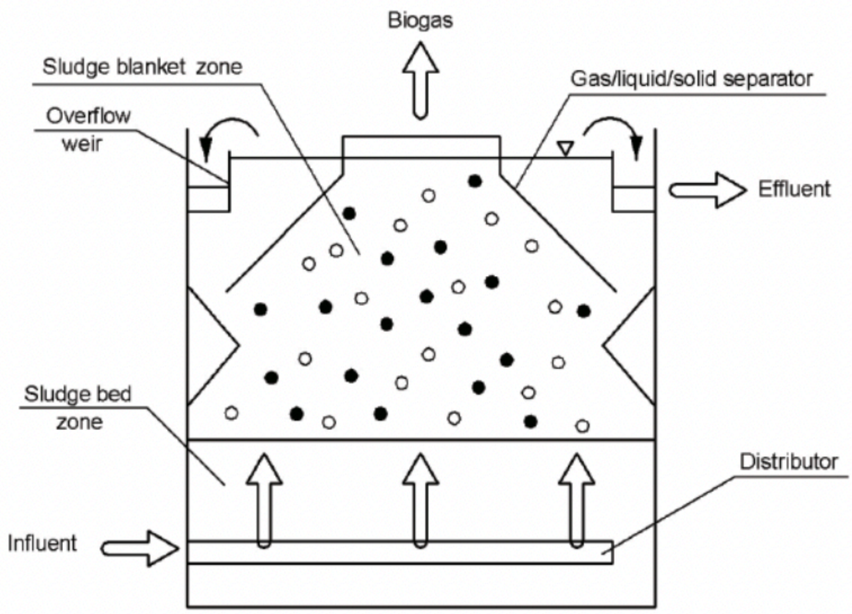


Figure 34: UASB Process Diagram

IV. The typical layout of STP based on UASB treatment technology is given below

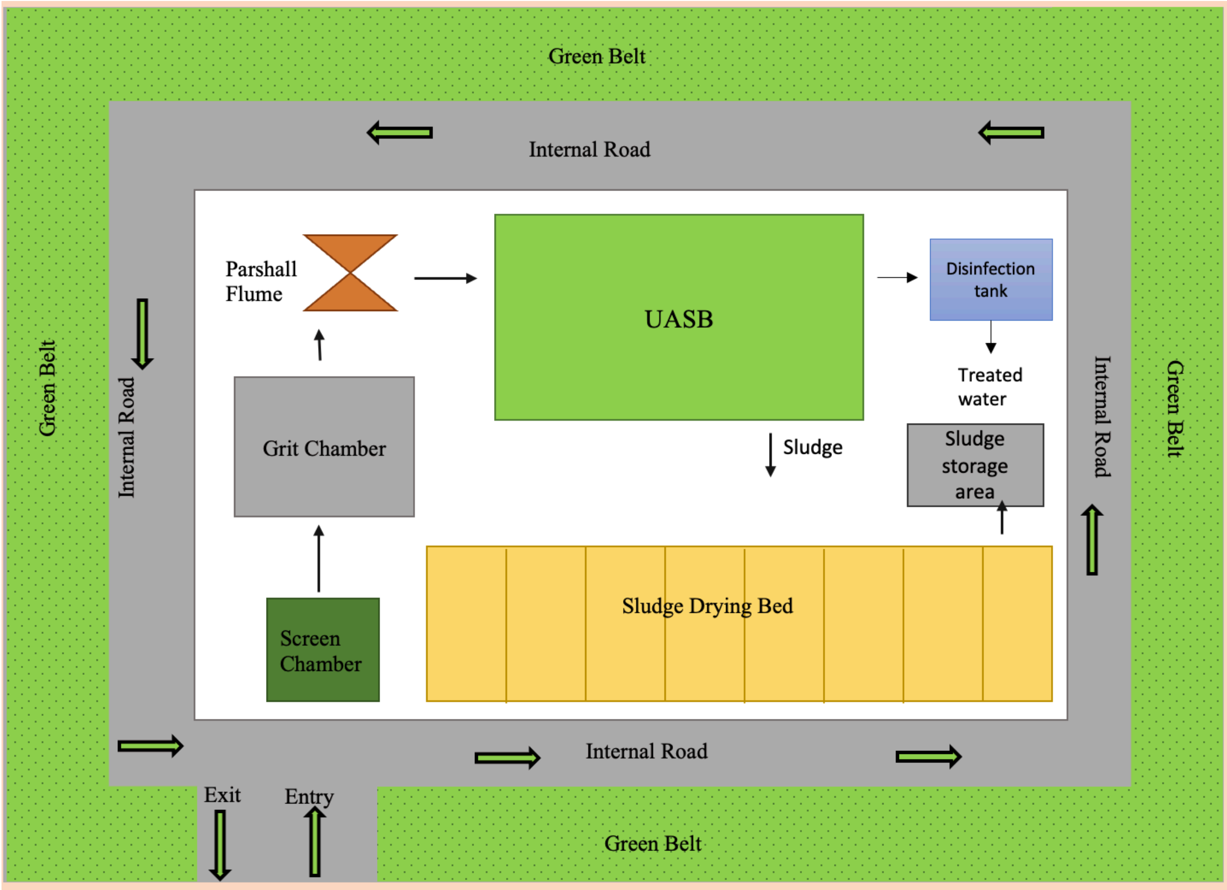


Figure 35: Typical Design Layout for UASB

V. The unit sizes for different capacities may vary based as indicated below in Table 21:

Table 21: Typical Design sizes of different unitsfor 1 2 and 5 MLD UASB

LIST OF STRUCTURES	**1 MLD**	**2 MLD**	**5 MLD**
	(L X B X D)	**L X B X D)**	**L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
UASB reactor(m)	12.0 x8.0x (5.0+0.50 FB)	18.00 x 11.00 x (5.00 +0.50 FB)	30.00 x 16.50 x (6.00 x0.50 FB)
Sludge Treatment			
***Sludge drying bed(m)*	12.00 x 5.00 4 Nos	13.00 x 6.006 No’s	24.00 x 6.00 8No’s
Disinfection tank (m)	5.60 x 5.60 x 1.50 + 0.5 FB	8.90 X 7.00 X 1.50 + 0.50 FB	10.90 X 8.70 X 1.50 +0.50 FB

L = Length, B = Breadth, D = Depth, ***FB*** *= Free Board* ** The dimension can be re-oriented according to the available space.*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar screen	10x10mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing
Provision for Flaring or methane can be trapped and stored *W = Working, S = Standby*			

2.3 Combination of Treatment processes (UASB or ABR + additional treatment)[29]

The Anaerobic baffled reactor (ABR) or Fluidised Baffled Reactor (FBR) is a modified form of UASB in which the flow occurs mainly by gravity, thus eliminating the need for mechanical pumps. The series of baffled tank forces the sewage through the fluidised sludge blanket resulting in a high degree of pollution reduction. The number of chambers in the series determine the extent of pollution reduction.

An Anaerobic filter (AF)or Fixed Film reactor (FFR) is a fixed bed biological reactor with one or more filtration chambers in series. Its construction is like the ABR, with media placed in the chambers. The media surface supports the growth of active biomass that helps in degrading the organic matter as it passes through them. The efficiency of the AF increases with the number of sequential chambers.

The effluents from anaerobic reactors like UASB or ABR usually require a post-treatment step to adapt the treated effluent to the requirements of the environmental legislation and protect the receiving water bodies.

The main role of the post-treatment is to complete the removal of organic matter, as well as to remove the constituents little affected by the anaerobic treatment, such as nutrients (N and P) and pathogenic organisms (viruses, bacteria, protozoans, and helminths). The post treatment technologies can be based on aerobic treatment or nature-based treatment. Some of the combination of UASB + post treatment technologies, widely implemented in Brazil (similar climatic condition as India) are given in subsequent para.

Wherever high standard effluent quality is required, such combination of treatment systems can be adopted.

2.3.1 UASB or ABR + Polishing Pond

- This is a very interesting alternative from the technical-economical- environmental point of view, mainly when there are area limitations for the construction of only stabilization ponds. The effluent from this combination can be used for agriculture purpose since the aim of polishing pond is removal of pathogenic organisms. Because of these advantages, this combination is very common in developing countries.

[29]Source: Biological Wastewater Treatment in Warm Climate Regions, Volume -I, IWA, 2006 and Urban Wastewater Treatment in Brazil, Sperling, 2016

- Besides the preliminary treatment units (screen and grit chamber), the flowsheet comprises basically the anaerobic treatment unit, the polishing pond (either a single baffled pond or ponds in series) and the dewatering unit for the sludge produced in the UASB reactor.
- Dewatering units using drying beds are also usual in smaller plants.
- The main disadvantage is the high concentration of algae in the final effluent, which leads to serious restrictions by some environmental agencies.

I. The **Typical Configuration of UASB & Polishing Pond** is given below.

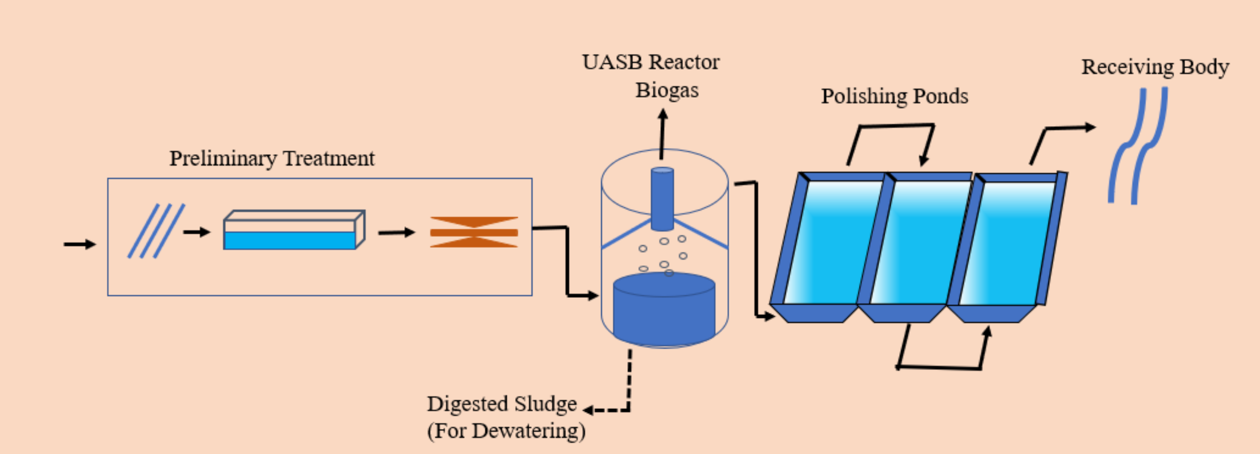


Figure 36*: UASB + Polishing Ponds – typical configuration*

II. The Typical Layout of UASB & Polishing Pond is given below.

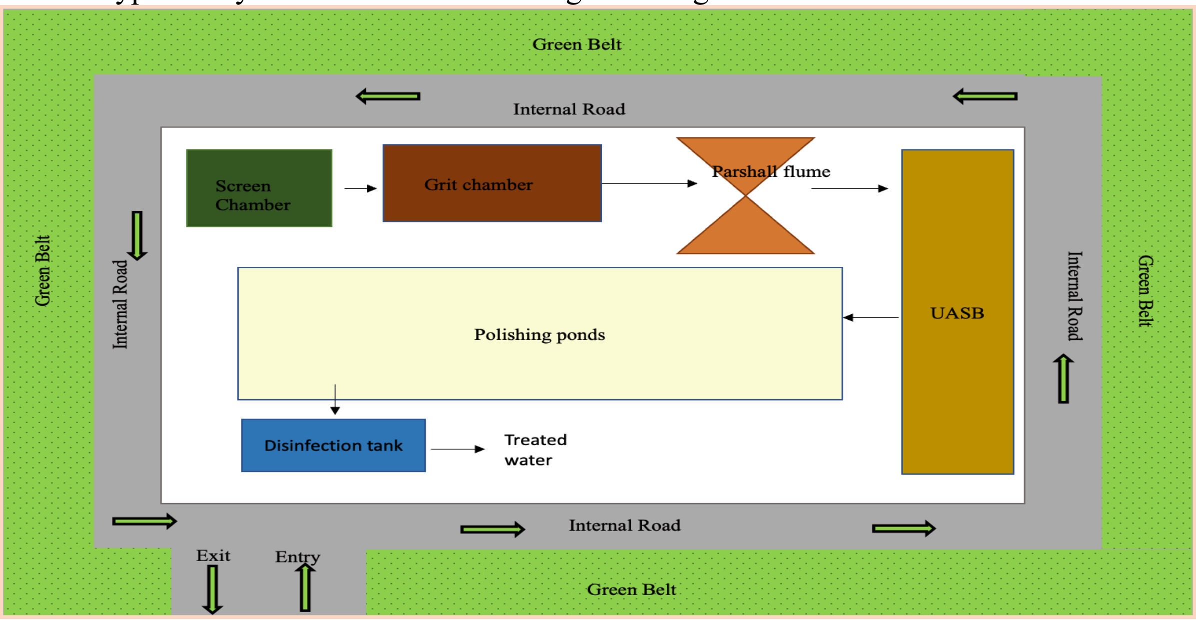


Figure 37: Typical Design Layout for UASB+ Polishing ponds

III. The **unit sizes of different capacities of UASB & Polishing Pond** based STP is given in Table 22.

Table 22: Typical Design sizes of different units for 1 ,2 5 MLD for UASB+ Polishing Pond

	1 MLD	2 MLD	5 MLD
LIST OF STRUCTURES*	**(L X B X D)**	**(L X B X D)**	**(L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x(0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
UASB reactor(m)	13.00 x 9.00 x 5.00	9.00 x 13.00 x 5 .00	13.00 x 20.00 x 5.00
Polishing pond	2200 sqm	4400 sqm	11000 sqm
***L** = Length, **B** = Breadth, **D** = Depth, **FB** = Free Board * The dimension can be re-oriented according to the available space.*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing

2.3.2 UASB or ABR + Land Disposal

- The overflow system as a means of post treatment of effluents from UASB reactor is covered in this document. This is least dependent on type of soil. In this method, the vegetation, associated with the top-soil layer, acts as a filter, removing nutrients and providing conditions for the retention and transformation of the organic matter contained in the sewage.
- This method is limited by the climate, cultural tolerance in relation to treated water and slope of the land. The application may be limited during wet weather.
- Besides the preliminary treatment units (screen and grit chamber), the flowsheet comprises the anaerobic treatment unit, the land treatment system and the dewatering unit for the sludge produced in the UASB reactor.
- Dewatering units using drying beds are also usual in smaller plants.

