



INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT DESIGN MODULE

PART A: PRESENTATION SLIDES



TITLE

Integrated Wastewater and Septage Management – Design Module (Part A: Presentation Slides)

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CONTENT

The module has been developed with the collaborative effort of NFSSMA partner organisations under Training Module Review Committee (TMRC) anchored by NIUA

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INTEGRATED WASTEWATER & SEPTAGE MANAGEMENT DESIGN MODULE

PART A: PRESENTATION SLIDES

Collaborative Effort Under Training Module Review Committee (TMRC)



Foreword

Acknowledgements

ABOUT NATIONAL FAECAL SLUDGE AND SEPTAGE MANAGEMENT ALLIANCE (NFSSMA)

The 'NFSSM Alliance' was formed with a vision to “Create an enabling environment which amplifies scaling of safe, sustainable and inclusive FSSM through knowledge, partnerships and innovative solutions by 2024.”

Convened by Bill and Melinda Gates Foundation in 2016, the Alliance is a voluntary body that aims to:

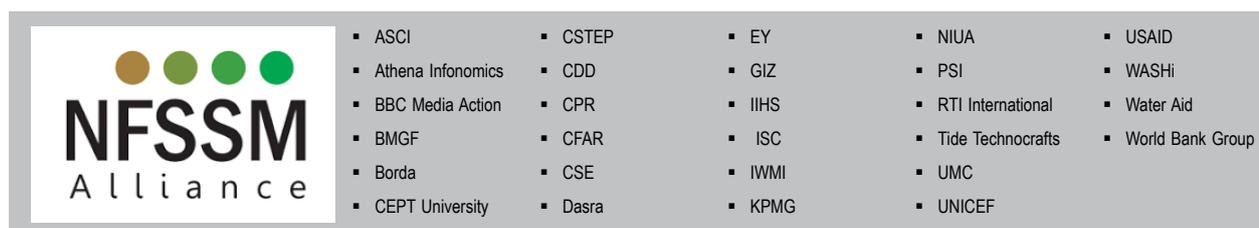
- Build consensus and drive the discourse on FSSM at a policy level, and
- Promote peer learning among members to achieve synergies for scaled implementation and reduce duplication of efforts

The Alliance currently comprises 28 organizations across the country working towards solutions for Indian states and cities. The Alliance works in close collaboration with the Ministry of Housing and Urban Affairs (MoHUA) and several state and city governments through its members to support the progress and derive actions towards mainstreaming of FSSM at state and national level. The NFSSM Alliance works on all aspects of city sanitation plans to regulatory and institutional frameworks across the sanitation value chain. The NFSSM Alliance working in collaboration with the Ministry of Housing and Urban Affairs has been instrumental in the passage of India's First Policy on FSSM launched in 2017. This resulted in 19 out of 36 states adopting guidelines and policies for FSSM in India.

The strength of the Alliance lies in its diverse membership, which includes research institutes, academic institutions, think-tanks, quasi-government bodies, implementing organizations data experts, consultants and intermediaries. This enabled a multi-disciplinary view of urban sanitation, with members building on each other's expertise. The alliance has had enormous success in championing FSSM as a viable solution to the Government of India by broadly focussing on:

1. Influencing and informing Policy
2. Demonstrating Success through innovation and pilots
3. Building Capacities of key stakeholders across the value chain

The collaborative effort continues to work towards promoting the FSSM agenda through policy recommendations and sharing best practices which are inclusive, comprehensive, and have buy-in from several stakeholders in the sector.



ABOUT TRAINING MODULE REVIEW COMMITTEE (TMRC)

To ensure quality control in content and delivery of trainings and capacity building efforts, a **Training Module Review Committee (TMRC)** was formed with the collaborative effort of all Alliance partners. TMRC which is **anchored by National Institute of Urban Affairs (NIUA)**, has the following broad objectives:

- Identification of priority stakeholders and accordingly training modules for Capacity Building
- Development of a Normative Framework – For Capacity Building at State Level
- Standardization of priority training modules – appropriate standardization of content with flexibility for customization based on State context
- Quality Control of Trainings – criteria for ensuring minimum quality of training content and delivery
- Strategy for measuring impact of trainings and capacity building efforts

ABOUT THE TRAINING MODULE

Title	Integrated Wastewater and Septage Management - Design Module
Purpose	<p>The Government of India has made sanitation its priority through the launch of Swachh Bharat Mission. SBM-U 2.0 goes beyond eliminating open defecation in cities, to focus on planning sanitation systems at city-level, through integrated wastewater and septage management targeted at recycle and reuse.</p> <p>Further, the recently announced Atal Mission for Rejuvenation and Urban Transformation (AMRUT 2.0) lays emphasis on creating a circular economy of water by ensuring treatment and reuse of wastewater and faecal sludge. This Module provides participants a holistic understanding of designing of wastewater and septage management solutions, to address the above mentioned priorities under these national missions.</p>
Target Audience	Officials with engineering background and professional experience in wastewater and septage management such as technical faculties from nodal training institutes, technical officials/ engineers from state govt, parastatal bodies and ULBs; consultants from TSU/ PMUs and sector partners.
Learning Objective	<ol style="list-style-type: none"> 1. Understand priorities under various national urban missions for wastewater and septage management to address aspects of circular economy. 2. Gain in-depth knowledge about sanitation systems and to understand the concept and principles of citywide inclusive sanitation. 3. Get hands-on experience in designing wastewater and septage treatment solutions. 4. To leverage various funding avenues and understand contracting mechanisms at city level. 5. Comprehend the aspects of IWSM, such as O&M and sustainability, occupational safety, public awareness and participation.
Structure of the Module	<p>The training is based on Case Method and includes an exercise which will enable the participants to improve analytical skills required to develop wastewater and septage management plans. It also includes a financial modelling tool which helps to calculate Life Cycle Cost of the project using different approaches of waste management.</p> <p>Case studies to demonstrate the learning from the module will be showcased through expert's lecture and handouts. This helps to trainee to apply the knowledge grasped during the session and reinforce it further.</p>
Duration	In a face-to-face training format, this training is conceptualized for two days without site visits and can be adopted for including the site visits depending upon the city where it is being conducted.

INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT (IWSM)

Advanced Training Module

AGENDA

Time Duration (Hours)	Session Title
Day 1	
9.30 - 10.00	Registration
10.00 - 10.30	Introduction, Setting ground rules, Understanding Expectation, Aims and Objectives of the training
10.30 - 11.15	Introduction to Integrated Wastewater and Septage Management
11.15 - 11.30	Tea & Coffee Break
11.30 - 12.15	Missions and Programs - Journey of Urban Sanitation in India
12.15 - 12.30	Swachh Bharat Mission 2.0
12.30 - 13.15	Planning Approaches for IWSM
13.15 - 14.00	Lunch Break
14.00 - 14.45	Baseline Surveys and Assessment
14.45 - 15.15	Exercise: Data Collection
15.15 - 16.00	Design Aspects
16.00 - 16.15	Tea & Coffee Break
16.15 - 16.45	Exercise: Population Projection
16.45 - 17.00	Wrap up

Time Duration (Hours)	Session Title
Day 2	
9.30 - 10.15	Recap, Feedback & Quiz
10.15 - 11.00	Collection & Conveyance System
11.00 - 11.30	Exercise: CapEx and OpEx of collection and conveyance system
11.30 - 11.45	Tea & Coffee Break
11.45 - 12.30	Wastewater Treatment
12.30 - 13.00	Exercise: CapEx and OpEx of wastewater treatment
13.00 - 14.00	Lunch Break
14.00 - 15.00	Project Management
15.00 - 15.45	Exercise: Financial Modelling
15.45 - 16.00	Tea & Coffee Break
16.00 - 16.45	O&M & Sustainability
16.45 - 17.30	Feedback and Wrap-up

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Session

01

Introduction to Integrated Wastewater & Septage Management

1. Introduction to Integrated Wastewater & Septage Management

Learning objectives

- To understand the basics of environmental sanitation and concept of natural and built environment
- To understand the point source and non point sources of water pollution
- To understand the waste products and their characteristics

Contents

- Environmental Sanitation
- Natural & Built Environment
- Sources of Water Pollution
- Waste products & it's characteristics

1.1 Environmental Sanitation

Sanitation

It is understood as the provision of facilities and services for the safe disposal/reuse of human excreta and wastewater



Infrastructure
(IHHT | CT | PT)



Regulations
for Safe Management



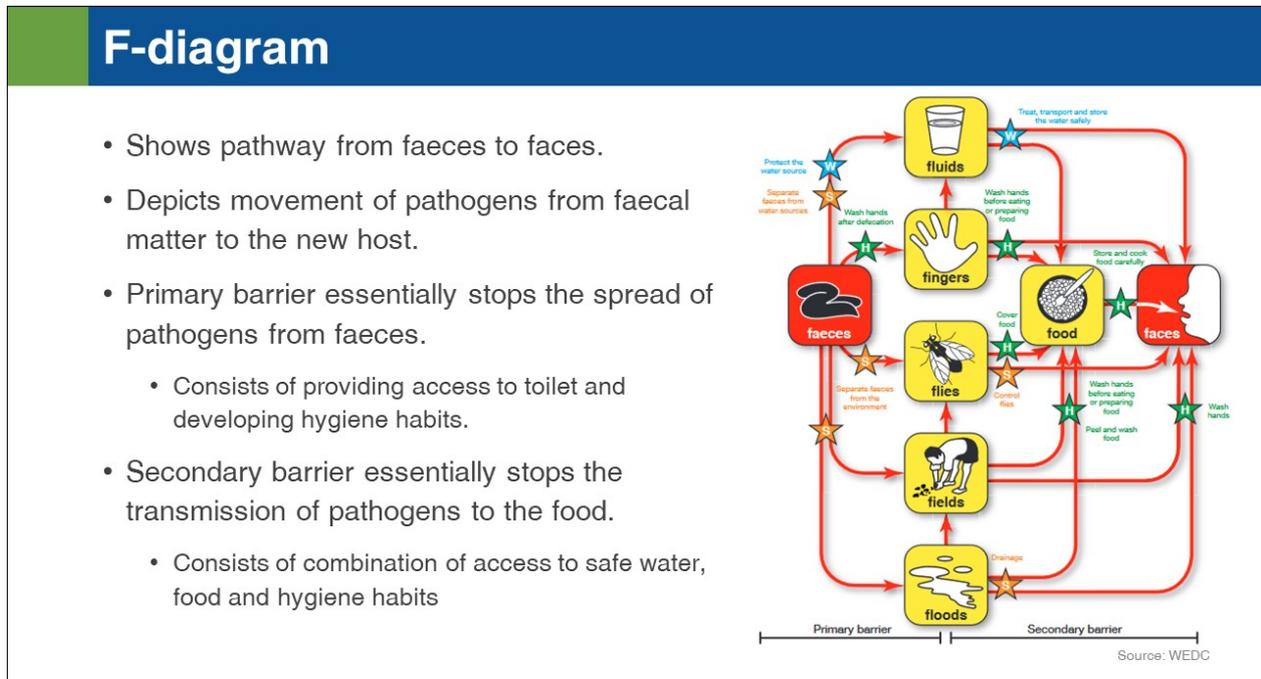
Personal Hygiene
Habits

Objectives

- To reduce faecal-oral disease transmission
- Potential reuse, safe disposal of human excreta or discharge of wastewater after treatment

Sanitation is defined in many ways; however, all the definitions are closely associated with public health and revolves around access to safe and adequate drinking water along with safe management of human excreta and wastewater.

In this module, our focus is mainly on the safe management of human excreta and wastewater. Sanitation includes both the ‘hardware’ (e.g., Toilets and sewers) and the ‘software’ (regulation, hygiene promotion) needed to reduce faecal-oral disease transmission. The second objective is to check the viability of potential reuse, safe disposal of treated end products.



Most diseases associated with water supply and sanitation, such as diarrhoea, are spread by pathogens found in human excreta. The faecal-oral mechanism, in which faecal pathogens from an infected individual are transmitted to the mouth of a new host through one of a variety of routes, is by far the most significant transmission mechanism. This mechanism works through a variety of routes, as shown in the F Diagram.”

Primary interventions with the most significant impact on health often relate to the management of faeces at the household level. This is because: (a) a large percentage of hygiene-related activity takes place in or close to the home, and (b) first steps to improving hygienic practices are often easiest to implement at the household level.

Secondary barriers are hygiene practices preventing faecal pathogens, which have entered the environment via stools or on hands, from multiplying and reaching new hosts. Secondary barriers thus include washing hands before preparing food or eating, and preparing, cooking, storing, and re-heating food in such a way as to avoid pathogen survival and multiplication.

Environmental Sanitation

Aims at contributing **social development** by improving the **quality of life** of individuals

Components of Environmental Sanitation



Solid & Liquid
Waste Management



Disease Vector
Control



Infrastructure for
Hygiene Practices



Behaviour &
Habit

Environmental sanitation aims at improving the quality of life of individuals and at contributing to social development. This includes safe disposal or appropriate management of solid and liquid waste, control of disease vectors (such as flies, mosquitoes) and provision of washing facilities (such as hand wash basins and bathrooms) for personal and domestic hygiene. Environmental sanitation comprises both behaviour and facilities to form a hygienic environment.

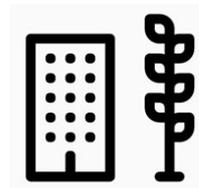
1.2 Natural and Built Environment

What is Natural and Built Environment?



That part of nature which remains untouched by human hand is known as **Natural Environment**

Eg.: Plants, air, river, animals, etc.



Anything that has been created by human beings within the natural environment is known as **Built Environment**

Eg.: Cities, houses, bridges, railways, roads etc.

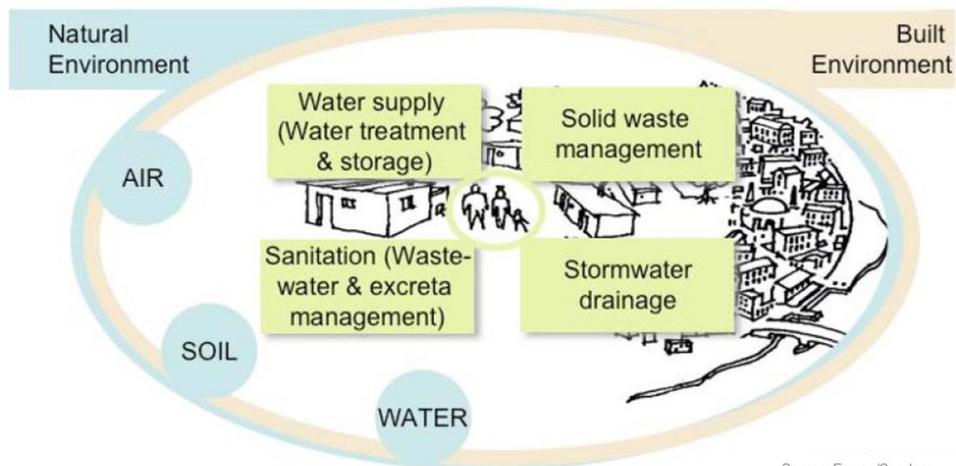
Natural and Built Environment



Source: Eawag Sandec Training Tool 1.0

The natural and built environment with its natural resources water, air and soil (blue); all services and facilities required to keep the environment clean and protect health (green). WASH focuses on water supply and environmental sanitation services, facilities and human behaviour (inside yellow line).

Environmental Health



Source: Eawag/Sandec

The water supply and environmental sanitation systems provide barriers between pollutants, the natural and built environment, and humans. The waste and resource sub-systems of water and environmental sanitation (green); the natural environment (blue); the built environment (brown).

1.3 Sources Of Water Pollution

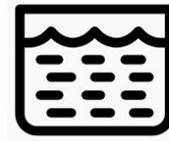
Sources of Water Pollution

Water is polluted by both **natural** as well as **man-made** activities

Sources of Water Pollution



Point Source
Pollution



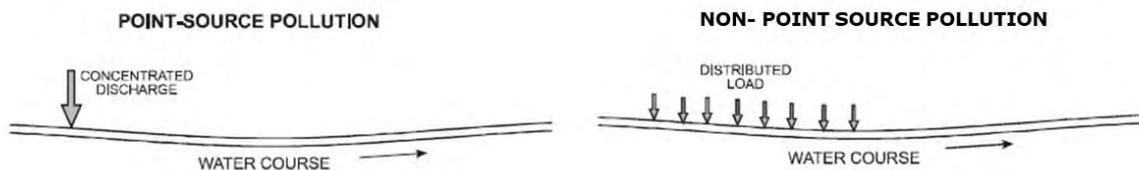
Non-point Source
Pollution

Water pollution refers to addition of unwanted matter into the water body which results in alteration of its state. Usually, addition of organic and inorganic pollutants in the natural water body results in decrease of dissolved oxygen level. The source of pollution in urbanized areas are many; however, they can be broadly classified into two – (a) point source of pollution and (b) non point source of pollution.

Point Source & Non-Point Source Pollution

In **Point-source Pollution**, the pollutants reach the water body in points concentrated in space.

In **Non-point source Pollution**, the pollutants enter the water body distributed at various locations along its length.



Point source pollution means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. E.g., includes discharge pipes, drainage ditches, Industrial discharges etc. (Source: USEPA Manual).

Non-point source pollution is the opposite of point-source pollution, with pollutants released in a wide area. E.g., rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters (Source: USEPA Manual). The discharge of urban runoff or agricultural runoff from the farmlands into the water body is considered as a non-point source of pollution. (Source: Wastewater characteristics, treatment and disposal- Marcus von sperling. Page- 8)



Examples of point and non-point source of pollution:

Point Source: The picture shows an open drain carrying wastewater from the houses and tanneries in the city of Kanpur to the River Ganga.

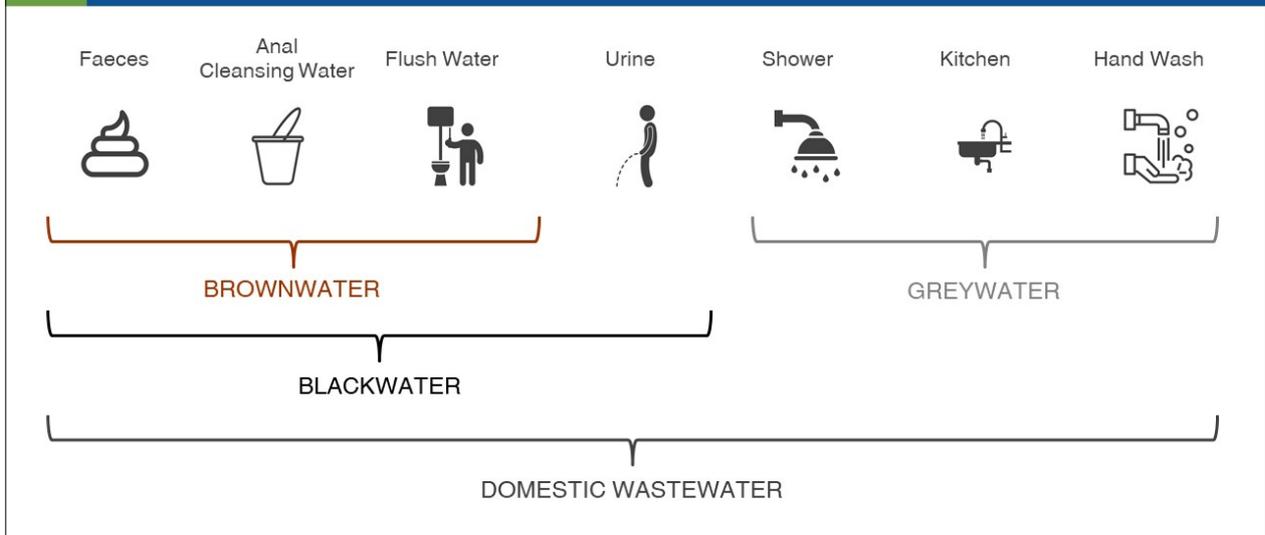
Non-Point Source: The illustration shows surface runoff from farmlands, agriculture, construction sites and urban pavement leading to river body at multiple places.

1.4 Waste Products and characteristics

Different kinds of household practices and human waste can lead to different types of wastewater. Brown water refers to the mixture of faeces, anal cleansing water and flush water. This is usually encountered in case of urine diversion toilets. When urine is mixed with the brown water, it is called as black water. Due to the addition of urine, the wastewater now contains adequate amounts of nutrients (N and P) to trigger the digestion of organic constituents by the bacteria already present in the waste. This process eventually turns the brown color of the wastewater to black.

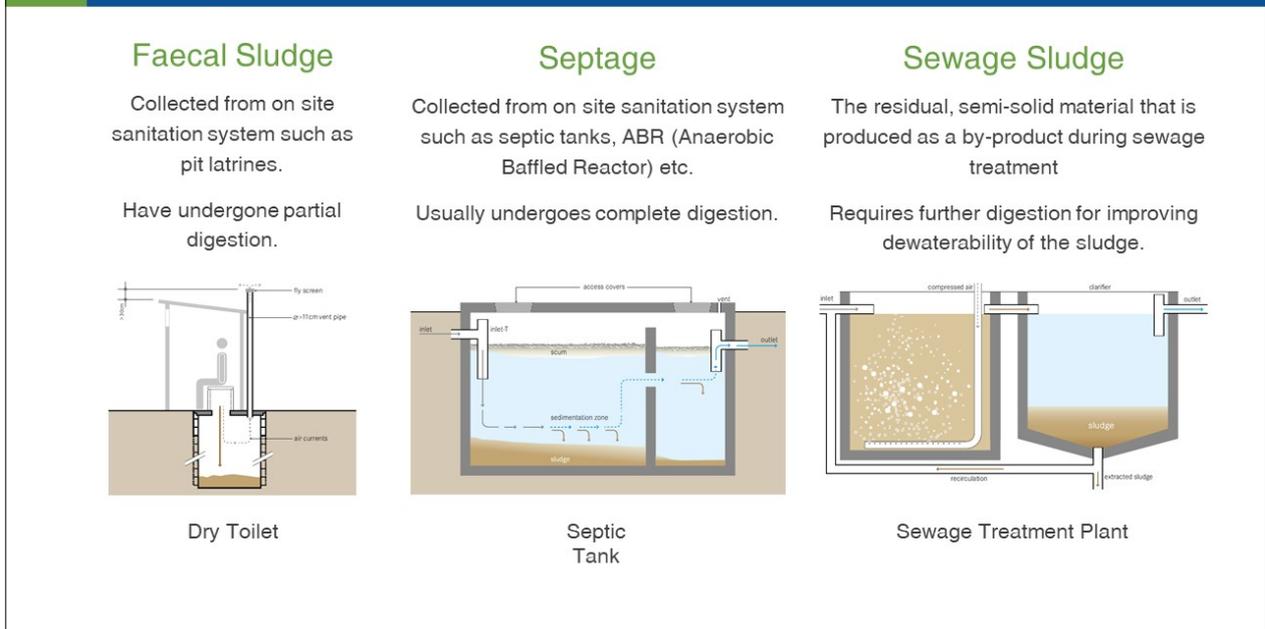
Grey water refers to the water coming from bathrooms and kitchen. The mixture of blackwater and greywater is known as domestic wastewater or sewage.

Waste products



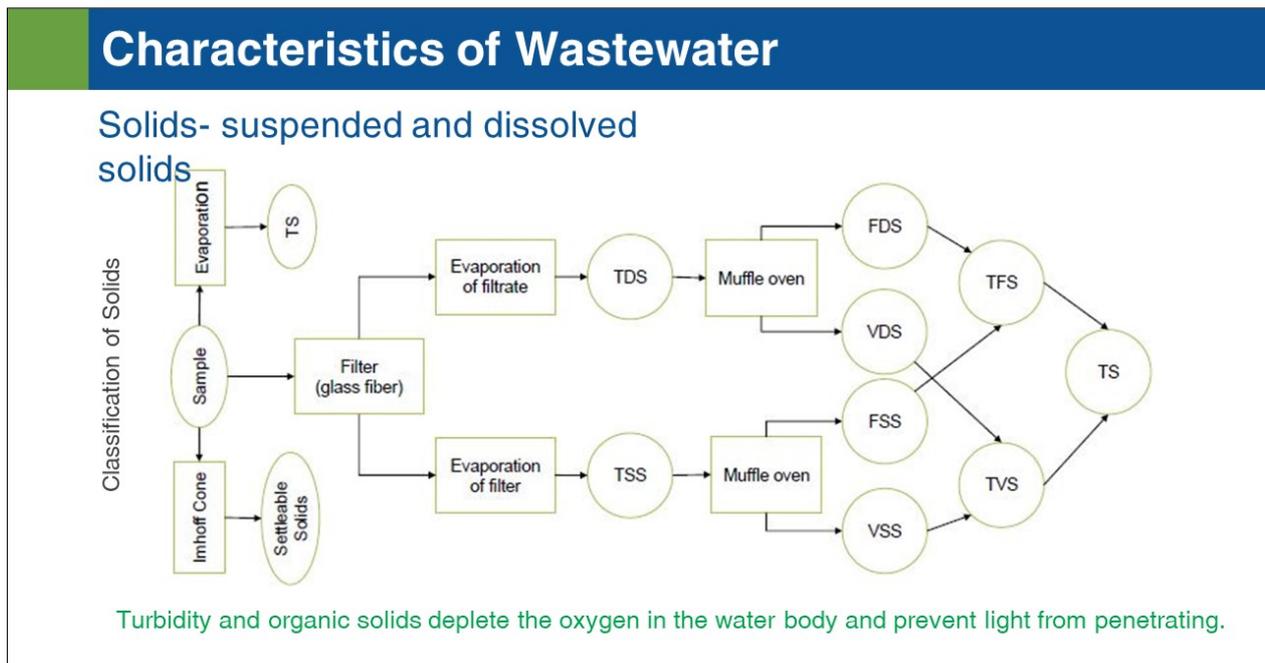
Faecal sludge is the partially digested sludge mainly from the lined pits such as single pit latrines. Septage refers to the digested sludge contained in a septic tank for over a year. It mainly contains the digested sludge from the bottom of the tank, the wastewater and the scum (layer of Fat, Oil and Grease) on the top of wastewater. Sewage sludge refers to the sludge obtained during primary and secondary stage treatment of sewage at a Sewage Treatment Plant. Depending upon the type of treatment unit, this sludge may require further treatment before disposal or reuse.

Sludge



Total suspended solids are those solids that do not pass through a 0.2-um filter. About 70% of those solids are organic, and 30% are inorganic. The inorganic fraction is mostly sand and grit that settles to form an inorganic sludge layer. Total suspended solids comprise both settleable solids and colloidal solids. Settleable solids will settle in an Imhoff cone within one hour, while colloidal solids (which are not dissolved) will not settle in this period. Suspended solids are easily removed

through settling and/or filtration. However, if untreated wastewater with a high suspended solids content is discharged into the environment, turbidity and the organic content of the solids can deplete oxygen from the receiving water body and prevent light from penetrating.



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Characteristics of Wastewater

Organic Constituents

- Heterogeneous mixture of various organic compounds
- BOD: Biological Oxygen Demand
- COD: Chemical Oxygen Demand
- Biodegradable organics: proteins, carbohydrates and fats.
- BOD signifies approximate amount of oxygen required to stabilise the organic matter.

Used to design treatment units, measure efficiency of the processes, evaluate compliance with the discharge standards.

Parameter	Septage [mg/L]	Sewage [mg/L]	Septage : Sewage
BOD	7000	220	32:1
COD	15000	500	30:1
COD : BOD	5 - 10	2	

Source: Linda et. Al; Faecal Sludge Management- System Approach and Implementation and US EPA Handbook on Septage Treatment & Disposal

Biodegradable organics are composed mainly of proteins, carbohydrates and fats. If discharged untreated into the environment, their biological stabilisation can lead to the depletion of natural oxygen and development of septic conditions. BOD test results can be used to assess the approximate quantity of oxygen required for biological stabilisation of the organic matter present, which in turn, can be used to determine the size of wastewater treatment facilities, to measure the efficiency of some treatment processes and to evaluate compliance with wastewater discharge permits.

This slide shows the strength of septage and sewage and provides us with a ratio to understand how concentrated septage can be when compared to sewage.

Characteristics of Wastewater

Nutrients

- TN: Total Nitrogen; TP: Total Phosphorus, also known as bio stimulants
- Essential for growth of microorganisms, plants and animals
- In aquatic environment – growth of undesired aquatic life
- On land – leads to groundwater pollution

Parameter	Septage [mg/L]	Sewage [mg/L]	Septage : Sewage
TKN	700	40	17:1
NH3-N	150	25	6:1
Total P	250	8	31:1

Source: US EPA Handbook on Septage Treatment & Disposal

Nitrogen and phosphorus, also known as nutrients or bio stimulants, are essential for the growth of microorganisms, plants and animals. When discharged into the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life, such as algal bloom, which rob the water of dissolved oxygen. When discharged in excessive amounts on land, they can also lead to groundwater pollution.

Wastewater contains significant concentrations of nutrients, which can be harnessed for beneficial resource recovery, but if not properly managed, can result in environmental contamination. In addition, the nutrients in wastewater can supplement synthetic nitrogen-based fertilisers that are heavily dependent on fossil fuels and phosphorus, which is a mined resource of which finite supplies are estimated to reach their peak availability within 100 years.

Characteristics of Wastewater

Pathogens

- TC (MPN): Total Coliform; FC (MPN): Faecal Coliform
- Communicable diseases can be transmitted
- Specific monitoring organisms is tested
 - to gauge the plant operation and
 - suitability for reuse

Characteristic	Septage	Sewage
Helminth eggs (no./L)	4000	300 - 2000

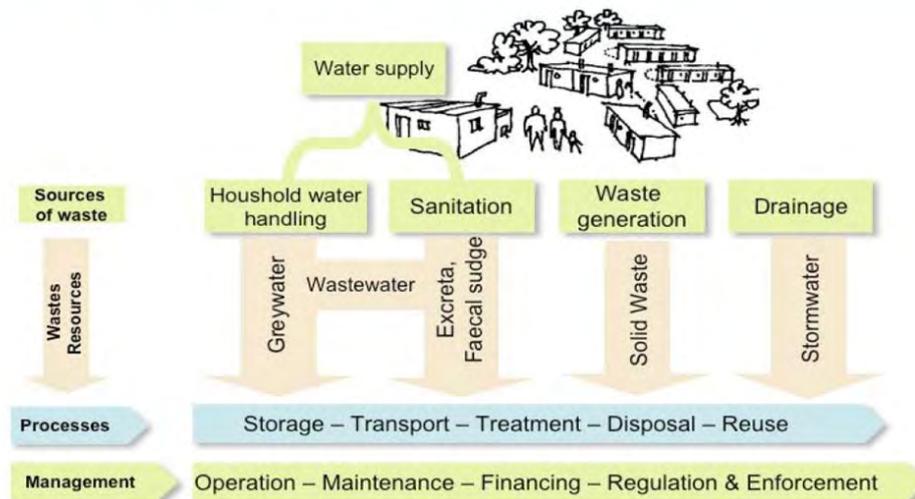
Source: Heinsse et al, 1998

Sludge contains large amounts of microorganisms, mainly originating from the faeces. These microorganisms can be pathogenic, and exposure to untreated sludge constitutes a significant health risk to humans, either through direct contact or through indirect exposure. Sludge needs to be treated to an adequate hygienic level based on the enduse or disposal option. For example, exposure pathways are very different for treated sludge discharged to the environment, used in agriculture, or combusted as a fuel.

Infectious diseases can be transmitted by pathogenic organisms present in wastewater. The presence of specific monitoring organisms is tested to gauge plant operation and the potential for reuse.

Coliform bacteria include genera that originate in faeces (e.g., *Escherichia*) as well as generation of faecal origin (e.g., *Enterobacter*, *Klebsiella*, *Citrobacter*). The assay is intended to be an indicator of faecal contamination; more specifically of *E. coli*, an indicator microorganism for other pathogens present in faeces. Presence of faecal coliforms in water may not be directly harmful and does not necessarily indicate the presence of faeces.

Waste and Resource flows



The figure shows the sources of waste in the household and neighbourhood (green) and the waste and resource flows (brown). All waste and resource flows require an integrated management (green) within a settlement: regulatory system and its enforcement, as well as operation and maintenance for safe transport, treatment, safe disposal, and/or reuse (blue).

Any environmental sanitation project (such as wastewater management or solid waste management) should cater to all the stages of processes as well as management.

Integrated Wastewater and Septage Management

Integrated Wastewater and Septage Management (IWSM) is a holistic approach that addresses the entire sanitation service chain, including both wastewater and septage.

It recognizes that sanitation for all cannot be achieved by managing either septage or wastewater alone.



Need for a Paradigm Shift

PAST TRADITIONAL APPROACHES

- Master planning/ investment only for centralized systems
- Financed by central government/loans
- Wealthy/business districts prioritized
- Limited coverage
- Sustainability challenges for O&M
- Resource recovery not considered
- No performance management
- On-site, small network not considered

PRESENT NSS/FSSM APPROACHES

- Often standalone pilots, not mainstream
- NGO / pilot financed
- FSM value chain/faecal sludge treatment plants
- Poor communities targeted but often missed
- Business models often unable to scale
- Limited professional capacity

FUTURE



CITYWIDE INCLUSIVE SANITATION

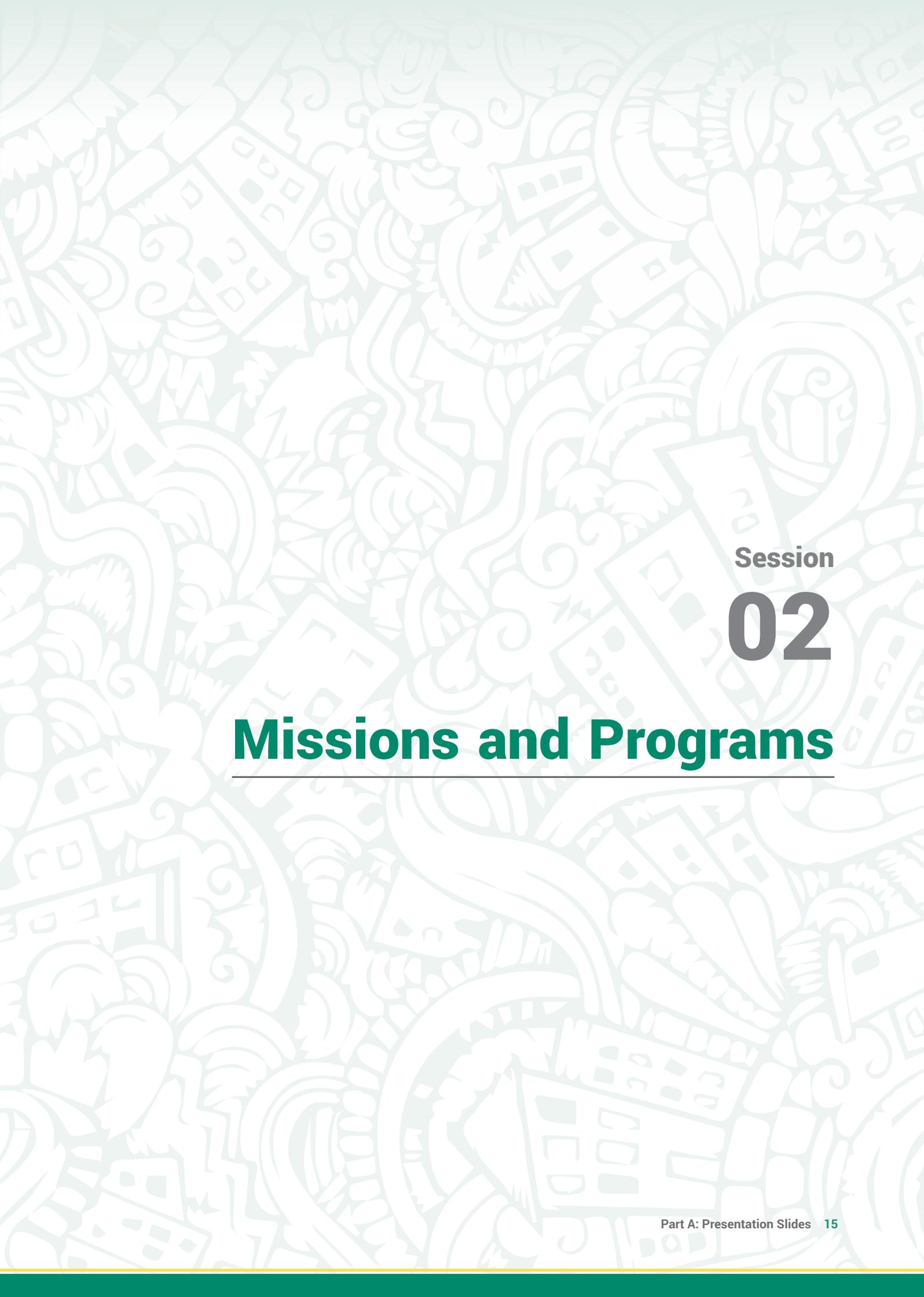
CWIS focuses on promoting public service approaches to ensuring everyone in an urban area is served by safe, equitable, and financially viable sanitation service systems. This means systems are designed to reach the poor and to ensure human waste is safely managed along the whole sanitation service chain

Source: <https://adb.eventsair.com/online-adb-sanitation-dialogue-2021/resources>

The slide showcases a trend in the changing of sanitation approach moving from traditional/conventional to NSS and CWIS. In the past 8 years NSS has gained a huge momentum but the problem is the scale and pilot projects run by NGOs. To tackle the gap, CWIS is promoted. Being a public service approach, it helps in establishing safe, equitable and financially viable sanitation services. Thus, ensuring marginalized and vulnerable group can also benefit from sanitation services.

Summary

- Environmental services such as solid and liquid waste management plays an important role to maintain the Environmental Sanitation.
- Point and non point source are two type of pollution sources which needs to be managed.
- There were different kinds of liquid waste (wastewater and sludge) based on their source and characteristics.
- Project should look at processes and management across the flow of waste products.



Session

02

Missions and Programs

2. Missions and Programs

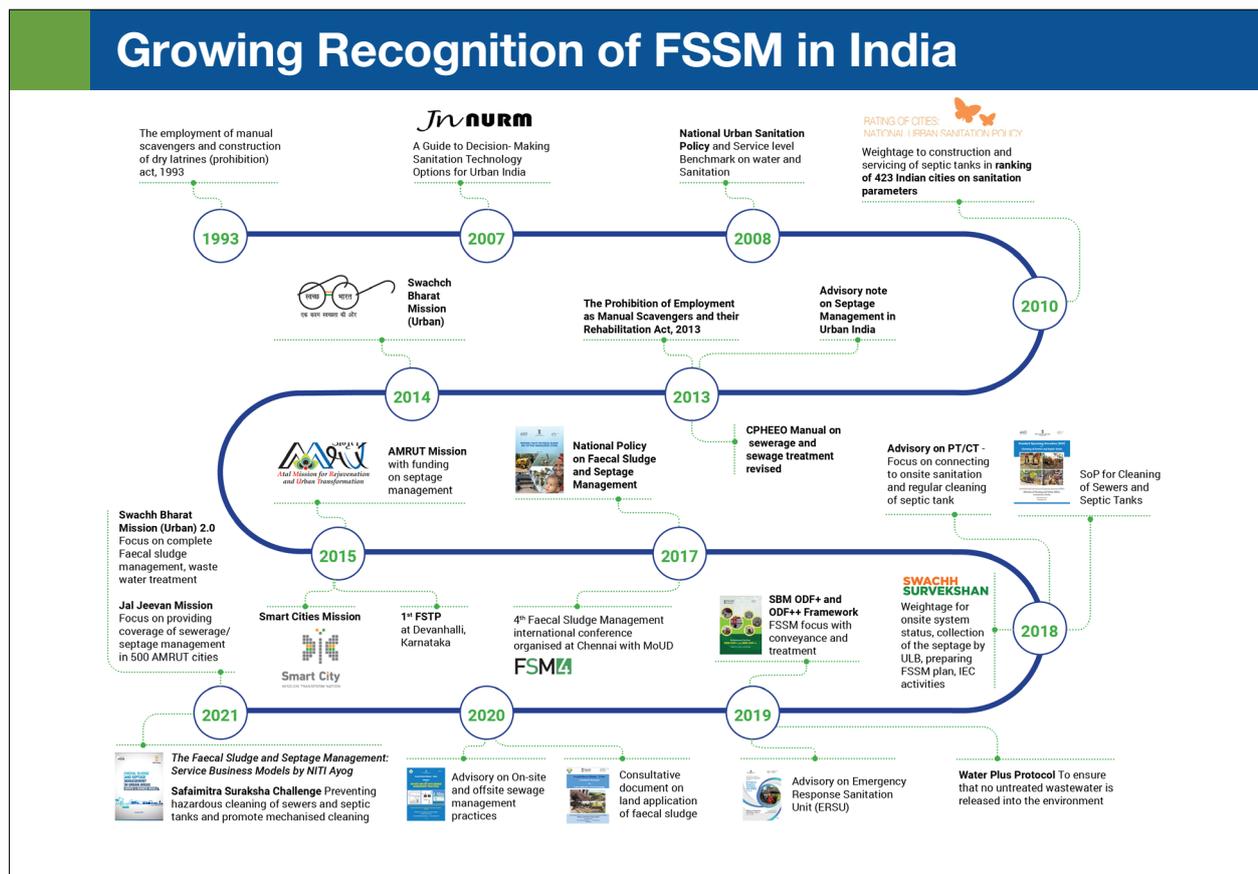
Learning objectives

- To inform genesis of sanitation policies and programs at national level with focus on non-sewered sanitation
- To understand priorities under various national missions with regards to urban sanitation, with a focus on non-sewered sanitation
- To gain knowledge of different policies and guidelines related to sanitation
- To analyse the funding options for the sanitation infrastructure under various national missions

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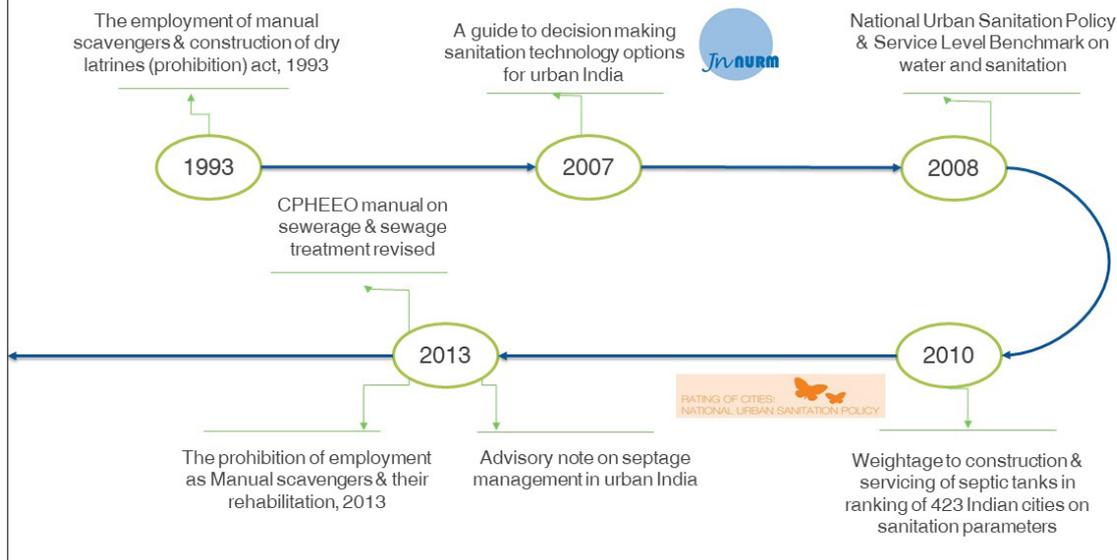
Growing recognition of FSSM
Swachh Bharat Mission 2.0
Jal Jeevan Mission
Policies & Guidelines

2.1 Growing recognition of FSSM Systems

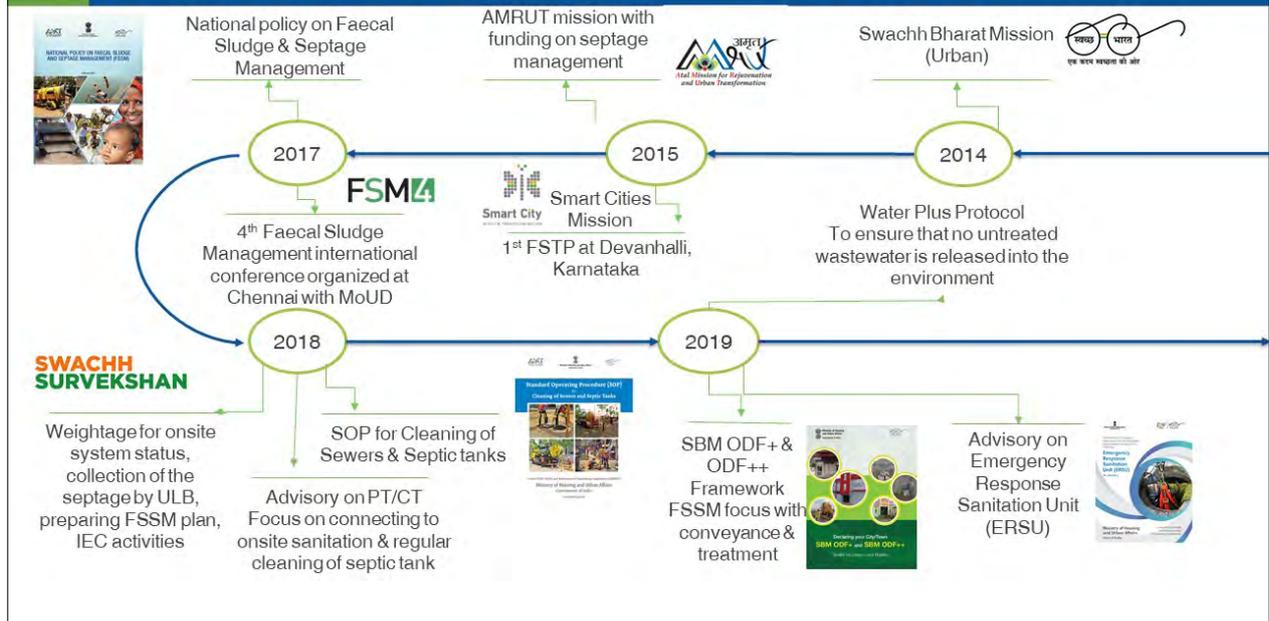


FSSM is fast gaining traction in India. In 2007, under JNNURM, a guide to decision making sanitation technology options for urban India was launched under which onsite sanitation systems were recognised. In 2010, under the National Urban Policy, rating of 423 Indian cities was done on various sanitation parameters. In 2013, ‘The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act’ came which focussed on safety protocols of sanitation workers. Also, the CPHEEO guidelines were revised from sewerage and sewerage treatment to sludge treatment and septage management and an advisory note on septage management was launched. In 2014, sanitation gained momentum with the launch of Swachh Bharat Mission and Amrut Mission with funding on septage management by the government. In 2015, the first FSTP was set up in Devanhalli, Karnataka. In 2017, National Policy of Faecal Sludge and Septage Management was launched. In 2018, under the Swachh Sarvekshan, weightage for onsite system status, collection of septage by ULBs, preparation of FSSM plans and IEC activities were considered. In 2019, MOHUA launched the SBM ODF+ and ODF++ framework with a focus on conveyance and treatment. An advisory on on-site and off-site sewage management was launched in 2020 thriving the FSSM momentum continuously.

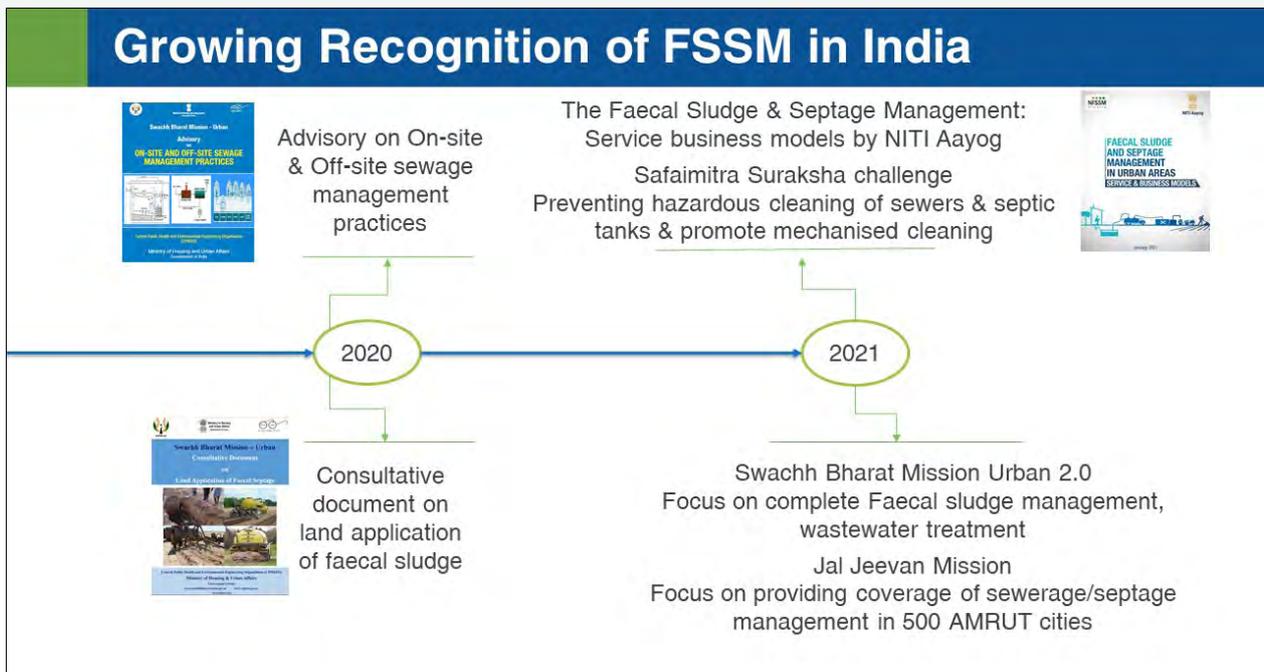
Growing Recognition of FSSM in India



Growing Recognition of FSSM in India



Growing Recognition of FSSM in India



2.2 National Missions and Programs

Smart Cities Mission



Smart City
MISSION TRANSFORM NATION

Started in June 2015

Objectives:

- Providing core infrastructure such as water supply, electricity, sanitation, solid waste management, mobility, housing, for **100 cities**
- Provide clean and sustainable environment

The focus is on:

- Application of smart solutions
- Sustainable and inclusive development

Mission Progress

Proposed Projects	Proposed Investments	Work Tended	Work Orders Issued	Work Completed
 5,151 projects	 2,05,018 crores	 1,74,570 crores  5,745 projects	 1,42,416 crores  5,060 projects	 41,960 crores  2,529 projects

Source: Smart Cities website, April 2021

Smart City Mission was initiated in June 2015 and aimed to promote cities that provide the basic infrastructure with a view to give a decent quality of life to its citizens, a clean and sustainable environment and application of ‘smart solutions’. The focus is on sustainable and inclusive development. The underlying idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities. The core infrastructure elements in a ‘Smart City’ would include adequate water supply, assured electricity supply, sanitation, including solid waste management, efficient urban mobility and public transport, affordable housing, especially for the poor, robust IT connectivity and digitalization, good governance, especially e-Governance and citizen participation, sustainable environment, safety and security of citizens, particularly women, children and the elderly, and health and education.

