

INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT PLANNING MODULE

PART A: PRESENTATION SLIDES



TITLE

Integrated Wastewater and Septage Management - Planning Module (Part A: Presentation Slides)

PUBLISHER

National Institute of Urban Affairs, New Delhi

RESEARCH PROJECT

Sanitation Capacity building Platform (SCBP)

GRAPHIC DESIGN

Deep Pahwa, Devender Singh Rawat, Bhavnesh Bhanot, Preeti Shukla

Copyright © NIUA (2021)

Year of Publishing: 2021

CONTENT

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

Editor	Authors	Contributor and reviewer
National Institute of Urban Affairs (NIUA)	National Institute of Urban Affairs Ecosan Services Foundation	National Faecal Sludge and Septage Management Alliance (NFSSMA)

DISCLAIMER

While every effort has been made to ensure the correctness of data/information used in this training module, neither the authors nor NIUA accept any legal liability for the accuracy or inferences drawn from the material contained therein or for any consequences arising from the use of this material. No part of this module may be reproduced in any form (electronic or mechanical) without proper acknowledgement.



Copyright 2021 National Institute of Urban Affairs. This work is licensed under Attribution-ShareAlike 4.0 International. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/4.0/>

CONTACT

National Institute of Urban Affairs
1st and 2nd floor Core 4B,
India Habitat Centre,
Lodhi Road, New Delhi 110003, India
Website: www.niua.org, scbp.niua.org
E-Mail: scbp@niua.org

INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT- PLANNING 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 32 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 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 - Planning Module (Part A: Presentation Slides)
Purpose	The module introduces a city/town perspective of an integrated planning approach to managing wastewater and septage including methods and technological options for treatment. With the announcement of SBM-U 2.0 and AMRUT 2.0, continuation of NMCG and the recommendations of the 15th Finance Commission, this course provides participants a holistic understanding of wastewater and septage management approaches, which is a key component in these national missions.
Target Audience	Decision-makers, technical and planning officials from state governments and ULBs with a basic understanding and professional experience in wastewater and septage management.
Learning Objectives	<ol style="list-style-type: none"> 1. Gain in depth knowledge of wastewater and septage management principles and approaches 2. Understanding of different sanitation systems and technologies with a focus on wastewater and septage conveyance technologies 3. Gain knowledge about the different treatment principles and technologies available for wastewater and septage management
Format of the Module	<p>The training module is based on case methodology where the sessions are combined with exercises based on real-life cases. This helps the trainee to apply the knowledge grasped during the session and reinforce it further.</p> <p>The module is divided into three parts:</p> <p>Part A: This contains the slides used during the session in the presentation format.</p> <p>Part B: This is a comprehensive compilation of the all the session briefs and further reading material which helps to strengthen the learning.</p> <p>Part C: This contains the exercise developed for training based on the real-life cases.</p>
Duration	In a face to face training format, this training is conceptualized for 3 days without site visits and can be adopted for including the site visits depending upon the city where it is being conducted.

GLOSSARY

Anal cleansing water	Water used to cleanse oneself after defecating and/or urinating; it is generated by those who use water, rather than dry material, for anal cleansing. The volume of water used per cleaning typically ranges from 0.5 L to 3 L.
Anaerobic Digestion	The degradation and stabilization of organic compounds by microorganisms in the absence of oxygen, leading to production of biogas
Biogas	Common name for the mixture of gases released from anaerobic digestion. Biogas is comprised of methane (50 to 75%), carbon dioxide (25 to 50%) and varying quantities of nitrogen, hydrogen sulphide, water vapour and other components. Biogas can be collected and burned for fuel (like propane).
Biomass	Refers to plants or animals cultivated using the water and/or nutrients flowing through a sanitation system. The term Biomass may include fish, insects, vegetables, fruit, forage or other beneficial crops that can be utilized for food, feed, fibre and fuel production. Blackwater is the mixture of urine, faeces and flush water along with anal cleansing Water
Blackwater	Contains the pathogens of faeces and the nutrients of urine that are diluted in the flush water
Brown water	Mixture of faeces and flush water, and does not contain urine. It is generated by Urine-Diverting Flush Toilets and, therefore, the volume depends on the volume of the flush water used. The pathogen and nutrient load of Faeces is not reduced, only diluted by the flush water. Brown water may also include Anal Cleansing Water (if water is used for cleansing) and/or Dry Cleansing Materials
Collection and Storage/Treatment	Describes the ways of collecting, storing, and sometimes treating the products generated at the User Interface. The treatment provided by these technologies is often a function of storage and is usually passive (e.g., requiring no energy input). Thus, products that are 'treated' by these technologies often require subsequent treatment before Use and/or disposal.
Compost	Decomposed organic matter that results from a controlled aerobic degradation process. In this biological process, microorganisms (mainly bacteria and fungi) decompose the biodegradable waste components and produce an earth-like, odourless, brown/ black material. Compost has excellent soil-conditioning properties and a variable nutrient content. Because of leaching and volatilization, some of the nutrients may be lost, but the material is still rich in nutrients and organic matter. Generally, Excreta or Sludge should be composted long enough (2 to 4 months) under thermophilic conditions (55 to 60 °C) in order to be sanitized sufficiently for safe agricultural use. This temperature is not guaranteed in most Composting Chambers, but considerable pathogen reduction can normally be achieved.
Conveyance	Describes the transport of products from one functional group to another. Although products may need to be transferred in various ways between functional groups, the longest and most important gap is between User Interface or Collection and Storage/Treatment and (Semi-) Centralized Treatment. Therefore, for the sake of simplicity, conveyance only describes the technologies used to transport products between these functional groups
Dewatering	The process of reducing the water content of a sludge or slurry. Dewatered sludge may still have a significant moisture content, but it typically is dry enough to be conveyed as a solid (e.g., shovelled).

Dried Faeces	Faeces that have been dehydrated until they become a dry, crumbly material. Dehydration takes place by storing Faeces in a dry environment with good ventilation, high temperatures and/or the presence of absorbent material. Very little degradation occurs during dehydration and this means that the Dried Faeces are still rich in organic matter. However, Faeces reduce by around 75% in volume during dehydration and most pathogens die off. There is a small risk that some pathogenic organisms can be reactivated under the right conditions, particularly, in humid environments.
Dry Cleansing Materials	Solid materials used to cleanse oneself after defecating and/or urinating (e.g., paper, leaves, corncobs, rags or stones). Depending on the system, Dry Cleansing Materials may be collected and separately disposed of. Although extremely important, a separate product name for menstrual hygiene products like sanitary napkins and tampons is not included in this Compendium. In general (though not always), they should be treated along with the solid waste generated in the household.
Effluent	General term for a liquid that leaves a technology, typically after Blackwater or Sludge has undergone solids separation or some other type of treatment. Effluent originates at either a Collection and Storage or a (Semi-) Centralized Treatment technology. Depending on the type of treatment, the Effluent may be completely sanitized or may require further treatment before it can be used or disposed of.
Excreta	Consists of Urine and Faeces that is not mixed with any Flushwater. Excreta is small in volume, but concentrated in both nutrients and pathogens. Depending on the quality of the faeces, it has a soft or runny consistency.
Faeces	Refers to (semi-solid) excrement that is not mixed with Urine or water. Depending on diet, each person produces approximately 50 L per year of faecal matter. Fresh faeces contain about 80% water. Of the total nutrients excreted, Faeces contain about 12% N, 39% P, 26% K and have 107 to 109 faecal coliforms in 100 mL.
Flushwater	The water discharged into the User Interface to transport the content and/or clean it. Freshwater, rainwater, recycled. Greywater, or any combination of the three can be used as a Flushwater source.
Greywater	The total volume of water generated from washing food, clothes and dishware, as well as from bathing, but not from toilets. It may contain traces of Excreta (e.g., from washing diapers) and, therefore, also pathogens. Greywater accounts for approximately 65% of the wastewater produced in households with flush toilets.
Nutrient	Any substance that is used for growth. Nitrogen (N), phosphorus (P) and potassium (K) are the main nutrients contained in agricultural fertilizers. N and P are also primarily responsible for the eutrophication of water bodies
Sanitation	The means of safely collecting and hygienically disposing of excreta and liquid wastes for the protection of public health and the preservation of the quality of public water bodies and, more generally, of the environment.
(Semi-) Centralized Treatment	Refers to treatment technologies that are generally appropriate for large user groups (i.e., neighbourhood to city level applications). The operation, maintenance, and energy requirements of technologies within this functional group are generally higher than for smaller-scale technologies at the S level. The technologies are divided into 2 groups: T.1-T.12 are primarily for the treatment of Blackwater, Brown water, Greywater or Effluent, whereas T.13-T.17 are mainly for the treatment of Sludge. Technologies for pre-treatment and post-treatment are also described (technology information sheets PRE and POST).

User Interface	Describes the type of toilet, pedestal, pan, or urinal with which the user comes in contact; it is the way by which the user accesses the sanitation system. In many cases, the choice of User Interface will depend on the availability of water. Note that greywater and Stormwater do not originate at the User Interface, but may be treated along with the products that originate from it
Use and/or Disposal	Refers to the methods by which products are ultimately returned to the environment, either as useful resources or reduced-risk materials. Furthermore, products can also be cycled back into a system (e.g., by using treated Greywater for flushing).

INTEGRATED WASTEWATER & SEPTAGE MANAGEMENT (IWSM)

Planning Module

AGENDA

Time	Session Title
Day 1	
10:00 – 10:30	Registration
10:30 – 11:00	Introduction: Round of Introduction; Setting ground rules; Understanding expectations, aims & objectives
11:00 – 11:45	Sustainable Sanitation & Water Management
11:45 – 12:00	Tea and Coffee Break
12:00 - 12:10	Missions and Programs
12:10 - 12:40	Sanitation Systems
12:40 - 13:30	Lunch Break
13:30 – 14:30	Sanitation Technologies
14:30 – 15:00	Building Sanitation Systems: Activity Session (F2F)
15:00 – 15:45	Liquid Waste Management
15:45 – 16:00	Tea and Coffee Break
16:00 – 17:00	Mapping the City- Activity Session (F2F)
17:00 – 18:00	Decentralised Wastewater Management – Exercise

Time	Session Title
Day 2	
09:30 – 10:15	Feedback & Quiz
10:15 – 11:15	Aspects of Decentralised Wastewater Management
11:15 – 11:30	Tea and Coffee Break
11:30 – 12:15	Understanding Faecal Sludge & Septage Management
12:15 – 13:00	Faecal Sludge & Septage Management Planning – Exercise
13:00 – 14:00	Lunch Break
14:00 – 15:00	Stakeholders Management
15:00 – 15:45	Faecal Sludge & Septage Treatment
15:45 – 16:00	Tea and Coffee Break
16:00 – 16:45	Financial Aspects of Faecal Sludge & Septage Management
16:45 – 17:30	Operation & Maintenance Cost for Faecal Sludge & Septage Management – Exercise
17:30 – 18:00	Conceptualizing Sewage Treatment Plant: Activity Session (F2F)

Time	Session Title
Day 3	
10:00 – 12:30	Site Visits
12:30 – 13:30	Lunch Break
13:30 – 14:15	Feedback & Quiz
14:15 – 15:15	Wastewater Treatment Principles
15:15 – 15:30	Tea and Coffee Break
15:30 – 16:15	Wastewater Treatment Technologies
16:15 – 16:45	Case Studies of STPs & FSTPs in India
16:45 – 17:00	Feedback & Wrap Up Session

Contents

1. Sustainable Sanitation & Water Management	1
1.1 Introduction to Environmental Health	4
1.2 Environmental Sanitation	7
1.3 Waste Products	10
1.4 EcoSan	13
1.5 Urban Challenges	16
2. Missions and Programs	25
2.1 Growing recognition of FSSM in India	28
2.2 National missions and programs	29
2.3 Advisories and guidelines related to sanitation in India	36
3. Sanitation Systems	41
3.1 Sanitation Systems	44
3.2 Functional Groups	48
3.3 Case Studies	56
4. Sanitation Technologies	61
4.1 Wet Sanitation Systems	64
4.2 Functional Groups	66
5. Building Sanitation System	77
6. Liquid Waste Management	79
6.1 Liquid Waste Management	82
6.2 Centralised Wastewater Management	86
6.3 Decentralised Wastewater Management	90
6.4 Other Aspects of Liquid Waste Management	94
6.5 Planning of Sanitation Systems	98
7. Mapping the City	103
8. Decentralised Wastewater Management	105
9. Aspects of Decentralised Wastewater Management	107
9.1 Economic Aspects	112
9.2 Technical Aspects	114
9.3 Legal Aspects	116
9.4 Regulatory Aspects	119
9.5 Social Aspects	122

10. Understanding Faecal Sludge & Septage Management	127
10.1 Needs & Challenges in FSSM	130
10.2 Planning of FSSM.....	136
10.3 Approaches of FSSM	143
11. Faecal Sludge & Septage Management Planning	147
12. Stakeholder Management	149
12.1 Stakeholder Analysis	152
12.2 Stakeholder Engagement	158
13. Faecal Sludge & Septage Treatment.....	165
13.1 What is Faecal Sludge & Septage?.....	168
13.2 Treatment Objectives.....	169
13.3 Treatment Stages.....	173
13.4 Treatment Units- Non-Mechanised	174
13.5 Treatment Units - Mechanised	178
13.6 FSTPs in India.....	183
14. Financial Aspects of Faecal Sludge & Septage Management	185
14.1 Financing FSSM	188
14.2 Finance & Contracting Models	192
15. Operation & Maintenance Cost of Faecal Sludge & Septage Management.....	199
16. Conceptualising Sewage Treatment Plant (STP).....	201
17. Wastewater Treatment Principles.....	203
17.1 Objectives	206
17.2 Wastewater treatment: processes and stages	207
17.3 Components of Headworks	209
17.4 Components of a sewage treatment plant.....	214
17.5 Layout of STP	217
18. Wastewater Treatment Technologies.....	221
18.1 Secondary Treatment.....	224
18.2 Non-mechanised Treatment System	225
18.3 Mechanised Treatment System	230
18.4 Selection Criteria.....	233
19. Case Studies of Sewage Treatment Plants & Faecal Sludge Treatment Plants in India	237
19.1 STP in India.....	240
19.2 FSTP in India	246

Session

01

Sustainable Sanitation & Water Management

1. Sustainable Sanitation & Water Management

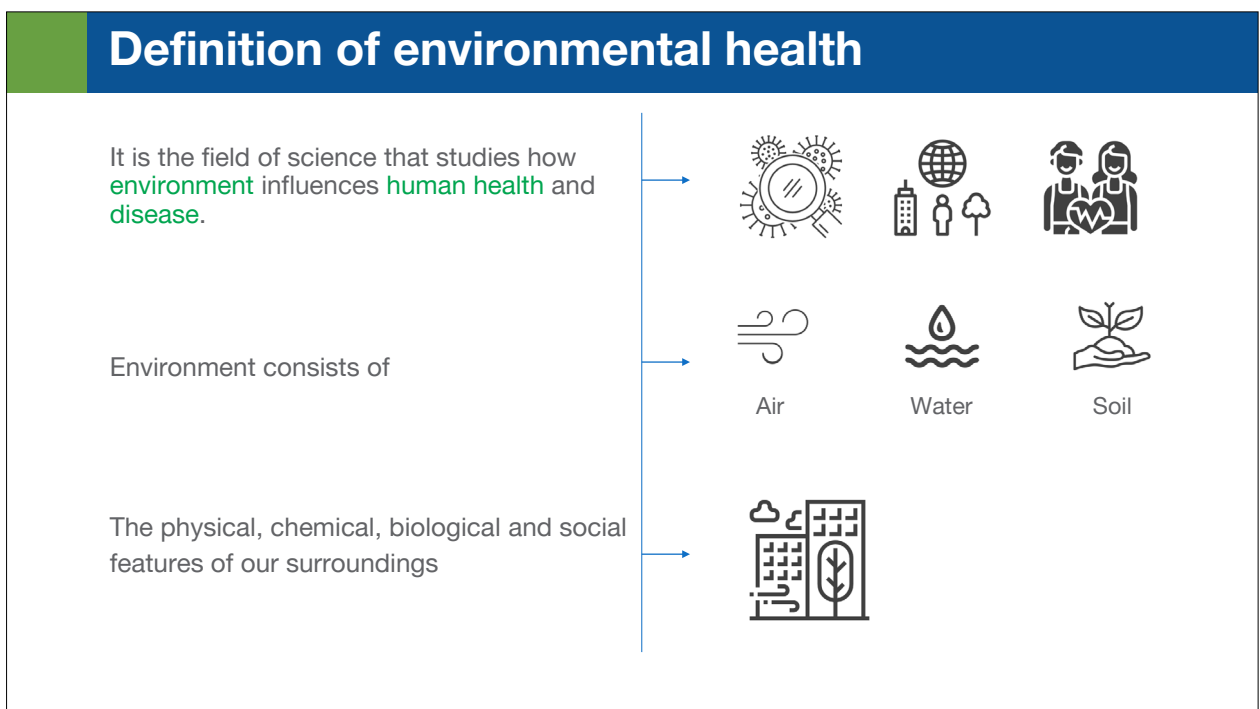
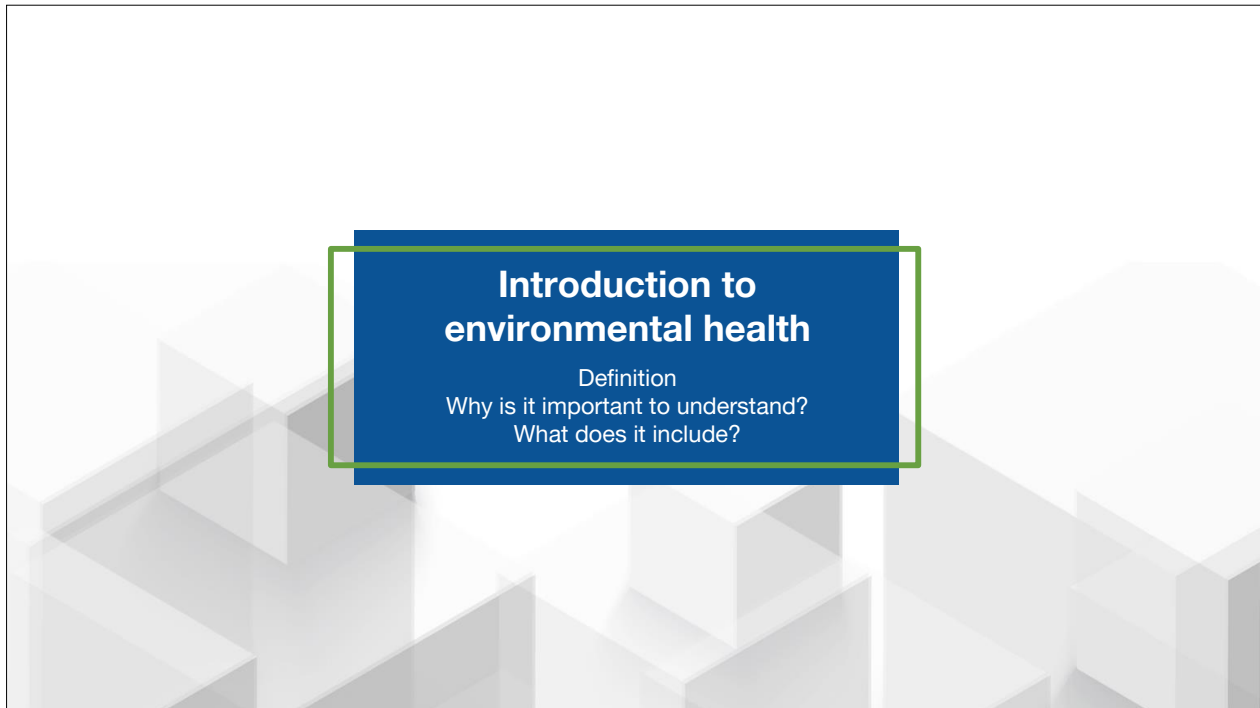
Learning objectives

- To understand the concept of environmental health, environmental sanitation and environmental services needed to maintain balance in the environment
- To understand various types of liquid waste products and their flow
- To understand the basis of ecological sanitation and its extension
- To understand urban challenges faced at various levels of sanitation and water management
- To gain knowledge about the need for a public service sanitation approach

Contents

Environmental health
Environmental sanitation
Liquid waste products and their flow
EcoSan concept
Urban challenges
Citywide inclusive sanitation approach

1.1 Introduction to Environmental Health



Environmental health is the field of science that studies how the environment influences human health and disease. Environment, in this context, means things in the natural environment like air, water and soil, and also all the physical, chemical, biological and social features of our surroundings. Features such as physical form, chemical and biological composition etc. provides characteristics to the environment and helps us to classify them.

Components of environmental health

- **Good environmental health presupposes:**
 - Water, air and food free of contamination; and
 - Facilities, services and hygienic behaviour provide for clean environment.
- **Individual health:**
 - Adequate, clean and safe drinking water; and
 - Clean water sources or reliable water treatment processes.
- **Community health**
 - Waste is collected, recycled, treated or disposed off in a safe manner.

- Good health presupposes that the water we drink, the air we breathe and the food we eat are free from contaminants and pathogens, and that facilities, services and hygienic behaviour provide for a clean environment in which to live, with measures to break the cycle of disease and contamination.
- Health is best protected by safeguarding the environment in various ways.
- Individual health benefits from enough clean and safe drinking water. This can be attained by clean water sources or reliable water treatment.
- Community health can be improved if waste is collected, recycled, treated or disposed off in a sanitary manner.

Environmental health

To achieve the objectives of environmental health one must:

- Maintain a natural environment free from undue hazards
- Ensure a built environment free from undue hazards
- Provide environmental services to households and communities

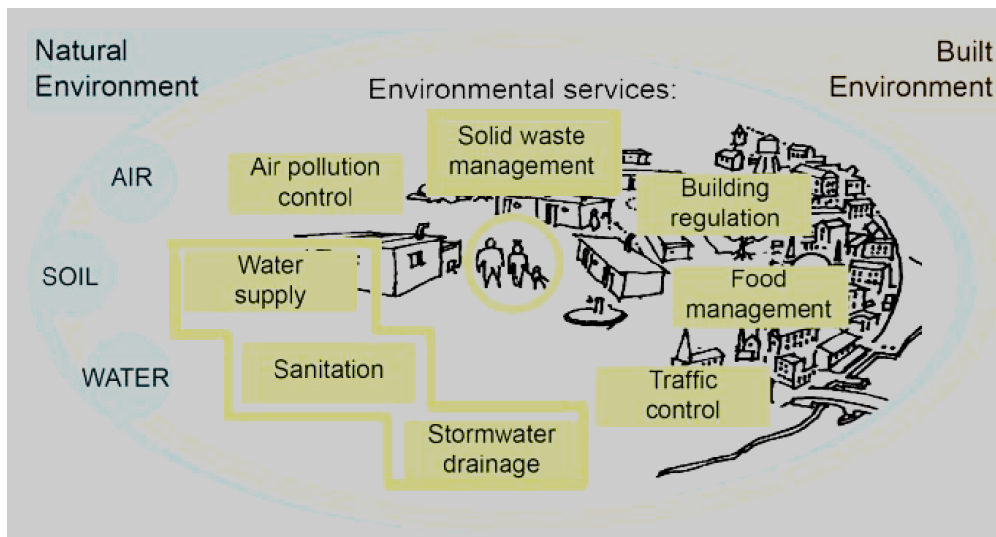
Environmental services

It includes provision of raw materials and energy used to produce goods and services, as well as removal of waste from human activities, and their role in life support and landscape maintenance.

Creating, changing and altering the natural and built environment has an impact on environmental health. Hence, to be able to achieve the objective of better environmental health, following things are recommended:

- While altering the natural environment and creating elements in built environment, care must be taken that it is free from undue hazards.
- In order to maintain the equilibrium between the two environments, environmental services needs to be provided to the household and communities.

Contents of environmental health



Source: Eawag/Sandec 2008

Ecological sanitation commonly known as EcoSan has three fundamental aspects: (a) rendering human excreta safe, (b) preventing pollution rather than attempting to control it after we pollute, and (c) using safe products of sanitized human excreta for agricultural purposes. This approach fits in the definition of circular economy and can be characterized as “sanitize-and-recycle”.

By treating and recycling the waste such as human excreta, pollution of the water cycle is avoided. Thus, the EcoSan concept goes a long way in contributing to sustaining environmental health.

The natural and built environment with its natural resources water, air and soil (shown in blue on the slide), and all services and facilities are required to keep the environment clean and protect health (shown in green on the slide). Our focus is on water supply and environmental sanitation services, facilities and human behaviour (inside yellow line on the slide).

1.2 Environmental Sanitation



Sanitation

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



Infrastructure
(IHT | CT | PT)



Regulations
for Safe Management



Personal Hygiene
Habits

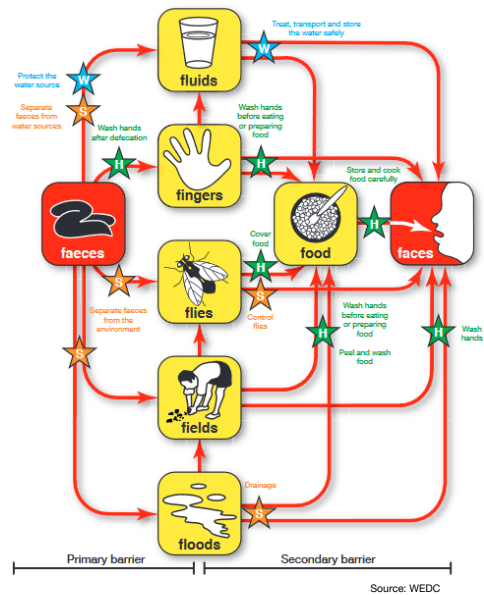
Objectives

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

There are many possible definitions of sanitation. Sanitation means the safe management of human excreta and wastewater. It therefore includes both the ‘hardware’ (e.g. latrines and sewers) and the ‘software’ (regulation, hygiene promotion) needed to reduce faecal-oral disease transmission. It encompasses potential reuse, disposal of human excreta or discharge of wastewater.

The F-diagram

- Shows pathway from faeces to faces.
- Depicts movement of pathogens from faecal matter to the new host.
- Primary barrier essentially stops the spread of pathogens from faeces.
 - Consists of providing access to toilet and developing hygiene habits.
- Secondary barrier essentially stops the transmission of pathogens to the food.
 - Consists of combination of access to safe water, food and hygiene habits



Most diseases associated with water supply and sanitation, such as diarrhoea, are spread by pathogens (disease-causing organisms) found in human excreta (faeces and urine). The faecal-oral mechanism, in which some of the faeces of 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 by the F Diagram.

Primary interventions with the greatest 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 household, 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



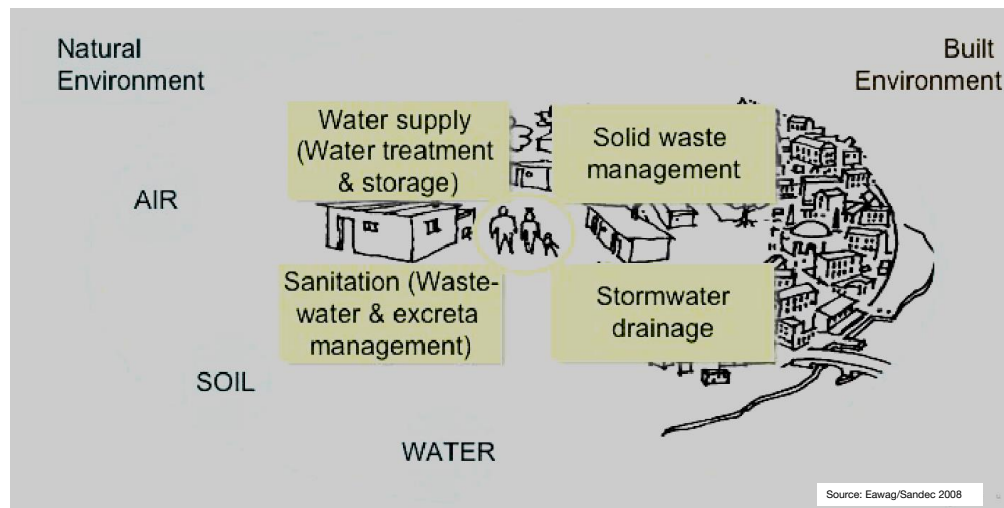
Infrastructure for
Hygiene Practices



Behaviour &
Habit

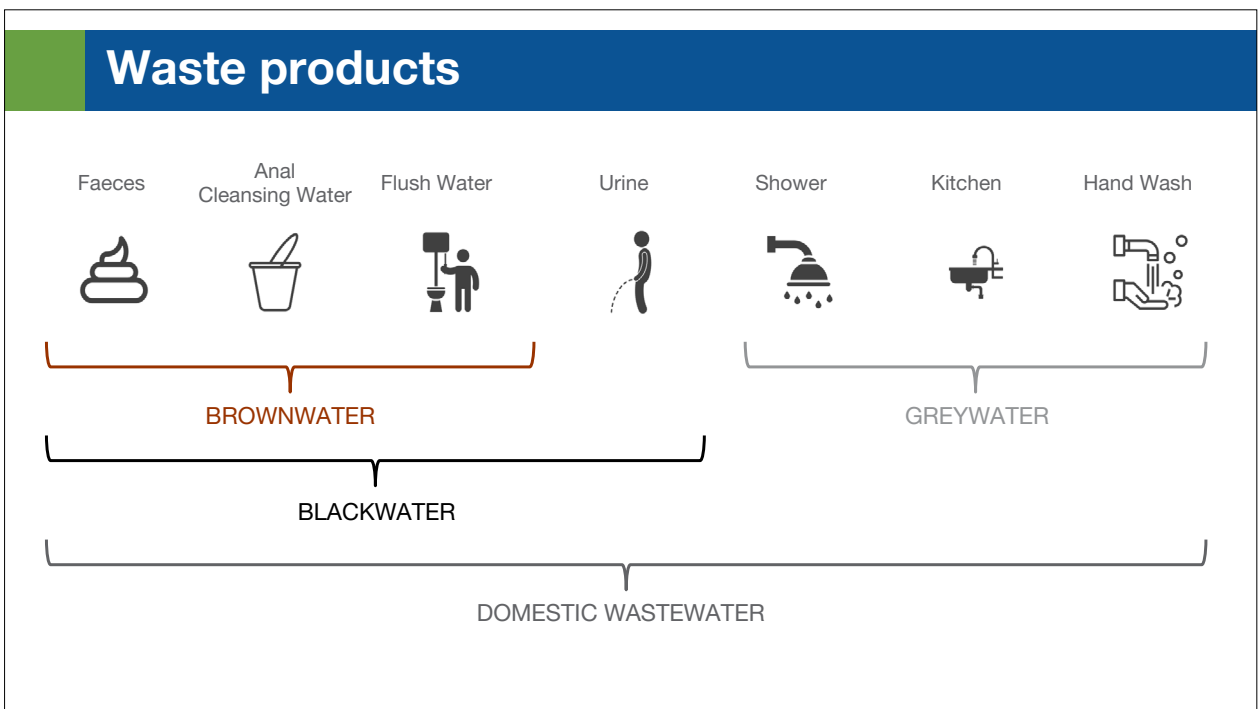
Environmental sanitation aims at improving the quality of life of the individuals and at contributing to social development. This includes disposal or hygienic management of liquid and solid human waste, control of disease vectors and provision of washing facilities for personal and domestic hygiene. Environmental sanitation comprises both behaviour and facilities to form a hygienic environment.

Environmental sanitation



Water supply and sanitation provide the necessary barrier between the pollutants, natural and built environment, and humans. The waste and resource sub-systems of water and environmental sanitation (yellow); the natural environment (blue); the built environment (orange) are shown in the slide.

1.3 Waste Products



Brown water is the mixture of faeces, anal cleansing water (if anal cleansing is practised) and flushing water. Blackwater is the mixture of urine with brown water.

Greywater is used water generated through bathing, hand-washing, cooking or laundry. It is usually mixed or treated along with blackwater in India.

Faecal sludge is the general term for the undigested or partially digested slurry or solid resulting from the storage or treatment of blackwater or excreta. Septage is well digested and blackish slurry or solids which needs lesser treatment than faecal sludge. Sewage sludge is usually generated during aerobic treatment of domestic wastewater at the sewage treatment plants.