I. The **Typical Configuration of UASB & Land disposal** is given below.

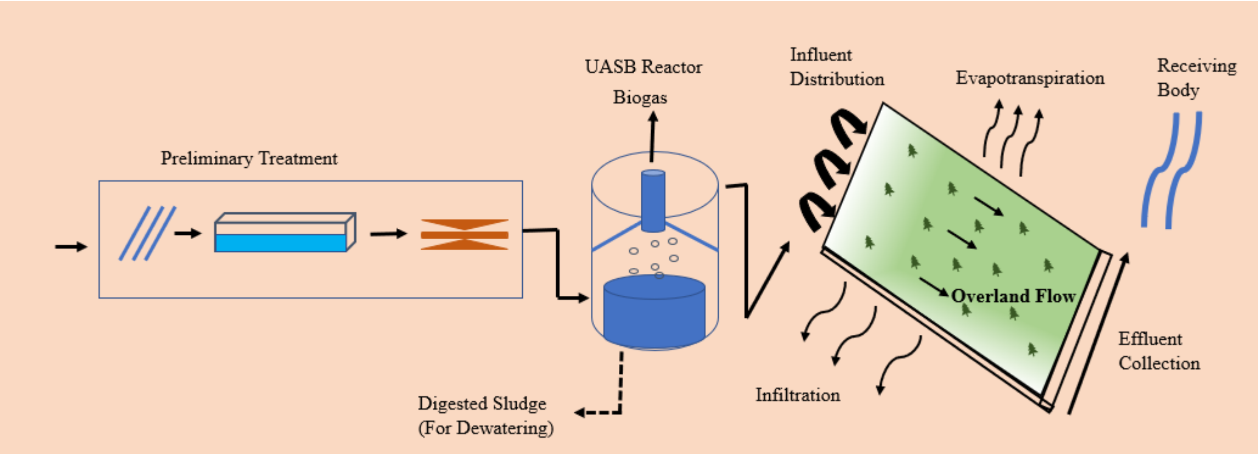


Figure 38: UASB + Land disposal – typical configuration

Source: Urban Wastewater Treatment in Brazil, Sperling, 2016

II. The **Typical Layout of UASB & Land disposal** is given below.

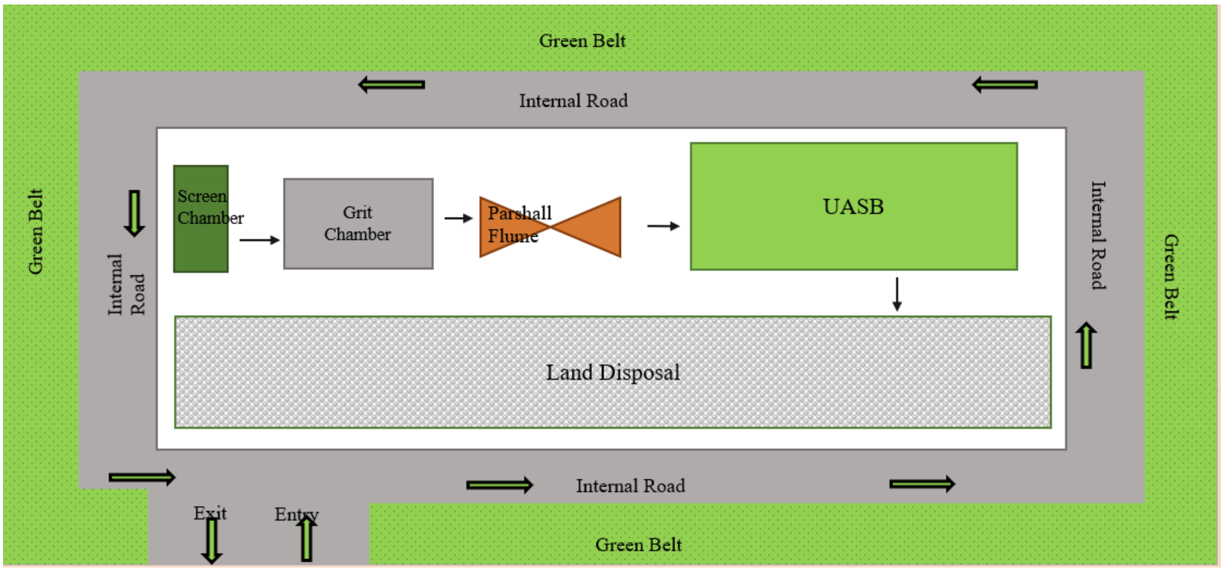


Figure 39: Typical Design Layout for UASB+ Land disposal

III. The **Unit sizes of different capacities of UASB & Land disposal** are in Table 23.

Table 23: Design inputs for 1, 2 and 5 MLD for UASB + Land disposal

	1 MLD	2 MLD	5 MLD
LIST OF STRUCTURES*			
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50

Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x(0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
UASB reactor(m)	9.00 x 6.00 x 5.00	9.00 x 13.00 x 5.00	13.00 x 20.00 x 5.00
Plantedgravel filter	750.00 x 3.00 x 1.40	1500.00 x 3.00 x 1.40	3750.00 x 3.00 x 1.40
***L** = Length, **B** = Breadth, **D** = Depth, **FB**= Free Board* ** The dimension can be re-oriented according to the available space.*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10x10mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing

2.3.3 UASB or ABR + Trickling Filter

- A trickling filter consists basically of a tank filled with a highly permeable material, onto which wastewater is loaded in the form of drops or jets. Wastewater percolates towards bottom drains, allowing growth on the surface of the packing material, in the form of a fixed film (biofilm). Wastewater passes over the biofilm, allowing a contact between the microorganisms and the organic matter.
- This combination helps in reduction of the power and operational costs of the treatment plant.
- Besides the preliminary treatment units (screen and grit chamber), the flowsheet comprises sequential anaerobic and aerobic biological units (UASB reactor, trickling filter, and secondary sedimentation tank), as well as the dewatering unit.
- In this configuration, the excess aerobic sludge removed from secondary sedimentation tank is returned to the UASB reactor for thickening and anaerobic digestion. Therefore, in this flowsheet, primary sedimentation tanks and separate units for thickening and anaerobic digestion of the excess aerobic sludge are not required, different from the conventional treatment plants that use trickling filters.
- Dewatering units using drying beds are also usual in smaller plants.

I. The **Typical Configuration of UASB &Trickling Filter** is given below.

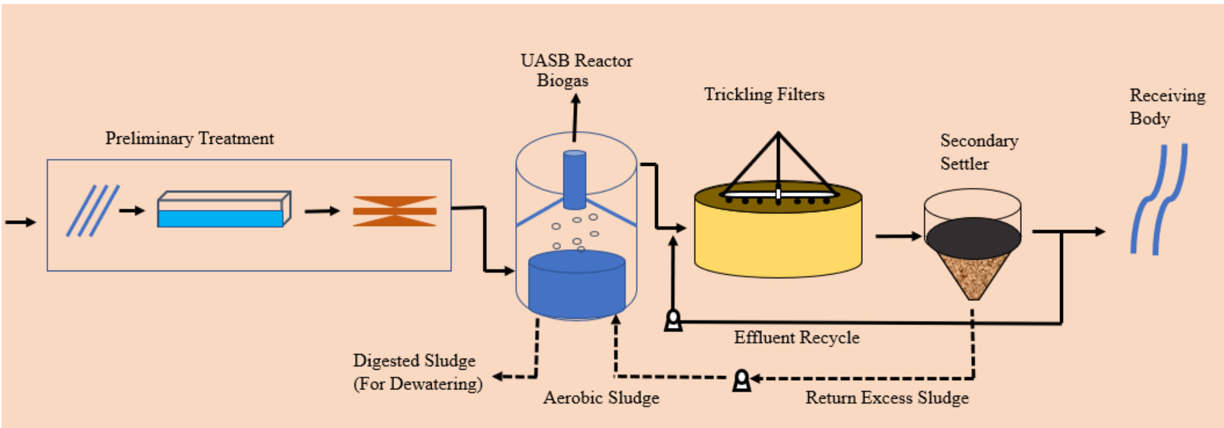


Figure 40: UASB + Trickling Filter – typical configuration

II. The **Typical Layout of UASB &Trickling Filter** is given below.

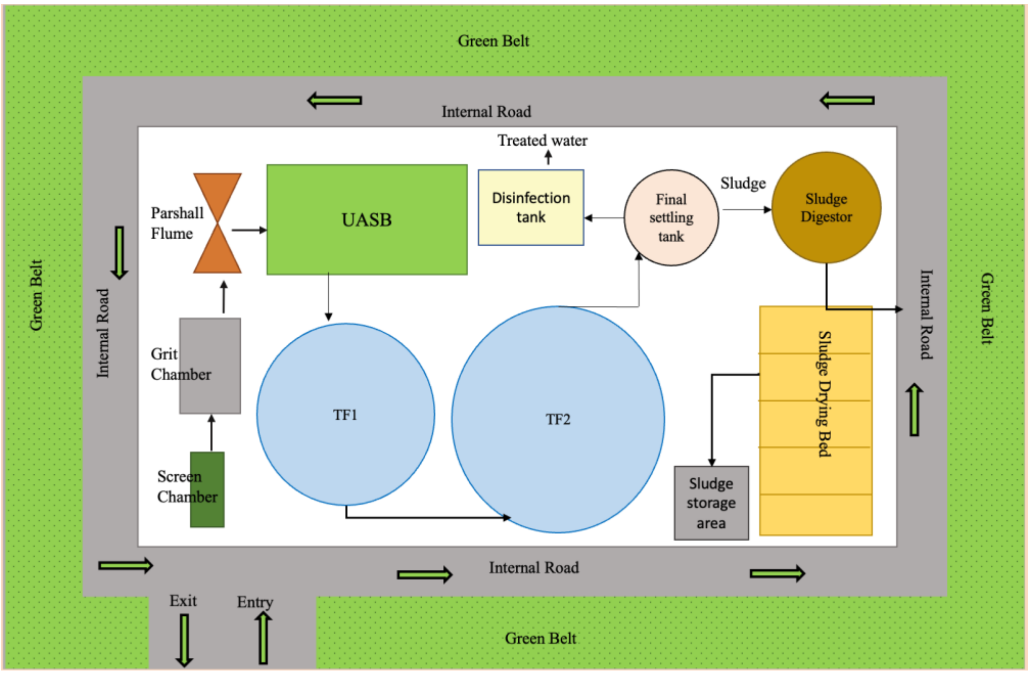


Figure 41: Typical Design Layout for UASB+TF

III. The **unit sizes of different capacities of UASB &Trickling Filter** are given in Table 24.

Table 24: Typical Design sizes for different units for 1, 2 and 5 MLD for UASB+TF

LIST OF STRUCTURES*	**1 MLD (L X B X D)**	**2 MLD (L X B X D)**	**5 MLD (L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x 0.4 + 0.3 FB	5.0 x 0.60 x 0.50 + 0.30 FB	7.0 x 0.8 x 0.7 +0.30 FB
Parshall Flume (m)	3.80 x 0.15 x 0.22 + 0.30 FB	3.80x 0.15 x 0.35 + 0.30 FB	3.80 x 0.15(throat) x 0.54 +0.30 FB
Secondary Treatment			
UASB reactor(m)	13.00x 9.00x 5	9.00 x 13.00 x 5.00	13.00 x 20.00 x 5.00
Trickling filter	2 no's (28.45m dia, 2 m depth,55.30 m dia, 2 m depth)	2 no's (13m dia, 2 m depth,25m dia, 2 m depth)	2 no's(20m dia, 2 m depth,40 m dia, 2 m depth)
Secondary settling tank	8 m dia, 2m depth	11 m dia, 2m depth	18 m dia, 2m depth
Sludge Treatment			
***Sludge drying bed*	25 x 60 x 3 m	(25 x 5 x 3 m) 17 no's	(25 x 5 x 3 m) 38 no's
*__L__ = Length, __B__ = Breadth, __D__ = Depth, __FB__= Free Board; * The dimension can be re-oriented according to the available space*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			
List of Equipment			
Bar screen	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing

2.3.4 UASB or ABR + Activated Sludge

- The essence of the continuous flow activated sludge process is the integration of the aeration tank (aerobic biological reactor), secondary sedimentation tank and sludge recirculation line. These three components are maintained in the alternative of activated sludge systems acting as post-treatment of effluents from anaerobic reactors.
- When the activated sludge system acts as post-treatment of anaerobic effluents, the anaerobic reactor is used instead of the primary sedimentation tank (which is an integral part of the conventional activated sludge system). The aerobic sludge is recirculated in the usual manner, that is, from the bottom of the secondary tank to the entrance of the aerobic reactor (aeration tank).
- The excess aerobic sludge generated in the activated sludge stage, not yet stabilized, is sent to the UASB reactor, where it undergoes thickening and digestion, together with the anaerobic sludge. As the return flow of the excess aerobic sludge is very low compared with the influent flow, there are no operational disturbances in the UASB reactor.
- There is no need for separate thickeners and digesters, and just the dewatering stage is necessary. The mixed sludge removed from the anaerobic reactor is digested, has solids concentrations like those from sludge thickeners and presents good dewatering ability.