Swachh Bharat Mission (Urban)

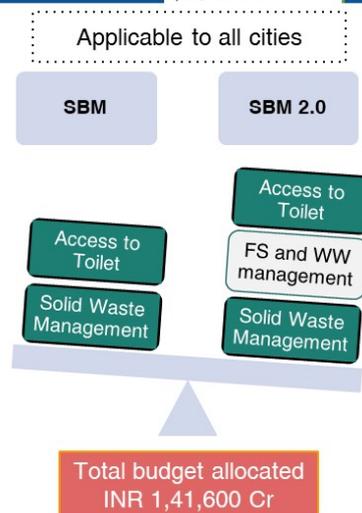


Objectives:

- 1 All statutory towns will be ODF+ certified
- 2 All statutory towns (below 1 lakh population) will be ODF++ certified
- 3 50% statutory towns (below 1 lakh population) will be Water+ certified
- 4 All statutory towns will be at least 3-star Garbage Free Rated
- 5 Bioremediation of all the legacy dumpsites

Key Focus of SBM 2.0:

- ❑ Complete FSM and wastewater treatment,
- ❑ Source segregation of waste,
- ❑ Reduction in single use plastic,
- ❑ Reduction in air pollution, and
- ❑ Bioremediation of all legacy dumpsites.



Swachh Bharat Mission (SBM) was launched in the year 2014 to eliminate open defecation and improve solid waste management. In first phase, it had aimed to achieve 100% ODF status for Urban and Rural areas by 2nd Oct 2019. The objectives of the first phase of the mission also included eradication of manual scavenging, generating awareness and bringing about a behaviour change regarding sanitation practices, and augmentation of capacity at the local level. The second phase of the mission (SBM 2.0) aims to sustain the open defecation free status and improve the management of solid and liquid waste. The mission is aimed at progressing towards target 6.2 of the Sustainable Development Goals (SDGs) established by the United Nations in 2015.

In continuation to SBM(U), the Ministry of Housing and urban Affairs launched SBM(U) 2.0 in 2021 with a focus on complete faecal sludge management, waste water treatment, source segregation of garbage, reduction in single use plastic, reduction in air pollution by effectively managing waste from construction and demolition activities, and bio-remediation of all legacy dumpsites.

Jal Jeevan Mission (Urban)



Har Ghar Jal
Jal Jeevan Mission

Objectives:

- 1 Rejuvenation of water bodies
- 2 Promoting circular economy of water
- 3 Conduct Pey Jal Survekshan
- 4 Initiate an IEC campaign about conservation of water
- 5 To start a technology submission for water

Key focus:

- Strengthening water security of the cities

4378
ULBs achieve 100%
coverage of water supply

20%
Water demand met
through reuse of water

500 AMRUT towns
to achieve 100%
treatment of sewerage
and septage

Total budget allocated
INR 2,87,000 Cr

Applicable to all cities

Jal Jeevan Mission is a new initiative of Ministry of Housing and Urban Affairs launched in 2021 which focuses primarily on providing universal coverage of water supply to all urban households (4,378 ULBs). Under JJM(U), the estimated gap of 2.68cr household taps and 2.64cr sewer connections/septage in 500 AMRUT cities is proposed to be covered.

Its key objectives are:

- To ensure the rejuvenation of water bodies to augment sustainable fresh water supply and creating green spaces and sponge cities.
- To promote circular economy of water through development of city water balance plan, focusing on recycle/reuse of treated sewage, rejuvenation of water bodies and water conservation. 20% of water demand to be met with reused water by development of institutional mechanism.
- To start a technology submission for water.
- To initiate an IEC campaign to spread awareness among masses about conservation of water.
- To conduct Pey Jal Survekshan to ascertain equitable distribution of water, reuse of wastewater and mapping of water bodies with respect to quantity and quality of water through a challenge process.

Jal Jeevan Mission (Urban)



Total Funding = Rs 2,87,000 Crore

Fund Sharing Pattern	
Sub components/ Sub missions under JJM	Centre: State funding pattern
Coverage	<ul style="list-style-type: none"> 100:0 for UTs without legislature 90:10 for NE & Himalayan states and UTs with legislature 50:50 for other States
Support Activities	<ul style="list-style-type: none"> 100:0 for UTs without legislature 90:10 for NE & Himalayan states and UTs with legislature 60:40 for other States

Source: JJM Guidelines, 2021

In addition to the key objectives, the mission has a reform agenda having focus on strengthening of urban local bodies and water security of the cities. Major reforms are reducing non-revenue water to below 20%; recycle of treated used water to meet at least 20% of total city water demand and 40% for industrial water demand at State level; dual piping system, electric vehicle charging points; Wi-fi infrastructure in new buildings; unlocking value and improving land use efficiency through adequate urban planning; GIS based master plans of the cities; raising funds through issuance of municipal bonds and rejuvenation of water bodies.

Objectives:

- Providing basic services (e.g. water supply, sewerage, septage management, urban transport) in the city
- To ensure that every household has access to a tap with the assured supply of water and a sewerage connection
- Increase the amenity value of cities by developing greenery and well-maintained open spaces
- Pollution reduction by using public transport or constructing non-motorized transport facilities

Mission Progress



The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) mission was initiated in June 2015 which aimed to provide the basic utility services (e.g. water supply, sewerage, septage management, urban transport) to households and build amenities in cities which will improve the quality of life for all. The purpose of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) is to ensure that every household has access to a tap with the assured supply of water and a sewerage connection, to increase the amenity value of cities by developing greenery and well-maintained open spaces (e.g. parks) and to reduce pollution by switching to public transport or constructing facilities for non-motorized transport (e.g. walking and cycling). All these outcomes are valued by citizens, particularly women, and indicators and standards have been prescribed by the Ministry of Housing and Urban Affairs (MoHUA) in the form of Service Level Benchmarks (SLBs).

15th Finance Commission

Funding for Million Plus Cities

- MoHUA as Nodal Ministry
- INR 38,196 Cr funds as Million Plus City Challenge Fund
- 33.33% Grant for improving air quality
- 66.66% Grant for improving water and sanitation services (drinking water, RWH, recycling, sanitation and solid waste management)

Funding for ULBs (< 1 Million Population)

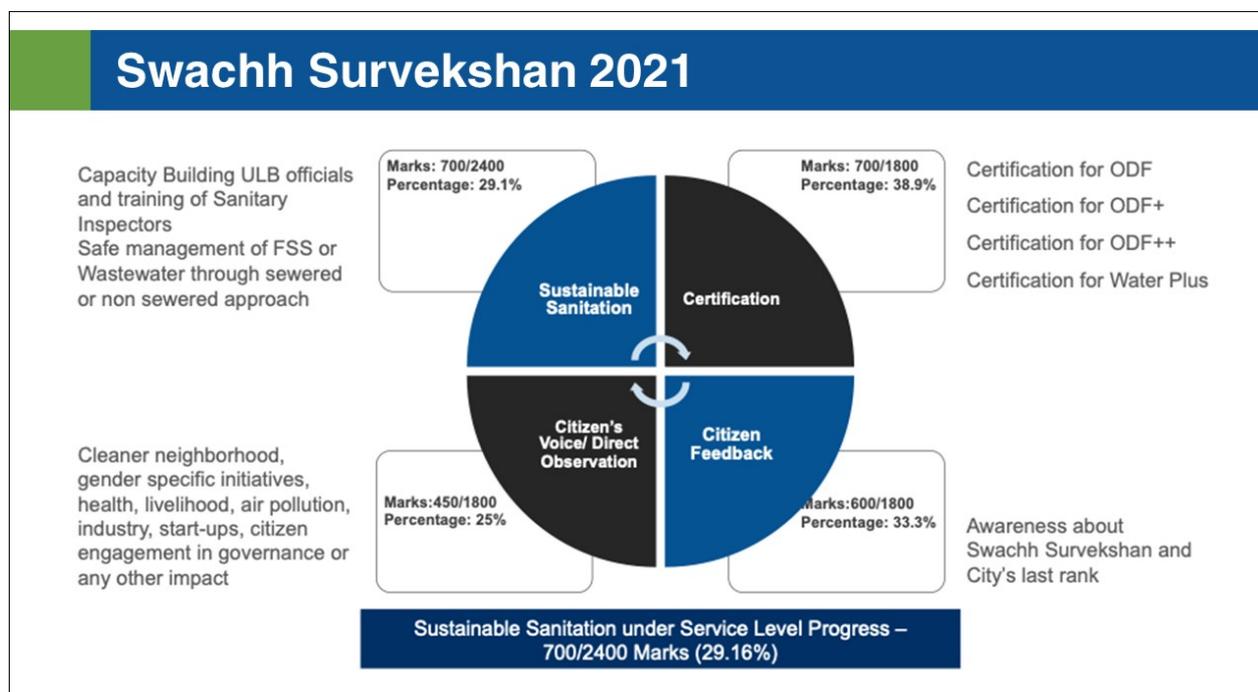
- INR 82,859 Cr for ULBs (< 1 Million)
- 30% Grant for sanitation and solid waste management and attainment of star ratings (as developed by the MoHUA)
- 30% Grant for drinking water, rainwater harvesting and water recycling

Fund allocation under 15th Finance Commission: To cater to the needs of the growing

urbanisation needs of the country, the 15th Finance Commission has recommended a total of Rs.1,21,055 crore for the urban local bodies for the period of 2021-26. Among the states and among the ULBs the fund will be primarily be distributed with a weightage of 90% on population and 10% on area.

Funds for Million Plus Cities UAs: Fifty urban centres with million plus population have been identified. They consist of forty-four urban agglomerations (excluding Delhi, Chandigarh and Srinagar) and six cities Jaipur, Visakhapatnam, Ludhiana, Faridabad, Vasai- Virar City and Kota. For these cities, during its five-year award period, grants have been recommended to the tune of INR. 38,196 crore in the form of a Million-Plus cities Challenge Fund (MCF). Each urban centre shall have one ULB as a nodal entity which will be made responsible for achieving the performance indicator for the whole UA. One third of the total MCF of each city is earmarked for achieving ambient air quality. The balance two thirds of the city-wise MCF is earmarked for achieving service level benchmarks for drinking water (including rainwater harvesting and recycling) and solid waste management. The MoHUA shall act as a nodal ministry for determining the urban agglomeration eligible to get MCF funds for drinking water (including rainwater harvesting and recycling), sanitation and solid waste management criteria under service level benchmarks.

Grants for ULBs (less than Million Plus): The other than Million-Plus cities/towns shall get the grants as per population. Thirty per cent of the total grants to be disbursed to urban local bodies shall be earmarked for sanitation and solid waste management and attainment of star ratings as developed by the MoHUA. In addition, 30 percent of the total grants to be disbursed to urban local bodies shall be earmarked for drinking water, rainwater harvesting and water recycling. However, if any urban local body has fully saturated the needs of one category and there is no requirement of funds for that purpose, it can utilise the funds for the other category.



The Government of India also validated the work done under the flagship program of Swachh Bharat Mission and AMRUT through Swachh Survekshan. Swachh Survekshan also includes parameters pertaining to FSSM as shown in the diagram above.

Prohibition of Employment as Manual Scavengers and their Rehabilitation Act & Rules, 2013

- Terminologies
 - **Manual Scavenger** – manual cleaning, carrying & disposal of human excreta from latrines, pits, septic tanks, drains, sewers.
 - **Hazardous cleaning** – cleaning without proper use of cleaning devices, protective gear.
 - **Protective gear** – safety equipment and personal gear to avoid direct exposure to hazardous substance or injury while cleaning work.
- Prohibition of insanitary latrines, Identification of manual scavengers and their rehabilitation
- **Roles and responsibilities** of employers and procedures to be followed
- Manual scavenging is **non bailable and cognizable offence**
- **Penalty**
 - First contravention – up to 2 years of jail and/or up to 2 lakhs fine
 - Subsequent contravention - up to 5 years of jail and/or up to 5 lakhs fine



As per the Manual Scavenging Act 2013, the hazardous cleaning by an employee, in relation to a sewer or septic tank, means its manual cleaning by such employee without the employer fulfilling his obligations to provide protective gear and other cleaning devices and ensuring observance of safety precautions, as may be prescribed or provided in any other law, for the time being in force or rules made thereunder. The act, prohibits the insanitary toilets and directs for the identification of manual scavengers and their rehabilitation. It also mentions the roles and responsibilities of employers and procedures to be followed during septic tank or sewer lines.

Safai Mitra Suraksha Challenge 2021



The 'Safai Mitra Suraksha Challenge' is a national level competition, on the transformation of septic tank/sewer lines cleaning and the improved health and safety of the sanitary workers. Under this challenge, all informal workers to be identified by the city need to be integrated with formal mechanism in place for cleaning Septic Tanks/Sewer Lines. Thrust will be on the mechanized

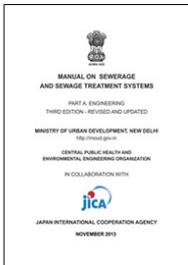
cleaning of sewers and septic tanks, to minimize necessity of human entry and to ensure the availability of proper protective gears and equipment in case manual entry is unavoidable. On your screen, you can see the various parameters and their weightage in the 2021 challenge. All these parameters are very crucial to implement at city level to achieve the objective of Manual Scavenging Act, 2013.

2.3 Policies and Guidelines

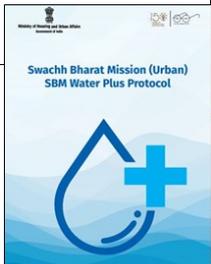
Advisories and guidelines

Water and Wastewater Management

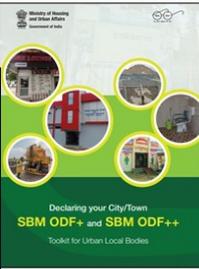
- Ensuring sustainability of sanitation status achieved through ODF, ODF+ & ODF++ protocols
- Efficient treatment & disposal of wastewater through sewerage systems



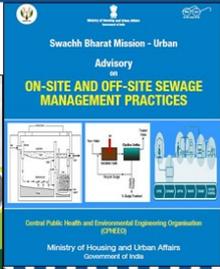
CPHEEO Manuals on Sewerage & Sewage Treatment Systems



SBM Water Plus Protocol



SBM ODF+ & ODF++ Protocol



Advisory on Onsite & Offsite Sewage Management Practices

SBM Water Plus Protocols: The purpose of this toolkit is to provide a readiness check and guideline for cities and towns that have already achieved Open Defecation Free (ODF)/ODF+ / ODF++ status as per the existing protocols prescribed by the Ministry of Housing and Urban Affairs (MoHUA) and to work towards ensuring the sustainability of sanitation status. This toolkit provides the detailed SBM Water Plus protocol laid down by MoHUA, along with declaration formats to be obtained from various stakeholders, that wards/work circles (in case under the jurisdiction of development authority) and cities are required to submit, as part of the SBM Water Plus declaration and certification process.

CPHEEO Manuals: The manuals on sewerage & sewage treatment systems provide a detailed process of the wastewater management, sewerage systems usage and everything related to sewage management spanning over 3 parts of engineering, operation & maintenance and management.

SBM ODF+ & ODF++ Protocol: This toolkit can serve as a readiness checklist for all ULBs/ Development Authorities/ Cantonment Boards to prepare themselves and their concerned stakeholders in achieving either SBM ODF+ and/or SBM ODF++ status and officially declare the same, followed by certification, as per the protocol outlined.

Advisory on onsite & offsite sewage management practices: This advisory describes integrated planning of sanitation in a city comprising onsite and off-site sewage management systems. It has identified interventions, as above, for optimal performance of on-site systems and subsequent progressive coverage of on-site systems with off-site systems as and when the necessity arises.

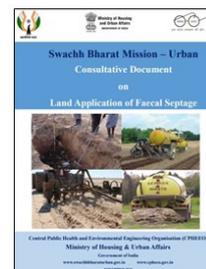
Advisories and guidelines

Faecal Sludge & Septage Management

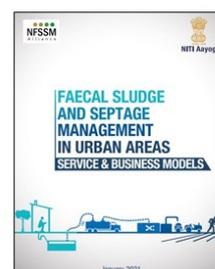
- Leveraging FSSM to achieve 100% access to safe sanitation
- Achieving integrated citywide sanitation
- Sanitary and safe disposal



National Policy on Faecal Sludge & Septage Management



Consultative Document on Land Application of Faecal Septage



FSSM in Urban Areas- Service & Business Models

National Faecal Sludge and Septage Management (FSSM) Policy was released in 2017 to set the context, priorities, and direction for and to facilitate, nationwide implementation of FSSM services in all ULBs such that there will be safe and sustainable sanitation approach at city level. The key objective of the policy is to mainstream the FSSM in urban India by 2019 and ensure that the all benefits of wide access to safe sanitation accrue to all citizens across the sanitation value chain with containment, extraction, transportation, treatment, and disposal / re-use of all faecal sludge, septage and other liquid waste and their by-products and end-products. Another objective of the policy is to enable and support synergies among relevant central government programs such as SBM, AMRUT and the Smart Cities Mission to realise safe and sustainable sanitation for all. The FSSM policy expects to mitigate gender-based sanitation insecurity directly related to FSSM, reducing the experience of health burdens, structural violence, and promote involvement of both genders in the planning for and design of sanitation infrastructure.

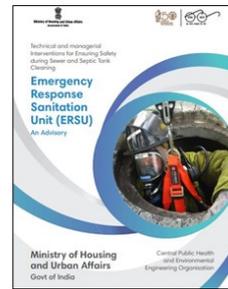
Consultative Document on Land Application of Faecal Septage: This Advisory covers all the key aspects of land application of faecal sludge and septage. It further discusses about the pre-treatment to be given to the faecal septage, precautionary measures to be taken, site selection criteria, dosage and various methods of land application. The monitoring mechanism and record keeping procedures for the land application process are also adequately addressed in the Advisory.

FSSM in Urban Areas- Service & Business Models: The Faecal Sludge and Septage Management: Service Business Models describes leading practices and innovations to improve how faecal sludge is managed, and how to expand services to the millions of people living in thousands of cities in urban India, lacking access to safely managed sanitation.

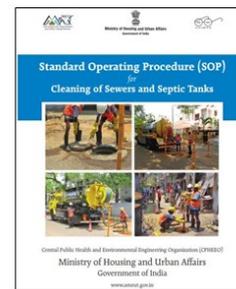
Advisories and guidelines

Occupational Health & Safety

- Occupational health deals with all aspects of health and safety at the workplace with special emphasis on primary prevention of hazards
- Safety and health of workers has a positive impact on productivity and economic and social development



Advisory on
Emergency
Response
Sanitation Unit



SOP for Cleaning of
Sewers & Septic
tanks

Advisory on Emergency Response Sanitation Unit: This advisory describes the technical & managerial interventions for ensuring safety during sewer & septic tank cleaning. It represents an innovative approach to institutionalizing safety practices & putting in place frameworks to mitigate the dangers of this practice.

SOP for Cleaning of Sewers & Septic tanks: The scope of the SOP is to impart the knowledge into the stakeholders about the cleaning of sewers and emptying of septic tanks before and after the assignment. This document would be found useful by all Urban Local Bodies (ULBs), Public Health Engineering Departments and other agencies engaged in the process of cleaning of sewers / emptying of septic tanks across the country.

Convergence and Financing Options



User Interface

Dry toilets
(Ecosan Toilets)
Wet toilets
(flush toilets,
vacuum toilets)

- SBM 1.0 and SBM 2.0



Containment Unit

Soak Pits
Septic tanks
Anaerobic
treatment units
(ABR, AF)

- State level funding (Community OSS)



Conveyance Unit

Gravity sewers
Small bore
sewers
Vacuum trucks

- SCM
- SBM 2.0
- AMRUT
- 15th Finance Commission
- NMCG



Treatment Unit

Mechanised / Non
mechanised
Centralised /
Decentralised

- SCM
- SBM 2.0
- AMRUT
- 15th Finance Commission
- NMCG



Disposal or Reuse

Surface water
bodies
Agriculture
Industry

- Jal Jeevan Mission (Urban)
- NMCG

It represents different financing options available under each functional group. There are national programs such as Swachh Bharat Mission (1.0 and 2.0), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) mission, Jal Jeevan Mission (Urban) and National Mission for Clean Ganga which covers the funding for different functional groups in sanitation service chain. There is also fund allocation for the sanitation infrastructure under 15th finance commission to the ULBs.

Summary

- Non-sewered sanitation (FSSM) is gaining traction due to its affordability and sustainability in various national missions and programs in India
- National missions like SBM-U, JJM-U and others have prioritised non-sewered sanitation to improve health of the environment and citizens
- Policies and guidelines have address the challenges in sanitation sector
- Various components of the sanitation service chain have defined funding mechanism as per the national missions and programs

The background of the slide is a dense, repeating pattern of white icons on a light green background. The icons represent various elements of the Swachh Bharat Mission, including buildings, trees, water taps, and people. The overall style is clean and modern.

Session

03

Swachh Bharat Mission 2.0

3. Swachh Bharat Mission 2.0

Learning Objectives

- To understand the guidelines of Swachh Bharat Mission 2.0
- To understand the checklist for the preparation of City Wastewater Infrastructure Status (CWWIS)

Contents

Swachh Bharat Mission 2.0

- Objective for Wastewater Management
- Proposed Strategy
- Components Covered for Funding
- Proposed Approach
- Population Distribution
- City Wastewater Infrastructure Status
- CWWIS Form Checklist

3.1 SBM 2.0 – Objectives for WWM

Swachh Bharat Mission (SBM) 2.0

Overall Objectives:

- All statutory towns will be ODF+ certified
- All statutory towns (below 1 lakh population) will be ODF++ certified
- 50% statutory towns (below 1 lakh population) will be Water+ certified
- All statutory towns will be at least 3-star Garbage Free Rated
- Bioremediation of all the legacy dumpsites



The focus is on:

Complete faecal sludge management and wastewater treatment, source segregation of waste, reduction in single use plastic, reduction in air pollution, and bioremediation of all legacy dumpsites.

Swachh Bharat Mission (SBM) was launched in the year 2014 to eliminate open defecation and improve solid waste management. The first phase aimed to achieve 100% ODF status for Urban and Rural areas by 2nd Oct 2019. The objectives of the first phase of the mission also included eradication of manual scavenging, generating awareness and bringing about a behaviour change regarding sanitation practices, and augmentation of capacity at the local level. The second phase of the mission (SBM 2.0) aims to sustain the open defecation free status and improve the solid and liquid waste management. The mission aims to progress towards target 6.2 of the Sustainable Development Goals (SDGs) established by the United Nations in 2015.

In continuation to SBM(U), the Ministry of Housing and urban Affairs launched **SBM(U) 2.0** in 2021 with a focus on complete faecal sludge management, wastewater treatment, source segregation of garbage, reduction in single use plastic, reduction in air pollution by effectively managing waste from construction and demolition activities, and bio-remediation of all legacy dumpsites. At the end of the mission, the following outcomes are expected to be achieved:

- All statutory towns will become ODF+ certified.
- All statutory towns with less than 1 lakh population will become ODF++ certified,
- 50% of all statutory towns with less than 1 lakh population will become Water+ certified
- All statutory towns will be at least 3-star Garbage Free rated as per MoHUA's Star Rating Protocol for Garbage Free cities
- Bio-remediation of all legacy dumpsites.

SBM 2.0 – Wastewater Management

SBM U (Phase I) has not included with Wastewater and Faecal Sludge Management

Legal Mandate

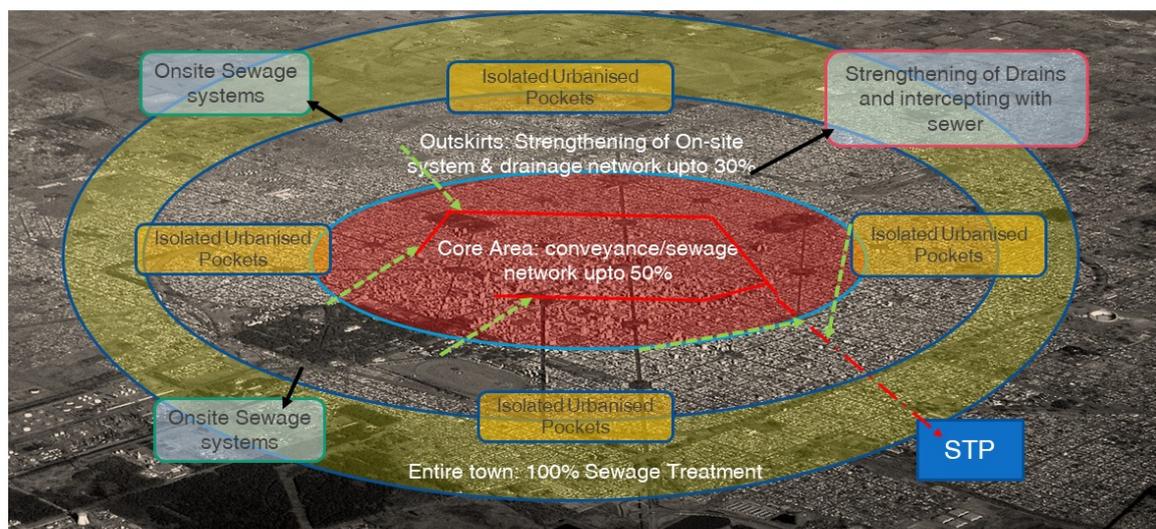
- As per mandate by Supreme Court and NGT, Wastewater Management projects to be taken up on priority
- Provision for heavy penalty for non compliance by ULBs

Objectives

- All statutory towns (with population less than 1 lakh) are expected to achieve ODF++
- At least 50% of cities (less than 1 lakh population) are expected to achieve Water+

As per the guidelines, SBM 2.0 program has main focus on wastewater management and faecal sludge management. As per the order by supreme court and National Green Tribunal (NGT), central government has focused on the wastewater management projects on priority in SBM 2.0 and there will be heavy penalties for non-compliance by the urban local bodies (ULBs).

Proposed Strategy – Wastewater Management



As per the proposed strategy, ULBs are encouraged to identify its “**Core Sanitation Zone (CSZ)**” for providing sewer network which should have at least 50% of the towns current population settled over an area comprising about 20-30% of the town’s spread. In next step, suitable sites for sewage treatment plants (STP) will be identified in vicinity of the CSZ. The STPs need to cater for 50% of the design population (Design year-2052) or 70% of current population.

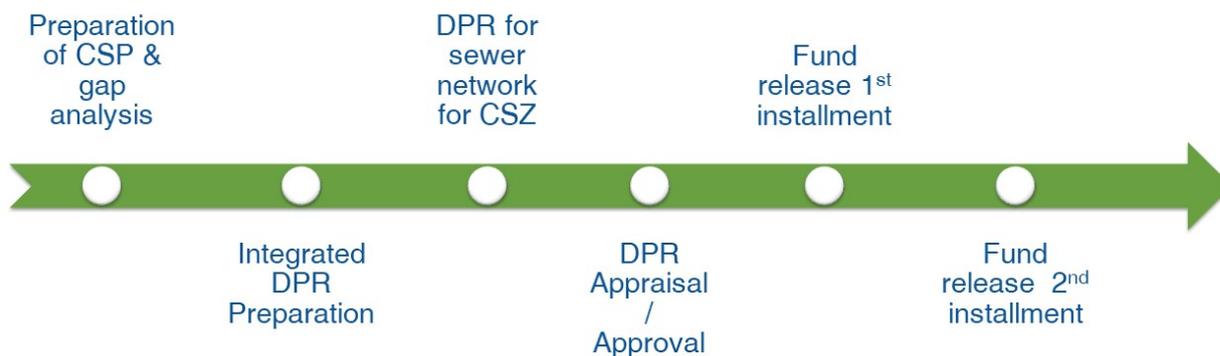
For inhabitants residing outside the CSZ (in fringe areas), the town authorities have to work out economically judicious solutions, opting between continuing with onsite disposal systems (septic tanks followed by soak pits) or providing localized community level sewage treatment plants. The septage from these households should continue to be safely hauled to a designated STP under professional arrangements. It is advised that the fringe areas may try to strengthen their onsite disposal arrangements by making soak fields or drain fields where missing and forcing the septic tank effluent into the ground adhering to design norms. Only some concentrated fringe pockets with population more than 10000 should opt for STP (Roughly 1 MLD caters for 10000 users). For smaller quantity flow (< 1 MLD), it is usually better to collect the sewage and pump it down to the larger plant catering to the CSZ.

3.2 SBM 2.0 Components for Funding

SBM 2.0 Components for Funding	
<p>Components covered under SBM 2.0</p> <ul style="list-style-type: none"> • Sewage Treatment Plant cum FSTP • Interception and diversion infrastructure <ul style="list-style-type: none"> • I&D infrastructure • Pumping stations • Gravity & Forced mains • FSM infrastructure <ul style="list-style-type: none"> • Desludging trucks • Solid liquid separation units 	<p>Components not to be funded by centre</p> <ul style="list-style-type: none"> • Sewer network • Strengthening of existing on-site systems such as septic tanks/soak pit etc. • Strengthening Municipal drainage system to convey sewage to STP

It represents the different components covered for funding under Swachh Bharat Mission 2.0 program. It includes the Interception and diversion (I&D) based Infrastructure, Sewage Treatment Plants (with septage co treatment infrastructure), faecal sludge management infrastructures I.e., desludging vehicles and solid liquid separation units. As per the guidelines, it is notified that there is no funding for sewer network, strengthening of existing on-site systems such as septic tanks/soak pit etc. or strengthening municipal drainage system to convey sewage to STP. We have to understand that these non-covered components are important and necessary to qualify the funding allocation under SBM 2.0.

Proposed Approach for WWM



It represents the approach which needs to be followed for wastewater management at city level. As a first step, ULB will be required to update City Sanitation Plan (CSP) for the town, if already available and if not available, the same needs to be immediately prepared. CSP must contain a gap analysis in sewage management and prospective projects to be taken up under SBM 2.0 along with its prioritization. The tentative block cost estimate (adopting thumb rule) for components like STP, sewer networks, pumping stations and I&D etc. to be prepared with suitable zoning.

In next step, State/ULB will be required to prepare Detailed Project Report (DPR), as per those identified in CSP, following the CPHEEO Manual on Sewerage & Sewage Treatment. ULBs also need to prepare detailed project report for sewer network for CSZ and they have to take approval of both DPRs for fund sanctioning.

Population Distribution (as per Census 2011)

Class of Cities based on Population		No of Cities	Total Population @2011 Census
Class II	50,000-99,000	535	3,65,66,049
Class III	20,000-49,999	1,434	4,46,63,972
Class IV	10,000-19,999	1,238	1,82,39,137
Class V	5,000-9,999	541	42,54,051
Class VI	<5,000	153	4,85,917
Total		3,901	33,01,26,548

This slide represents the different classes of cities based on census 2011 population. It reflects the number of cities as per classes, total number of cities and total population covered under SBM 2.0 program.

3.3 City Wastewater Infrastructure Status

City Wastewater Infrastructure Status

Objectives

- To understand the current situation of the WW infrastructure in ULBs
- To assess the gap in WW infrastructure in ULBs
- To assess existing policy of states on sewage treatment and conveyance network such as sewer network
- To assess STP cum FSTP planning & implementation scenario



ULBs need to understand the current situation of the wastewater infrastructure and have to assess the gaps in it. ULBs also need to assess the existing policy on sewage treatment and conveyance network such as sewer network and existing STP cum FSTP planning and implementation scenario at city level.

As per the SBM 2.0 guidelines, ULBs have to check the city wastewater infrastructure status and need to upload on the SBM Urban website integrated MIS through official login.

CWWIS Form – Checklist

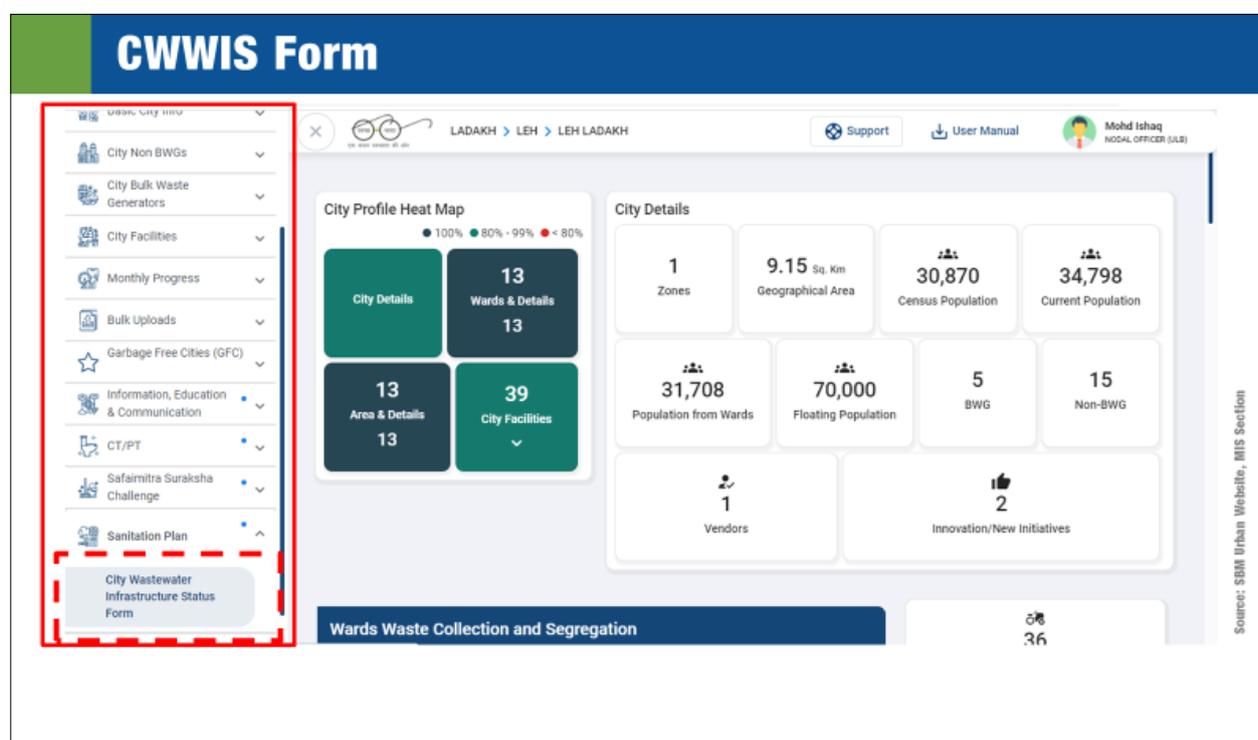


City Profile	<ul style="list-style-type: none">• Population• Households• Water supply, etc.
Off-site infrastructure	<ul style="list-style-type: none">• Sewerage network coverage• House Sewerage Service Connection• Sewage Treatment Plant
On-site infrastructure	<ul style="list-style-type: none">• On-site system coverage• Desludging trucks• Faecal sludge treatment infrastructure
Interception & Diversion infrastructure	<ul style="list-style-type: none">• Interception & Diversion Infrastructure plan

This slide includes the checklist for the city wastewater infrastructure status. ULBs have to collect and upload data such as city profile, off-site sanitation infrastructure, on-site sanitation infrastructure and existing interception and diversion infrastructure. There is section wise checklist given on the MIS platform which ULBs have to upload in certain deadline given by the centre. In next few slides, we have provided the instructions based on which ULBs has to upload information.



Step 1: Login in using your login id and password



Step 2: After logging in, this dash board will open as shown on the slide.

Step 3: On the left-hand side, go to “Sanitation” and click on “City wastewater infrastructure form” as highlighted in red coloured dotted rectangle box

CWWIS Form – City Profile and Existing Infrastructure

ULB Code: 800047 | ULB Name: LEH LADAKH | District: LEH | State: LADAKH

Census population: 30870 | Current population: 34798 | Area (in sq.km): 9.15 | Total No. of HHs (2011):

Click Here to modify the above details.

* Total No. of HHs (2021) | * City Sanitation Plan Status | * Water supply sources | * Water supply quantity (in lpcd)

* SBM or ODF Certification | * Quantity of Sewage generate... | * Quantity of Faecal Sludge generated (KLD)

1. Does your ULB have 100% sewerage network coverage? *
 Yes No

Source: SBM Urban Website, MIS Section

Step 4: The CWWIS form will open and ULBs need to fill the information as per the instructions given in the boxes.

Summary

- Swachh Bharat Mission Urban 2.0 is mainly focuses on the wastewater and faecal sludge management
- SBM-U 2.0 is the crucial program which covers ODF++ and Water+ status of the ULBs
- SBM-U 2.0 has the initial step of City Wastewater Infrastructure Status followed by the detailed project reports at city level.



Session

04

Planning Approach

4. Planning Approach

Learning objectives

- To understand the concept and principles of City Wide Inclusive Sanitation in planning sanitation systems
- To understand City Wastewater Infrastructure Status (CWWIS) as per new SBM 2.0 guidelines and data required to make the CWWIS plan.
- To understand centralized and decentralized approach of a city to manage wastewater.
- To get in-depth knowledge about Sanitation System and its approach in city for safe collection and disposal of generated wastewater.
- To know the stages in preparation of Detailed Project Report under SBM 2.0

Contents

- City Wide Inclusive Sanitation
- City Wastewater Infrastructure Status
- Wastewater Management Approaches
- Sanitation Systems Approach
- Sewered Sanitation
- Stages in DPR preparation

4.1 City Wide Inclusive Sanitation

City Wide Inclusive Sanitation

CWIS is an approach to urban sanitation that involves the following:

- Adequate sanitation service delivery for every citizen
- Safe management of human waste along the whole sanitation service chain
- Selection of appropriate sanitation systems & technology solution with consideration of resource recovery & re-use.



Access to all



Whole service chain



Thriving economy



Working Partnership

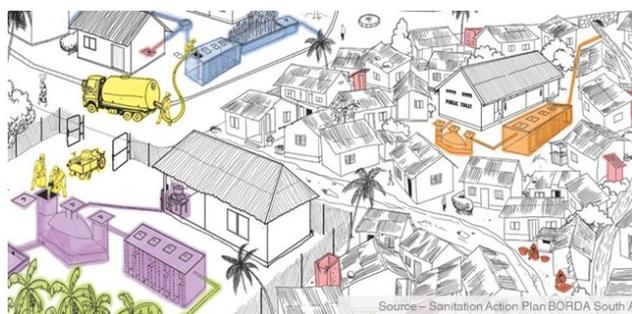
From the first session, we have understood that the town has built and natural environment. This environment is very specific to the town and features such as topography, population density etc varies largely. Thus, the kind of sanitation infrastructure and services shall also vary a lot. Sanitation projects have been largely considered as an infrastructural project. For wastewater management, centralized approach with gravity sewers and STP at the end of pipe has been considered as ultimate solution. However, achieving equitable and just sanitation service delivery is not possible with a single approach.

Citywide Inclusive Sanitation is a state of urban sanitation, where all members of the city have access to adequate and affordable sanitation services through appropriate centralized and decentralized systems, without any contamination to the environment along the sanitation value chain.

CWIS Principles for Planning

Six CWIS principles that help in achieving objectives of sanitation systems:

- Equity
- Environment & public health
- Availability and affordability of technologies
- Comprehensive planning
- Monitoring & accountability
- Mix of business models



Conventional Sewers – where economy of scale works

Decentralised systems – areas dictated by topography, population density

Faecal Sludge Management – areas where access is an issue

Adopting a one-size-fits-all sanitation approach will fail in achieving the aim of protecting the health of environment and of residents. Adopting principles of CWIS is useful for cities where a combination of on-site and sewerred solutions exist, either or both centralized or decentralized systems should be adopted for providing adequate sanitation services to everyone in the city.

- Everybody’s benefits
- safely managed along the whole sanitation service chain
- diversity of appropriate technical solutions both on-site and sewerred solutions, centralized or decentralized systems
- political will, leadership, and new and creative long-term funding options
- Institutional arrangements and regulations
- non-infrastructure aspects of service delivery
- Complementary urban services
- Target specific unserved and underserved groups

CWIS: A Public Service Approach

CWIS presents a paradigm shift in the urban sanitation towards adopting more contextual solutions that are sustainable and equitable in nature and includes soft institutions as much as hard infrastructure

CWIS highlights that the planning and designing of projects demand a more comprehensive process that looks at the:

- Policies, institutions, regulations
- Involves all stakeholders – both users and providers
- Contextually considers all appropriate technical options
- Makes an inclusive and equitable decision

CWIS brings various evolved thinking of urban sanitation under one umbrella

A public service approach to planning and implementing urban sanitation systems to achieve the outcomes of SDG6

Source: Schrecongost, A., et al. (2020). Citywide Inclusive Sanitation: a public approach for reaching the urban sanitation SDGs

CWIS is a **public service approach to planning and implementing urban sanitation systems** to achieve **outcomes** of SDG 6: safe, adequate, equitable, and sustainable sanitation for everyone in an urban area, paying special attention to the needs of the poor, the marginalized, and of women and girls.

4.2 City Wastewater Infrastructure Status

City Wastewater Infrastructure Status

CWWIS as per SBM 2.0 guideline includes;

- Wastewater management for grey and black water
- Faecal Sludge and Septage Management

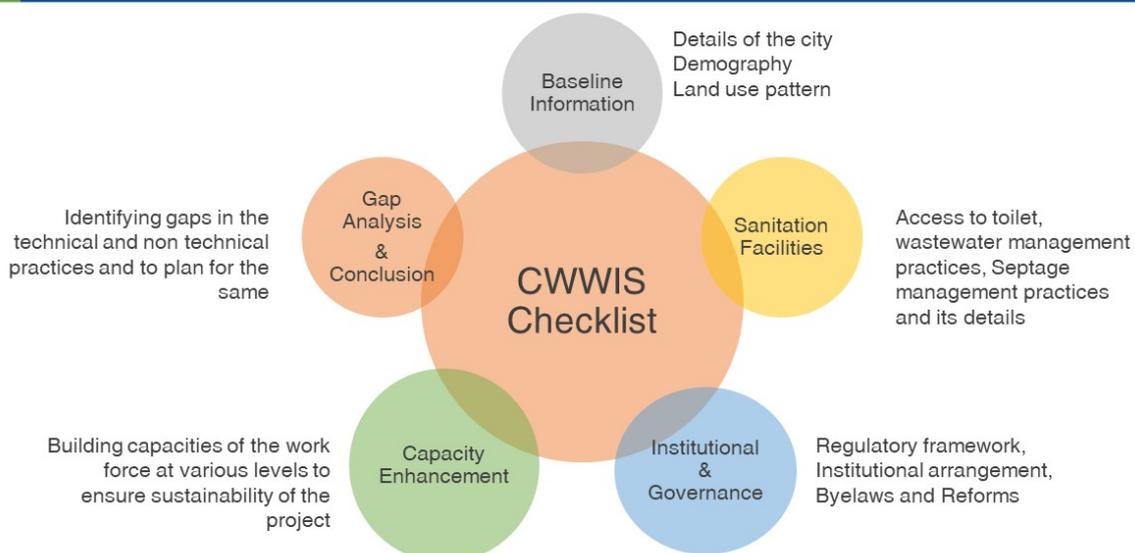
Important components of CWWIS

- Baseline Information
- Technical Information – Water and Sanitation Facilities
- Institutional & Governance
- Capacity Enhancement
- Gap Analysis & Conclusion



As a first step, ULB will be required to create or update City Wastewater Infrastructure Status (CWWIS) for the town, if already available. The CWWIS is expected to contain the information on current sewage management practices and other non-technical aspects such as institutional and governance. It needs to bring out the gaps in the management system, so that the same can be addressed in the DPR. CWWIS must contain the prospective projects to be taken up under SBM 2.0 along with its prioritization for achieving the objectives in the short term (5 years), midterm (15 years) and long term (30 years). The tentative block cost estimate for components like STP, sewer networks, pumping stations and I&D etc. to be prepared with suitable zoning.

City Level Data Collection - Checklist



Baseline Information - Details of the city – Maps, locations etc., Demography – Census data & growth, Land use pattern – Population settings

Technical Information (Sanitation Facilities) - Access to toilets – IHHT, CT, PT, Existing Sewage Infrastructure – STPs, Drains, sewers etc., Sewage Management

Institutional & Governance - Regulatory Framework, Institutional Arrangement, Governance & Reforms

Capacity Enhancement - Human Resource Development

Gap Analysis & Conclusion - I&D & STP cum FSTP, Sewer network, Storm water drainage system, Recycle & reuse projects

Please check the **Checklist for CWWIS** provided with this module.

4.3 Wastewater Management Approaches

Levels of management

Changes in built environment causes significant variation in

- Population density
- Type of housing
- Availability of space for utility infrastructure such as treatment plants etc.
- Affordability of environmental services



There are different levels in liquid waste management. There are few factors which we have to consider while planning the wastewater management. The factors are like population density, the type of housing, availability of space or land for development of utility infrastructure such as sewerage lines or treatment plants and affordability of the environmental services by the local administration. Liquid waste management has two approaches centralized systems or decentralized systems.

Centralized system

Characteristics of Urban Habitat

- Very high population density
- Characterized by high-rise buildings
- High affordability of services
- Lack of space for utility infrastructure

Households connected to sewerage systems
Wastewater is transferred between urban watersheds
Centralised treatment plant
Water disposed off in surface water bodies (rivers or sea)



In centralized system approach, it is very crucial to understand the level or type of habitat while planning liquid waste management. There are different levels or types of habitats like URBAN, PERI-URBAN, RURBAN or RURAL. In the first part we will understand the URBAN habitat which has the very high population density and has areas with high rise buildings. Generally, urban administrations and urban population have high affordability of implementing and maintaining these environmental services but there is problem of lack of space or land for development of utility infrastructure. In URBAN case, it has suitability of centralized system i.e., household connections with sewerage system and wastewater transferred in centralized treatment system which further disposed of into the surface water bodies after treatment.

Decentralized system

Households have IHHT and Septic tank

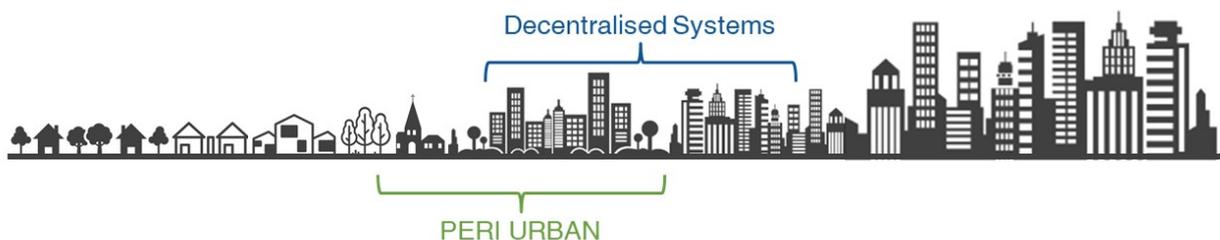
Collection happens only by gravity
(no sewage pumping stations)

Wastewater treatment plant at
an urban watershed level

Treated water disposed off in
surface water bodies (ponds or lakes)

Characteristics of Peri-urban Habitat:

- High population density
- Characterised by multi-storey buildings
- Affordability of services



In the case of PERI-URBAN habitat, which generally has the high or medium population density and has areas with high rise buildings. Generally, local administration and local people have affordability of developing and maintaining the environmental services. In PERI-URBAN case, it has suitability of decentralized system i.e., household have individual household toilets and

on-site septic tanks which can be connected with sub lines (no sewage pumping stations) and wastewater is collected at decentralized treatment system by gravity. Further, it can be disposed into the surface water bodies after treatment or reused for irrigation.

Clustered system

Households have IHHT and septic tank

Collection happens only by gravity (solid-free sewers)

Wastewater treatment plant at a neighbourhood level in an urban watershed

Treated water used for non-potable purposes

Characteristics of Rurban Habitat:

- Scattered housing
- 2 – 3 storey buildings
- Less affordability of services

Clustered systems

RURBAN

In the case of RURBAN habitat, which generally has the scattered housing with medium or low population density and has areas with 2-3 story buildings. Generally, local administration and local people have less affordability for developing and maintaining the environmental services. In RURBAN case, it has suitability of clustered or regional approach for wastewater management system i.e., household have individual household toilets (IHHT) and septic tanks which can be connected with solid free sewers and wastewater is collected at clustered based wastewater treatment systems by gravity. Further, it can be disposed off into the surface water bodies after treatment or reused for irrigation or other non-potable purposes.

On-site system

Households have IHHT and septic tank/soak pits

Blackwater and greywater segregation

Disposal using leach pits or soak away zones

Wastewater management at household level

Primary treatment before disposal

Characteristics of Rural Habitat:

- Low population density
- Scattered hamlets
- Single-storey building
- Very less affordability of services

On-site systems

RURAL

In the case of RURAL habitat, which generally has the scattered hamlets with low population density and has areas with 1-2 story buildings. Generally, local administration and local people

have very less affordability for developing and maintaining the environmental services. In RURAL case, it has on-site sanitation system i.e., household have individual household toilets and septic tanks / soak pits and has segregation of black water and grey water. Generally, the disposal happens using leach pits or soak away zones. In this case, the wastewater management at individual household level with primary treatment. Some cases, toilets are connected with biogas systems which are in farmland premises or household premises.