Characterising wastewater	
<p>Solids</p> <ul style="list-style-type: none"> • TS: Total Solids & TSS: Total Suspended Solids • Suspended solids bigger than 0.2µm • Settleable and colloidal solids • 70% organic solids; 30% inorganic solids <p>Turbidity and organic solids deplete the oxygen in the water body and prevent light from penetrating.</p>	<p>Organic Constituents</p> <ul style="list-style-type: none"> • 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. <p>Used to design treatment units, measure efficiency of the processes, evaluate compliance with the discharge standards.</p>

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.

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.

Characterising 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

Pathogens

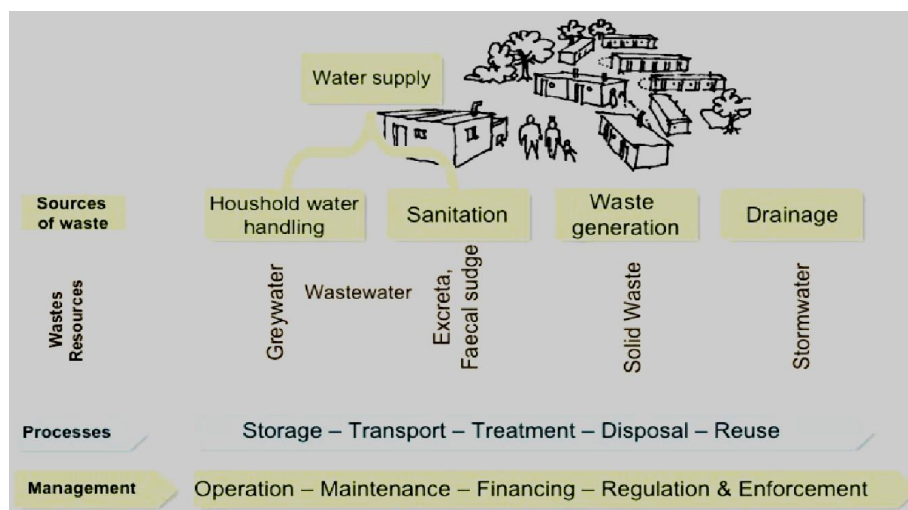
- TC (MPN): Total Coliform; FC (MPN): Faecal Coliform
- Communicable diseases can be transmitted
- Specific monitoring organisms is tested
 - to gauge the plant operation and
 - suitability for reuse

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, which rob the water of dissolved oxygen. When discharged in excessive amounts on land, they can also lead to groundwater pollution.

Communicable 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 genera not of faecal origin (e.g. Enterobacter, Klebsiella, Citrobacter). The assay is intended to be an indicator of faecal contamination; more specifically of E. coli which is an indicator microorganism for other pathogens that may be 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

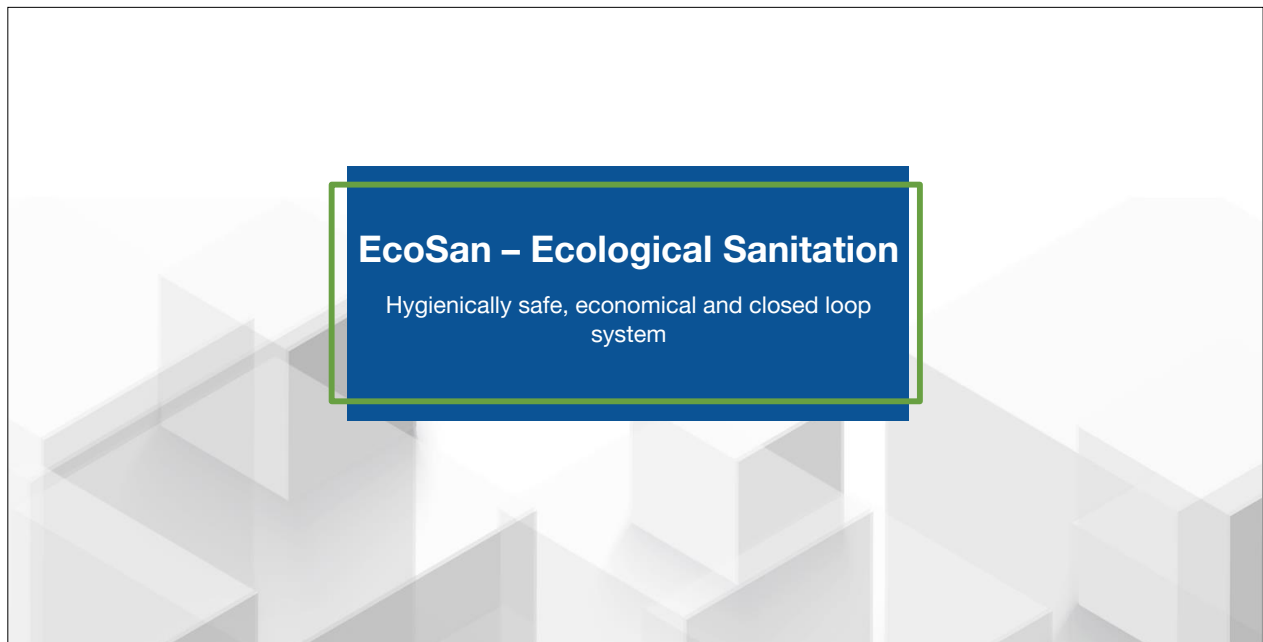


Source: Eawag/Sandec 2008

The figure shows the sources of waste in a household and neighbourhood (green) and the waste and resource flows (brown). All waste and resource flows require 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).

We should regard waste as resources to develop an integrated view point. For example, in India we call a wastewater treatment facility as STP, however in Singapore where fresh water is very limited, they call it water reclamation facility.

1.4 EcoSan



Ecological Sanitation

- Closing the loop considering sanitation and agriculture without compromising health.
- Also known as circular economy, which eliminates waste by continuous use of resources.
- Balance between nutrients excreted by humans and nutrients required for producing their food
- Improvement in health by minimising the introduction of pathogens from human excrement into water cycle

A circular diagram titled "EcoSan Cycle" showing a continuous loop of four stages: "Grow" (represented by a plant), "Eat" (represented by a person eating), "Excrete" (represented by a person using a toilet), and "Compost" (represented by a hand holding soil). Green arrows connect the stages in a clockwise direction, forming a closed loop. The text "EcoSan Cycle" is written in the center of the diagram.

Source: www.ecosancap.co.za

Ecological sanitation commonly known as EcoSan has three fundamental aspects – (a) rendering human excreta safe, (b) preventing pollution rather than attempting to control it after we pollute, and (c) using the safe products of sanitized human excreta for agricultural purposes. This approach fits in the definition of circular economy and can be characterized as “Sanitize-and-recycle”.

By treating and recycling the waste such as human excreta, pollution of the water cycle is avoided. Thus, the EcoSan concept goes a long way in contributing to sustaining environmental health.

Objectives

- Resource recovery and reuse
- Minimising the consumption of non-renewable resource

Hygienically safe, economical and closed loop system!

CLOSING THE LOOP ON SANITATION

- EcoSan is not just a toilet interface.
- The concept of EcoSan is resource recovery and reuse oriented.
- It is a concept that is characterized by the desire to safely close the loop.

Characteristic comparison

	Total	Greywater	Urine	Faeces
Volume (L/cap.yr)	25,000-100,000	25,000-100,000	500	50
Nitrogen (kg/cap.yr)	2.0-4.0	5%	85%	10%
Phosphorus (kg/cap.yr)	0.3-0.8	10%	60%	30%
Potassium (kg/cap.yr)	1.4-2.0	34%	54%	12%
COD (kg/cap.yr)	30	41%	12%	47%
Faecal coliform (per 100 mL)	-	10^4 - 10^6	0	10^7 - 10^9

Greywater is a reflection of household activities, its main characteristics strongly depend on factors such as cultural habits, living standard, household demography, type of household chemicals used etc. Greywater is the least contaminated type of wastewater which needs very less degree of treatment.

The concentration of nutrients in the excreted urine depends on the nutrient and liquid intake, the level of personal activity and climatic conditions. In its pure form, it is sterile and quite rich in nutrients.

From a risk perspective, exposure to untreated faeces is always considered unsafe on account of the high levels of pathogens whose prevalence is dependent on the given population.

Limitations in conventional off-site sanitation systems

- Inequitable distribution and use of water resources such as ground and surface water.
- Challenging to provide access to sanitation in rapidly urbanising city.
- Part of the domestic wastewater is captured and part of the collected wastewater is treated up to the discharge standards.
- Untreated wastewater finds its way into the nearby water body or contaminate the groundwater.
- Overuse of inorganic fertilisers lead to depleting reserves of nutrients.

Does not follow concept of Environmental Sanitation and negatively impacts the Environmental Health!

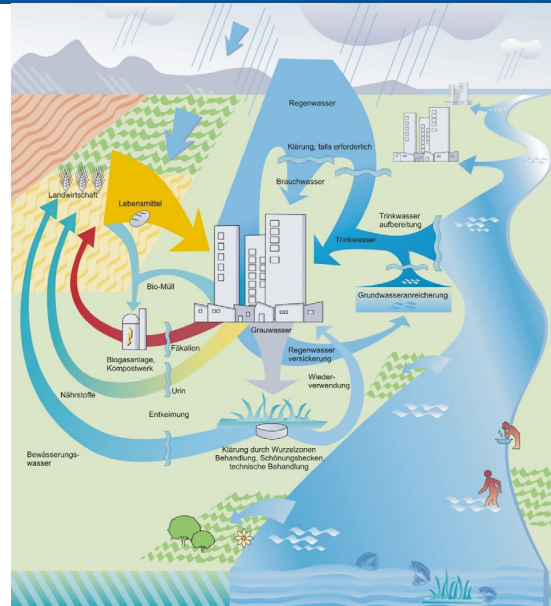
Source: GIZ/Esosan

The conventional offsite sanitation systems is mainly dependent on sourcing raw water from surface water body. The deficit demand is met through groundwater. However, in absence of appropriate regulations and their enforcement, this often leads to inequitable distribution and use of water. Implementing off site sanitation system in a rapidly urbanizing city is a challenge. Resources such as funds, expertise for design and implementation and human resources etc. required for scaling up of sanitation systems are not available. As a result of which, part of the wastewater is collected and treated and discharged in to the surface water bodies, while large quantity of wastewater goes untreated. This leads to pollution of water resources.

To feed the residents of the city, agriculture mainly depends on inorganic fertilizers which are extracted from natural resources. Over use of these inorganic fertilizers not only depletes reserves but also lead to greater pollution through agriculture runoff.

Extending Ecosan Concept

- Managing the water resources to maintain the environmental flow in the rivers.
- Appropriately managing the waste resources at the source, the energy and nutrients (such as P and K can be used as soil conditioner) can be recovered and recycled.
- Prioritisation of reuse of treatment end-products over disposal.
- Enforcement on stormwater management to reduce dependency of surface water bodies.
- Reducing dependency on inorganic fertilisers.



Scaling up of EcoSan concept is possible at the city scale. This will not only reduce the dependency on the surface water bodies, but also result in significant decrease in water pollution. The concept promotes segregation of waste streams into black water, urine and greywater. The nutrients from the black water and urine can be recovered through treatment processes and reused in the agriculture. The grey water can be treated at various levels and reused locally. Stormwater management can also provide additional source of water.

1.5 Urban Challenges

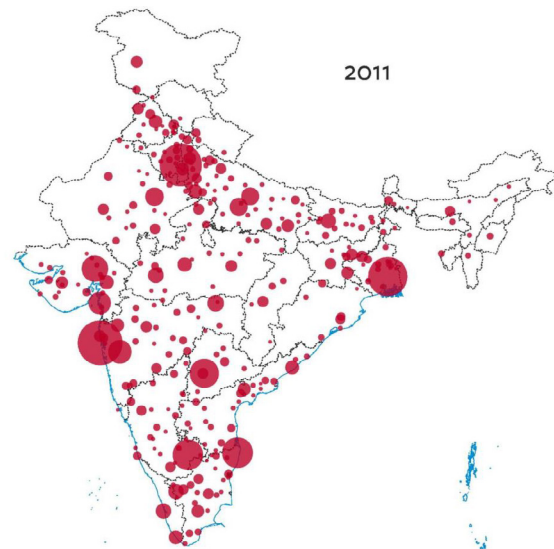
Urban challenges

Challenges in sanitation planning by ULBs.

Urbanization in India

- About **377 million** i.e. 1/3rd of the country lives in urban settlements
- Share of India's urban population
 - ❖ 28% (2001)
 - ❖ 31% (2011)
- India is set to become half urban by 2041

Source: Census 2001 and 2011



Source: India Urban Conference 2011 : Evidence and Experience -IIHS

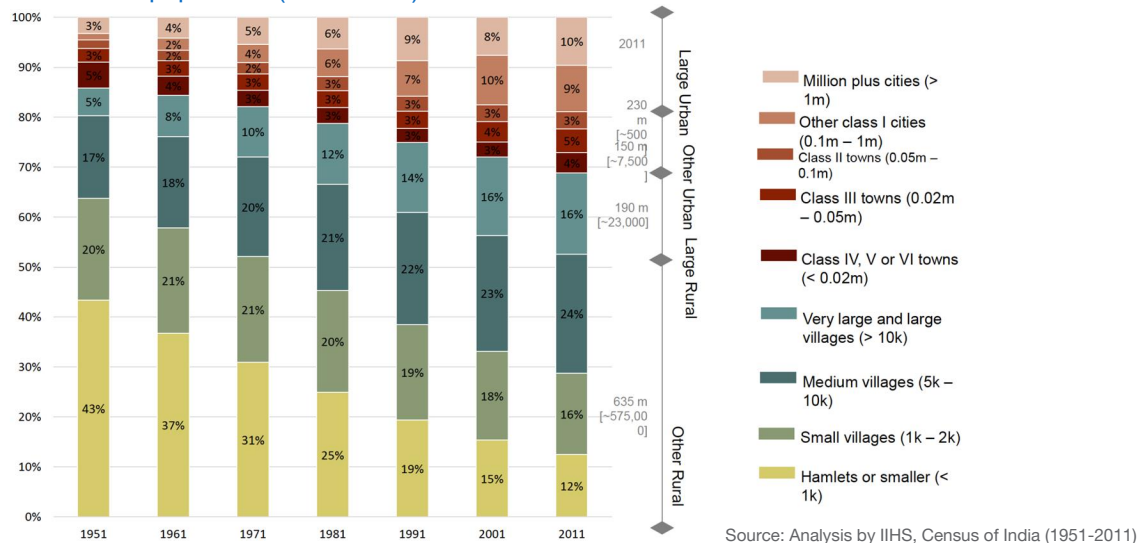
This slide shows the pace at which India has undergone urbanization as compared to other countries in the world. Although, India will have less percentage of population living in the urban centers, it will be host to many cities having population more than 10 million. The pace at which the urban centers are experiencing population explosion, it is very difficult to provide adequate municipal services such as drinking water, access to toilet and safe management of solid and liquid waste. Add to this the population migrating from the rural to urban centers in search of better employment opportunities puts more stress in the infrastructure.

Definition of Urban:

- All places with a Municipality, Corporation, Cantonment Board or notified town area committee etc
- All other places which satisfies the following criteria:
 - » A minimum population of 5,000
 - » At least 75% of the male main working population engaged in non agricultural pursuits
 - » A density of population of at least 400 persons per sq.

Urbanization in India

Distribution of population (1951-2011)



In India, 70% of the population is residing in class 1 cities. The decadal growth rate in India has decreased from 21.5% during 1991-2001 to 17.6% during 2001-2011. The growth rate of urban population heading for stabilisation has witnessed a decadal variation of around 31.5% in last two decades. The rate of growth has majorly reduced in the three urban agglomerations namely, Delhi, Mumbai and Kolkata. The million plus cities have witnessed a growth rate of 48%.

Sanitation planning

- Cities are engines of economic & social development
- Urban development relies on good infrastructure and reliable service provision
- Sanitation systems are only considered partially
- Inadequate & unachievable regulations lead to choice of unsustainable solutions
- Failures or unsustainable solutions put huge financial burden on ULBs



City Infrastructure

- Water Supply
- Sanitation blocks
- Liquid waste management
- Solid waste management
- Stormwater management



Cities, as engines of economic growth and social development, require large quantities of natural resources to meet the inhabitants' economic and social needs. Good infrastructure and reliable service provision are keys to a sustained urban development.

To respond to the lack of sanitation infrastructure affecting especially the urban poor, many governments, development agencies and NGOs have launched programmes to provide the poor and vulnerable population with sanitation options.


The sanitation systems are often only considered partially. For example on-site based sanitation solutions (latrine or septic tank-based) frequently do not include excreta and faecal sludge emptying, transport or treatment services and facilities.

Additionally, local business opportunities, as well as demand and potential use of waste resources, such as water, nitrogen or biosolids, are given little attention.


Failures or unsustainable solutions put huge financial burden on municipalities.

Challenges faced by small cities

- Out of 7933 towns in India, approx. 6300 towns have a population between 5,000 to 50,000 (class 3, 4 and 5). Source: Census of India, 2011
- These cities are most affected by population growth and urbanisation.



Lack Professional Capacity
To plan and develop the appropriate infrastructure



Management Gap
To operate and maintain the infrastructure through steady financial income

According to Census of India 2011, any town having a population between 5,000 to 50,000 is considered as a small town. Problems faced in such small towns:

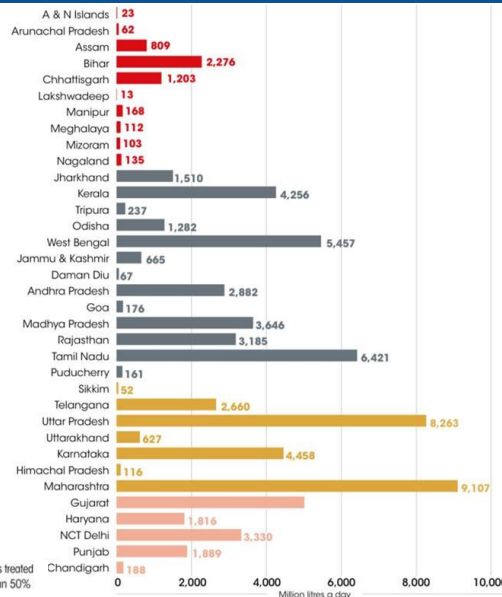
- Weak governments.
- No official water and sanitation utilities/institutions.
- No professional staff.
- Neglected by governments and donors.

The spatial distribution of the population has always been a key factor on the policy agenda of governments. The governments of developing countries have often expressed concern about their inability to provide basic services for their rapidly growing urban populations, including safe drinking water, sanitation, affordable housing, and public transport.

Sanitation Challenges in India

Raising a stink

- ❑ Another 13 states/UTs treat less than 20% of their daily sewage.
- ❑ 7 treat less than 50% of their waste.
- ❑ The remaining 5 states/UTs treat more than 50%.



Source: State of India's Environment 2021 by CSE

From the graph in the above slide it is evident that only 5 states/UTs namely, Gujarat, Haryana, NCT Delhi, Punjab and Chandigarh treat more than 50% of their sewage. Whereas, 10 states do not treat their sewage at all.

Sanitation Challenges in Urban India

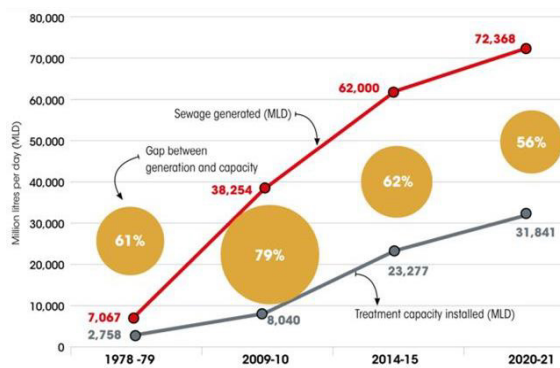
Sewage overload

Only 28% of India's sewage gets treated. This is because the current installed capacity is only 44% of what the cities generate and even these plants remain underutilized.

Between 2014-15 and 2020-21
17% increase in India's sewage generation
37% increase in the installed treatment capacity

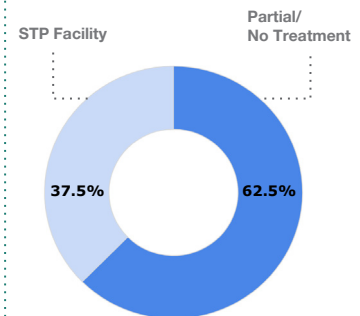
72% of sewage generated in 2020-21 was dumped untreated

Source: State of India's Environment 2021 by CSE



Source: National Inventory of Sewage Treatment Plants Released by the Central Pollution Control Board

Status Of Wastewater Treatment in Urban India (MLD)



Source: CPCB- National Inventory of STPs (2021)

Sewage generation from urban centers is estimated as 72,368 MLD. There are 1631 STPs (including proposed STPs) with a total capacity of 36,668MLD covering 35 States/UTs. Out of 1,631 STPs, 1,093 STPs are operational, 102 are Non-operational, 274 are under construction and 162 STPs are proposed for construction.

The actual utilized capacity is 20,235 MLD (27.9 %). This is due to lack of infrastructure for conveyance system (Household connectivity, sewer lines, Sewage pumping stations).

Sanitation Challenges at city level

40% of our population or 600 million Indians are expected to live in our urban centres by 2030 compared to 377 million people in 2021. The rapid pace of urbanisation is expected to worsen existing challenges and create new ones in water and sanitation.

Some of these challenges are:

Incapacity of public utilities to keep pace with urbanisation rate in infrastructure creation

Constraints in recovering costs and O&M of infrastructure

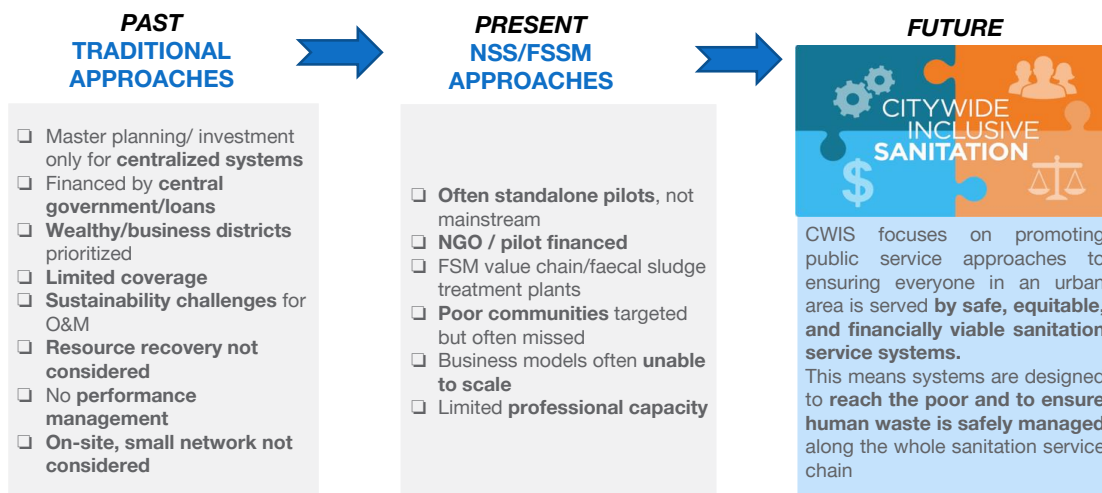
Provision of required facilities in unplanned and informal settlements

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



Need for a Paradigm Shift



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 being pilot projects run by NGOs. To tackle the gap, CWIS is promoted. Being a public service approach, it helps in establishing safe, equitable and financial viable sanitation services. Thus ensuring marginalized and vulnerable group can also benefit with sanitation services.

CWIS Framework: Promoting a public service approach



Source: <https://az659834.vo.msecnd.net/eventsairseasiaproduct/production-adb-public/083330cb31114d17ab6dba74745669f>
Schrecongost, A., et al. (2020). Citywide inclusive sanitation: a public service approach for reaching the urban sanitation SDGs. *Frontiers in Environmental Science*, 8, 19.

The core outcomes of a system are valid for everyone in an urban area, not just those in sewered areas. However they will vary by country/city. Thus to achieve these outcomes, system must demonstrate functions of a public service delivery system for sanitation, relevant across diverse

city contexts – who will be the response authority(ies) for executing mandate for inclusive urban service delivery. The legal authorities must be accountable for performance, planning and managing resources with transparency and accountability. For e.g. how will the funds be allocated from centre to state. Also consideration of range of technologies and business models catering to the service needs for all.



India is also signatory to the ‘2030 Agenda for Sustainable Development’, adopted at the Sustainable Development Summit of the United Nations in September 2015. It comprises of seventeen Sustainable Development Goals (SDGs) and 169 associated targets. Of these, 3 SDGs namely SDG No. 6: Ensure availability and sustainable management of water and sanitation for all, SDG No. 11: Make cities and human settlements inclusive, safe, resilient and sustainable, and SDG No. 12: Ensure sustainable consumption and production patterns, are directly related to sanitation sector. This also obligates Government of India as well as State Governments to develop strategies to cover entire population with sanitation facility by year 2030.

SDG 6 relates to clean water and sanitation with the following goals -

- Target SDG 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation. Special focus on needs of women and girls and those in vulnerable situations
- Target SDG 6.3: By 2030, improve water quality by reducing pollution and halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

In order to achieve SDG 6, we will need to think beyond toilets

Summary

- To maintain clean and healthy natural environment by managing built environment properly through environmental sanitation services
- Environmental sanitation consists of proper management of human excreta and wastewater
- Ecological sanitation introduces the concept of water and nutrient resource management for closing loop at local level for ensuring sustainability
- Urban challenges in sanitation planning constitute of different aspects, however are mainly driven by lack of professional capacity and management gap
- To tackle the sanitation gap, CWIS is being promoted which acts as a public service approach

Session

02

Missions and Programs

2. Missions and Programs

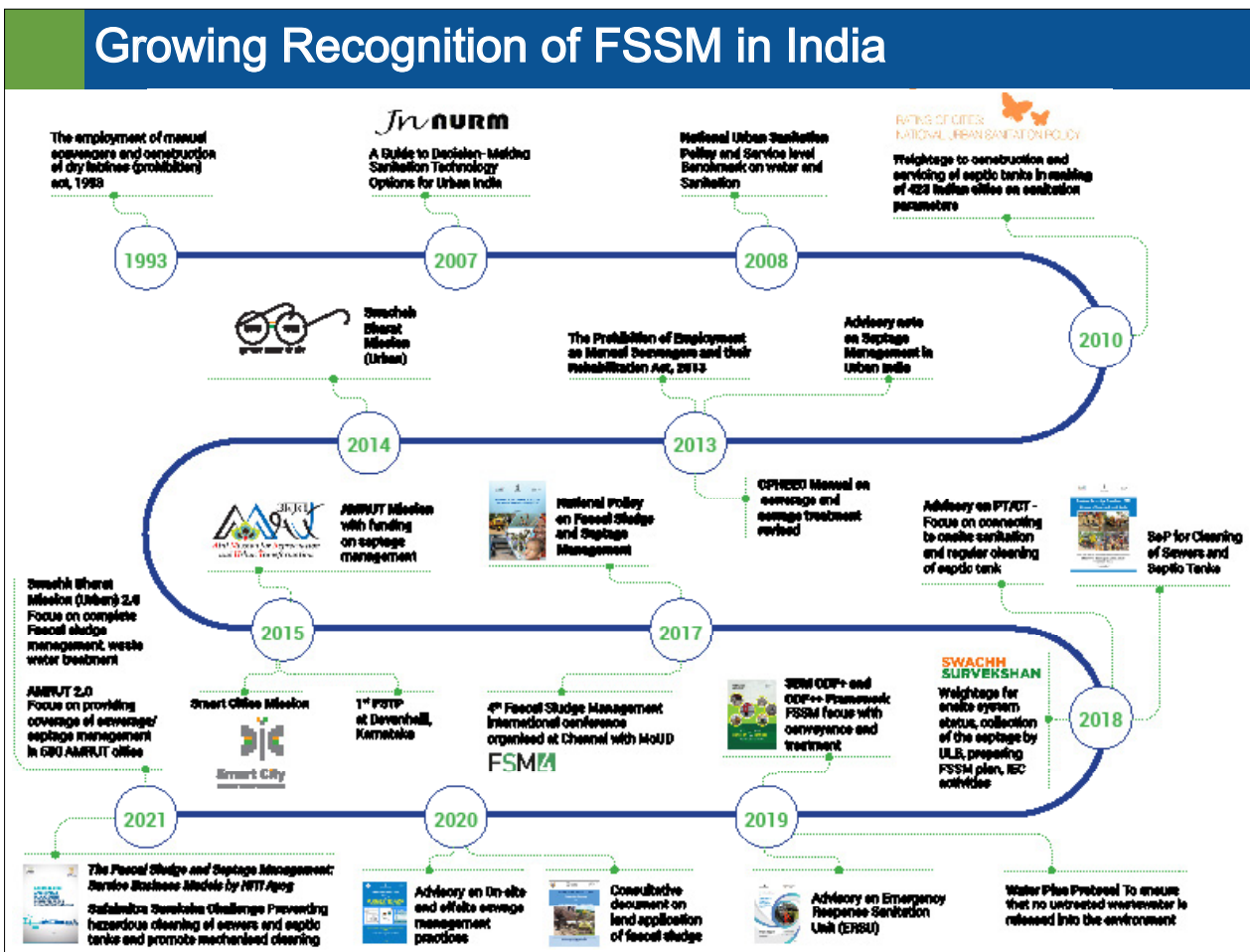
Learning objectives

- To understand the background of the overall FSSM scenario in India.
- To gain knowledge of different policies and guidelines related to sanitation
- To analyse the funding options for the sanitation infrastructure under various national missions

Contents

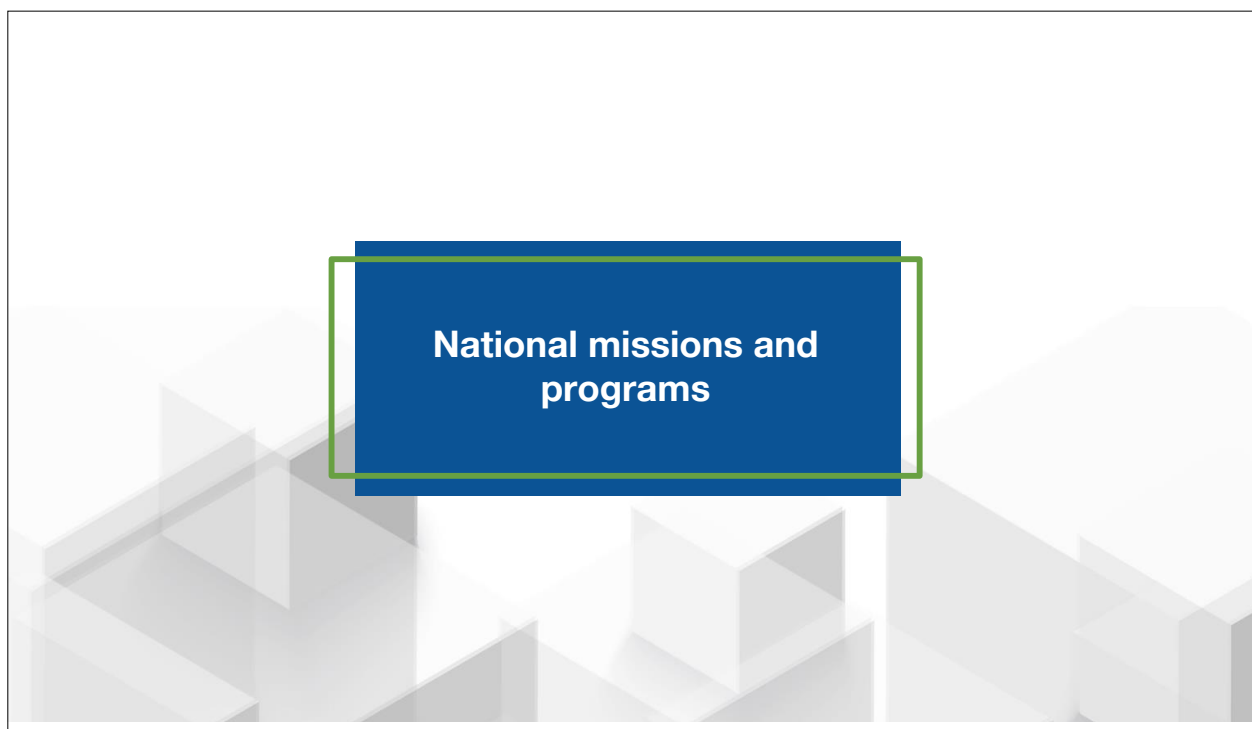
- Growing recognition of FSSM in India
- National missions and programs
- Advisories and guidelines related to sanitation in India

2.1 Growing recognition of FSSM in India



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 Survekshan, 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. In 2021, MOHUA launched the Swachh Bharat Mission (Urban) 2.0 and AMRUT 2.0.