I. The **Typical Configuration of UASB & Activated Sludge** is given below.

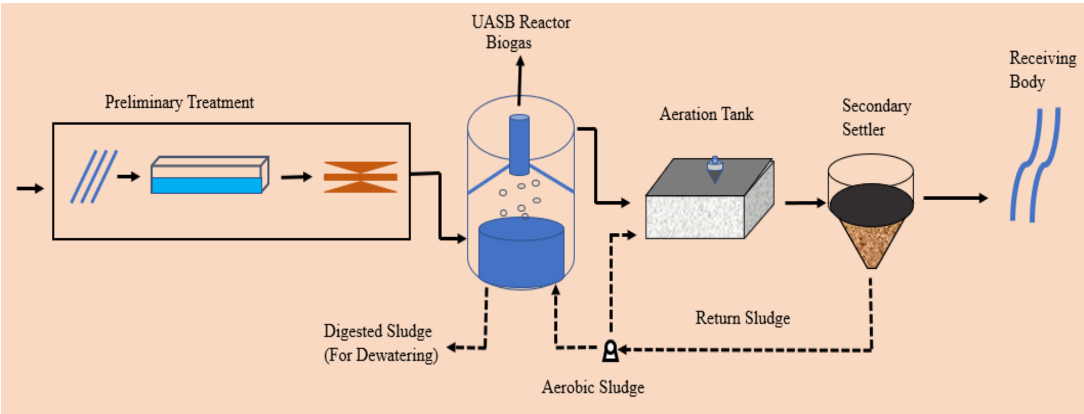


Figure 42: UASB + Activated sludge - typical configuration

II. The **Typical Layout of UASB &ASP** is given below.

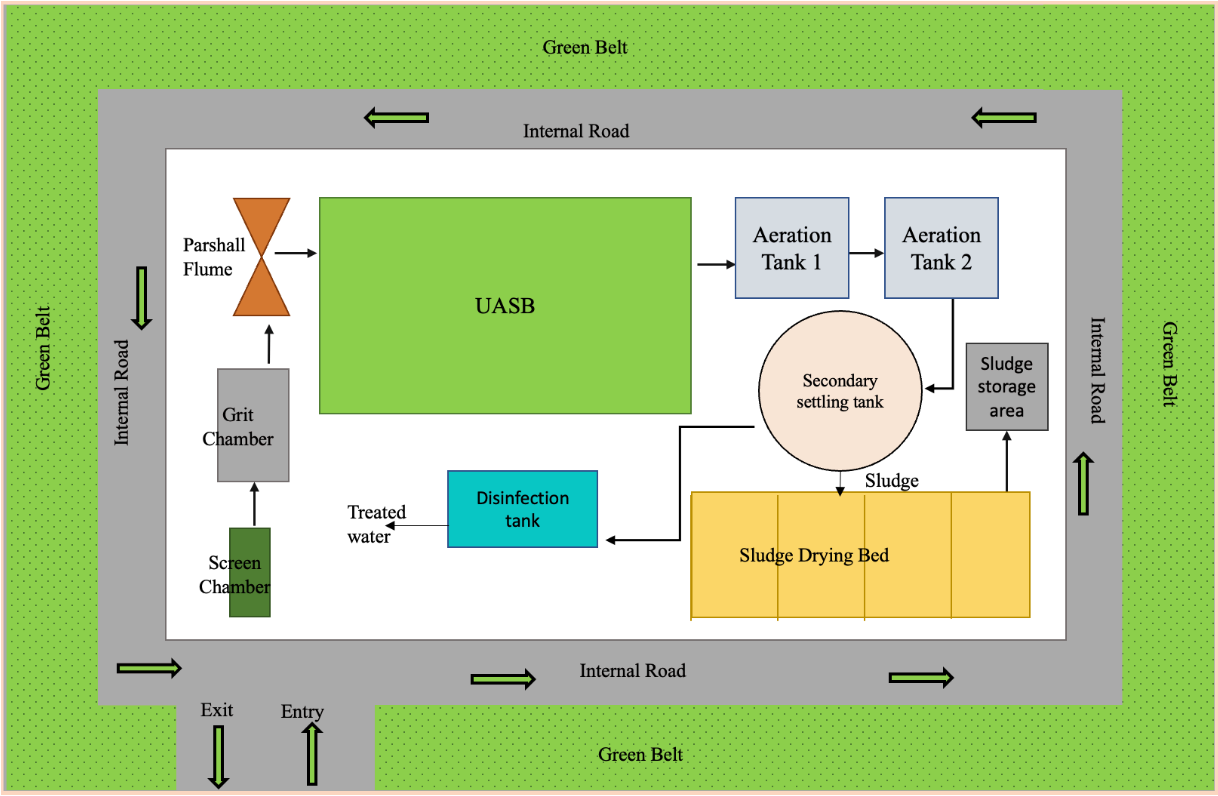


Figure 43: Typical Design Layout for UASB+ASP

III. The **Unit sizes of UASB &ASP** are in Table 25.

Table 25: Typical Design sizes of different units for 1, 2 and 5 MLD for UASB+ ASP

LIST OF STRUCTURES*	**1 MLD (L X B X D)**	**2 MLD (L X B X D)**	**5 MLD (L X B X D)**
Primary Treatment			
Screen (m)	1.75 x 0.35 x 0.30	2.25 x 0.45 x 0.40	2.75x 0.55x 0.50
Grit chamber (m)with Proportional flow	3.0 x 0.50x (0.4 + 0.3 FB)	5.0 x 0.60 x (0.50 + 0.30 FB)	7.0 x 0.8 x (0.7 +0.30 FB)
Parshall Flume (m)	3.80 x 0.15 x (0.22 + 0.30 FB)	3.80x 0.15 x (0.35 + 0.30 FB)	3.80 x 0.15(throat) x (0.54 +0.30 FB)
Secondary Treatment			
UASB reactor (m)	13.00 x 9.00 x 5.00	13.00 x 9.00 x 5.00	13.00 x 20.00 x 5.00
Aeration tank	2x (3 x 3 x 3.5 m)	2x (4.5 x 4.5 x 3.5 m)	2x (7 x 7 x 3.5 m)
Secondary settling tank	8 m dia, 2.7m depth	11m dia, 2.7 m depth	18m dia, 2.7 m depth
Sludge Treatment			
*Sludge drying bed	(25 x 5 x 0.16 m) 19beds	(25 x 60 x 3 m) 35 beds	(25 x 60 x 3 m) 83 beds
***L** = Length, **B** = Breadth, **D** = Depth, **FB** = Free Board* ** The dimension can be re-oriented according to the available space*			
***Area required for Sludge drying bed can be drastically reduced by providing Mechanised sludge dewatering unit*			

List of Equipment			
Bar screen	10x10mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing	10 x 10 mm bar, 25mm spacing
Blower with motor	Capacity 3053 m^3/hr	Capacity 3053 m^3/hr	Capacity 3053 m^3/hr.)
GLSS	Aperture 13 x 0.7m, width of deflector beam 1m	Aperture 13 x 0.7m, width of deflector beam 1m	Aperture 13 x 0.7m, width of deflector beam 1m
Sludge transfer pump	1(W) + 1(S)	1(W) + 1(S)	1(W) + 1(S)
Recirculation pump	1(W) + 1(S)	1(W) + 1(S)	1(W) + 1(S)
Aerator	3 nos. of 20 HP + 1 standby	3 no's of 20 HP + 1 standby	3 no's of 20 HP + 1 standby
			***W** = Working, **S** = Standby*

2.4 Decentralised and On-site treatment technologies

2.4.1 Decentralised Treatment System

Decentralised Treatment System (DTS) is a combination of a series of Anaerobic Baffled Reactor followed by the Fixed Film Reactor. The DTS is based on the principle of making effective use of natural processes like gravity, microbiological activity, and temperature. This results in a system which works without wasting scarce energy resources and needs only minimal maintenance. In fact, the system produces energy in form of methane/biogas. DTSs are typically placed underground and offers a chance to reuse the roof surface for alternate applications such as roads, parking spaces and parks, thus offering an alternative to ULBs with land constraints.

Note: *The Decentralised Systems such as DEWATS/BIO STP DTS and many other of constructed wetland family (some of them are patented as well) are being used independently or in combination with other treatment systems in domestic market which provides desired level of effluent.*

Since performance of these technologies varies in handling sewage from medium and small towns, therefore, the Urban Local Bodies are advised to select one or two suitable technologies on pilot basis and on successful testing the results, can go ahead for replicating in other towns.

I. **Factsheet about DTS** is given in Table 26 below.

Table 26: Factsheet – DTS

Decentralised Treatment System (DTS)		
1.	**Process and units**	• It is a combination of different wastewater treatment technologies cascaded in modules to a full-blown system, to achieve the required effluent quality for the claimed reuse purpose. • The settler in DTS acts as a gas tight septic tank with low hydraulic retention times. The digestion process in settler ensures that the accumulated sludge is reduced and stabilized. • Fluidized Baffled Reactor in the treatment plant helps in reduction of BOD by the activated sludge process occurring within the chamber. • Fixed Film Reactor helps in treating non settleable and dissolved solids by bringing them in close contact with a surplus of active bacterial mass fixed on filter material.
2.	**Land Requirement**	• 0.13 - 0.14 Ha/ MLD installed capacity
3.	**Energy Requirement**	• <Nil, (gravity flow)
3.	**Capital Cost**	• INR 80-200 lakh/MLD capacity
4.	**O&M Cost**	• INR 2-2.5 lakh/year/MLD Installed capacity (annual desludging required)
5.	**Effluent Quality**	• BOD<30 mg/l; COD<100 mg/l • TSS < 100 mg/l, BOD removal efficiency: 75 -80% (High rate); 85-90% (Normal rate) COD: 85-90%, TSS: 95%
6.	**Advantages**	• Construction by locally available materials and makes it very affordable. • No power requirement for treatment processes • Tolerance to high fluctuation • Low operational cost &no skilled labour required • No noise pollution. • Zero space required, as STP goes underground • Sludge clearance to be done only once in 2 years.
7.	**Disadvantages**	• High construction cost
8.	**O&M**	• Scum removal in settler checked once in 3 months- The scum accumulation leads to lower efficiencies. • Desludging of Settler done once in 18 months- It may wash the accumulated sludge to the subsequent stages Desludging of FBR done once in 12 months - Excess sludge causes reduction in treatment due to lowering of hydraulic retention time.
9.	**City/ plant examples**	• Kundalahalli lake, Karnataka 1MLD (2017) • Martha's Hospital, Karnataka 1MLD (2009)
10.	**Sludge generated**[30]	• 50 T /year for 1MLD
11.	**Suitability**	• Suitable for all location and weather condition with a moderate to high temperature . If the available temperature is low appropriate change can be made in the design of the treatment system required.

[30] Source: Case study of Kundalahalli Lake

II. Flowchart of **DTS** is given below.

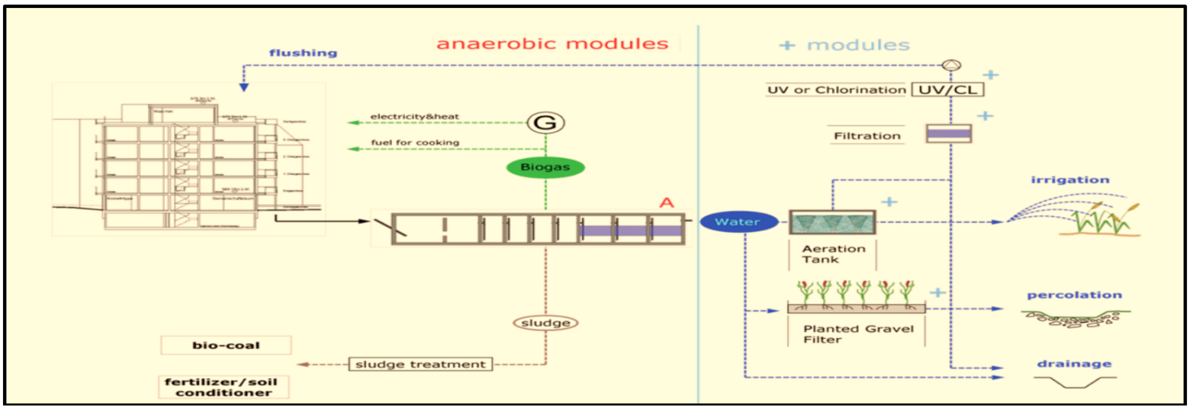


Figure 44: Flowchart of DTS

III. DTS being constructed underground enables space utilisation for other purpose such as Car parking, gardening, roads etc., An example of DTS roof space utilisation for Car parking is shown in the following figure.