4.4 Sanitation Systems Approaches

Sanitation System

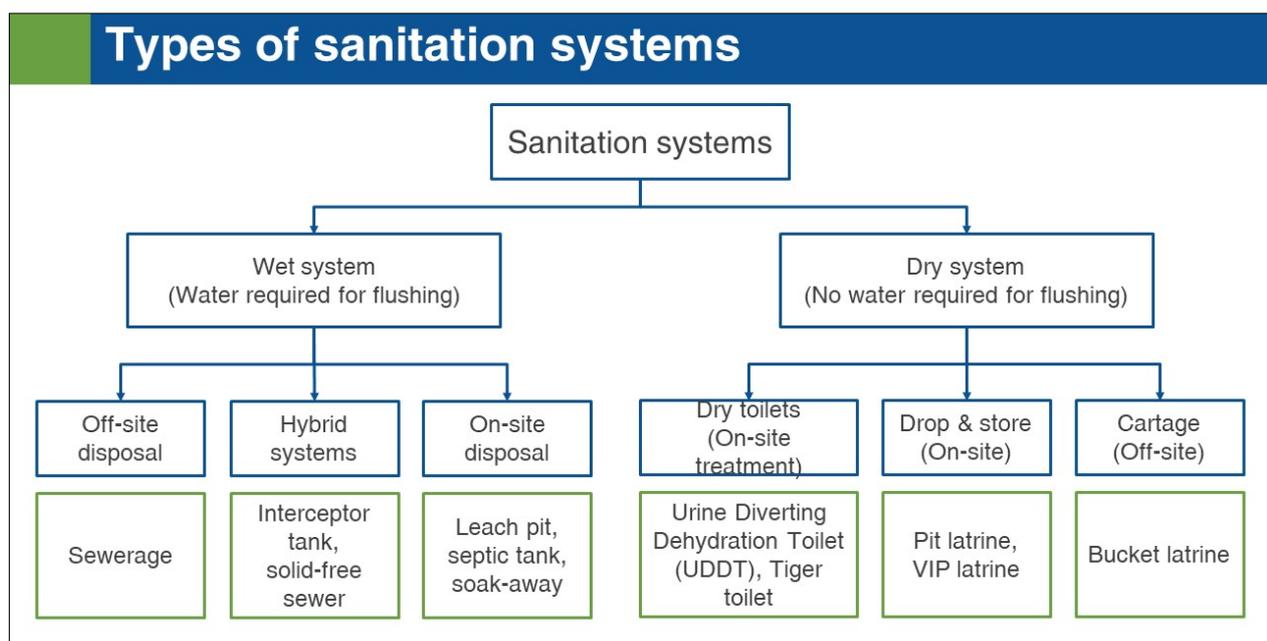
Multi-step process in which **human excreta** and **wastewater** are managed from the point of generation to the point of reuse or safe disposal with minimal human intervention.

Objectives

- Protect and promote health
- Be affordable
- Protect the environment
- Be culturally acceptable
- Be simple in technology
- Work for everyone

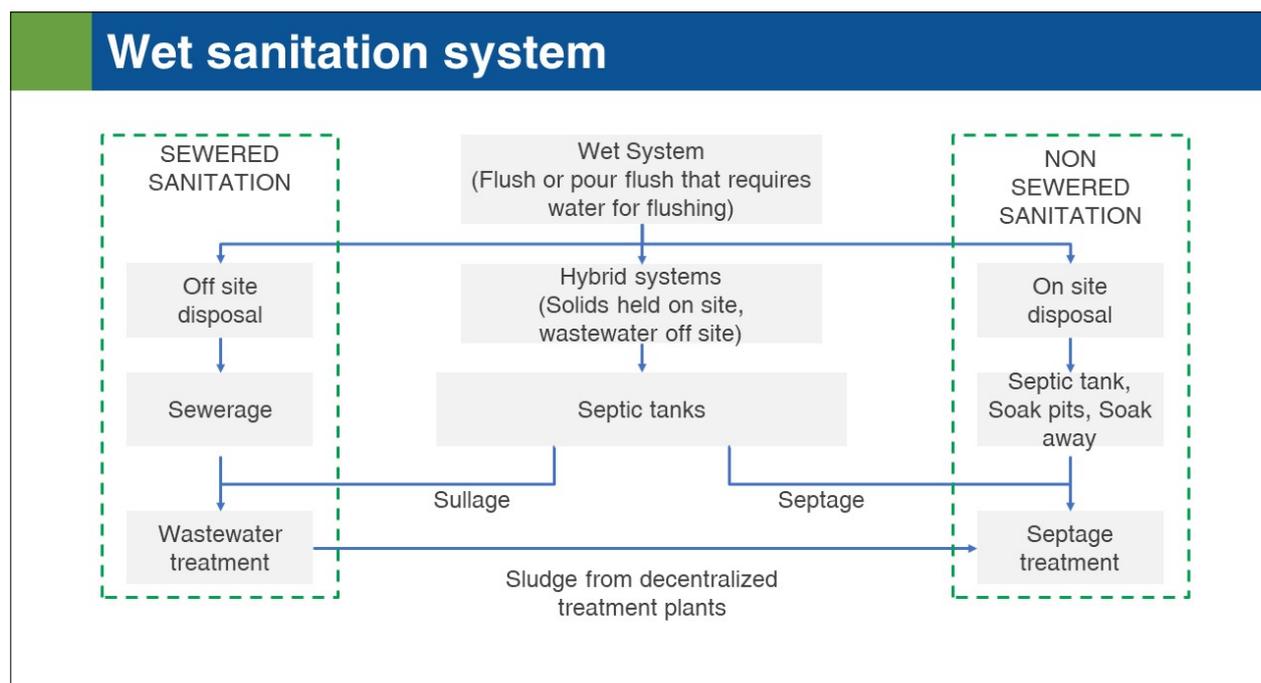


A sanitation system is comprised of (waste) products that travel through different sanitation units (functional groups) which contain technologies that can be selected according to the context. By selecting a technology for each product, one can design a logical Sanitation System. A sanitation system also includes the management, operation and maintenance (O&M) required to ensure that the system functions safely and sustainably. As the households pay for the environmental services through taxes or fees, affordability of the sanitation system plays a key role in ensuring sustainability of the project.



Sanitation Systems are broadly classified into two groups based on the requirement of water to flush the solids (human waste) from point of generation to point of disposal: (a) Dry system: In this system water is not used for flushing. Dry system further has three types depending collection, conveyance and disposal is done. (b) Wet system: In this system, water is used for flushing of waste. This system is further classified in to three types depending on the location of treatment and disposal.

In general, on site refers to treatment and disposal of the waste at the point of generation i.e., household level. Offsite refers to system where collection and conveyance of the waste is done to a location away from the point of generation. Here, the waste is treated and disposed or send to reuse.

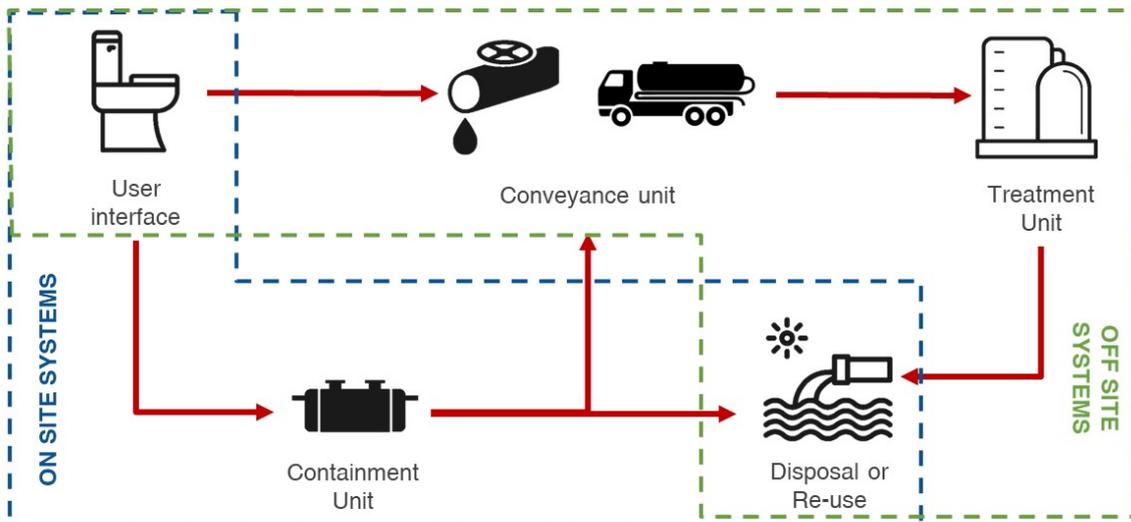


In case of “Off Site” disposal, the liquid and solids are carried away from the point of generation using sewerage network. The sewerage network brings the waste from all the households to one point where a wastewater treatment plant is set up. This type of system is called as sewered sanitation.

In case of “On Site” disposal, the solids are stored in the containment unit and the liquid effluent is disposed off into the ground using soak pits or soak away. After a duration of few years, the contained solids are emptied and transported for further treatment. Since this conveyance of solids is done by mechanised equipment such as vacuum trucks, this type of sanitation system is called as non sewered sanitation.

However, in India, we have developed a hybrid system where in the solids are contained in the septic tank at the household level and the sullage is disposed off into the drains outside the houses. The network of drains thus collects the sullage from all the households and by gravity brings it to the surface water body such as rivers, lakes and ponds. The septage from the septic tank is emptied after few years and transported by vacuum trucks for either treatment or direct disposal. Since a network of drains is involved for conveyance of the sullage, these systems cannot be classified as completely sewered or non sewered sanitation system.

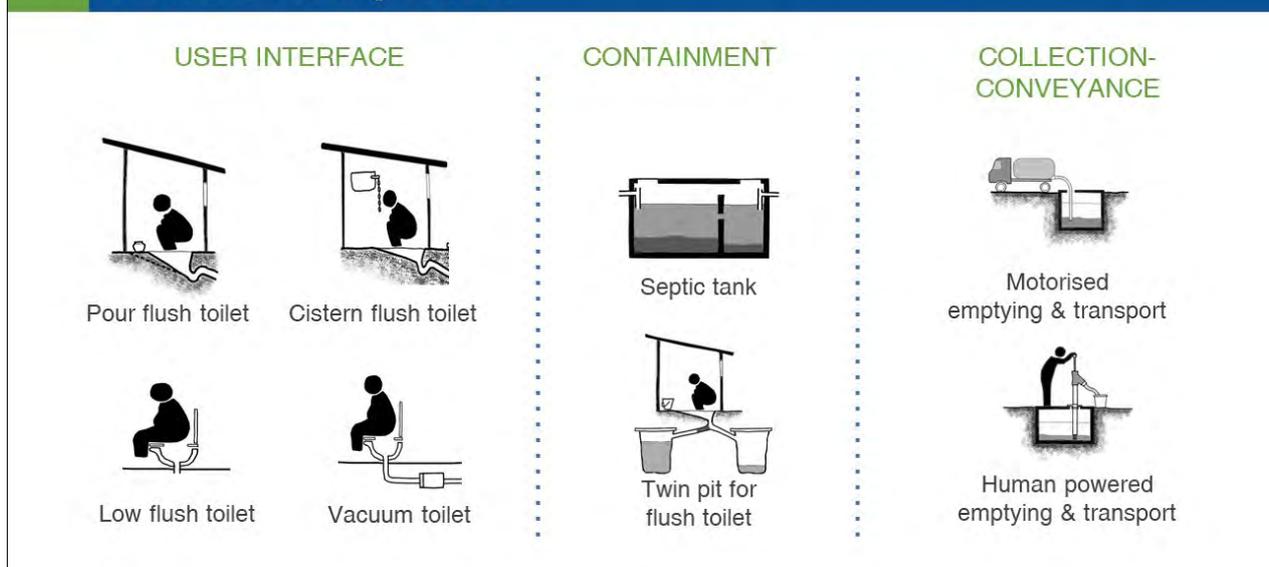
Functional groups



Various technologies which perform the same or similar type of function are called as Functional Groups. When different technologies from different functional groups are clubbed together, a sanitation system is made. Careful selection of the technologies needs to be done to make the sanitation system functional. A sanitation system should consider all the products generated and all the Functional Groups these products are subjected to prior to being suitably disposed of. Domestic products mainly run through five different Functional Groups, which form together a system.

A sanitation system consists of five different components as shown in the slide- User Interface, Containment Unit, Conveyance Unit, Treatment Unit and Disposal or Reuse. A sanitation system can be formed using three or more components. The options available under each component is listed in the boxes on the slide. We will be looking into different sanitation systems which will make the picture clearer as to how each component connects with other.

Technical Options



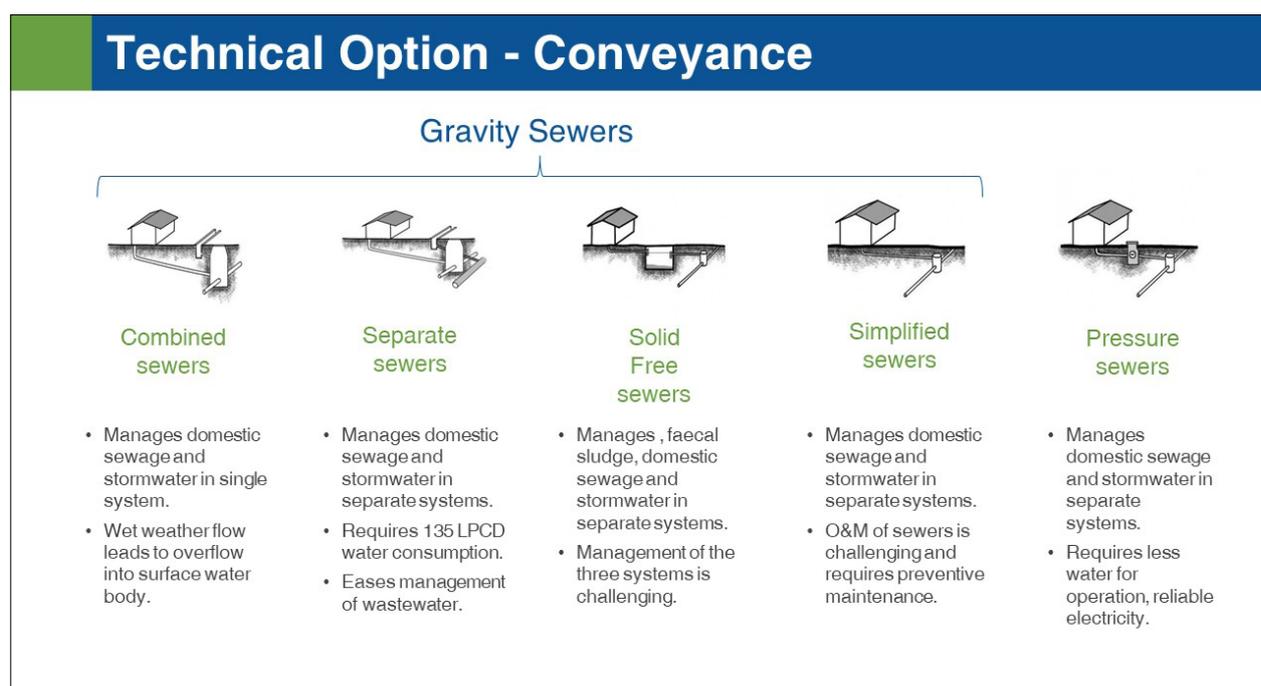
User interface refers to the unit where the waste products are introduced in to the sanitation system. Typically, it consists of different types of sanitary fixture in the toilet such as toilet, urinal or even a washbasin. Usually in wet sanitation system, user interface is the place, where the waste comes in contact with water for the first time. Depending upon the type of the interface and the amount of water mixed, the final composition and characteristic of the waste is determined. Choice of user interface is often perceived to be cost driven, however, lately due to increasing scarcity of drinking water, availability of water also determines the choice of user interface.

Containment refers to the technologies which are used for the collection and storage of the products generated at the user interface. In the case of extended storage, some treatment may be provided, though it is generally minimal and dependent on storage time.

All the units have to be either connected to conveyance or use/disposal function group for liquid effluent and to conveyance to solids.

All the units need to be emptied regularly (depending on the design criteria) for solids. These solids in turn need to be treated or processed before use/disposal.

Conveyance describes the way in which products are moved from one process to another. Although products may need to be moved in various ways to reach the required process, the longest and most important gap lies between on-site storage and (semi-) centralized treatment. For the sake of simplicity, conveyance is thus limited to moving products at this point.



The products generated at the user interface or in the containment unit are conveyed for treatment offsite. Different type of sewers is considered for conveyance of liquid waste from the flush toilets, bathrooms and/or septic tanks to the offsite location where treatment is done or appropriate disposal is done.

Following is the type of sewers:

A combined sewer is a sewage collection system of pipes, tunnels, and bodies of water designed to simultaneously collect surface runoff and sewage water in a shared system.

Separate sewer consists in the separate collection of municipal wastewaters (blackwater from toilets, greywater and industrial wastewater) and surface run-off (rainwater and stormwater).

A solids-free sewer is a network of small-diameter pipes that transports pre-treated and solids-free wastewater (such as Septic Tank effluent). It can be installed at a shallow depth and does not require a minimum wastewater flow or slope to function.

A simplified sewer describes a sewerage network that is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than Conventional Sewers. The simplified sewer allows for a more flexible design at lower costs.

Pressure sewerage systems consist of pumps which creates positive or negative pressure depending on the type of system. The different in the pressure, helps to convey the waste from one point to another. Example: Vacuum Sewers.

Disposal and/or reuse

End products may be used in industry, agriculture, aquaculture, as soil supplements or to generate energy from sludge

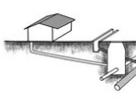
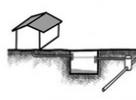
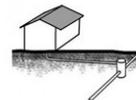
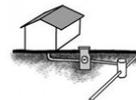
Industry	Agriculture	Bio solids
<ul style="list-style-type: none">• Thermal Power Plants• Manufacturing Plants• Cooling Towers	<ul style="list-style-type: none">• Agroforestry• Pisciculture• Aquaculture• Energy Crops• Non edible Crops	<ul style="list-style-type: none">• Energy• Soil Conditioner• Co composting

There are mainly three types of treated end products: (1) treated water, (2) treated bio solids and (3) fuel in the form of methane or biosolids.

Treated water can be mainly used in industry as process water and in agriculture. Industry such as thermal power plant and manufacturing plants use lot of water for processes. The treated will have to be further treated in some cases to meet certain additional standards as required by the process.

In agriculture, treated water and biosolids can be used in agroforestry. Treated water can very well be used for non-edible crops and energy crops. Pisciculture (fish farming can also be done in the treated water in a sustainable way. Biosolids can be mainly used as solid conditioner or as a raw material for co composting.

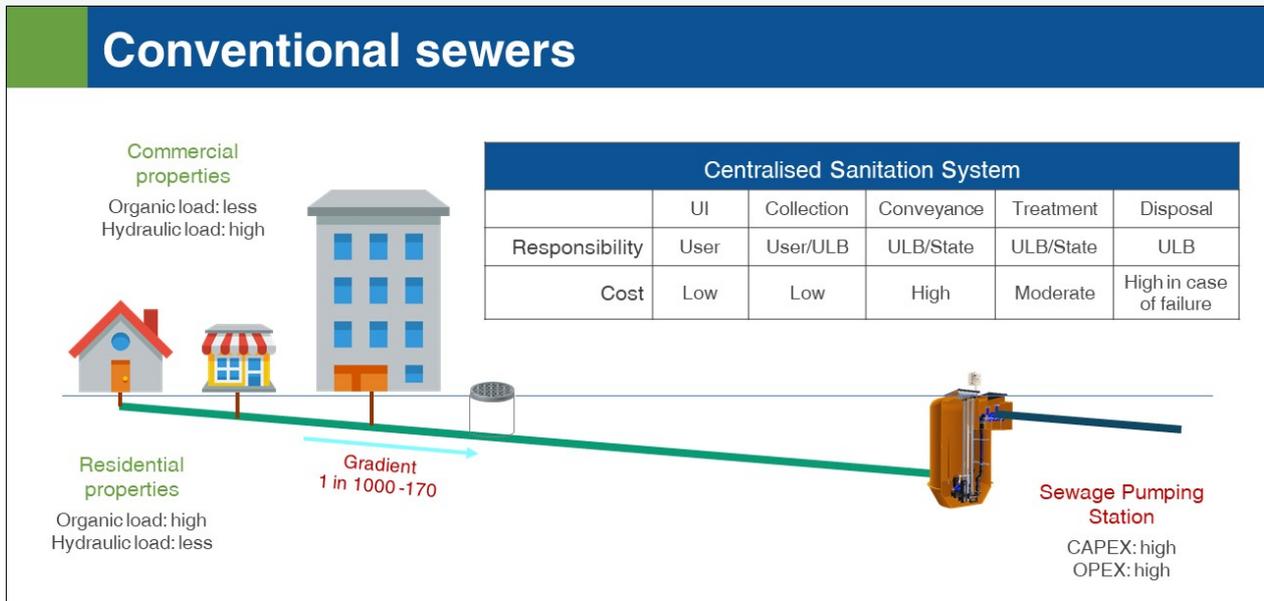
4.5 Sewered Sanitation

Sewerage Options					
Criteria	 Combined sewers	 Separate sewers	 Solid Free sewers	 Simplified sewers	 Pressurized sewers
Water Consumption					
CapEx	₹ ₹ ₹	₹ ₹ ₹	₹	₹ ₹	₹ ₹
STP Operation					
OpEx	₹ ₹	₹ ₹	₹	₹ ₹	₹ ₹ ₹
Management					

Various sewerage options are compared based on certain practical criteria:

- Water consumption:** Water consumption is very important factor which governs functioning of the sewers. Hence, CPHEEO Manual on Sewerage and Sewage Treatment recommends that water supply of 135 LPCD must be present or at least 100 LPCD of wastewater generation must happen for proper functioning of combined sewers or separate sewers. The slide shows the need of water for functioning of various sewerage options.
- Capital Expenditure:** This represents the cost of implementing the sewers in the same geography keeping all the key parameters such as topography, strata, groundwater table etc. constant.
- STP Operation:** Although STP can accommodate variation in the characteristics of sewage, too much variation is not good for the biological processes. In case of combined sewers, the characteristics of incoming influent will vary as per the precipitation and industrial discharge (if any). Thus, the STP operator needs to be knowledgeable about the processes and mitigation measure to be undertaken in case of variation.
- Operational Expenditure:** the collection and conveyance of wastewater is costly to operate and maintain as compared to its treatment. Combined and separate sewers have almost similar O&M procedures; however, pressurized sewers employ pumps and sensors which needs to be maintained at frequent intervals to avoid breakdown. Thus, its operational expenditure is the highest.
- Management:** The complexity of management is highest in case of solid free sewers. This is mainly because, to keep the sewers operational, the septic tanks at the household needs to be desludged at frequent interval for which scheduled desludging is required. This increases the challenges in management of the entire sanitation system.

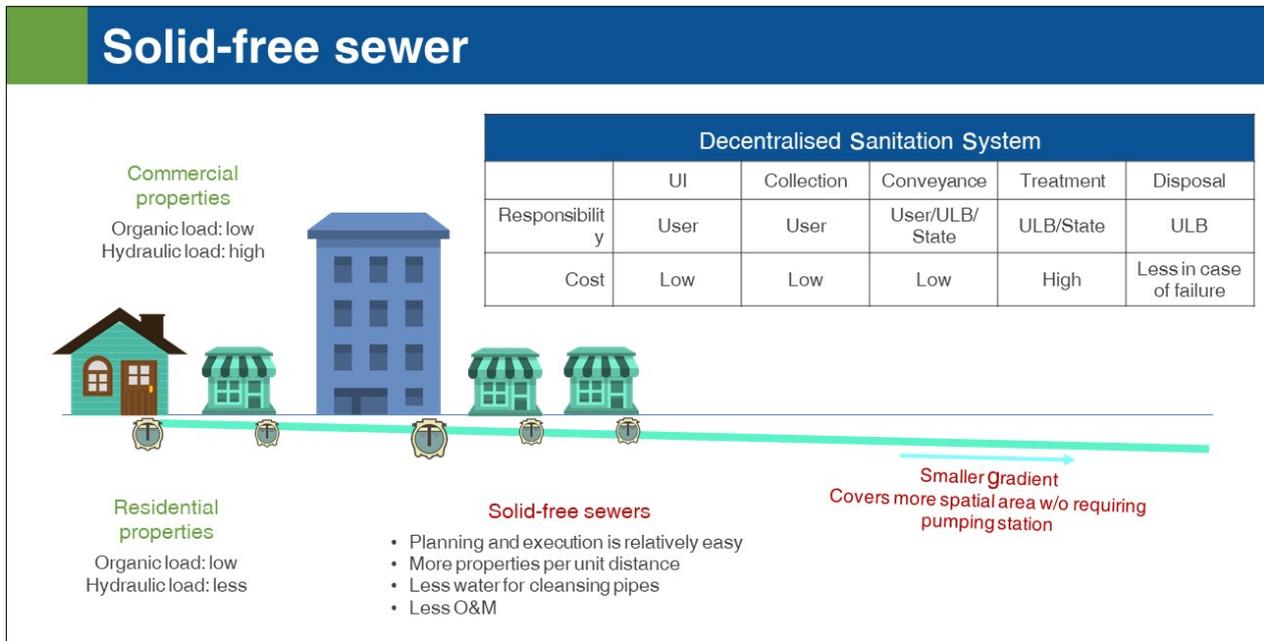
Conventional sewers



Conventional gravity sewers are large networks of underground pipes that convey blackwater, greywater and, in many cases, stormwater from individual households to a (Semi-Centralized Treatment facility, using gravity (and pumps when necessary).

The conventional gravity sewer system is designed with many branches. Typically, the network is subdivided into primary (main sewer lines along main roads), secondary and tertiary networks (networks at the neighbourhood and household level).

Solid-free sewer



A solids-free sewer is a network of small-diameter pipes that transports pre-treated and solids-free wastewater (such as Septic Tank effluent). It can be installed at a shallow depth and does not require a minimum wastewater flow or slope to function. Solids-free sewers are also referred to as settled, smallbore, variable-grade gravity, or septic tank effluent gravity sewers. A precondition for solids-free sewers is efficient primary treatment at the household level. An interceptor, typically a single-chamber Septic Tank, captures settleable particles that could clog small pipes. The solids interceptor also functions to attenuate peak discharges. Because there is little risk of

depositions and clogging, solids-free sewers do not have to be self-cleansing, i.e., no minimum flow velocity or tractive tension is needed. They require few inspection points, can have inflective gradients (i.e., negative slopes) and follow the topography. When the sewer roughly follows the ground contours, the flow is allowed to vary between open channel and pressure (full-bore) flow.

Components of Sewerage Network

Property Connection and Cleanouts

The diagram illustrates the connection between a house and the public sewerage network. It shows a 'Right-of-Way' boundary. On the property side, there is a 'Water Meter' and a 'Sewer Cleanout'. Inside the house, a 'Water Line' and a 'Sewer Lateral' are shown. The 'Sewer Lateral' connects to a 'Sewer Stub' which then joins the 'Sewer Main' in the 'Public Utility' area. A 'Manhole Cover' is also shown on the public utility side. A legend indicates that blue represents 'Drinking Water' and orange represents 'Wastewater'. Source: Gwinnett County.

Type of Machine Holes

- **Shallow Holes**
 - Inspection chambers
 - < 0.9 m depth
 - Start of branch
 - Not heavily trafficked surface
- **Regular Holes**
 - Maintenance activity
 - < 1.5 m depth
 - Heavily trafficked surface
- **Deep Holes**
 - Connecting branches at various levels
 - > 1.5 m depth
 - Need safety equipment for entry
 - Incorporate heavy cover

Property connections and cleanout: This is a vital component of any sewerage system. Without property connections, the system cannot be made functional. Property connection can be charged to the household as onetime fee, or spread over few years in the tax or can be subsidized or completely covered under the project. While providing household connection, plumbing must be below the level of water connection pipe and a cleanout shall be placed at appropriate place.

Machine holes (also known as manholes) are the commonly used maintenance utility underground structures to provide access to installed pipelines for inspection and preventive maintenance. There are three types of machine holes: (a) Shallow holes: these are mainly used for inspection and cleaning and are placed at the start of branch under the foot path or sidewalk. (b) Regular holes: these are mainly used for carrying out preventive maintenance such as jetting and dredging of silts. These are mainly placed on main line and are placed under motorable road. The covers of such holes are heavy duty covered and should be able to withstand the load coming from top. © Deep holes: these are used where two or more pipes at various levels are meeting. The depth is more than 1.5 m and hence special equipment such as tripod (or davit arm) is recommended for entry procedures. The cover for these holes should not only be heavy but shall also have lock and key arrangement, so that only authorized person can open and enter.

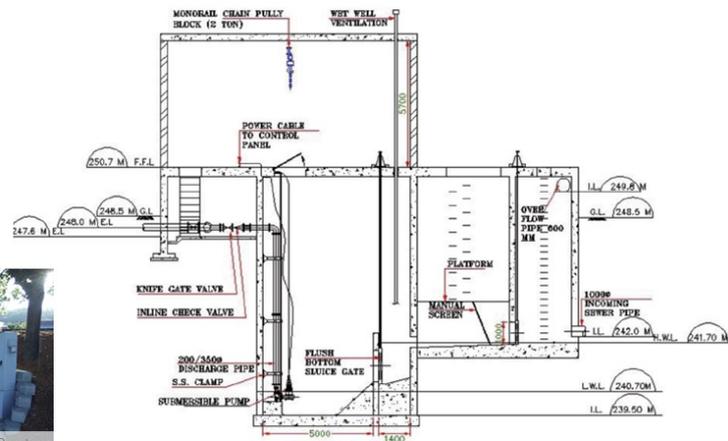
Types of Pumping Stations

Lift Station



Source: Romtec Utilities

Pumping Station

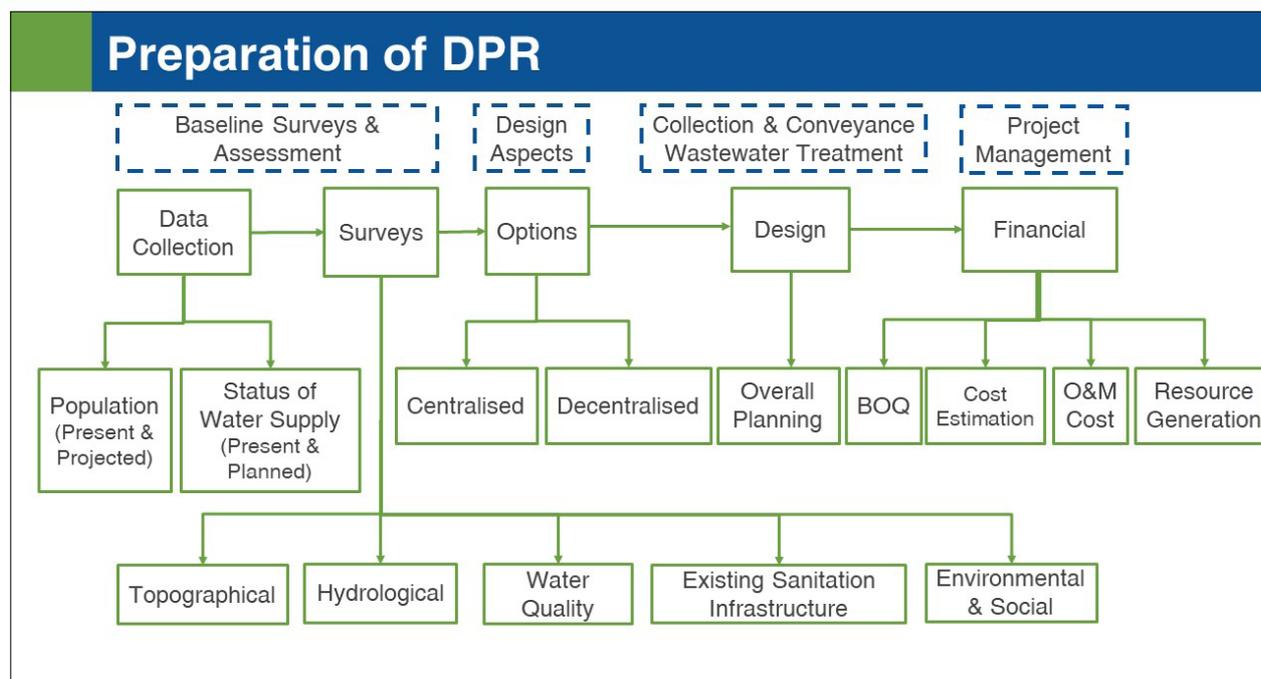


Source: Manual on Sewerage and Sewage Treatment, CPHEEO (2013)

Lift stations are used in gravity sewer network where depth of cut of sewers poses a problem in high water prone areas. The procedure is to sink a wet well on the road shoulder or an acquired plot after the shoulder and divert the deeper sewer there. The submersible pump will lift the sewage and discharge it to the next on-line shallow sewer. This is a very useful practice in such locations. Equipment located in the wet well should be minimized, including suction and discharge valves, check valves, or other equipment that require routine, periodic maintenance. This equipment can be located in separate and suitable dry pits located adjacent to the wet well to facilitate accessibility and maintenance for the operator.

Pumping stations are either as in-line for lifting the sewage from a deeper sewer to a shallow sewer or for pumping to the STP or the out fall. They are required where low lying development areas cannot be drained by gravity to existing sewerage infrastructure, and/or where development areas are too far away from available sewerage infrastructure to be linked by gravity. The O&M of pumping systems presented here applies to all such types of pumping stations.

4.6 Stages in DPR preparation



ULBs are to prepare DPR for Wastewater Management (including Faecal Sludge & Septage Management) of their city in consultation with state governments. Smaller cities can form clusters to become viable entities to attract private investment. State/ULB will be required to prepare Detailed Project Report (DPR) for the solutions identified in CSP. The sub sequent sessions will cover all the stages for DPR preparation.

Summary

- CWIS approach emphasizes on the whole sanitation service chain for a 'safe management' of human waste.
- CWWIS focuses on mainly on Wastewater Management along with FSSM as per SBM 2.0 guidelines.
- Centralized and decentralized approach for city sanitation zone depends on the local condition and viability of the same shall be carried out in CWWIS and/or DPR.
- Conveyance infrastructure is complex and CapEx and OpEx intensive. Hence, its viability shall be checked in detailed.
- Detailed Project Report of a city under SBM 2.0 includes data collection, surveys, treatment options, designs and financial aspects.



Session

05

Baseline Survey and Assessment

5. Baseline Survey and Assessment

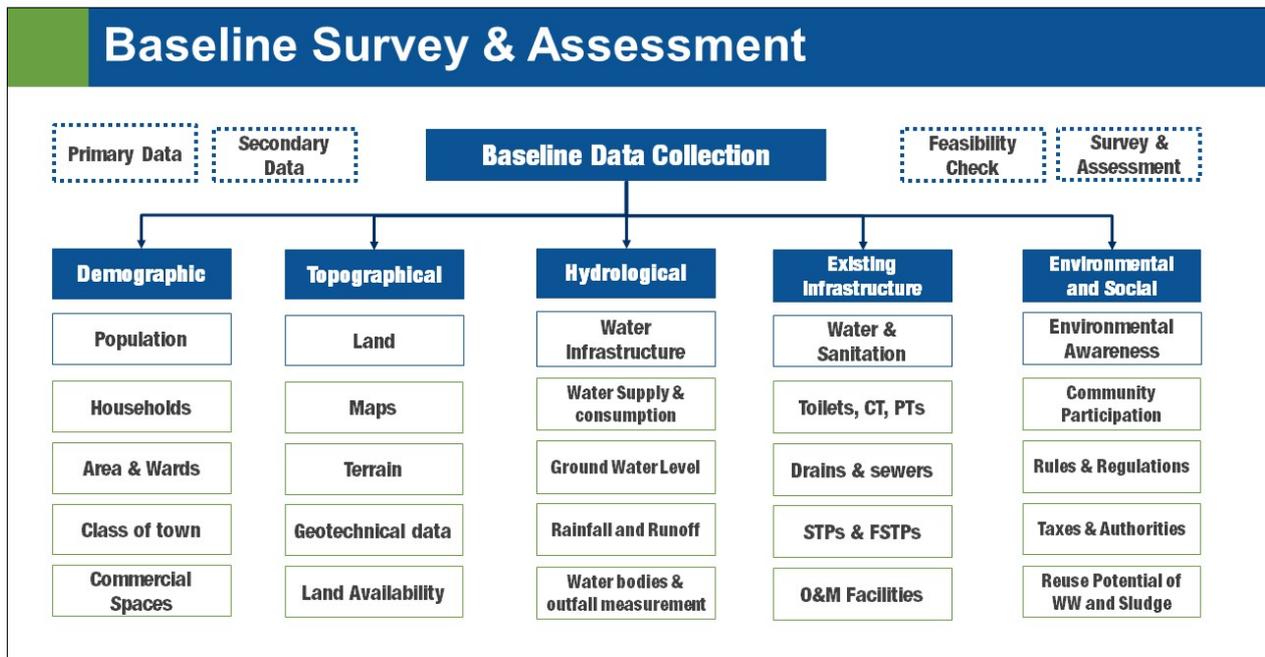
Learning objectives

- To understand the approach for identification of project area and collection of baseline information
- To know data assessment for the gap identification and selection of technological solutions

Contents

- Identification of Project area
 - Demographics
 - Hydrology and Geographical features
 - Sources of Data
- Application of Remote Sensing and Geographic Information System (GIS)
 - Application in City Mapping
 - Application in Sanitation and Water Management
- Access to Water and Sanitation
 - Access to Water
 - Access to sanitation
- Investigation and Pollution Monitoring
 - Soil and Groundwater investigation
 - Bulk Generators and Consumers

5.1 Identification Of Project Area



Baseline data collection consists of five components: (a) demographics, (b) topographical data, (c) hydrological data, (d) existing infrastructure and (e) environmental and social data. In each section we have several data points which will be looked in to in detail in this session.

Project Area

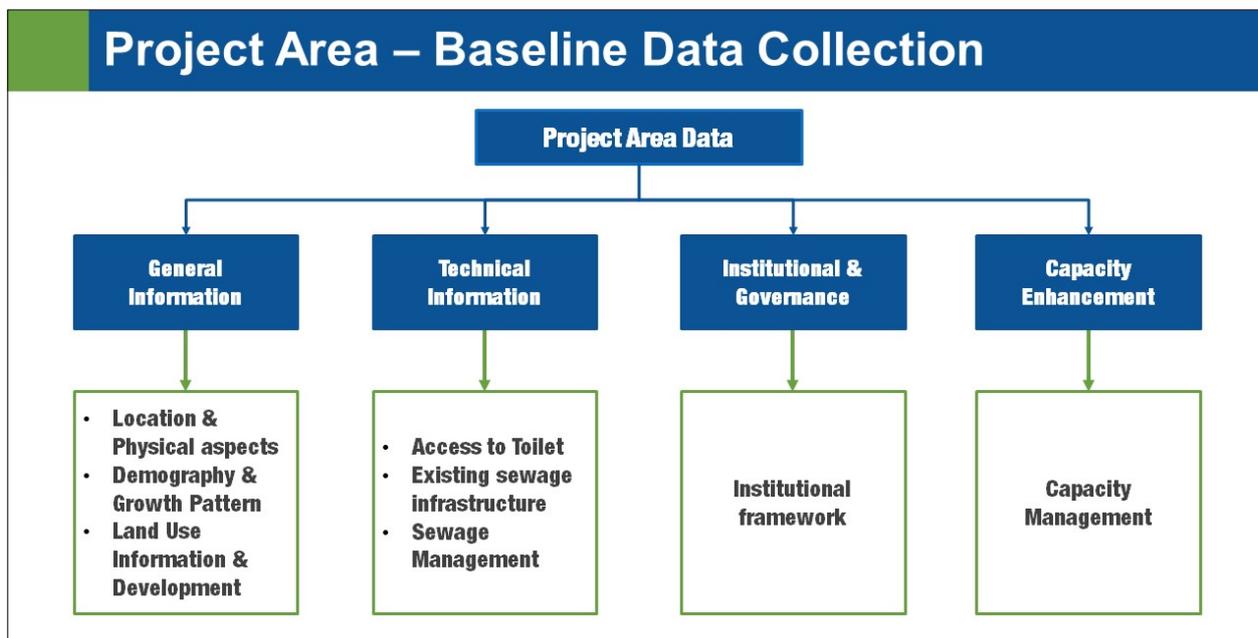
Identification of Area

- Existing coverage of Sewer System
- Intercepting Drains & Diverted to STPs
- Non Sewered Area

Demarcation of project area is utmost important

The identification of the project area after studying the available data and priority needs is the important step. Considering the wastewater management approach, i.e., sewer network system with sewage treatment plants (STPs) or intercepting the urban drains and treating the diverted sewage in the STP, the concerned administrative agencies need to demarcate the project area and the data collection has to be initiated.

In case of I&D, there are possibilities that the identified project area might be from the ULB's administrative boundaries or out of the boundaries as it is difficult to limit the contributing pollution sources of the drains which is subsequently polluting the river. It is utmost important to precisely demarcate the project area so as to correctly project design population, sewage flows and design proposed works. The project area under consideration should be clearly marked on a map of the city so that the area can be measured and considered in the project planning.



For the selected project area following are the data sets that need to be collated: (1) general information pertaining to location and physical aspects, demographics etc. (2) statistical information such as access to water, toilet and other infrastructure in place to manage wastewater, (3) institutional and governance- which deals with the roles and responsibilities of various agencies involved in the project, (4) capacity enhancement- building capacity of those are involved so as to implement and sustain the project.

Project Area: Baseline Information

Baseline Data Required

- Locations
- Historical Information
- Demographic Information
- Hydrological features
- Geographical features
- Climatic conditions
- Landuse / Landcover
- Socio-economic activities

Source: Surat City, Google Image
Image © 2021 Maxar Technologies

It includes the baseline information required for the identified project area in the preparation of Detailed Project Report (DPR). This kind of baseline information can be collected from the different sources e.g., planning documents i.e., city master plan, City Development Plan (CDP), City Sanitation Plan (CSP), DPRs etc. The respective documents can be collected from different concerned administrative agencies i.e., Urban Local Body (ULB), Urban Development Department (UDD), Town Planning Department (TPD), Pollution Control Board (PCB), Survey of India, Meteorological Department, Water Resources Department, Agricultural Department etc. This baseline information is important to understand the project area and designing of the wastewater management system.

Project Area: Baseline Information

Demographic Information

- Population
- Household
- Decadal population growth
- Population density
- Area (sq.km)

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Ward wise data helps to make a reliable CSP and DPR.

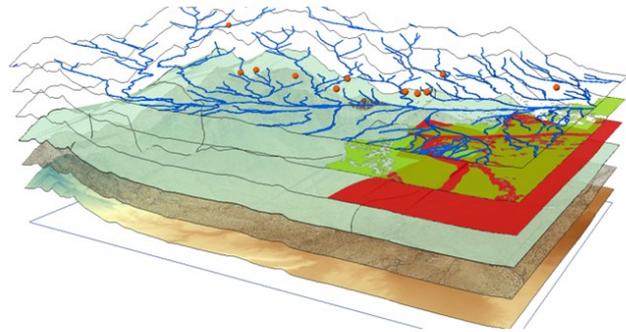
Source: Priyanka P Patel, International Journal of Engineering Research, No.5, Issue No. 6, pp-447-451

This includes the list of demographic information required while preparing detailed project report. The demographic information is a crucial data set for the population projections and designing of the wastewater management systems. The baseline information is available with the ULB and in Census of India. The two pictures in the slide are the map of city with different wards and their population (in shades blue) and population density (in shades of green). Such heat maps can be prepared when the data is collated on to a GIS platform. Heat maps help us to visualize data at macro level.

Project Area: Baseline Information

Hydrology and Geographical Features

- Topography
 - Plain, Terrain, Hilly region
- Elevation
- Landuse / Landcover
- Hydrological features
 - Rivers, Lakes
 - Drainage area
- Watershed area



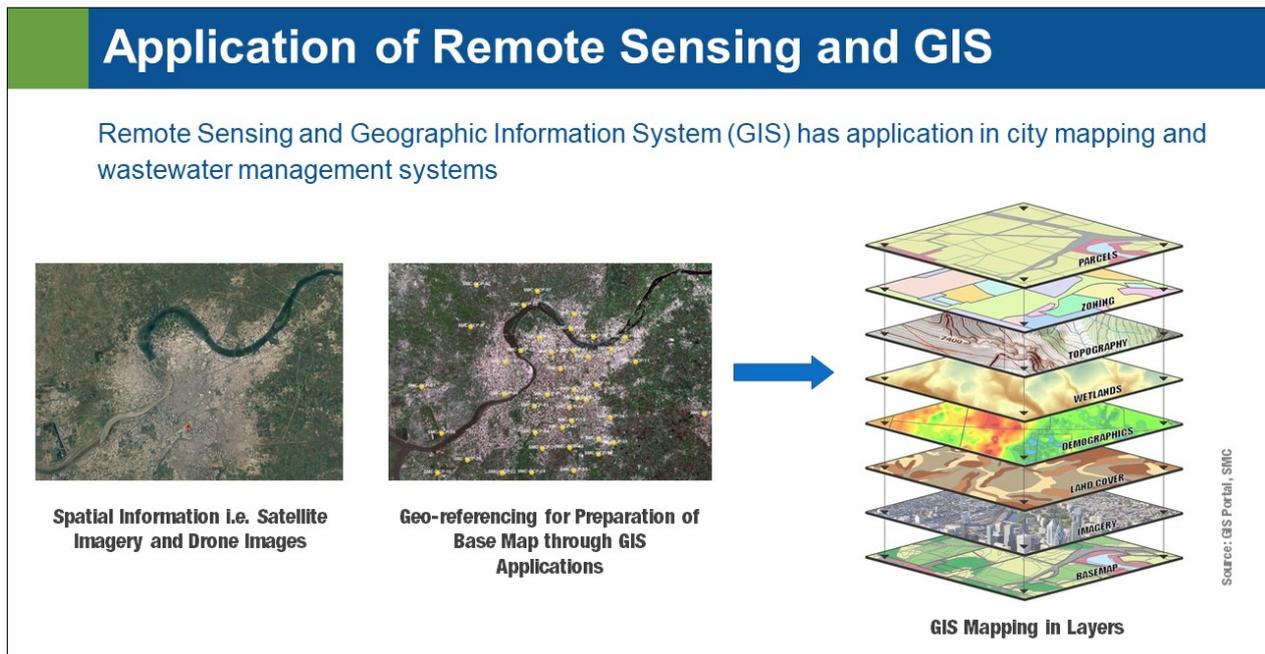
It includes the list of hydrological and geographical data required for the preparation of DPR. The topographical, elevation and land use / landcover data of the project area represents the morphometric characteristics of the hydrological features i.e., rivers, lakes, drainage basins etc. In wastewater management using gravity sewers, topography plays an important role a gently sloping gradient allows to have a smaller number of pumping stations and there by decrease the overall project cost. The features such as surface water bodies are also important in case of centralized wastewater management approach. They act as a disposal point for the treated water. The STP in centralized approach treats high volumes of wastewater and most of it needs to be discharged into the water body. The water body shall be adequately large and capable of handling the BOD and nutrient load coming from treated water.

Sources of Data

- Central and State Pollution Control Boards.
- Water Resources department for drainage basins and rivers.
- District planning office
- District officers of agriculture, forests etc.
- Survey of India topographical sheets
- India Meteorological Department
- State Remote Sensing Agency
- Census Office / Library
- Urban Local Body
- Parastatal bodies i.e. Jal Sansthan, Pey Jal Nigam, MJP, PHED etc.
- Central and State Ground Water Board
- Urban Development Departments
- Water & Sewerage Board / Authority
- Technical Institutions and Universities
- Households / Bulk Generators
- Desludging Service Providers

These are the different sources of baseline data required in the preparation of DPR for wastewater management system at city level or regional level. These respective administrative agencies or departments usually has the baseline information (primary or secondary data) in the different formats e.g., planning documents/reports or monitoring and evaluation through digital platforms, varied thematic maps etc.

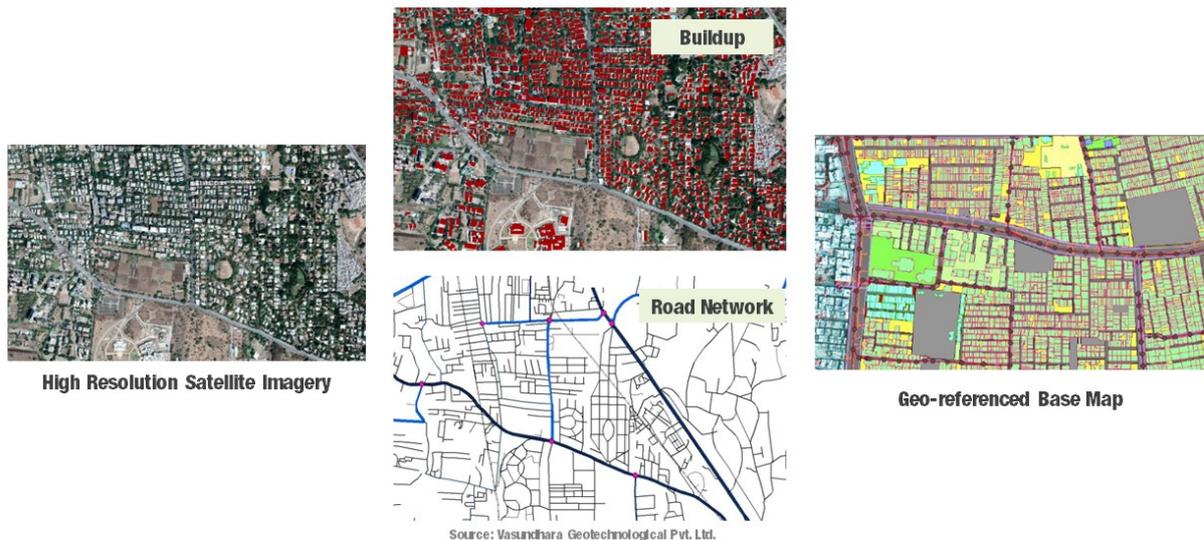
5.2 Application of Remote Sensing and Geographic Information System (GIS)



Remote Sensing Technology coupled with geographic information system (GIS) has opened up new vistas of adopting geo-spatial database for effective planning and execution of various projects. GIS can also be further used during O&M phase of the projects for real time monitoring of the system. These tools can effectively support the urban planners, technical engineers, decision/policy makers in the development of sanitation infrastructure and water management systems.