2.2 National missions and programs



Swachh Bharat Mission (SBM) 2.0

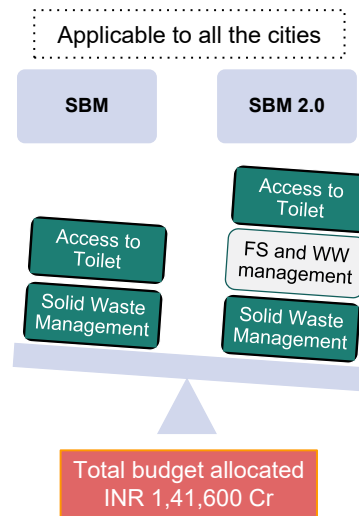


Objectives:

- 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.

AMRUT

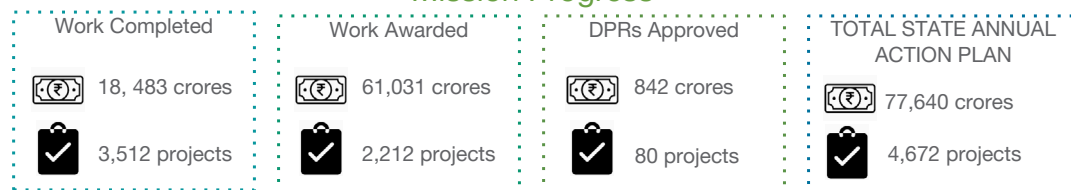


Started in June 2015

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).

AMRUT 2.0

Key focus is on **strengthening water security of the cities.**

Applicable to all cities

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

4800 ULBs achieve 100% coverage of water supply

20% Water demand met through reuse of water

Total budget allocated INR 2,77,000 Cr

Objectives:

Source: Operational Guidelines AMRUT 2.0 Oct, 2021



AMRUT 2.0 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. Under AMRUT 2.0, 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 and urban aquifer management will be undertaken to augment sustainable fresh water supply.
- 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 sub-mission for water that will leverage latest global technologies in the field of 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.
- To protect fresh water bodies from getting polluted to make natural resources sustainable.
- Cities having million plus population to take up PPP projects worth minimum of 10% of their total project fund allocation which could be on Annuity/ Hybrid Annuity / BOT Model.

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; unlocking value and improving land use efficiency through proper master planning; improving credit rating & accessing market finance including issuance of municipal bonds and implementation Online Building Permission System under EoDB.

The Mission also seeks to promote AatmaNirbhar Bharat through encouraging Start-ups and Entrepreneurs with an aim to promote GIG economy and on-boarding of youth & women.



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.

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)

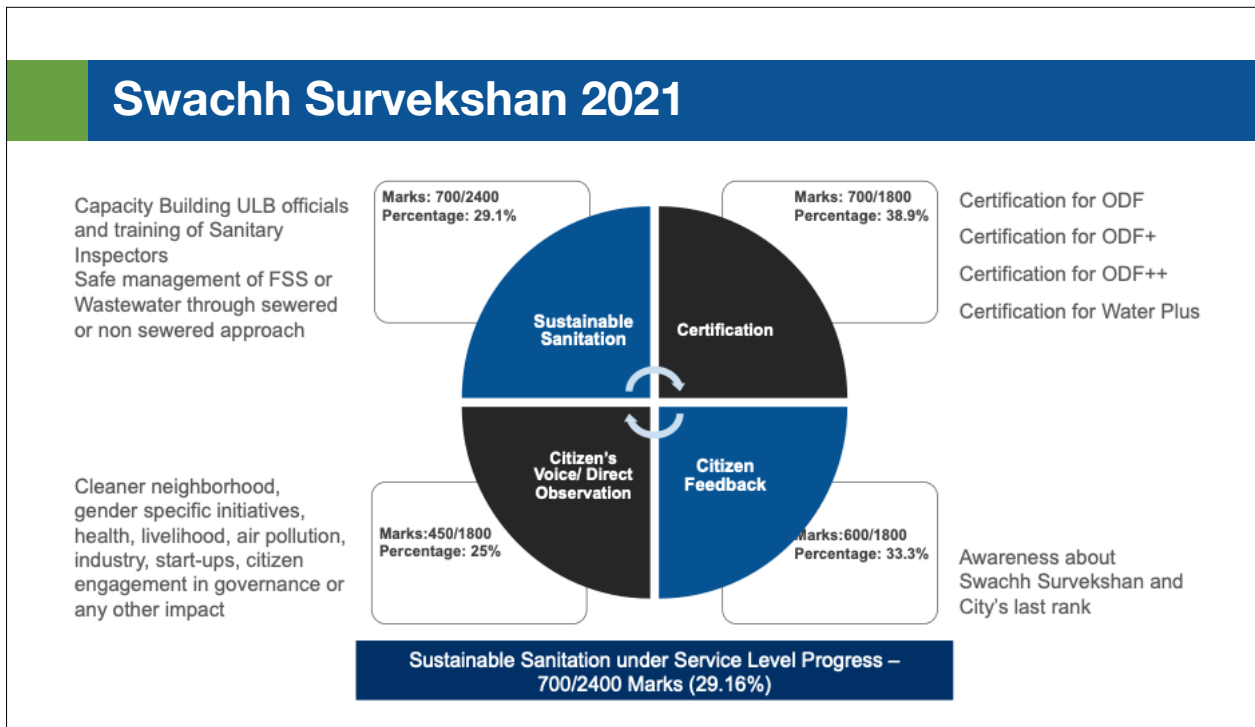
Funding for ULBs (< 1 Million Population)

- 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

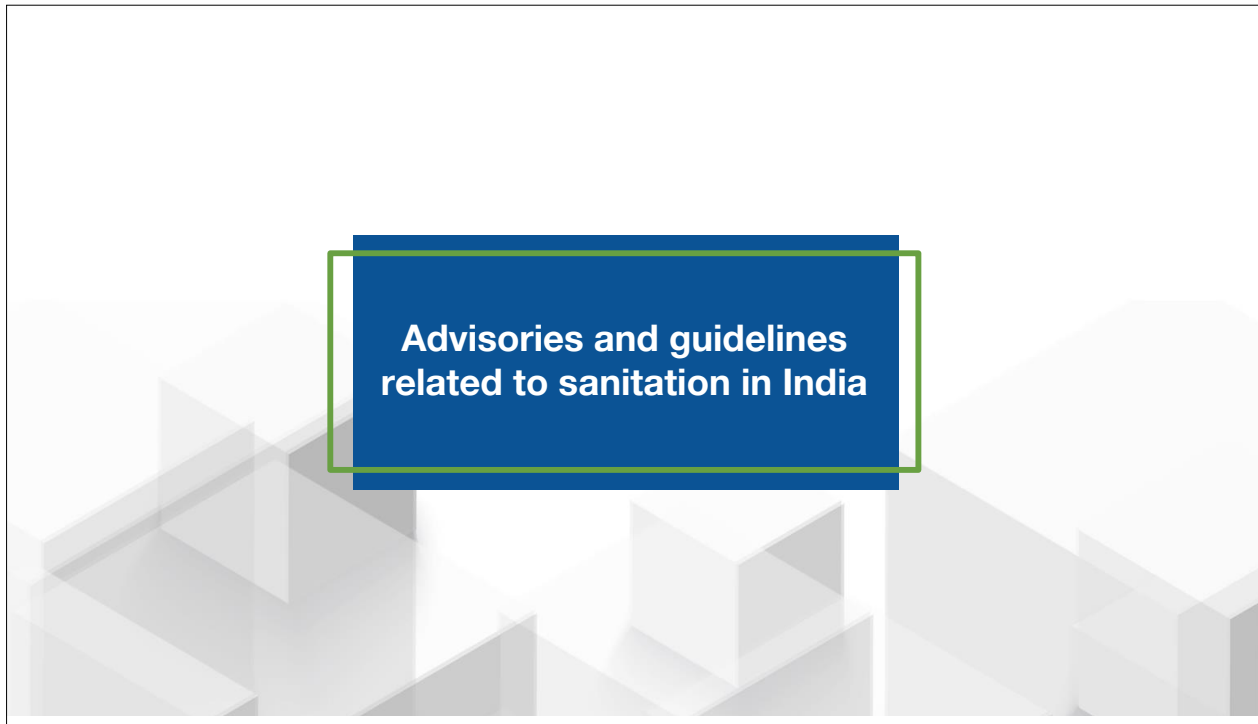
- Terminologies
 - **Manual Scavenger** – manual cleaning, carrying & disposal of human excreta from latrines, pits, septic tanks, drains, sewers.
 - **Hazardous cleaning** – cleaning without proper use of cleaning devices, protective gear.
 - **Protective gear** – safety equipment and personal gear 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.



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 Advisories and guidelines related to sanitation in India



Policies 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 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 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.

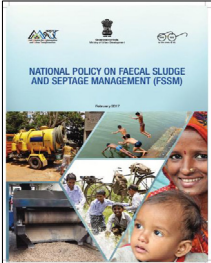
SBM ODF+ & ODF++ Protocol: This toolkit can serve as a readiness checklist for all ULBs/ Development Authorities/ Cantonment Boards to prepare themselves and their concerned stakeholders in achieving either SBM ODF+ and/or SBM ODF++ status and officially declare the same, followed by certification, as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

Advisory on onsite & offsite sewage management practices: This advisory describes the way of integrated planning of sanitation in a city comprising of 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 necessity arises.

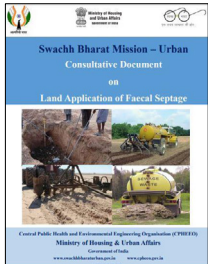
Policies and Guidelines

Faecal Sludge & Septage Management

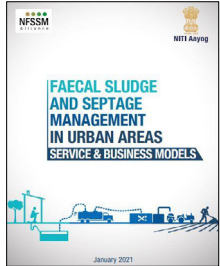
- Leveraging FSSM to achieve 100% access to safe sanitation
- Achieving integrated citywide sanitation
- Sanitary and safe disposal



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.

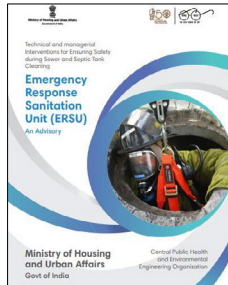
Consultative Document on Land Application of Faecal Septage: This Advisory covers all the key aspects of land application of faecal sludge and septage. It further discusses about the pre-treatment to be given to the faecal septage, precautionary measures to be taken, site selection criteria, dosage and 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.

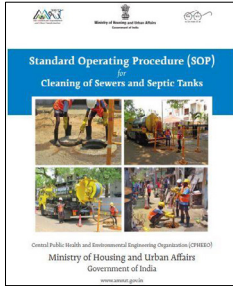
Policies and Guidelines

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

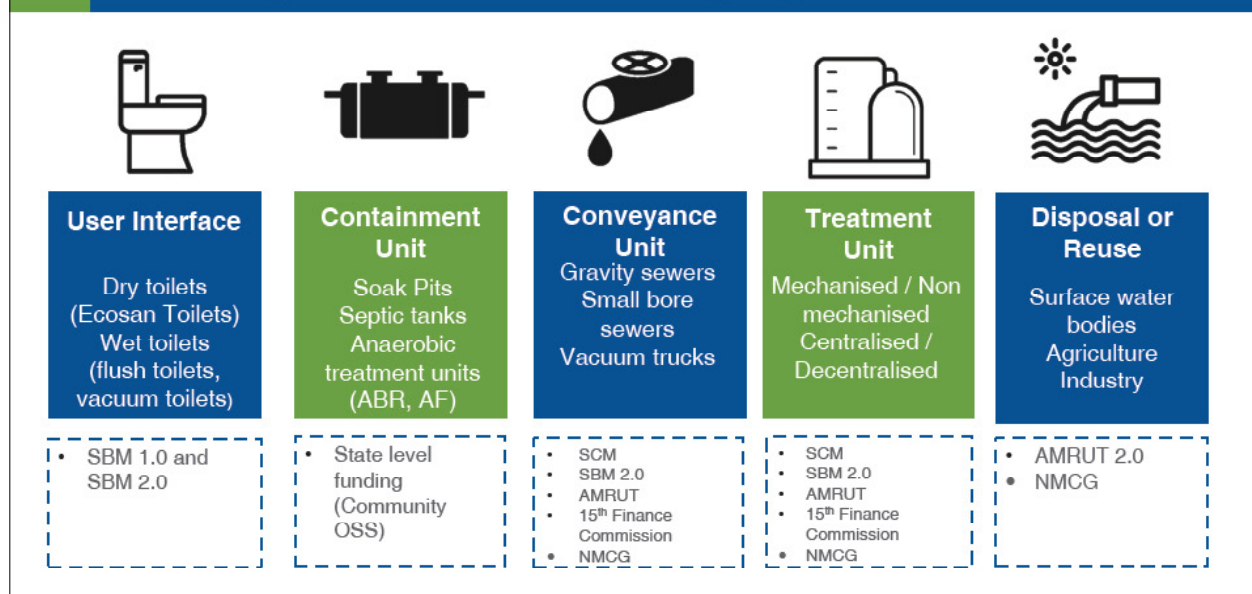


SOP for Cleaning of
Sewers & Septic
tanks

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



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 (1.0 and 2.0), and National Mission for Clean Ganga (NMCG) 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, AMRUT 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



Session

03

Sanitation Systems

3. Sanitation Systems

Learning objectives

- To get in-depth knowledge of sanitation systems and suitability of different types of sanitation systems
- To understand different functional groups in sanitation systems and specific objective of each functional group
- To understand options for each functional group and their inter-linkages

In this session we will introduce the concept of sanitation systems. This will enable the reader to look at complete process of liquid waste management, from generation to disposal. We are also introducing the participants to the types of sanitation systems, thereby familiarizing them with the most prevalent type of sanitation system being used in India. The session continues to focus on types of sanitation system around us.

Contents

Sanitation systems

- Definition
- Objectives
- Types

Functional groups

- User interface
- Containment unit
- Conveyance
- Treatment
- Reuse or disposal

Case studies

- Reuse of treated end products

3.1 Sanitation Systems



Definition & objectives

“It is a 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
- Protect the environment
- Be simple in technology
- Be affordable
- Be culturally acceptable
- Work for everyone



A sanitation system is comprised of Products (wastes) that travel through Functional Groups which contain Technologies that can be selected according to the context. By selecting a Technology for each Product from each applicable Functional Group, 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.

Role of CWIS in sanitation systems

The three CWIS principles that help in achieving objectives of sanitation systems:

- “**Everyone benefits** from adequate sanitation service delivery outcomes that meet user aspirations and that protect health of users.”
- “Human waste is **safely managed along the whole sanitation service chain** ensuring protection of the environment and of human health.”
- “A **diversity of appropriate technical solutions** is adopted, combining both **on-site and sewer solutions**, in either **centralised or decentralised systems**, with consideration on **resource recovery and re-use**.”



Access to all



Whole service chain



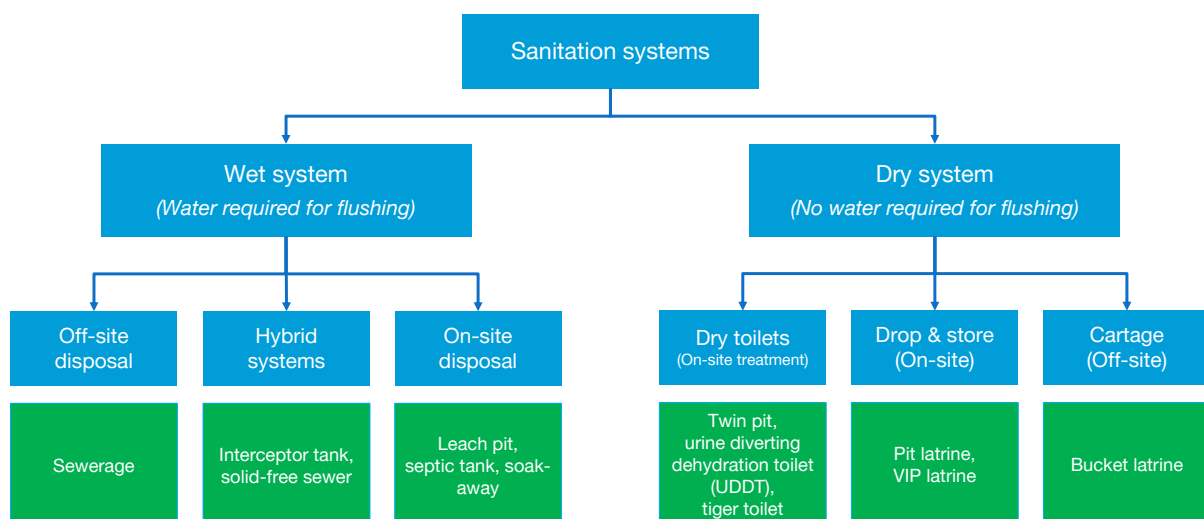
Thriving economy

In the Citywide Inclusive Sanitation (CWIS) approach, emphasis is laid on the **whole sanitation service chain** for a ‘safe management’ of human waste.

What is covered in a sanitation service chain? Everything from user interface (source) upto disposal or re-use of treated waste products (end-point).

- How is CWIS different than a conventional sanitation approach?
 - » Conventional sanitation approach only focuses on sewerage and wastewater treatment; this is often **expensive, inconvenient and unmanageable**.
 - » CWIS does not oppose the conventional approach but improves it by combining **centralized and decentralized systems** as well as **on-site and sewer solutions**.

Types of sanitation systems

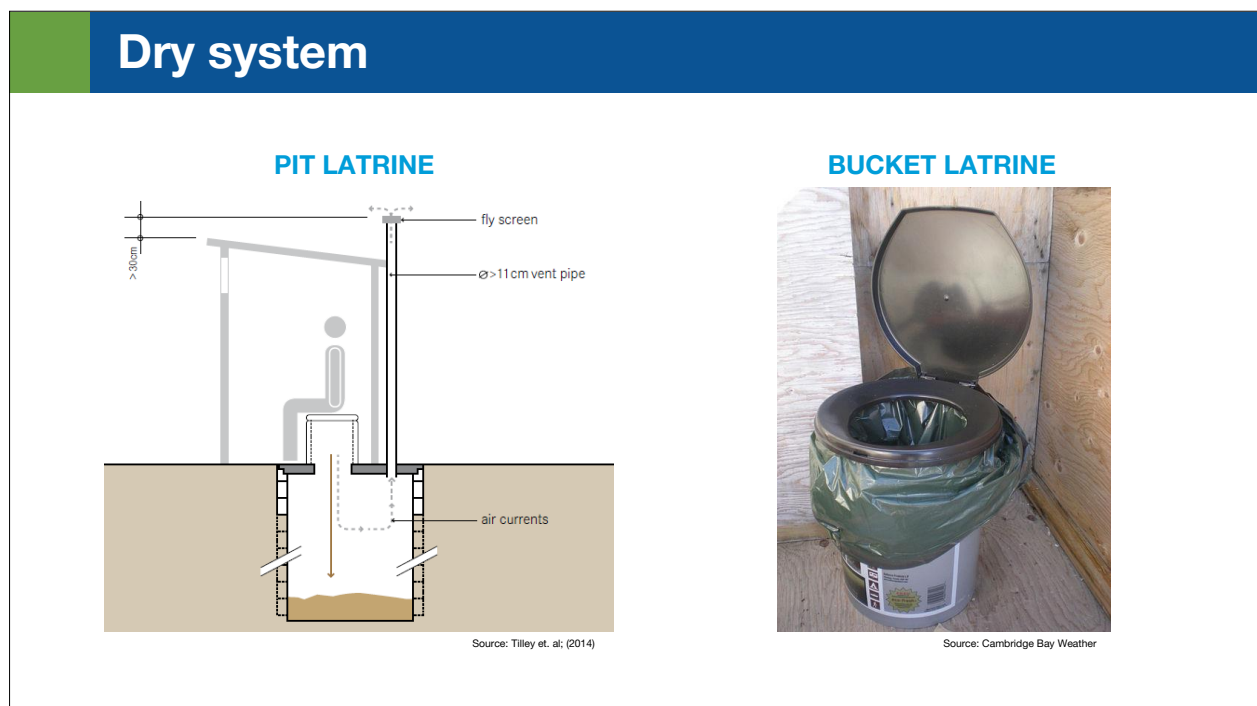


In the urban centres of the developing countries, due to availability of the water, use of flush toilets and the myth that wet systems are the easiest to operate and maintain, water borne systems are used. Water is used to transport the waste from one point to another. These systems are called wet systems. The wet systems can be classified into two types depending on where the treatment of waste is done.

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.



Dry sanitation is defined as the disposal of human waste without the use of water as a carrier and the by-products i.e. decomposed solids and urine are then used as fertilizer.

Urine diversion toilet

- Segregates waste – faeces, urine and anal cleansing water at source
- Can be used in onsite, hybrid and offsite sanitation systems
- Recovers undiluted urine, which is a nutrient concentrate



Source: Waffler (2010)

Urine Diversion Dehydration Toilet
Squatting Three Hole Pan



Source: Waffler (2010)

Urine Diversion Dehydration Toilet
Western Two Hole Pan



Source: Ulrich (2009)

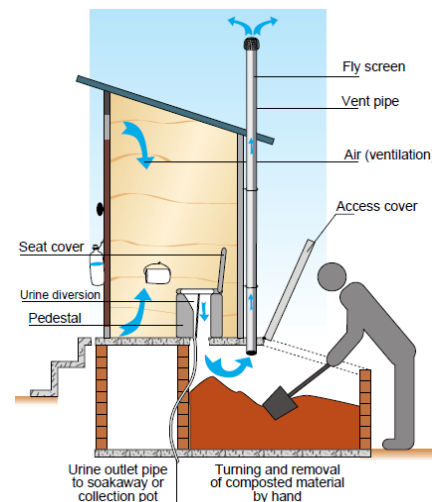
Urine Diversion Flush Toilet
Western Two Hole Pan

Urine diversion toilets where faeces, urine and anal cleansing water segregated separately at source. A urine-diverting dry toilet (UDDT) is a toilet that operates without water and has a divider or three-hole pan so that the user, with little effort, can divert the urine away from the faeces.

The effectiveness of faeces management in most UDDTs relies on the faecal material remaining as dry as possible in the vault.

Urine diversion dehydration toilet (UDDT)

- Does not require water for flushing
- Most appropriate for rural and farming families
- End products:
 - Urine = liquid fertiliser after hygenisation
 - Humanure = soil conditioner
- Can be constructed with locally available material such as bricks, mortar etc.
- Relatively high capital cost

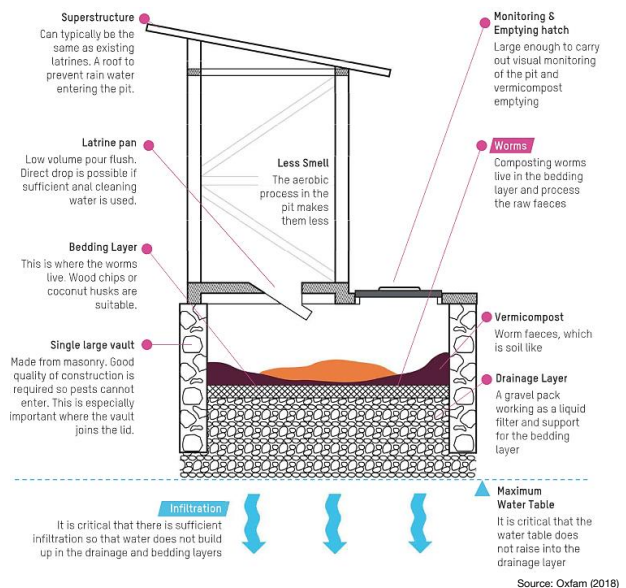


Source: susana/sani-tech-options-2010

It does not require a constant source of water. There are no real problems with odour and vectors (flies) if used and maintained correctly (i.e. kept dry). It can be built and repaired with locally available materials which indirectly effects in low capital and operation costs. These are suitable for all types of users(sitters, squatters, washers, wipers).

Tiger toilet

- Suitable in areas with low water table
- Cost lies in between that of pit latrine and UDDT
- Water required only for anal cleansing
- Tiger worms are used to biologically degrade the faecal matter
- Timely emptying of compost is needed



The tiger toilet is a pour-flush pit latrine toilet that uses vermifiltration to treat waste. The vermifiltration technology uses earthworms or tiger worms to decompose the waste from latrines rapidly into vermi-compost, while liquids drain out of the system. It consists of a strong and durable toilet room and the Tiger bio-digester attached to it. The system needs minimal maintenance and offers users a flush-and-forget experience.

3.2 Functional Groups

Functional groups

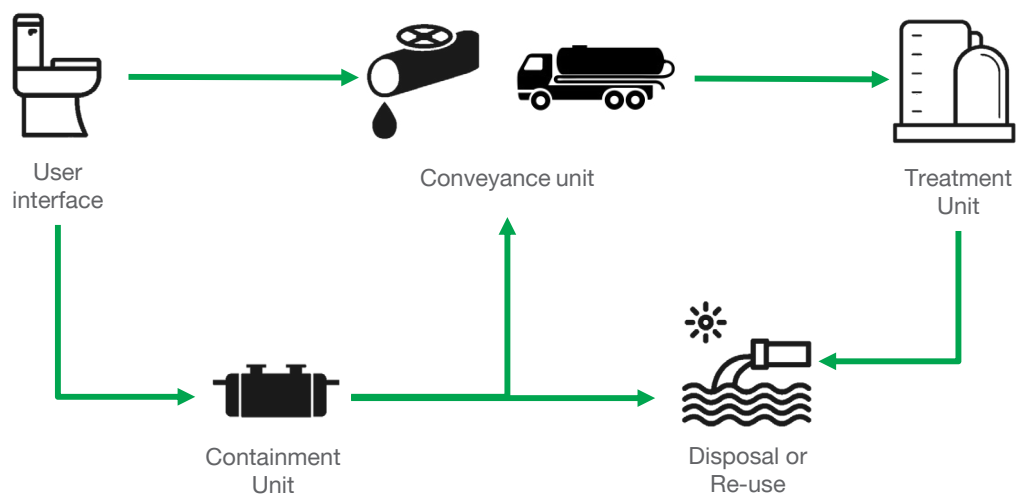
Types of functional groups
 Importance of functional groups
 Technical options in each functional group

Functional groups

- Technologies which perform the same or similar functions are grouped into functional groups
- A sanitation system is a combination of technologies through which the products flow, and only select combinations of technologies make a sanitation system functional
- Domestic products mainly run through five different 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. picture clearer as to how each component connects with other.


Functional groups



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 more clear as to how each component connects with other.

User interface

- It is the type of toilet, pedestal, **pan** or **urinal** the user comes in contact with
- It is the point where **waste** and **water** is introduced in the system
- This determines the **final composition** of the product
- Choice of user interface is often dependent on **affordability** and **availability of water**



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.

User interface



Source: SSWM Tool Box

Collection & storage/treatment

- It is the mode of **collecting** and **storing** products generated at the user interface
- Storage often performs a basic level of **treatment**
- A user interface is connected to a **soakaway zone** or **conveyance system** for discharge of liquid
- On-site sanitation units have to be **regularly emptied** for solids



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.

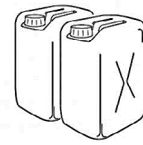
Collection & storage/treatment



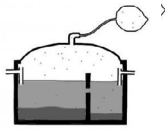
Twin pit for flush toilet



Urine diversion dehydration toilet



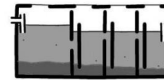
Jerry cans for urine storage



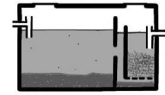
Biogas reactor



Septic tank



Anaerobic baffled reactor



Anaerobic up-flow reactor

Source: SSWM Tool Box

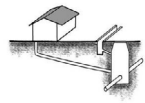
Conveyance

- Defined as the way by which waste products are **moved/transferred** from one point to another
- Conveyance can either be **gravity-** or **energy-**driven
- Longest and most important **gap** lies between user interface and treatment stage
- Products may need to be moved in **various ways** to reach the required process, for example, sewage pumping stations, vacuum trucks, etc.

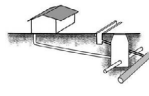


Conveyance describes the way in which products are moved from one process to another. Although products may need to be moved in various ways to reach the required process, the longest and most important gap lies between on-site storage and (semi-) centralised treatment. For the sake of simplicity, conveyance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

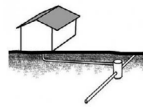
Conveyance



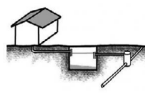
Conventional sewers



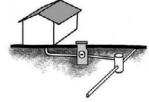
Separate sewers



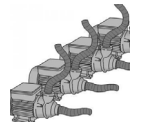
Simplified sewers



Small bore sewers



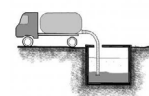
Vacuum sewers



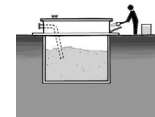
Pumping stations



Human powered emptying & transport



Motorised emptying & transport



Transfer stations

Source: SSWM Tool Box

Treatment

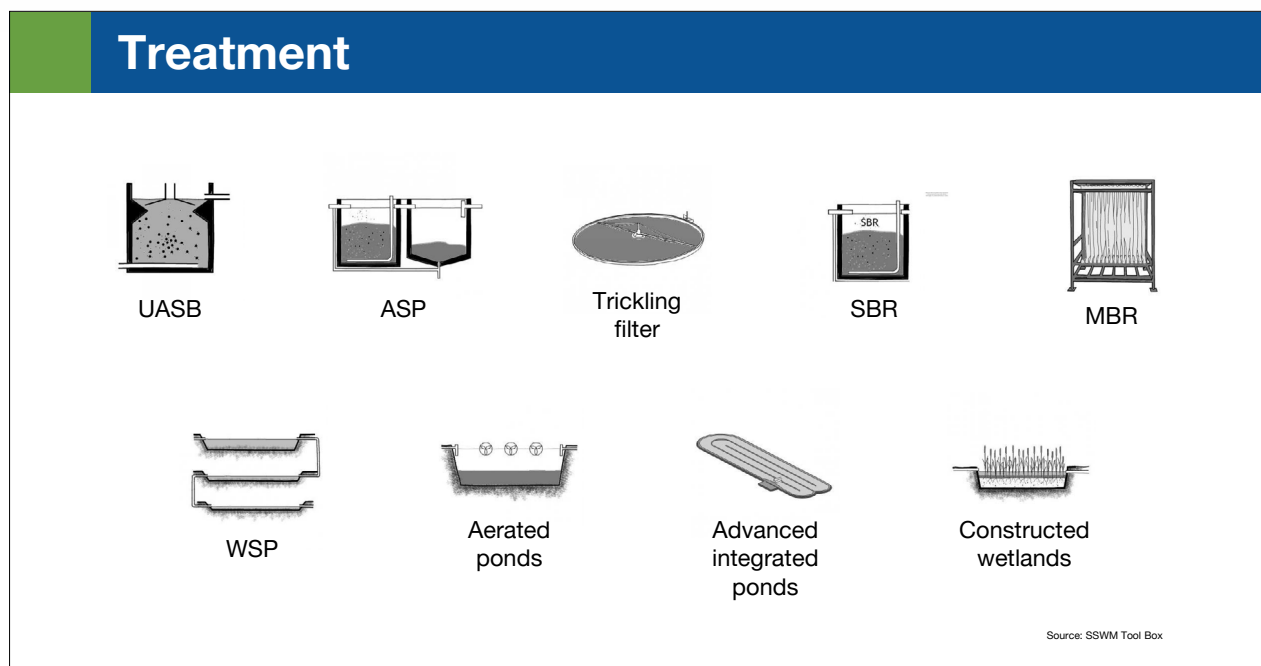
- It requires a large area as compared to user interface or containment stage
- It is designed based on the characteristic of the waste products to be treated (sewage or faecal sludge/septage)
- Treatment systems can be **mechanised** or **non-mechanised**
- **Treatment processes** can be physical, biological, chemical or photolytic
- **Skilled persons are required** for operation and maintenance



The technical and physical criteria for choosing appropriate technology for treatment are as follows: 1. Climate, 2. Availability of space, 3. Ground condition, 4. Ground water level and contamination. There are two different types of treatment systems i.e. mechanized or non mechanized. These treatment systems are depended on physical, biological, chemical or photolytic treatment processes.