Figure 45 Construction of DTS

Figure 46 DEWATS of 307 KLD, Pondicherry

Figure 47 Landscaping above DTS

IV. Layout of **DTS** is given below.

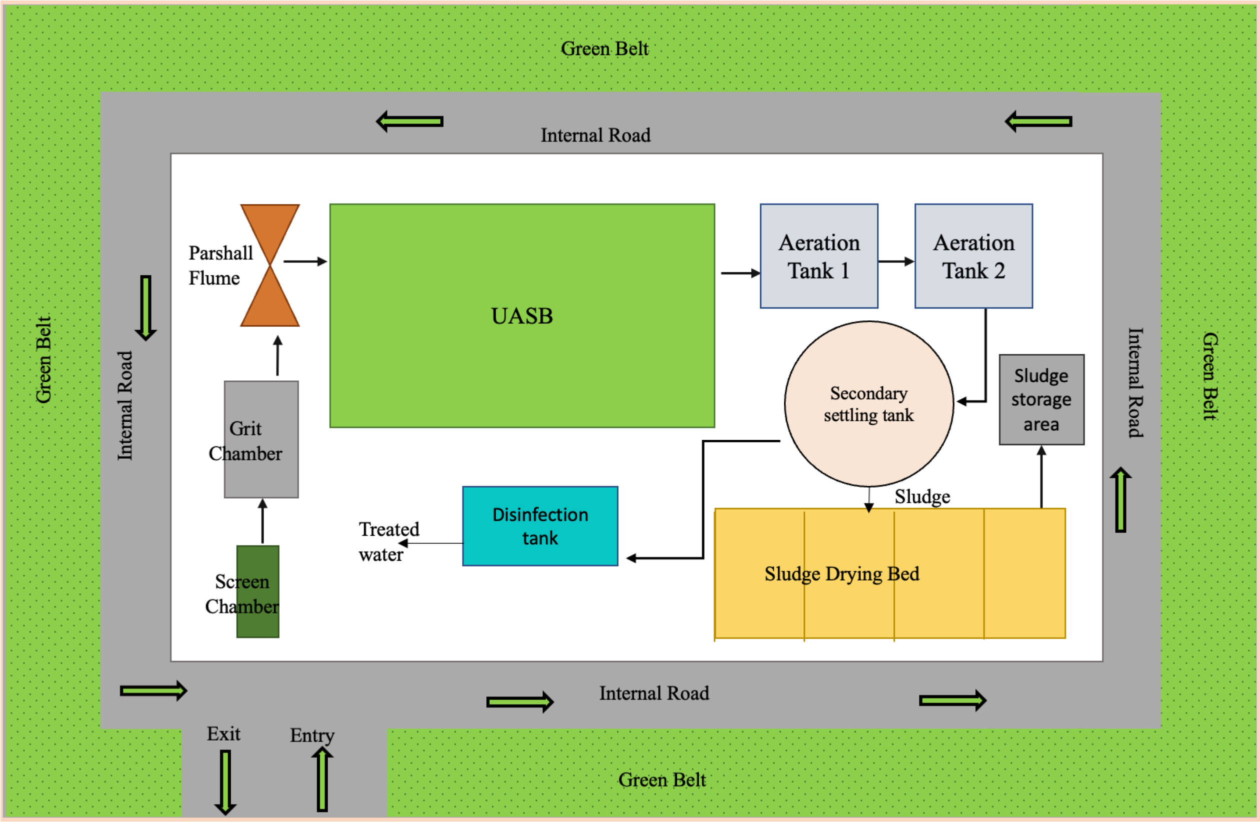


Figure 48 Typical Layout for the DTS

V. The unit sizes for different capacities for DTS STP may vary based as indicated below:

Table 27: Typical Design sizes of different units for 1, 2 and 5 MLD DTS

LIST OF STRUCTURES	1 MLD	2 MLD	5 MLD
Dimensions*	**(LxBxD)**	**L X B X D)**	**L X B X D)**
Primary Treatment			
Settler	*15.00 x10.00x(3.20+0.8FB)*	*15.00 x20.00x(3.20+0.8FB)*	*15.00 x50.00x(3.20+0.8FB)*
Fluidized Bed Reactor	*1.50 X 92.00 X (3.20+0.80FB) 6 Nos*	*1.50 X 184.00 X (3.20+0.80FB) 6 Nos*	*1.50 X 470.00 X (3.20+0.80FB) 6 Nos*
Fixed Film Reactor	*3.00 x 75.00 x (3.20+0.50 FB) 1 No*	*3.00 x 150.00 x (3.20+0.50 FB) 1 No*	*3.00 x 400.00 x (3.20+0.50 FB) 1 No*
L = Length, B = Breadth, D = Depth, FB= Free Board * The dimension can be re-oriented according to the available space.			
Disinfection Treatment			
Disinfection tank (m)	5.60 x 5.60 x 1.50 + 0.5 FB	8.90 X 7.00 X 1.50 + 0.50 FB	10.90 X 8.70 X 1.50 +0.50 FB

2.4.2 On-site treatment technologies

On-site usedwater treatment is typically used in locations where housing density is sufficiently low that centralized wastewater treatment is not economically feasible. It is also used in areas where technology and resource limitations do not permit centralized wastewater treatment systems. The purpose of the packaged or prefabricated systems for on-site wastewater treatment application is to reduce the concentrations of contaminants to acceptable levels before the treated waste water discharged. The system plays a vital role in removing scum, nutrients, pathogens, grease, and settleable solids, thus, protecting the living system. Some of the packaged treatment plants are mentioned below.

> **Note :** *The following prefabricated or packaged technologies are available and claim to cater to domestic market.*
>
> *Since these technologies are not adequately rested in handling sewage from medium and small towns, the Urban Local Bodies are advised to select one or two suitable technologies on pilot basis and on successful testing the results, go for replicating in other towns.*

2.4.2.1 Anaerobic Packaged Systems

Process: Anaerobic Packaged Systems with floating media is a wastewater treatment solution based on the principle of making effective use of natural processes like gravity, microbiological activity, floating media, and temperature. This results in a system which can work without wasting scarce energy resources and needs only minimal maintenance. In fact, the system produces energy in form of methane/biogas. The solution is also designed to meet environmental laws. Anaerobic packaged System (AnPS – FM) core system generally consists of Settler, Fluidized Bed Reactor (FBR) and Fixed Film Reactor (FFR). The treated water can be disposed into soak pit also.

I. The **photograph of a typical Anaerobic Packaged system with floating media** is given below.

Figure 49: Photograph of Modular DTS being installed in Discovery village Banglore

II. The **Design parameters for Modular DTS** is given below.

Table 28: Design Parameters for Modular DTS

Sl. No.	Design parameters	Wastewater Characteristics
1	Capacity	0.5 -3.0 KLD
2	CAPEX	INR 60,000 - 80,000
3	OPEX	INR 1500 - 3000/year
4	Chemical Oxygen Demand (CODin)	800 mg/l
5	Biochemical Oxygen Demand (BODin)	400 mg/l
6	MOC	Ferrocement
7	Mode of Installation	Horizontal type
8	Treatment Efficiency	BOD: <20mg/l
9	Dimensions of 0.50m3/d to 30m3/day	2.4 m x 1.2m x 2.2m to 13.5m x 4.0m x 2.2

2.4.2.2 Packed Anaerobic-Aerobic On-site Treatment Systems

Process: This is an on-site compact sewage treatment plant which was developed in Japan (also known as Johkasou) and adopted by households/ group of households not connected with sewerage system. It is usually installed underground as a single compact tank. There are five functional chambers namely, sedimentation, anaerobic, aeration, storage, and disinfection in a tank.

There are similar modified packaged on-site treatment systems available in market. However, before adopting such packaged treatment systems, their performance need to be monitored by setting up one or two such plants.

The brief details of widely used Johkasou or its variants is given below:

I. The **photograph for Johkasou** is given below.

Figure 50: A Typical site installation picture of Johkasou

II. The **Factsheet for Johkasou** is given below.

Table 29: Factsheet for Johkasou System

1.	**Process and units**	• **Pre-treatment process: This process removes insoluble substances that are difficult to decompose biologically by means of sedimentation, floating, and screening. In the large-scale system, a flow equalizer is planned for stabilizing the biological treatment.** • **Main treatment process: The main treatment process biologically removes BOD-related contaminants by aerobic treatment and removes nitrogen by combination of anoxic and aerobic treatment. The system employs a sedimentation tank for solid-liquid separation in most cases, but use of a membrane separator in place of the sedimentation tank makes it possible to downsize the system and to improve the quality of treated sewage further.** • **Advanced treatment process (to be installed if necessary): This process removes COD-related contaminants and phosphorus from the biologically treated sewage by means of flocculation sedimentation, sand filtration, activated carbon absorption, and dephosphorization.** • **Disinfection process: This process disinfects E. coli and other bacteria to make effluent water safer.**
2.	**Capital Cost**	INR 2.2 – 3.4lakh/KLD capacity higher unit cost for small capacity plants.
3.	**O&M Cost**	INR7,650/KLD/year
4.	**Effluent Quality**	• BOD< 30 mg/l; COD<150 mg/l • TSS <50 mg/l; BOD removal efficiency: 75-90%
5.	**Advantage**	• Short installation time and early realization of the effects • Johkasou-treated water and sludge are easy to reuse
6.	**Disadvantage**	• High Initial Investment Cost • Uninterrupted Power Supply required • Periodic Operation and Maintenance
7.	**City/ plant examples**	• Aizwal • Mizoram • Chennai

III. The **Process Diagram of Johkasou** is given below.

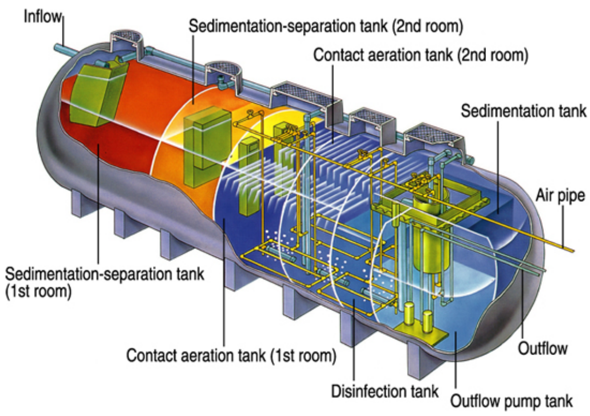


Figure 51: Process diagram of Johkasou

Note: *It should be understood that these (decentralised and on-site treatment) technologies are proprietary /patented and should be chosen carefully, as the dependence on these suppliers/vendors will be needed for the entire life of the plant. Special attention needs to be undertaken to operation and maintenance aspects like - dependence on electricity and chemicals for operation, special skilled labour, replacement of membranes, bio-culture, durability and/or dependence on proprietary* *components. Preference should be given to technologies that use local material, compliance to prescribed norms etc., In case the proprietary technology is of imported origin, then the dependence of spare parts, replacement of components etc., will be expensive and time consuming for importing. The effluent may need further polishing in some cases, and hence, additional steps may need to be taken to comply with reuse norms. Selection decision should be made after considering all these factors.*

2.5 In-line treatment of Drain (Nallah)

Drains carrying sewage or grey water can be tapped and treated through Ex-situ treatment or In-situ treatment. Ex-situ treatment involves installation of a complex network of drainage pipes to collect sewage or pumping the same to a sewage treatment plant with intake structures. On the other hand, In-situ nallah treatment treats the sewage in the nallah/drain by the most natural and environment friendly way. Wastewater treatments using constructed wetland treatment systems for have become widely used world-wide, since the last few decades as it offers a low-cost alternative technology for wastewater treatment. However, In-line treatment can normally reduce the pollution load of the wastewater and often not a complete treatment and any further improvement can be achieved by combining any one of the packaged systems which above mentioned.

I. The **Factsheet of In-line treatment of drain** is given below.

Table 30: Factsheet of Inline drain treatment

Inline Drain Treatment		
1.	**Process and units**	1. **Screens:** Screens and Oil & Grease trap are provided to remove the floating matter such as paper, shampoo sachets, sanitary napkins along with fat, oil, grease and scum. 2. **Primary treatment:** The Grit chamber, sedimentation zone and the Anoxic zone are provided to remove the organic and inorganic solids by settling and by enhanced anaerobic digestion. 3. **Secondary treatment:** In secondary treatment, Anoxic zone, Bio media and Diffused Aeration are provided to degrade the organic matter in the sewage by the microorganisms. 4. **Phyto-remediation:** Planted beds are created to remove the nutrients and Suspended solids from the sewage. These units contained beautiful wetland plant species like cattails (Typha sp.), reeds (Phragmites sp.), bulrushes (Scirpus sp.), sedges (Carex sp.), Canna indica etc. which purifies the Sewage and increase the DO Level of the sewage as well as add to the aesthetics of the locality. 5. **Disinfection:** To remove the bacteria from sewage, disinfection is done before discharging wastewater in the waterbody.
2.	**Land Requirement**	In-line
3.	**Energy Requirement**	Zero or negligible
3.	**Capital Cost**	INR 25-35 lakh/MLD capacity, higher unit cost for small capacity plants.
4.	**O&M Cost**	INR 50 lakh/year/ML Installed capacity
5.	**Effluent Quality**	• BOD<20 mg/l; COD<100 mg/l • TSS <30 mg/l; BOD removal efficiency: 75-90%,

6.	**Advantage**	• Beautiful aesthetics • Low Capital and O&M Cost • Zero or negligible electricity requirement
7.	**Disadvantage**	• This system is not a complete treatment solution, and it only improves the quality of the wastewater flowing in the drains. • It requires periodical removal of the plants, the decayed plant can add up BOD to the treated water • During heavy rainfall, stormwater runoff in drains can occur in such conditions it should be removed, or raw water should be bypassed
8.	**O&M**	• **Records -**operation should include recording of flow rates of wastewater flowing in drain, DO, BOD, COD
9.	**City/ plant examples**	• Jhansi, Prayagraj

II. The **Photograph of In-line treatment of drain** is given below.

Figure 52: Photographs of the nature-based treatment 12 MLD at drains in Prayagraj

2.6 Community Soak pit

A Community Soak Pit is an extended version of household soak pit, where multiple houses can be connected to a single pit. Areas where faecal septage and grey water are managed separately and places where higher amounts of greywater are generated, such as schools, restaurants, community stand ponds, etc. should adopt the community leach pit based on the volume of greywater generated. To avoid clogging and condition of soil sickness these soak pits are to be provided with post treatment technology such as Planted Gravel filter etc. This method is often not well controlled and is used to reduce pollution load.

I. The **Factsheet of Community Soak pit** is given below.

Table 31: Factsheet of Community soakpits

Community Soak Pits		
1.	**Process and units**	• It is a covered, porous structure that allows water to slowly soak into the ground. It is filled with graded stones and gravels. The stones increase the surface area over which biological and chemical actions take place. As used water percolates through the

		layers of graded aggregates and soil, small particles get filtered out and organics gets digested. • The number of houses to be connected should be calculated based on the used water discharged from each house and the space available for the community soak pit. • The Grey water generated from the HHs are collected through a drainage channel and the outlet of this channel is connected to an Inspection chamber and then to the Community Soak Pit.
2.	**Energy Requirement**	Nil
3.	**Capital Cost**	INR 12,500 for Community Soak Pits for Common Places INR 1,33,000for Community Soak Pits horizontal Filter Type INR 1,27,000for Community Soak Pits vertical Filter Type
4.	**Advantage**	• Low cost and easy to construct • Can be built and repaired with locally available materials
5.	**Disadvantage**	• low function ability in semi-permeable soils • Not suitable for areas with high water table
6.	**City/ plant examples**	• Tamil Nadu
7.	**Suitability**	• Suitable for all location and weather condition with a temperature of 20°C +. If the required temperature is not achieved appropriate change can be made in the design of the treatment system