The remote sensing is the acquisition of information about an object or phenomenon without making physical contact with it. Geographic information system (GIS) is the conceptualized framework which provides the ability to capture, manage and analyse spatial and geographic data. GIS applications are computer-based tools that allow the user to store and edit spatial and non-spatial data, analyse spatial information output, and visually share the results of these operations by presenting them as thematic maps. The data is stored in the form of layers which can be overlapped on a base map. Examples of such layers is land use, demographics, surface water bodies, groundwater table etc. These layers can also be embedded with data in form of attributes. For example; land use layer can have population density as an attribute, groundwater table can have depth, salinity, TDS etc as attributes.

GIS Application: City Mapping

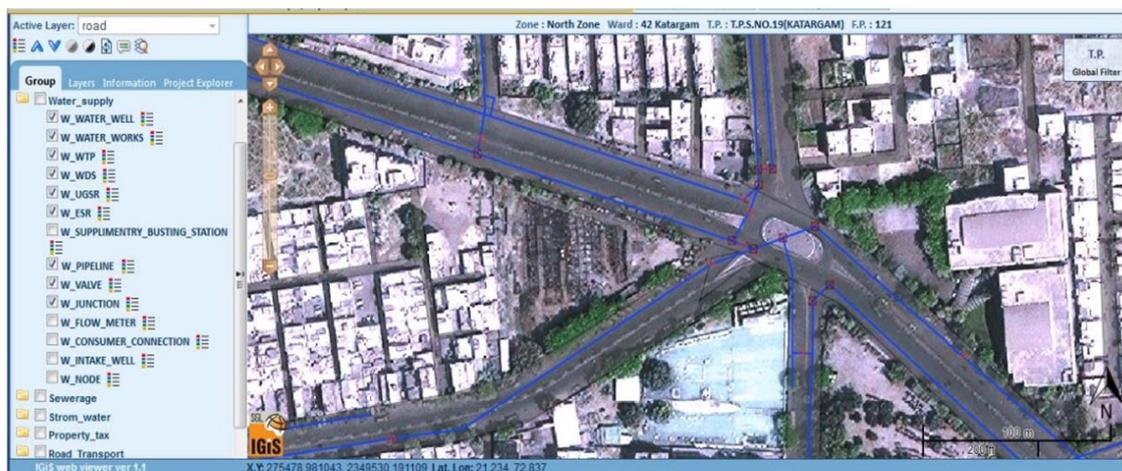


This slide represents the application of Geographic Information System (GIS) in city mapping. GIS tools can extract varied information through high resolution satellite imagery or drone imagery and can represent the city level data set like land use or landcover, build-up areas or other urban infrastructure, hydrological and geographical features, etc. The GIS tool can also integrate the specific city level information pertaining to natural and built environment with spatial information and it can be represented in form of thematic maps and tables.

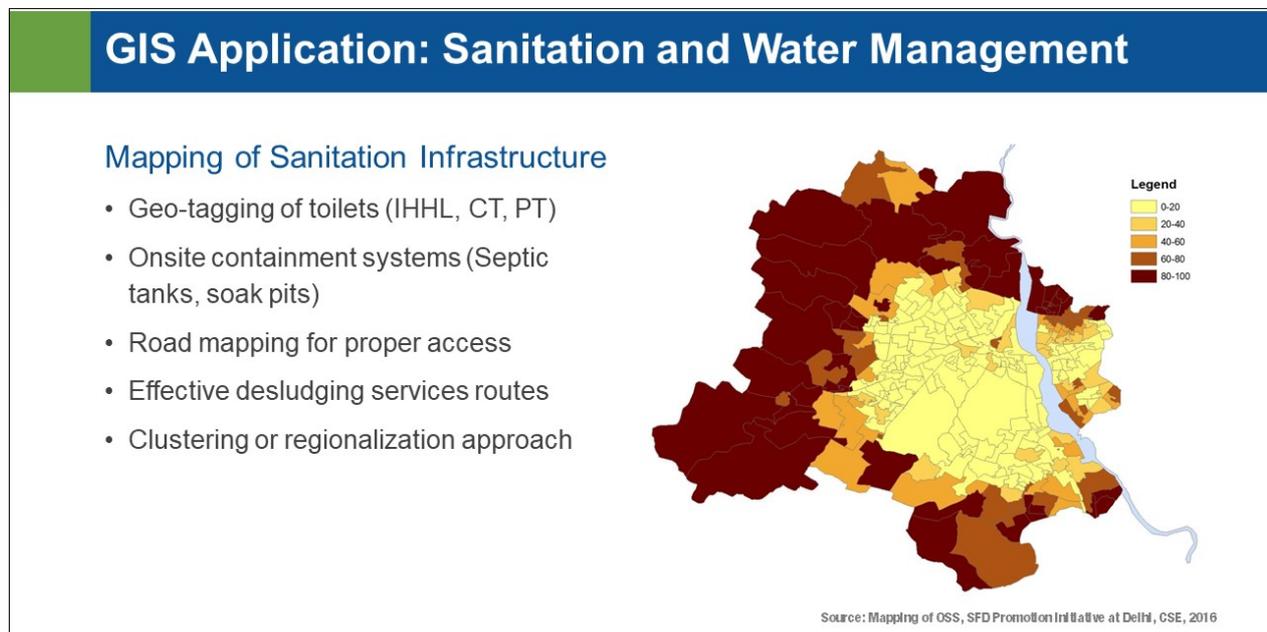
From a single image, road network, number of building structures and similarly, water bodies such as lakes and drains etc. can be extracted. These layers can be attributed with statistical data procured from different organizations to visualize a large amount of data in an image format.

GIS Application: Sanitation and Water Management

Mapping of Water Supply System



This slide represents the application of GIS in water and sanitation management while providing essential environmental services to the citizens. It represents the integration of water supply system dataset i.e., water supply pipelines, junctions, water meters, water treatment plants etc. with the georeferenced spatial data inform of thematic map (Source: GIS Portal, Surat Municipal Corporation)



This slide represents the application of GIS in water and sanitation management while understanding available sanitation services in the city or area. It represents the integration of sanitation infrastructure dataset i.e., type of toilets (IHHL, CT, PT, etc.), the onsite containment system (i.e., septic tanks, soak pits, anaerobic baffle reactors, etc.), road mapping for proper access of onsite sanitation facilities to services providers, effective desludging services with route optimization, mapping of clustering or regionalization approaches, etc. with the georeferenced spatial data inform of the thematic map.

GIS Application: Sanitation and Water Management

Mapping of Sanitation Infrastructure and Sewage Management



This slide represents the application of GIS in sanitation and water management in urban planning. It represents the integration of sanitation and sewerage management dataset i.e., sanitation infrastructure like IHHL, community and public toilets, on-site containment systems like septic tank soak pits, collection and transportation systems like existing sewer network, manholes, sewage pumping stations, rising mains, sewage treatment plants (STPs) etc. with the georeferenced spatial data inform of thematic map (Source: GIS Portal, Surat Municipal Corporation). GIS tool is also useful for the modelling of sewer network and other infrastructure.

Under SBM 2.0 guidelines, ULBs or para statal bodies has to utilize the GIS application and need to prepare the thematic maps while preparation of DPR of wastewater management system. It would help in visualizing the project area with proposed solutions, fast-moving decision-making process and finalizing appropriate sewer network system without disturbing other infrastructure.

5.3 Access to Water and Sanitation

Access to Water

Sources of Water



Reservoirs



Rivers



Borewells

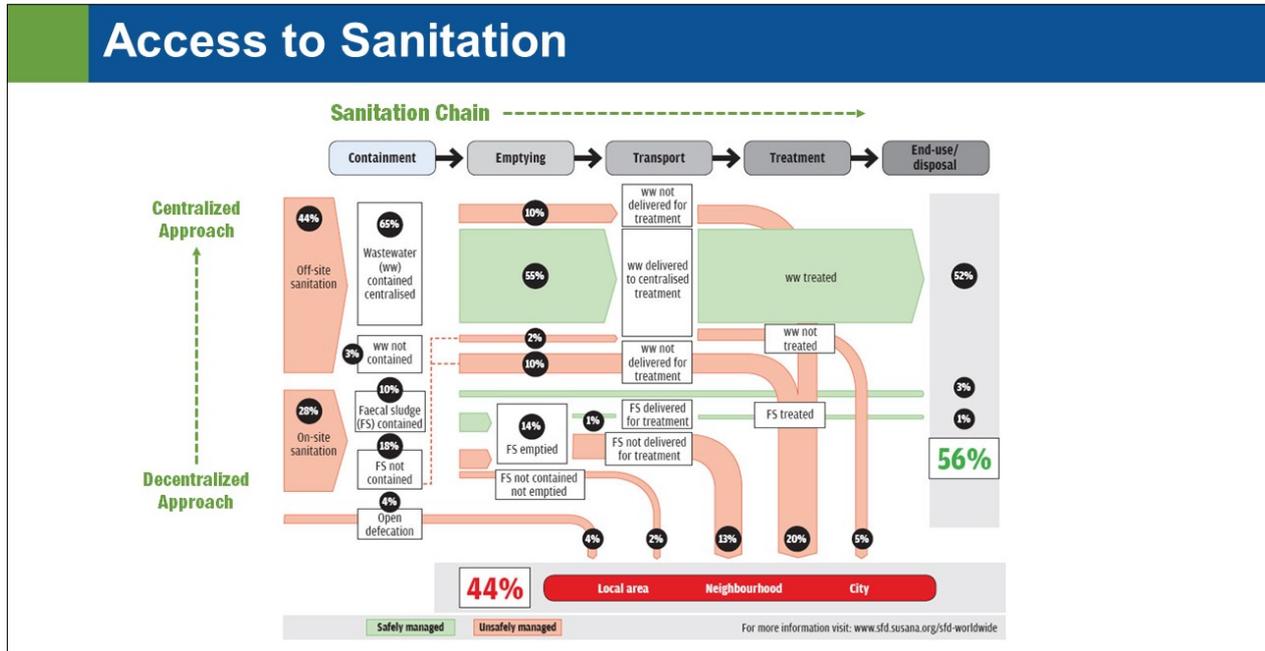


Dugwells

Required Data

- Existing sources of water
- Existing water supply systems
 - Water treatment plants capacity (MLD)
 - Water connections (No.)
 - Water supply network (kms)
- Water consumption (LPCD)
- Augmentation plan of water supply

This slide includes the list of data sets required to understand the status of access to water in the project area. It helps to understand the existing water consumption/person/day, existing water supply infrastructure like water connections, coverage of water distribution network, existing water treatment plant(s) (WTPs) and any proposed plan for the augmentation of water supply.



The details of existing sanitation infrastructure at city level or project area level are the necessary dataset while planning for wastewater management system. The sanitation infrastructure includes access to toilets (i.e., IHHL, CT and PT), existing collection and conveyance of the sewage. This shit flow diagram represents the access to sanitation accepts with respect to sanitation value chain. The details need to be collected from the data sources like city master plan, city development plan, city sanitation plan or detailed project report of sewerage system projects etc.

Access to Sanitation

Data required

- Details of existing sewerage system
 - Coverage of sewer network
 - Number of sewage pumping stations (SPS), Manholes, Rising Mains
 - Designing details and year of commissioning
- Number of drains out falling into the rivers, lakes
- Number of drain interceptions and diverted to STPs
- Existing components i.e. manholes, sewage pumping stations, rising mains, sewage treatment plants
- Sewage treatment plants (STPs) – designed capacity, technology, treatment efficiency
- River stretches and quality of water

This slide includes the list of data sets required to understand the status of access to sanitation in the project area or at city level. The details of the existing sewerage system like coverage of sewer network, sewage pumping stations, manholes, rising mains, existing STPs need to be collected. The existing drains out falling into the surface water bodies i.e., rivers or lakes etc. also need to be monitored.

The administration needs to understand the existing situation of rivers and the polluted stretches. The water quality monitoring is necessary to assess the current water quality and the extent of improvement that can be achieved through interventions proposed in the DPR. The sampling for water quality should be from well-mixed section of the river or in the main stream; 30 cm below the water surface to represent accurate impact.

5.4 Investigation and Pollution Monitoring

Soil and Groundwater Investigation

Soil and Groundwater Investigation

- Necessary for planning and designing sewerage system and STP
- Required at all sites i.e. laying of sewers, sewage pumping station, sewage treatment plants

Required Parameters

- Soil type and characteristics
- IS classification, dry and wet content, water content, specific gravity, permeability
- SBC – standard penetration test
- Ground water levels (pre-monsoon and post-monsoon)

Source: IS Code 1892: 1979 for Sub-Surface Investigation for Foundations



Soil and groundwater investigation shall be carried out at all the identified sites for deep Sewers, Sewage Pumping Stations (SPSs), STPs and locations having dispersive soil characteristics. For laying deep sewers, soil and groundwater investigation and test bores need to be carried out at suitable intervals along the alignment of sewers to ascertain the type of soil at different depths, behaviour of groundwater table and Soil Bearing Capacity (SBC). The information about groundwater levels and their fluctuation should be obtained along the river bank where the interception sewer needs to be laid. The levels should be recorded pre monsoon and just after the monsoon when the levels are the highest. Soil and groundwater investigation report should include soil description i.e., type, classification and characteristics, SBC, pre and post monsoon groundwater levels etc. These investigation reports are important for structural design of the components and thereby its cost.

Bulk Generators and Consumers

- Bulk generators of sewage and consumers of end products
- Identification of commercial and industrial establishments
- Mixing of industrial effluent with domestic sewage - adversely affects water quality
- Difficulty in designing - sewer network and I&D based wastewater management projects

Data required

- Industrial wastewater discharge and characteristics
- Effluent from commercial establishments

Data Source

- Pollution control boards (PCB)

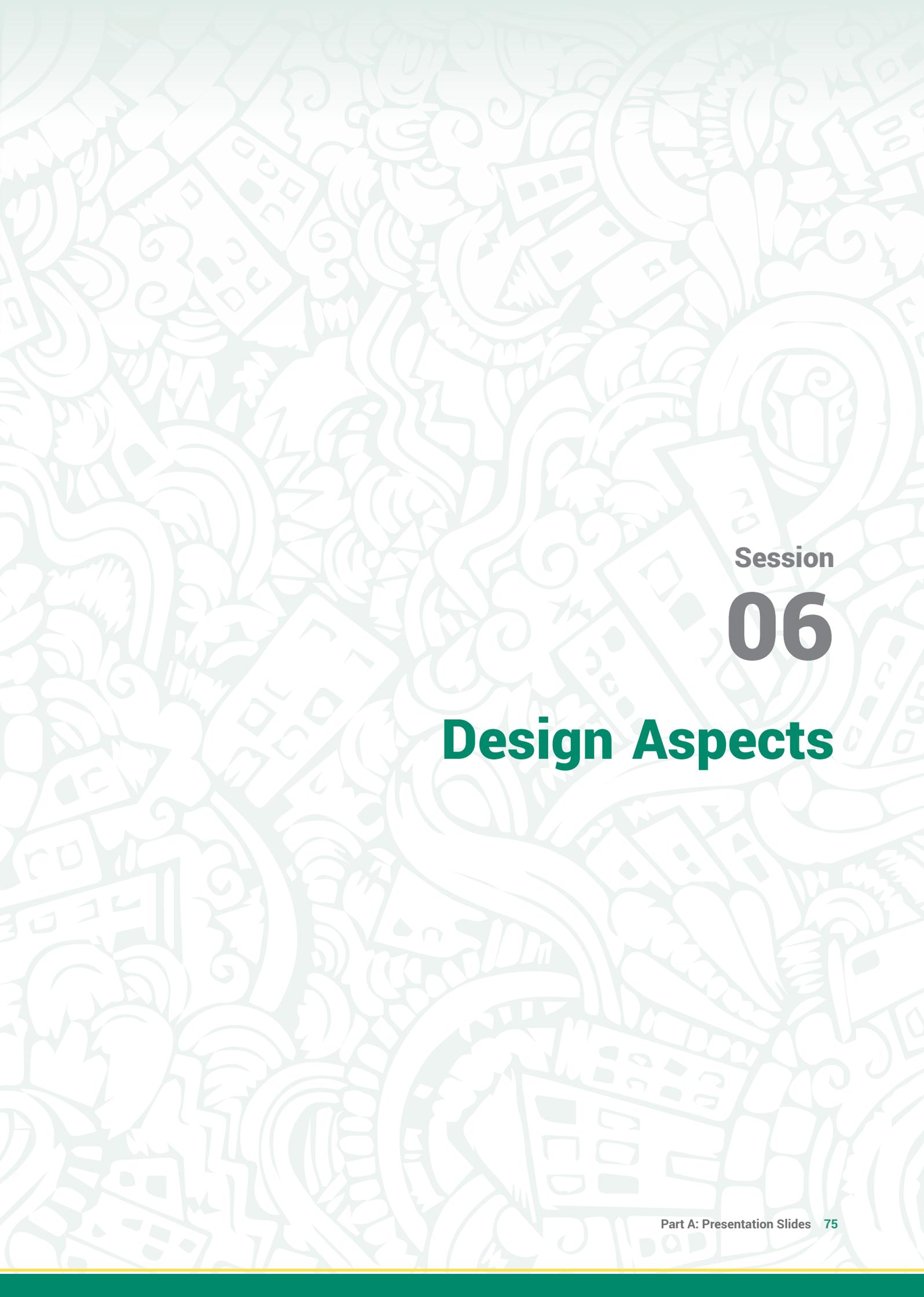


Apart from domestic pollution sources, it is important to identify and monitor the commercial and industrial for pollution. Depending on the nature of the activity that is undertaken in the city or project area, appropriate parameters need to be monitored in the water samples drawn from the drain or the river.

The mixing of industrial effluents with domestic sewage adversely affects the sewage treatment process. In such cases, necessary corrective / enabling actions need to be adopted and the flow parameters should be measured accordingly before finalizing the treatment technology for the sewage treatment plant (STP). The data related to industrial wastewater, points of discharge into the sewer network/drains etc. can be provided by the state or regional pollution control boards or concerned government bodies.

Summary

- Appropriate baseline data collection and assessment is important for identification of project area and selection of technical solutions.
- Application of GIS for sanitation and water management projects can play crucial role in rapid decision making
- GIS mapping simplifies the process of visualizing and understating the project area
- Baseline data of existing infrastructures, gaps identification and site investigation are the necessary aspects for the preparation of detailed project report on wastewater management systems.



Session

06

Design Aspects

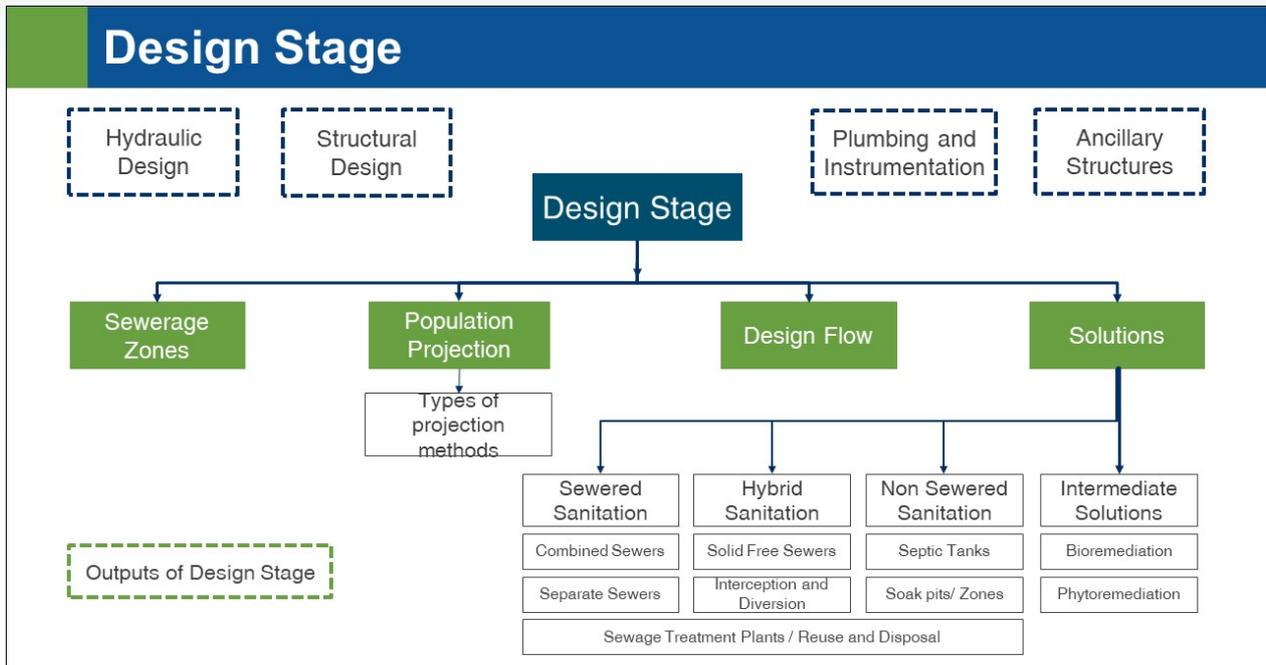
6. Design Aspects

Learning objectives

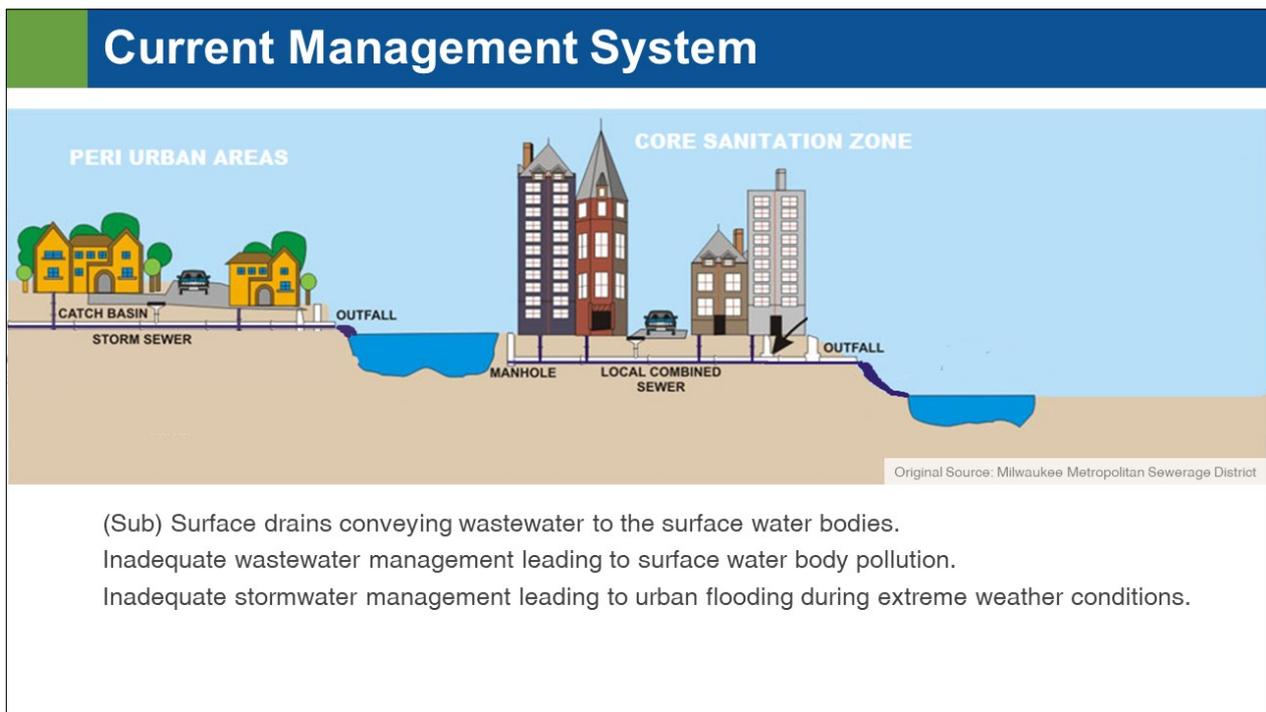
- To understand the basic principles of developing wastewater management options using sanitation systems approach.
- To introduce in situ treatment technologies as intermediate solutions for wastewater treatment.
- To understand different reuse options considering circular economy
- To understand various population projections techniques and their application.

Contents

- Developing Options
- Water Consumption vs Water Supply
- Population Projection
- Design Periods
- Intermediate Solutions
- Reuse Options – Circular Economy

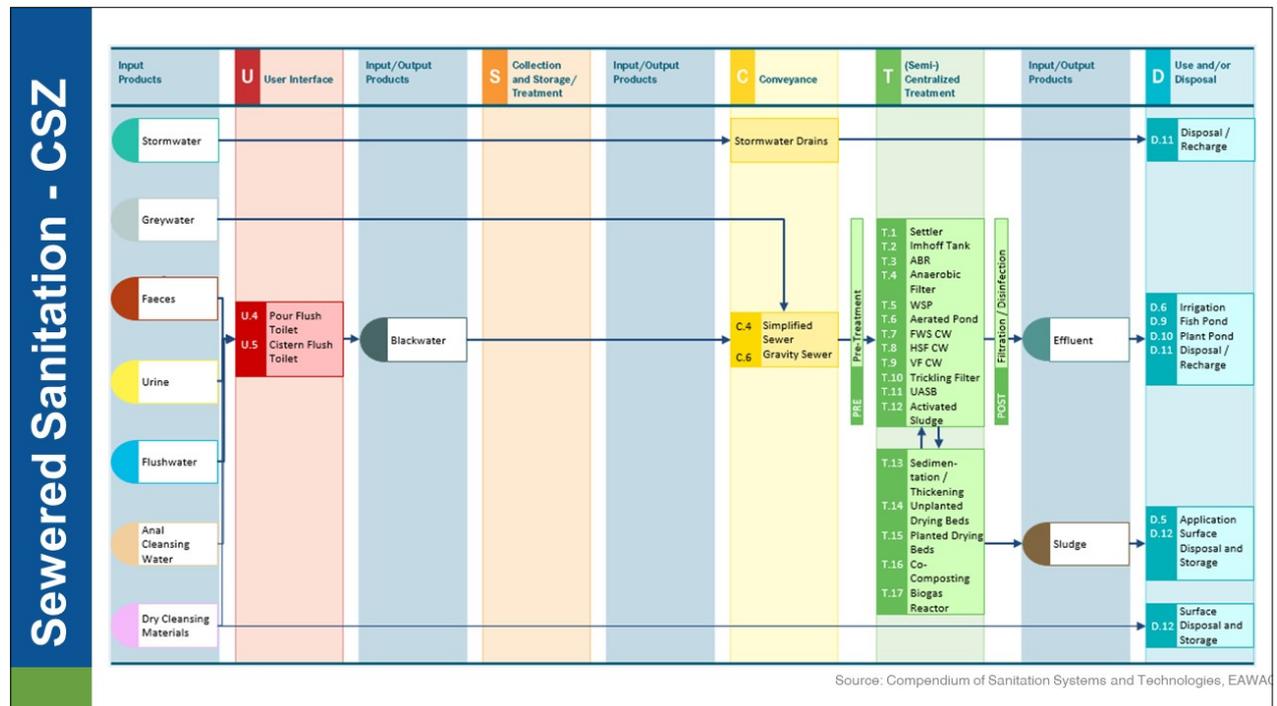


6.1 Developing Options



The rapid pace of urbanization in towns and cities is not matched by the rate at which implementation of wastewater management infrastructure takes place. Currently, most of the towns are served using network of stormwater drains which carry the wastewater from the households to the lowest point i.e., a surface water body such as a lake or a river. Few towns do have partial sewerage network with or without a STP at the end of the network. As a result of which, most of the rivers are polluted in India.

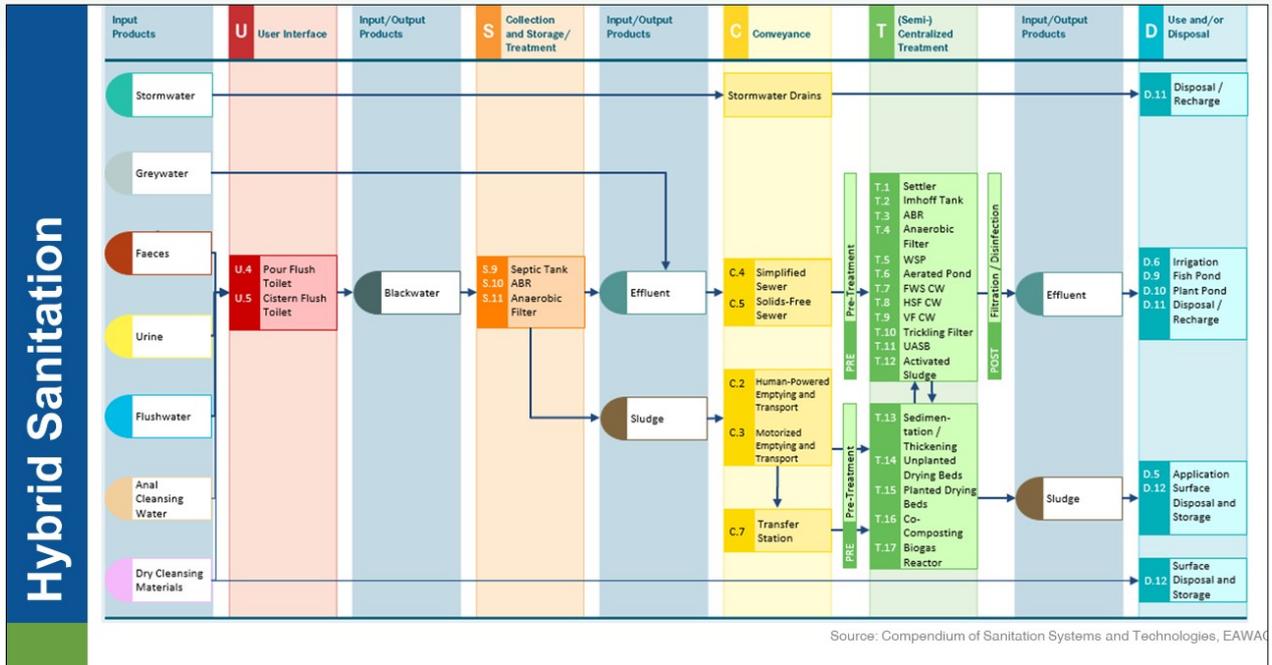
In the cities where water consumption is less and have unlined stormwater drains, the dry weather flow consisting of mainly sewage does not reach the water body due to infiltration and evaporation losses. However, during monsoon, the wet weather flow (mix of sewage and stormwater) overflows into the river body polluting it.



This is a water-based sewer system in which blackwater is transported to a centralized or semi-centralized treatment facility. The important characteristic of this system is that there is no collection and storage/treatment (also known as containment unit). Inputs to the system include faeces, urine, flush water, anal cleansing water, dry cleansing materials, greywater and possibly stormwater.

There are two user interface technologies that can be used for this system: a pour flush toilet or a cistern flush toilet. In case of commercial establishment, urinal could be additional interface. The blackwater that is generated at the user interface together with greywater is conveyed to a (semi-) centralized treatment facility through a simplified or a conventional sewer network.

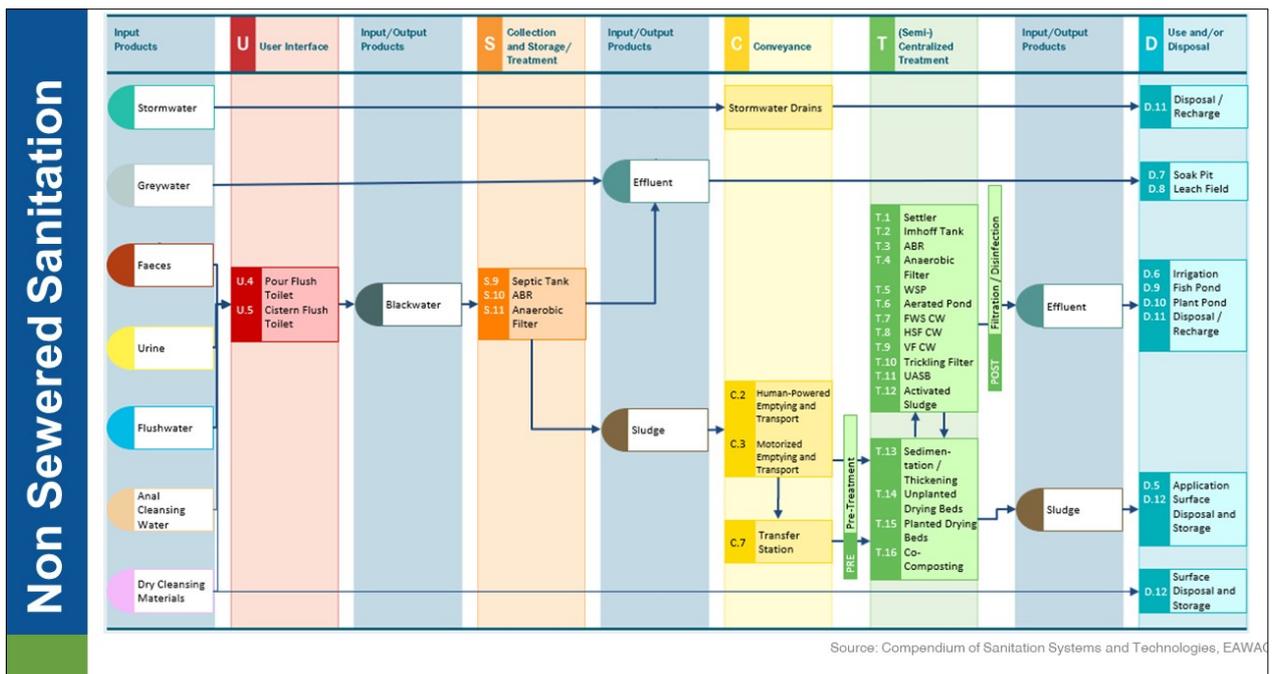
Stormwater could also be conveyed using combined sewer network; however, this would dilute the wastewater and require combined sewer overflow infrastructure. Therefore, additional local retention and infiltration of stormwater or alternatively a separate drainage system for stormwater are the recommended approaches.



This system is characterized by the use of a containment unit such as a septic tank (also known as interceptor tank) and the household level to arrest settleable solids from the blackwater, and a simplified or solids-free sewer system to transport the effluent to a (semi-) centralized treatment facility. Inputs to the system can include faeces, urine, flush water, anal cleansing water, dry cleansing materials and greywater.

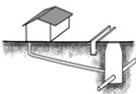
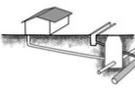
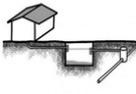
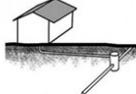
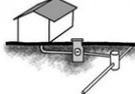
The liquid effluent from the households (i.e., septic tank effluent and greywater) is collected using simplified sewers or solids free sewer and conveyed to (semi-)centralized treatment facility. The faecal sludge/septage from the containment unit is collected using vacuum trucks and conveyed to the treatment plant.

Stormwater should be managed separately using stormwater drains in this case.



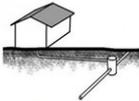
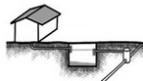
This is a water-based system that requires a flush toilet and a containment unit that is appropriate for receiving blackwater. Inputs to the system can include faeces, urine, flush water, anal cleansing water, dry cleansing materials and greywater.

The user interface is connected to containment unit. Black water from the flush toilet is received in the containment unit such as a septic tank. The solids from blackwater shall settle down in the septic tank and the liquid effluent is sent for onsite disposal into a soak pit along with greywater. The faecal sludge/septage from the septic tank is emptied using vacuum trucks and conveyed to treatment plant. The stormwater shall be handled separately using stormwater drains.

Selection Criteria					
Criteria	 Combined sewers	 Separate sewers	 Solid Free sewers	 Simplified sewers	 Pressurized sewers
Low Access to Water	+	+	+++	++	+++
Hard Strata	+	+	+++	+++	+++
High Water Table	+	+	+++	++	+++
Low Population Density	+	+	+++	+	+++
Weak Municipal Finances	+	+	+++	++	+
Low Affordability	+++	+++	++	+++	+

The slide provides criteria for selection of type of sewers. As scouring velocity is essential for transporting solids, combined sewers, separate sewers are least feasible options in case of town where there is low access to water. Solids free sewer, simplified sewers and pressurized sewers are laid at shallow depths and hence strata do not have significant impact on the cost of the sewers. High water table can lead to higher volumes of water infiltration into the sewers and buoyancy. This increases the cost of combined sewers and separate sewers as they are laid at average depth of more than 0.9-1.5 m. Population density determines how many people/properties can be connected to per unit length of sewer. Hence, solid free sewers and pressurized sewers are preferred in case of low population density. The O&M cost of sewers mostly consist of electricity/fuel cost which is required for running pumping stations. Since combined sewers and separate sewers are laid with higher gradients, requirement of pumping/lift station is higher and hence cost of O&M of such sewers is higher when compared to other sewers. If the municipal finances are weak, then the O&M of such sewers won't be possible leading to failure in near future. Affordability to the household also contributes to the sustainability of the project. In case of combined sewers, separate sewers and simplified sewers, the capital cost of project is mostly borne by the government and ULB; however, in case of solid free sewers the cost of septic tank and its regular desludging is to be borne by the household. If the households delay the desludging, this will lead to clogging of pipes eventually leading to its failure.

Sewered Sanitation

Criteria	 Conventional sewers	 Simplified sewers	 Solid Free sewers
Application	City, Ward	Community, Ward	Community, Ward, City
Components	House Connection, Pipes, Machine holes, Lift Stations, Sewage Pumping Stations	House Connection, Pipes, Machine holes, Lift Stations	Septic Tanks, Connection, Pipes, Cleanouts and Vents, Lift Stations
Management Level	Public	Public, Shared	Household, Shared, Public
Aspects	Min. Water Consumption: 135 LPCD Min. Diameter: 150 mm Min. Velocity: 0.6 m/s Max. velocity: 3 m/s Max. Depth of flow: 0.8 x D	Min. Water Consumption: 60 LPCD Min. Flow: 1.5 L/s Min. Diameter: 100 mm Min. Pop. Density: 15,000 pe/sq km	Min. Diameter: 75 mm Max. velocity: 3 m/s Max. Depth of flow: 0.8 x D

The tables provide detail about planning and design of sewers. Here, conventional sewers refer to combined / separate sewers. The application, components involved, management level and engineering design criteria has been provided in the table.

Site Selection

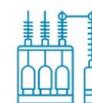
Land availability

- Sewers are laid under the publicly owned pathways
- Pathways to be wide enough
- Need of acquiring land - Lift stations, Sewage Pumping stations, STP
- Land acquisition - 30 years
- Site should have 3 m wide motorable approach road



Electricity Requirement

- To run the components in the sewerage network and STP
- Supply from local power grid
- Dedicated feeder line from nearby sub station is recommended
- Adequate area shall be reserved for setting up DG set in case of power cut



Sewers are laid on the road side on a publicly owned land. Hence no land acquisition is required. However, land is required for sewage pumping stations and sewage treatment plants. This land needs to be acquired or leased at least for a period of 30 years. The sites shall be accessible via motorable road with at least 3 m width for facilitating movement of vacuum trucks. These trucks will be carrying septage for co treatment at STP.

Sewage pumping and treatment need uninterrupted electricity supply. Therefore, average duration of supply of electricity should be ascertained so that the number of hours during which the Diesel generation (DG) sets will need to be operated can be known. Diesel generation sets will need to be provided to ensure constant running of the same. However, provision of dedicated electricity feeders for SPSs and STPs is also essential to meet programme objectives. DPR should contain details of such feeders like the length of the cable from the source of power, specifications of transformers, and estimated cost. However, capacity is to be determined on the basis of requirement.

6.2 Water Consumption vs Water Supply

Access to water

- Access to water to improve with Jal Jeevan Mission
- No. of households with access to piped water supply has significantly changed
- Access to water does not translate in higher water consumptions
 - Water supply schemes have been designed for 135 LPCD water supply
 - Scarcity of good and perennial water resources
 - Losses due to leakages – Non revenue water
 - Intermittent water supply
 - Drying of groundwater aquifers
- In scarcity of water, sewage generation less than 80% of water consumed.
- Increases the O&M of separate/simplified sewers – negatively impacts economic viability.

Increase in Piped Water
Supply Connections

≠

Higher Water Consumption

Access to water can be interpreted and measured in different ways. However, one indicator which is used for measurement is number of households having piped water supply connection. Through the Jal Jeevan Mission, the piped water supply connections are going to increase, however, there are multiple reasons that this will not translate into high water consumption- which is necessary for achieving scouring velocities in the sewers.

Water supply projects are designed to for water demand of 135 LPCD. Hence, the water treatment plant, distribution system, overhead reservoirs etc. are all designed for achieving 135 LPCD water supply at consumer end. However, due to the seasonal variation in the raw water availability from different sources of water, 135 LPCD cannot be achieved for most of the time of the year. Due to improper maintenance and monitoring, there is increase in loss of water through leakages and non-revenue water. In most of the towns having high piped water supply connection rate, supply water intermittently. Properties have to depend on groundwater aquifers and these too are under lot of stress.

As a conclusion, the even though access to water through piped water supply is high, water consumption in the town might be still low. In such towns the O&M of conventional sewers will be very high and design of I&D projects will be complex and economically unviable.

Water Supply and Consumption

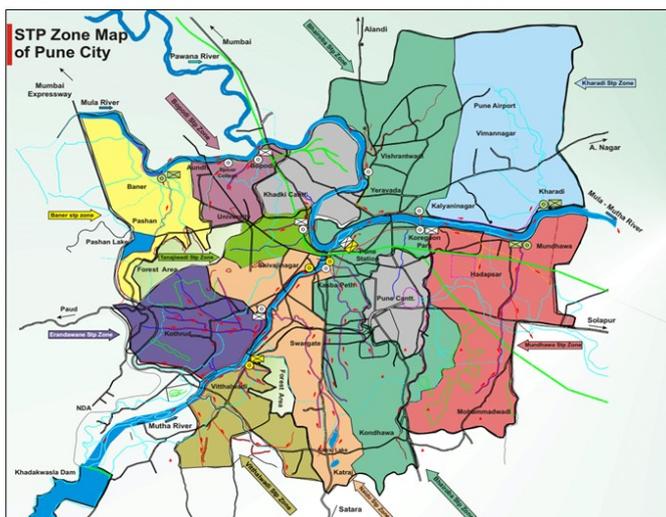
- Long term planning of wastewater management to consider incremental increase in the water supply/consumption.
- Variation in piped water supply schemes
 - 60 LPCD for small towns without perennial water source
 - 90 LPCD for small towns with perennial water source
 - 135 LPCD for large towns
 - 150-250 LPCD for metro cities
- Affordability of households impact the water consumption behavior
 - In case of low supply, people tend to store water and use judiciously
 - Piped supply with 24x7 water – wastewater generation is highest (> 80% of water consumed)
 - In high income families, water saving fixtures are used which minimizes wastewater generation (< 60%)
- Wastewater management planning should respond to water consumption pattern and affordability of households

(Source: CPHEEO Manual, 2013)

Wastewater management plan shall take into consideration incremental increase in the water consumption. Typical design water demand in water supply scheme is provided in the slide; however, it is recommended that the water consumption shall be verified through a survey and measurement of flows in the drain to estimate the design flow capacity. Water consumption behaviour varies a lot with the social and economic class of the society. In wards having low water supply or communal tap system tend to store water and use it judiciously. It is observed that 24x7 water supply leads to more wastewater generation. In high income residential units such as gated communities and townships, water saving fixtures are implemented which significantly reduce the water consumption.

Wastewater management plan should respond to the water consumption pattern and affordability of the pocket of population.

Sewerage Zones



Source: CDP, Pune Municipal Corporation

Sr. No.	Existing STPs	Capacity of the Plant (MLD)
1	Bhairoba	130
2	Erandwane	50
3	Tanajiwadi	17
4	Bopodi	18
5	Naidu Hospital	90
6	Baner	30
7	Mudhawa	45
8	Kharadi	40
9	Vithhalwadi	32
10	New Naidu Hospital	115

 Rivers
 Drains or Nallahs

This slide includes the representation of sewerage zone mapping of a city. Based on the city administrative boundaries, topography and drainages, existing physical infrastructure and future development planning, the city usually divided in different sewerage zones for the wastewater management in case of sewerage sanitation approach. In the case of Pune city STP zone map, it is currently divided into 10 different sewerage zones and sewage treatment plant infrastructure respectively. This map also represents the existing drains or nallahs which reaches to the surface water body i.e., Mula and Mutha rivers.

6.3 Population Projection

Population Projections		
Types of Projection	Arithmetic Increase Method	Incremental Increase Method
Applicability	Large & Old cities	Average sized town
Calculated by	$P_n = P + n.C$ <p>P_n = Population after n decades P = Present population C = Rate of change of population w.r.t time is constant</p>	$P_n = P + n.X + \left\{ \frac{n(n+1)}{2} \right\}. Y$ <p>P_n = Population after nth decade X = Average increase Y = Incremental increase</p>
Output	Gives a low value & suitable for well-settled & established communities	Gives increased values compared to the figures obtained by the arithmetical increase method

Source: CPHEEO Manual on sewerage treatment, Part A: Chapter 2, Page-10 Dr. Pallavi Badry, Population forecasting 2016

Arithmetic Increase Method: This method is generally applicable to large and old cities. In this method, the average increase of population per decade is calculated from the past records and added to the present population to estimate population in the next decade. This method gives a low value and is suitable for well-settled and established cities with very less possibility of spatial growth.

Incremental Increase Method: In this method, the increment in arithmetical increase is determined from the past decades and the average of that increment is added to the average increase. This method gives increased values compared to the figures obtained by the arithmetical increase method. This method is suitable for most of the towns where urbanization and spatial growth has started.

Population Projections

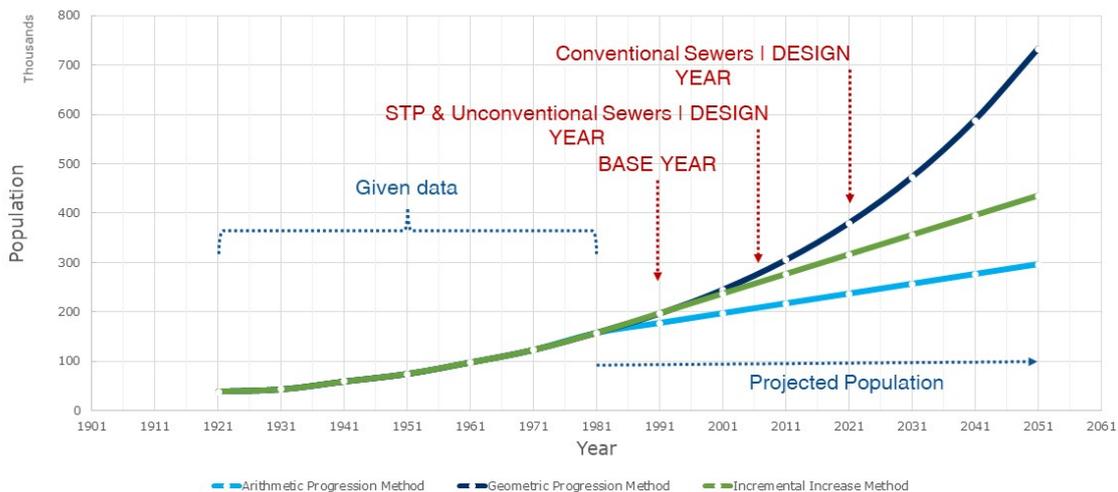
Types of Projection	Geometrical Increase Method	Method of Density
Applicability	Growing towns & cities having vast scope of expansion	Sector wise areas of city
Calculated by	$P_n = P \left(1 + \frac{Ig}{100} \right)^n$ <p> P_n = Population after n decades P = Present population Ig = Geometric mean (%) </p>	$P = P_1 + P_2 + \dots$ <p> P = Total Population P_1, P_2 = Populations in different sectors </p>
Output	Gives a much higher value	Trends in rate of increase in population density for each sector of city

Sources: CPHEEO Manual on sewerage treatment, Part A: Chapter 2, Page-10 Dr. Pallavi Badry, Population forecasting 2016

Geometric Increase Method: In this method, the percentage increase is assumed as the rate of growth and the average of the percentage increase is used to determine the increment in future population. This method gives a much higher value and is applicable to growing towns and cities having a vast scope of expansion.

Method of Density: In this approach, the trend in rate of increase in population density for each sector/ward of a city is determined and population is forecast for each sector based on the previous three approaches. Addition of population sector-wise, gives the population of the city.

Population Projections



The populations from 1921 to 1981 are common for all the types of projections here. Considering the base year as 1981, the population projections for the next 30 years right from 1986 to 2016 are calculated as per the above methods of projections with 15 years gap in between them. The geometric increase method is a simple realistic population model based on past information. This method tends to give a higher estimate than normal since it behaves compounding manner. It more accurately describes the continuous and cumulative nature of population growth.

Floating population shall also be considered while doing population projections. Floating population becomes very critical for towns which are epicentre of tourism or religious importance. Ex. Haridwar, Port Blair etc.