Based on the level of liquid waste management, the treatment stage is classified as centralized or decentralized treatment plant. Centralized treatment plant needs a conveyance unit which collects the wastewater and bring it offsite at one point for treatment. In case of decentralized treatment plant, conveyance unit is optional. Based on type of the treatment technology, the requirement

of expertise and skills vary. However, it is safe to say that without operation and maintenance by skilled and appropriately trained person, any treatment technology is bound to fail.



There are different types of treatment technologies which can be implemented at various levels of wastewater management. The choice of technology depends on different criteria. Session 17 is dedicated to discussing the treatment technologies and their working in detail.

Disposal and/or reuse

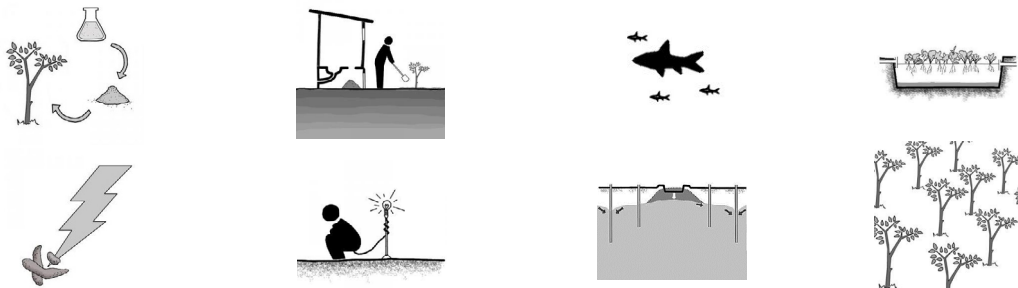
- It is the way through which products are returned to the environment, either as **harmless** substances or **useful resources**
- Products can also be **re-introduced** in the system as new products
- **End Products** may be in the form of dehydrated faeces, sterilised urine, treated wastewater, or bio-solids

The icon shows a sun in the upper left corner, a pipe in the center, and wavy lines representing water in the lower right corner, symbolizing the discharge of treated effluent into the environment.

Use and/or disposal refers to the ways in which products are ultimately returned to the soil, either as harmless substances or useful resources. Furthermore, products can also be re-introduced into the system as new products. A typical example is the use of partially treated greywater used for toilet flushing.

Disposal and/or reuse

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



Source: SSWM Tool Box

Agriculture: The dried faecal matter is used as soil conditioner in agriculture. The soil conditioner improves the texture of the soil and helps to increase the moisture retention capacity of the soil. The sterile urine after disinfection is used as fertilizer in the agriculture. Urine as a liquid fertilizer contains high amount of nitrates and phosphates which can reduce the consumption of inorganic fertilizers.

Aquaculture: The term aquaculture refers to the controlled cultivation of aquatic plants and animals by making use of various types of wastewater as a source for nutrients and/or warm temperatures for plants and fish to grow. Fish can be grown in ponds that receive effluent or sludge where they can feed on algae and other organisms that grow in the nutrient-rich water. The fish, thereby, remove the nutrients from the wastewater and are eventually harvested for consumption. You can also read the description of plant aquacultures.

Recharge or disposal: This can be done in several ways. The most common way is to have a leach field or soak pit. However, there are other ways like soil aquifer treatment, short crop rotation which are popular in other countries and utilize the treated wastewater in most sophisticated way.

Energy products from sludge: The sludge can be processed to make solid or liquid fuel depending on the treatment process used. The biogas generated through anaerobic digestion can be directly used as liquid fuel or alternatively converted into electricity. Dried sludge can also be used as solid fuel in furnaces or brick kilns due to its high calorific value.

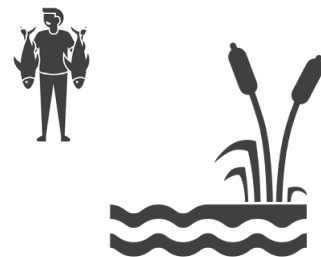
Further reading: <http://www.sswm.info/category/implementation-tools/reuse-and-recharge>

3.3 Case Studies

Case studies

East Kolkata Wetland System

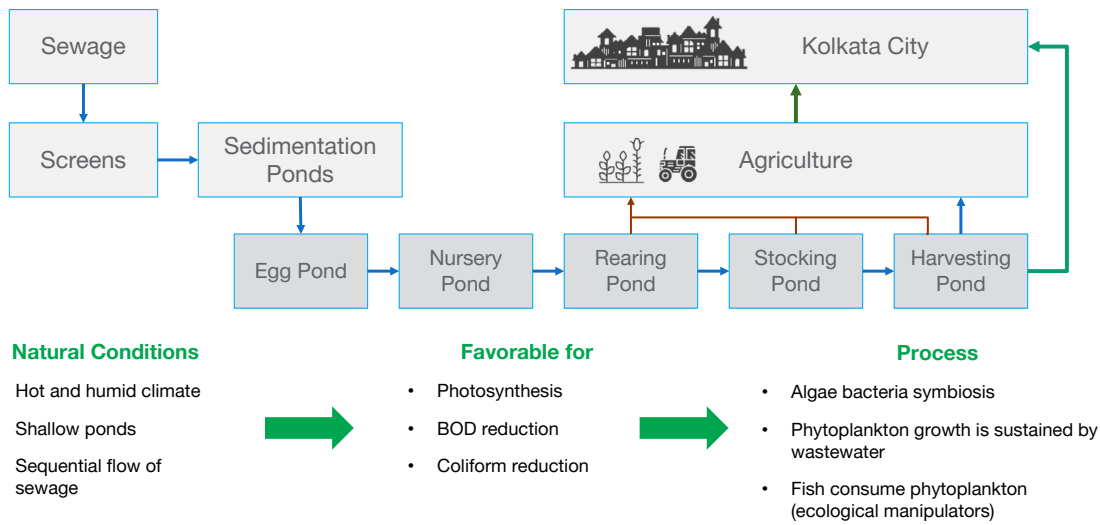
- Almost 600 million liters of sewage is channelised into the EKW everyday
- Wastewater treatment of East Kolkata is done through 125 square kilometers of wetlands
- Wetlands are 8.5 feet below city's highest point
- The process used is called Rhizofiltration



The East Calcutta Wetlands are a complex of natural and human-made wetlands lying east of the city of Kolkata, of West Bengal in India. The wetlands cover 125 square kilometers, and include salt marshes and salt meadows, as well as sewage farms and settling ponds. The wetlands are used to treat Kolkata's sewage, and the nutrients contained in the wastewater sustaining fish farms and agriculture.

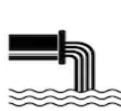
Wastewater will pass through a water hyacinth tank where some amount of heavy metals and suspended solids may be absorbed from the wastewater before this water is allowed to enter into the fish ponds the process is called RHIZOFILTRATION. Here the plant roots act as biocurtains or bio-filters for the passive remediation of wastewater.

East Kolkata Wetland System



STP at Bhandewadi, Nagpur

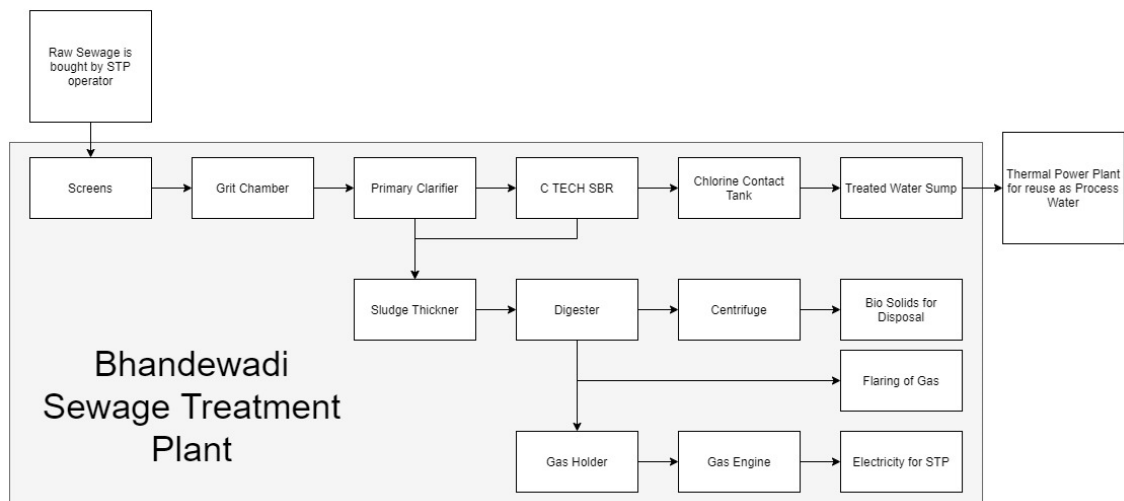
- 130 MLD STP is spread on an area of 12.5 acres
- Treatment process used is Sequential Batch Reactor (SBR)
- Treated wastewater is supplied to thermal power plant 18 km away from the STP, where the treated water is used for cooling and ash handling.



STP along with secondary and tertiary treatment to be constructed, operated and maintained by MAHAGENCO as per their requirements.

- Grant of Rs. 90 Cr received from JnNURM by NMC shall be passed on to MAHAGENCO towards construction.
- Land required for the project shall be provided by NMC.
- NMC shall supply 110 MLD (+10%) sewage to MAHAGENCO @ Rs 15 Cr / year.

STP at Bhandewadi, Nagpur



The 130 MLD Sewage Treatment Plant at constructed near NMC Dumping Ground at Bhandewadi, Nagpur is a Joint Project of Nagpur Municipal Corporation (NMC) & MAHAGENCO. MAHAGENCO is the Principle Employer of the Project. MAHAGENCO has signed the Memorandum of Understanding (MOU) with NMC in support of NMCs Water Reuse Planning and to supply treated wastewater from Nagpur Municipal Sewage Treatment Plant as water linkage to meet additional demand of proposed expansion plan at TPS at Koradi.

The MOU includes construction of 110 MLD STP with 10% overloading capacity for supplying treated sewage water from the Sewage Treatment Plant to meet the water demand. Mahagenco appointed M/s GSJ Envo Ltd. in consortium with SMS Limited as a lead contractor for this project. This is an EPC Contract which also includes Comprehensive Operation & Maintenance of the Sewage Treatment Plant for the period of ten years.

COST OF DELIVERED WATER

1. Capital Cost of the Project (130MLD) : Rs. 180 Cr
 - » JnNURM Grant : Rs. 90 Cr
 - » MAHAGENCO Share : Rs. 90 Cr
2. Operation and Maintenance Cost : Rs. 1.50 Cr/Year
3. Payment to NMC for raw sewage purchase : Rs. 15 Cr/Year
4. Cost of water to MAHAGENCO : Rs. 3.40 per Cum.
5. Cost of fresh water from irrigation department : Rs. 1.20 to 9.60 per Cum.

Videos

[Ecosan Toilets - Urine Dehydration Dry Toilet \(UDDT\)](#)

[East Kolkata Wetland](#)

[Bhandewadi STP Nagpur](#)

Summary

- The main objective of sanitation system is to protect environmental health
- Choice of sanitation system depends on affordability and availability of water
- There are five functional groups in sanitation systems
- An appropriate sanitation system consists from 2 to 5 functional groups
- The type of user interface decides the succeeding functional groups



Session

04

Sanitation Technologies

4. Sanitation Technologies

Learning objectives

- To know the flow of products in wet sanitation system and its types
- To understand the functional groups involved in a wet sanitation system
- To know the working of following functional groups – user interface, containment unit, conveyance unit/collection and transport

In this session, participants are introduced to technological options for various stages of IWSM and FSSM service chain – containment unit, desludging equipment and conveyance, collection and transport.

Contents

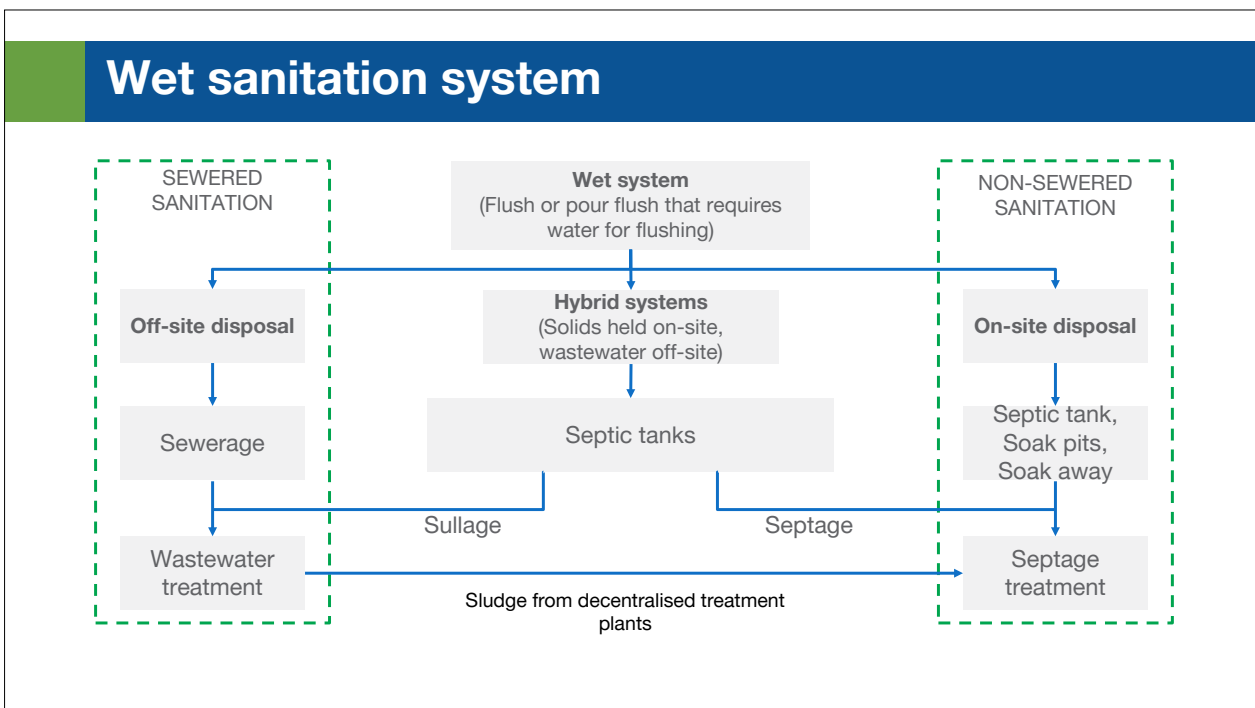
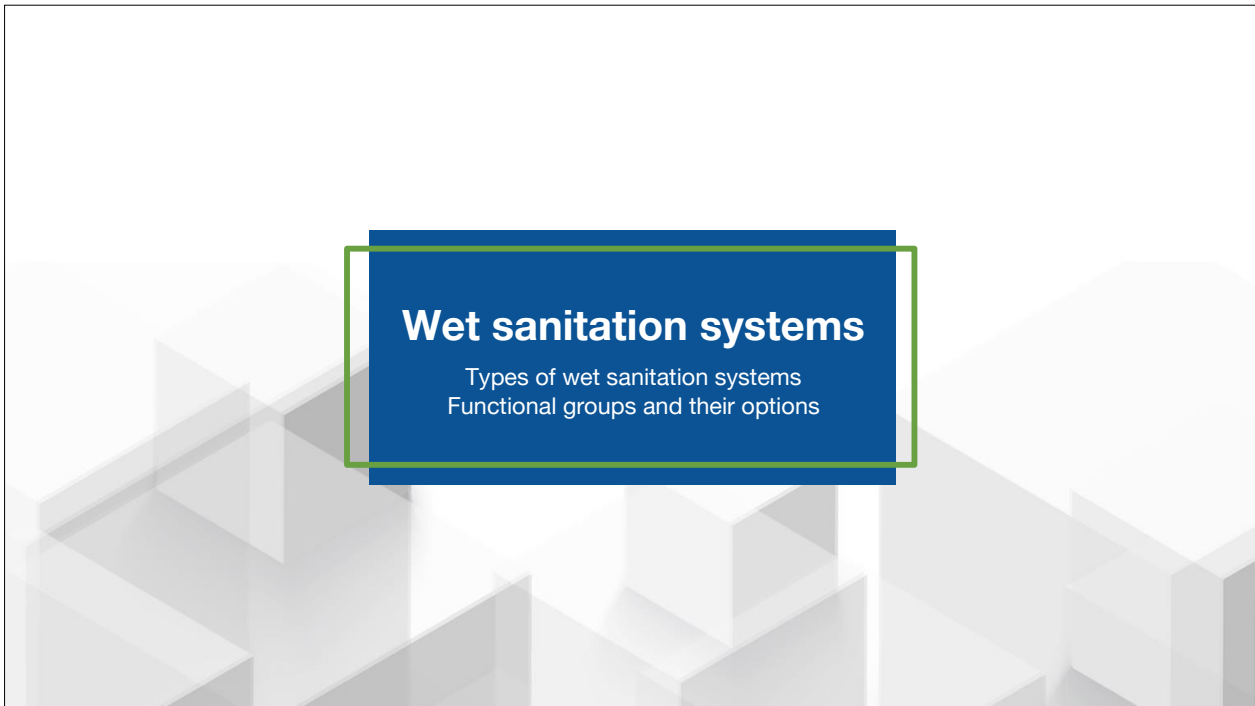
Wet sanitation systems

- Flow of products
- Functional groups involved

Functional groups

- User interface
- Containment unit
- Collection and transport
- Conveyance unit

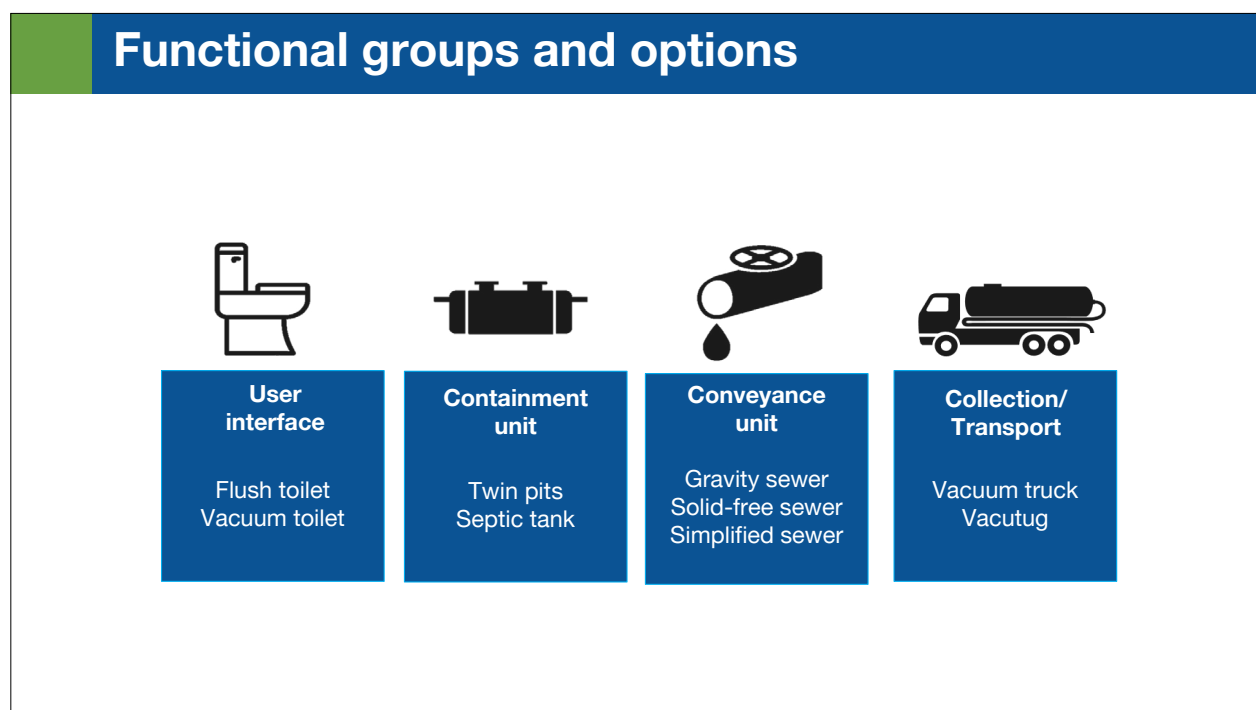
4.1 Wet Sanitation Systems



In urban centres of developing countries, due to availability of water, use of flush toilets and the myth that wet systems are easy to operate and maintain, water borne systems are used. Water is used to transport the waste from one point to another. These systems are called wet systems. The wet systems can be classified into two types depending on where the treatment of waste is done. 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.

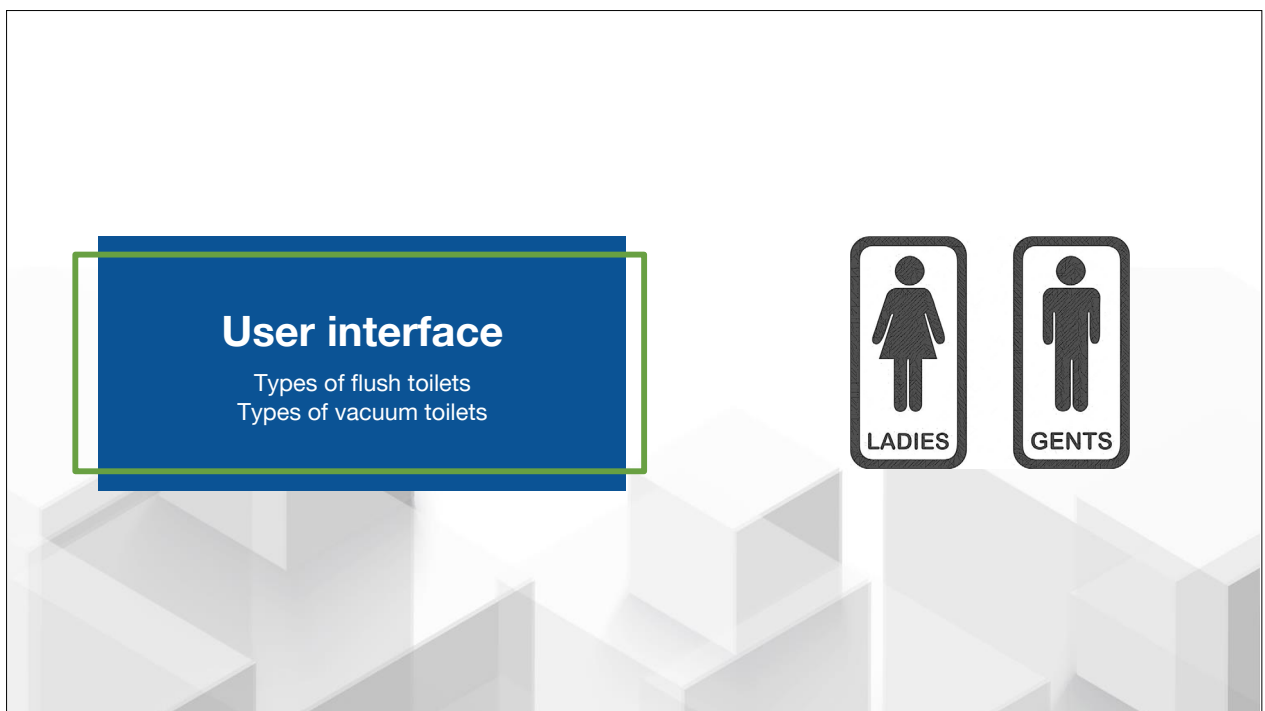
In the case of “On-site” disposal, solids are stored in the containment unit and the liquid effluent is disposed off into the ground using soak pits or soak away. After a duration of a few years, the contained solids are emptied and transported for further treatment. Since this conveyance of solids is 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 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 sewerred or non-sewerred sanitation 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. We will be looking into different sanitation systems which will make the picture clearer as to how each component connects with other.

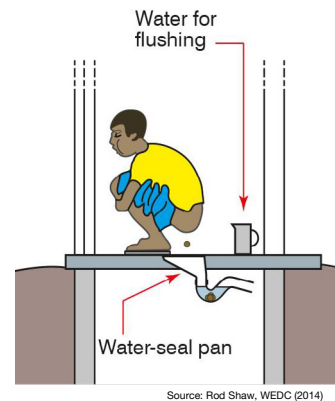
4.2 Functional Groups



User interface describes the type of toilet, pedestal, pan or urinal the user comes in contact with. User interface also determines the final composition of the product, as it is the place where water is introduced in the system. Thus, the choice of user interface is often dependent on the availability of water.

Pour flush toilet

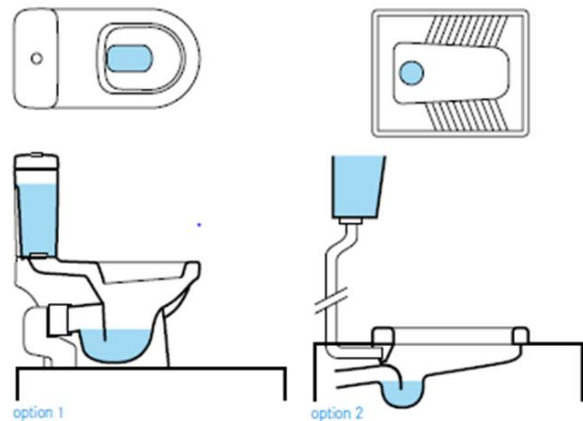
- Excreta of one user is flushed before the next user arrives
- Prevents odour
- Suitable for most users (except for persons with disability)
- Material can be ceramic, plastic, FRP, etc.
- Variants rural pan, squatease, etc. available
- Low capital cost



- The water seal effectively prevents odour.
- The excreta of one user are flushed away before the next user arrives.
- Suitable for all types of users (sitters, squatters, wipers and washers).
- Low capital costs; operating costs depend on the price of water.

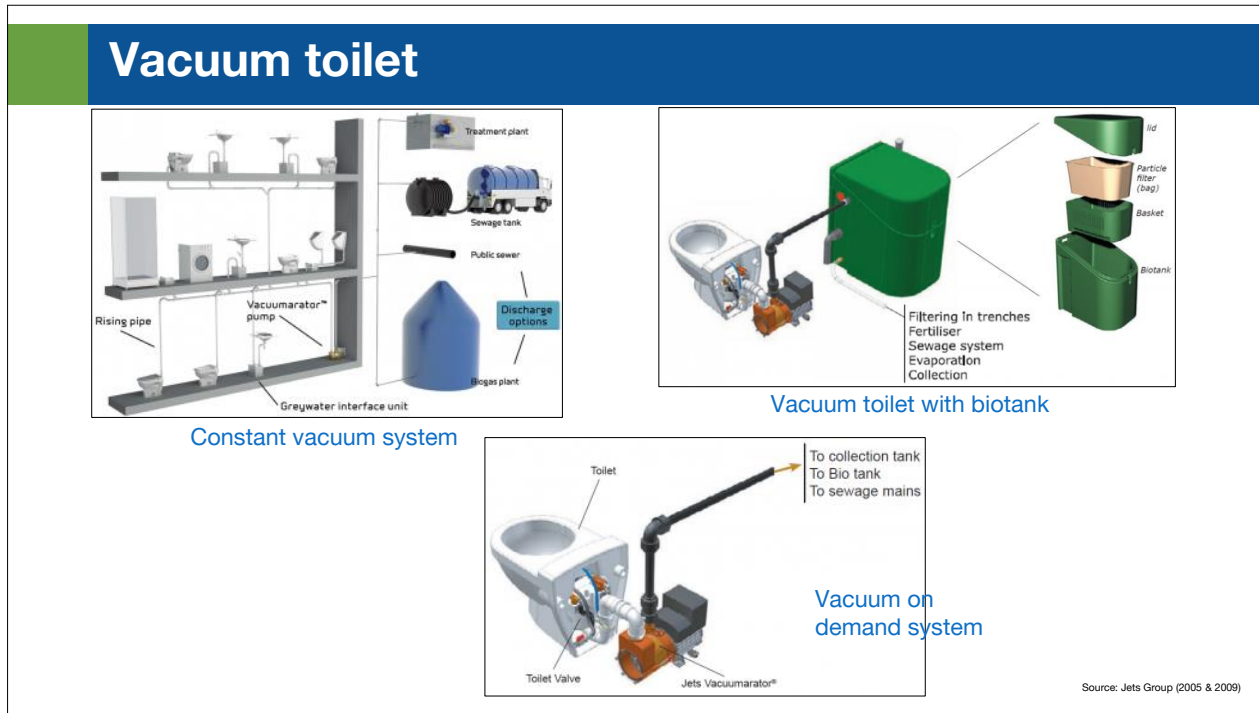
Cistern flush toilet

- Flush toilet with a cistern
- Extra plumbing is required
- Western WC pan is used in toilets for persons with disability
- Flush uses 8-12 liters of water per flush
- Low flush toilet uses 4-6 liters of water per flush



The cistern flush toilet is usually made of porcelain and is a mass-produced, factory-made User Interface. The flush toilet consists of a water tank that supplies the water for flushing the excreta and a bowl into which the excreta are deposited.

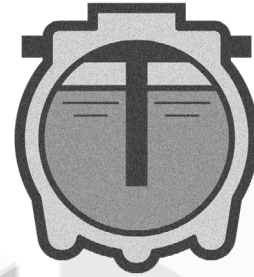
The attractive feature of the cistern flush toilet is that it incorporates a sophisticated water seal to prevent odours from coming back up through the plumbing. Water that is stored in the cistern above the toilet bowl is released by pushing or pulling a lever. This allows the water to run into the bowl, mix with the excreta, and carry them away.



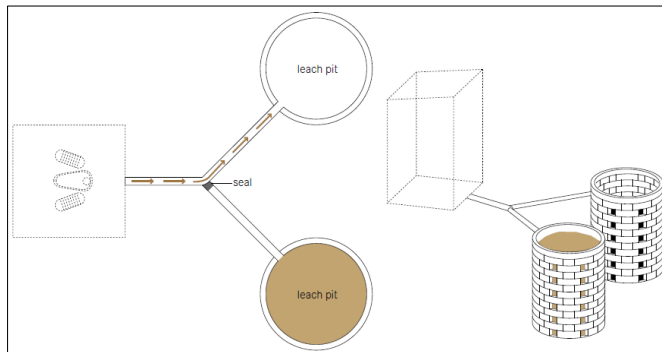
Vacuum toilets are flush toilets that use suction for the removal of faeces and urine resulting in a minimal requirement of water (0.5 to 1.5 litres). Vacuum toilets provide the same level of comfort as traditional flush toilets and they help saving costs due to the minimised amount of flush water. Due to the fact that the effluent has a high organic matter content, vacuum toilets are specifically adapted for the use in combination with separate greywater and blackwater treatment; or aerobic digestion treatment for biogas production. Vacuum toilet systems are applicable both in large and small buildings, trains, ships and airplanes.

Containment

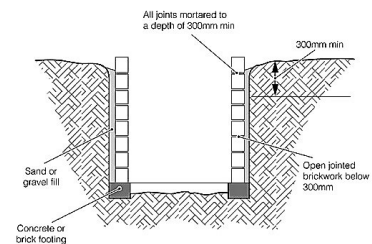
Twin pit unit
Septic tank



Twin pit unit



Source: Tilley et al. 2014



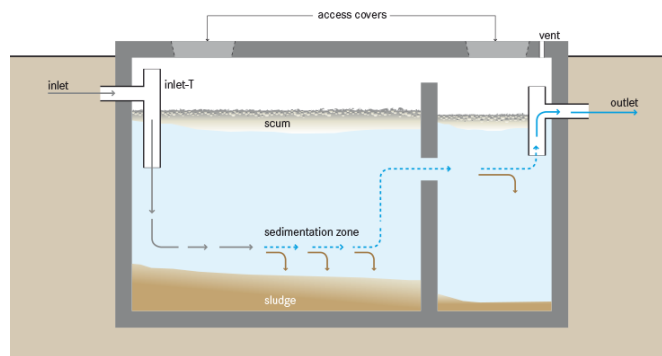
Source: D. Friedman

This technology consists of two alternating pits connected to a pour flush toilet. The blackwater (and in some cases greywater) is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel and reused on-site, much like compost, to improve soil fertility and fertilise crops. Although most pathogens are filtered during soil infiltration or die-off with time and distance, there remains a risk of groundwater pollution, particularly in densely populated areas or in areas with a high groundwater table.