II. The **Type Design Drawing of Community Soak pit** is given below.

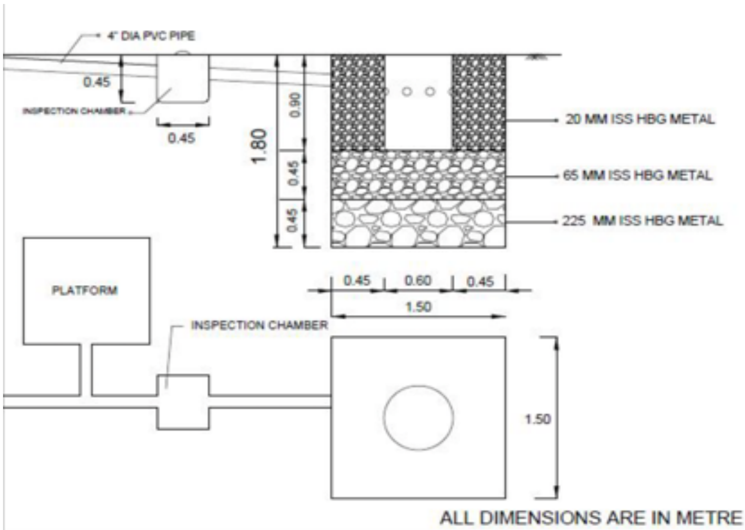


Figure 53: Type Design Drawing of Community Soak pit

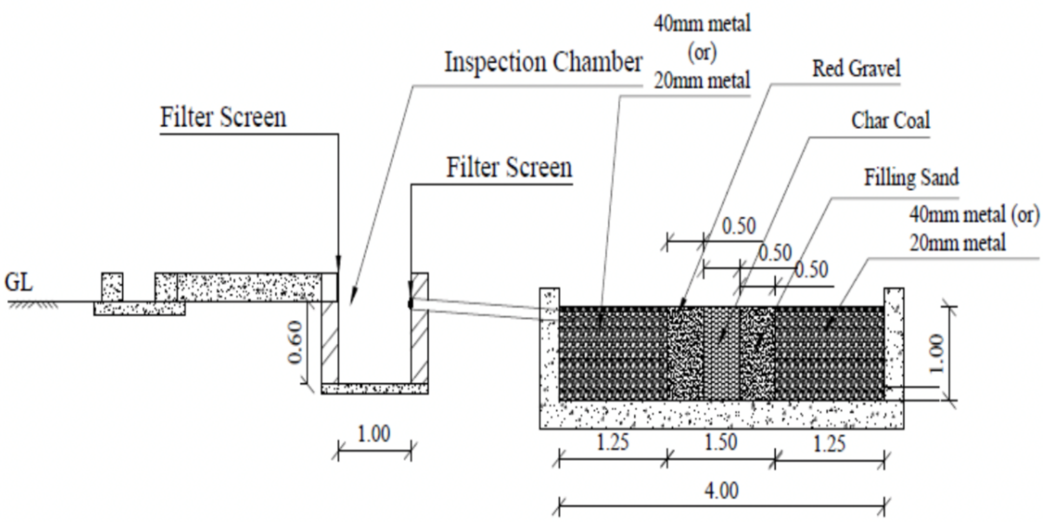


Figure 54: Type Design Drawing of Community Soak pit Horizontal Filter Type

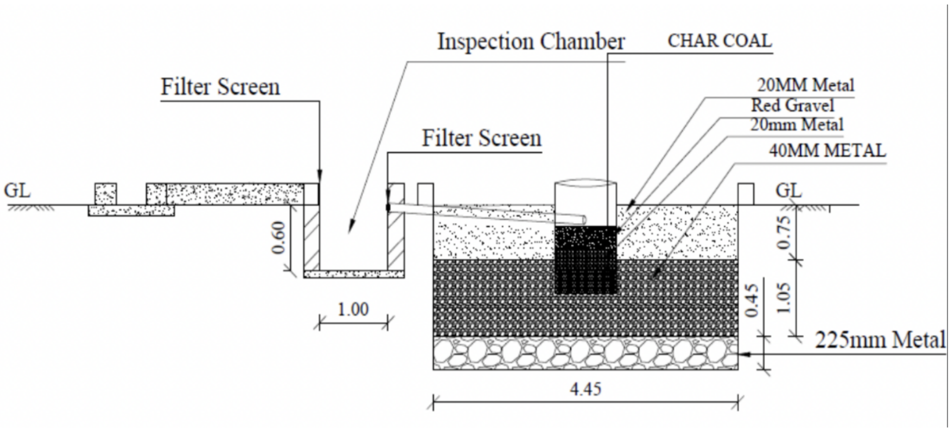


Figure 55: Type Design Drawing of Community Soak pit Vertical Filter Type

III. The **Photographs of Community Soak pit** are given below.

Figure 56: Photograph of Community Soak pit Horizontal & Vertical Filter Type at Tamil Nadu

3 Co-Treatment of Faecal Septage

This section provides guidance on co-treatment of septage at either STP or Solid waste treatment facility. In case of new STPs, septage co-treatment facility can be simultaneously built. However, in case of existing STPs, supporting infrastructure components like ramp for desluding, screens, solid-liquid separation facility etc. can be created to facilitate co-treatment. This will eliminate the requirement of separate facilities for treatment of solid and liquid portions, after its separation at solid liquid separation units, normally required at FSTPs.

Co-treatment of septage simply means treating faecal septage (FS) along with domestic sewage at a sewage treatment plant (STP) or some times at Solid waste treatment plants as well. Septage is more concentrated in its strength than domestic sewage, but otherwise, its constituents are similar to municipal wastewater. Co-treatment is the most desirable option to treat faecal septage having many advantages such as saving funds (CAPEX and OPEX), land and better capacity utilization.

Broadly, co-treatment at STPs can be carried out in two ways: (1) addition of faecal septage with sewage (liquid stream), and (2) addition of faecal septage with STP sludge (solid stream). Similarly, at compost plants also, the septage can be dewatered and solid fraction can be composted and liquid fraction can be treated at leachate treatment plants. The co-treatment options at STPs are explained as under:

3.1 Addition of faecal septage with sewage

This option is best suited in situations where (a) septic tanks are periodically emptied or (b) comparatively low number of population covered with septic tanks, where the solid concentration in sludge is comparatively low (< 4%). This option should be practiced only when source of septage is known along with its characteristics, else, it may impair functioning of STPs and have to be avoided.

Generally, faecal septage desludged in a city/town accounts only about 1-3% that of the existing/proposed STP capacity of the town. Therefore, adding faecal septage into existing/proposed STPs can be a quick solution to its safe management.

Currently, the most popular practice under the pretext of co-treatment in India is direct disposal of faecal septage in the nearby manholes. This uncontrolled direct discharge of faecal septage in the nearby manhole can have damaging effects on the sewerage infrastructure. Therefore, ULBs need to curb these uncontrolled direct discharge of faecal septage in the nearby manholes and ensure that the faecal septage is either added to the trunk sewer line at sewage pumping stations or added at the inlet of the STPs. Care shall be taken by the ULBs for uniform mixing of faecal septage with incoming sewage over some time based on the design criteria of the receiving STP rather than abrupt discharging. In addition some preliminary treatment shall also to be given for the septage received to remove the trash/grit present with them. In no case the resultant concentration after addition of faecal septage shall exceed the design loads of the receiving STP.

In case of co-treatment of septage at existing STP, it will be necessary to construct a septage receiving station for ensuring the aforementioned points and having better control over the system. Such a station will consist of an unloading area (sloped to allow gravity draining of septage hauling trucks), preliminary treatment units such as screen/grit chamber, a septage storage tank with mixing arrangement and flow control valve/pump arrangements. The detailed description of the faecal septage receiving facility is given in the later part of this section.

Once the infrastructure for co-treatment is implemented, it has to be tested by adding faecal sludge gradually, starting from 25% of the co-treatment potential to 100% in a few days. This gives time to record and monitor any deviations or process abnormalities in the STP. During such trial runs, the system must be monitored by a competent engineer. During peak septage loadings, aeration basin's dissolved oxygen (DO) concentrations should be checked frequently to ensure that adequate levels (usually ≥ 2.0 mg/L) are present.

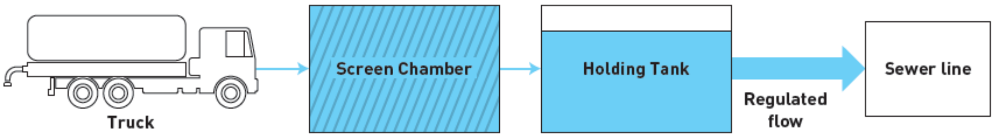


Figure 57: Process flow for direct addition of FS in Pumping Station

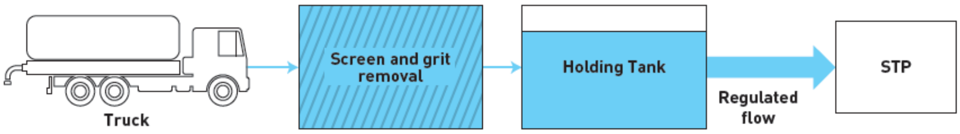


Figure 58: Proc Process flow for direct addition of FS in STP

Source: Ecosan Services Foundation's Training Module on Co-Treatment of Septage and Sewage

3.2 Addition of faecal septage with STP sludge

This option is ideally suited in situations where the solid concentration in faecal septage is usually very high (i.e. >5%) as septic tanks are usually emptied after a long periods (say > 5 years) & often filled with sludge. This option is better, in general, when compared to that of mixing septage into the liquid stream because most STPs designed, generally, with facilities for sludge handling and treatment.

In this case, the faecal septage needs to be screened for removing trash followed by solid-liquid separation. Various methods are existing for the solid-liquid separation process depending on the extent of dewatering that is being aimed. Ministry's Manual on Sewerage and Sewage Treatment Systems, 2013 may be referred to for details on the various solid-liquid separation technologies. This is, in turn, dependent on the downstream solid handling processes. A Typical solid liquid separation layout is given below and explained in subsequent section in detail.

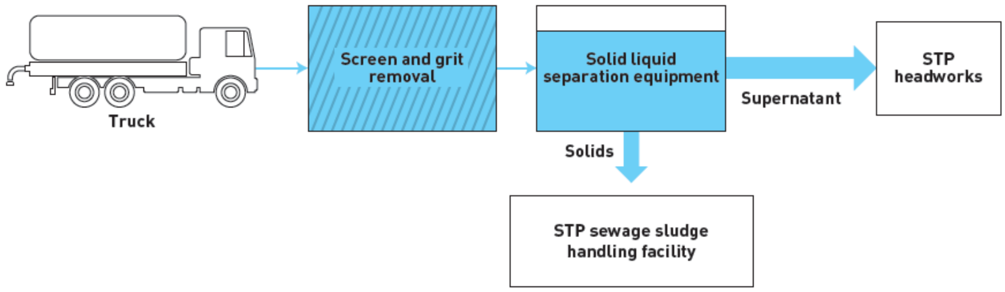


Figure 59: Process flow for addition of faecal septage with STP sludge (solid stream)

Source: Ecosan Services Foundation's Training Module on Co-Treatment of Septage and Sewage

3.3 Solid Liquid Separation

Solid-liquid separation is desirable in all cases of co-treatment for the faecal sludge having solids content of at least 1% or greater. After separation, the supernatant (liquid fraction) is diverted to the headworks of the STP where it is treated along with sewage inflows and the separated solids are sent for further processing along with the STP sludge at the solid management facility of the STP.

Depending upon the solids content of the inlet FSS, the following solid–liquid separation techniques may be preferred:

i. FSS with solids content between 1–5%
   a) Settling thickening tanks
   b) Geo-bags
   c) Mechanical De-watering – Belt filter press, Screw press

ii. FSS with solids content greater than 5%
   a) Sludge drying beds

3.4 Faecal Septage Receiving Facility at Co-treatment STPs

The aim of the receiving station is to reduce the impact and risk on the STP due to co treatment of septage and sewage. While designing a receiving station, one must consider the following:

- The quantity of the septage to be received daily along with the number of the trucks to be simultaneously emptied.
- The design and dimension of the desludging truck, especially the turning radius, its power to operate in reverse mode.
- Degree of pre-treatment to be given to the raw septage. This depends on the appurtenances and the STP where the mixed septage and sewage will be co treated.
- Disposal mechanism of the solid waste and grit separated from the raw septage

- Odor nuisance. If the receiving station is near the residential/commercial area, odor control measures needs to be provided at the receiving station.

The most common way is the controlled addition of the septage based on design and actual loading. However, by providing a septage receiving station (SRS) that provides adequate raw solids screening and de-gritting, the risk of hindering the performance of the STP can be reduced. The SRS, depending on need, should also have additional features such as odor control, flow equalization, site monitoring, and access control. SRS is the most common way of pre-treatment of septage before it is co-treated at the STP.

The receiving septage facility generally consists of the following components:

1. **A septage unloading zone (Dumping station):**It enables safe transfer of the raw septage from hauler truck to the pre-treatment components such as screens. It is important that dumping station provides a leak proof equipment for transfer of raw septage and avoid odour nuisance. Odour control can be done using chemical scrubbers or activated charcoal filters. Dumping station has normally following components such as

(i) Ramp for the truck to enter and exit, the ramp should be sloping towards the dumping inlet so that any spillage or wash water will drain into the dumping hole,

(ii) Dumping inlet arrangements with a removable lid

(iii) Water hydrant with pressurised water hose to wash down any spillage or the truck components after dumping.

(iv) Chemicals such as lime or chlorine can also be added to the septage in the storage tank @ 2.4 kg/1000 litre of septage to neutralize it, to render it more treatable, or to reduce odours.

However, a decision to be taken regarding necessity of a unit/component to be constructed so as to economize cost involved.

Figure 60: Photographs of the Septage Receiving Station

Alternatively, at larger STPs, depending on quantum of septage to be desludged, septage unloading zones may be completely computerized with appropriate quick connection coupling and an access card reader system for drivers with or without sampling arrangements.

2. Manual screens are used for smaller receiving station and mechanical screens are used where human intervention needs to be completely eliminated and higher flows need to be accommodated.
3. A tank housing a 6 mm fine screen, auger, and screenings washer/compactor system.
4. A washed screenings bagging system.
5. A Grit Removal System where needed. However, it is recommended to have it so that inert grit along with the fat and grease can be removed from the septage. Both these constituents have a potential to upset the biological treatment processes at the STP.
6. Holding tank with submersible transfer pumps. This allows controlled addition of pre-treated septage to the liquid stream depending on the actual flow rate of domestic sewage.