6.4 Design Periods

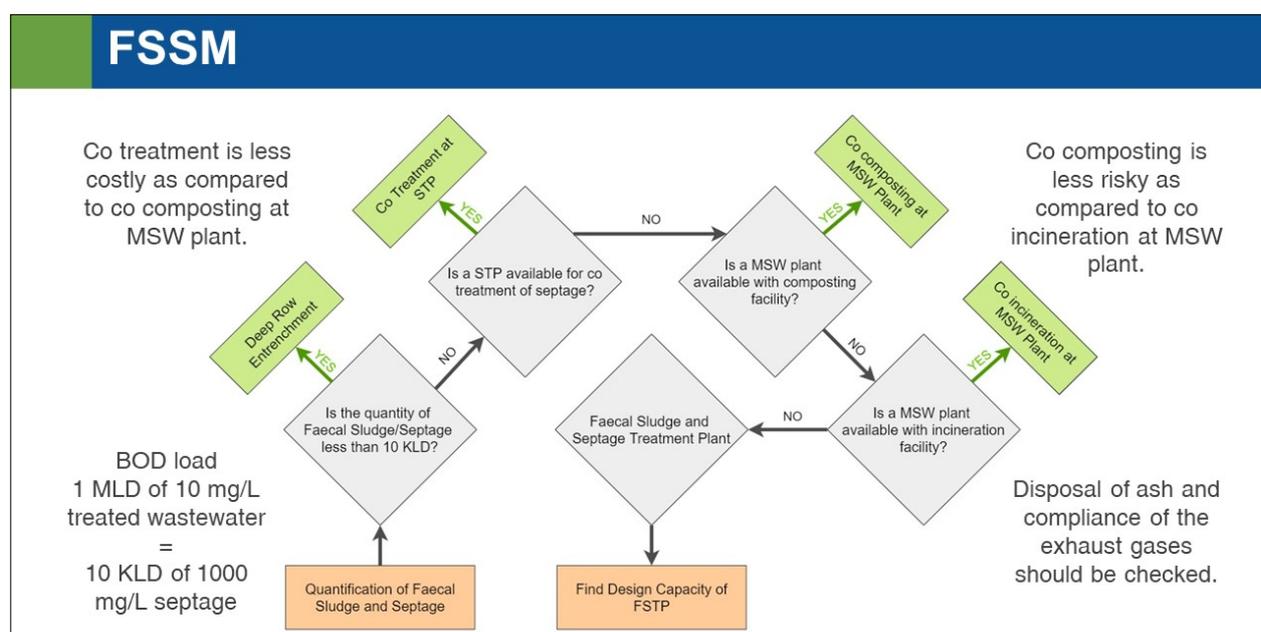
No.	Components	Design Period (Years)
1.	Land Acquisition	30 years or more
2.	Conventional Sewers	30
3.	Non- conventional Sewers	15
4.	Pumping Mains	30
5.	Pumping stations- Civil Work	30
6.	Pumping Machinery	15
7.	Sewage Treatment Plants	15
8.	Effluent Disposal	30
9.	Effluent Utilization	15 or as the case may be

Source: CPHEEO Manual on sewerage treatment, Part A: Chapter 2, Page-9

The slide provides details of design period for various components of wastewater management system. This shall be followed in each DPR. Non-conventional sewers refer to solid free sewer, simplified sewers and pressure sewers. Combined sewers and separate sewers are considered as conventional sewers.

The design period is calculated from the base year. Base year refers to the year when the project is completely implemented and commissioned. For example, if the DPR preparation starts in the year 2021, then the base year can be any year until 2024.

6.5 Incremental Solutions



The approach for FSSM depends on the quantity and quality of the sludge to be handled. The diagram above provides a decision-making algorithm for choice of the approach. It is always recommended to check the infrastructure already present with the ULB. This will ensure a high benefit to cost ratio in achieving the aim of FSSM. For ULBs with municipal finances up to the mark and generating smaller quantity of sludge to be handled, scientific land application such as Deep Row Entrenchment (DRE) is recommended. As capital expenditure, DRE only requires an appropriate plot of land with a fence to restrict entry of unauthorized persons and animals. Co-treatment of sludge can be achieved either at Sewage Treatment Plant (STP) or Municipal Solid Waste (MSW) Management Plant. Co-treatment of the faecal sludge and septage with sewage is recommended as expense involved is minimal. Co-treatment at MSW plant can be done either at the composting stage or incineration stage. Composting is beneficial as the sludge contains nutrients which are necessary for composting. Incineration is only recommended when the energy required for drying of sludge is less than to energy produced by incineration.

In Situ Treatment

- Use of micro organisms to degrade the organic pollutants in the flowing water.
- Ecological principles of Phyto Remediation and Bioremediation are used.
- Does not treat the water to mandated discharge standards; however, augments the self cleansing power of water body.

Bioremediation based techniques

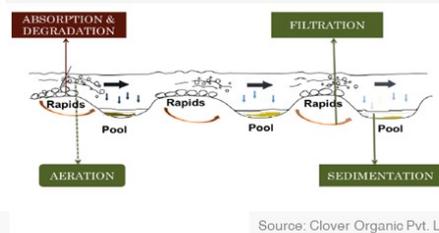
Bokashi or Mahubay Balls



Eco Bio Blocks



Bio Mimicry

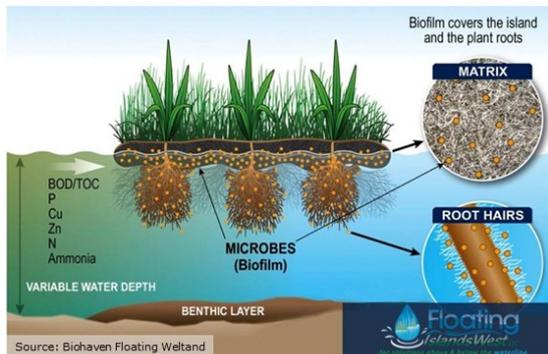


These techniques involve treating polluted substances at the site of pollution. It does not require any excavation; therefore, it is accompanied by little or no disturbance to soil structure. Ideally, these techniques tend to be less expensive compared to ex situ bioremediation techniques, due to no extra cost required for excavation processes; nonetheless, cost of design and on-site installation of some sophisticated equipment to improve microbial activities during bioremediation is of major concern.

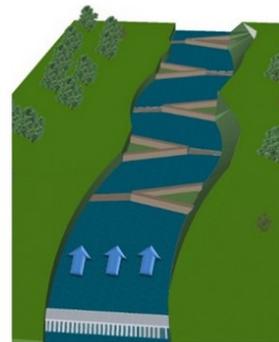
Mahubay Balls (also known as Bokashi Balls) are mud balls consisting of mix of Effective Microorganisms (EM), rice husk and clay. The balls when put in the lake disintegrate and release the EM slowly over a period of time. The EM accelerates the digestion of organic pollutants and restrict the growth of algae. Eco bio blocks are installed on the bottom of the drains and are laden with EM. EM are released through the porous surface of the eco bio block. Bio mimicry is process which combines the processes and also provides natural aeration. However, this needs alteration in the channels to create rapids which can be costly.

In Situ Treatment

Phyto remediation based techniques



The micro organisms are supported by the roots and the substrate of the island



Green Bridges

The horizontal eco-filtration system
A grafting of ecological system to treat the pollution flowing through the streams and rivers



Source: Joshi S. (2015)

V Shaped structures are built and filled with EM and planted with wetland plants

This technique relies on the use of plant interactions (physical, biochemical, biological, chemical and microbiological) in polluted sites to mitigate the toxic effects of pollutants. Depending on pollutant type (elemental or organic), there are several mechanisms (accumulation or extraction, degradation, filtration, stabilization and volatilization) involved in phytoremediation. Some important factors to consider when choosing a plant as a phytoremediator include: root system, which may be fibrous or tap depending on the depth of pollutant, above ground biomass (which should not be available for animal consumption), toxicity of pollutant to plant, plant survival and its adaptability to prevailing environmental conditions, plant growth rate, site monitoring and above all, time required to achieve the desired level of purification.

6.6 Reuse Options – Circular Economy

End products

Treated end products

- Treated wastewater – New Water – Reclaimed Water
- Bio solids

Standards for Class-A Bio solids of US EPA

- Faecal coliform density < 1000 MPN/gm total dry solids
- Salmonella sp. Density <3MPN/4gm total dry solids
- Helminth egg concentration < 1/gm total dry solids (WHO, 2006)
- E-Coli 1000/gm total solids (WHO,2006)

Parameters	Old norms 1986	Draft norms 2015	MoEF & CC notification Oct 2017
BOD (mg/l)	<30	<10	<30 & <20 (metro cities)
COD (mg/l)	<250	50	No limit
TSS (mg/l)	<100	<20	<100 & <50 (metro cities)
Total Nitrogen (mg/l)	<100	<10	No limit
Ammoniacal Nitrogen (mg/l)	<50	<5	No limit
Total Phosphorus (mg/l)	No limit	No limit	No limit
Fecal Coliform MPN/100 ml	No limit	<100	<1000

Source: NGT Order, 2019

Treated end products in wastewater management projects are: (1) treated water (also known as New Water or Reclaimed Water in other countries) and (2) Bio solids. In India, discharge standards have been prescribed by CPCB as per the MoEF notification and are given in the table above. These standards are applicable for large scale, centralized STPs. Decentralized wastewater treatment plant is supposed to follow the original norms as per the MoEF regulations of 1986. It is also recommended under various programs, that the treated water be reused and if possible, this shall be explored as a potential revenue for covering part of the O&M cost of the STP.

Sewage sludge which is generated during the treatment of sewage at the STP is treated to obtain biosolids. In India, currently, there are no discharge standards for bio solids and hence, the dewatered sludge (partially treated and not disinfected sludge) is either given away to the farmers or sent to landfill. Sewage sludge is rich in nutrients (i.e., Nitrogen and Phosphorus). If it is appropriately dried or disinfected, it has a potential to replace inorganic fertilizers in the agriculture.

Reuse Opportunities	
Reclaimed Water	Bio solids
<ul style="list-style-type: none"> • Industrial establishments <ul style="list-style-type: none"> • Thermal power plants • Stone cutting / polishing • Prefab concrete components industry • Washing of train, metro coaches • Commercial establishments <ul style="list-style-type: none"> • Non potable purposes • Flushing of toilets and urinals • Maintenance of sewer appurtenance • Agriculture <ul style="list-style-type: none"> • Irrigation of non edible plants • Agro forestry 	<ul style="list-style-type: none"> • Raw material to municipal composting plant <ul style="list-style-type: none"> • Nutrients assisting aerobic decomposition • Improves quality of compost • Soil conditioner to public gardens and large nurseries <ul style="list-style-type: none"> • Saving on costly manure • Capping soil to land fill sites • Land application to fallow – barren land <ul style="list-style-type: none"> • Supports afforestation and creates pasture land
<div style="border: 1px dashed green; padding: 5px;"> <p>Case Studies</p> <ul style="list-style-type: none"> • Bangalore Water Supply and Sewerage Board (BWSSB) is providing reclaimed water to Bangalore Airport Authority • Nagpur Municipal Corporation is providing reclaimed water to thermal power plant. </div>	

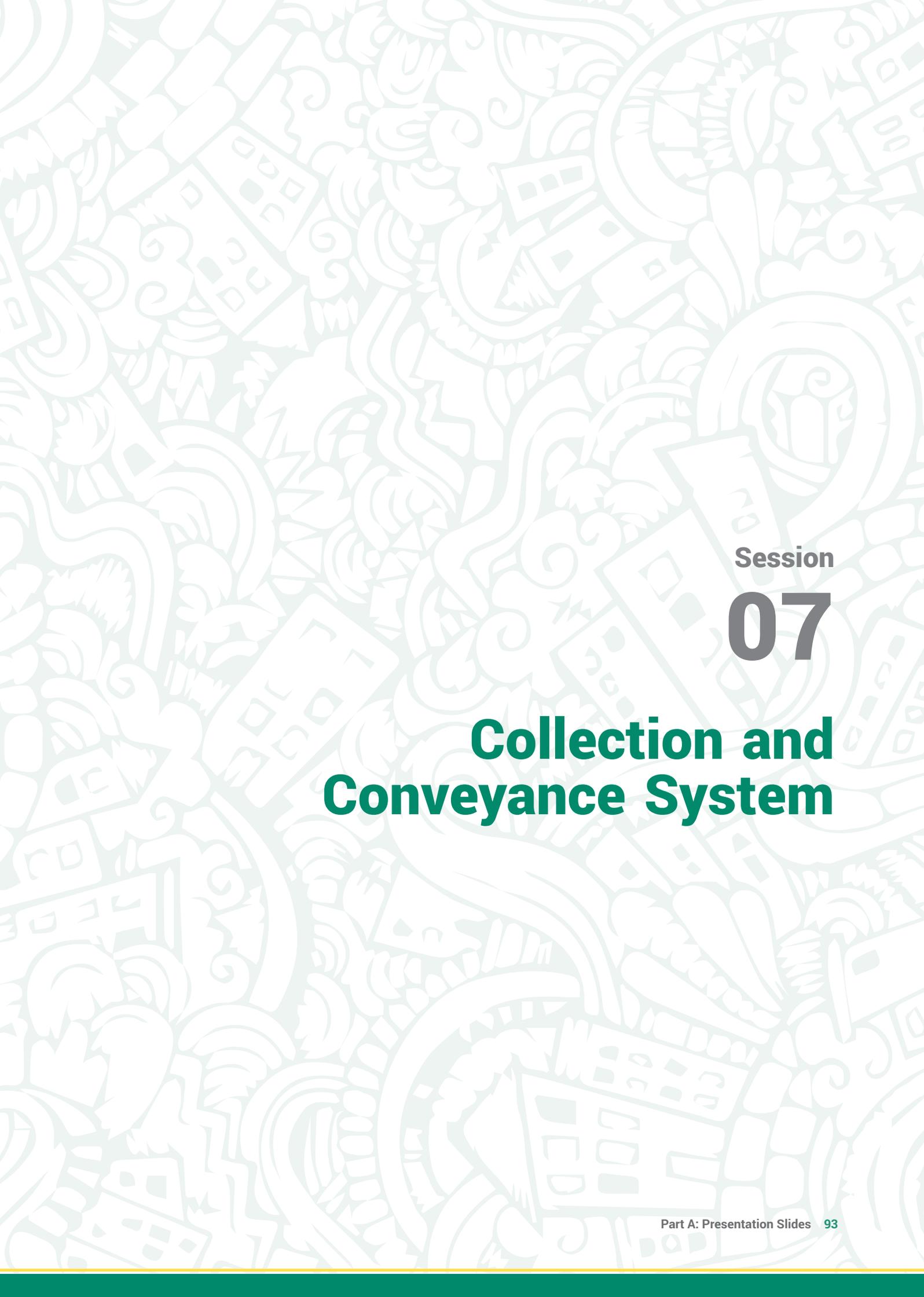
There are several reuse opportunities which can also become potential revenue streams. However, these opportunities are to be explored at the beginning of the project to ensure success of PPP project and sustainability of the project.

Reclaimed water can be used industrial establishment as process water. Several industries are currently using precious groundwater (as it is free of cost and very cheap compared to municipal water) to fulfil their demands. However, its appropriate byelaws and enforcement, this practice can be stopped and reclaimed water can be supplied to industrial estates and subsidized rates (as compared to commercial municipal water rate). Commercial establishment should be able to reuse and recycle the water for non-potable purposes. Non potable purposes require maximum quantity of water in such establishments. Agriculture has always been the largest consumer of water in India. Irrigation water does not need to be of drinking water quality. The disinfected reclaimed water with rich in nutrients can prove to be useful for agriculture.

Biosolids can also be reused for several purposes as mentioned in the slide, however without regulations and standards, it is quite difficult to enforce and promote reuse of bio solids in a safe manner.

Summary

- Different technical options are possible in sewerage sanitation approach
- Develop and assess different conveyance options for a region/city
- Land and Power availability plays an important role
- Access to water and wastewater generation impacts sustainability of wet infrastructure
- Intermediate solutions shall be planned until the base year



Session

07

Collection and Conveyance System

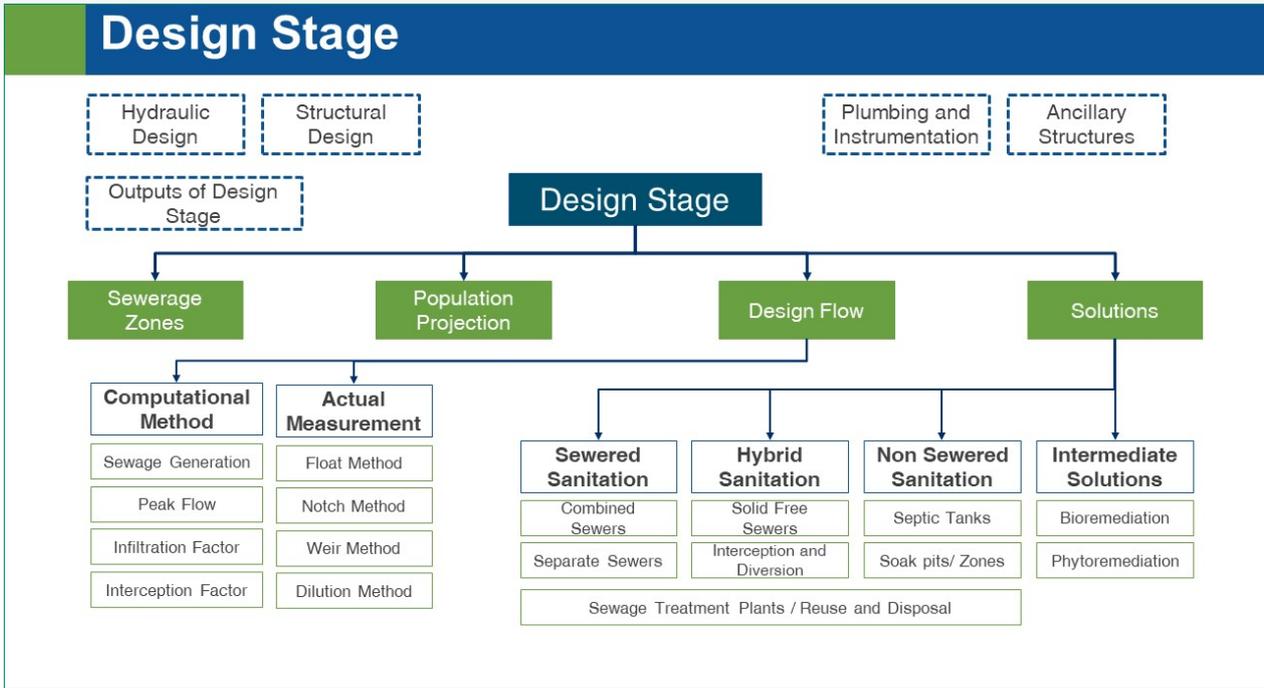
7. Collection and Conveyance System

Learning objectives

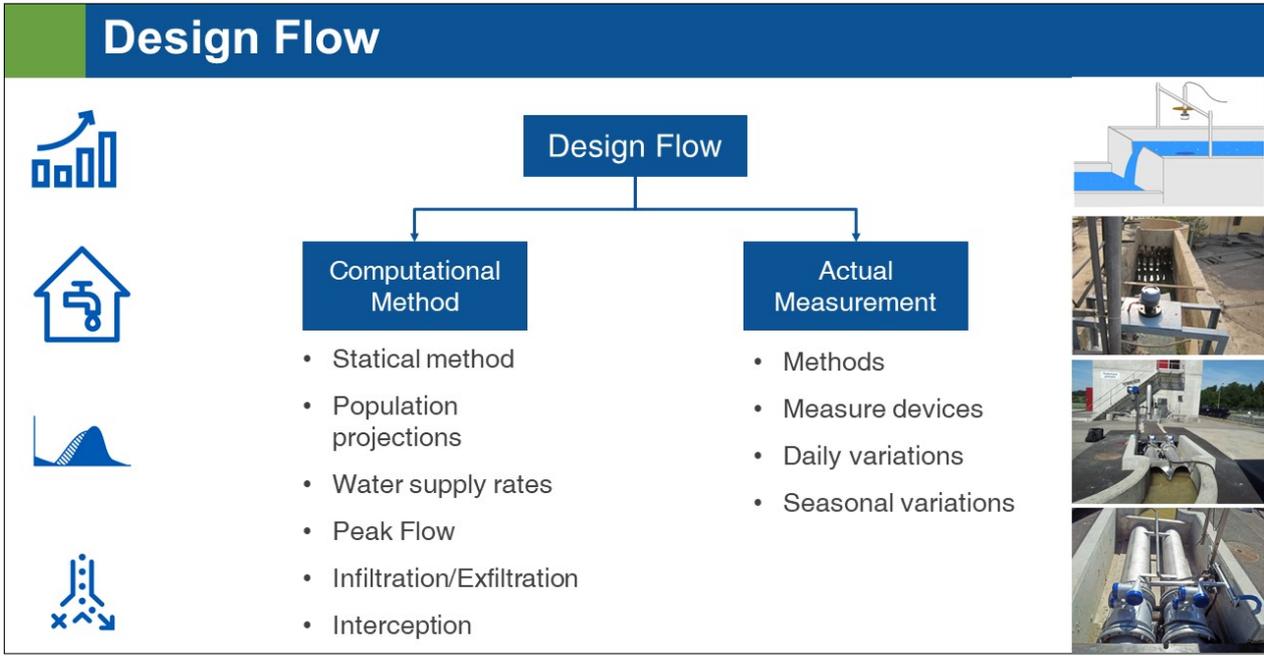
- To understand how design flows are computed using data available and to confirm the same using actual measurements at the drain
- To understand the interception and diversion for surface drain and sewer
- To understand the components of interception and diversion components and their design criteria

Contents

- Design Flows
 - Computational Method
 - Sewage Generation
 - Peak Factor
 - Groundwater Infiltration
 - Interception Factor
 - Actual Measurement Method
- Interception and Diversion Components



7.1 Design Flow



Design flow can be estimated using two methods: (a) computational method and (b) actual measurement. The computation method is based on the statistical information and assumptions whereas the actual measurements indicate the actual flow in the drain/pipe at the specific time of the day.

Sewage flows in design years (base, 10, 15 and 30 years), should be worked out by computational method. Design flow is the important factor to find out the capacity of the treatment systems, sizes of sewers. Design flows shall also include the flow reaching STPs from drains flowing into the city from areas outside city boundary limits.

Design flows adopted in different years shall be worked out and tabulated sewerage zone wise / drain wise so as to indicate the raw sewage flow to be diverted for treatment.

Computational Method

Sewage Generation

Part of the water consumed at the household level is converted into wastewater.

Sr. No.	Use	Consumption [LPCD]	Percent
1	Drinking	5	3.5
2	Cooking	5	3.5
3	House cleaning	10	7.5
4	Bathing	55	40.5
5	Washing Clothes	20	15.0
6	Washing Utensils	10	7.5
7	Flushing Water Closet	30	22.5
TOTAL		135	100

Use of thumb rules for decentralized management of wastewater is not recommended!

}

Greywater (~60%)

Blackwater (~20%)

Source: Garg S.K. (1977)

Sewage generation = 80% x 135 LPCD = **108 LPCD**

Use of thumb rule in planning of centralized sewerage and STP is more reliable.

Sewage generation is usually calculated as 80% of the water supplied; which means, when the water supply is 135 LPCD, the sewage generation will be 108 LPCD. This thumb rule work well for centralized approach for large cities for rough estimate of the capacity of STP. However, for estimating design flows at sewerage zone level or a community level, the thumb rule provides a very unreliable estimate. The table on the slide shows, water consumption by a person for various day to day activities. It can be observed that approximately 60% of the water consumed is transformed in grey water and 20% is transformed into black water. However, the water consumption pattern is also related to socio – economic level of the family. So, when such assessment is being done at decentralized level, instead of thumb rules, data shall be collected from sample survey and used for estimation.

Peak Factor

Peak factor varies with the population;

Formula Name	Peaking Factor	Conditions of Application
Harmon (Harmon 1918), (Alberta Environment 2006), (Fair, 1954), (City of Toronto 2009), (Ontario 2008), (State of Washington 2003)	$1 + \frac{14}{4 + \sqrt{P}}$	P in thousands
Babbitt (Babbitt et al., 1958), (Ontario, 2008)	$\frac{5}{(\frac{P}{1000})^{0.107}}$	$10^3 \leq P \leq 10^6$
Giff (Giff 1945) (Davis et al., 1969)	$\frac{14}{p^{0.1667}}$	Maximum PF. = 3 Minimum PF. = 1.6
Tchobanoglous (Metcalf et al. 2003)	4 for P < 5000 $7.7 - \log P$ for 5000 < P < 50000	

Diurnal Curve

Sr. No.	Contributory Population	Peak Factor
1	Up to 20,000	3
2	Above 20,001 to 50,000	2.5
3	Above 50,001 to 7,50,000	2.25
4	Above 7,50,001	2

Source: CPHEEO (1993) - Manual on Sewerage & Sewage Treatment

The water consumption by a person varies on an hourly basis during the day and hence the wastewater generation also varies. The graph on the top right corner of the slide shows the hourly variation of the wastewater in a building complex. This curve is known as diurnal curve. It is observed that 80-90% of the wastewater generation happens in 8-10 hours of the day. Hence, the design of the collection and conveyance shall take into consideration this peak flows.

Peak factor is a number which is multiplied to the average flow to obtain design peak flow. There are various methods to estimate the peak factor and it is dependent on the population. Table on the left is the peak factor provided in the CPHEEO Manual on Sewerage and Sewage Treatment (2013). However, the range of population are quite wide and hence it is recommended to use formulae provided in the table on the left. This empirical formula provides specific peak factor as per the population of the city.

Groundwater Infiltration

- Important especially in high groundwater table areas.
- Calculated based spatial area covered, length of sewer and number of machine holes.
- Maximum infiltration – 10% of the design flow.
- High water table areas;
 - Stoneware/Vitrified clay pipes shall not be used
 - Cast iron/Ductile iron pipes are better
 - Non metallic pipes are recommended
 - Safe guard against flotation

Sr. No.	Unit	Minimum	Maximum
1	Litres/ha/day	5,000	50,000
2	Litres/km/day	500	5,000
3	Litres/day/manhole	250	500

Source: CPHEEO (1993) - Manual on Sewerage & Sewage Treatment

Estimate of flow in sanitary sewers may include certain flows due to infiltration of groundwater through joints. Since sewers are designed for peak discharges, allowances for groundwater infiltration for the worst condition in the area should be made as per the table.

Once the flow is estimated as per table, the design infiltration value shall be limited to a maximum of 10% of the design value of sewage flow. Care shall be taken that in high ground water locations and coastal locations, the sewer pipes shall not be stoneware or vitrified clay pipes and instead shall be cast iron / ductile iron pipes or other non-metallic pipes with safeguards against floatation as discussed later in the section on laying of sewers.

Interception Factor

- Dry weather flow reaching the sewer system
- Less as compared to wastewater generated
 - Exfiltration through surface drains
 - Evaporation
- Suggested Interception factor
 - Covered lined drains: 90%
 - Lined drains: 75%
 - Unlined drains: 60%
 - Unlined drains with vegetation: 40%

For conventional gravity sewers, sewage flow shall be 100 LPCD.



Lined Drain



Unlined Drain I



Unlined Drain w/ vegetation

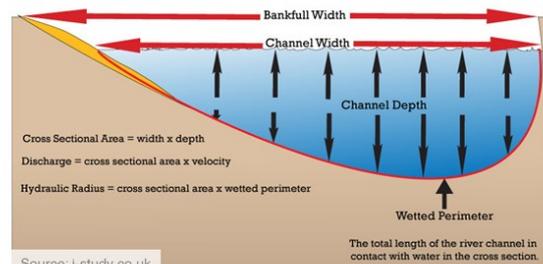
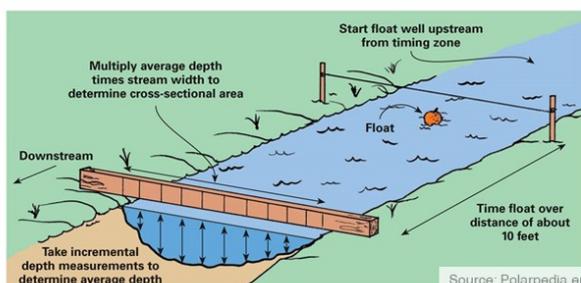
The observed dry weather flow reaching the sewer system is less than that of the per capita water supply and subsequent wastewater generation at household level due to loss of some water in leakage and evaporation. It varies from 40% of water supplied in arid regions to 90% in well developed areas. For sewerage system with household connections, the interception factor will be 1 i.e., 100% of the wastewater generated at the household level is collected and transferred to the STP. However, in cases where sewerage system is not implemented and the wastewater is to be conveyed using surface drains as shown in the pictures, the interception factor will be less than 1 and will depend on the kind of drain and its current condition. The suggested interception factor for various types of drain is provided in the slide.

7.2 Actual Measurement

Float Method

- Cross sectional area measurement
- Divide channel width (w) in multiple segments (m)
- Measure depth (d) of each segment

$$\text{Cross-sectional area} = \sum_{n=0}^m d_n \times wn$$



- Use of float – plastic ball, paper boat, wooden stick etc.
- Distance to cover (D) – 3m
- Time taken to cover the distance – (t) sec

$$\text{Velocity} \left[\frac{m}{s} \right] = \frac{D [m]}{t [s]}$$

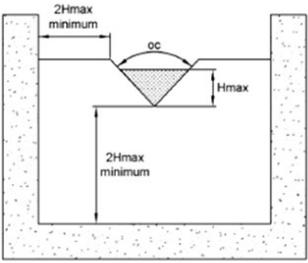
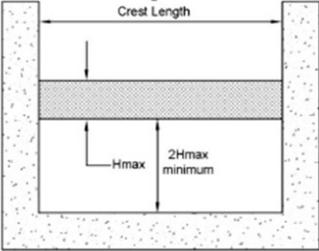
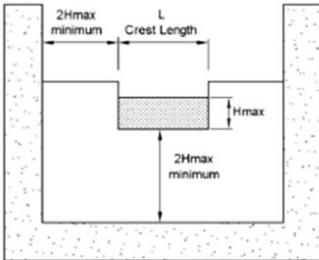
Float Method consists of two stages: (1) Stage 1: Measuring the cross section of the drains and (2) Stage 2: Measuring the time taken by a float to cover a predetermined distance in the drain.

Stage 1: Cross section of a lined and well-shaped drain in relatively easy. Usually, these drains are either rectangular or trapezoidal in cross section and simple mathematical formula can be used to determine the cross-sectional area. For measuring cross section of an irregular shaped drain, the width of the channel is divided into number of multiple sections as shown in the figure (top right). Depth is measure for each section and area is calculated by the formula given on the slide.

Stage 2: A distance of 3 m or approximately 10 feet is marked in a straight line as shown in the picture on the slide. A float (plastic ball, paper, match box etc.) is used. The float is released upstream of the start point and allowed to float till the end point. Time is measured for the float to cover the distance and velocity is determined.

Flow in the drain is equal to product of velocity of the flow and the cross-sectional area of the drain.

Notch and Weir Method

V Notch Method	Weir Method	Rectangular Weir Method
	<p>Suitable for small drains</p> 	<p>Suitable for large drains</p> 
$Q \left[\frac{m}{s} \right] = 1.42 \times \tan \theta \times H^{2.5} [m]$	$Q \left[\frac{m}{s} \right] = 1.85 \times L [m] \times H^{1.5} [m]$	$Q \left[\frac{m}{s} \right] = 1.85 \times (L - 0.2H) [m] \times H^{1.5} [m]$
All methods can be used for flow up to 20 MLD		

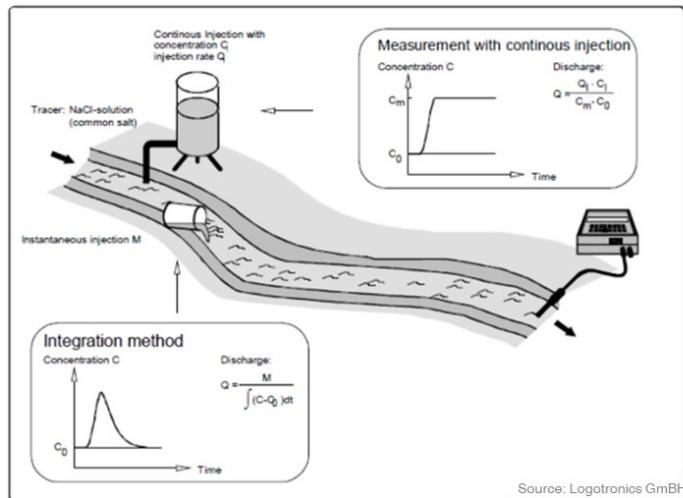
Notch and the Weir Method is more accurate as compared to the Float Method. It can be applied in any kind of drain of a pipe.

V Notch - This requires the insertion of a V notch plate in the drain at a location where the downstream discharge can be a free fall. This plate can be cut out from stainless steel (SS) or Teflon sheets of nominal thickness of about 2 mm and inserted tightly into the drain and the gaps can be closed by a mixture of clay and cement in equal proportion mixed to a thick consistency and smeared on the downstream side. The V notch is best chosen such that the angle subtended is 90 degrees.

Rectangular Notch - This can be used if there is already an existing levelled overflow weir like the overflow culverts in irrigation canals. In smaller drains and in places where workmanship of V notch cuts is difficult, these can be used easily by cutting a mild steel or wood sheet.

Dilution Method

- Tracer (eg. Common salt) is injected in to the stream
- Electrical conductivity is measured at down stream end
- Types:
 - Continuous Injection Method
 - Instantaneous Injection Method
- Accuracy - $\pm 7\%$
- Reliable for wide range of streams



In this method, the tracer i.e., common salt and other chemicals is injected at some point along the stream, and the tracer concentration in stream water is measured at a downstream point by an electrical conductivity meter, where the tracer has become uniformly mixed with the stream water. The probe of conductivity meter should be immersed, close to the bed of the stream or ideally at the mid depth. After injecting the salted water, the salt starts spreading itself out while travelling downstream. At a certain point downstream, it will have filled the width of the stream. For a given volume or rate of injection, greater stream discharges will result in greater tracer dilution and lower concentrations measured at the downstream site. Equations based on the mass balance principle are applied to compute the stream discharge.

The method of flow is easy to accomplish, accurate ($< \pm 7\%$), and reliable for a wide range of stream types. Using this method, stream flow can be measured in less than 10 minutes and minimal preparation is needed.

Flow Measurement Sheet

Drain Name and No.:
 Method of Measurement: Float Method/Current Meter/V-notch, Rect. Notch/Other:
 Station:
 Place/Location of measurement:
 Global Positioning:
 Name of the outfall point:

Date of measurement t	Week of the month (e.g. Monday)	Day of the week (e.g. *Mon-Sat)	Time												Av. Discharge cu sec / mld	Remark		
			8:00 am	9:00 am	10:00 am	11:00 am	12:00 noon	1:00 pm	2:00 pm	3:00 pm	4:00 pm	5:00 pm	6:00 pm	7:00 pm			8:00 pm	
	I	*Mon-Sat																
	II	**Mon-Sat																
	III	*Mon-Sat																
	IV	**Sunday																
Average																		

*Any day between Monday to Saturday
 **The last & IV measurement should be taken on Sunday only.

Sheet 1/3

- One sheet for one drain
- Four measurements days in each month
- One day shall be a Sunday
- Each day from 8 am – 8 pm

SN	Name of Drain	Date	Flow carried by drain		
			Average Flow, Mld	Peak Flow, Mld	Non Peak Flow, Mld

Sheet 2/3

- Summary of the measurements from sheet 1
- Records diurnal variation in flow

No/Name of STP	Daily (Monthly Average) Incoming raw sewage at STP, Mld					Average Inflow, Mld
	Jan				Dec	
1						
n						

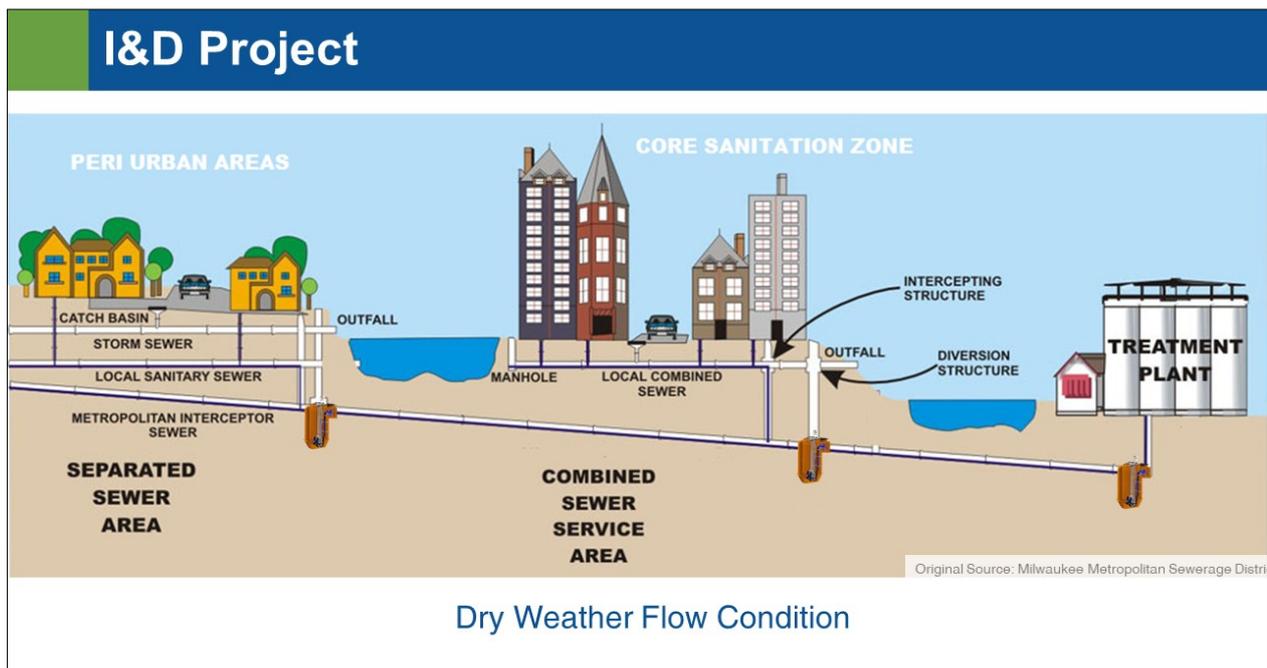
Sheet 3/3

- Summary of the measurements from sheet 2
- Records seasonal variation in flow

Slide shows three sheets which are used to measure flow in the drains. The first sheet is to be used for measuring the flow in the drain. The measurements need to be taken four times in a month, out of which one measurement has to be on a Monday. Readings are taken for 12 hours to measure the diurnal variation of flow in the drain. The second sheet is used to summarize the first sheets used for various drains in the town. It records the drain at which measurements were taken, date, average flow, peak flow and non-peak flow in the drain. The third sheet is the summary of the measurements from sheet 2. This sheet records the monthly average flow in the drain or STP.

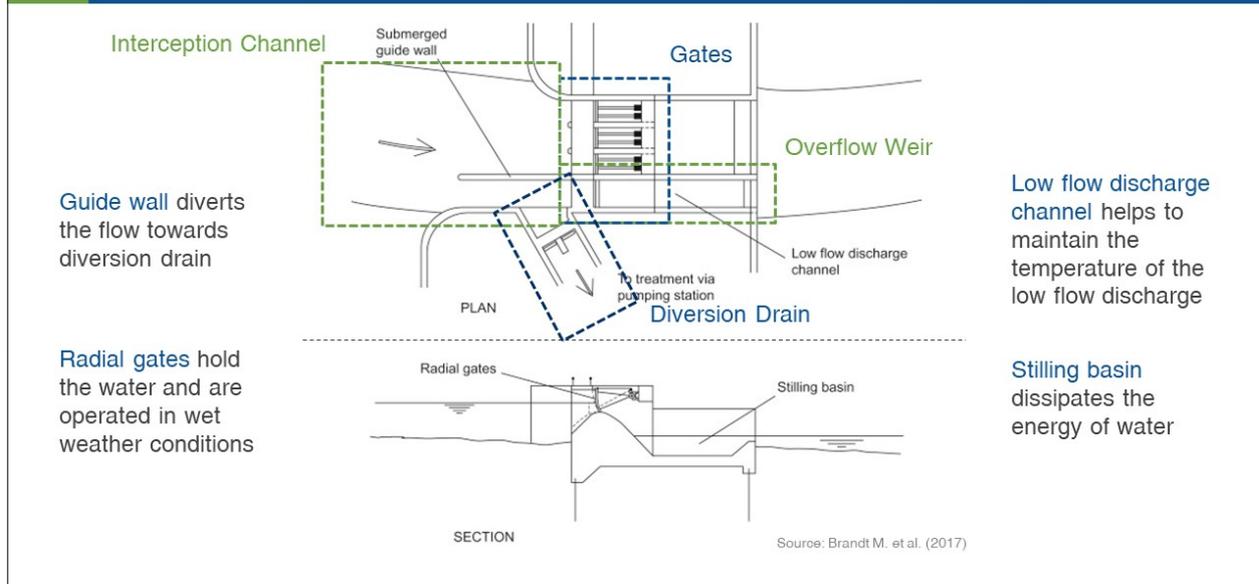
All these sheets are to be attached as annexure in the DPR.

7.3 Interception and Diversion Components



Interception and Diversion project refers to intercepting the surface/sub surface drains before they reach to the disposal point and divert the flow in them to the treatment facility. So as shown in the picture, the Core Sanitation Zone (CSZ) is being served by combined sewers and the peri urban areas are serviced solids free or separate sewers. The flow from these sewers is intercepted and the wastewater is pumped conveyed to the STP using pumping stations and trunk line. During summer and winter season in India, the sewerage system will be conveying mostly sewage. This is known as dry weather flow condition.

I&D Components – Surface Drain Tapping



In case of I&D project on the surface drain, there are various components involved.

- **Interception channel:** The channel which needs to be intercepted and diverted is known as interception channel. In case of irregular drains, this refers to the spot where the I&D project will be implemented. The interception channel shall have a guiding wall submerged into the water to divert the solids with the wastewater to the diversion drain.
- **Weir gates:** A small weir with gates needs to be installed to block the flow of wastewater to go forward in the drain. The gates can be raised and lowered to increase or decrease the effective height of the weir.
- **Overflow weir:** An overflow weir with a low flow discharge channel is provided adjacent to the weir and gates. This helps to release some overflow during peak hours. The discharge channel ensures a certain depth of water which does not get heated up while flowing down the concrete surface of the weir. Controlling temperature of the overflow is important as higher temperature favors algal growth as nutrients are present in the wastewater.
- **Diversion drain:** The diversion drain diverts the flow into the trunk line or a sewage pumping station. The mouth of the diversion drain also has hydraulic gates to control the inflow of wastewater.

Gates



Tilting Weir Gate

- Easy to operate manually / mechanically
- Water passes over the gate
- Better energy dissipation
- Better control over the flow



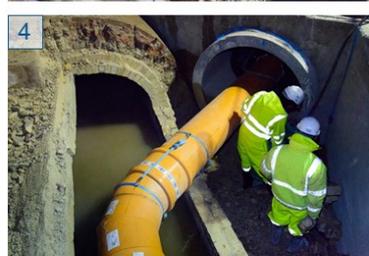
Sluice Gate

- Easy to operate manually / mechanically
- Water passes under the gate
- Allows the silt to pass when open



Different types of hydraulic gates can be used for different types of application. The two types shown in the slide are recommended for I&D works. The sluice gate is to be implemented at the diversion gate. It can be operated manually or automatically (can also be controlled remotely if required). Its main function is to control the amount of water from the interception channel into the pumping station or the trunk line. The tilting weir gate is to be implemented on the interception weir. It can also be operated manually or automatically using motors. Its main function is to control the overflow into the disposal point in events such as rainfall. The main feature of this gate is it allows the water to overflow from the top. Thus, the sediments do not get washed away and better control is provided.

Sewer Diversion Process



1. Excavation and cutting of sewer
2. Removing the pieces of sewers and debris
3. Use of sewer plug to divert
4. Diversion of sewage
5. RCC work to complete the chamber

Source: British Airways i360 Viewing Tower

Diversion of sewer process to STP:

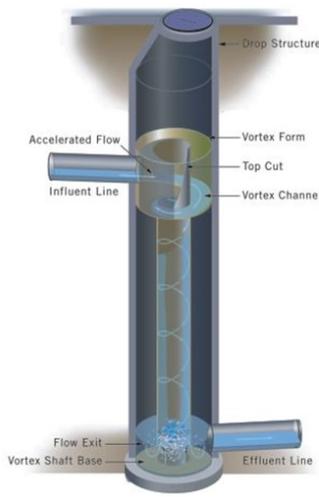
- Diversion sewers is constructed until the I&D point of the original drain pipe.
- The site is excavated with taking proper care not to damage the old and new pipes. The old pipe carrying wastewater is then cut open from the top as shown in the picture.
- Debris are removed from the site and the balloon type pipe plug is installed. The pipe plug is first installed in the diversion drain and inflated to create a water tight seal and the same procedure is repeated in the old drain.
- The pipe plug helps to transfer the flow into the new drain through the orange pipe as shown in the picture. This helps to keep the site dry and eliminates the hazard for the workers completely.
- The casting of the diversion structure is done in RCC. In this case, the flow is completely diverted into the new drain and a smooth bend is created.

I&D Components – Sewer Tapping

Components:

- **Diversion chamber**
 - Similar to sewer diversion
 - Weir and sluice gates
- **Drop Shaft**
 - For drop of more than 60 cm
 - Dissipate energy
- **Ventilation Control Unit**
 - To vent out hazardous gases
- **SPS / Trunk Line**
 - Depending upon the depth of the trunk line SPS might be required





Diversion facilities include a diversion chamber, approach channel, drop shaft, and ventilation control vault. The new diversion chamber will direct flow from the existing sewer to the approach drain and drop shaft, which will then convey flow vertically into the trunk line. The drop shafts are there to dissipate energy associated with the vertical drop and flow to minimize air entrainment in the trunk line. Ventilation control vaults is used to include radial flow activated carbon systems and ductwork to mitigate the potential for fugitive emissions from the SPS or trunk line.

Necessity of FSSM in I&D

- Regular desludging of septic tanks is essential
- Surface drains create environmental hazards
 - Odour and vector nuisance
 - Groundwater pollution
- Solid free sewers experience clogging
 - O&M cost increases

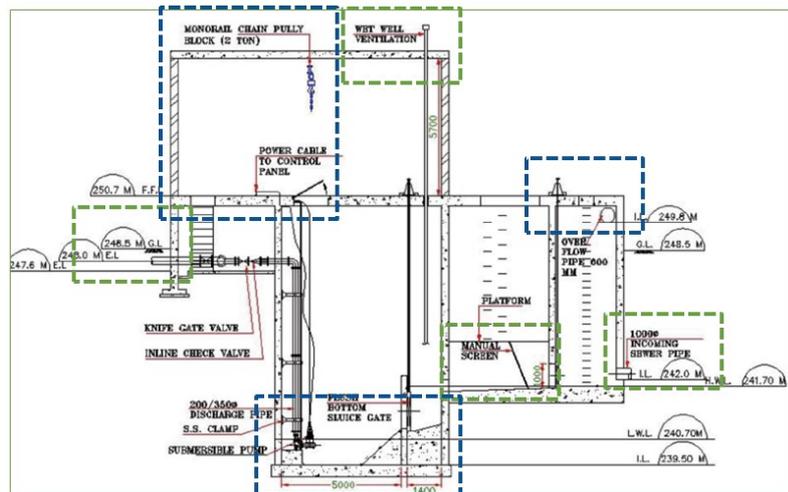


FSSM is required in case of I&D project involving surface drain tapping and solid free sewers. The surface drain receiving faecal sludge and septage from the overflowing septic tank possess environmental hazard. It creates odour and vector nuisance which can lead to spread of diseases and unpleasant experiences. In case of unlined or broken drains, it can also lead to groundwater pollution. The functioning of solid free sewers is dependent removal of solids before the wastewater enters the sewers. If the septic tank is not emptied regularly, the solids will settle in the sewers and eventually will get choked. Frequent cleaning of the sewers will be required.

Sewage Pumping Station

Components of Pumping Station

- Gate
- Screens
- Grit chamber
- Wet well (2 no.)
- Dredging equipment
- Odour control unit



Sewage Pumping Station (SPS) handle sewage either as in-line for pumping the sewage from a deep sewer to a shallow sewer or for conveying to the STP or outfall. They are required where sewage from low lying development areas is unable to be drained by gravity to existing sewerage infrastructure, and / or where development areas are too remote from available sewerage infrastructure to be linked by gravity means. SPS consist of different components as shown in the picture.

Design Aspects

Wet Well

Estimated volume is to be provided below the invert level of incoming sewer.

$$Volume [m^3] = \frac{T [min] \times Qp \left[\frac{m^3}{min} \right]}{4}$$

Where;
T = Time period of one pump cycle ~ 15min
Qp = Pumping flow rate

$$Volume [m^3] = HRT [min] \times Q \left[\frac{m^3}{s} \right]$$

Where;
HRT = 3.75 min
Q = Design peak flow

Pump Configuration

HP depends on static lift and frictional losses

Pumping station	Pumps	No. of Pumps
Small (< 1 MLD)	1 pump of 1 DWF 1 pump of 2 DWF 1 pump of 3 DWF	3
Large	2 pump of 0.5 DWF 2 pump of 1 DWF 1 pump of 3 DWF	5

DWF: Dry Weather Flow
100% standby capacity is required

Source: Manual on sewerage and sewage treatment, Part A (2013)

Sizing of the wet well and pump configuration is critical while designing a pumping station. The design shall take into consideration that the pumps do not have to start and stop frequently in an hour. This affects the pumping efficiency and leads to frequent breakdown of pumps. The volume of the wet well is calculated using the formula given in the slide.

Capacity and the number of pumps to be installed at the pumping station as per the recommendation given in the table. Multiple small capacity pumps help to reduce the power consumption and optimally utilize the full volume of the wet well.