Further reading: <http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/twin-pits>

Septic tank

- On-site treatment unit
- Provides primary treatment
- Physical process – sedimentation and floatation
- Biological process – anaerobic treatment
- Digestion of sludge occurs over a period of time
- Designed solids retention time is 2 – 3 years



A septic tank is a watertight chamber made of brick work, concrete, fibreglass, PVC or plastic, through which blackwater from cistern or pour-flush toilets and greywater through a pipe from inside a building or an outside toilet flows for primary treatment. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate. Effluent is infiltrated into the ground or transported via a sewer to a (semi-) centralised treatment plant. Accumulating faecal sludge needs to be dug out the chamber regularly and correctly disposed off.

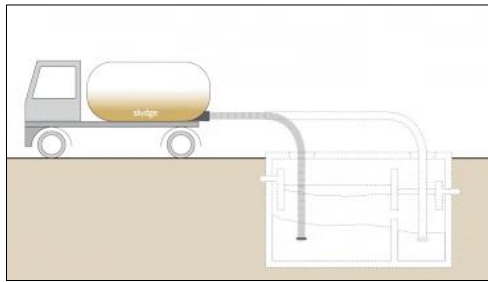
Further reading: <http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/septic-tank>

Collection & Transport

Vacuum truck
Vacutug

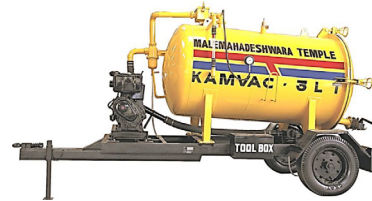


Vacuum truck



Source: Tilley et al. 2014

Trailer mounted	3,000 – 4,500 L
Truck mounted	3,000 – 11,000 L
Price range	Rs. 5 Lakhs and above (for assembly only)



Source: KAMAVIDA

Trailer mounted assembly

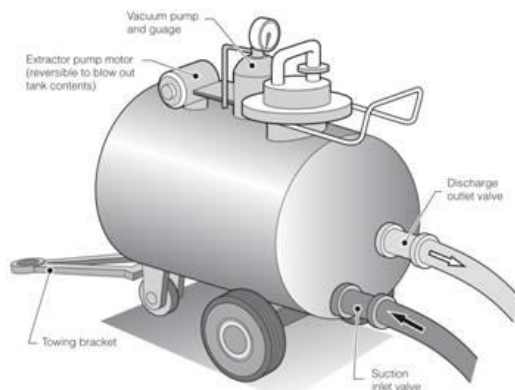


Source: KAMAVIDA

Truck mounted assembly

Vacuum truck is widely used for desludging of containment systems such as septic tanks. The vacuum trucks come in different sizes and types. As shown in picture trailer mounted tank fitted with vacuum pump is the most basic form of equipment. In this case, the trailer can be tugged with tractor and the vacuum pump is operated using diesel run motor. An improved version is a truck mounted tank fitted with the vacuum pump. In this case there is possibility that the vacuum pump can be coupled with the drive train of the truck, thus eliminating the need of separate diesel run motor. Vacuum trucks fitted with jetting equipment are also available for cleaning sewerage network and manholes.

Vacutug



Source: www.lboro.ac.uk

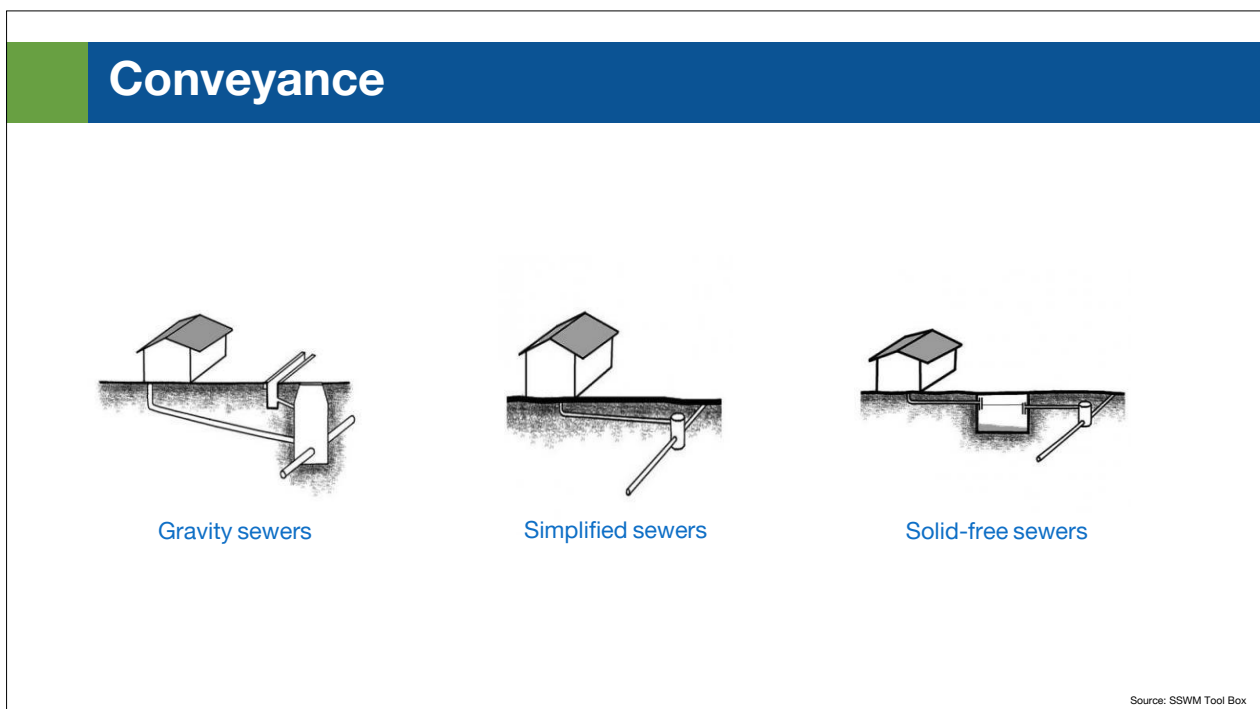
Non-motorised Option
Volume: 300 L
Cost: up to Rs. 3.5 lakhs



Source: Bangladesh Practices and UN-HABITAT, 2006

Motorised Option
Volume: 300 L – 700 L
Cost: Rs. 4 lakhs & above

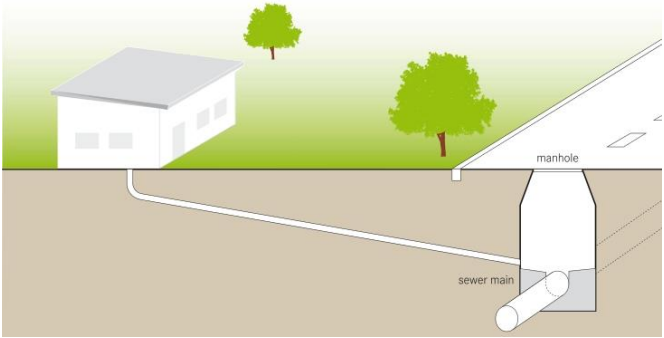
Vacutug is a smaller version of the trailer mounted type of vacuum truck. The need of such a smaller size desludging equipment arises from the fact that not all the containment units are easy to access. Especially in the unorganized settlements such as urban slums, the access roads are small and a vacuum truck cannot be driven to the household. Hence, vacutug is used to empty the content of the septic tank in batches and empty it into the bigger truck. The tugs can be as small as 300 KL. The most important thing while making a vacutug is to keep in mind that it should be easy enough to pull it by persons or vehicle.



The products generated at the user interface or onsite collection and storage/treatment technology by removing and/or transporting them to a subsequent offsite (semi-) centralized treatment, use and/or disposal technology. They are sewer-based technologies.

Gravity sewers

- Designed to handle all types of wastewater along with solids
- Separate sewers carry domestic sewage and stormwater
- Designed for attaining cleansing velocity in pipes
- Laying of sewers is generally done by ULB
- House connection charges to be paid by household



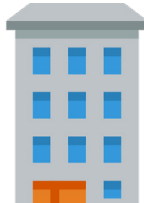
Source: Tilley et al. 2014

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 neighborhood and household level).

Gravity sewers


Commercial properties
Organic load: less
Hydraulic load: high



Residential properties
Organic load: high
Hydraulic load: less




Gradient
1 in 1000 -170



Centralised sanitation system

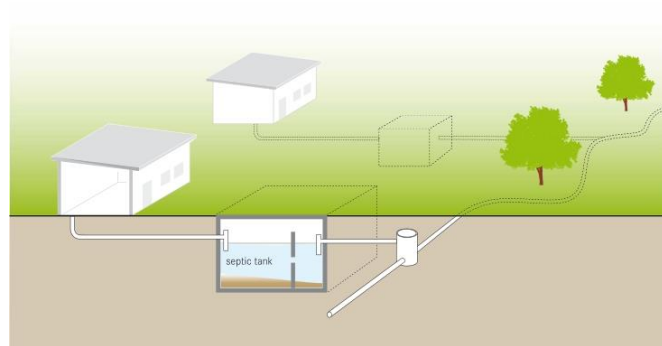
	UI	Collection	Conveyance	Treatment	Disposal
Responsibility	User	User/ULB	ULB/State	ULB/State	ULB
Cost	Low	Low	High	Moderate	High in case of failure



Sewage Pumping Station
CAPEX: high
OPEX: high

Solid-free sewer

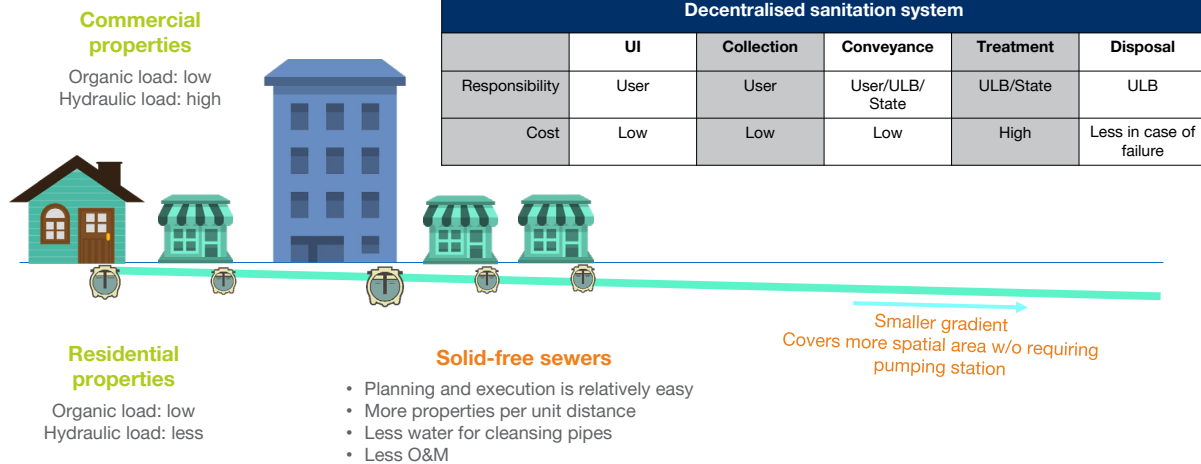
- Works where water supply is limited
- Can handle septic tank effluent and greywater
- Smaller gradients are possible
- Lower capital cost as compared to gravity sewers
- Household to construct septic tank and pay for connection to sewer



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.

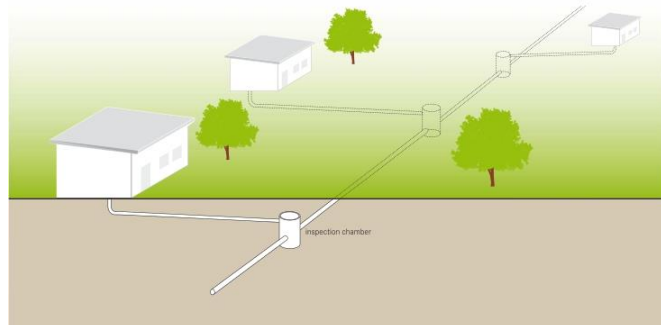
Solids-free sewers are also referred to as settled, smallbore, variable-grade gravity, or septic tank effluent gravity sewers. A precondition for solids-free sewers is efficient primary treatment at the household level. An interceptor, typically a single-chamber septic tank, captures settleable particles 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.

Solid-free sewer



Simplified sewer

- Appropriate for densely populated areas with low availability of area
- Laid at shallower depths with cleanout points
- Lowest capital cost as compared to other type sewers
- Needs frequent O&M in the form of cleaning clogs and flushing



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.

Conceptually, simplified sewerage is the same as conventional gravity sewerage, but without unnecessarily conservative design standards and with design features that are better adapted to the local situation. The pipes are usually laid within the property boundaries, through either the back or front yards, rather than beneath the central road, allowing for fewer and shorter pipes. Because simplified sewers are typically installed within the condominium, they are often referred to as condominial sewers. The pipes can also be routed in access ways, which are too narrow for heavy traffic, or underneath pavements (sidewalks). Since simplified sewers are installed where they are not subjected to heavy traffic loads, they can be laid at a shallow depth and little excavation is required.

Adopting CWIS principles for planning

In an ideal scenario, development of **urban spaces are planned**, wherein households will be served through a centralised sewerage sanitation system

However, due to rapid urbanisation, planning is not always possible, **resulting in organic growth of urban spaces**

Therefore, there is a **need to move beyond conventional approach to sanitation**, by implementing the most appropriate system

CWIS principles allow **adopting both conventional and innovative methods** for planning sanitation infrastructure by pooling them together as complementary urban sanitation services, and linking it with **reuse and resource recovery**

Summary

- In India, hybrid sanitation system is mostly followed, where septic tank effluent along with the greywater is discarded by the household
- Solid-free sewer is an appropriate collection and conveyance system for sullage
- Regular emptying of on-site sanitation system like septic tank is necessary for proper functioning of solid-free sewers

Session

05

Building Sanitation System

This is an activity session for face to face trainings
– Kindly refer Part B: Learning Notes for activity instructions

Session

06

Liquid Waste Management

6. Liquid Waste Management

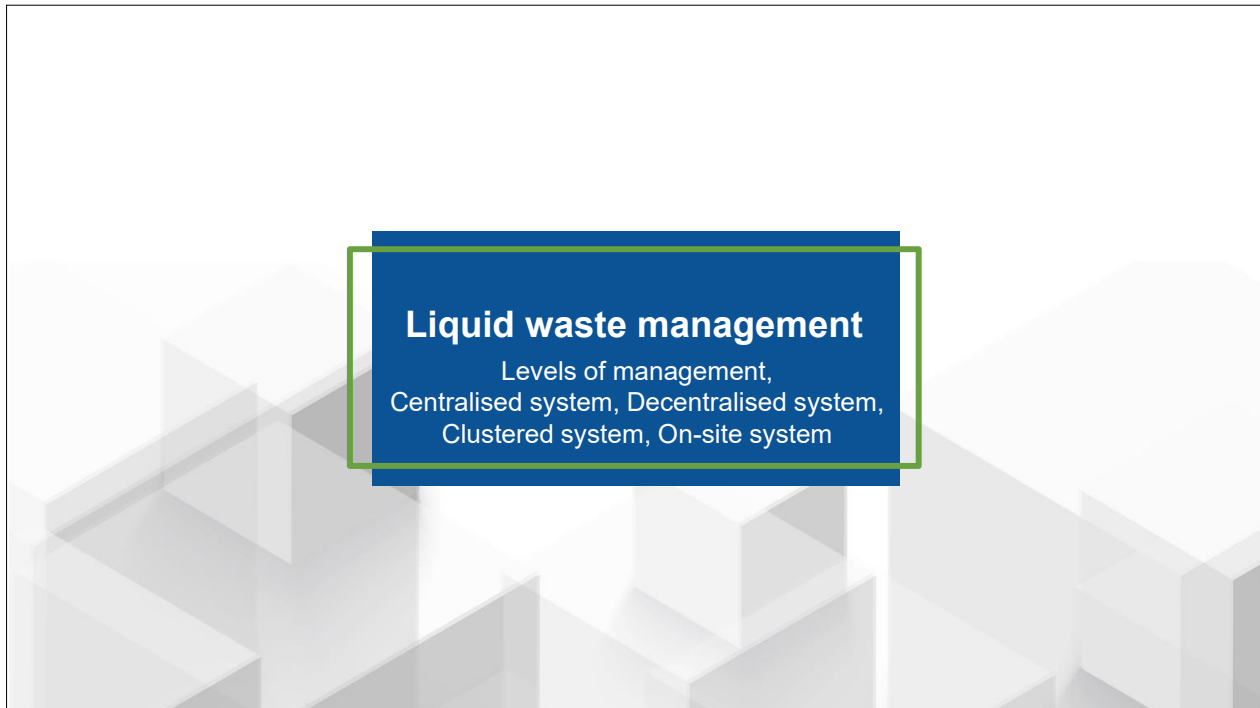
Learning objectives

- To understand different levels of liquid waste management with respect to changing urban settings
- To gain a detailed understanding of different aspects of liquid waste management
- To understand the different aspects and tools used for planning of liquid waste management

Contents

- Levels of wastewater management
- Centralised wastewater management
- Decentralised wastewater management
- Planning of sanitation systems

6.1 Liquid Waste Management



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



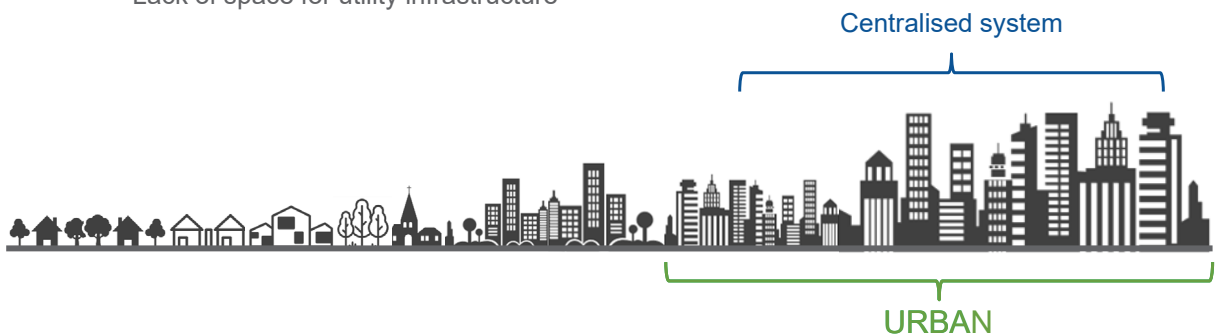
There are different levels in liquid waste management. There are few factors which we have to consider while planning the wastewater management. The factors are population density, the type of housing, availability of space or land for development of utility infrastructure such as sewerage lines or treatment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

Centralised systems

Characteristics of urban habitat:

- Very high population density
- Characterised 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)



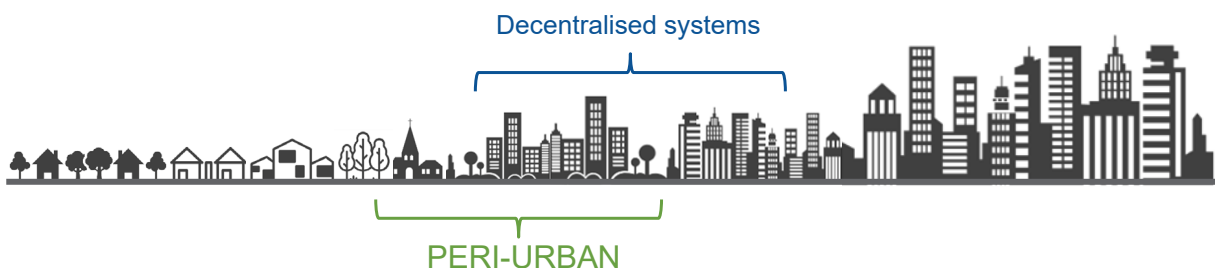
In centralised system approach, it is very crucial to understand the level or type of habitat while planning liquid waste management. There are different levels or types of habitat like urban, peri-urban, rurban or rural. In the first part we will understand urban habitat which has very high population density and has areas with high rise buildings. Generally, urban administrations and urban populations 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 centralised system, i.e., household connections with sewerage system and wastewater transferred through a centralised treatment system which is further disposed off into surface water bodies after treatment.

Decentralised systems

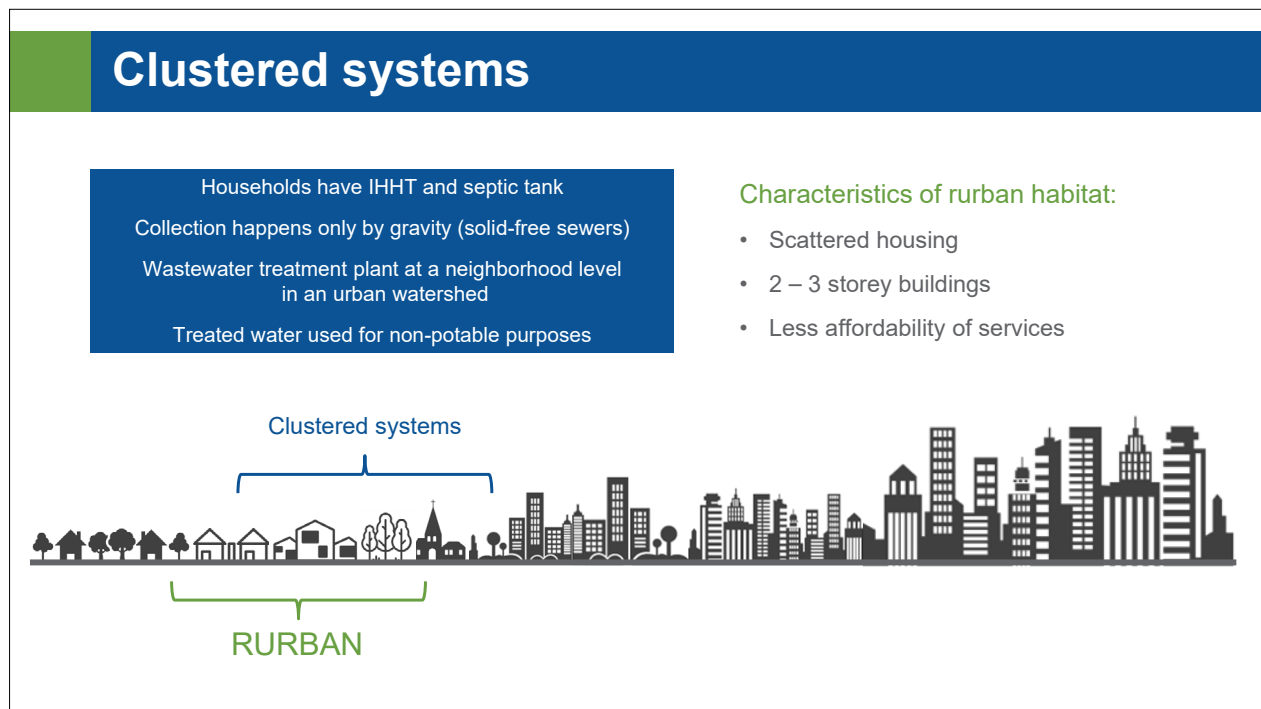
Households have IHHT and Septic tank
Collection happens only by gravity (no sewage pumping stations)
Wastewater treatment plant at an urban watershed level
Treated water disposed off in surface water bodies (ponds or lakes)

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 high or medium population density and has areas with high rise buildings, generally, local administration and local people have affordability of developing and maintaining environmental services. In peri-urban case, it has suitability of decentralised system, i.e., households have individual toilets and on-site septic tanks which can be connected with sub-lines (no sewage pumping stations) and wastewater is collected at decentralised treatment system by gravity. Further, it can be disposed into the surface water bodies after treatment or reused for irrigation.



In the case of rural habitat, which generally has 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 environmental services. In rural case, it has suitability of clustered or regional approach for wastewater management system, i.e., households have individual 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 systems

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



In the case of rural habitat, which generally has 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 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.

Adopting CWIS principles for planning

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 sewered solutions exist**, either or both **centralised or decentralised systems** should be adopted for providing adequate sanitation services to **everyone in the city**.



Complementarity of Systems

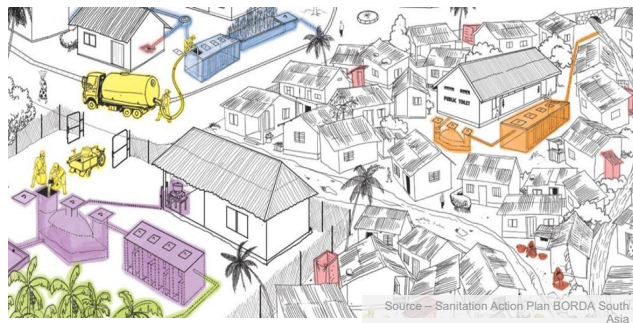
- Conventional sewers where economy of scale works.
- Decentralised systems in areas dictated by topography, population density
- Fecal Sludge Management in areas where access is an issue. Eg- slums, and peri urban regions not served by piped systems

Eawag: Swiss Federal Institute of Aquatic Science and Technology

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

6.2 Centralised Wastewater Management

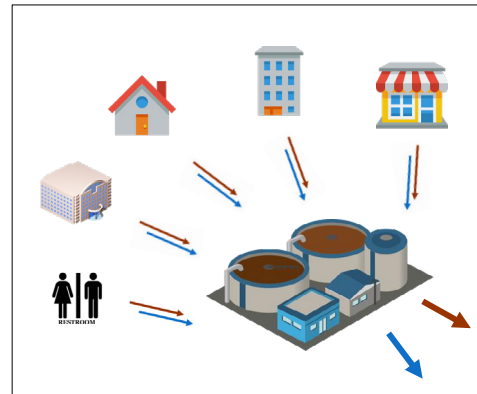
Centralised wastewater management

Characteristics,
Requirements, Components of systems,
Limitations and Economic aspects

Centralised system should have water driven infrastructure where excreta or solids are mixed with water to facilitate conveyance to wastewater treatment systems. As per CPHEEO, the water consumption is considered as 135lpcd in urban areas, which must be kept in mind while designing the wastewater treatment system. In treatment system, liquid and solids are separated and treated water is disposed off/reused.

Characteristics

- Water driven infrastructure for solids (excreta)
- Water consumption assumed as 135 LPCD
- Objective of designing sewerage network is no deposition of solids
- Treatment plant to separate solids and liquids, remove organic matter, pathogens, safely dispose treated waste products or adopt it for reuse

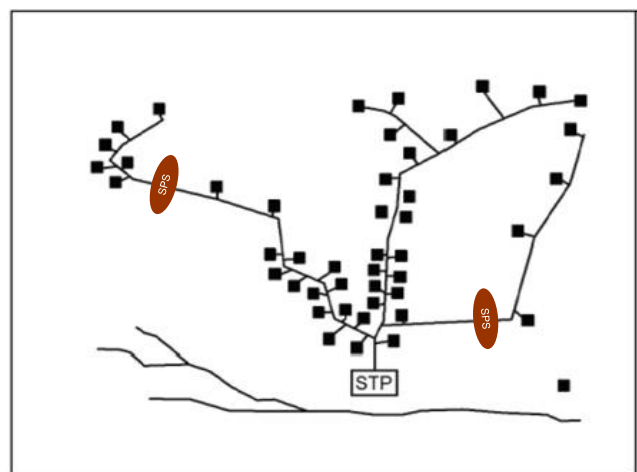


In centralized system the following components have to be present:

- The individual household toilets have to be flush toilet with sewerage connections,
- The sewerage network with sewer pumping stations for collecting and conveying the wastewater from the households,
- The sewage treatment plant (STP) with mechanization and appropriate control system,
- A suitable disposal point where the treated water can be disposed. In absence of disposal point, appropriate reuse infrastructure should be available.

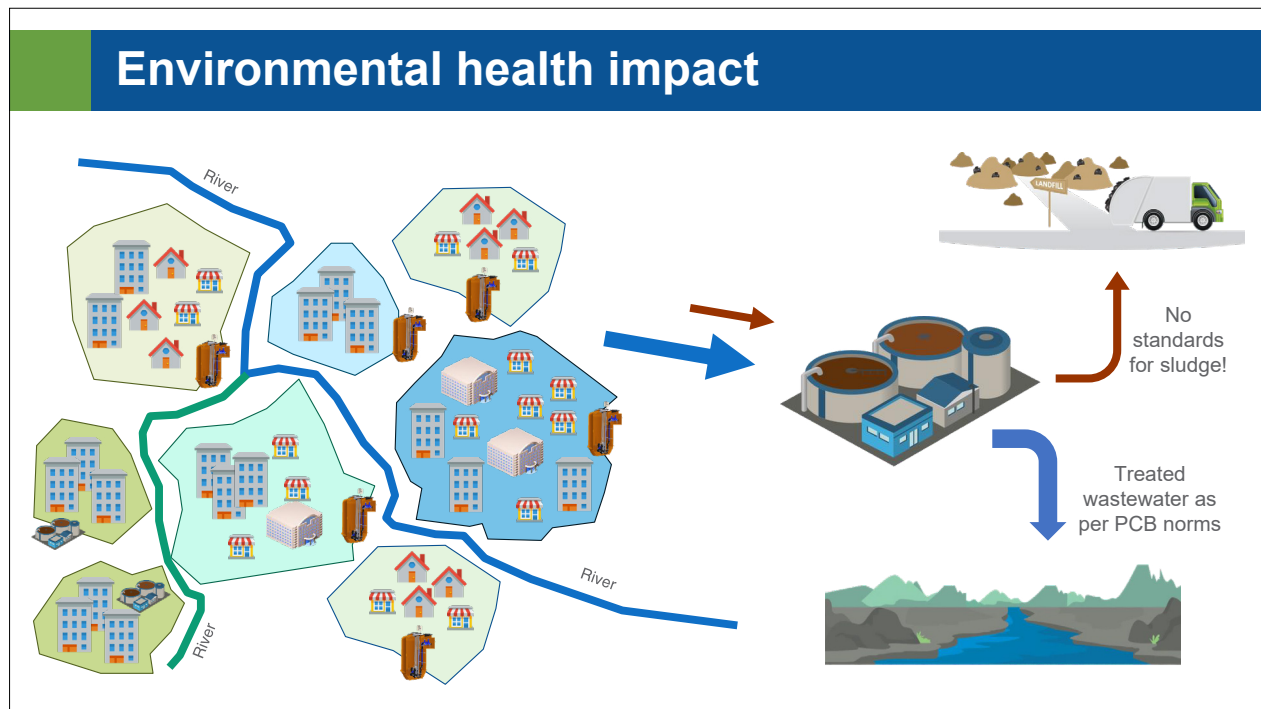
Requirements

- All properties to have flush toilets with **sewerage connections** to receive wastewater
- Sewerage network with **sewage pumping stations** for collecting and conveying the wastewater
- Centralised treatment plant with **mechanisation** and **sophisticated control systems**
- Disposal point large enough to **accommodate daily load** of organic constituents and nutrients



Source: Manual on sewerage and sewage treatment, Part A

Centralized system consists of: i) Centralized collection system (sewers) that collects wastewater from many wastewater producers: households, commercial areas, industrial plants and institutions, and transports it to ii) Centralized wastewater treatment plant in an off-site location outside the settlement, and iii) Disposal/reuse of the treated effluent, usually far from the point of origin.



Aside from its proven benefits, the centralised wastewater management system is nothing more than a transport system for human excreta and industrial waste to a central discharge point or a treatment system. This system is dependent on potable water as a transport medium for the waste generated.

A centralised wastewater management system reduces wastewater reuse opportunities and increases the risk to humans and the environment in the event of system failure.

In the past, conventional thinking favoured centralised systems since they are easier to plan and manage than decentralised treatment units. This belief is partly true if municipal administration systems are centralised. However, experience reveals that centralised systems have been particularly poor at reaching peri-urban areas and informal settlements.

Centralised treatment systems are usually much more complex and require professional and skilled operators. Operation and maintenance of centralised systems must be financed by the local government often unable or unwilling to guarantee regular operation.

Centralised systems: Advantages and disadvantages

Advantages	Disadvantages
If planned and designed well, the capital expenditure is less	Operational expenditure is high
Most favorable approach for a planned city with high-rise buildings	Poor reach in peri-urban areas and informal settlements
Requires less human resources for operation and maintenance of infrastructure	Requires professional expertise in operation
Operation can be controlled from a centralised location	Requires sophisticated equipment for maintaining infrastructure
Bulk water consumers such as industries can reuse the water, if the cost of treated water is favourable	Reduces the opportunities for reuse of treated wastewater if not planned at early stage

NOTE: Risk upon failure of system is very high!