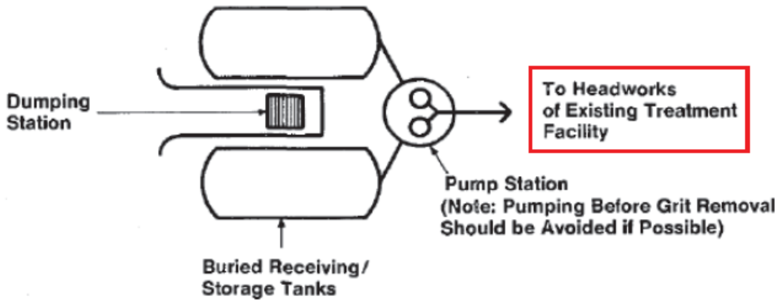


Figure 61: Septage Receiving Facility

Source: Advisory on On-Site and Off-Site Sewage Management Practices, 2020

At larger existing STPs where the volume of septage to be desludged is high, a homogenization tank of 10 KL capacity or so with a valve or pump is proposed for a controlled discharge to the STP. In this method, the FS is mixed with the influent with a pre-defined ratio. The ratio of FS addition can initially be restricted to 0.2% and increased gradually while monitoring the treatment efficiency of the plant. The module for this option includes

a. Screening
b. Homogenization cum mixing tank
c. Valve chamber
d. Pump for conveyance to the existing STP

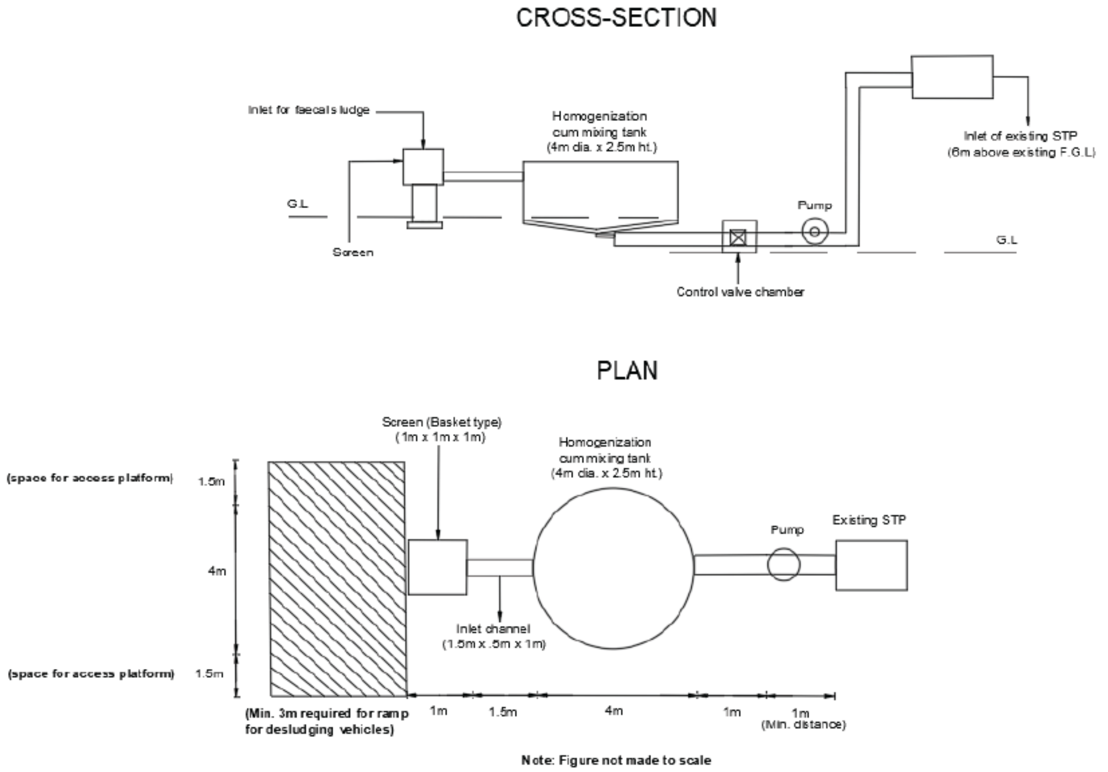


Figure 62: Co-treatment of FSS options at Bharwara STP Lucknow(suitable for larger towns having population more than 1 lakh)

Source: Mainstreaming Co-treatment of Faecal Sludge &Septage (FSS) in STPs in Uttar Pradesh: Co-treatment of FSS options at Bharwara STP Lucknow, Centre for Science and Environment, 2019

The cost estimation of a homogenization and controlled discharge unit of capacity 10 KLD is about Rs 8.0-10.0 lakhs depending upon capacity and land area required would be approximately 60–70 sqm. Approximate O&M cost for the option would be Rs 10,000 per month.

3.5 Cost estimate of Solid liquid separation unit and & O&M cost

The estimated cost estimate and area required for solid liquid separation is tentatively as below for guidance. The solid liquid separation is separately given for two scenarios i.e. (1) where STPs exist (generally large in size) and (2) in smaller towns where STPs doesn't exist.

3.5.1 Solid Liquid Separation option at Existing STP

A representative cost estimate for a Solid–Liquid Separation unit of capacity 10 KLD (for 30,000 population equivalent) is given below for guidance:

S No	Description	Amount (INR Lakhs)
1	1. **Tanker receiving station (with ramp), screening, receiving chamber**	**2.5**
2	2. **Homogenization tank for FS receiving and polymer dozing including civil works for conveyance**	**3.5**
3	3. **Pump-house with sump**	**1.5**
4	4. **Electrification**	**1.5**
	Total	**9.0**

Approximate O&M cost for the option would be Rs 10,500 per month. This would include manpower, power cost for pumping, consumables and periodic repair and maintenance. Break-up shown below:

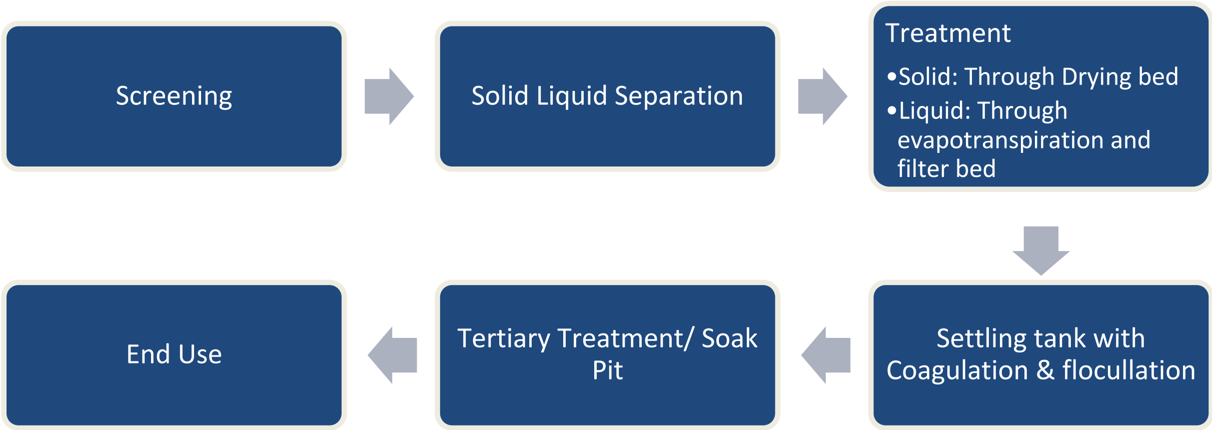
S No	Description	Amount (INR per month)
1	5. **Operator (1/2 workday of unskilled staff @ Rs 400/day)**	**6,000**
2	6. **Power requirement for pumping (@ 8 hrs pumping; Rs 10 per unit)**	**3,000**
3	7. **Periodic Repair & Maintenance (LS)**	**1,500**
	Total	**10,500 (approx..)**

The approximate land area required for this option is 60-80 sqm. However, where larger STPs exist to reduce land requirement mechanized sludge dewatering devices may be used.

3.5.2 Low-cost Gravity based Faecal Septage Treatment Plant for Smaller Towns

The faecal sludge and septage collected can be treated at standalone faecal sludge treatment plants (FSTPs) or co-treated at existing STPs in the vicinity. For the towns where population is less than 20,000, this option as an interim measure till STP is being implemented, can be considered. It is to be noted that, these low cost gravity based FSTP only treats the collected Faecal septage from the Septic tanks. The main operation involved in this process is of solid liquid separation, is described by the following process flow diagram

Process Flow Diagram



The main unit of this energy-saving FSTP is planted drying bed method which dewatering and stabilizes the collected faecal sludge. The bed is filled with filler material, usually with varying sizes of Aggregates ranging from 20mm to 4.75mm. Plants selected for a specific climate grow in the filter media. Dewatered solid sludge is removed every few months to years. Plants are harvested according to their growth cycle.

Drawing- Design of 3/5/8/10 KLD-Decentralised FSTP

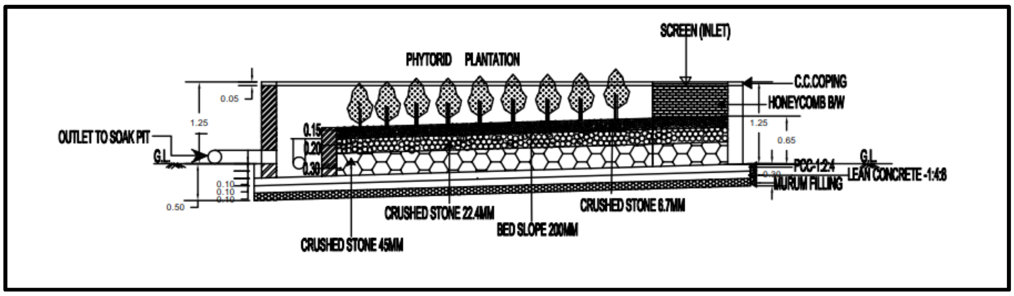


Figure 63: Low cost gravity based FSTP

Costing for Low Cost Gravity based FSTP

S.no	Size of FSTP	Cost of FSTP (in Lakhs)	O&M Cost (in Lakhs per annum)
1	3 KLD	3.50	2.50
2	5 KLD	4.50	3.00
3	8 KLD	5.50	3.50
4	10 KLD	6.50	4.00
5	20 KLD	11.00	4.50
6	100 KLD	25.00	9.00

Note: The derived costing is only for Gravity based FSTP, as per those implemented in Chattisgarh

It is highlighted that the faecal sludge is semi digested and its safe containment, treartment and disposal/ re use can be ensured following above methods economically rather going for high end FSTPs which entail high CAPEX and OPEX.

4 Criteria for selection of technologies

The selection of a particular technology depends upon various parameters – qualitative, quantitative and performance. Of course, any type of synthesis is subject to a degree of uncertainty because of strong influence of the local conditions. The synthesis is presented only to allow a fast comparison and selection between the treatment process, and the values should not be taken as invariable.

Process: The process is to be selected based on required quality of treated water. While treatment costs are important, other factors should also be given due consideration. For instance, effluent quality, process complexity, process reliability, environmental issues and land requirements should be evaluated and weighted against cost considerations. Important considerations for selection of sewage treatment processes are given in Table 31.

Table 32 Sewage treatment process selection considerations

Consideration	Goal
Quality of Treated Sewage	Production of treated water of stipulated quality without interruption
Power requirement	Reduce energy consumption
Land requirement	Minimize cost and constraints in land acquisition
Capital cost of plant	Optimum utilization of capital and financial viability
O&M cost	Low recurring expenditure and financial viability
Maintenance requirement	Simple and reliable
Operator attention	Easy to understand process
Reliability	Consistent delivery of treated sewage
Resource recovery	Production of quality water and manure
Load fluctuations	Withstand variations in organic and hydraulic loads

- **Oxygen requirement:** The choice between aerobic and anaerobic technologies need to consider mainly based on the complexity of the oxygen supply. The supply of large amounts of oxygen by a surface aeration or bubble dispersion system adds to the capital cost of the aeration equipment substantially, as well as, to the running cost because the annual energy consumption is rather high (it can reach 30 kWh per population equivalent (pe).
- **Mechanized:** The choice between mechanized or non-mechanized technologies centers on the locally or nationally available technology infrastructure which may ensure a regular supply of skilled labour, local manufacturing, operational and repair potential for used equipment, and the reliability of supplies (e.g., power, chemicals, spare parts).

Conclusion: Inoverall, the selection process for the most appropriate treatment technology may be decided using multi-criteria analysis involving overall unit costs, the environmental, aesthetic, health risks involved, quality standards, efficiency of removal(as given in Table 33), skilled staff ,land requirements and the reliability of the potential for recovery by the technology. All must be evaluated to give a total score that indicates the feasibility of each technology for a particular country or location to select appropriate one. Comparison of key treatment technology along with critical parameters is given Table 32. Steps involved in project preparation and implementation is also provided in the Figure 71.

Table 33Performance of various treatment technologies along with various parameters for selection of suitable technology

S.no.	Process	Effluent quality	Coliform Removal	Process Reliability	Land Use	Ease of Operation	Ease of Maintenance	Energy recovery	Electrical demand	Capital Cost	Track Record
1	ASP	3	3	4	3	3	3	4	2	2	4
2	EA	4	3	4	2	4	4	1	1	3	3
3	MBBR	4	4	1	3	4	1	2	1	2	3
4	SBR	4	4	3	4	3	3	1	2	2	3
5	UASB	2	2	3	3	2	4	3	2	2	3
6	WSP	2	1	1	1	2	4	1	4	3	2
7	CW	1	1	1	1	3	4	1	4	3	2
8	TF	2	1	2	3	3	3	2	2	3	2

Source: *Guidelines for Decentralized Wastewater Management Prepared by MoUD Centre of Excellence, Indian Institute of Technology Madras – Chennai, India for Ministry of Urban Development, Government of India*

Abbreviations: ASP-Activated Sludge Process; EA- Extended Aeration; MBBR- Moving Bed Bio-Reactor; SBR- Sequencing Batch Reactor; UASB- Up flow Anaerobic Sludge Blanket Reactor; WSP- Waste Stabilisation Pond; CW- Constructed Wetland; TF- Trickling Filter;
Grading for performance: 1- Poor; 2- Average; 3- Good; 4- Very Good