Pump Installation Videos:

Installation examples of Sulzer XFP sewage pumps –

<https://www.youtube.com/watch?v=CkNOzVuSWJU>

Submersible pump installation - https://www.youtube.com/watch?v=JDEH4_C83aM

Design Aspects

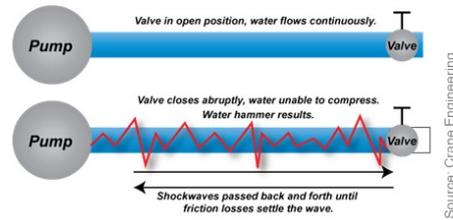
Rising Main

- Depends on the flow rate and power of pump
- Minimum velocity: 0.6 m/s, to avoid sedimentation of solids
- Maximum velocity: 3 m/s, to avoid frictional losses

Recommended range: 1 – 2.7 m/s

Reduces formation of H₂S – elongates life of pipes

Water Hammer



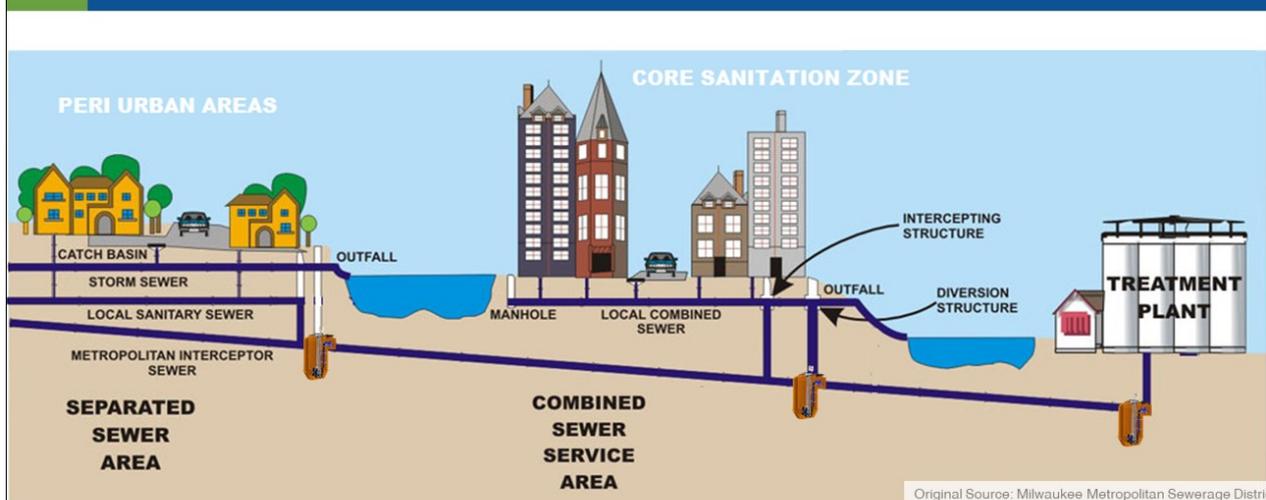
TH < 1.1 x (AP/WP)	Use same class of pipe
1.1 x (AP/WP) < TP < 1.5 x (AP/WP)	Use same class of pipe with control device
TP > 1.5 x (AP/WP)	Use higher class pipe

TH: Total Head = Pumping Head + Hammer Head
 AP: Allowable Pressure of pipe
 WP: Working Pressure of pipe

Pressurized pipe line after a lift station or a SPS is known as rising main. The design of rising main is critical as velocity of the wastewater needs to be maintained between 0.6 m/s and 3 m/s. The rising main should be as far as possible be laid with an even gradient with a minimum of sharp bends and curves.

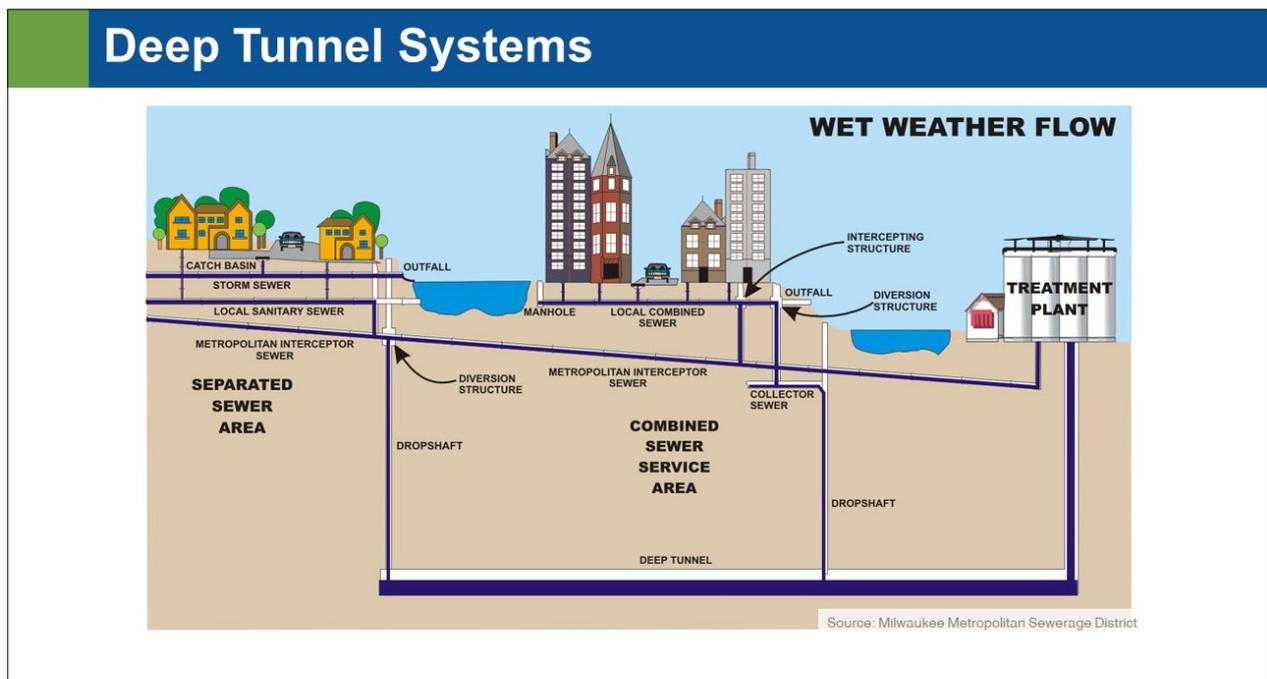
The selection of material of sewer pipe should take into consideration pumping head and water hammer head. Water is a non-compressible fluid. Hence, when its movement is suddenly stopped in the pipe, a shock wave is created and it travels in the pipe as shown in the diagram. This sudden shock wave damages the pipes, joints and pumps. To mitigate this issue, the class of pipe is appraised and/or installation of water hammer arrestor is done.

I&D Project – Wet Weather Flow



The picture represents the state of I&D project during the wet weather condition (i.e., high intensity rainfall). In peri urban areas, where separate sewers are implemented, only the stormwater will overflow in the surface water body. However, the combined sewer system in the CSZ will overflow into the surface water body once the interceptor sewer reaches its full capacity. Ideally, the I&D project should be so designed that this combined sewer overflow is restricted to four time in a year.

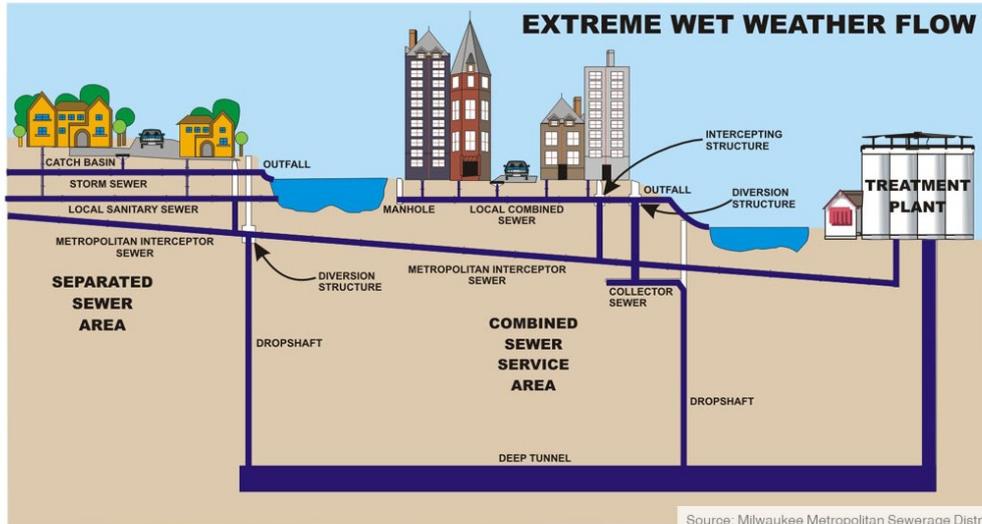
Due to rampant urbanization, leading to larger impervious surfaces coupled with irregular-high intensity rainfall leads to numerous overflows per year. Cities in developed countries are facing the problem and are solving the issue in two ways. First way to promote stormwater management at the community level. This is covered in the last session of the module and second way is an engineering solution discussed in the next slide.



The engineering solution to reduce the overflows into the surface water body is deep tunnel or overflow surge tanks.

Deep tunnel is a solution where, a large diameter tunnels (up to 7m) are constructed at the depth of 30-60 m. Alternatively, large surge tanks are built underground where the overflow is collected. Post storm, the stored wastewater is then pumped into the STP and treated over a period of days. Although these solutions have numerous advantages in countries like Singapore and US, they tend to be cost intensive and economically not feasible for most of the cities in India.

Deep Tunnel Systems



This slide shows that engineering solutions can also not provide a comprehensive solution. In case of storm like event, the deep tunnel or surge tank might reach to its capacity and overflow can still take place. Thus, it is essential, that stormwater management is promoted at various levels – household, community and city.

Summary

- Computational method for design flow estimation is based on statistical data and assumption, hence can lead to inaccurate estimates.
- Actual measurement on surface drains and sewers help to confirm the estimate through computation method.
- Data collection throughout the year is key to avoid risk of failure.
- I&D approach might possess operational challenges to STP at lead to urban flooding.
- Infrastructural projects might be required to manage the wet weather overflow to avoid urban flooding in future.



Session

08

Wastewater Treatment Technologies

8. Wastewater Treatment Technologies

Learning objectives

- To understand the objectives and mechanisms of wastewater treatment
- To understand the different treatment stages in a wastewater treatment system
- To understand the technical aspects of non mechanised and mechanised treatment technologies
- To understand the different sludge management units required to cater the solid stream in the wastewater treatment plant.

Contents

- Wastewater Treatment
 - Treatment Objectives
 - Treatment processes
 - Treatment stages
- Wastewater Treatment Technologies
 - Treatment Chain
 - Non mechanized treatment units
 - Mechanized treatment units
- Selection of Treatment Technology
- Sewage Sludge Management

Wastewater Treatment Objectives

To preserve environmental health by limiting the pollutant load in the natural environment



Replenish / Restore surface water bodies



Reuse in industry where reasonable quality process water is required



Reuse in agriculture areas not covered under irrigation schemes



Reuse in indirect recharge to replenish groundwater aquifers

Although the ultimate aim of wastewater treatment is to reduce the quantity of pollutants entering the natural environment, the specific goals can change from case to case. Specific goals of wastewater treatment can be as follows:

- To supply water to the industry such as cement, pipe manufacturing, stone cutting or thermal power plant as process water
- To replenish or restore the surface water bodies such as lakes
- To reduce the dependency on the rain and irrigation canal water by reuse in agriculture in drought prone areas
- To improve the ground water table through indirect aquifer recharge techniques

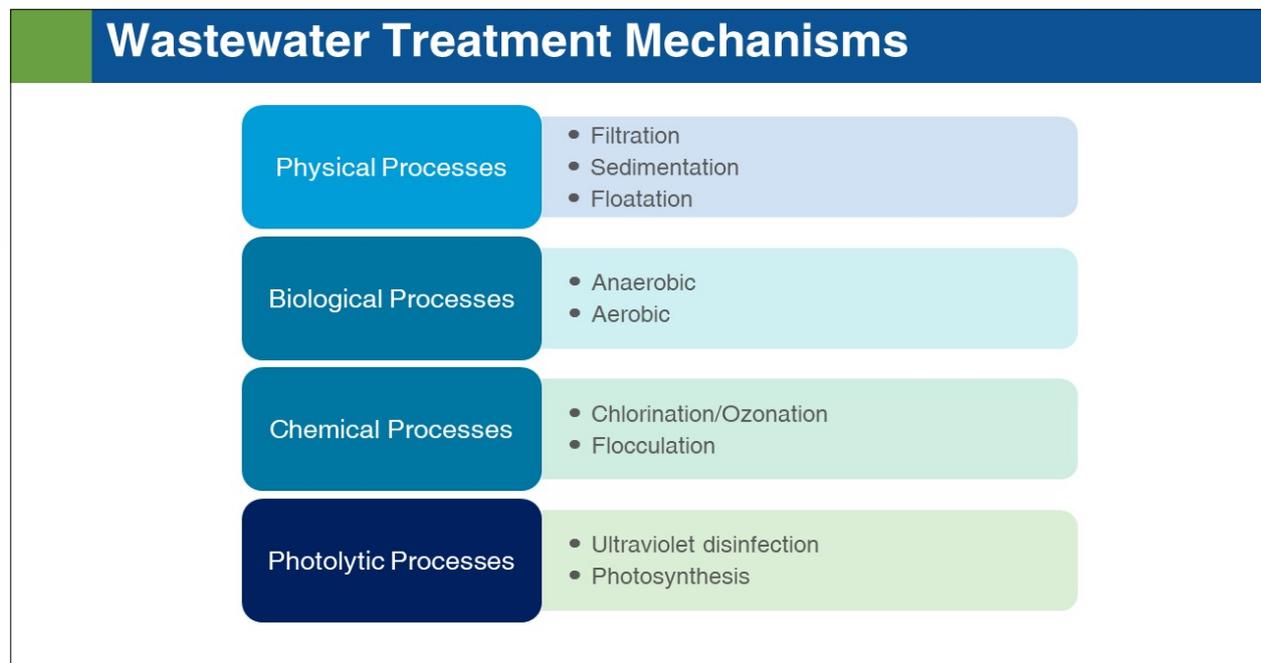
8.1 Wastewater Treatment – Mechanisms and Stages

Design Parameters

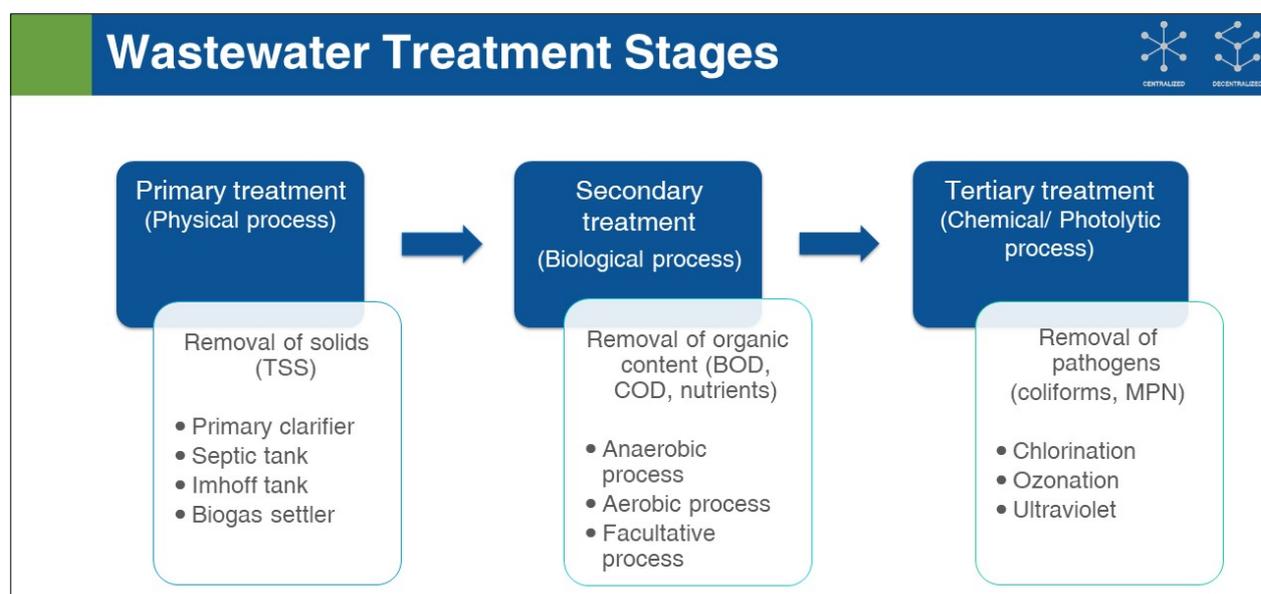
- Organic loading (kgBOD/d, kgCOD/d)
- Solids loading (kg TSS/d)
- Volumetric loading rate (m^3/d)
- Temperature ($^{\circ}\text{C}$)
- Sludge Retention Time (SRT)
- Biomass yield (kgVSS/ kgCOD)
- Hydraulic retention time (HRT)
- Up flow velocity (m/s)
- Specific surface area (m^2/m^3)



The slide lists down the design parameters for STP. There are multiple stages in a STP, and at each stage one or more treatment mechanism can be important. Thus, the design parameter depends on the stage and the mechanism. However, in general, volumetric loading, organic loading and solids loadings are three main criteria for design of STP.



Wastewater treatment mechanisms are of different types: Physical, Biological, Chemical and Photolytic. Physical processes are based on the physical characteristic of the wastewater constituents. Mainly it's the specific gravity of the constituent which assists the separation from the water. Biological processes rely on the microorganisms to carry out digestion of the organic matter in anaerobic or aerobic conditions. Biological processes are the main heart and soul of any wastewater treatment plant. Chemical processes rely on the use of chemicals either to treat the water (e.g., Ozonation- to kill pathogens) or to assist the physical or biological processes (e.g., Alum or ferric chloride to coagulate the sludge). Photolytic processes rely on the photon in the light to treat the wastewater directly (e.g., UV to kill pathogens) or indirectly (e.g., Photosynthesis help to uptake the nutrients from the wastewater in case of constructed wetlands).



A waste treatment facility consists of different treatment stages combining different treatment processes. In case of wastewater treatment plant, after the preliminary treatment i.e., screening; the wastewater undergoes treatment in primary stage. In primary stage, the physical treatment processes are used to remove the easily settleable solids usually known as grit. The units which provide primary treatment are listed in the slide above. In secondary stage, biological treatment processes remove the BOD and COD using the digestion process carried out by anaerobic and aerobic microorganisms. In the tertiary stage, chemical or photolytic treatment process is used to disinfect the wastewater. It includes the chlorination, ozonation and ultraviolet based disinfection systems.

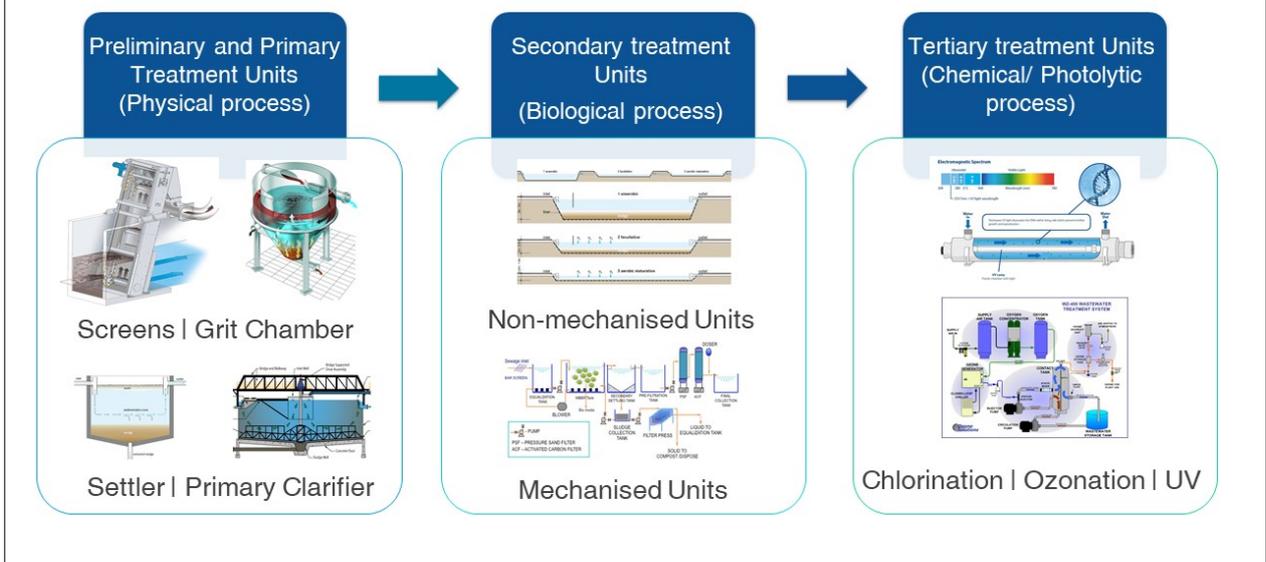
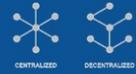
Characteristics of Wastewater

- Organic loading plays a very important role in functioning of the secondary stage.
- In case of I&D projects having surface drains or combined sewers,
 - Organic load of dry weather and wet weather will vary significantly
 - The organic loading decreases due to dilution
- Lower organic loading affects the F/M ratio in the secondary reactor.
- These parameters need to be monitored for ensuring optimal efficiency of treatment.

The input design criteria of organic loading, solids loading and volumetric loading can vary significantly in the case of I&D projects consisting of surface drains and combined sewers. Variation in the volumetric loading can be normalized using sump and pumping station; however, normalizing variation in organic and solids loading is difficult.

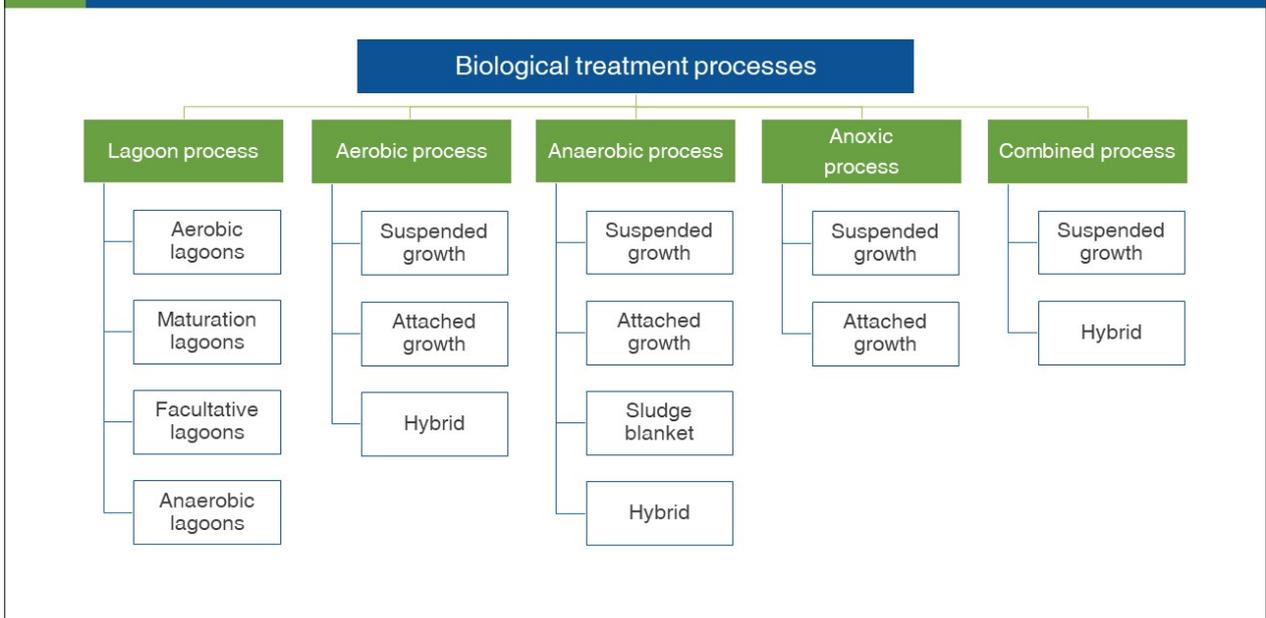
The organic load of the wastewater determines the population of bacteria and the presence of oxygen required to degrade the organic material. This is denoted by F/M (Food to Microorganism) ratio. This ratio needs to be maintained in a certain range for maintaining the efficiency of the plant. When the F/M ratio is not maintained, the efficiency of the treatment reduces and the STP is unable to produce the treated water as per the discharge standards.

Wastewater Treatment Chain



A waste treatment facility consists of different treatment stages combining different treatment processes. In case of wastewater treatment plant, after the preliminary treatment i.e., screening; the wastewater undergoes treatment in primary stage. In primary stage, the physical treatment processes are used to remove the easily settleable solids usually known as grit. The units which provide primary treatment are listed in the slide above. In secondary stage, biological treatment processes remove the BOD and COD using the digestion process carried out by anaerobic and aerobic microorganisms. The units which provide secondary treatment are of two types i.e., mechanized treatment units and non-mechanized treatment units. In the tertiary stage, chemical or photolytic treatment process is used to disinfect the wastewater. It includes the chlorination, ozonation and ultraviolet based disinfection systems.

Biological Treatment Processes



Benefits of Biological Treatment Processes:

- Most of the aerobic processes provide **carbonaceous BOD removal** and **nitrification**.
- All anoxic processes provide **denitrification**.
- Most of the anaerobic processes provide **carbonaceous BOD removal** and **stabilization**.
- Combined processes provide carbonaceous BOD removal, nitrification, denitrification & **phosphorus removal**.

8.2 Wastewater Treatment Technologies

Waste Stabilization Pond (Non Mechanised System)

- Lagoon biological process
- Anaerobic, Facultative and Aerobic Maturation
- High pathogen reduction and relatively high removal NH₃ and P
- HRT: 20 to 60 days

Performance

- BOD & TSS removal: 90%
- NH₃: 70-90% and P: 30-45%
- Coliform reduction: up to 6 log units

Source: TILLEY et al. (2014)

Waste Stabilization Ponds (WSPs) are large, manmade water bodies. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds: (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics.

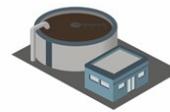
In a series of WSPs, the effluent from the anaerobic pond is transferred to the facultative pond, where further BOD is removed. The top layer of the pond receives oxygen from natural diffusion, wind mixing and algae-driven photosynthesis. The lower layer is deprived of oxygen and becomes anoxic or anaerobic. Settleable solids accumulate and are digested on the bottom of the pond. The aerobic and anaerobic organisms work together to achieve BOD reductions of up to 75%. Anaerobic and facultative ponds are designed for BOD removal, while aerobic ponds are designed for pathogen removal. For the most effective treatment, WSPs should be linked in a series of three or more with effluent flowing from the anaerobic pond to the facultative pond and, finally, to the aerobic pond. The anaerobic pond is the primary treatment stage and reduces the organic load in the wastewater. The entire depth of this fairly deep pond is anaerobic. Solids and BOD removal occurs by sedimentation and through subsequent anaerobic digestion inside the sludge. Anaerobic bacteria convert organic carbon into methane and, through this process, remove up to 60% of the BOD.

Waste Stabilization Pond (Non Mechanised System)



Benefits and Applicability

- Resistant to organic and hydraulic shock loads
- Low operating costs
- No electrical energy is required
- Suitable in warm Indian climatic conditions



Land Requirement
0.80 to 2.3
hectares/MLD



Energy Requirement
10 KWh/ML
Treated

Challenges

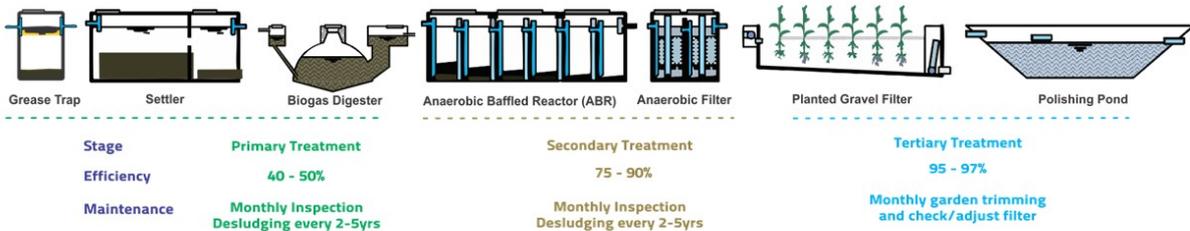
- Requires a large land area
- Requires expert design and construction
- Sludge requires proper removal and treatment



Capex vs **Opex**
INR 1.1 Cr / MLD for lined ponds vs Rs 2.5 Lakhs/ Annum / MLD

Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

DEWATS / Phytorid / Constructed Wetland (Non Mechanised System)



Source: DEWATS, BORDA

- Anaerobic Treatment System followed by Phytorid System or Constructed Wetlands
- Anaerobic System + Aerobic System
- Suspended and Attached growth processes
- Design Flow: 1 – 1000 KLD
- Reliability, longevity and tolerance towards inflow fluctuation
- Periodic desludging of sludge required in the anaerobic tanks

DEWATS is a technical approach to decentralized wastewater treatment in developing communities. The design uses physical and biological treatment mechanisms such as sedimentation, floatation, aerobic and anaerobic treatment to treat both domestic and industrial wastewater sources. Aim of DEWATS is to make wastewater treatment affordable at the decentralized scale. Hence, at different stages, different components are used. All the components mentioned on the slide have one thing in common, the O&M cost is low and it can be performed by non-skilled person after basic training. DEWATS is designed to be low maintenance, use local materials, and meet environmental laws and regulations. DEWATS has application in small and medium-sized enterprises including communities, schools, municipalities, agro-industry, emergency settlements, hospitals, hotels, and prisons.

DEWATS / Phytorid / Constructed Wetland (Non Mechanised System)

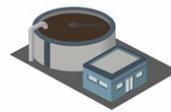


Benefits and Applicability

- Simple to construct
- Low operation and maintenance cost
- Self-sufficiency, ecological balance, and economic viability is greater
- Suitable for domestic, commercial wastewater or industrial effluent

Challenges

- Area requirement for Phytorid system
- Not feasible for larger capacities



Land Requirement
0.16 to 0.18
hectares/MLD



Energy Requirement
Negligible



Capex
INR 3 Cr /
MLD



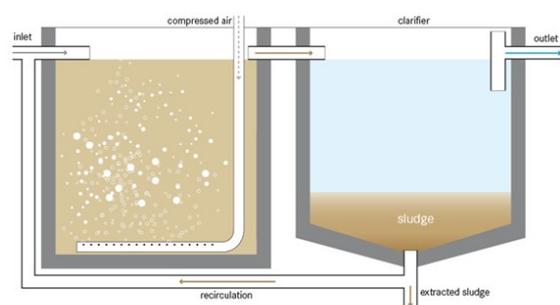
Opex
Rs 3 Lakhs/
Annum / MLD

Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

Activated Sludge Process (ASP) (Mechanised System)



- Aerobic suspended growth biological process
- Continuous and well-timed supply of oxygen is required
- P accumulated in biomass and removed via sludge
- High N removal (anoxic reactor)
- Low pathogen removal
- SRT: 3-5 days (BOD Removal) and 3-18 days (Nitrification)



Source: TILLEY et al. (2014)

Performance

BOD and TSS removal: 85 to 95%

An activated sludge process refers to a multi-chamber reactor unit that makes use of highly concentrated microorganisms to degrade organics and remove nutrients from wastewater to produce a high-quality effluent. To maintain aerobic conditions and to keep the activated sludge suspended, a continuous and well-timed supply of oxygen is required.

Different configurations of the activated sludge process can be employed to ensure that the wastewater is mixed and aerated in an aeration tank. Aeration and mixing can be provided by pumping air or oxygen into the tank or by using surface aerators. The microorganisms oxidize the organic carbon in the wastewater to produce new cells, carbon dioxide and water. Although aerobic bacteria are the most common organisms, facultative bacteria along with higher organisms can be present. The exact composition depends on the

reactor design, environment, and wastewater characteristics. The flocs (agglomerations of sludge particles), which form in the aerated tank, can be removed in the secondary clarifier by gravity settling. Some of this sludge is recycled from the clarifier back to the reactor. The effluent can be discharged or treated in a tertiary treatment facility if necessary for further use.

Activated Sludge Process (ASP) (Mechanised System)

Benefits and Applicability

- Tried and tested
- Resistant to organic and hydraulic shock loads
- Can be modified to meet specific discharge limits

Challenges

- High energy consumption
- High Capex and Opex
- O&M by skilled personnel



Land Requirement

0.15 to 0.25 hectares/MLD

Energy Requirement

180 – 225 KWh/ ML Treated


Capex

vs


Opex

INR 2.1 Cr / MLD for lined ponds

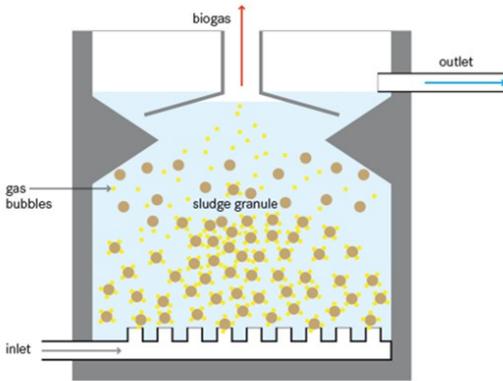
Rs 12.5 Lakhs/ Annum / MLD

Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

Treatment efficiency can be severely compromised if the plant is under- or over-dimensioned. Depending on the temperature, the solids retention time (SRT) in the reactor ranges from 3 to 5 days for BOD removal, to 3 to 18 days for nitrification. The excess sludge requires treatment to reduce its water and organic content and to obtain a stabilized product suitable for end-use or final disposal. It is important to consider this step in the planning phase of the treatment plant.

Upflow Anaerobic Sludge Blanket (UASB) (Mechanised System)

- Anaerobic suspended growth biological Process
- Recovery of biogas.
- Needs continuous and stable water flow and energy.
- Low pathogen reduction and minimal removal of nutrient
- Upflow velocity of 0.7 to 1 m/h for sludge blanket in suspension
- HRT: Min 2 hrs., 4 - 20 hrs.



Source: TILLEY et al. (2014)

Upflow anaerobic sludge blanket (UASB) reactor is a methane-producing digester, which uses an anaerobic process and forming a blanket of granular sludge and is processed by the anaerobic microorganisms. UASB reactor is based on the so-called three-phase separator, which enables the reactor to separate gas, water, and sludge mixtures under high-turbulence conditions. Wastewater flows upwards through the blanket and is processed (degraded) by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants.

✦

Upflow Anaerobic Sludge Blanket (UASB) (Mechanised System)

Performance

- BOD & COD: 80 to 90%
- TSS: 70 to 85%

Benefits

- Can with stand high organic and hydraulic loading rates
- Low sludge production
- Biogas can be used for energy



Source: UASB Gemini, Aquanos

UASB Reactor works very well for high strength wastewater having high TVSS to COD ratio. The volatile solids upon digestion generate methane gas. The process is aided with mechanical agitator and the internal flow of sludge. The technology has very high efficiency to remove BOD, COD and TSS. However, its biggest limitation is that the treated water still needs aerobic treatment further to achieve the discharge standards.

✦

Upflow Anaerobic Sludge Blanket (UASB) (Mechanised System)

Applicability

- higher strength wastewaters: domestic, commercial and industrial

Challenges

- Unstable with variable hydraulic and organic loads
- O&M by skilled personnel
- Long Start-up



Land Requirement

0.2 to 0.3 hectares/MLD



Energy Requirement

10-15 KWh/ML treated



Capex

INR 1.8 Cr / MLD

vs



Opex

Rs 3.6 Lakhs/ Annum / MLD

Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

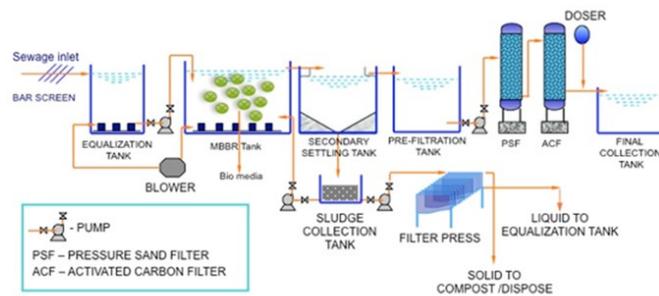
Moving Bed Bio Reactor (MBBR) (Mechanised System)



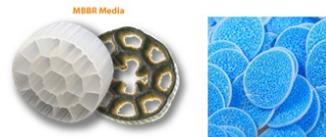
- Aerobic attached growth biological process
- Floating media and aeration
- Specific surface area of media varies from 300 to 4000 m²/m³
- Low pathogen removal

Performance

- BOD and TSS removal: 80 to 90%



Source: www.ecomena.org/

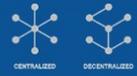


The MBBR is a complete mix, continuous flow through process which is based on the biofilms principle that combines the benefits of both the activated sludge process and conventional fixed film systems without their disadvantages.

MBBR is a highly effective biological treatment process based on a combination of conventional activated sludge process and biofilm media. The MBBR process utilizes floating media within the aeration and anoxic tanks. The microorganisms consume organic material. The media provides increased surface area for the biological microorganisms to attach and grow. The increased surface area reduces the footprint of the tanks required to treat the wastewater. The treatment process can be aerobic and/or anaerobic and operates at high volume loads. Moving Bed Bio Reactor (MBBR) processes improve reliability, simplify operation, and require less space than conventional wastewater treatment systems (ASP).

The MBBR process utilizes floating plastic carriers (media) within the aeration tank to increase the number of microorganisms available to treat the wastewater. The microorganisms consume organic material. The media provides increased surface area for the biological microorganisms to attach to and grow in the aeration tanks. The increased surface area reduces the footprint of the tanks required to treat the wastewater. The media is continuously agitated by bubbles from the aeration system that adds oxygen at the bottom of the first compartment of the aeration tank. The microorganisms consume organic material. When compared to conventional secondary treatment it provides superior efficiency and value.

Moving Bed Bio Reactor (MBBR) (Mechanised System)

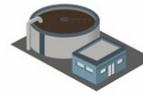


Benefits and Applicability

- Compact design and requires less space
- High response to shock loads
- Suitable in small and medium sized towns and decentralized approach

Challenges

- High O&M cost
- Skilled operators required



Land Requirement

0.05 hectares/MLD



Energy Requirement

282 KWh/ML treated



Capex

INR 2.3 Cr / MLD

vs



Opex

Rs 9.6 Lakhs/ Annum / MLD

Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

8.3 Selection of Treatment Technology

Checklist for Technology Selection

- ✓ Influent characteristics
- ✓ Climatic constraints
- ✓ Finance
- ✓ Performance
- ✓ Reliability
- ✓ Complexity
- ✓ Compatibility
- ✓ Environmental constraints
- ✓ Chemical requirements
- ✓ Energy requirements
- ✓ Resource requirements
- ✓ Land availability
- ✓ Treatment residual and its disposal
- ✓ Inhibiting and unaffected constituents

Performance Based Technology Comparison

Technologies	Effluent Quality	Coliform Removal	Nitrification Denitrification / Phosphorus Removal	Process Reliability	Land Use	Ease of Operation and Maintenance	Energy recovery	Electrical demand	Capital Cost
Waste Stabilisation Ponds	M	A	A	A	A	M	A	VG	G
DEWATS / DTS+CW	A	A	A	A	A	M	A	VG	G
Activated Sludge Process (ASP)	G	G	A	VG	G	G	VG	M	M
UASB Reactor	M	M	A	G	G	M	G	M	M
Moving Bed Biological Reactor (MBBR)	VG	VG	A	A	G	VG	M	A	M

Very Good (VG) 
 Good (G) 
 Moderate (M) 
 Average (A) 

Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

In this slide, the performance-based aspects are listed which have to be considered for the selection of appropriate wastewater treatment technology.

Technology Comparison

Technology	Land Requirement (Hectare/ML D)	Energy Requirement (KWh/ML)	CAPEX	OPEX
DEWATS / DTS+CW	0.16 – 0.18	Negligible	High	Low
Waste Stabilisation Ponds	0.8 – 2.3	10	Moderate	Low
UASB Reactor	0.2 – 0.3	10 - 15	Moderate	Moderate
Activated Sludge Process (ASP)	0.15 – 0.25	180 - 225	Moderate	High
Moving Bed Biological Reactor (MBBR)	0.05	282	Moderate	High

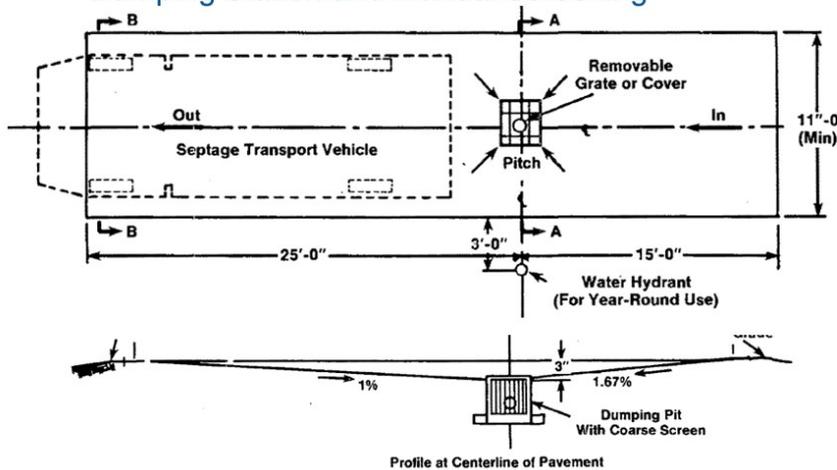
Source: Advisory on On-site and Offsite Sewerage Management, CPHEEO and MoHUA (2020)

This slide includes the comparison of wastewater treatment technologies considering the land area required, energy requirement, capital investment required and operational cost. It can be observed that the natural treatment systems require least energy and operational cost than other mechanized treatment technologies.

8.4 Sewage Sludge Management Units

Septage Receiving Station

Dumping Station and Manual Screening



Source: Bridgewater MA

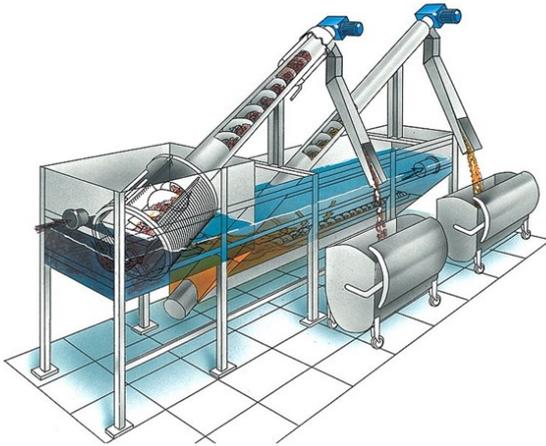
Source: USEPA Manual On Septage Management

The aim of the septage receiving station is to reduce the impact and risk on STP due to co treatment of septage and sewage. Faecal sludge and septage receiving facilities provide the interface between FSS delivery vehicles and the sewage treatment plant. The aim of the facility is to allow for FSS transport vehicle access, providing adequate space for vehicles to discharge their contents and exit the treatment facility.

The key objectives of the receiving station are: (1) it should enable safe and hygienic transfer of septage from desludging truck to the next unit of STP (2) It will be like the preventive measure to keep a check on O&M cost of the STP, (3) storage and controlled discharge (addition) of septage into the sewage and (4) reduce impact on the secondary stage of the liquid and solid treatment chain at the STP.

The components of the septage receiving station are: a) dumping unit b) screening c) grit removal d) storage or equalization e) odor control.

Integrated Pretreatment Module



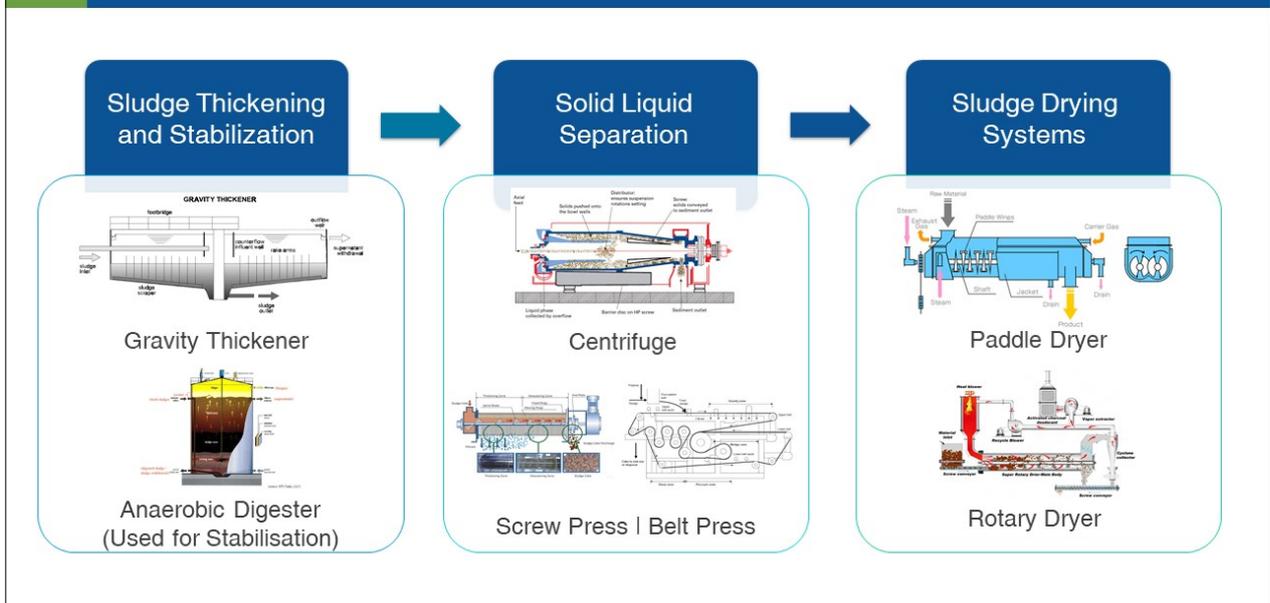
Source: HUBER Complete Plant ROTAMAT Ro5



Source: ECUA, Huber Technology

It represents the mechanized system for the septage receiving station which includes the dumping site, mechanized screening system and mechanized longitudinal grit trap. Integrated pretreatment module combines the mechanical screen and longitudinal grit trap. This is a single equipment which can be placed after the dumping station. Washing, and dewatering is optional and is recommended so that the solid waste and grit can be safely handled and disposed appropriately.

Sewage Sludge Management Units

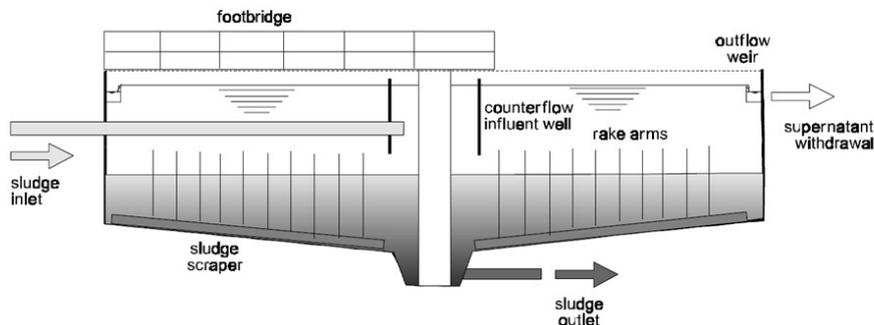


Solid liquid separation is an important step in sludge handling at faecal sludge treatment facility or at co-treatment facility. After solid liquid separation, the semi thickened sludge has transferred to further sludge handling facility and liquid has be transferred to liquid treatment system. It has two different approaches natural system (i.e., settling thickening tank etc.) or mechanized system (i.e., by mechanical presses like screw press or belt press etc.)

Gravity Thickener

Aim: To separate free water from the mix of primary sludge and secondary sludge

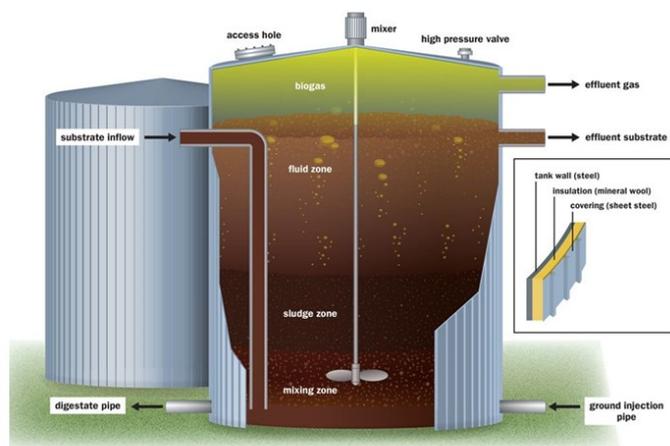
Mechanism: Similar to sedimentation tank (secondary clarifier)



The solids content of the mixed sludge i.e., primary sludge and secondary sludge is < 3%. Thus, the sludge requires thickening before stabilization. The aim here is to reduce the volume of the sludge, thus reducing the required volume of the anaerobic digester. Significant reduction in the volume is achieved by separating the free water from the sludge. The treatment is based on the physical mechanisms of separation takes place because of difference in the specific gravity of the solids and the water. The picture of the gravity thickener is shown above. The important components of the thickener are: (1) influent well, (2) sludge scraper which also provides necessary flocculation, (3) sludge inlet and outlet provision and (4) outflow weir for drawing out the supernatant water.

Anaerobic Digester

- Digestion = Stabilization
- Digestion of organic matter by bacteria in absence of oxygen
- Three stage process:
 - Enzymes break down complex organic compounds into soluble compounds
 - Micro organisms converts first stage products into low molecular weight acids
 - Methane forming organisms convert acids to methane, CO₂ and H₂



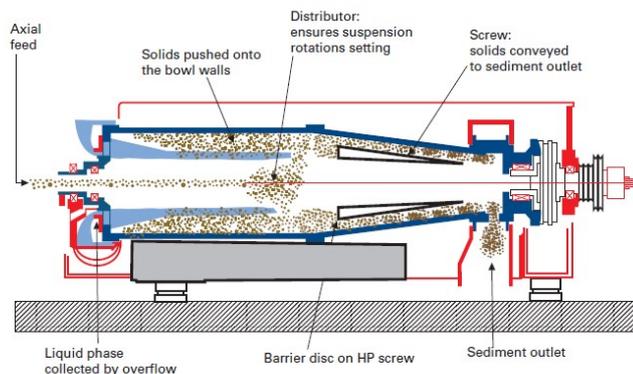
Source: Jane Whitney

Anaerobic digester provides stabilization of sludge by digesting the volatile solids using bacteria in absence of oxygen. Anaerobic digestion is a three-stage process: (1) The enzymes break down the complex organic compounds in the soluble compounds. This mainly happens through hydrolysis process. (2) In the second stage the soluble compounds are converted into low molecular weight

acids. The formation of acids results in decrease of pH. (3) The methanogenic bacteria convert the acids into more stable products such as methane, CO₂ and H₂. Along with this the digested sludge containing mainly fixed solids and some volatile solids (difficult to digest solids) settle down. The methanogenic bacteria are sensitive to pH and methanation process is affected if the pH of the digester is not around neutral.