In a centralized approach, the ULB has to bear the capital and O&M cost of the infrastructure. However, taking into consideration the efficiency of collection of taxes in Indian cities, maintaining the infrastructure and providing services to the masses becomes more of a burden.

On the contrary, in a decentralized approach (depending on the selected sanitation system) the household (who is the consumer of the services) bears most of the cost. Since private service providers in terms of collection – transport and treatment are available, the costs get distributed among different stakeholders.

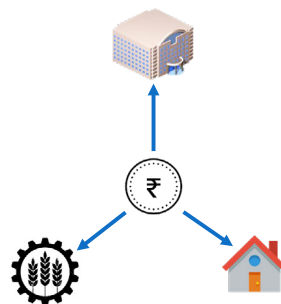
Economic aspects

Governing authority:

To plan, finance and execute sewerage network with sewage treatment plant

To maintain records and collect taxes from properties

To set up infrastructure and provide treated water to agriculture and industries



Points for reuse:

To sign contract for treated water reuse

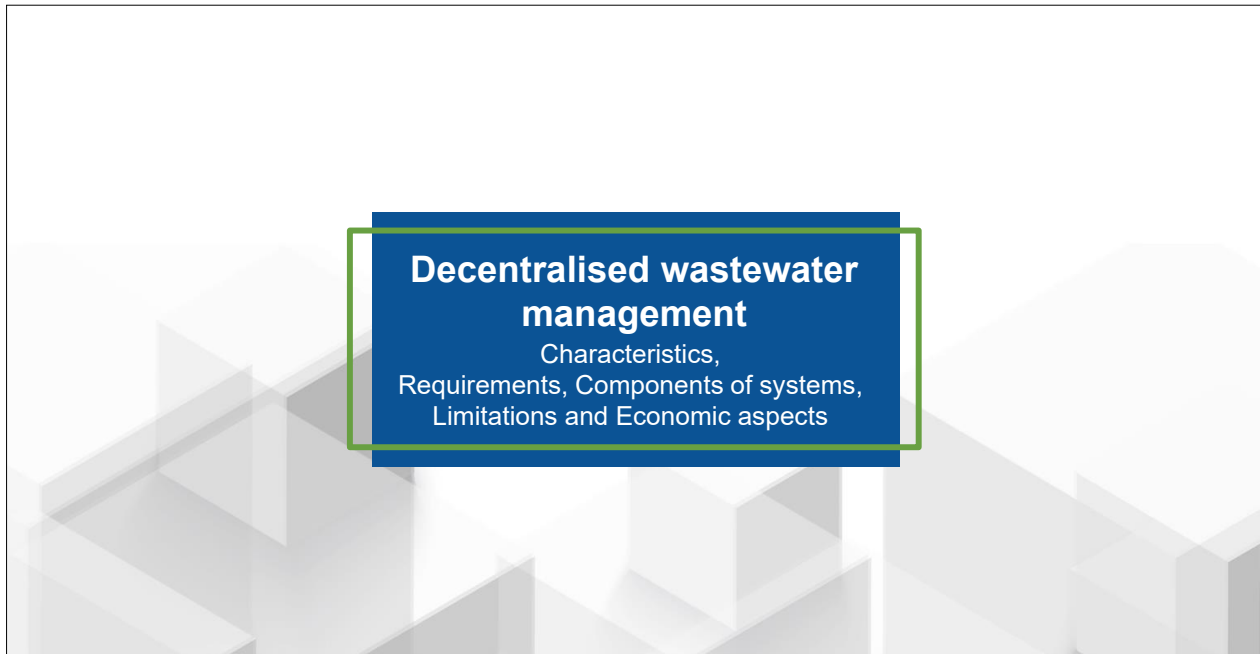
Abide by the quantity and rate as per contract.

Households:

To apply and pay for sewerage connection

Pay sewerage tax regularly

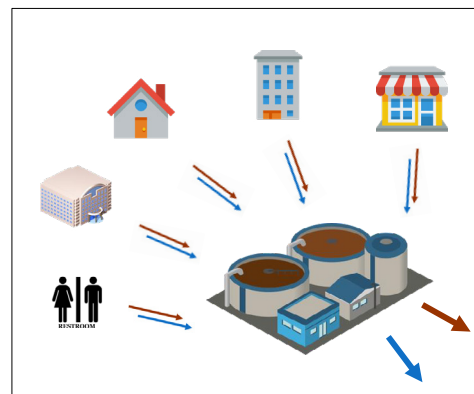
6.3 Decentralised Wastewater Management



In decentralised system, the solids are arrested in the on-site system. The greywater and effluent will be collected and transported to the decentralised wastewater treatment system using sewerage network. In decentralised treatment system, the dissolved and suspended solids in water will be treated and the treated water will be disposed /reused.

Characteristics

- Water driven infrastructure for solids (excreta)
- Water consumption assumed as 135 LPCD
- Objective of designing sewerage network is no deposition of solids
- Treatment plant to separate solids and liquids, remove organic matter, pathogens, safely dispose treated waste products or adopt it for reuse



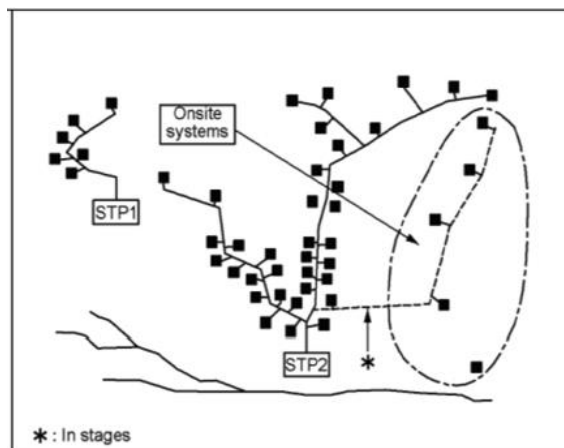
In centralised system the following requirements have to considered:

- The individual household toilets have to have a containment system or on-site system
- The sewerage network for collecting and conveying the greywater and effluent should be present

- The decentralised wastewater treatment plant with mechanised or non mechanised treatment approach should be available

Requirements

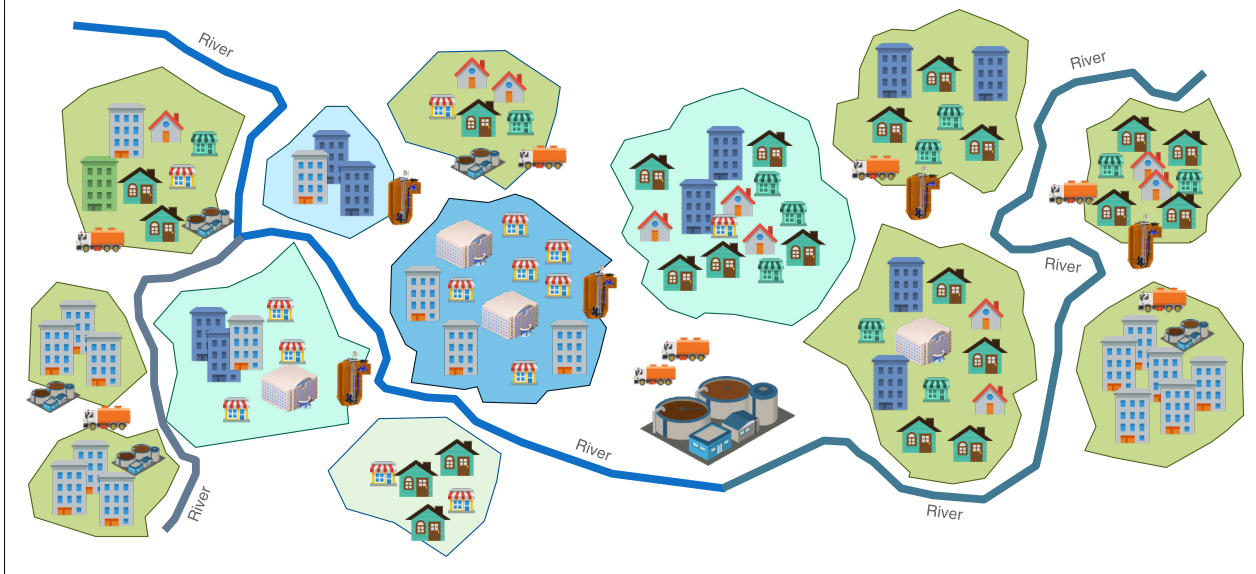
- All properties should have flush toilets with **containment/treatment unit**
- Sewerage network for collecting and conveying wastewater
- Decentralised treatment plant with **mechanised or non-mechanised** treatment
- Appropriate disposal point to **accommodate daily load** of organic constituents and nutrients



Source: Manual on sewerage and sewage treatment, Part A

Decentralised System consists of: i) decentralized collection systems (sewers) that locally or regionally collects effluent from on-site containment systems and grey water from many regional producers: households, commercial areas, industrial plants and institutions, and transports it to ii) regional or areas wise decentralized wastewater treatment plant in an on-site location near the settlements, and iii) disposal/reuse of the treated effluent, usually in the same premises. The sludge accumulated in the on-site containment systems will be desludged or emptied with the specific time interval and can be treated in decentralised faecal sludge treatment system or co treated at the centralized wastewater treatment plant if available in the city.

Environmental health impact



Decentralised wastewater management decreases the risk associated with system failure. The probability of simultaneous failure of many small systems is significantly lower than failure of one system serving the entire community.

Decentralised treatment processes can be tailored to the quality of the wastewater stream generated by each separate subsystem and to the effluent quality required. The treatment requirements will vary considerably depending on the final destination of the treated wastewater (Eg. agricultural reuse, discharge into water bodies, infiltration).

Decentralised management increases wastewater reuse opportunities by keeping the wastewater as close as possible to the generating community. Demand for treated liquid waste in developing countries often comes from urban centres for use in public parks and urban agriculture. Where wastewater is used for irrigation, it is pointless to collect the waste flow in one location for treatment and subsequently distribute the treated effluent where it is needed.

Decentralised management may apply a combination of cost-effective solutions and technologies, which are tailored to the prevailing conditions in the various sections of the community. For example, a sewerage system and treatment works can be provided to highly developed and densely populated commercial and residential centres of a community. Sparsely populated housing neighbourhoods can be served by a settled sewerage system or dry sanitation systems where soil and groundwater conditions allow such options.

Decentralised management allows incremental development and investment in community wastewater systems. Settled sewers can be used to upgrade already existing decentralised systems such as septic tanks if necessary. New, independent and properly sized systems can be added to serve new and well defined residential, industrial or commercial developments. In contrast, investments in centralised systems have to be made within a short time, thus burdening the local economy. Centralised systems are usually sized to handle wastewater flows planned to occur in 30-50 years. Centralised systems are initially often oversized but eventually become undersized.

Decentralised systems: Advantages and disadvantages

Advantages	Disadvantages
Increases responsiveness to local demands	Needs policy framework and enforcement for scale-up and implementation
Allows adoption of tailor-made or context appropriate solutions	Requires capacity to plan, design, implement and operate
Reduces pollution and helps in preserving environmental health	Success dependent on effective coordination between government, private sector and civil society
Provides opportunity to reduce freshwater consumption	Capital expenditure of multiple smaller systems is higher than a single centralised system
Allows incremental development and investment	

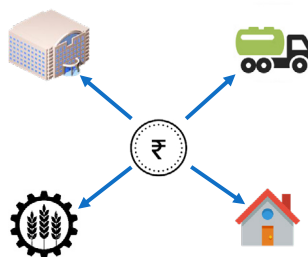
NOTE: Risk upon failure of system is very low!

In a centralized approach, the ULB has to bear the capital and O&M cost of the infrastructure. However, with low efficiency in tax collections at city-level, maintaining the infrastructure and providing services to the masses becomes more of a burden.

On the contrary, in a decentralized approach (depending on the selected sanitation system) the household (who is the consumer of the services) bears most of the cost. Since private service providers in terms of collection, transport and treatment are available, the costs get distributed among different stakeholders.

Economic aspects

Governing authority:
 Prepare and enforce appropriate policy
 Plan, finance and execute sewerage network with sewage treatment plant
 Maintain records and collect taxes from properties

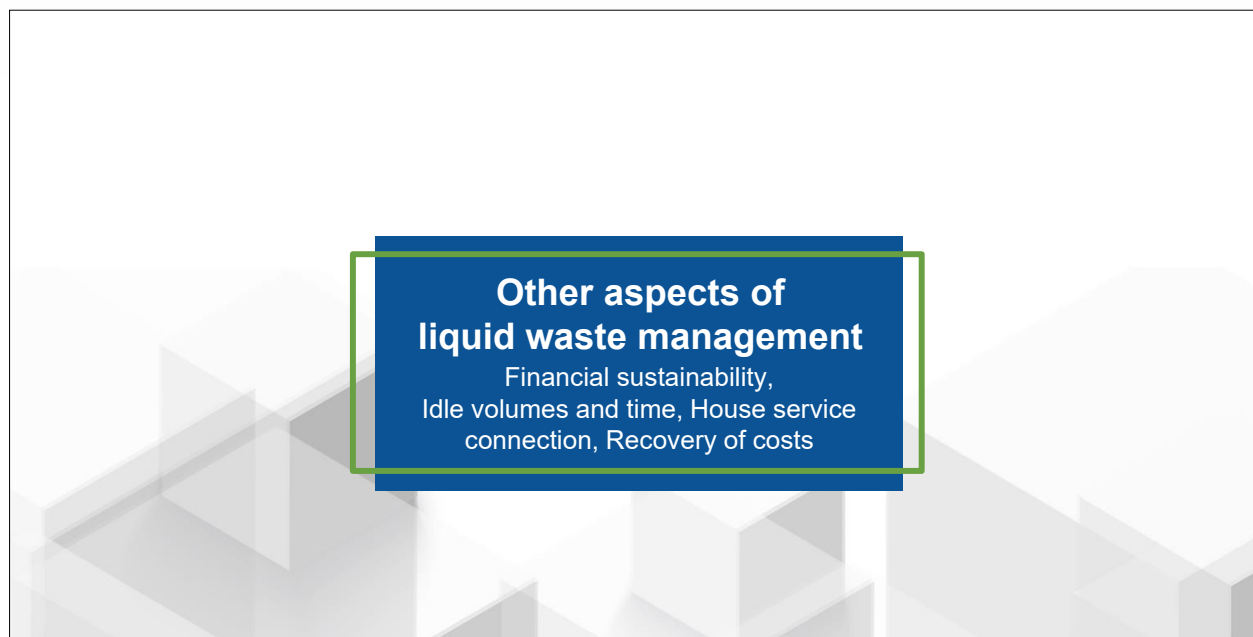


Service provider:
 Register with governing authority and obtain license for operating services
 Provide services to households

Points of reuse:
 Prioritise treated wastewater over groundwater and freshwater

Households:
 Constructing containment (or treatment) unit on-site
 Regular desludging of containment unit
 Paying sanitation tax regularly

6.4 Other Aspects of Liquid Waste Management



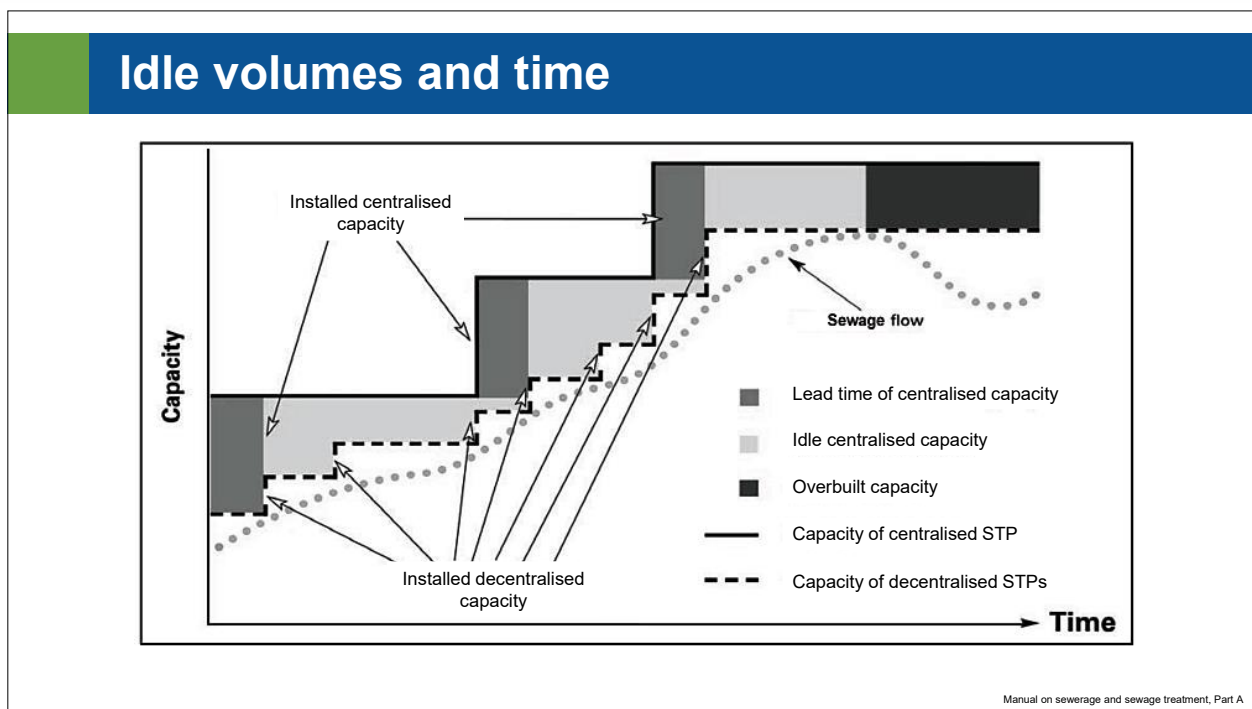
There are few aspects which have to be considered for the financial sustainability of the project: i) The components of centralised sanitation systems are designed for a span of 30 years except the pumping stations which are generally designed for a period of 15 years, ii) The implementation of sewerage network is very slow and tedious process, iii) Higher water supply to limited people leads to a situation where the full capacity of the treatment systems is reached even though sewerage network is not completed as per the planning, iv) To keep up the infrastructure, tax should be linked to metered water consumptions.

Financial Sustainability

- Capacity of centralised sanitation system are designed for 30 years (for the exception of sewage pumping stations which are designed for 15 years)
- Construction of sewerage network is a slow and tedious process
- Peri-urban areas and unorganised settlements are difficult to reach
- With increasing supply to limited number of people, the sewage treatment plant (STP) reaches its full capacity, even though the sewerage network is not completed as per the plan
- To keep up the infrastructure, tax should be linked to metered water consumption

Invariably, sewers as a convention are designed for the projected population for a period of 30 years and the realization of the sewage volumes to use the designed sewer capacities results in




idle volumes and idle expenditures. The underground sewers laid there become defunct with time and eventually go into repair. This is a non-productive expenditure, implying that the investment could have been utilized elsewhere such as in decentralised treatment systems.



While the investment on provision of sewerage is usually met from capital grant funding, the cost of house service connections is met by house owners when they occupy the property. Hence, repeated road cuts become a perpetual affair and results in higher costs for every connection. As and when houses are built, service connection requests arise. An approach that has been tried out is the provision of house service connection sewers in the beginning and kept blank at the property boundary and is connected only when the house gets built and the applicant pays the costs. An additional challenge is illegal connections by house owners and the impracticality of checking each and every such connection by the limited staff of the local body.

House service connection

- Investment cost is covered through a capital grant
- Household owner needs to pay for a service connection as and when they occupy the property
- Repeated digging and filling of roads for new service connections results in a higher cost of connection
- Illegal connections and inability to monitor the connections is a challenge

The capital costs are mostly carried out of grant funding whereas most of the time the O&M expenses are to be generated by the ULB. The revenues generated by taxes and water and sewerage charges are usually inadequate for such expenses, let alone increasing reserve funds. When an unwieldy coverage of conventional sewerage is implemented, the problem gets compounded because the house service connections do not keep pace and the revenues are meagre. Thus, even the cost spent on the house sewer connections becomes a virtual write-off over a period of time.

Recovery of costs

- O&M expenses are to be generated by the ULB
- Insufficient revenues are generated through taxes:
 - Low or non-existent sanitation/sewerage charges
 - Low efficiency of collection
- House service connections do not keep pace with installation of sewerage network
- Charges are written-off over a period of time

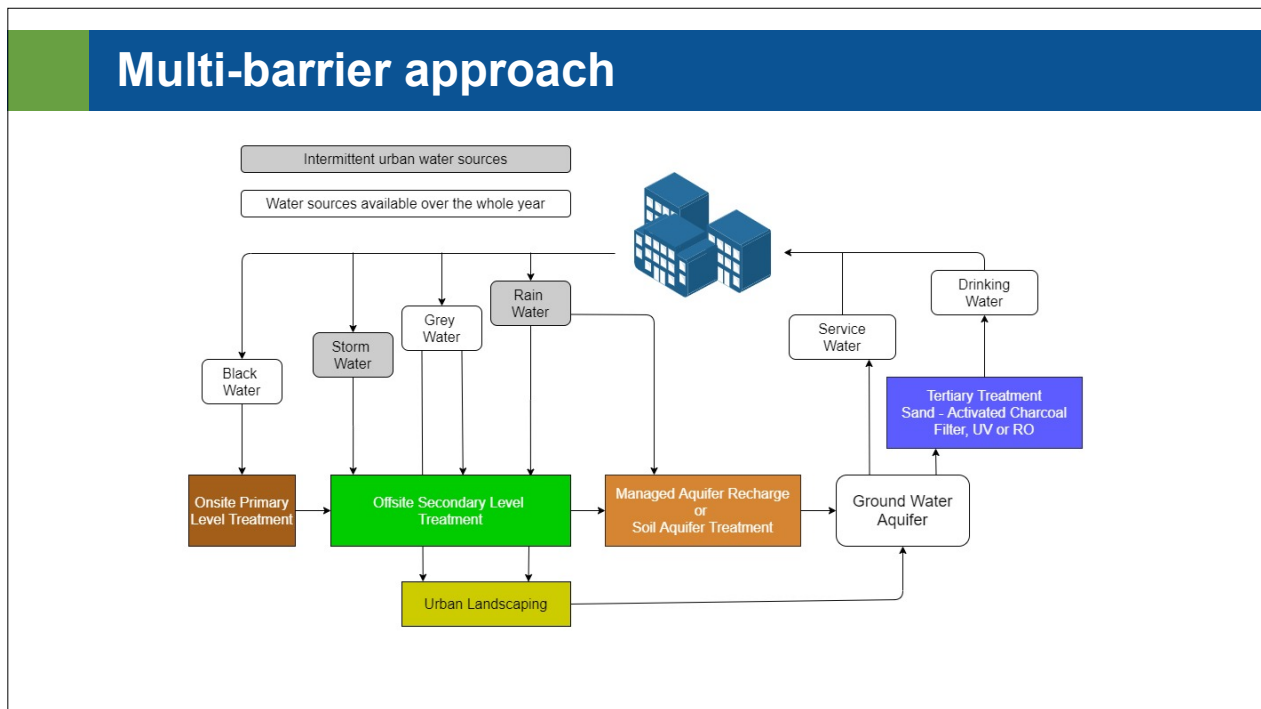


With enough political will and the creation of adequate incentives for businesses and policy makers alike, sustainable and productive sanitation can be a major contributing factor to the achievement of greener economies, fostering job creation and poverty reduction along the whole sanitation, wastewater treatment and re-use chain.

Reuse aspects

- IWSM has a strong link with resource recovery & reuse
- Reuse is a demand driven process
- Quality, quantity and affordability of the treated effluent plays an important part
- Equilibrium needs to be achieved between conveyance infrastructure and cost of the treated effluent

The multi barrier approach focuses more on integration of natural water treatment technologies in the urbanscape. These technologies treat perennial and intermittent water sources with special emphasis on resource recovery and reuse. The approach was successfully demonstrated through Indo-EU project called NaWaTech.



For example, residential developers in large metropolitan cities are required have housing complexes with dedicated sewage treatment plant which treat domestic sewage and reuse it for either gardening and flushing purposes within their residential complex.

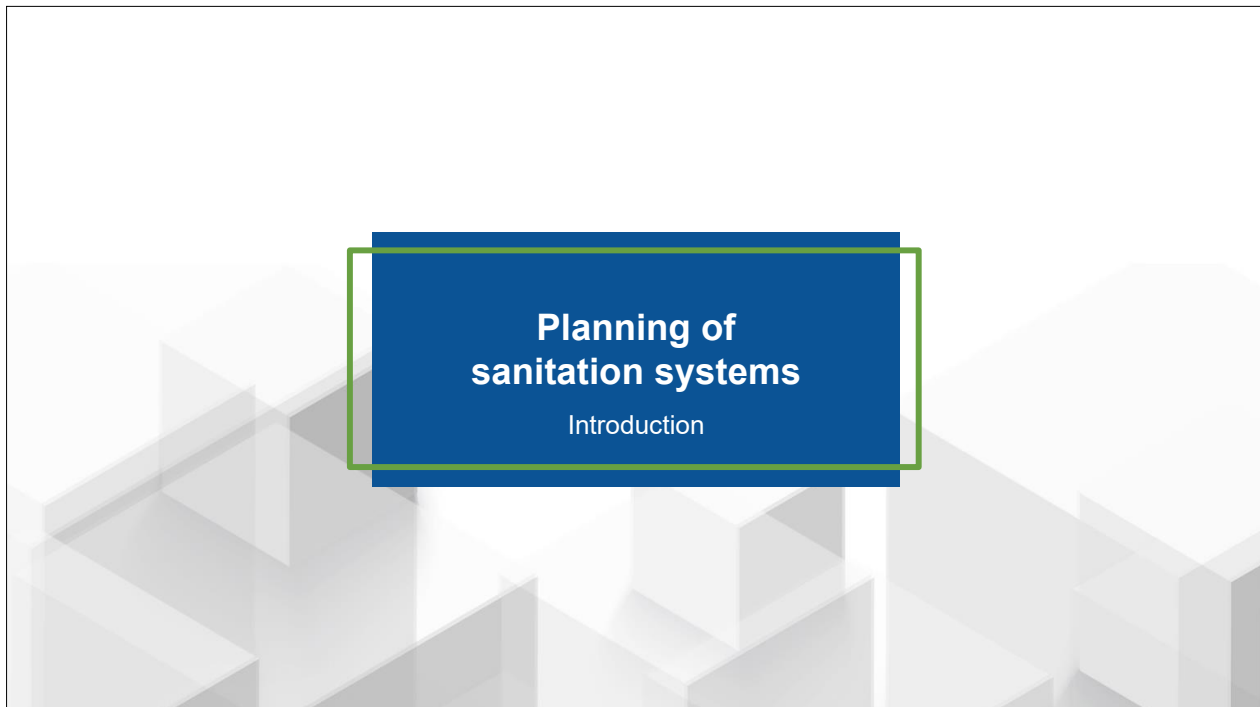
CWIS = The multi-barrier approach

Multi-barrier approach = create a water loop and follow the principle of “**3R - Reduce, Reuse, Recycle**”.

This approach is embedded in the following principles of CWIS:

- Pooling of **complementary urban services** like water supply, stormwater drainage, greywater management, and solid waste management and considering them in **sanitation planning**.
- Identifying **diversity of appropriate technical solutions**, combining **both on-site and sewerred solutions**, with consideration of **resource recovery and re-use**.

6.5 Planning of Sanitation Systems



Example of Kochi: In the case of Kochi, although centralized approach was logically the most favourable, the high ground table influenced the construction techniques and associated costs. Hence Kochi had to adopt decentralized approach in the form of septage management. Kochi has India's first working Septage Management Plant.

Key determinants for planning

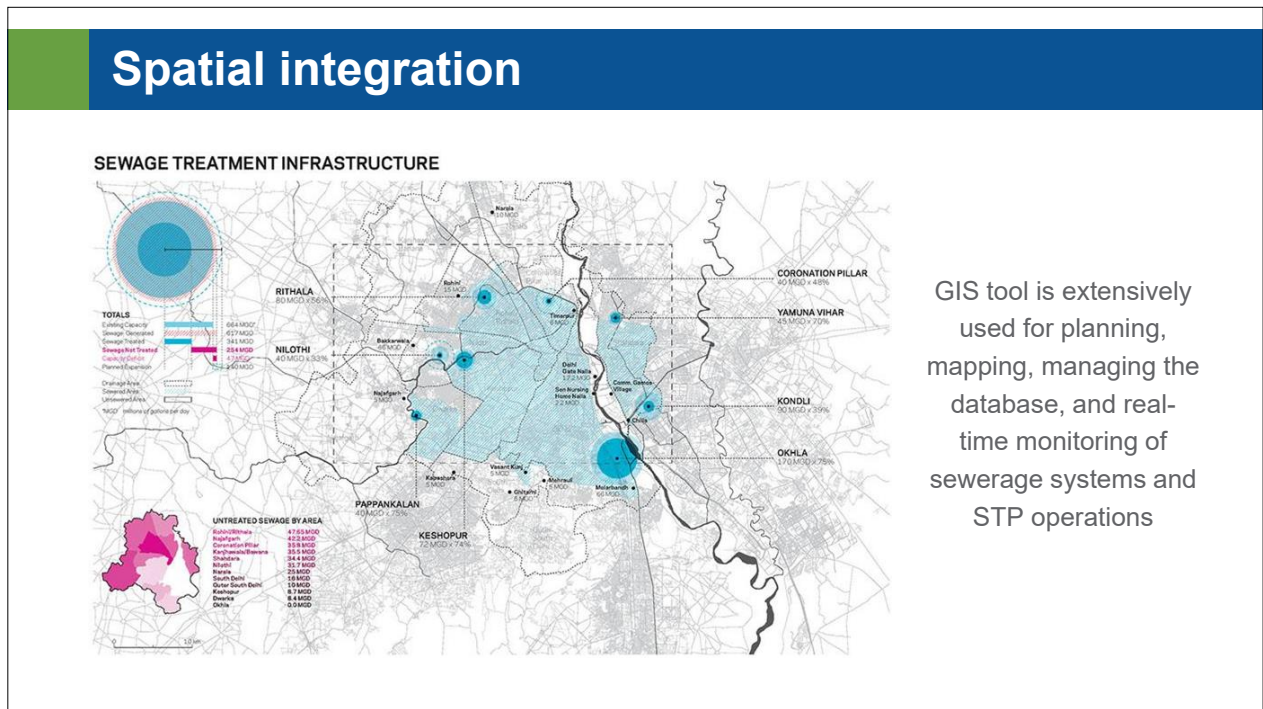
Population size and density of a settlement

- Physiographical parameters such as soil type, topography, altitude, terrain and groundwater table
- Land availability and social acceptance

Design of sewers, gradient of network, pumping requirements, technology options, construction techniques and associated costs

The cities should integrate the new added areas to the municipal limits / urban agglomerations & newly developed areas (eg. due to change in master plan) within the municipal limits, with the proposed system.

Tools such as GIS helps to visualize the reach of the services and compare it with growth of the city. This helps to identify the section of the city which needs immediate attentions in terms of infrastructure. Such tools help to have planning and implementations in different phases.

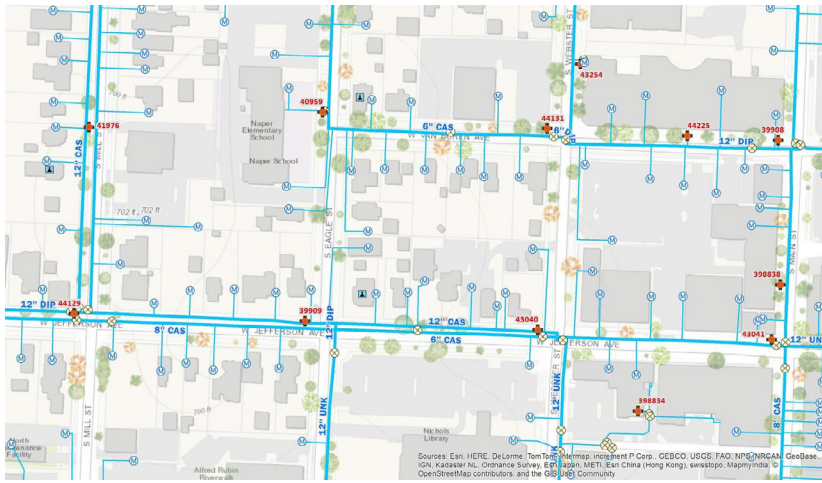


GIS tool is extensively used for planning, mapping, managing the database, and real-time monitoring of sewerage systems and STP operations

The cities should integrate the new added areas to the municipal limits / urban agglomerations & newly developed areas (eg. due to change in master plan) within the municipal limits, with the proposed system.