4.1 Comparison of key treatment technologies along critical parameters

Table 34Comparison of key wastewater treatment technologies

Technology	Land requirement	Capital cost	O&M cost	Electricity required.	Effluent Quality	
	Ha/ MLD	INR lakh / MLD	INR lakh / MLD	kWh/ ML treated	BOD, mg/ lit	TSS/ SS, mg/ lit
Nature Based Technologies						
Waste Stabilization Pond (WSP)	0.5 - 1.0	30 –60	0.6 –2.5	negligible	15-50	SS: 75-125
Root Zone Aeration/ Contructed Wetland	0.6-1.5	30-150	1.2-3.0	negligible	20-30	SS: 60-90
Mechanised Treatment Technologies						
Extended Aeration (EA)	0.15 - 0.25	90-200	7.0-12.0	180 - 225	20-30	SS: 50-100
Aerated Lagoon (AL)	0.27 – 0.4	40-60	1.5-3.0	15-20	25-50	SS: 40-150
Sequencing Batch Reactors (SBR)	0.10 - 0.15	150-300	10.0-20.0	150 - 200	<5	TSS< 10
Moving Bed Biofilm Reactor (MBBR)	0.04 - 0.05	170 - 230	8.0-12.0	200 - 250	<10	TSS: <20
Activated Sludge Process (ASP)	0.15 - 0.25	80 - 170	6.0-10.0	180 - 225	20-30	SS: 20-50
Trickling Filter (TF)	0.25-0.50	50-80	2.0-5.0	150-180	25-30	---
Up flow Anaerobic Sludge Blanket (UASB)	0.2 - 0.3	40-60	2.0 -3.5	10.0-15.0	70-100	TSS: 75-100
Onsite treatment Technologies						
Decentralised Treatment System (DTS/DEWATS)	0.13 – 0.14	80 - 200	2.0 – 2.5	negligible	<30	TSS <10

4.2 Steps Involved in Preparation of Projects and Implementation:

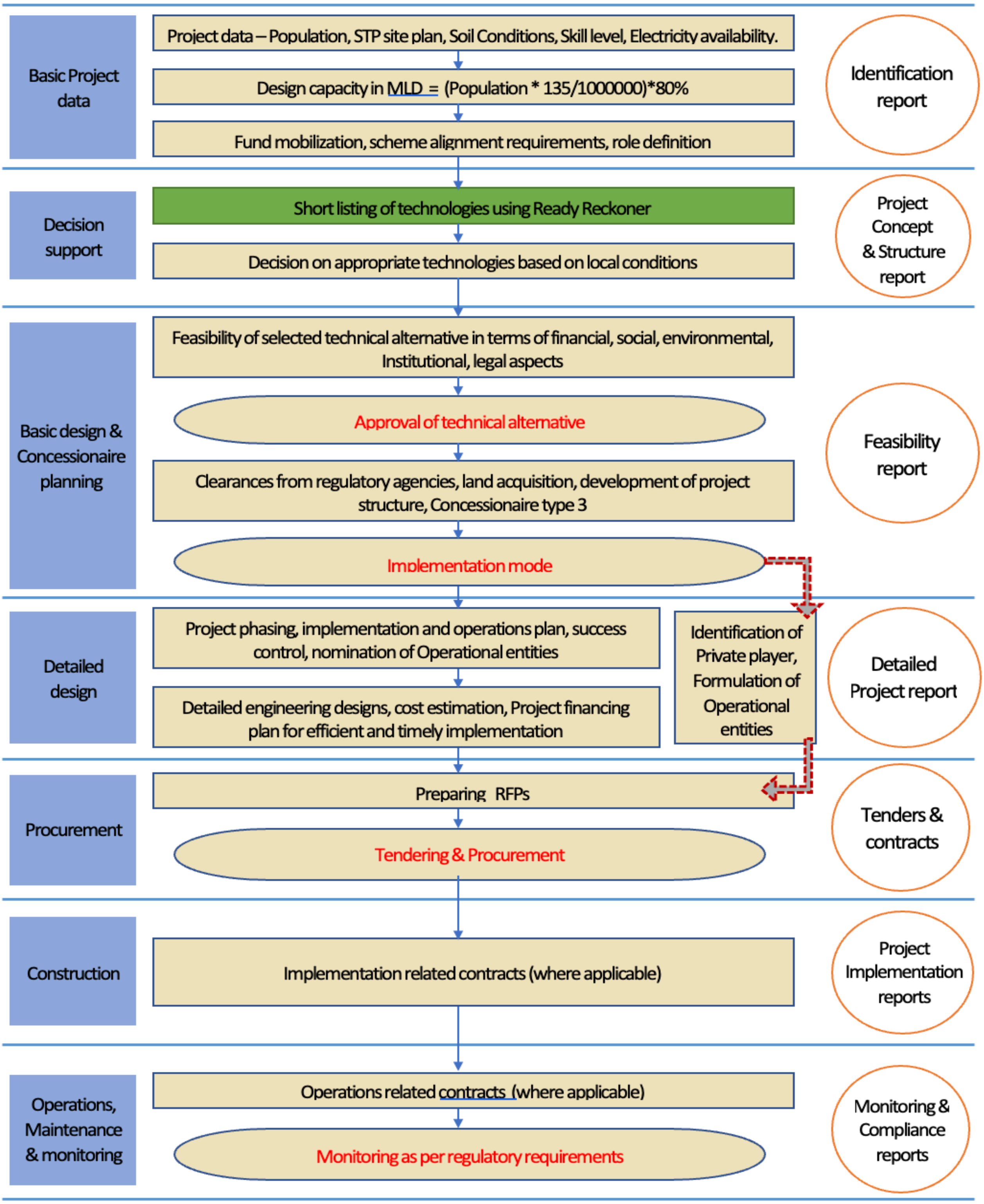


Figure 64: Flow Chart of project preparation and implementation

5 Case Studies

These case studies are compiled after getting information from vendors/plant operators/ULBs. These case studies are for sensitization of ULBs, however, in case State decides to implement any one of them, it is advised to do so in selected one or two cities on pilot basis and depending on performance of technology, the same can be scaled up in other towns.

5.1 Decentralised Wastewater Treatment Systems

1.	Site & Name of town	Mahadevapura lake, Bangalore Owned by BBMP
2.	Name of State	Karnataka
3.	Population served by STP	Approx. 10,000
4.	Capacity of STP	1 MLD
5.	Year of commissioning	2019
6.	Duration of construction	12 months
7.	Land area required	950 sq.m.
8.	Capital cost of the project	₹ 2.5 Crore
9.	O&M arrangement *(In house/Out sourced)*	Outsourced to an NGO which deployed part time resources to manage the treatment system
10.	O&M cost (per KL)	₹0.73 /KL
11.	Recycle & reuse of treated water	Inland surface water disposal
12.	Reuse of treated sludge	Agricultural fields
13.	Description of technology	The wastewater treatment includes primary, secondary and tertiary treatment process, chosen and combined in order to handle the pollution load entering through the selected inlet drain. It also has designed with aim of very low Operation and Maintenance requirements. • **Preliminary treatment**- Screen with grit collection structure with gate for wastewater diversion • **Primary treatment**- Diversion channel with two stages of screening, sedimentation basin and balancing tank • **Secondary treatment** – Integrated Anaerobic Baffle Reactor

		with Anaerobic filters • **Tertiary treatment**- Combination of gabions followed by floating wetlands.
14.	Influent Parameters (BOD, COD, TSS etc)	BOD : 200-250 mg/l COD : 400-500 mg/l TSS: 250-300mg/l TN: 40 mg/l
15.	Outlet Parameters (BOD, COD, TSS etc)	BOD : <20mg/l COD : <100 mg/l TSS: <20 mg/l TN: <20 mg/l
16.	Skill requirement for O&M	Automation of pumps were done, a Part time operator who can clean the screens and check flow is sufficient
17.	Mode of collection of Sewage from Household to the Treatment Facility	Open storm water drain (partially cemented)
18.	Unit Sizing- (including layout map)	Primary treatment: 165sq.m Secondary treatment: 550 sq.m Tertiary treatment: 250sq.m
19.	Remarks	More details can be found in 1. https://cddindia.org/wp-content/uploads/2019/04/Mahadevapura-Factsheet.pdf

Figure 65 Screen with grit collection structure (left) floating wetlands (right)

Figure 66 Aerial View of DEWATS treatment system

5.2 Waste Stabilisation Pond

1.	Site & Name of town	Goniana, Jaito Road,
2.	Name of State	Punjab
3.	Population served by STP	19,147 persons approx.
4.	Capacity of STP	3.00 MLD
5.	Year of Commissioning	2011
6.	Time taken for Construction	1 year
7.	Land area required	4046.86 sq.m
8.	Capital Cost of the Project	₹ 85.95 Lakh
9.	O&M arrangement *(In house/Out sourced)*	Out sourced to contractor maintained by MC Goniana Mandi
10.	Recycle & Reuse of Treated water	Land Irrigation
11.	Reuse of Treated Sludge	Being used as manure, removed on 6 monthly bases.
12.	Description of Technology	Based Stabilization of ponds consisting of Anaerobic ponds, Maturation, and Facultative ponds
13.	Inlet Parameters (BOD, COD, TSS etc)	BOD : 150 to 175mg/l, COD: 250mg/l, TSS 2000 to 2500
14.	Outlet Parameters (BOD, COD, TSS etc)	BOD: ≤30 mg/l, COD : ≤100 mg/l, TSS : ≤50 mg/l
15.	Skill requirement for O&M	Training to maintain the plant.

16.	Mode of collection of Sewage from Household to the Treatment Facility	Existing sewerage network

Figure 67 Aerial view of WSP located in Goniana, Punjab

5.3 Root Zone or Constructed Wetland or Phytorid

1.	Name of town	Bangalore
2.	Name of State	Karnataka
3.	Population served by STP	22000
4.	Capacity of STP	500 KLD
5.	Year of commissioning	March, 2020
6.	Time taken for construction	60 Days
7.	Land area required	2000 sq.m.
8.	Capital cost of the Project	₹1.85 crore
9.	O&M arrangement *In house/Out sourced*	Outsourced

10.	O&M cost (per year)	Total O&M cost –₹13 lakh/year *Detailed breakdown:* Microbes: ₹ 7,10,000 SME/Retainer: ₹ 2,40,000 Power: ₹ 1,20,000 Gardener: ₹ 2,40,000
11.	Recycle &reuse of treated water	Used for gardening.
12.	Reuse of treated Sludge	Anaerobic digestion & partly digested treated within the wetland
13.	Description of technology	Passive Wetland System
14.	Influent Parameters (BOD, COD, TSS etc)	pH: 6.5, BOD: 150 mg/l, COD: 150 mg/l, TSS: 125 mg/l, O&G: <12 mg/l
15.	Effluent Parameters (BOD, COD, TSS etc)	pH: 7.5, BOD: <10 mg/l, COD: <10 mg/l, TSS: <10 mg/l, O&G: <5 mg/l
16.	Skill requirement for O&M	Low level
17.	Mode of collection of Sewage from Household to the Treatment Facility	Through pipes/drains taken to the Screens, holding tank followed by wetlands.
18.	Unit Sizing- (including layout map)	Holding tank: 500 m^2 Wetland: 2000 m^2

Figure 68 Side view of constructed wetland treatment system installed in Hyderabad

5.4 Up-flow Anaerobic Sludge Blanket Reactor

1.	Site & Name of town	Hukumpeta, Rajamahendravaram
2.	Name of State	Andhra Pradesh
3.	Population served by STP	3,43,903
4.	Capacity of STP	30 MLD
5.	Year of commissioning	2010
6.	Duration of construction	5 years
7.	Land area required	113312
8.	Cost of the Project	₹10 Crores
9.	O&M arrangement *In house/Out sourced*	Outsourced
10.	O&M cost (per KL)	₹49.95 lakhs
11.	Recycle &reuse of treated water	Gardening & Horticulture
12.	Reuse of treated sludge	Can be used as manure, removed on 6 monthly bases.
13.	Description of technology	(UASB) Sedimentation separation followed by Anaerobic contact media, Aerobic attached growth process, secondary sedimentation & disinfection.
14.	Influent Parameters (BOD, COD, TSS etc)	pH – 7.34 TDS – 728 TSS – 142 COD – 380 BOD – 124

15.	Effluent Parameters (BOD, COD, TSS etc)	pH – 7.49 TDS – 696 TSS – 18 COD –40 BOD –12
16.	Skill requirement for O&M	Product works automatically; Common service person was given desired training to maintain the plant.
17.	Mode of collection of Sewage from Household to the Treatment Facility	Existing Sewage network
18.	Unit Sizing- (including layout map)	400m x 230m
19.	Description on technical details (A) Design F/M ratio B) Design MLSS C) HRT D) SRT E) Design SOTE	Design MLSS - (attached growth process) **HRT**- Sedimentation Separation: 4 hrs Anaerobic chamber: 4 hrs Disinfection chamber: 3.5 hrs

Figure 69 UASB technology based STP installed in Rajamundry, Andhra Pradesh

5.5 Activated Sludge Process:

1.	Site & Name of town	Yelahanka new town, Bangalore
2.	Name of State	Karnataka
3.	Population served by STP	1.01 Lakh
4.	Capacity of STP	10 MLD (including Tertiary Treatment Plant)
5.	Year of commissioning	2003
6.	Duration of construction	2 years
7.	Land area required	14,771 sq.m
8.	Capital Cost of the Project	₹22.00 Crore
9.	O&M arrangement *In house/Out sourced*	Out sourced
10.	O&M cost	₹5.70/KL
11.	Recycle &reuse of treated water	Reused for sale of treated water to consumers Like BIAL, Airforce, BEL, Prestige, ITC and others for Gardening/landscaping purpose
12.	Reuse of Treated Sludge	Sludge generated are being discharged to Jakkur TTP through pipeline
13.	Description of Technology	Activated sludge process & Biological treatment
14.	Influent Parameters (BOD, COD, TSS etc)	BOD-380: COD-720:TSS-450
15.	Effluent Parameters (BOD, COD, TSS etc)	BOD-≤5: COD-≤50:TSS-≤5 TN-<10
16.	Skill requirement for O&M	Mechanical, electrical and operational aspects
17.	Mode of collection of Sewage from Household to the Treatment Facility	Sewerage network
18.	Description on technical details (A) Design F/M ratio B) Design MLSS C) HRT D) SRT E) Design SOTE	 A) 0.5 B) < 3500 C) 2.5 DAYS D) 5.69 HR E) 10%

Figure 70 Aerial view of Activated Sludge Process based STP in Yelahanka, Bengaluru

5.6 Extended Aeration:

S.no.	Particulars	Details
1.	Site & Name of town	Lalbagh STP, Bangalore
2.	Name of State	Karnataka
3.	Population served by STP	11,112
4.	Capacity of STP	1.5 MLD (1500 M3/Day)
5.	Year of commissioning	2003
6.	Duration of construction period	2 Years
7.	Land area required	2.4 acres
8.	Capital cost of the Project	₹3 Crore
9.	O&M arrangement *In house/Out sourced*	 Out Sourced
10.	O&M cost	₹15/ KL