Anaerobic Digester

- Mechanized dewatering:
 - Low area requirement
 - High processing capacity
 - Low CAPEX
- Centrifuge is most commonly adopted mechanized unit, followed by screw press
 - Flow rate: 10-40 L/s
 - Area requirement: 40 m²

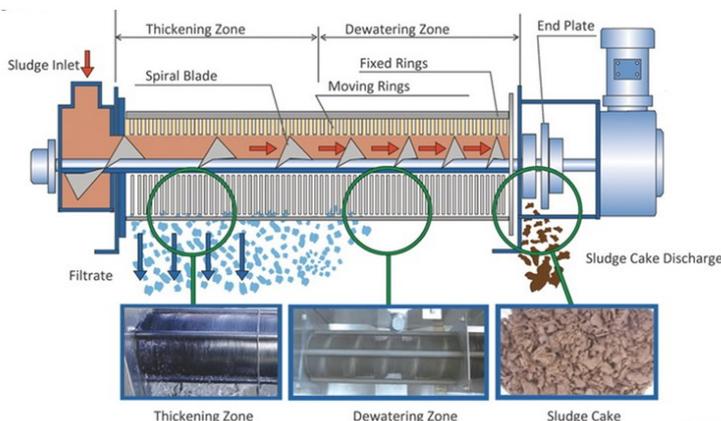


Source: Suez Water Handbook

Dewatering of the stabilized sludge is used to further separate the solids from the liquid in the sludge. Dewatering can be achieved using non mechanized treatment units such as planted and unplanted drying beds but in centralized STPs due to space constraints, mechanized dewatering is preferred. There are options in mechanized dewatering equipment such as centrifuge, screw press, belt press, filter press. The most commonly used unit at STPs is centrifuge. Centrifuge provides continuous dewatering process and is within less time provides sludge cake with relatively higher solids content. In centrifuge, the physical mechanisms of solid liquid separation based on specific gravity is again put into operation. The centrifugal force on the heavier solids particles sends it closer to the rotating bowl and the remaining water is drained out of the equipment using gravity.

Screw Press

- Simpler operation
- Can receive sludge with low solid content (<1%)
- 15-25% final dry solids
- Enclosure keeps surrounding environment clean and safe
- Low energy consumption
- Less inventory to maintain

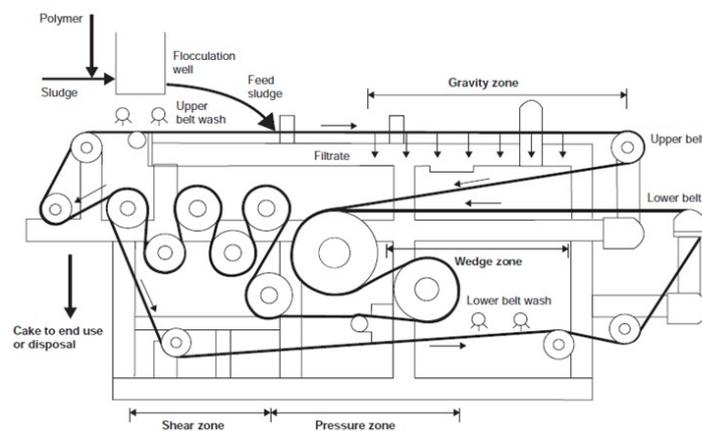


Source: www.ecologixsystems.com

Screw presses separate liquid from solids by forcing sludge through a screw or auger contained within a perforated screen basket. The screw diameter increases with distance along the shaft while the gap between its blades decreases so that the gap between basket, shaft, and flights continuously decreases and sludge is squeezed into a progressively smaller space. This results in an increase in pressure along the press. Pressure probes are used to control and monitor the pressure to ensure treatment performance. The inclined press includes a pneumatic or manually adjusted counter-pressure cone that maintains a constant sludge pressure at the discharge end of the press. The water squeezed from the sludge drops into a collector channel at the bottom of the press, which conveys it to the next stage of treatment. The dewatered cake drops out of the end of the press for storage, disposal, or further drying on a drying bed or in a thermal dryer. High-pressure water is used periodically inside the press for cleaning.

Belt Press

- Can receive sludge with solid content < 0.5%
- 15-25% final dry solids
- Unenclosed units are messy to operate and present health hazard; however, allow visibility of process performance
- Simple equipment to maintain (rollers, bearing, belt)
- More parts to monitor- inspect and maintain

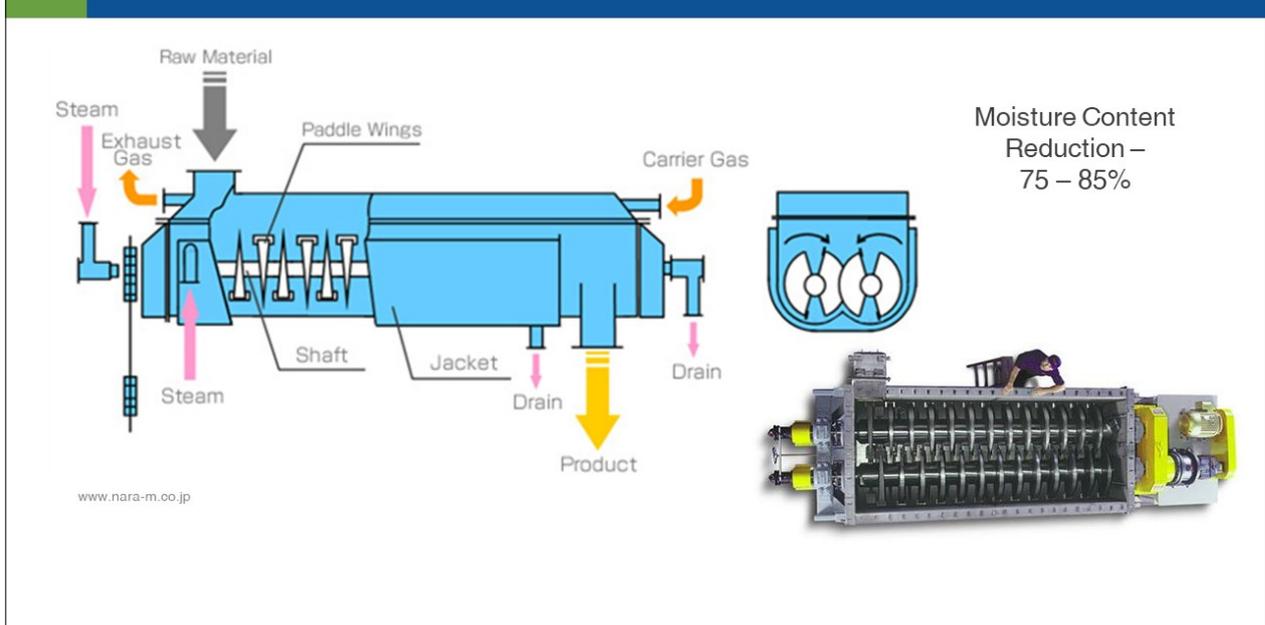


Source: WEF (2010)

Belt filter presses separate liquid from solids, using gravity and applied pressure between fabric belts. The process typically involves four steps: preconditioning, gravity drainage, low-pressure linear compression, and high-pressure roller compression (and shear). After preconditioning, sludge passes through a gravity drainage zone where liquid drains by gravity from the sludge. It is then moved on to a low-pressure zone where two belts come together to squeeze out liquid from the solids, forcing liquid through the fabric belts. In most cases, the sludge is then subjected to higher pressure as it is forced between a series of rollers, which create shearing forces and compression to further dewater the sludge.

The dewatered sludge cake is then scraped off the belts for conveyance to the next stage of treatment or disposal. The belts are cleaned with high-pressure washwater after each pass.

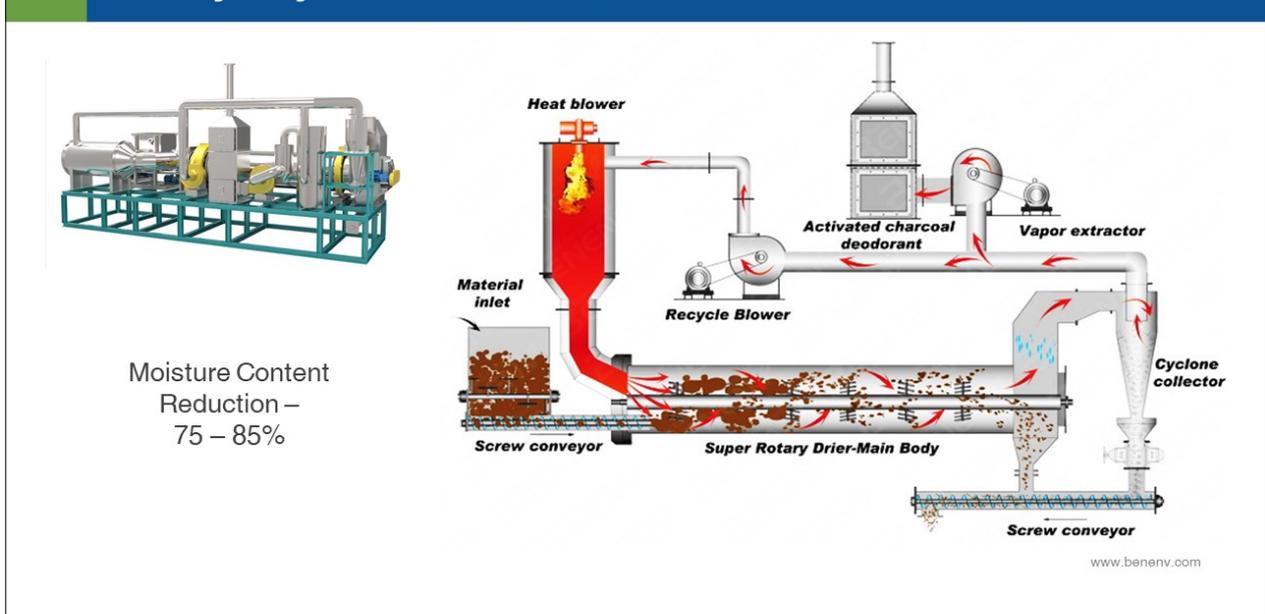
Paddle Dryer (Mechanised System)



Paddle dryer has paddle wings which are hollow from inside so that steam can be circulated from it. The paddle system is also encompassed into a jacket which is fed by steam. When raw material is introduced into the paddle dryer, the heat is transferred from the paddles to the sludge. The sludge moves in the forward direction and get churned as it moves ahead. From the other end the dried solids come out of the dryer. Dry air is introduced in the jacket to drive away the moisture laden air out of the dryer.

- Can achieve 75 - 85% dry solids
- Can produce biosolids for beneficial reuse as soil conditioner
- Can achieve intermediate dryness for composting or combustion
- Can remove hazardous volatile organic compounds

Rotary Dryer (Mechanised System)

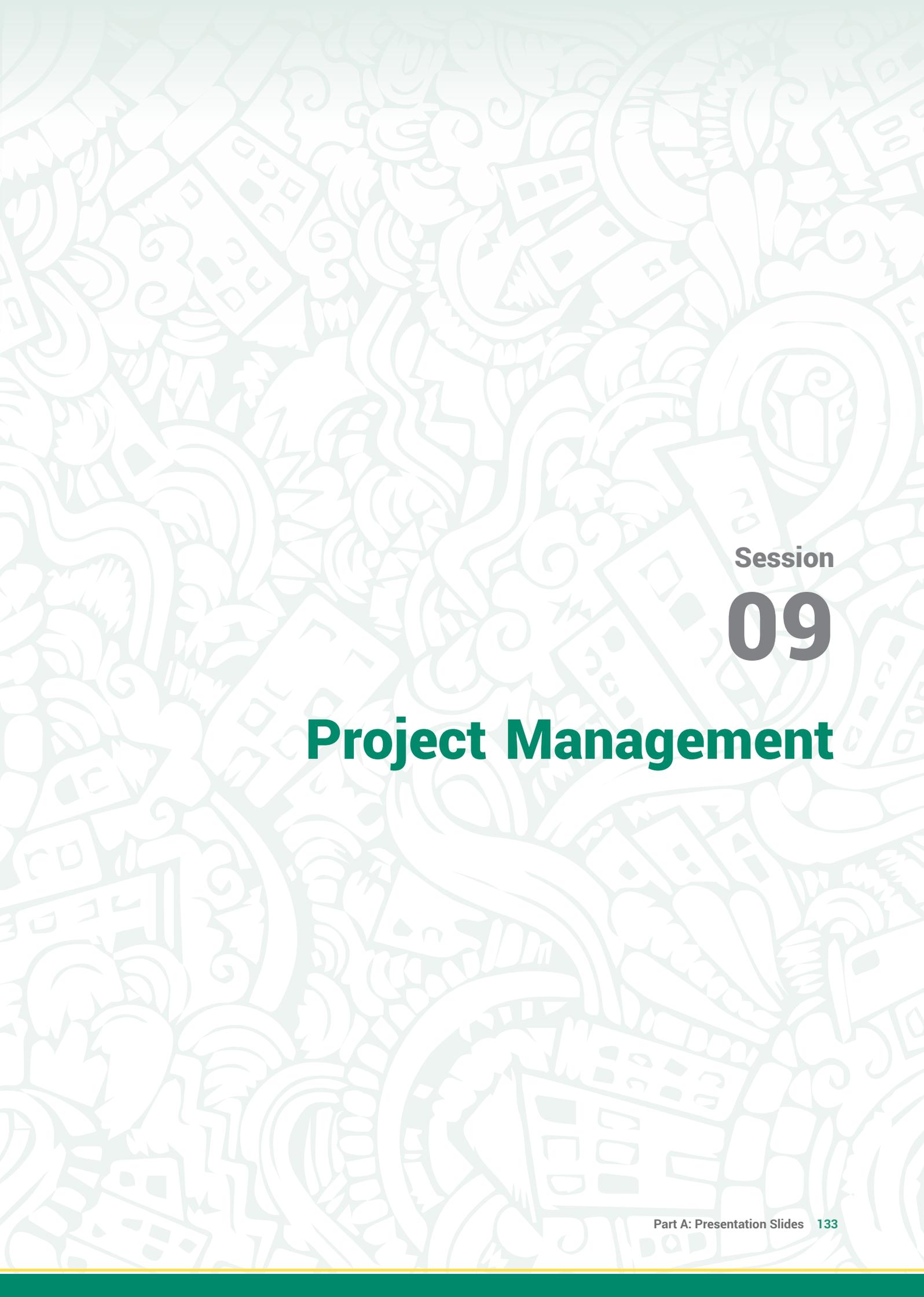


The simplest form of dryer is the direct rotary dryer. This consists of a cylindrical steel shell that rotates on bearings and which is mounted horizontally, with a slight slope down from the feed end to the discharge end. The feed sludge is mixed with hot gases produced in a furnace and is fed through the dryer. As it passes through the dryer, flights (fin-like attachments to the wall of the cylinder) pick up and drop the sludge, causing it to cascade through the gas stream. Moisture in the sludge evaporates, leaving a much dryer material at the discharge end of the dryer. The dried sludge is separated from the warm exhaust gas, part of which is recycled to the dryer while the remainder is treated to remove pollutants and is then vented to the atmosphere.

- Can achieve 75 - 85% dry solids
- Can produce biosolids for beneficial reuse as soil conditioner

Summary

- Objectives of wastewater treatment should be clearly understood before considering different options for treatment
- Non-mechanised and mechanised options are possible with respect to feasibility of the wastewater treatment system
- Capital cost of the project should not be the driving principle for selection of wastewater treatment technology
- Appropriate sewage sludge management is necessary for further reduction of pollution load in the environment



Session

09

Project Management

9. Project Management

Learning objectives

- To gain knowledge about the stages of project management and steps to be followed for holistic planning and implementation of a project.
- To understand the components and to critical points to be reviewed.
- To understand financial modeling of the project to assist choosing of solution and technology.
- To realize that ultimately the project cost should be affordable to the households and shall be recovered in form of conservancy tax/fees.
- To understand project delivery methods in order to successfully implement and sustain the project.

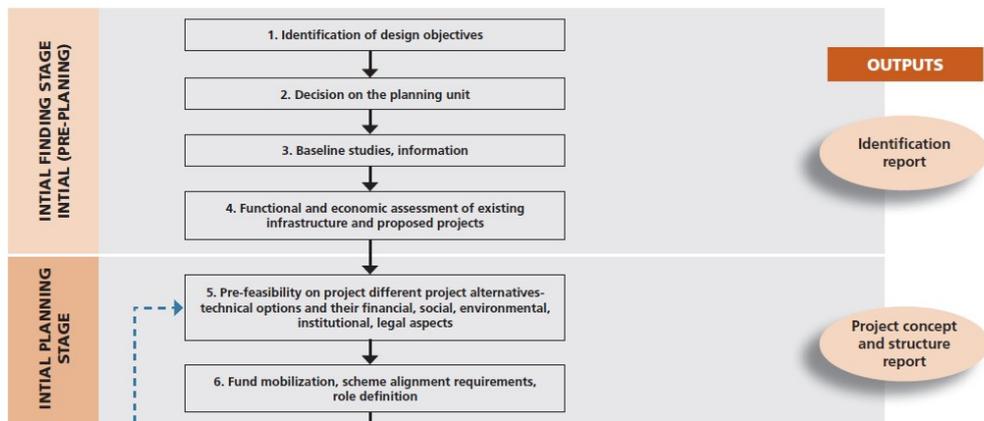
Contents

- Project Management
- DPR Review
 - Components of DPR
 - Things to review
- Financial Modeling
 - Life Cycle Cost
 - Net Present Value
 - Equivalent Annual Cost
- Project Delivery Method
 - EPC
 - PPP

9.1 Project Management

A step-by-step holistic and integrated planning process, not necessarily linear, is needed for all ULBs to ensure safe, hygienic and sustainable sanitation systems. These steps are multi-pronged approach to identify the steps to be followed while bringing people oriented projects into the picture which are based on temporal and spatial phases.

Holistic and integrated planning process

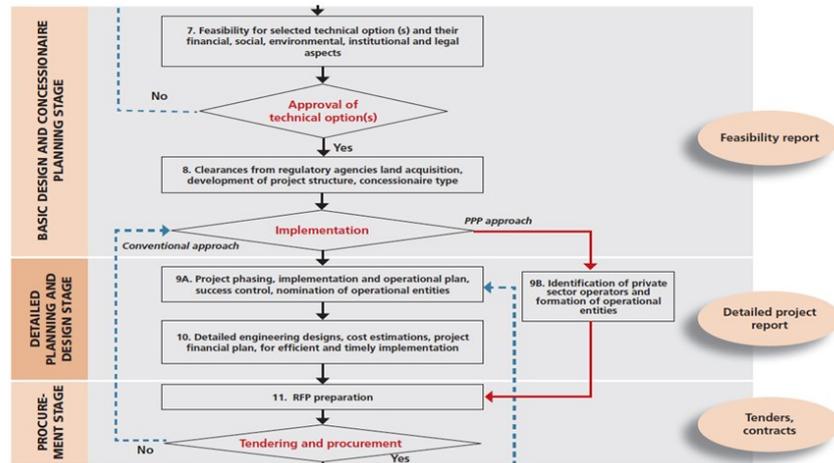


Source: WFM Guidelines, GIZ, 2018

Pre-feasibility on project different project alternatives- technical options and their financial, social, environmental, institutional, legal aspects. The ULBs shall identify the demand for the services and the design requirements based on the baseline information and data collected. Clearances from regulatory agencies land acquisition, development of project structure, concessionaire type The critical decision requirements at this stage shall be related clearance before initiation of the project to avoid legal conflict at later stages.

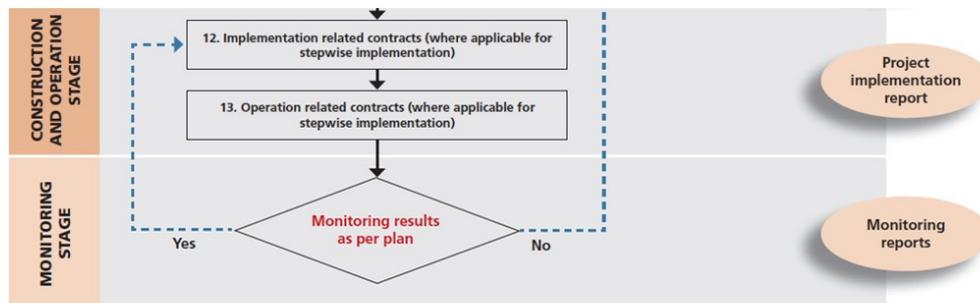
Robust Expression of Interest (EOI) and Request for Proposal (RfP) documents shall be developed. Diligent and efficient bid with appraisal mechanisms shall be carried out based on principles of fairness, transparency, integrity, accountability, and competence in compliance with the statutory rules. Implementation related contracts (where applicable for stepwise implementation) The procurement process shall result in the establishment of governance structures and implementation frameworks that will guarantee safe and sustainable service delivery in the long term. Detailed engineering designs should be developed for the new assets and/ or retrofitting/ rehabilitation of the existing assets and infrastructure, with emphasis on the process design. The designs will provide details of unit capacities/dimensions, context-specific choice of material for construction and phase-wise design. Financial estimates will be based on the civil Schedule of Rates (SoR).

Holistic and integrated planning process



Source: WFM Guidelines, GIZ, 2018

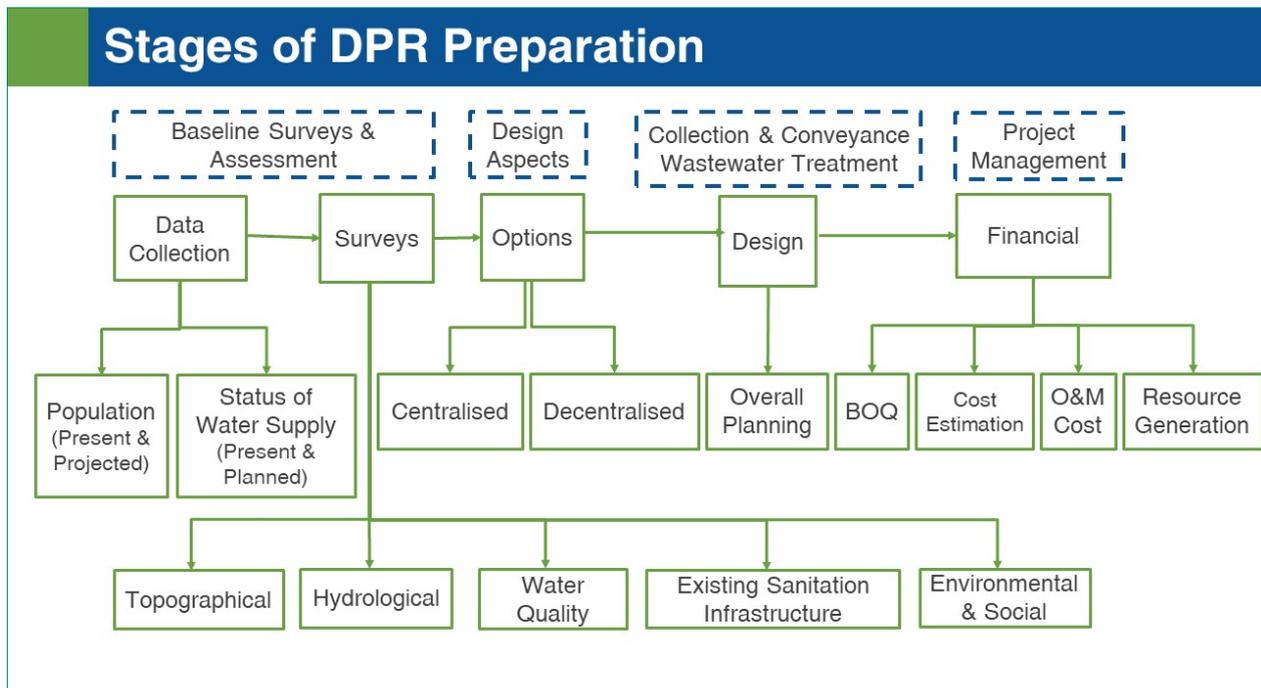
Holistic and integrated planning process



Source: WFM Guidelines, GIZ, 2018

The concerned authorities shall monitor the efficiency of services based on the national or international standards. There shall be a mechanism of monitoring the aftereffects of the implementation along with service delivery with an objective to meet step 1. The authorities can also assign responsibilities, besides the government agencies, to national and international research think-tanks and the private sector as per the contract. Responsibilities may not be limited to monitoring the implementation and service delivery only.

9.2 DPR Review



First stage of DPR is to create a foundation based on which an informed decision pertaining to choose of sanitation system, its plan and design. The foundation stage consists of five sections: (A) Description of Project Area- In this section, the project area is demarcated. Different types of planning document such as master plan, CSP etc. are collected and studied. Feature such as floating population and its fluctuation shall be noted. (B) Existing Wastewater Management- The existing way of managing wastewater shall be documented. The functionality, structural integrity and life of the assets need to documented. (C) Project area and Population- Delineation of urban watersheds based on topography and population projection for each watershed needs to be done. The population projection for base year, 15th year and 30th year is done as per the recommended

design period. (D) Sewage Generation- Use of various factors and assumption is done to arrive at computed sewage generation. However, the same must be confirmed by performing actual measurements and noting diurnal changes and seasonal changes in the flow. (E) Qualitative Analysis- This refers to sampling the wastewater to understand its characteristic and the variations.

Stage 2: Design

<p>2.1 Overall Planning</p> <ul style="list-style-type: none"> • Regional / City level • Developing scenarios • Integration with future plan <p>2.2 Interception & Diversion</p> <ul style="list-style-type: none"> • Weir & gates • HFL <p>2.3 Sewer Network</p> <ul style="list-style-type: none"> • Type of sewer network • Alignment • Invert Levels 	<p>2.4 Sewage Pumping Station</p> <ul style="list-style-type: none"> • Siting • Hydraulic Design • Pumps Configuration • Rising main & Water Hammer Protection <p>2.4 Sewage Treatment Plant</p> <ul style="list-style-type: none"> • Technology selection rationale • Siting and Land Acquisition • Layout of STP • Ancillary provisions • Reuse potential of end products
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The second stage in DPR is Design. In this stage, overall planning and design of each component of sanitation system is done: (A) Overall Planning- In this section, regional/city level planning is done and scenarios are developed using different sanitation systems. The integration of each is checked with future plan so that the assets continue to provide service throughout its design period. (B) Interception and Diversion- Interception and diversion of surface drains and sewers leading to surface water bodies such as rivers are intercepted and the flow is diverted to the STP. The design of the components of I&D shall be done with respect to Highest Flood Level. (C) Sewer Network- In this section, choice of sewer technology and its design is made. Alignment is the sewer pipes should follow the natural topography as much as possible to avoid need of sewage pumping stations. (D) Sewage Pumping Station- In this section, locations of SPS, its design and its ancillary components pumps and rising main etc. is covered. (E) Sewage Treatment Plant- This section shall contain a rationale for choosing a certain technology and go deeper into design of each component. The layout of STP and other ancillary provision must be included here. Reuse potential of the treated end products shall be indicated here.

Stage 3: Non Technical Aspects

3.1 Capacity of ULB – Municipal **finances**, human resources, adherence to municipal **byelaws**

3.2 **Environmental Sanitation** Management Plan – Converging the solutions for long term impact

3.3 **Governance** and **Accountability** Action Plan – Key stakeholders, roles and responsibility

3.4 Communication and Outreach Plan – **Engaging** with stakeholders

3.5 Capacity Building – Project Implementation Monitoring, **O&M and Sustainability**

3.6 **Quality Control** and Assurance Plan – Ensuring longevity of the life of components



The third stage in DPR is pertaining to non-technical aspects. This section is necessary in a DPR, as a certain management solution might entail setting up a committee, performing an environmental impact assessment report and other plans. The topics involved here are: (a) assessment of capacity of the ULB to carry out O&M of the asset and keep it functional, (b) converging intermediate, short term, long term solutions together to achieve objectives of environmental sanitation, (c) governance structure and accountability action plan, (d) stakeholder engagement to avoid any litigation by citizens or activists and improve the tax collection efficiency, (e) capacity building of the staff for developing the project implementation monitoring plan and O&M of the assets and (f) quality control and assurance plan for ensuring the achievement of key performance indicators.

Stage 4: Financial Modelling

4.1 Capital Cost

- Land **acquisition** cost
- Electromechanical components (inclusive **freight** charges and **installation**)
- **Establishment** cost

4.2 Operation and Maintenance Cost

- Human resource
- Power
- Consumables
- Annual **Maintenance**
- **Replacement** Cost

4.3 Life Cycle Cost Assessment

- **Net Present Value**
- Equivalent **Annual** cost
- **Life** of components
- Revenue
- Tax calculation

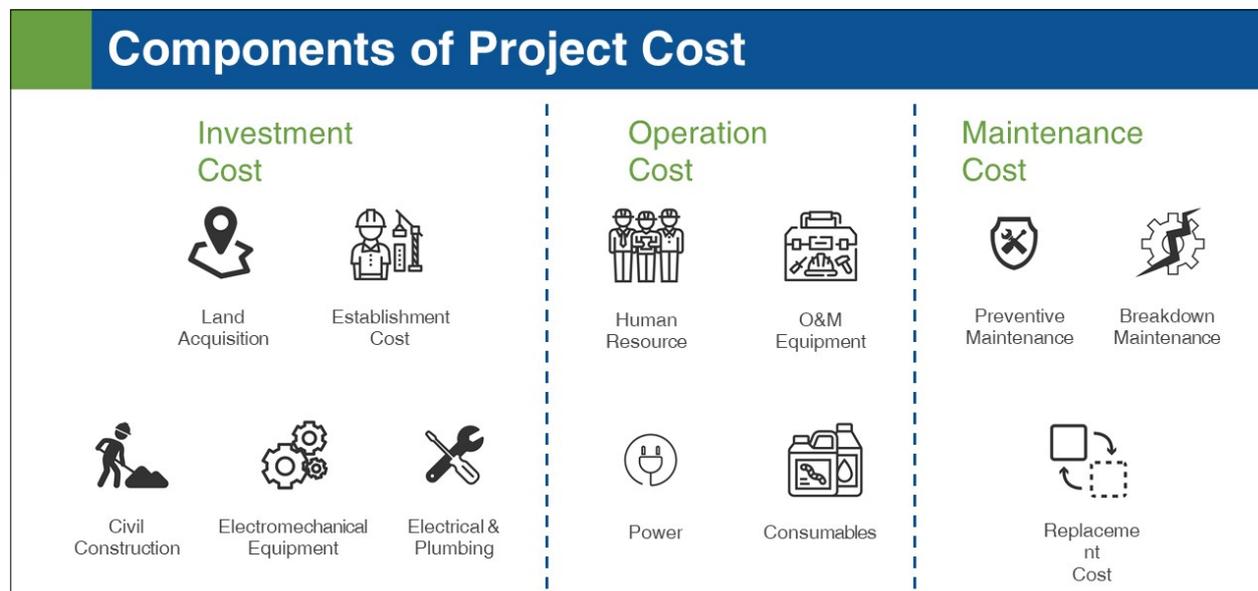
4.4 Fund Management

- Project **planning** (PERT, Gantt Chart)
- **Schedule** of fund with milestones

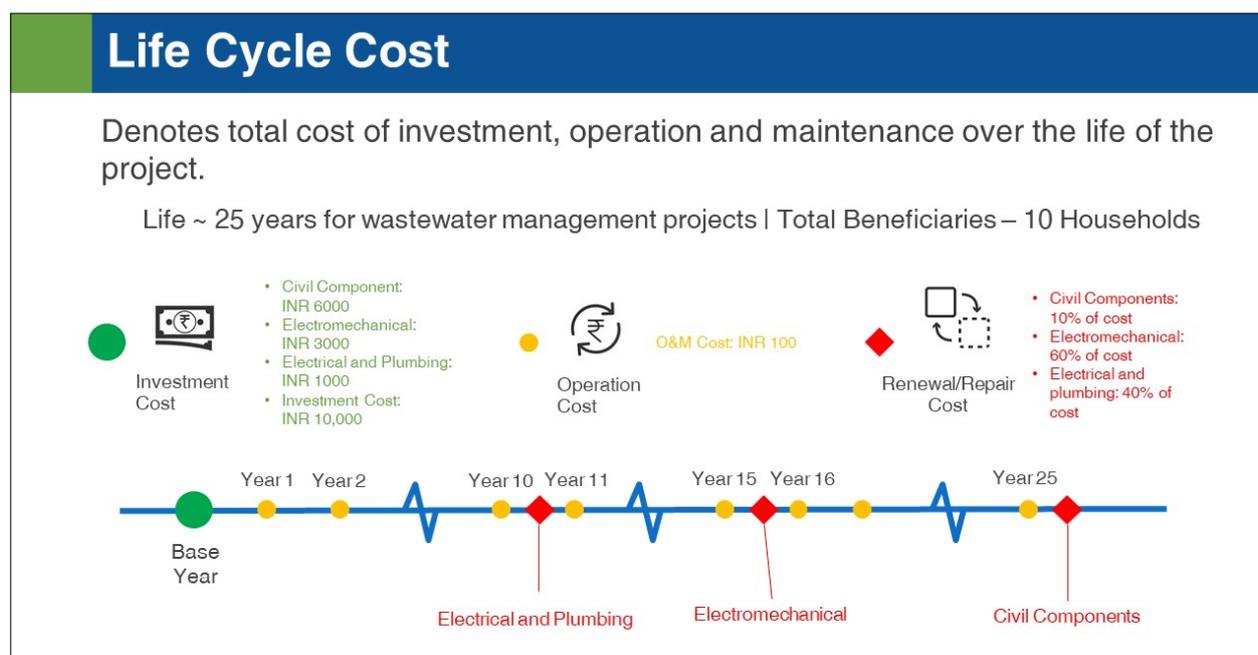
The fourth and the final stage of the DPR is Financial Modelling. It mainly consists following four sections: (A) Capital cost- this part covers cost of all the construction, procurement, implementation, establishment of the project, (B) Operation and Maintenance Cost- this section elaborates on all the components of O&M and its related cost. The cost of repair and replacement at the end of life of certain components shall also be mentioned. (C) Life Cycle Cost Assessment- this section is key

to understand economic viability of the project and tries to combine the CapEx, OpEx and provide total cost of project over its design life. (D) Fund Management- this section provides details about project implementation and schedule of funds requirement based on the milestones indicated in the timeline.

9.3 Financial Modelling

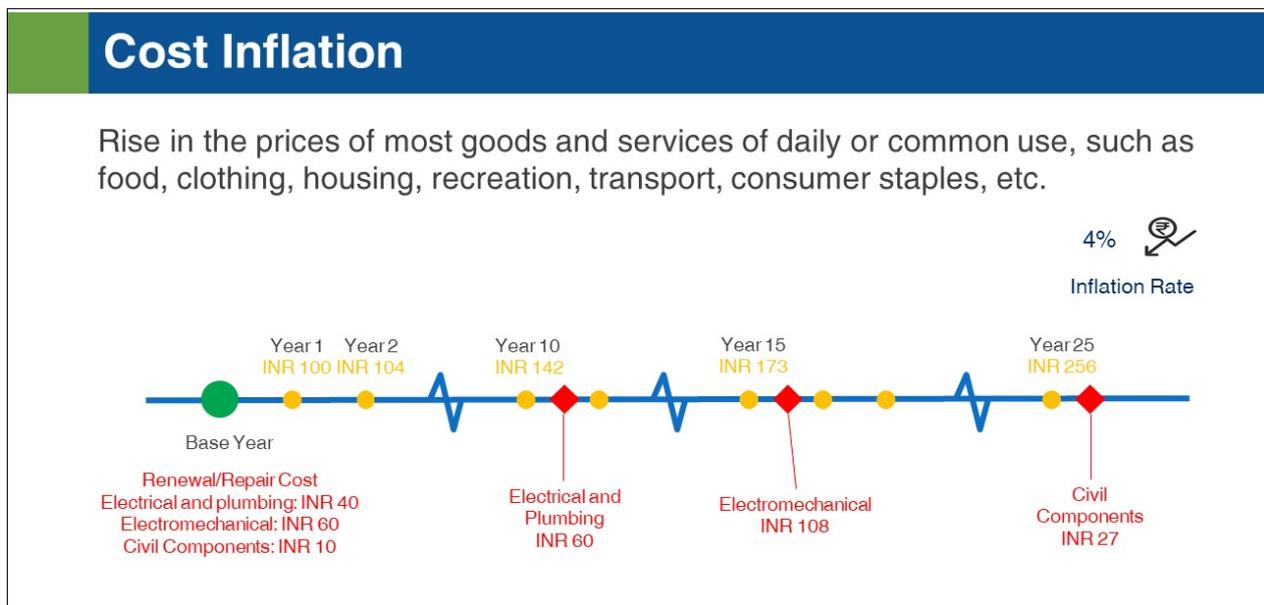


There are mainly three components of project cost: (1) Investment cost- This is a onetime investment which is realized during the construction period of the project. This includes several costs such as land acquisition cost, establishment cost and cost of setting up or procurement of the components of sanitation systems. (2) Operation cost- This is a recurring expenditure required for upkeep of the assets and to maintain their functionality. This mainly includes, cost of power, consumables, human resources etc., (3) Maintenance cost- This expenditure is incurred at a certain interval to carry out preventive/breakdown maintenance or to replace certain components of electromechanical equipment after its end of life.



Life Cycle Cost (LCC) denotes the total cost of investment, operation and maintenance over the life of the project. It shall cover all the cost mentioned in the previous slide. Typically, the life of electrical and plumbing component is assumed as 10 years, that of electromechanical component as 15 years and that of civil structures as 25 years. Hence, the Life Cycle Cost Assessment is done for the period of 25 years. Investment cost (also known as capital cost or CapEx) is a onetime investment incurred at the base year. Operation cost if the recurring expense every year and the renewal and repair cost is incurred at the end of life of the component. At the end of the life, certain repair and replacement might be needed in the components and that is assumed to be 10%, 60% and 40% of the initial cost for civil components, electromechanical components and electrical and plumbing components respectively.

All the recurring cost shall be inflated as per the inflation rate and later discounted to arrive at the life cycle cost of the project.



Inflation is a phenomenon which reduces the buying power of money. The prices of most goods and services increase over a period of time and this leads to reduction in the buying power. Ex. A good that can be purchased in INR 10 today will be priced higher after a certain year. This is due to increase in the cost of raw material, transportation, human resources etc. required to manufacture the product and get it delivered to shops or home.

For calculating the real cost of the project over its life time, the recurring cost or the future cost (repair and renewal cost) shall be inflated using the inflation rate. The example in the slide shows that O&M cost which costs INR 100 in the first year will gradually increase to INR 256 in the 25th year if the inflation rate is assumed to 4% during its life time. Similarly, the cost of renewal and repair which is assumed to 10%, 60% and 40% for civil, electromechanical, electrical and plumbing component respectively is at the base year. The same needs to be inflated for 10th year for electrical and plumbing component, 15th year for electromechanical component and 25th year for civil component.

Net Present Value

Value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present.



Net Present Value is one way of calculating the cost of project. In this case, all the recurring and future costs (now inflated) are discounted using a rate of interest to calculate the net worth of the project today. In simple terms, it provides you the amount which when deposited in a bank as fixed deposit will earn you interest and subsequently cover the O&M expenses and become zero at the end of the life of project which is 25th year in this case.

Thus, if the previous example is continued, the NPV of the O&M cost at a discount rate of 6% is approximately INR 4000. Since cost of investment is calculated as on date it is taken as it is (i.e., INR 10,000). Thus, today's net worth of the project will be approximately INR 14,000.

In case the project is funded through loan or grants from central government then INR 14,000 will be needed today. Out of this INR 14,000, INR 10,000 will be spent by the base year and the rest will be deposited in the bank to fund the O&M in future.

Equivalent Annual Cost

Equivalent Annual Cost (EAC) is the annual cost of owning and maintaining an asset.

$$EAC = \frac{NPV \times R}{1 - (1 + R)^{-n}}$$

6% 
Discount Rate

Where;

EAC: Equivalent Annual Cost [INR]

NPV: Net Present Value [INR]

R: Discount rate [%]

n: Number of years

EAC_{O&M} = INR 309 per year

EAC_{Investment Cost} = INR 782 per year

EAC_{Project Cost} = INR 1,091

Equivalent Annual Cost (EAC) is the annual cost of the owning and maintaining the asset over its life period. EAC discounts the NPV of the project into annual cost. In simple words, it is the amount to be deposited in the bank account every year and the balance in the account will support the annual expenses denoted by EAC over a period of 25 years in this case.

If the complete project is funded through loan, then EAC is the annual payment to be made to the lending agency. Thus, in this case it will be approximately INR 1,100 per year. This amount shall be recovered through municipal taxes or conservancy tax.

In case if the investment cost of the project is covered by grants and the O&M needs to be financed by the municipal body, then approximately INR 310 per year shall be recovered through the end beneficiaries in the form of tax.

Conservancy Tax

Tax collected by Municipal Body to fund the management, maintenance and improvement of common property within its administrative boundary.

Sinking Fund-

Fund established by setting aside revenue over a period of time to fund a future capital expense (such as repairs and maintenance), or repayment of a long-term debt (in case of projects funded through loans).

Scenario A: CapEx covered through grant but OpEx to be recovered through tax

$$Tax = \frac{EAC_{O\&M}}{No. of Properties}$$

INR 31 / household / annum

Scenario B: Project Cost covered through loan/Self funding

$$Tax = \frac{EAC_{Project Cost}}{No. of Properties}$$

INR 110 / household / annum

Conservancy tax is a tax collected by municipal body to fund the complete project or O&M of the project over its life time. It can be calculated using the formula given in the slide. Since, the tax is based on the EAC, its collection for initial few years will lead to higher revenue than needed. This extra revenue shall be deposited in the sinking fund. The amount in sinking fund earns interest and supports the O&M cost in the later year when the annual O&M cost is more than the tax collected.

9.4 Project Delivery Method

Project Delivery Method

System used by an agency or owner for **organizing and financing** design, construction, operations, and maintenance services for a structure or facility by entering into legal agreements with one or more entities or parties.

 EPC Method Engineering – Procurement – Construction	 PPP Method Public Private Partnership
<ul style="list-style-type: none">• Funded by government through grants• Contractor to do EPC• Fixed budget and timelines• Clearances done by government	<ul style="list-style-type: none">• Funded by private through debt, equity and government• Design, Build, Finance, Operate, Own, Transfer

Project delivery method is a system which is structured and used by two or more agency to collaborate in the form of client and contractor to implement a project. The project includes different stages such as organization the stakeholders, financing, design, construction, operation and maintenance in order to ensure functionality of the project over a certain period of time. There are mainly two methods- EPC and PPP method of project delivery.

EPC stands for Engineering-Procurement-Construction (sometimes also called as EPCC where the last C stands for Commissioning). This is straightforward project, where the funds required to implement the project are available with the government and the government tenders out the engineering design, resource procurement, construction and in some cases even commissioning of the project. The selected contractor then enters into EPC contract with the government which entails that the contractor will deliver the project in a certain timeline in a quoted budget. The clearances of permission required during the project period are taken by government. This ensures that there is no unnecessary time lag due to bureaucratic procedures and thereby cost escalation.

PPP stands for Public Private Partnership. The key difference in EPC and PPP is that the financial risk is partly or fully transferred upon the private entity (contractor). The financing of the project is done mainly by the private party through debt, equity funding and institutional funding. There is various variation in PPP method based on the different components of the project which have been discussed in the next slide.

PPP Variations

Model	Identify need	Propose solution	Design	Finance	Construction	Operation	Maintenance	Ownership	Concession
BF	Public Sector			Private Sector		Public Sector			No
BOT	Public Sector		Private Sector					Public Sector	Temporary
BOOT	Public Sector		Private Sector						Temporary
BOO	Public Sector		Private Sector						Yes
BLT	Public Sector		Private Sector			Public Sector	Private Sector		Temporary

BF: Build – Finance; All designs are done by the contractee before hiring contractor.
BOT: Build – Operate – Transfer; National Highways & Expressways
BOOT: Build – Operate – Own – Transfer; Power Plants
BOO: Build – Operate – Own; Water Treatment Plant
BLT: Build – Lease – Transfer; Prisons

The table in this slide provides insights into different variations of PPP method.

- Build - Finance:** In this case, all the designs are provided by the contractee to the contractor. In this method, the contractee (client) has more control on the choice of solution and its design.
- Build - Operate – Transfer:** In this case, the complete project right from the design stage until the maintenance stage. The duration of the contract may vary from project to project; however, in case of sewerage and STP project it is usually up to 15 years.
- Build – Operate – Own – Transfer:** In this case, in addition to the BOT format, the ownership of the asset is retained with the contractor until the end of the contract. This gives a certain advantage to the contractor, as he/she can use the land or the asset for other complimentary purposes.
- Build – Operate – Own:** In this case, in addition to the BOT format, the ownership of the asset is retained with the contractor even after the end of contract. This gives more advantage to the contractor, as the residual value of the project and land can be recovered at the end. Projects with low financial viability / affordability are carried out in this way.
- Build – Lease – Transfer:** In this case, the except the responsibility of maintenance is with the government, everything else is taken care of by the contractor.

[https://en.wikipedia.org/wiki/Project_delivery_method#Build%E2%80%93own%E2%80%93operate_\(BOO\)](https://en.wikipedia.org/wiki/Project_delivery_method#Build%E2%80%93own%E2%80%93operate_(BOO))

https://en.wikipedia.org/wiki/Public%E2%80%93private_partnership#Delivery_models

Risk Allocation

Method	Financing Risk	Revenue Collection Risk	O&M Risk
EPC Model Short Term Contracts	Government	Government	Government
BOT Long Term Contracts	Private	Private	Private
Viability Gap Funding Economically justified but financially non viable	Government & Private	Private	Private
Annuity Model Long Term Contracts	Private	Government	Private
Hybrid Annuity Model Long Term Contracts	Government & Private	Government	Private

This slide provides comparison between different types of project delivery methods based on risk allocation. Three different types of risks are used here- financing risk, revenue collection risk and O&M risk.

In case of EPC model, all the three risks are directed towards government/client. To reduce this risk, PPP models are used. In case of BOT, all the three risks are upon the private party/contractor. However, projects done through this model usually face opposition as they are looked upon as privatization of services. In some projects such as waste management the return on investment is relatively less; hence it is difficult to find financing institution. Hence, an improved version known as Viability Gap Funding was introduced. Here, the financing risk was shared by the government for meeting the investment cost. However, the risk of revenue collection and O&M still lies with the private party. In cases, where the it is ensuring collection of revenue consistently from the beneficiaries, project face issues with O&M and the quality-of-service declines over a period of time. To overcome this difficulty, Annuity Model is used, where the government bears the risk of revenue collection. The collection is made through property tax etc. and transferred to the private party through escrow account.

The latest model known as HAM tries to mitigate all the issues and are considered as fair by experts. In this case, similar to Viability Gap Funding Model, the portion of the initial investment cost is borne by government (usually 40%) and the rest is borne by the private party. The revenue collection risk is borne by government and carried out similar to Annuity Model. The O&M risk is with the private party. However, there are certain disadvantages too in this model. While calculating future payments certain assumptions for inflation rate and discount rate are made. If these rates change due to certain event such as pandemic or natural calamity, the project can quickly become financially non-viable for the private party incurring huge losses. Since, maximum risks are borne by the private party, it is expected that at the end of the project the party is able to get good returns on its investment. Thus, in order to attract private player in HAM, the good margins need to be considered.

<https://www.civildaily.com/recent-ppp-models-epc-ham-an-analysis/>

Summary

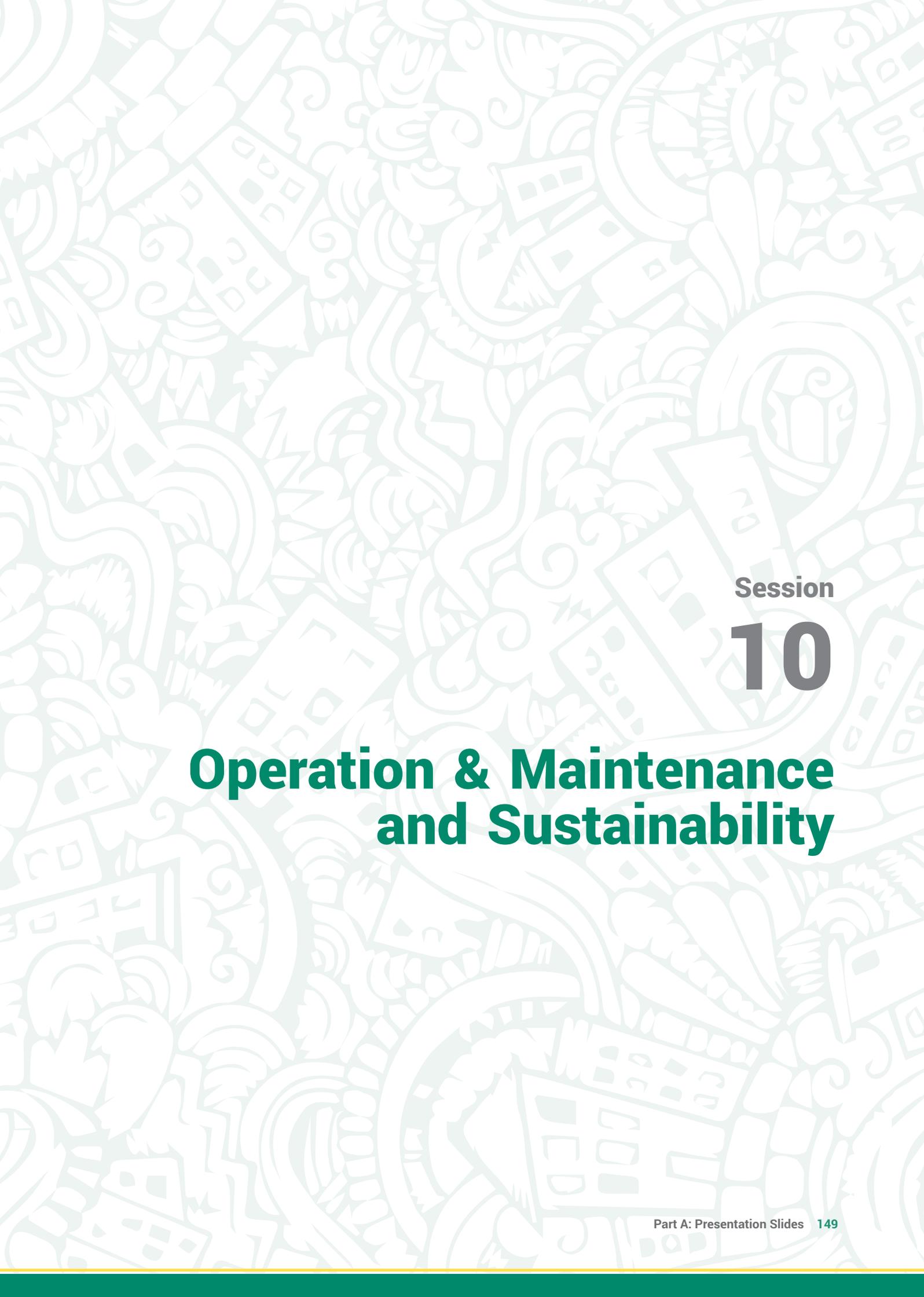
- DPR shall be a technology agnostic document encompassing all aspects of the project – technical, non technical, financial, environmental etc.
- Financial modeling is key to check financial viability and long term sustainability of the project.
- For PPP projects, financial modeling is necessary for fair allocation of risk in the project.
- Project delivery method helps to bind the key stakeholders of the project together.
- Choosing right project delivery method, helps to complete the project time without cost escalations and sustain it for its design life.