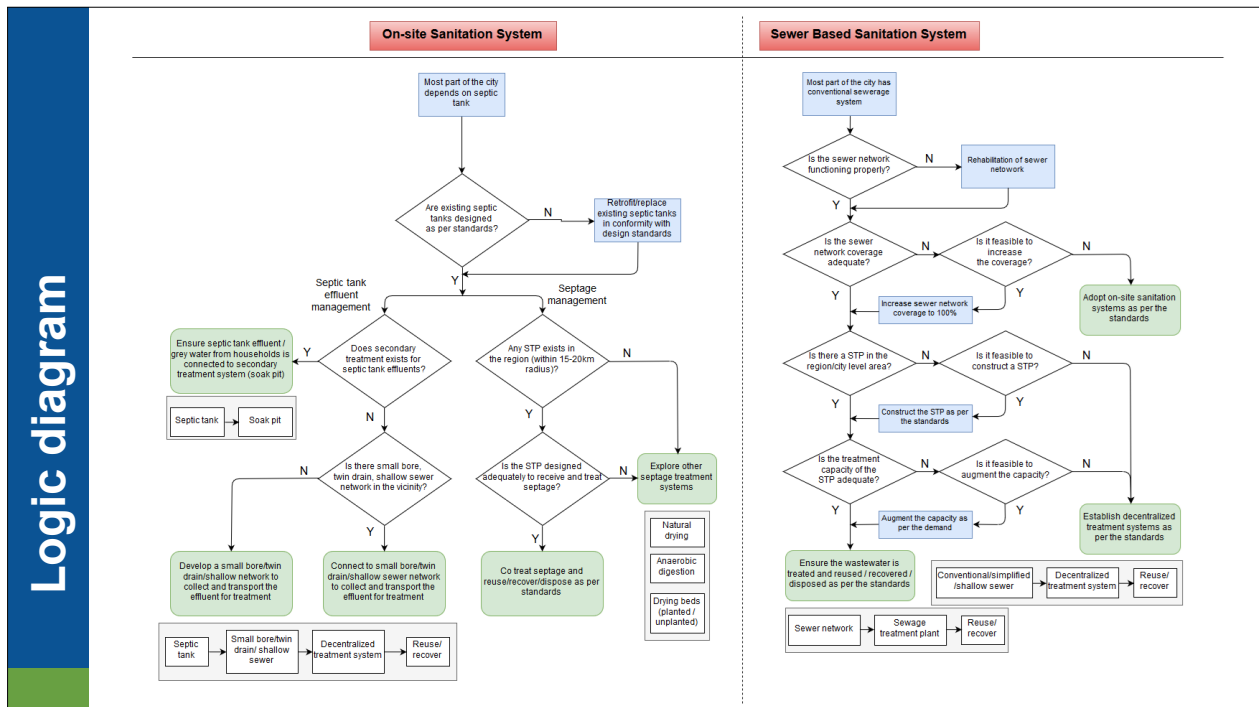
Tools such as GIS helps to visualize the reach of the services and compare it with growth of the city. This helps to identify the section of the city which needs immediate attentions in terms of infrastructure. Such tools help to have planning and implementations in different phases.

Spatial integration



Use of GIS tools is also extended to real-time data collection and monitoring sewerage systems and STPs

A logical approach needs to be defined keeping in mind the local natural and built environment. Such logical framework is specific to an area and needs to be altered or adopted from place to place. Logic diagrams help to identify gaps in the sanitation value chain and thereby zero down on suitable options to complete the sanitation value chain.



Summary

- Liquid waste management is crucial for maintaining environmental health
- Different levels of management are appropriate for different urban and rural scenarios
- Planning of sanitation systems needs to take into consideration affordability and long term sustainability of infrastructure
- Centralised and decentralised management complements and provides maximum sanitation coverage



Session

07

Mapping the City

This is an activity session for face to face trainings
– Kindly refer Part B: Learning Notes for activity instructions

Session

08

Decentralised Wastewater Management

This is an exercise session – Kindly refer Part C: Workbook

Session

09

Aspects of Decentralised Wastewater Management

9. Aspects of Decentralised Wastewater Management

Learning objectives

- To understand various technical and non-technical aspects of decentralised wastewater management
- To understand the importance of an enabling environment to scale decentralised wastewater management

Contents

Economic aspects

- Treatment quality
- Treatment cost
- Investment capital

Technical aspects

- Decentralisation
- Construction
- Substrate

Legal aspects

- Sectors for application
- Political environment

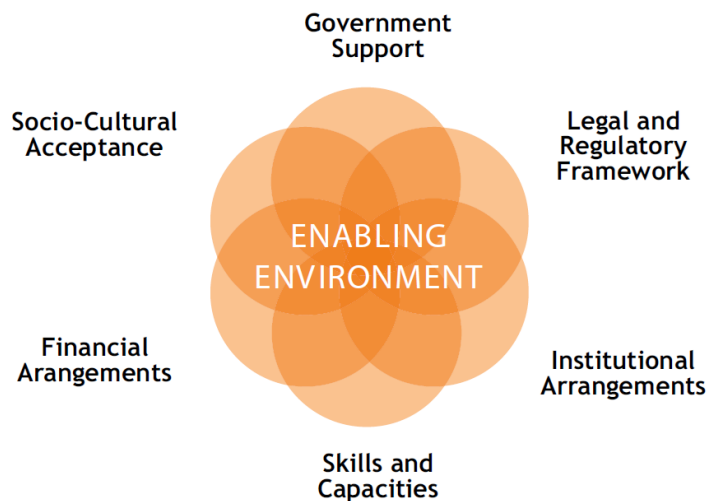
Regulatory aspects

- Regulations and standards
- Bureaucracy

Social aspects

- Waste disposal
- Partners

Enabling environment



Government Support: Political support at all levels is essential. Programme promoters should plan to invest considerable efforts to familiarise elected officials, senior sector staff and advisers with the concepts of the planned sanitation programme. The municipal authority is the focal point in both the creation of an enabling environment and implementation of the programme, as it is, along with senior staff, responsible for providing infrastructural services to all stakeholders within the municipality. It is important that the actions necessary for project implementation fit the policy and strategic framework without violating specific existing legal requirements.

Legal Frameworks: Since many of the existing standards (national or municipal) are derived from those developed in industrialised countries under totally different conditions, they are often inappropriate. Unrealistic standards are sometimes applied to national and municipal aspects like health and building codes, but also to technical requirements in the field of water supply and wastewater management.

Institutional Arrangements: Institutional arrangements can, on the one hand, refer to the formation of special interest groups like CBOs; on the other hand they can also refer to agreements and relationships between different groups, for example public, non-state, community-led and donor institutions. Local organization may provide support in the form of technical assistance. This may range from information dissemination and capacity building at household, neighbourhood and community level (help to improve the understanding of service benefits and stakeholders' responsibilities) to the provision of advice and support services to local service providers. Examples: Public institutions, Non state institutions, Community led institutions, Donor institutions.

Capacity Building: Many groups and organisations will need training and orientation if they are to be involved in a participatory planning process. In some cases (such as government and municipal officials), this will have to occur at a very early stage of the process, whereas for others, capacity building will be more appropriate at a later stage to improve the understanding of their roles in implementing the approach.

Financing: Financing is a key factor, which has to comply with administrative rules and provisions governing expenditure for local service improvements. National, regional and local level investment plans and budgetary allocations should prioritise the areas of greatest need. Rather than resorting to grants or subsidies, governments and their agencies should consider the establishment of a line of credit or the provision of equipment and materials against regular payments. The provision of grants and subsidies often has the unintended effect of encouraging users and organisations (at whatever level) to choose systems and technologies they are unable to sustain, thus leading to rapid deterioration of the facilities and to deficient services. Therefore, they should only be considered where other strategies have been tried and failed.

CWIS approach to create an enabling environment

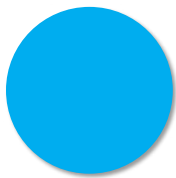
- A key pillar of CWIS is to collaborate with stakeholders to deliver sanitation services across the city
- The following CWIS principles should be kept in mind to implement a successful sanitation plan:
 - **Embed sanitation within the urban governance framework** through an integrated approach to include all urban infrastructural services.
 - **Leverage financial resources from different avenues** like health, education, urban development and environment protection to improve sanitation services.
 - **Create regulatory framework and institutional arrangements** that clearly define the roles and responsibilities of each stakeholder involved in service provision.
 - Build demand and **engage with citizens** to raise awareness about improved sanitation services.

9.1 Economic Aspects

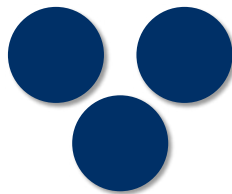


Decentralisation

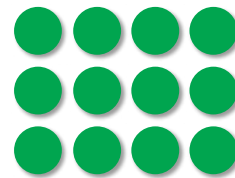
- Which is better? A decentralised or centralised wastewater management system?
- Understanding life-cycle cost analysis and cost benefit analysis
- Levels of wastewater management



Totally centralised system



Semi-centralised system



Totally decentralised system

In this section, the economic aspects of the decentralisation approach will be presented. We have to understand the economic viability of decentralised wastewater management against the centralised wastewater management. Life-cycle cost analysis and cost benefit analysis are the tools for understanding the economic aspect.

Treatment quality

- Strict discharge standards are required for protecting the environment
- However, they should be based on:

LOCATION OF DISCHARGE

Location of discharge can be surface water, land, sewers/drains, water bodies

Characteristic of receiving body is different (eg: dilution, risk)

Reuse of wastewater for non-potable purposes

QUANTUM OF EFFLUENT

Although quality of the effluent is same, absolute pollution load varies in different levels of wastewater management

Pollution load is same in:
 1 MLD | 10 mg/L BOD
 500 KLD | 20 mg/L BOD
 333 KLD | 30 mg/L BOD
 100 KLD | 100 mg/L BOD
 40 KLD | 250 mg/L BOD
 1 KLD | 10,000 mg/L BOD

QUALITY OF INFLUENT

Concentration of wastewater increases with increase in the level of decentralisation for a city

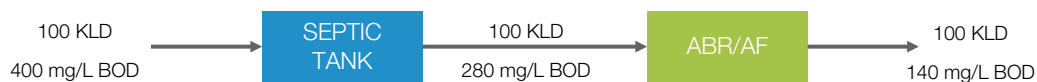
Hence, for a wastewater treatment technology, the absolute cost of treatment increases

In case of decentralised wastewater management, there is requirement of strict discharge standards for protecting the environment. These standards should be based on: i) The location of the discharge ii) Quantum of effluent and iii) Quality of influent.

Treatment cost

Level		Centralised		Decentralised		On-site treatment	
	Unit	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Volume	KLD	1000	1000	100	100	100	100
BOD	mg/L	250	20	400	30	400	200
Load	Kg/d	250	20	40	3	40	20
BOD removed	Kg/d	230		37		20	
Efficiency		92%		93%		50%	

- Primary settling using septic tank can reduce pollution load by 30% - 50%
- ABR or AF can reduce the pollution load by 40% - 50%
- Any further treatment is expensive, and requires aerobic treatment
- Nitrogen, phosphorus or removal of specific contaminant is more expensive



In comparison with centralised treatment, decentralised treatment and on-site treatment approaches can reduce around 30%-50% of the organic pollution load which are low cost options. Any further treatment is expensive and require aerobic treatment processes. For example, nitrogen, phosphorus or removal of contaminants is more expensive.

Investment capital

- No financial returns – little genuine interest to invest in wastewater treatment
- Polluters pay principle: imposed fines > investment in wastewater treatment
- The National Green Tribunal (NGT) is imposing fines on ULBs polluting the rivers

NGT says situation of water pollution grim, directs 100% treatment of sewage entering rivers

The NGT warned that if this is not done, the local bodies and concerned departments of the states and Union Territories (UTs) will be liable to pay compensation of Rs 5 lakh a month per drain in the case of river Ganga and Rs 5 lakh for default in commencement of setting up of sewage treatment plant.

River pollution: NGT gives ultimatum to state governments

Action plan for 380 km river stretch in TN approved; the tribunal has ordered that by March 31, 2020, the States must commence the work for setting up of STPs and connecting drains

NGT gets strict on discharge of sewage, industrial effluents into sea

The National Green Tribunal has ordered all coastal states and Union Territories to [submit action plans to the Central Pollution Control Board \(CPCB\)](#) to prevent sewage and industrial effluents from being discharged into the sea. As per the tribunal orders, the relevant information should be provided to the CPCB within one month of the direction, failing which defaulting states and Union Territories will be liable to pay Rs 10 lakh each month until they comply. The tribunal has also ordered CPCB to submit a comprehensive status report with regard to coastal pollution by way of classification of coastal areas in priority-I to V within three months positively. (*Business Standard*)

NHRC orders Centre to establish a central monitoring agency to manage water resources

In connection with the floods in Maharashtra and Karnataka in August this year, the National Human Rights Commission (NHRC) has asked the Centre to [look into the issue of establishing a central monitoring agency](#) to manage and control water resources that are shared by two or more states within specific time limit. The order has come following a petition filed that blamed the 'careless attitude' of two state governments and the Centre for the flood which led to loss of over 40 lives, thousands of livestock, and large scale destruction of crops and property. (*The Indian Express*)

Generally, there are no financial returns and even less genuine interest with the administrations to invest in wastewater treatment. As we know, there is polluters pay principle which demands investment in wastewater management when fines are imposed by pollution control authorities. In India, there are many cities which are polluting rivers and the National Green Tribunal (NGT) has imposed fines on ULBs.

9.2 Technical Aspects

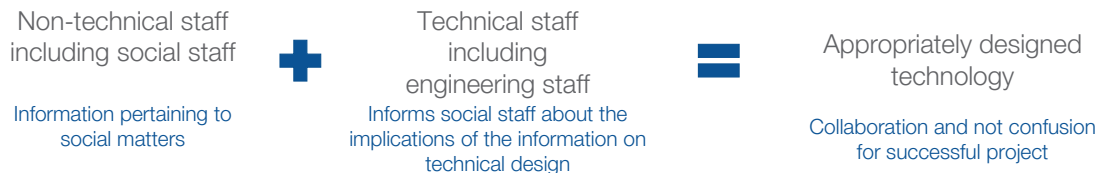
Technical aspects

Decentralisation
Construction
Substrate

Decentralisation

- A decentralised system needs a simple technology
- Sophisticated technology will be prohibitively expensive to maintain in the long-term
- Black-box approach is adopted when there is lack of information and examples available about the project implementation

Designer/Engineer should be able to deliver an appropriate design which can be realised with appropriate technology

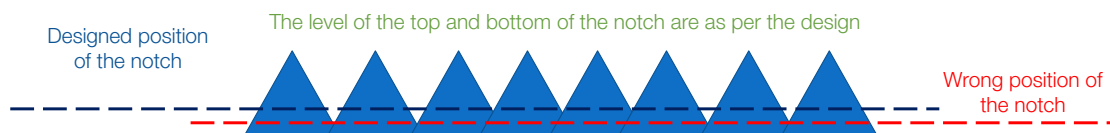


There are few technical aspects which have to be kept in consideration while planning for decentralised approach such as selection of simplified and appropriately designed technology. It's a combination of non-technical staff with information pertaining to social matters and technical/engineering staff with the knowledge of implications on technical design which in matter results in appropriately designed technology for decentralised wastewater management.

Construction

- Local availability of material required for adoption of technology helps reduce the cost of implementation of the project
- Any change in material will lead to a change in design (for example, any change in the construction material or filter material (AF or CW) will lead to a change in structural or hydraulic design)

Familiarity with the design principles and mastery in structural details will be crucial for proper implementation of the treatment system



In construction aspect, the information about the local availability of hardware required for deployment of technology helps to reduce the implementation cost of the project. Thorough technical knowledge of the design principals and structure details is very crucial for proper implementation of the treatment system.

Substrate

- Wastewater characteristics: quality, quantity and other properties
- Other parameters influencing the design: geography, structural and socioeconomic conditions
- Expertise required to sample, analyse, design or choose appropriate treatment system
- In absence of expertise, black-box approach will be required
- Distinguish between 'standard' wastewater and 'other' wastewater
- Sampling of wastewater becomes crucial

Tweaks can be made during O&M of the system to meet system requirements

Addition of nutrients | Addition of enzymes

In technical aspects, the study of wastewater characteristics i.e. quality, quantity and other parameters are important for technical staff while designing the system. Other parameters which can influence the design of the system like geography, structural and socio-economic conditions have to be studied. There is need of expertise to sample, analyse, design or select the appropriate treatment system.

9.3 Legal Aspects

Legal aspects

Sectors for DEWAM application
Political environment
Political priorities

Decentralised wastewater management (DEWAM) application

Human settlements

- Low-, middle- and high-income residential areas
- ‘Temporary’ bylaws should be made after taking into account administration, financial and logistical capacities
- Rather than focusing on bylaws and discharge standards, one must focus on implementing DEWAM at various stages
- A centralised maintenance service or control over a decentralised service is needed to guarantee sustainability of multiple DEWAM projects

There are different human settlements like low income areas, middle class housing colonies and high-income enclaves where DEWAM (Decentralized Wastewater Management) can be adopted suitably. Temporary bylaws should be made after taking into account the administrative, financial and logistical capacities of the specific human settlements. One must focus on implementing DEWAM at different stages rather than only focusing on the bylaws on discharge standards. A centralised maintenance service or control over a decentralised service is needed to guarantee sustainability of multiple DEWAM projects.

Residential application

SCENARIO 1: For high-income residential areas



- A residential unit to have its own complete DEWAM unit with anaerobic and aerobic treatment, and disinfection stage
- Allows recycle and reuse of water at local level to maximise profits.

SCENARIO 2: For low- and middle-income residential areas



- Basic and robust anaerobic treatment should be provided at the household level
- Solid-free sewers to convey and collect wastewater for further treatment at a semi-centralised level
- Aerobic treatment and disinfection stage to be done at a semi-centralised level

There are different scenarios which we can focus on considering water sensitive designs. Scenario 1 covers high-income enclaves where there should be separate DEWATS which allows recycle and reuse of water at a local level to maximise profits. Scenario 2 covers low- and middle-income

housing where basic and robust anaerobic treatment should be provided at the household level and solid free sewers are laid to convey and collect water for further treatment at semi centralised level.

Commercial application

Commercial units: hospitals, schools, camps, hotels & resorts



- Bylaws for hospitals and hotels
- Schools should be targeted for creating awareness for wastewater recycle and reuse
- Durability and permanence should rule over the tendency to set the highest standards of treatment performance

Industrial estates: small and large-scale industries



- Large-scale industries to have their own treatment systems
- Small-scale industries to have common effluent treatment plant (CETP) at the industrial estate level

DEWAM can also be applied at commercial units as well as industrial estates considering the need of bylaws and awareness within the stakeholders.

Political environment

- Political climate is as important as the administrative framework
- Roles, responsibilities, and recognising key decision-makers from political background is important

Politicians need to be made aware of the following:

- Step-by-step approach where each stage of DEWAM removes some pollutant load to a certain extent
- DEWAM promises permanency and guarantee of treatment because of its simple and robust nature
- Operation and maintenance of DEWAM should be kept to an absolute minimum

Consideration of political environment is as important as the administrative framework. The understanding of roles, responsibilities and recognizing the movers in the political ecosystem is

important. Politicians need to realize that: i) Step by step approach that each stage of DEWAM removes certain pollutants to certain extent. ii) DEWAM promises permanency and guarantee of treatment as it is simple and robust iii) Operation and maintenance of DEWAM should be kept to an absolute minimum to avoid future financial conflicts.

Political priorities

- Political and administrative preferences lean heavily towards large-scale, centralised wastewater treatment, and sewerage systems.

Balancing industrial economy vs. environmental health

- Obstacle: unrealistic and overly ambitious master plans
- Standards are borrowed from developed, industrialised countries having expertise through research and development in treatment technologies
- In developing countries, these strict discharge standards are hardly followed because their application is too expensive, therefore, licensing/ import of technologies from developed countries is done to address this issue

9.4 Regulatory Aspects

Regulatory aspects

Regulations and standards
Bureaucracy

Regulations and standards

Developed countries use a permit system, wherein the following are defined:

- Quantity: volume of water allowed to be discharged in a day
- Quality: characteristic of treated effluent allowed to be discharged
- Frequency of monitoring
- Standards depend on the point of discharge or reuse purpose of treated products

There are many different systems for controlling the release of wastewater into the environment. One such system that is common in North America and Europe is a permit system: when used water or wastewater is discharged into the environment, a permit is issued which describes, quantitatively, the wastewater that can be discharged.

Parameters that may be described include the amount of water to be discharged (volume), the parameters to be monitored (e. g. BOD, total phosphate etc.) and their monitoring frequency (weekly, monthly etc.).

All these factors will be based on the type of water body into which the water is being discharged (i. e. recreational, ocean etc.).

Regulations and standards

In developing countries, a permit system does not exist or is not enforced, therefore:

- Household and community based decentralised sanitation systems are beyond the scope of regulations
- Growing number of on-site sanitation or decentralised systems lead to regulations and standards not being enforced strictly
- No standards for sludge handling and no standards for reuse/disposal of biosolids

In many developing countries, such a permit system may not exist or if it does it may not be enforced. Household and community-based sanitation systems are generally beyond the scope of most regulations. However, their growing number will also increase the likeliness of regulations and standards being introduced.

Regulations and standards

Case Study: Malaysia

- Sewerage Services Act, 1993 and Water Services Industry Act, 2006
- Licenses required for water supply or sewerage facilities or services
- Permits required to discharge effluent from on-site sanitation or small STPs or centralised STPs

Bureaucracy

- Three tier structure of government (central, state and local), where different departments handle different components of sanitation services
- In many cases, responsibilities of departments are not clearly defined, including for enforcing regulations
- Lack of coordination and communication mechanism leads to situations such as plans, drawings, etc. not being shared amongst the different departments
- As a result, sanitation plans get hindered in terms of implementation

In many developing countries, responsibilities of different authorities are not clearly defined and reveal lack of coordination/communication mechanisms between them. The responsibilities between central, regional and local authorities are also not well defined, thereby resulting in a slow and inefficient working manner. Sanitation programmes can be hindered by such bureaucratic procedures. Applications may be delayed because documents require the approval of various offices. Requests to different authorities can lead to contradictory answers.

9.5 Social Aspects



Waste disposal perspective



Somebody must do something!

27

Everyone should understand that someone (i.e. decentralised level by specific stakeholders or city level by ULB administrations etc.) has to take initiative for managing the wastewater otherwise it will be difficult to manage in extreme stages. Appropriate waste disposal management and awareness in society or people is important to avoid the illegal and indiscriminate disposal of waste in surface water bodies.

Neglecting waste management

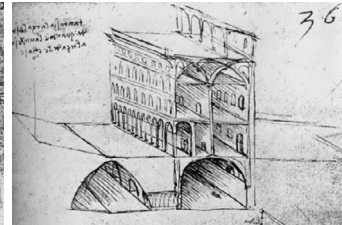
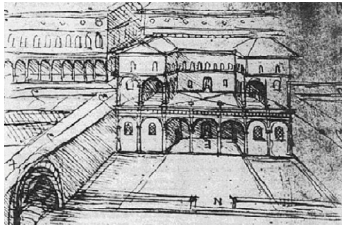
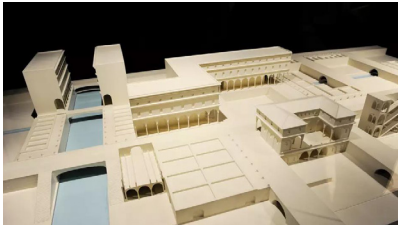


The Palace of Versailles, Paris

One of the most iconic monument among architects, the palace did not have a toilet!

For example, the Palace of Versailles, Paris, which is one of the most iconic monuments among architects but it's surprising that this monument doesn't have a single sanitation facility or toilet.

Neglecting waste management



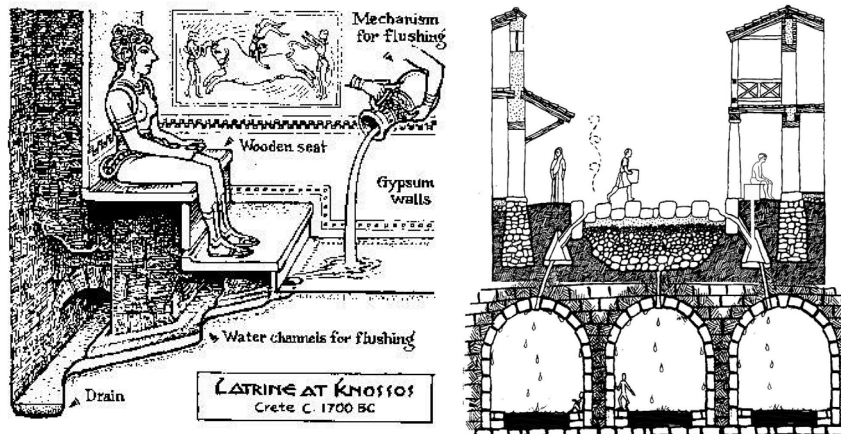
Leonardo Da Vinci's plague inspired Model City of 1484

Tier approach

Lower level canals leading to the nearby water body to flush the waste away from the habitation

This is another example where Leonardo Da Vinci's Plague Inspired Model City of 1484 has the tier approach as the planned lower level canals are leading to the nearby water body to flush the waste away from the habitation.

Neglecting waste management



History tells us that very little development has been made in the wastewater management approach

If we can compare today's waste management with historical approaches, it can be inferred that very little development has been made in the wastewater management approach.

People

- Collecting investment capital
- Contributing land
- Permission for trespassing of sewers over private land
- Collective operation and maintenance
- Collective financing of services for operation
- Use of effluent for irrigation, sludge as soil conditioner

Public willingness is low and is expected to increase only in case of severe crisis or likelihood of substantial economic benefit, as in case of reusing of wastewater

In decentralised wastewater management, the collective participation of people is crucial. The collective participation leads to collection of capital investment for the project, land availability, easy permissions for trespassing of sewers over private land, collective finances for O&M.

Partners

Polluter as customer

Under social agreement or threat of punishment, they would be obliged to contact private engineering firms

Investment capital will come from individual, from bank loans or through subsidy from public funds

Neither bank want to give loans nor there are any subsidies from public funds in India

Government

To form appropriate bylaws and oversee their implementation

Lack of enforcement and dissemination results in polluter being unaware of the bylaws

Less demand for product and service makes the product and service expensive

Lack of incentives, due to which buy-in is less

Private companies

Engineering & design firms, EPC firms and project management firms

Private firms are business oriented and wish to have good profits for a product or service having low demand

Due to lack of knowledge, firms try to solve the problem with same approach

Project planning and execution always involves the participation of different stakeholders. In case of decentralised wastewater management projects, there are three major partners which are involved i.e. polluter as customer, government administration and private companies or project management firms.

Summary

- Due to lack of enforcement of regulations without financial returns, wastewater management will not be a priority for polluters
- Black-box approach can be followed through understanding the changing variables and using reliable analysis and monitoring systems
- Political backing to legal framework is vital and required
- Regulatory framework required to adopt for growing wastewater management assets in India
- People's participation is key for success of decentralised wastewater management

Session

10

Understanding Faecal Sludge & Septage Management

10. Understanding Faecal Sludge & Septage Management

Learning objectives

- To realise the importance of FSSM as an integral part of sanitation system in India
- To understand basics of faecal sludge and septage quantification and types of desludging
- To understand approaches for FSSM

Contents

Needs and challenges in FSSM

Planning for FSSM

- Quantification of septage
- Demand vs. scheduled desludging

Approaches to FSS treatment

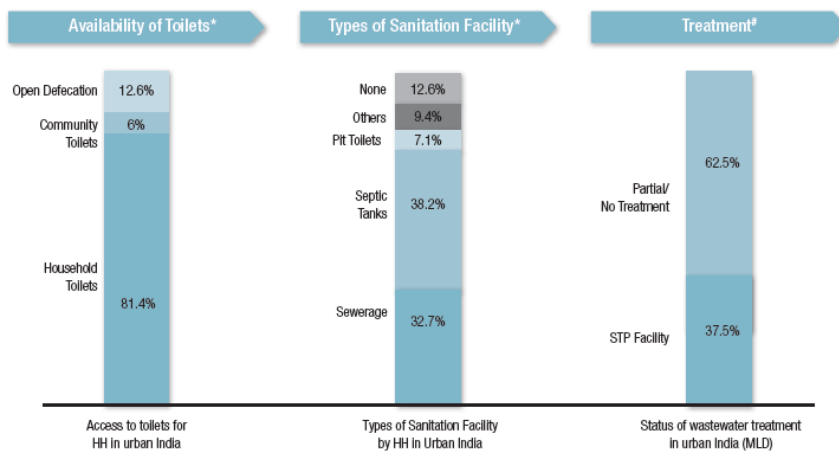
- Deep row entrenchment
- Co-treatment at STP or MSW plant
- Faecal sludge treatment plant

10.1 Needs & Challenges in FSSM

Needs and challenges in FSSM

Why is it important to understand FSSM?
What are the needs of FSSM in India?
What are the issues and challenges which India is facing?

Status of sanitation in urban India

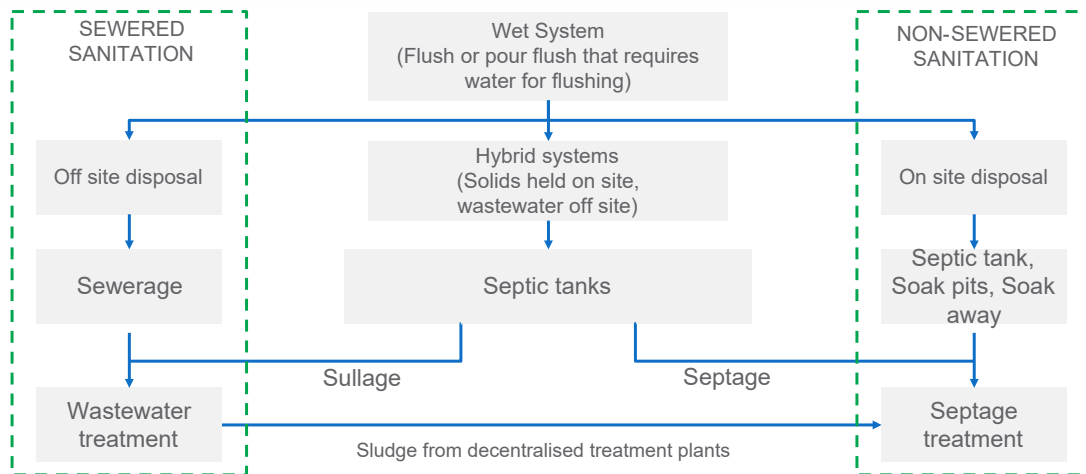


Source: * Census of India 2011; # CPCB, Inventorization of STPs (2015)

The percentage might be deceiving, but when we calculate the absolute numbers, the picture is horrifying:

- 37 million people practice open defecation in urban India
- 28 million people with individual toilets use insanitary methods of disposal of waste
- 43,117 MLD of untreated wastewater is discharged in water bodies or on land

Sanitation systems around us



In the urban centres of the developing countries, due to availability of the water, use of flush toilets and the myth that wet systems are the easiest to operate and maintain, water borne systems are used. Water is used to transport the waste from one point to another. These systems are called wet systems. The wet systems can be classified into two types depending on where the treatment of waste is done. 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 sewerage 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 sewerage 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 sewerage or non sewerage sanitation system.

Need for FSSM



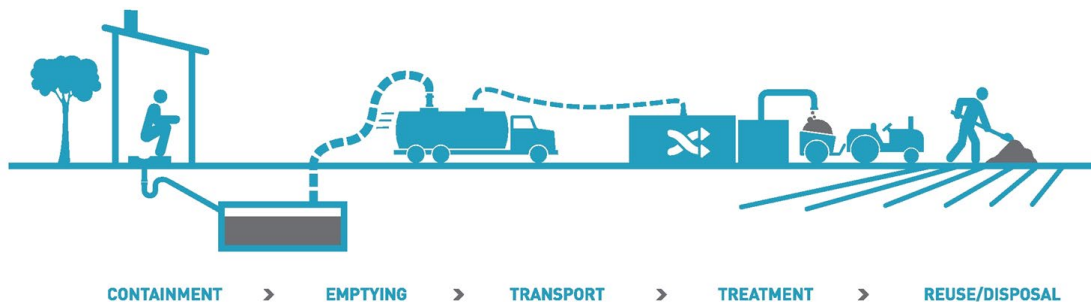
Insufficient infrastructure: The cities do not have adequate, properly designed and maintained infrastructure for managing the wastewater generated at city level. The coverage of the gravity sewer network and capacity to treat wastewater is limited. Hence, there is a need of acknowledging the need of FSSM. Through FSSM, the septage from the septic tank can also be well managed to reduce the pollution load on water resources.