11.	Recycle &reuse of treated water	Plant Domestic purpose, gardening, Construction etc
12.	Reuse of treated Sludge	Horticulture department and local farmers
13.	Description of technology	Extended aeration followed by tube settling and UV disinfection
14.	Influent parameters (BOD, COD, TSS etc.)	BOD: 330 mg/l, COD: 660 mg/l, TSS: 450mg/l, pH: 7-8
15.	Effluent parameters (BOD, COD, TSS etc.)	BOD: <5 mg/l, TSS: <5mg/l, Turbidity: <3NTU, pH:6.5-7.5
16.	Skill requirement for O&M	6 (Manager, Engineer, Chemist, Skilled operators for Membrane)
17.	Mode of collection of Sewage from Household to the Treatment Facility	Sewerage network
18.	Description on technical details A) Design F/M ratio B) Design MLSS C) HRT D) SRT E) Design SOTE	 A) 0.1 Based on MLSS B) 3000- 4000 mg/l C)22 Hours D) 14 days E) 130 Kg/h

Figure 71 Snapshots of treatment plant, Cubbon park, Bengaluru

5.7 Sequencing Batch Reactor

1.	Site & Name of town	Jetpur STP, Taluka-Jetpur, Dist Rajkot
2.	Name of State	Gujarat
3.	Population served by STP	1,29,653
4.	Capacity of STP	23.50 MLD
5.	Year of commissioning	2021
6.	Duration of construction	51 Months
7.	Land area required	9100 m2
8.	Capital cost of the project	₹30.10 Crore
9.	O&M arrangement *(In house/Out sourced)*	Out sourced to implementing agency for 5 years under same contract
10.	O&M cost (per KL)	₹2.00
11.	Recycle & reuse of treated water	Currently reuse of treated wastewater is not practiced. Discharged into Bhadar River.
12.	Description of technology	SBR Technology. In this technology, all process i.e. filling, aeration, settling and decanting are performed in one tank which saves the foot print.
13.	Influent Parameters (BOD, COD, TSS etc)	BOD-250 mg/l COD- 475 mg/l; TSS- 350 mg/l
14.	Outlet Parameters (BOD, COD, TSS etc)	BOD- less than 10; COD- Less than 50; TSS- less than 10
15.	Mode of collection of Sewage from Household to the Treatment Facility	Underground drainage network
16.	Description on technical details (A) Design F/M ratio B) Design MLSS C) HRT D) SRT E) Design SOTE	 A) 0.135 B) 4500 mg/L C) 14.65 Hrs D) 12.7 Day E) 20%

Figure 72 Aerial view of SBR treatment system installed in Jetpur, Gujarat

5.8 Johkasou

S.no.	Particulars	Details
1.	Name of the Site	Jahapnah City Forest Park, Chirag Delhi
2.	Name of State	NCT of Delhi
3.	Capacity of STP	100 KLD
4.	Year of commissioning	2021
5.	Duration of construction	4 months
6.	Land area required	70 m2 approx.
7.	Capital cost of the project	₹33.00 lakhs
8.	O&M arrangement *In house/Out sourced*	Part of Contractor Scope (by M/s Jai Maa Associates), It is EPC+O&M Contract
9.	O&M cost (per year)	Contract has many other items so please refer to the O&M Sheet for Johkasou O&M Cost.
10.	Recycle &reuse of treated water	Treated water is used in horticulture replacing borewell water as per NGT order
11.	Reuse of treated sludge	Can be used as manure
12.	Description of technology	Sedimentation and separation of settleable & floating solids, followed by anaerobic filter & MBBR attached growth aerobic process and finally sedimentation, disinfection and filtration (Johkasou

		Technology)
13.	Influent parameters (BOD, COD, TSS etc.)	BOD: 290 ppm, COD: 400 ppm, TSS: 245 ppm, O & G: 52 ppm, pH: 6.5
14.	Effluent Parameters (BOD, COD, TSS etc.)	BOD: 20 ppm, COD: 48 ppm, TSS: 18 ppm, O & G: 5 ppm, pH: 7.8
15.	Skill requirement for O&M	Semi-skilled person with few weeks of training can handle
16.	Mode of collection of Sewage from Household to the Treatment Facility	Sewage is collected from municipal drain/well by submersible pump
17.	Unit Sizing	11 x 6 meter approx. for treatment area + 10 m2 for Blower and Panel

Figure 73 Pre-fabricated Johkasou treatment unit installed in New Delhi

5.9 Other Methods

There are other options developed/under development in the country, which can be considered where there is land constraint. Although, these options have high OPEX in comparison to above mentioned options, but many of such methods (some of them are patented as well) are being used independently or in combination with other treatment systems in domestic market which provides desired level of effluent.

Since performance of these technologies varies in handling sewage from medium and small towns, therefore, the States are advised to select one or two suitable technologies on pilot basis and on successful testing the results, can go ahead for replicating in other towns. Cases of a few of such methods are presented below.

5.9.1 Container based or Packaged Treatment Systems

1.	**Site & Name of town**	**Residential quarters, Wazirabad Water Works, Delhi Jal Board**
2.	Name of State	Delhi
3.	Population served by STP	700 + 100 = 800 people
4.	Nature &Capacity of STP	200 KLD (MBBR based containerized STP)
5.	Year of commissioning	February 2022
6.	Duration of construction	Prefabricated, Compact STP
7.	Land area required	70 Sqm
8.	Capital cost of the project	₹ 95.00 Lakhs
9.	O&M arrangement *(In house/Outsourced)*	In house
10.	O&M cost (per KL)	₹ 8 per KL
11.	Recycle & reuse of treated water	Reuse in flushing and horticulture
12.	Reuse of treated sludge	As fertilizer in city parks
13.	Description of technology	Prefabricated, Decentralized, Mobile, Compact & Shipping Containerized wastewater treatment system with Dual technology and customized design and application, delivered at door step for treatment and conservation with Aerobic, Anaerobic and Anoxic method, which can be easily customized according to the availability of space and contaminated discharged water quality.

		Advanced Oxidation Process based on Moving Bed Bio-reactors with Multi Stage Reactors. Primary Treatment – Secondary Treatment & Tertiary Treatment
14.	Influent Parameters (BOD, COD, TSS etc)	46mg/l, 168mg/l, 8.8mg/l
15.	Effluent Parameters (BOD, COD, TSS etc)	3mg/l,12 mg/l,<5 mg/l
16.	Skill requirement for O&M	Semi-Skilled (Plumbing, Electrical)
17.	Mode of collection of Sewage from Household to the Treatment Facility	Sewerage Pipeline to Equalization Tank
18.	Unit Sizing	One Unit 40x8x8.5 – 320 Sq/ft x 2 = 640 Sq/ft

Figure 74 Package sewage treatment plant installed in a residential complex in New Delhi

5.9.2 IN-SITU BIOREMEDIATION-BASED ISR MODULAR STP

In-line drain treatment such as *'In-situ bioremediation-based ISR modular STP'* is designed to function on "the principles of Bioremediation" at 3-stage operations, namely, primary, secondary, and tertiary wastewater treatment in the drain. Following are the features of this option.

- This modular-based ISR treatment plant can be installed on drains; this space and reduces the land requirement.
- This technology is effective in continuing the wastewater treatment via advanced Bioremediation techniques on downstream water bodies and producing minimal sludge generation.
- This modular-based ISR STP can be rapidly installed (30 – 45 days) and requires minimal space (100 – 250 sq. m.) than conventional technologies.

S.no.	Particulars	Details
1.	Site & Name of town	Mankameshwar Ghat, Lucknow
2.	Name of State	Uttar Pradesh
3.	Population (2011)	17,500
4.	Population served by STP	30,000
5.	Capacity of STP	2.5 MLD
6.	Year of commissioning	2019
7.	Duration of construction period	3 months
8.	Land area required	250 sq.m
9.	Capital cost of the Project	4.5 Cr.
10.	O&M arrangement *In house/Out sourced*	In house
11.	O&M cost	Rs. 2.29 Cr. for five years (Inclusive of consumables and repairs) (Rs. 5.6/KL)
12.	Recycle & reuse of treated water	Reuse of treated water for secondary purposes, road cleaning, vehicle washing, construction activities, and gardening.
13.	Reuse of treated Sludge	Reuse of treated sludge as soil conditioner/manure for gardening.
14.	Influent parameters (BOD, COD, TSS etc.)	BOD: 250, COD: 400, TSS: 300, TN:45, TP:5, FC:>1000
15.	Effluent parameters (BOD, COD, TSS etc.)	BOD: <20, COD: <30, TSS: <20, TN:<15, TP:<1, FC:<1000
16.	Skill requirement for O&M	Manpower – 1 technician + 3 shift operator
17.	Mode of collection of Sewage from Household to the Treatment Facility	Open Drain (Ganda Nallah)
18.	Description of technical details A) Design F/M ratio B) Design MLSS C) HRT D) SRT E) Design SOTE	 0.1 gBOD/gMLVSS/d 3000 mg/L 2 hours 20 days 25%

Bioremediation mediated ISR modular STP, Lucknow

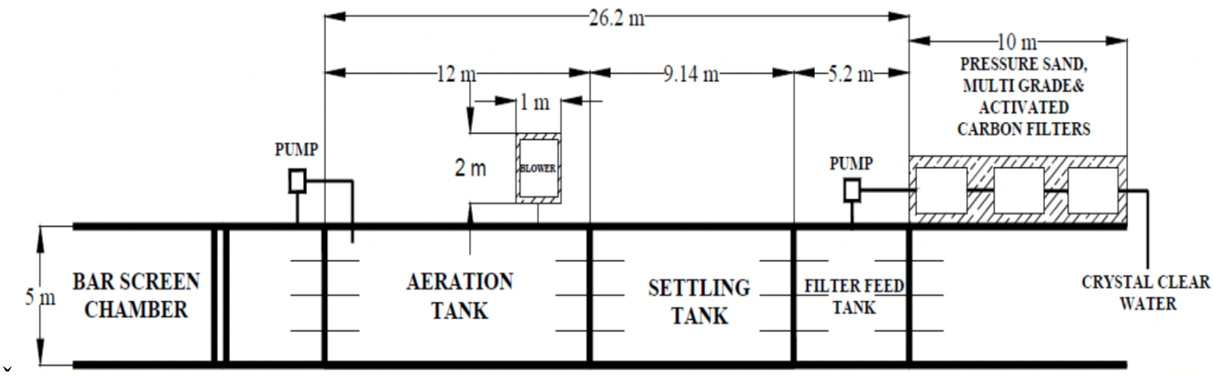


Figure 75 Units and Process diagram of the treatment facility in drain

5.9.3 TIGER BIO-FILTER BASED STP

1000 KLD Capacity Sewage Treatment Plant based on Tiger Biofilter Technology at Poona Golf Club, Yerawada, Pune		
1.	Site & Name of town	Poona Golf Club, Yerawada, Pune
2.	Name of State	Maharashtra, India
3.	Population *2011 Census* *Current Population*	Pune City As per 2011- 31,24,458 As per 2021- Approximate 45,00,000
4.	Population served by STP	As per 2011 Census- 10,000
5.	Capacity of STP	1000 KLD or 1000 Cum/Day
6.	Year of commissioning	March 2022
7.	Duration of construction	6 Months
8.	Land area required	1800 SqM.
9.	Capital cost of the project	1,75,70,000/-
10.	O&M arrangement *(In house / Out sourced)*	In House
11.	O&M cost (per KL)	Rs. 3.42 per KL
12.	Recycle & reuse of treated water	Treated Water is used for Gardening and irrigation purpose. Currently treated Water is used to irrigate 100 Acres of Golf Club Greens.
13.	Reuse of treated sludge	No sludge generation. Vermicompost is generated as a byproduct and is it used as compost in garden area.
14.	Description of technology	The system comprises of a Screen Chamber, Grit chamber, raw sewage sump and a Tiger Bio filter unit followed by optional tertiary treatment. The system configuration can be altered depending upon end use of treated sewage. The screened and degrited raw sewage is pumped and allowed to pass through specially designed Tiger Bio filter bed. The bed consists of various layers of filter material along with Tiger worms and bacterial culture. It forms ecology to treat the wastewater aerobically.
15.	Influent Parameters (BOD, COD, TSS etc)	• pH- 7.0-8.5 • BOD_5 @ 20^0C- 250 mg / liter (Max.) • COD- 400 mg / liter (Max.)

		• TSS- 200 mg / liter (Max.)
16.	Outlet Parameters (BOD, COD, TSS etc)	• pH- 6.0-8.5 • BOD_5 @ 20^0C- <10 mg / liter • COD- <50 mg / liter • TSS- <20 mg / liter • Color- Unobjectionable
17.	Skill requirement for O&M	Unskilled labor can operate the Plant by operating only TBF flow distribution network
18.	Mode of collection of Sewage from Household to the Treatment Facility	The sewage is tapped from the existing trunk sewage line of Pune Municipal Corporation. All collected wastewater is diverted and receiving at inlet of the Screen Chamber of STP by Conveyance System.
19.	Description on technical details (A) Design F/M ratio B) Design MLSS C) HRT D) SRT E) Design SOTE	The Technology employs different design parameters than conventional activated sludge process. Following design parameters are used • Surface Loading Rate for TBF Beds- 1.5-2.0 Cum / Sqm / Day • Organic (BOD) Removal Rate- 0.50 KG BOD / KG Tiger Worms • HRT for Raw Sewage Sump- 4-8 Hrs • HRT for TBF Beds- 15-30 Minutes

Photographs

Screen Chamber and Intermediate Sump

Screen and Grit Chamber, Raw Sewage Sump

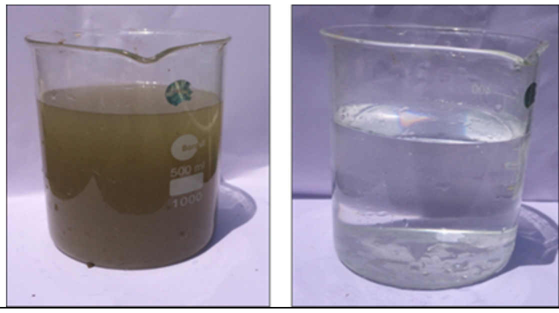
	
Tiger Bio Filter Beds-Sprinkling water	Tiger Bio Filter Beds-Sprinkling water
	
Filter Feed Tank with PSF and ACF Units	Raw Water and Treated Water Sample

Figure 76 Treatment units of Tiger Biofilter treatment facility

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