The DPR can be broken down in to four stages and each stage has its own significance. Each stage consists of certain critical points, which need to be checked before approving the DPR and proceeding with implementation of project.

Financial modelling is key to understand the financial viability of the project. It is necessary in order to make fair allocation of risks in PPP projects.

Project delivery methods play an important role in binding different stakeholders. Its terms and conditions should be drafted as neutral as possible with fair allocation of risks.

In order to complete the project in time without cost escalation, choosing right contractor and method of project delivery is important.



Session

10

Operation & Maintenance and Sustainability

10. Operation & Maintenance and Sustainability

Learning objectives

- To realize the importance of standardizing O&M of wastewater management system.
- To understand nitigrities of O&M plan for improving reliability and averting breakdown of system.
- To promote occupational health and safety to improving dignity of sanitation workers
- To understand the importance of public awareness and participation in optimizing management aspects of system.

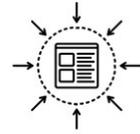
Contents

- **Operation and Maintenance (O&M)**
 - O&M Consideration and Plan
 - O&M Activities of Drains, Interception and Diversion Components, Sewage Treatment Plants (STPs)
 - Monitoring and Record Keeping
- **Occupational Health and Safety**
- **Public Awareness and Participation**
 - Objectives, Target Audience
 - Communication Methods
- **Reducing combined sewer overflow**
 - Control Methods

10.1 Operation & Maintenance

O&M Plan Contents

- Engineering drawings and Specifications of WWM System Components
 - Drains, Interception and Diversion Components, Sewer Systems
 - Sewage Treatment Plants
- Manufacturer's literature and equipment operation guidelines
- Responsible person for each task
- Frequency of each activity
- Operation procedures and tools required to perform the task
- Safety measures required
- Information to be monitored and recorded



The O&M plan should contain the details mentioned in the slide above. The engineering drawings and specification of the wastewater management system components i.e. drains, I&D components, sewer systems, STP etc. In case of electromechanical components, manufacturer's details along with the manual provided with the equipment and its operation guidelines should be attached. There are different types of people who will be working on the wastewater management system such as sanitation workers, sewer cleaning staff, environmental / civil engineer, head operator, operators, chemist, lab assistant, skilled labour etc. The list of tasks and person responsible for it should be clearly mentioned along with its frequency.

Operation procedure and tools required to perform the task should be mentioned. Safety working procedure and use of appropriate safety and protective equipment should be covered in the O&M plan. Information that needs to be monitored and logged into the operator's handbook should also be mentioned.

O&M Plan Contents

- Chemicals and consumables
 - Quantity and quality required for operation
 - Name of the supplier and specifications
- Non regular activities
 - Name and contact details of the company
- Emergency situation
 - Steps to be followed
 - Contact details for emergencies- Fire, Hospital



O&M plan should consist of consumables such as chemicals and their required quantities or dose, name of the supplier and its specification. Storage details of these consumables should also be mentioned. In case of non regular activities such as overhauling of equipment etc. name and contact details of the supplier or the technician shall be mentioned. The plan should also contain the steps that need to be taken in case of emergencies such as fire or medical emergency or natural calamity etc.

Signages for hazards and safe work practices shall be displayed at the pumping stations and treatment facilities.

Maintenance Planning

Preventive Maintenance

- Regularly performed to reduce the likelihood of failing
- Performed while the equipment is still functional so that it does not break down unexpectedly.

Breakdown Maintenance

- Repairs that are done when equipment has already broken down
- To restore the equipment to its normal operating condition

Maintenance Procedures

- ✓ Tasks
- ✓ Frequency of actions
- ✓ Tools and supplies needed
- ✓ Step by step procedure
- ✓ Inspection

Maintenance procedures are of two types- Preventive maintenance and Breakdown maintenance.

Preventive maintenance- It refers to the maintenance which needs to be carried out in order to reduce the likelihood of equipment failure. It needs to be performed when the equipment is still functional so that it does not breakdown unexpectedly causing disruption of the operations. Ex. Applying grease to the moving mechanical parts to reduce the wear and tear or over heating of the equipment.

Breakdown maintenance- It refers to the repairs that need to be carried out to make the equipment functional after its breakdown.

The maintenance procedure sheets shall be prepared for each treatment unit and should consist of all the information mentioned above in the slide. The list of tasks which need to be performed for complete maintenance of the unit. The frequency of the action, certain activities such as oiling and greasing might have to be done on weekly basis where as checking of overhauling of the equipment needs to be done in each quarter. Tools required for performing the tasks needs to be mentioned clearly. A step by step procedure to do the task needs to be mentioned. Exactly what needs to be inspected and what does the situation means should be checked and recorded into the log book.

O&M Requirements

Wastewater Management System Components		O&M Activities
Surface drains	Lined / Unlined Opened / Covered Screens	Periodic cleaning of solid waste and grit, Removing unwanted vegetation
I&D/ Sewer Systems	Gates, Overflow Weir, Interception Channel, Diversion Drain, Sewer lines	Inspections, Periodic cleaning using jetting machine, vacuum/dredging machine, Greasing of gates and valves and anti rust treatment.
SPS and STP	Civil, Electromechanical, Electrical and Plumbing	Daily operations, Preventive maintenance, Inspection and control measures, Monitoring and record keeping

The slide provides details about the various tasks to be performed under O&M activities for surface drains, I&D and sewer systems, SPS and STP. Having a Standard Operating Procedure (SOP) and following it meticulously diagnoses the problem ahead of time and helps to solve it before any major breakdown happens. Preventive maintenance plays an important part to reduce breakdowns of systems which usually costs higher and cannot be avoided.

O&M of Drains

Drains	Lined / Unlined Opened / Covered Screens (at intervals)	Cleaning of Screens (Weekly) Cleaning of Drains (Regular Intervals)
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Poorly designed Screen on open drain



Screen on open drain with raking platform

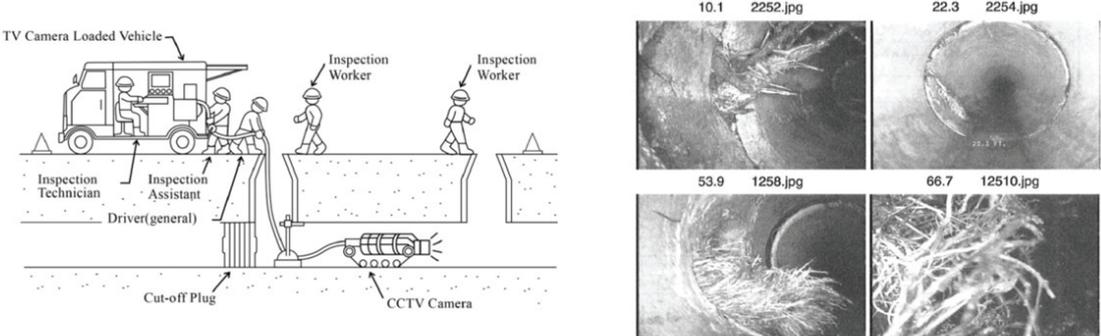


Screens must be installed at certain interval on the surface drains to arrest the solid waste from moving ahead and clogging the drain. The solid waste shall be raked regularly depending upon the screenings collected. The community must be sensitized regarding hazards of disposal of solid waste in the drains. The drain shall also be cleaned regularly to remove the grit and unwanted vegetation if any. These tasks are to be performed using mechanical instruments shown on the subsequent slides.

The screen should be installed with a) the inclination of 45-degree, b) the standing platform for raking/cleaning activity c) the proper access path with safety rails for safe movement of the workers.

O&M of Interception and Diversion (I&D) / Sewer Systems

Inspection of Closed Drains / I&D / Sewer System Components



The diagram illustrates the setup for a Closed Circuit Television (CCTV) inspection of sewer lines. A 'TV Camera Loaded Vehicle' is positioned on the ground surface. An 'Inspection Technician' and an 'Inspection Assistant' are inside the vehicle, while a 'Driver (general)' operates it. A 'CCTV Camera' is lowered into the sewer line through a manhole. A 'Cut-off Plug' is installed in the sewer line to isolate the section being inspected. Two 'Inspection Workers' are shown on the ground surface near the manhole. To the right, four sample images from the inspection are shown, labeled with file names: 10.1_2252.jpg, 22.3_2254.jpg, 53.9_1258.jpg, and 66.7_12510.jpg. The images show various blockages, including roots and debris. A vertical text on the right side of the images reads 'Source: CPHEEO Manual, 2013'.

For Closed Drains / Sewer Lines / Manholes / SPS | Intrusion of roots, blockages, broken pipes etc.

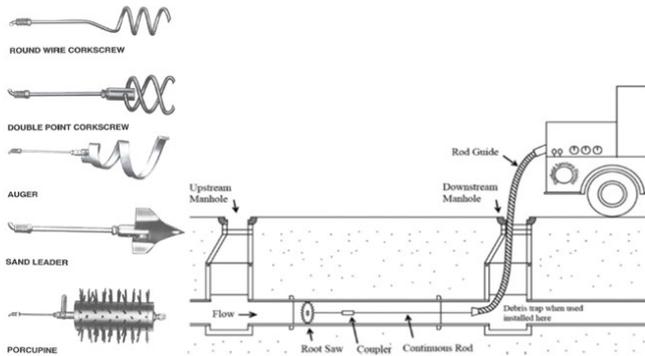
CCTV equipment cost | 6 lakh – 15 lakh

The closed drains with less than 3 ft width or sewer pipes with inside diameters ranging from 150 mm to 900 mm can be inspected by CCTV. The TV camera may be the traveling type or the towed type. Either the direct method (taking panoramic shots of the overall scene) or the side view method of taking local shots of only abnormal locations may be used.

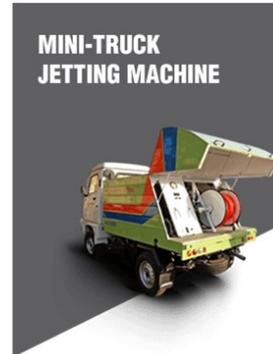
The procedure is as follows:(a) The site needs to be isolated from the traffic using traffic safety equipment. (b) The two machine holes between which the pipe needs to be inspected are opened and safety rails or hole guards are installed. (c) Sewer plugs are installed to restrict and/or divert the flow of wastewater. (d) The CCTV camera is lowered into one of the machine holes and the inspection is carried out. The length to be inspected can be up to 300 m depending upon the length of wires. (e) Video is recorded and photographs are taken as shown in the slide to detect the nature of issue.

Inspection Sheet and Daily Report Sheet (Part B: Operation and Maintenance, Chapter 2: Sewer Systems), PP 27-28

Mechanised Cleaning of Drains / I&D / Sewer System Components



Power Driven Rodding Machine



High Pressure Jetting Machine

Power Driven Rodding Machines

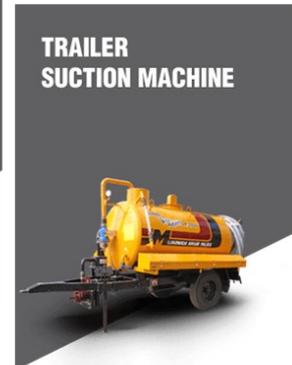
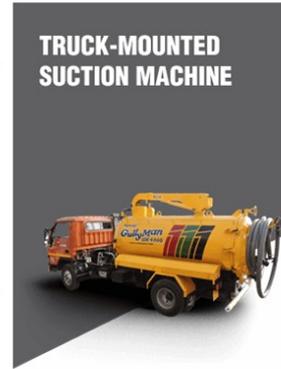
It is used for removing the hard choke (solid waste and root intrusions) and unclogging the drains, sewer lines or other components. The to and fro movement along with the specially designed rodding head makes it easy to cut through, grab and remove the blockage. There are different rodding heads used for different purposes. There are different sizes of rodding machines depending upon the size of the pipes. For example, a cutter type head is used of specific diameter to cut the root intrusions in the drain.

High Pressure Jetting Machines

Jetting machine is used to clean the soft choke and clean the insides of sewer lines. The inside surface of sewer pipes gets covered with slime, dirt and grit over a period of time. If this is not cleaned at the right time, it hardens and starts building up hard choke. The jetting head propels due to hydraulic pressure of the water coming out of the head. It dislodges the wax and grit and pushes it back into the machine hole. Vacuum trucks or dredging machine can be further used to lift the grit from the machine hole.

O&M of Interception and Diversion (I&D) / Sewer Systems

Mechanised Cleaning of Drains / I&D / Sewer System Components



Dredger Machine or Desilting Machines

It consists of a grab bucket on a wire rope, which is lowered into the manhole or drains in the open condition with the help of a crane and pulley. On reaching the bottom of the drains or manholes, the segments are closed, and the accumulated silt is picked up. The bucket is then raised above ground level where the bucket opens and the silt is automatically dropped into a truck or a trailer. The bucket can be closed by wire ropes or by a pneumatically operated cylinder.

Suction Machines

Suction units create the vacuum required for siphoning of mud, slurry, grit and other materials from sanitary, storm and combined sewerage systems. The vacuum elevated is such as to siphon the materials from the deep manholes catch-pits etc., having depth ranging from 1m to 8m in normal cases with an option to suck an additional 4m with the help of special accessories for the purpose. The unit can be truck mounted or trailer mounted

O&M of Sewage Treatment Plants

- Asset Management
- Preventative maintenance
- Cleaning of equipments
- Regular inspection and monitoring
 - Treatment processes and performance
 - Electromechanical components
- Monitoring and Record Keeping



The O&M plan of sewage treatment plant includes the following activities:

- **Asset Management** – It refers to the management of specific treatment facilities (e.g., electromechanical components) which need special attention to avoid breakdown.
- **Preventive maintenance** – It refers to the maintenance which needs to be carried out in order to reduce the likelihood of equipment failure. The regular preventive maintenance needs to be performed when the equipment is still functional so that it does not breakdown unexpectedly causing disruption of the operations. E.g.
- **Cleaning of equipments** – It includes the regular cleaning of equipments such as screens, grit removal systems, solid handling facilities etc.
- **Inspection and monitoring** – Regular sampling and analysis is required to understand the processes and performance of the treatment units. The records of it have to be maintained by the operator for any troubleshooting requirements.
- **Monitoring and record keeping** – It helps to understand the working of the treatment units i.e., treatment processes and performance. It serves as an early detection of any issue or failure. Record keeping and reporting of operating conditions are essential tools for operators or managers to control the facility and satisfy the compliance reporting requirements. It needs to be done in different document formats by the staff with specific responsibilities.

Monitoring and Record Keeping

Record Keeping

- Operator's log book
- Inlet and outlet monitoring report
- Treatment unit operation sheets
- Interpretation and communication of technical data



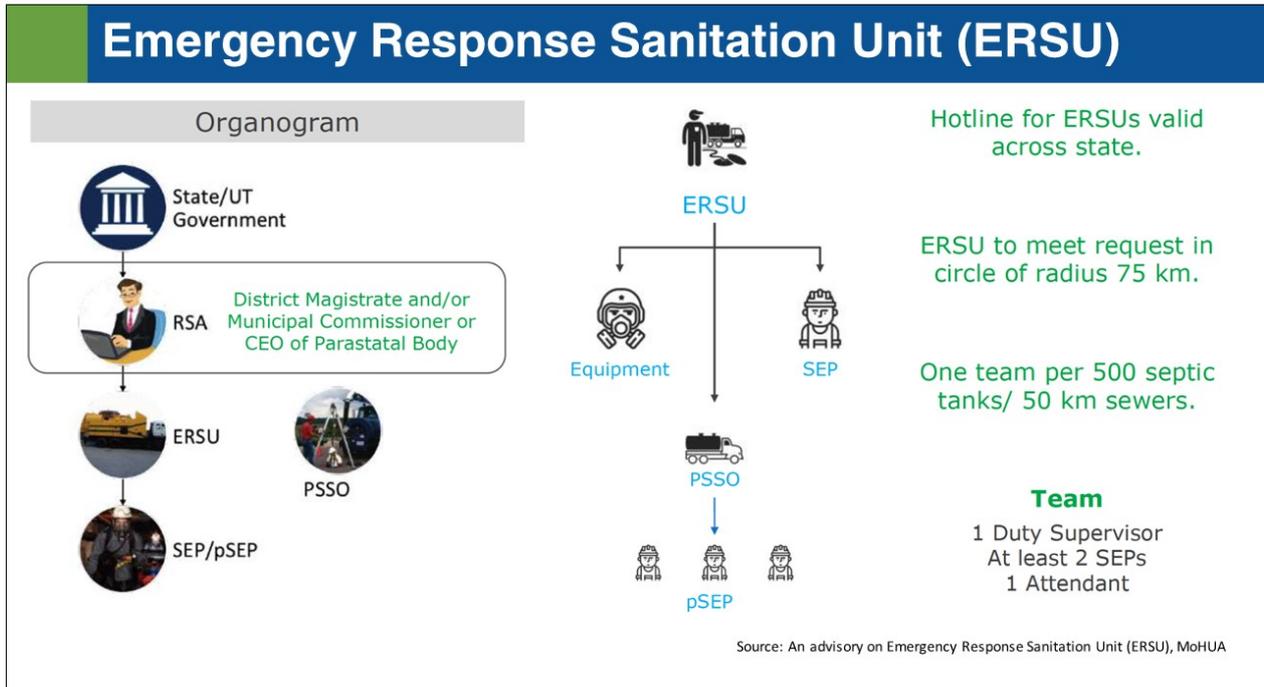
- Disaster response and emergency recovery records
- Preventive and corrective maintenance records
- Compliance reports
- Employee records, schedules, time sheets and injury reports



Record keeping is a part of monitoring activity. Record keeping is in different forms and might have to be done by different persons. For example, the operator's log book needs to be maintained by one or more operators appointed at the treatment facility. The inlet and outlet log book should be maintained and report should be prepared. Disaster or emergency response record helps to record the accidents happened at the facilities. These are required in case the facility goes for ISO certification. The preventive and corrective maintenance records are kept for electromechanical components so as to understand the right time to place orders for spares etc. Compliance's report is necessary and are to be produced in case to pollution control board from time to time.

Such record keeping helps to trace the issues, challenges and solutions for overcoming them. This documentation becomes of utmost importance, then the operators are changed during shifts or O&M contract is awarded to the new party.

10.2 Occupational Health and Safety



The main objective of the ERSU is to provide a professional, well trained, motivated and appropriately equipped workforce for the maintenance and management of sewers and septic tanks. This will thereby eliminate the deaths caused by entry of workers into sewers and septic tanks without proper PPEs & training and nonadherence to security protocols. ERSU are to be set up in major cities which have Municipal Corporation and/or Water & Sewer Board and in capital cities of each State/UT. The ERSU shall be responsible to meet sanitation emergency requests from all smaller towns within a cluster say 75 Km radius.

Occupational Safety - PPE

- Municipalities should provide workers with safety gear.
- Each worker should be made aware of the risks of the work through trainings.
- Workers should be held liable for not using available protective gear

Basic Personal Safety Kit

			
Oxygen Cylinder	PVC Safety kit	Safety Grills	First-Aid Kit
			
Torch Light	Radium Jacket	Safety Belt with Rope	Glasses

Source: Training Module for Sanitary Workers on Cleaning of Sewers and Septic Tanks,

PPEs are very crucial for the better health and safety of the sanitary workers. ULBs should provide the workers with personal protective equipment or if private operators are involved, ULBs should ensure through contract that the private operator provides the same to the persons on duty. Basic PPE includes helmet, goggles, mask, boots and torch. Use of PPE should be made mandatory as well as strictly monitored and appropriate action should be taken for noncompliance. It is essential to make the workers primarily handling septage aware of health hazards if PPE is not used.

Personal Protective Equipments

HEAD PROTECTION		EAR PROTECTION		BODY PROTECTION		FOOT PROTECTION	
							
Hard Hat	Ear Plugs	Full Sleeves Shirt	Full Length Pants	Protective Footwear			
LUNG PROTECTION				HAND PROTECTION			
							
Full Face Respirator <small>Used in well ventilated</small>	Powered Air Purifying Respirator	Self Contained Breathing Apparatus	Supplied Air Respirator	Mechanical Resistant Gloves	Chemical Resistant Gloves		

On your screen, you can see various personal protective equipments like hard hat, ear plugs, protective footwear, hand protection etc, which are required to safeguard health of the workers, during the cleaning of septic tank or sewer lines.

10.3 Public Awareness and Participation

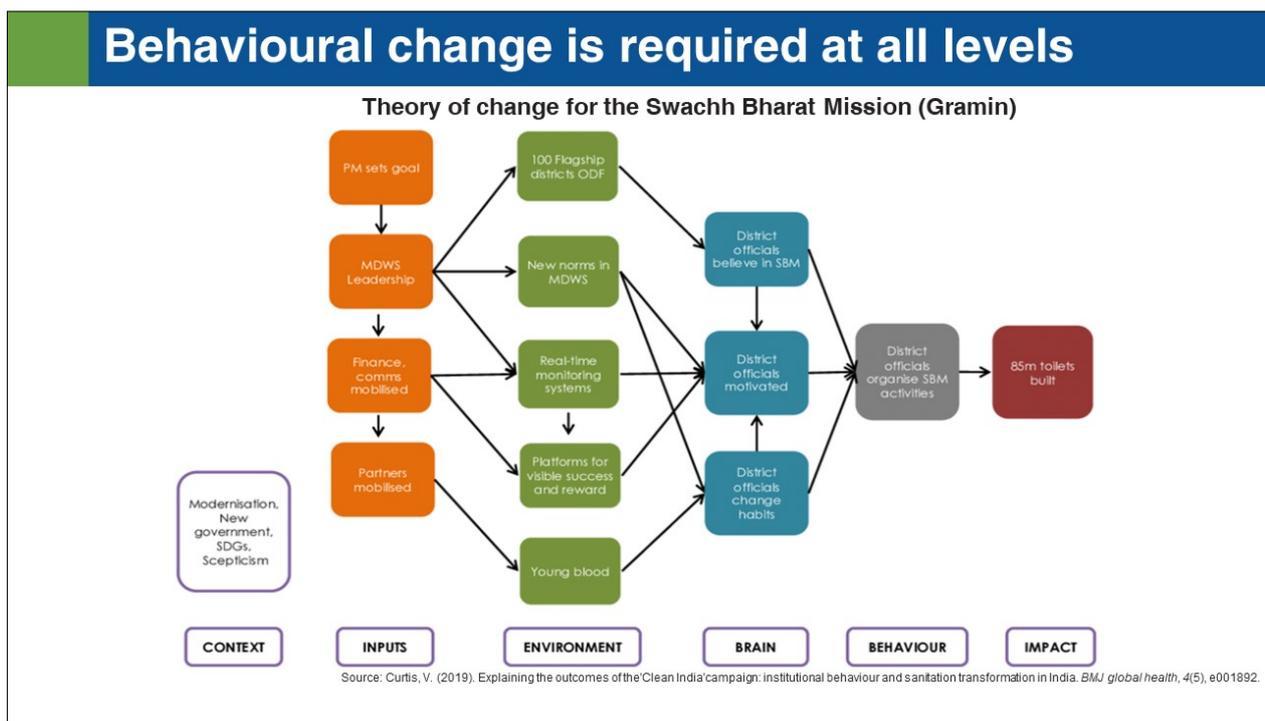
Public Awareness and Participation

<p>Objectives</p> <ul style="list-style-type: none"> • Community awareness of the project • Community involvement at all stages – generate a sense of ownership • Keep the stakeholders and community informed of the progress 	<p>Target Audience</p> <ul style="list-style-type: none"> • Residents • Local and state departments • Local influential leaders, NGOs • Elite groups, Schools • Representatives of political & religious leaders, trade unions, industries, media.
	

Community awareness and participation is the key to success for achieving 100% sanitation and to ensure personal hygiene in the community. It is necessary to formulate an effective public education, awareness and participation programme as part of the wastewater management system DPR.

The objective of any community awareness and participation programme is to develop an understanding of the benefits of sewage collection, treatment and disposal, improved sanitary conditions, better user-understanding and involvement in terms of time and money, and enhanced acceptability of this concept and organizational credibility.

On the other hand, the community has the responsibility for participating willingly in awareness and involvement programmes, understanding the significance of sewerage system to achieve sanitized community, and bring about behavioral changes aimed at adoption of healthy sanitation practices.



The slide showcases how the theory of change for SBM(G) resulted in one of the biggest peoples' movement towards ODF. On the right are the observed changes to the state of the world through toilet coverage. Left of this, in grey, is the change in behaviour of district officials. In blue, are the psychological changes in these actors, brought about by changes in their operating environments, shown in green. The orange boxes are aspects of the intervention (ie, the activities of SBM(G) as led by the MDWS (now Ministry of Jal Shakti) that caused this cascade of changes.

Communication Methods - IEC and BCC Tools



Manuals/
Educational
materials



Hoardings



Films/ Videos/
Television
commercials



Newspaper
advertisements



Audio tapes/
Radio
advertisements



Exhibitions



Theatre



Mobile phone
messages



Wall writings/
Paintings



Pamphlets/
Brochures/ Flyers



Street plays/
Songs/ Dance



IPC, Involvement
of NGOs

Information Education and
Communication
(IEC)

(TEACH)

Information provision and
telling people how they should
behave

Behaviour Change
Communication
(BCC)

(TEACH + SUPPORT TO ENABLE CHANGE)

Information provision
+
Help people to **make personal decision**
+
Provides **supportive environment**

There are variety of media and communication methods exist, each with its own advantages and disadvantages. The use of a combination of several media at the same time can reinforce the necessary messages. Person to person contact carried out through community members, who are already convinced of the truth of the message, is usually the most effective means of communication. This slide includes the list of some user-friendly measures that could be effectively used in community awareness programme for attaining complete transparency in operations.

Malasur Campaign: Wall Painting, Posters And Miking



Pattamundai Municipality, Odisha



Chunar Nagar Palika Parishad, UP



Kichcha Nagar Palika Parishad, Uttarakhand



Dewas Municipal Corporation, MP



Vadgaon Municipal Council, Maharashtra

Septic Tank Desludging: Hoardings, Paintings, Pamphlets



Source: BBC media and Municipal Corporation of Chhattisgarh

ODF Plus Sustainability: Hoardings, Wall paintings, Pamphlets, News paper

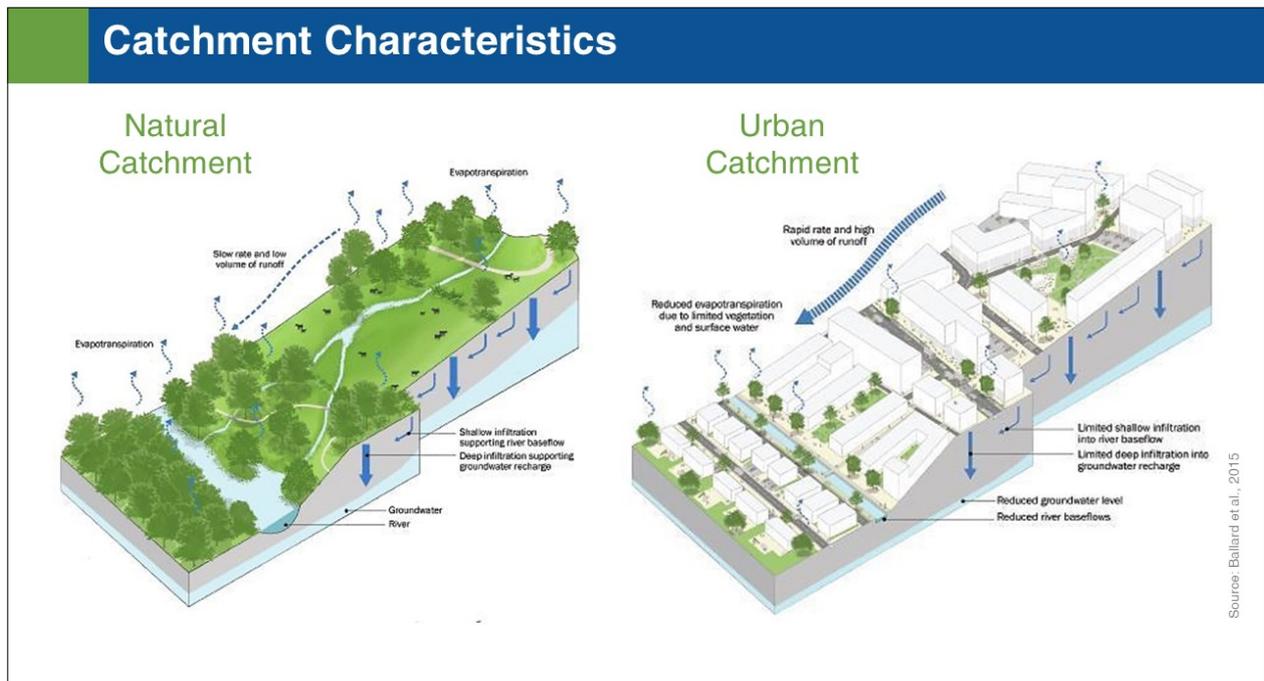


In the context of covid19, people who shifted from open defecation to using community toilets may revert to old habits of open defecation. There is a need to instill a sense of pride in the ODF status and moving collectively towards sustaining ODF behaviours.

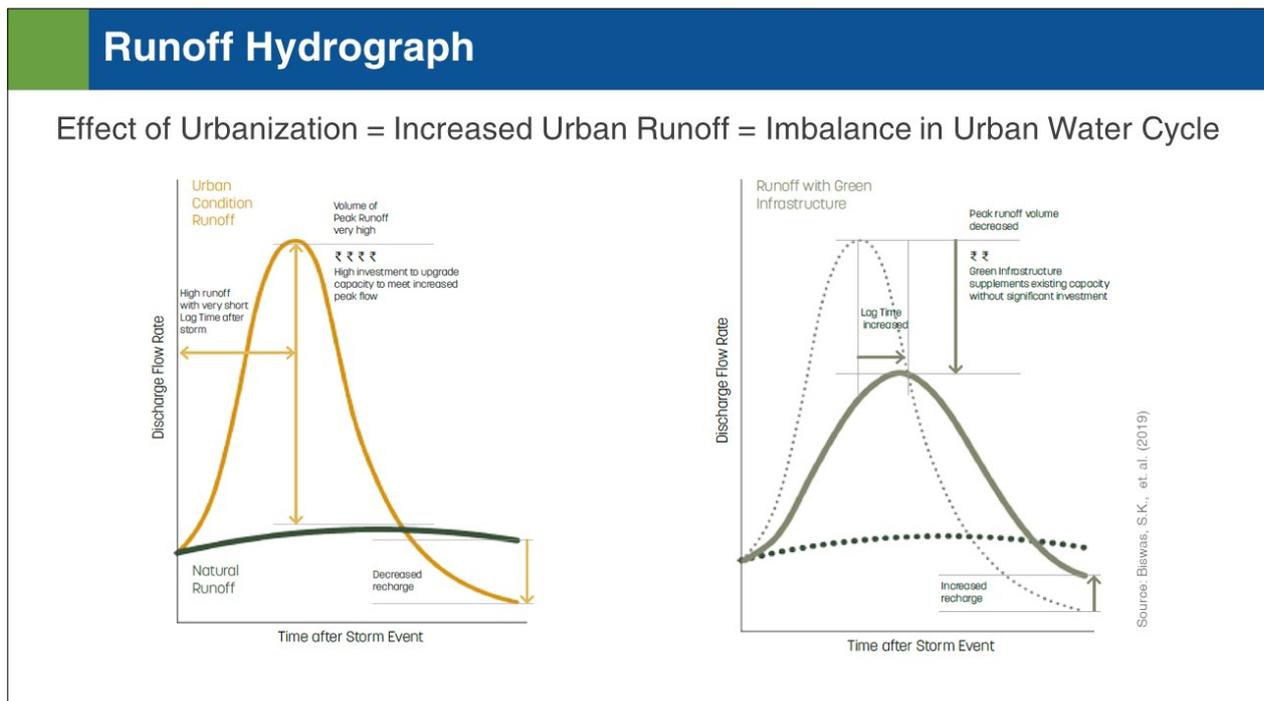
The objective is to promote and reinforce continued usage of toilets among citizens. With this object BBC media designed this campaign for the continued usage of toilets.

Source: BBC media

10.4 Reducing Combined Sewer Overflow (CSO)

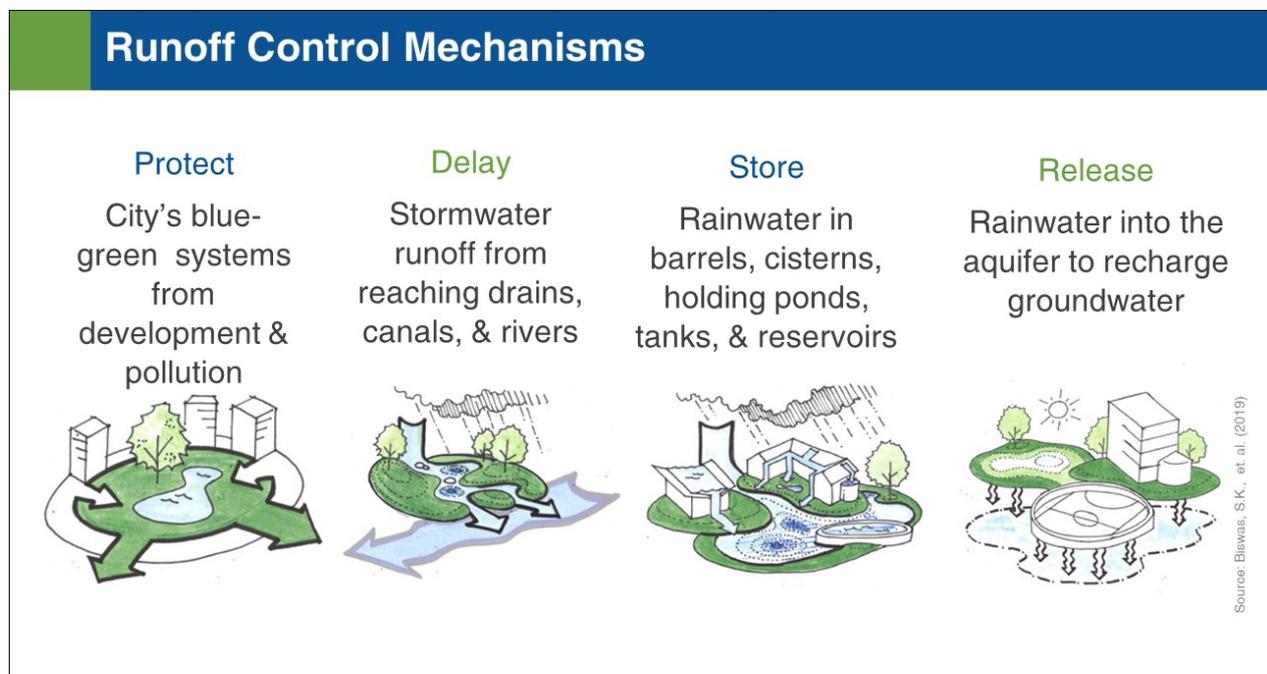


The characteristics of the catchment play important role in the water cycle. The picture on the left shows a catchment with natural environment and its features. During wet weather, as shown in the picture, most of the water will find its way into the ground water aquifer. Runoff generation will be low as lot of rain water will be used to first wet the natural surface, saturate it with water. On the other hand, the picture on the right shows a catchment with built environment and its features. In this case, during wet weather, the impervious surface will immediately generate runoff. This leads to urban floods in the low-lying areas of the city.



The slide shows two hydrographs. The first graph on the left is the hydrograph showing the discharge flow rate in a drain during a storm event for natural catchment and urban catchment with grey infrastructure. Grey Infrastructure refers to the drainage systems such as combined sewers or storm water sewers in place to manage urban runoff. In this hydrograph, it can be observed that the discharge peak in urban catchment is significant as compared to that in natural catchment. It should also be observed that the peak occurs before the discharge peaks in case of natural catchment.

The hydrograph on the right shows the plot of discharge in urban catchment with green infrastructure. Green infrastructure refers to soft systems put in place to delay, release, filter or store the runoff. It can be observed that this time, the peak is significantly lowered and also it occurs later than it did before. Thus, it can be inferred that, (a) scaling up grey infrastructure to handle extreme conditions is a prohibitively expensive approach without any benefits of public realm improvements or natural recharge and (b) leveraging green infrastructure and other natural methods to manage runoff can significantly lower upgrading and maintenance costs of stormwater infrastructure.

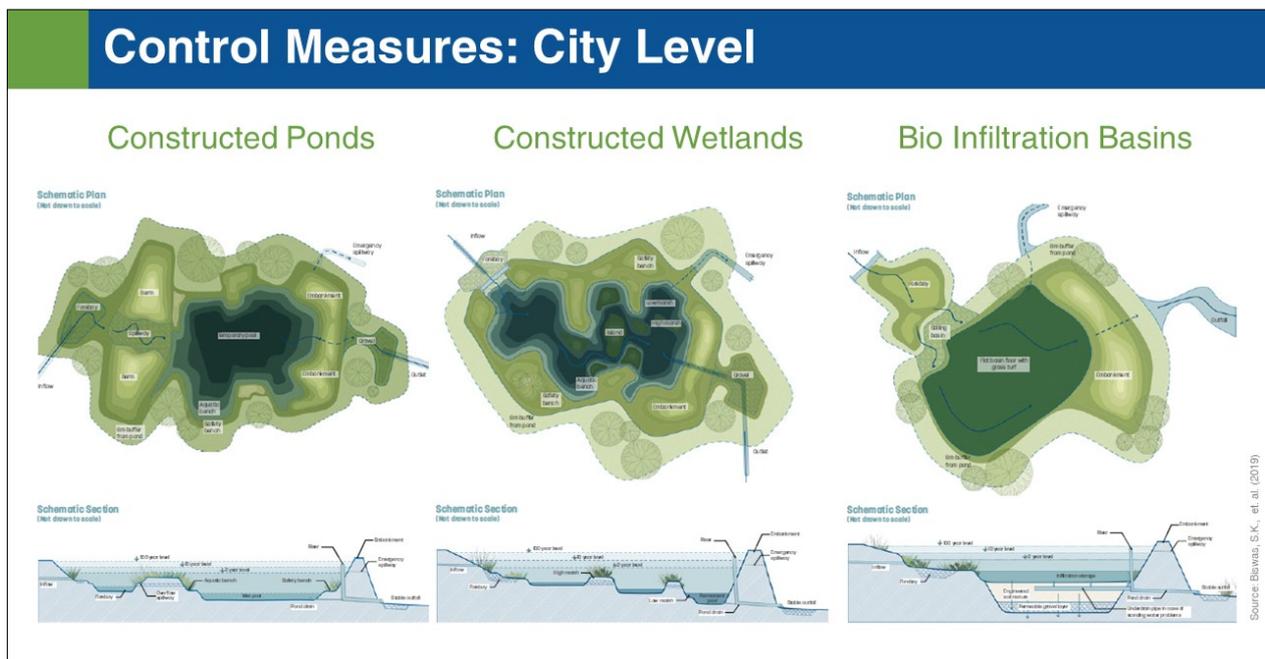


The slides show various runoff control mechanisms.

- **Protect:** Refers to protection of the city's green spaces and water bodies from development, encroachment, and pollution. Natural systems that have been compromised by encroachment or pollution have to be restored into fully functioning systems.
- **Delay:** It is a vital principle to mitigate the risk of flooding during a storm event or cloudburst. It refers to absorbing the runoff for a period of time, there by delaying the peak discharge.
- **Store:** It refers to storing the runoff in detention tanks, basins, ponds etc. there by arresting its contribution to the discharge.
- **Release:** It refers to release of the stored runoff into the ground water aquifer during and after the storm event.

The slides show three control measures which can be implemented at the community level.

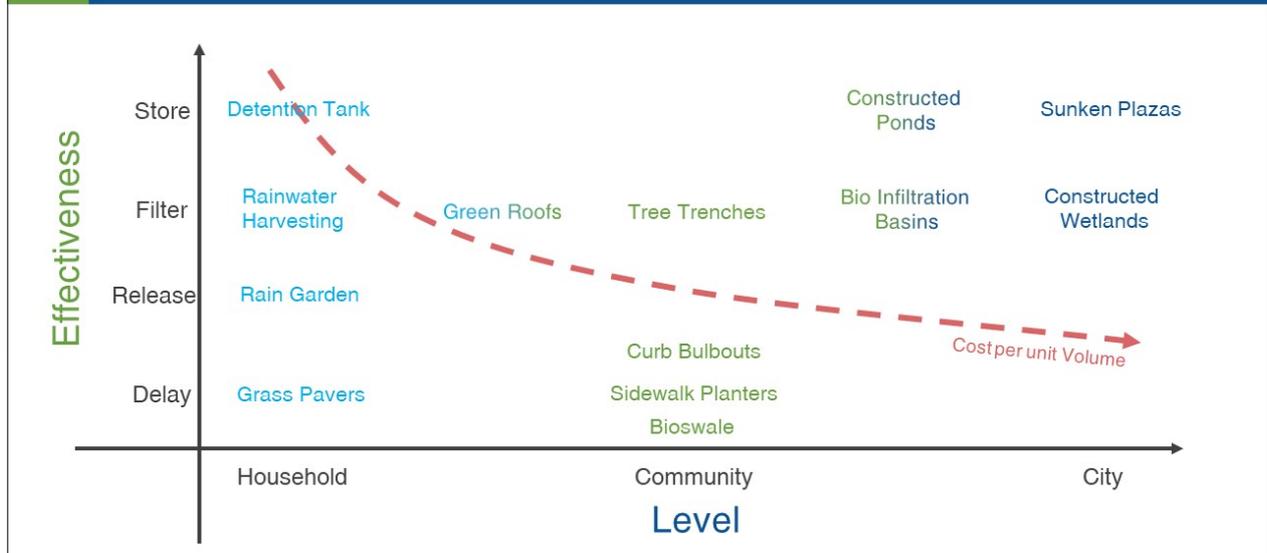
- **Bioswale:** Bioswales are channels designed to concentrate and convey stormwater runoff while removing debris and pollution. Bioswales can also be beneficial in recharging groundwater. Bioswales are typically vegetated, mulched. They consist of a swelled drainage course with gently sloped sides.
- **Sidewalk planters:** This technique refers to utilizing a portion of the sidewalk to create a smaller version of bio swale with larger surface area to catch the stormwater runoff.
- **Tree trench:** In this technique, the trees along the roads are used as center piece of an infiltration trench. Such trench arrests the stormwater runoff and after filtration transfers it to the drain. It delays and filters the stormwater runoff.



This slide shows three measure that can be implemented at the city level for stormwater and combined sewer overflow management.

- **Constructed Ponds:** This refers to creating a series of ponds in which the water flows by gravity. Each pond helps to reduce the sediments and pollutants in the stormwater runoff. The pond and its bank shall have wetland species such as Typha, Cyprus, cattail etc. which helps to further uptake the heavy metals and hydrocarbons from the stormwater runoff.
- **Constructed Wetlands:** In this case, instead of pond, basins of various depths are created. The basins are filled with civil aggregates and planted with wetland species. The presence of vegetation in the basins augments the treatment efficiency further.
- **Bio infiltration basins:** Unlike constructed ponds and wetlands, bio infiltration basins are structures which are not water logged throughout the year. These are bowl shaped structures which collect the runoff during storm event and later slowly release the water into the groundwater aquifer. The top layer of the strata is engineered in such a way that most of the sediments are trapped and the water gets clarified as it percolates down.

Control Measures Application

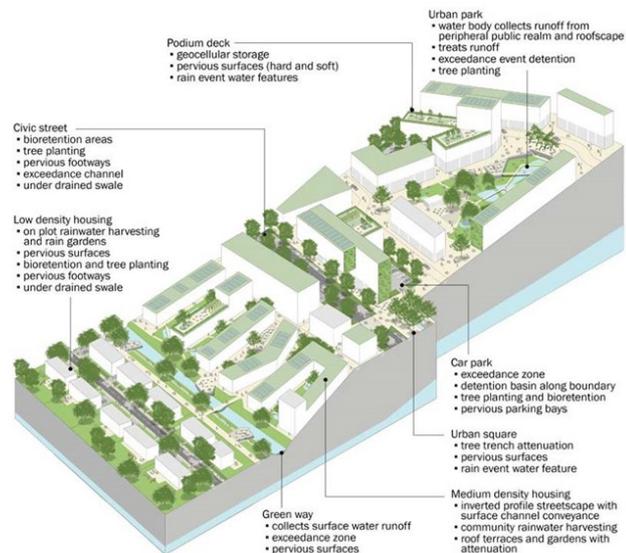
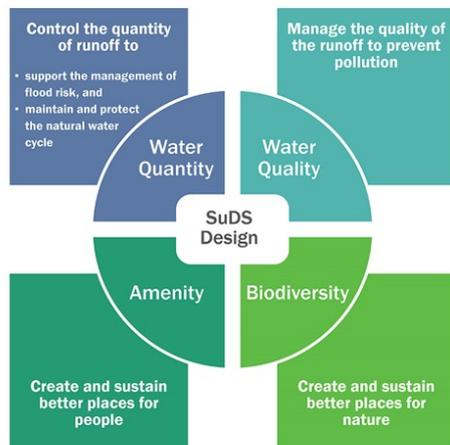


This slide shows the control measures for managing the stormwater runoff and compares their effectiveness and level of application. Effectiveness is measured based on impact a control measure has to eliminate the runoff. Thus, detention tanks and sunken plazas are highly effective as they arrest the runoff from going into the grey infrastructure. The control measures at the household level can be implemented through enforcement of byelaws by the ULB whereas the control measures to be implemented at community level can be implemented through enforcement of byelaws on the land and project developers. All the control measures discussed for household and community level are also applicable in commercial areas, malls and market places. The control measures to be implemented at the city level shall be considered by the ULB and Urban Development Authority while preparing master plan, CSP and stormwater management DPRs for city and its adjoining areas.

The cost per unit volume of runoff managed decreases as the scale increases. This happens due to the economy of scale. However, the cost of the measures to be implemented at city scale are to be borne by the ULB and State, whereas the cost of measures to be implemented at household and community level is borne by the households directly.

Stormwater Management

Sustainable Drainage Systems



Stormwater Management has evolved over a period of years. The importance of green infrastructure has been realized and the same has been incorporated in the Sustainable Drainage Systems (SuDS) concept. The SuDS design principle is based on four pillars – Water quantity, Water quality, Amenity and Biodiversity. Water quantity refers to controlling the quantity of the runoff there by protecting the urban areas from the risk of flooding. Water quality refers to improving the quality of runoff to prevent pollution of surface water bodies. Amenity refers to the creating and sustaining infrastructure which not only provides environmental function of managing stormwater runoff but also improves the places for people. Biodiversity refers to create and sustain green infrastructure which helps to increase the bio diversity in the build environment.

The picture on the right shows the implementation of various control measures in the urban catchment in order manage stormwater runoff in a sustainable way.

O&M plan should consist of consumables such as chemicals and their required quantities or dose, name of the supplier and its specification. Storage details of these consumables should also be mentioned. In case of non regular activities such as overhauling of equipment etc. name and contact details of the supplier or the technician shall be mentioned. The plan should also contain the steps that need to be taken in case of emergencies such as fire or medical emergency or natural calamity etc.

Signages for hazards and safe work practices shall be displayed at the pumping stations and treatment facilities.

Summary

- O&M plan is very important and need to holistically cater to all the tasks that need to be performed by the operator to keep the system operational.
- Monitoring of the processes at the treatment facility help in early detection or completely avoid issues and challenges at the treatment facility.
- Occupational health and safety contributes to improving dignity and social status of sanitation workers.
- Public awareness and participation is the key for achieving 100% sanitation and to ensure personal hygiene in the community.

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About NIUA

NIUA is a premier national institute for research, capacity building and dissemination of knowledge in the urban sector, including sanitation. Established in 1976, it is the apex research body for the Ministry of Housing and Urban Affairs (MoHUA), Government of India. NIUA is also the strategic partner of the MoHUA in capacity building for providing single window services to the MoHUA/states/ULBs.

About SCBP

The Sanitation Capacity Building Platform (SCBP) is an initiative of the National Institute of Urban Affairs (NIUA) to address urban sanitation challenges in India. SCBP, supported by Bill & Melinda Gates Foundation (BMGF) is an organic and growing collaboration of credible national and international organisations, universities, training centres, resource centres, non-governmental organisations, academia, consultants and experts. SCBP supports national urban sanitation missions, states and ULBs, by developing and sourcing the best capacity building, policy guidance, technological, institutional, financial and behaviour change advice for FSSM. SCBP provides a unique opportunity for:

- Sharing and cross learning among the partner organisations, to pool in their knowledge resources on all aspects of urban sanitation capacity building;
- Developing training modules, learning and advocacy material including key messages and content, assessment reports and collating knowledge products on FSSM. Through its website (scbp.niua.org), SCBP is striving to create a resource centre on learning and advocacy materials, relevant government reports, policy documents and case studies;
- Dissemination of FSSM research, advocacy and outreach to State governments and ULBs.

Its strength is its ability to bring together partners to contribute towards developing state sanitation policy, training of trainers and training content development, technical and social assessments, training programme delivery, research and documentation.



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INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT—DESIGN MODULE

PART A: PRESENTATION SLIDES