Health and environmental implications: Water resources are usually shared by the cities. However, most of the cities having inadequate capacity to manage liquid waste, dispose it into the surface water bodies. The same surface water bodies are used as source of raw water by the cities in the downstream. Poorly designed gravity sewer system, also needs special attention. To clean the deposits (silt, grit and solid waste) from the sewer network, sewage workers are employed. Most of the times, no suitable PPE is provided to these workers during the work.

Regulations: The regulations demand the ULBs to provide desludging services to the households having septic tanks. The faecal sludge and septage further needs to be treated before putting it for reuse/disposal.

Resource recovery: Faecal sludge and septage if treated appropriately can provide ample amount of nutrients. It can also be used as soil conditioner for improving the fertility and water retention properties of the soil. Some other treatment processes convert the biochar or fly ash. The biochar has decent calorific value and can be used in brick kilns small scale furnaces. It has good adsorption capacity and can be used to improve the soil conditions when mixed in appropriate quantities. Flyash on the other hand is used for making bricks.

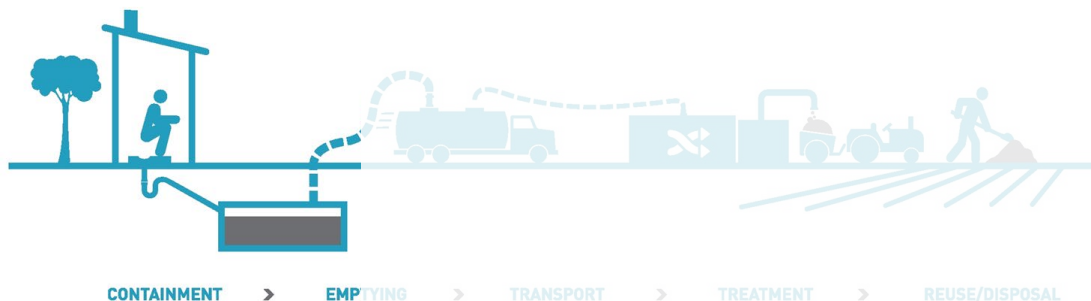
Sanitation service chain



- Safe and appropriate handling of excreta across the sanitation system by optimising emptying, transport and treatment in order enable safe reuse of biosolids

To manage faecal sludge and septage, the sanitation system needs to be equipped for emptying and conveyance along with treatment and reuse/disposal. The mismanagement of any part of the service chain leads to a negative impact on the environment and water resources.

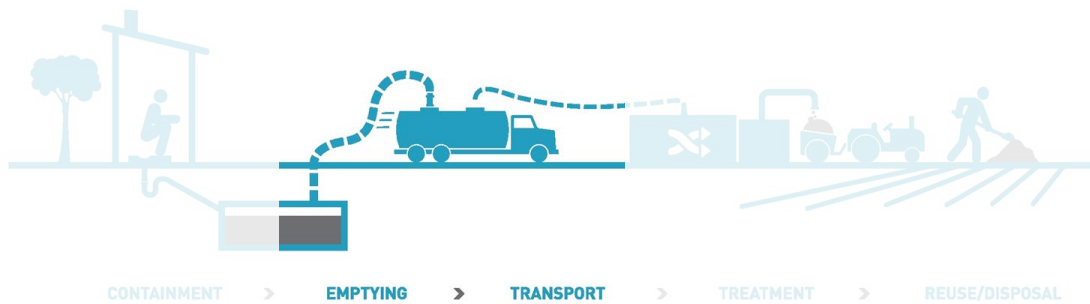
Current challenges in FSSM



- Containment systems such as septic tanks are not designed as per IS Code 2470
- No database of containment units or on-site sanitation system available under a Management Information System (MIS)

In case of containment systems, space and affordability is the major challenge. Lot of houses do not have standard twin pits or septic tanks. Since containment units were not the focus under SBM, it is an added expenditure. Hence, in most of the places, containment systems were not built properly following the standard design as per IS Code 2470.

Current challenges in FSSM

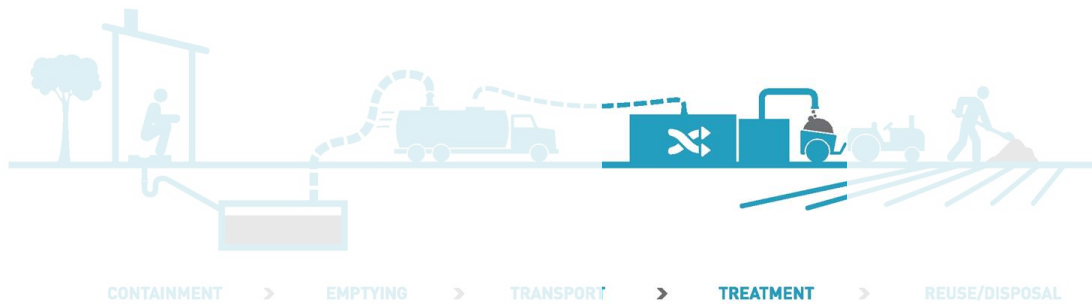


- Demand based desludging is practiced
- Lack of formalisation of sector has led to irregular and unplanned practices
- Lack of enforcement of existing laws has led to continuance of practices such as manual scavenging

The challenges of containment systems in turn result in operational difficulties. The maintenance of such units become costly and inefficient. In most instances, the septic tank is located at the back of the house, with limited access to it. In such cases emptying the septic tank becomes a challenge as most of the vacuum trucks have a service limitation of 100 ft.

The main challenges faced by ULBs in emptying and conveyance is lack of equipment for providing desludging services, monitoring and irregular desludging frequencies. Due to insufficient equipment, in most cases there is a delay of one day to provide the desludging service. Apart from the ULB, in most cities there is a fleet of privately operated vacuum trucks to also provide the desludging services. In absence of the appropriate regulations, the trucks are emptied in open drains or water bodies. Hence, strict monitoring is required. Since there is no awareness regarding frequency of desludging of septic tanks and its importance, the demand for desludging is usually seen during emergencies such as back flow/ over flow from the septic tanks and strong stench from the toilets. Septic tank needs to be desludged at a certain frequency for maintaining its efficiency of sedimentation.

Current challenges in FSSM

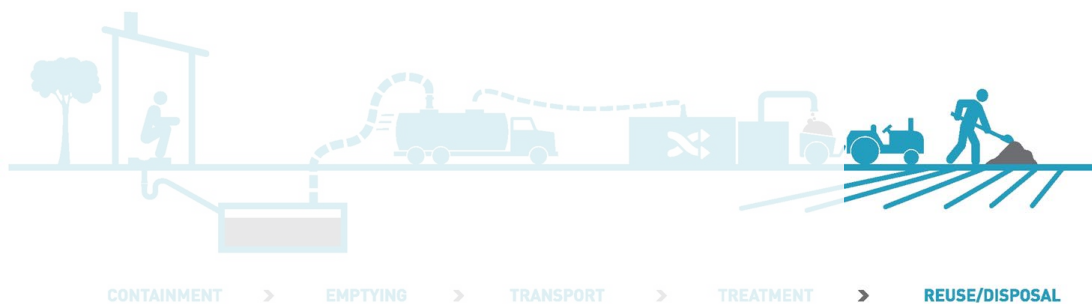


- Very few treatment plants available for safe handling of faecal sludge and septage which leads to indiscriminate disposal
- High cost of treatment due to strict standards of treated wastewater disposal

Most of the cities do not have FSTPs or STPs for treating the wastewater or septage. Hence, in absence of a proper disposal point, the septage is indiscriminately disposed off in surface water bodies or on to land. This leads to more pollution and health hazard when compared to open defecation.

There are no regulations at the ULB level for proper disposal of FSSM in absence of treatment facility. Since the solid content of faecal sludge and septage is significantly high when compared to wastewater, indiscriminate disposal of it possesses a bigger health hazard. As a precautionary measure, the ULBs should at least practice scientific land disposal to reduce the spread of the pollution.

Current challenges in FSSM



- No priority given to reuse of treated end-products in policies and regulations
- Low reuse even when high quality treated end product available

Solving FSSM challenges through CWIS

It is evident that:

- Cities in India are served through a hybrid system of sanitation, i.e., a combination of sewer and on-site sanitation systems
- Sewered sanitation systems do not address waste generated by on-site sanitation systems

Current scenario indicates a low acceptance of FSSM

However, the CWIS approach to sanitation specifically targets these challenges by addressing them through:

- Adopting a wide range of applicable and adaptable technical solutions through a combination of on-site and sewer solutions, in either a decentralised or centralised system, and emphasise on resource recovery and re-use.
- Creating a regulatory framework for local conditions and bring together institutions responsible for the complete operation and maintenance of the full sanitation service chain.

10.2 Planning of FSSM

Planning for FSSM

Quantification of FSS
Demand vs. scheduled desludging

Why is quantification necessary?

- Type of desludging envisaged
 - Demand desludging
 - Scheduled desludging
- Scale of collection and transport network
- Identifying discharge sites (co-treatment)
- Proper sizing of infrastructure
 - Faecal sludge and septage treatment plant
 - End-use and disposal mechanism



Quantification of faecal sludge and septage and the data needed to arrive at the number largely depends on the type of desludging envisaged for the city. Quantification is a real challenge in case of demand desludging where in-depth understanding is required about behaviour of households towards emptying of septic tanks. In case of scheduled desludging, the data can be collected from ULBs and coupled with sample surveys. However, to operationalize scheduled desludging appropriate regulations need to put in place at the ULB level.

Quantification is necessary for gauging the scale of collection and transport network, identifying the number and types of discharge sites. It is also needed to arrive at required design capacity of FSTP and adopt a suitable financial model for sustaining FSSM services.

Methods of quantification

Sludge production method

- Estimates sludge loading rate at a treatment plant
- Starts with collection and transport companies (legal & illegal)
- Carried out in case of demand desludging

Sludge collection method

- Estimates total sludge production
- Starts with primary data collection – household survey
- Carried out in case of scheduled desludging

Many assumptions need to be made in both the methods due to lack of available information

There are two methods of quantification- production method and collection method. The sludge production method is based on the standard septage generation rate. This method needs to be followed, in case where scheduled desludging needs to be practiced. The collection method is based on the quantity of the septage collected from the households by the existing vacuum trucks and its operators. This method needs to be followed in case demand desludging needs to be followed.

However, one needs to understand that both the methods individually are not completely reliable and requires assumption. Hence the methods need to be tweaked depending on the data already available with the ULB and ground conditions.

Sludge production method	
• Number of users	IS: 2470 Code for practice for Installation of Septic Tanks (Part 1: Design Criteria and construction)- 1985
• Location	Volume of digested sludge 0.00021 m ³ /cap/d ~ 76.65 L/cap/annum
• Types and number of various on-site systems	US EPA: Technology Transfer Handbook on Septage Treatment and Disposal
• Population of different socio - economic levels	Average per capita septage generation 230 L/cap/annum

The sludge production method is based on the empirical number called volume of digested sludge in a septic tank. As per the IS 2470 which gives the practice of installation of septic tank the volume of digested sludge can be calculated as 0.00021 cum per person per day. In US, the septage generation rate varies from 190 L/cap/d to 265 L/cap/d; whereas the same in Germany is between 110 to 4380 L/cap/d. In the US EPA manual, the average per capita septage generation is recommended as 230 L per capita per day. However, this number needs to be used carefully as it differs depending criteria linked to dietary habit of the person and usage of the toilet.

Challenges faced

- Faeces production varies significantly as it is highly dependent on dietary habits
- Not just the quantity, but quality of the faecal sludge also varies
- Volume of urine excreted also changes depending on liquid consumption, physical activity and climatic conditions
- Scarcity of data since on-site sanitation systems are built informally
- Not all waste that is generated gets collected

The sludge production rate may vary depending on dietary habit. It's not just the quantity but also the quality which may change due to this. The scarcity of the data pertaining to onsite sanitation systems (containment units) built is quite prevalent in the ULBs. Since the desludging frequency is not set, not all the faecal sludge which is generated every year is collected annually.

Sludge collection method

- Number of collections/day, volume of FS per collection
- Average emptying frequency at a household level
- Estimated proportion of the population that employ the services of E&T companies

These can be collected through interviews, site visits, and a review of internal records of FSS collection/emptying and transport (E&T) companies

Data points for quantification

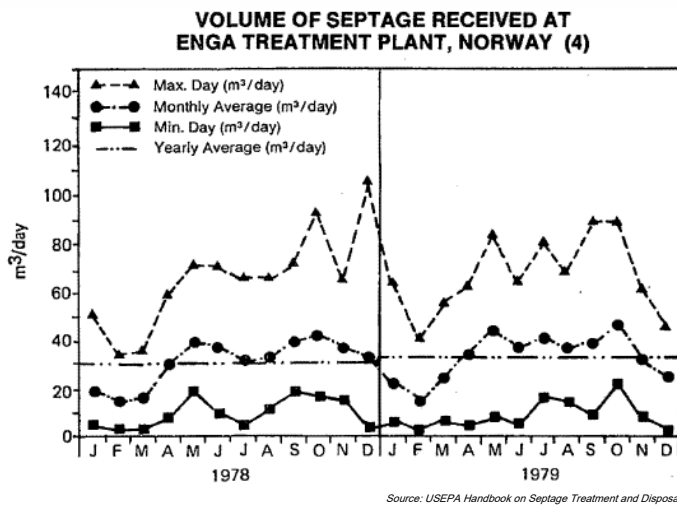
Factors affecting collection

- Acceptance and promotion of FSSM
- Demand for emptying and transportation services
- Availability of legal discharge points or treatment sites

The sludge collection method relies on the inferences drawn from the structured interviews conducted with various stakeholders of FSSM. There are various factors affecting the collection and all are taken into considered during the data collection.

A structured interview consists of direct and indirect questions leading to data needed for assessing the quantity of faecal sludge and septage collected on a daily basis. Inferences need to be drawn from the responses received during the interviews.

Variation in collection



For little variation in yearly average of influent:

- Variation in maximum daily influent is very high
- Difference in maximum daily and monthly average is significant

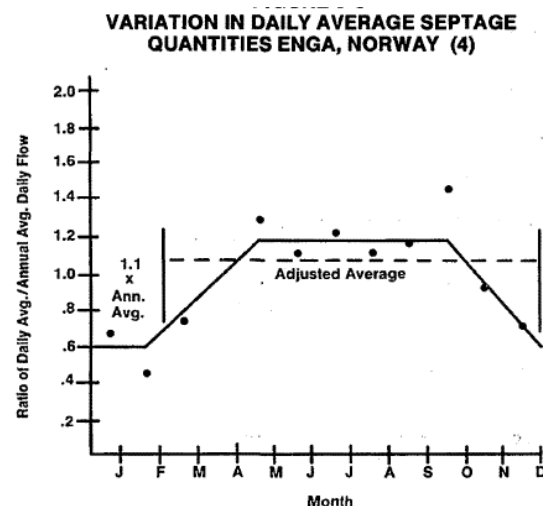
Causes for variation:

Precipitation, temperature, tourism, seasonal holidays, pilgrimage etc.

Seasonal variation needs to be taken into consideration during the structured interviews. The graph on the slide shows that the average monthly collection differs for the same plant. In case of demand desludging, the demand for septic tank emptying might increase or decrease depending upon certain factors such as high intensity rainfall leading to over flow of septic tank, or decrease in ambient temperature leading to reduction in digestion rate. However, there are still some properties such as restaurants and commercial offices, public sanitation facilities which regularly desludge the septic tanks throughout the year.

Peaking factor in FSSM

- Peaking factor is the ratio of the maximum to the average quantity of faecal sludge and/or septage received over a period of time.
- Peaking factor - 1.5 to 4.0
- Treatment plant should be able to handle peak loads.
- Peaking factor depends on local conditions and varies on a case-to-case basis.



Peaking factor needs to be understood while estimating the quantity of septage. The peaking factor caters to variations in the monthly collection of septage. The peaking factor can range from 1.5 times to 4 times the monthly average. This needs to be fixed based on the inferences drawn from the structured interviews.

Challenges faced

- Number of discharge locations or demand for septage for reuse
- In case of discharge at an STP, affordability of discharge fee
- Presence of a large informal sector in the business of cleaning of containment units such as septic tanks, pits, etc.
- Not all waste collected reaches a treatment plant or designated disposal point
- Identification of new legal discharge points might increase the frequency of desludging

The quantity of septage collected also depends on availability of discharge locations or demand of septage among farmers. If there are multiple discharge points available, then operators will not have to turn down the request of desludging. The collection might also change depending upon the desludging fees. A large informal sector exists in emptying of septic tanks which goes unmonitored. Not all collected septage reaches the designated discharge point for treatment. In absence of proper monitoring, the FSTP might still receive less septage because of indiscriminate disposal.

Demand desludging

Customers call the service provider directly to request for service
Service may be performed by a public or private operator



Advantages

- Provides the households more control over their facility as they determine when to request for service
- No requirement of database of septic tanks for MIS and collection of sanitation tax

Disadvantages

- Containment may be full before the request for service is made
- Lump-sum payment at the time of service
- Expensive as the process is time consuming
- No opportunities for optimisation of the service
- No guarantee of income/month for the operators

Demand Desludging: Desludging of containment units such as septic tanks is critical and should be practiced at a regular frequency. However, currently in India ULBs are practicing demand desludging. The provision of desludging services upon request by the household is called demand or “on demand” desludging. The household can opt for calling a private operator or the ULB for availing this service. Demand desludging has more disadvantages as compared to advantages.

Scheduled desludging

Regular and periodic emptying service provided to the household
Zone-wise planned desludging
Financial management done by ULB



Advantages

- Ensures performance efficiency of containment units
- Helps preserve environmental health
- Avoids emergency situations - preventive measure
- Cost effective through program efficiency
- Better affordability as payments are spread out over time

Disadvantages

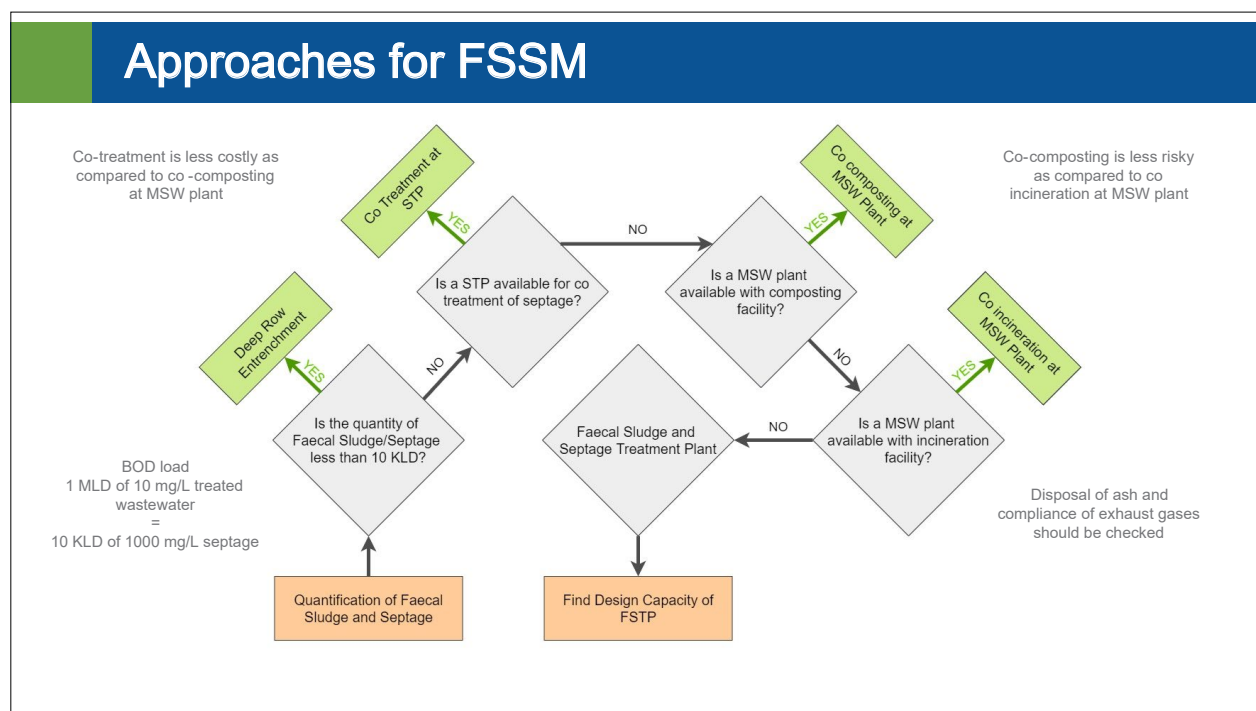
- Requires strong IEC and BCC
- Difficult to be practiced in ULBs with low tax collection efficiency
- Different sludge accumulation rates and variation in storage capacities makes estimation of “optimal desludging frequency” difficult

Scheduled Desludging: This is where the containment units are emptied at a fixed frequency decided by the ULB. The households need to be informed in advance regarding the service time. Financial management is done by ULB. The advantage of practicing scheduled desludging is that it helps the septic tank to perform consistently. Since the scum is still soft, the desludging process

is quite easy and requires less time. The cost of desludging can be brought down by optimising the route. Since the cost of desludging reduces, it becomes more affordable to the households.

Although there are advantages, scheduled desludging does face some challenges. Operationalising scheduled desludging requires a strong IEC campaign. If the desludging charges are to be recovered in the form of tax, then the ULB should focus of increasing and maintaining the tax collection efficiency. In this case, ICT can be used for improving the performance. Since the sizes of the tank and sludge accumulation rates can differ, the optimal frequency of desludging cannot be gauged easily.

10.3 Approaches of FSSM



In this slide, we can understand the different treatment approaches in faecal sludge and septage management. The selection of treatment approach is dependent on the few specific factors like quantification and characteristics of the FSS, type of sludge, seasonal variations and local conditions. There are different treatment approaches as: i) Deep row entrenchment ii) Co-treatment at STP iii) Co-treatment in MSW iv) Faecal sludge treatment plant (FSTP).

Co-treatment at STP

- **Limiting factor:**
Organic & hydraulic loading on various treatment units of STP
- **Application:**
 - At the manhole chamber before the inlet of STP, or
 - At the inlet of screens of the STP, or
 - At the sludge management process of the STP



Source: ESF/Dhawal Patil



Source: ESF/Dhawal Patil



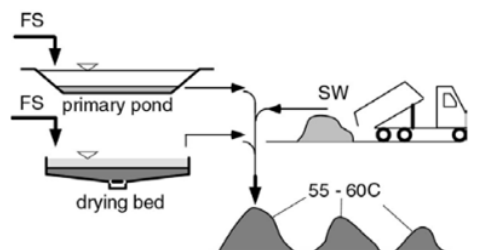
Source: Faecal Sludge Management, IWA

Co-treatment of FSS in STP is one of the treatment approaches. It is mainly dependent on the effect of organic and hydraulic loading on various treatment units at STP. In this approach, FSS can be applied at different stages as: i) At the manhole chamber before the inlet of STP ii) At the inlet of screens of the STP iii) At the sludge management process of the STP.

Co-treatment in MSW Plant

Co-composting

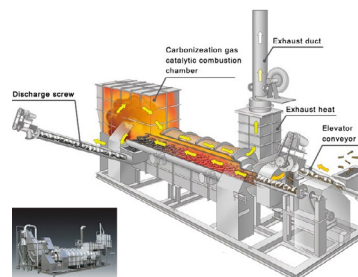
- Dewatering of sludge
- Dry solid content in the range of 40 - 45%
- Provides nitrogen to the compost



Source: Eawag/Sandec, 2008

Incineration

- Dewatering and drying
- Dry solid content - at least 80% or higher
- Increases heat production



Source: www.waterfeeds.com

Dry Solid Content Requirements:

- **Combustion:** Dry solids content should be at least 80 per cent and preferably higher. The precise requirements will depend on the process used to burn the sludge.
- **Composting:** For optimum results, the dry solids content should be in the range 40–45 per cent. This corresponds to a water content which, in the case of compost, is normally referred to as its moisture content, of 55–60 per cent. It is possible to achieve solids contents in the required range by increasing the retention time on sludge drying beds; however, the usual approach is to co-compost dewatered sludge with materials that have both a higher carbon to nitrogen ratio and lower moisture content.

Deep Row Entrenchment

- Requires appropriate plot of land with secure fencing
- Deep trenches are filled with faecal sludge/septage and covered with soil
- **Advantages:** Simple, low cost, limited O&M, low visibility or odour nuisance
- **Limiting factor:** Land and groundwater table, legislation



Source: S. Vishwanath, Biome Environmental Trust and Eawag/Standec, 2008

Deep row entrenchment (DRE): It refers to the method where septage is fed to an excavated pit. Once the pit is fed with septage, the liquid seeps into the surrounding soil and the solids are arrested in the pit. Once the pit is full it is topped off with the excavated earth so that the solids can be stabilized. Once stabilized the content of the pit are converted into terra preta, which can be safely used in agriculture to improve the characteristic of the soil. DRE is very simple and low on operational expenditure. It does not create any visible or olfactory nuisance. ULBs usually have heavy machinery for earth excavation readily available with them and hence, no specialised equipment is required to start practicing DRE. DRE cannot be practiced in low lying areas and region where ground water table is high.

Summary

- FSSM is required to preserve environmental health as the dependency on on-site sanitation systems is high in India
- Currently many challenges exist in operationalising FSSM
- Two approaches of desludging practiced - demand and scheduled desludging - and both have disadvantages and advantages
- Multiple primary approaches exist for faecal sludge and septage management, such as deep row entrenchment, co-treatment and dedicated treatment plant for faecal sludge and septage

Case study - videos

- [Spillover Effects of Faecal Sludge Management: Dumaguete City](#)
- [Co-composting of FSS with MSW – Shakhipur Municipality](#)

Session

11

Faecal Sludge & Septage Management Planning

This is an exercise session – Kindly refer Part C: Workbook

Session

12

Stakeholder Management

12. Stakeholder Management

Learning objectives

- To understand the process of identification and characterisation of stakeholders
- To learn about stakeholder engagement and different tools involved in it

Contents

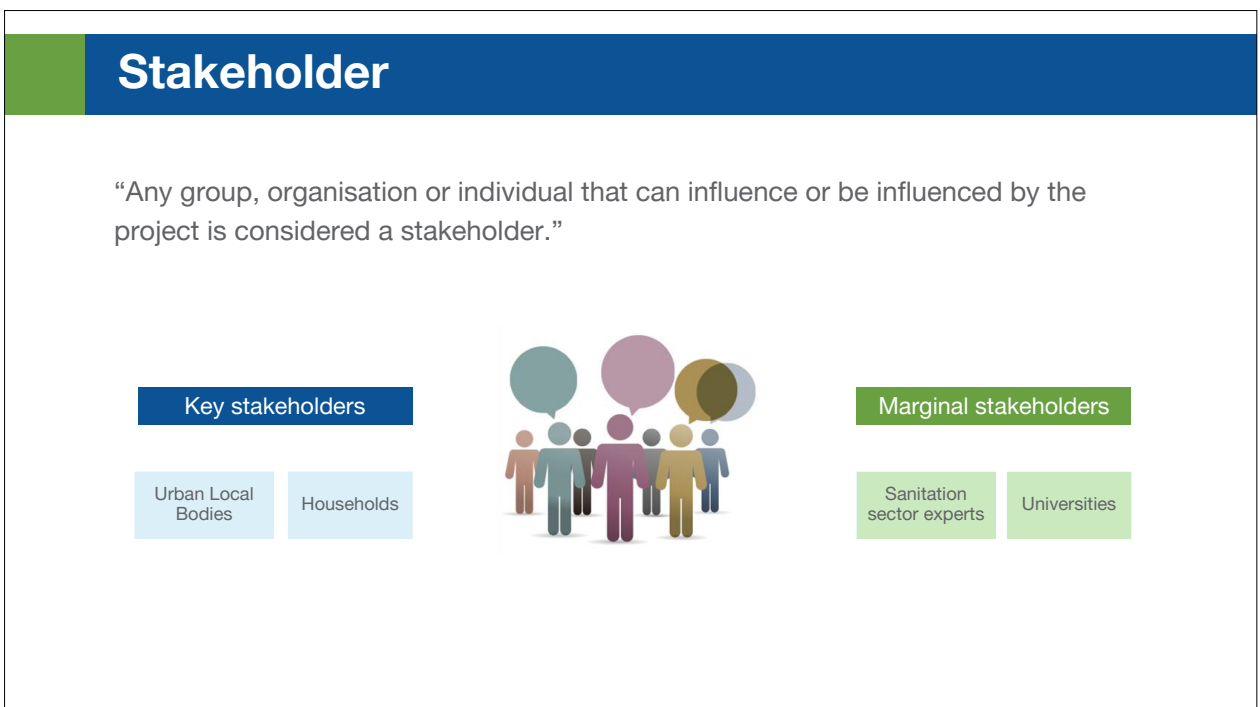
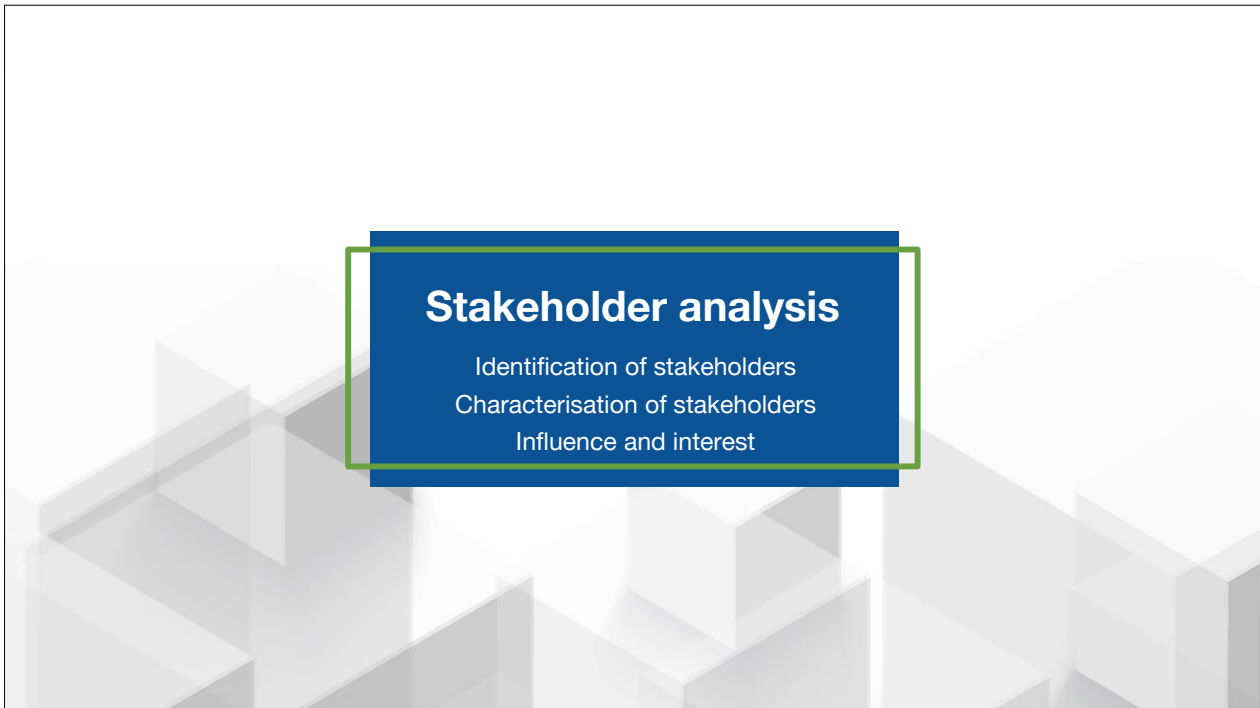
Stakeholder analysis

- Identification of stakeholders
- Characterisation of stakeholders

Stakeholder engagement

- Participation levels
- Involvement tools
- Milestones and cross-cutting tasks
- Distributing and formalising roles and responsibilities

12.1 Stakeholder Analysis



Stakeholders are a group, organisation or individual that can influence or be influenced by the project. There are key stakeholders (e.g. ULBs or Households) and marginal stakeholders (e.g. sanitation sector experts or universities).

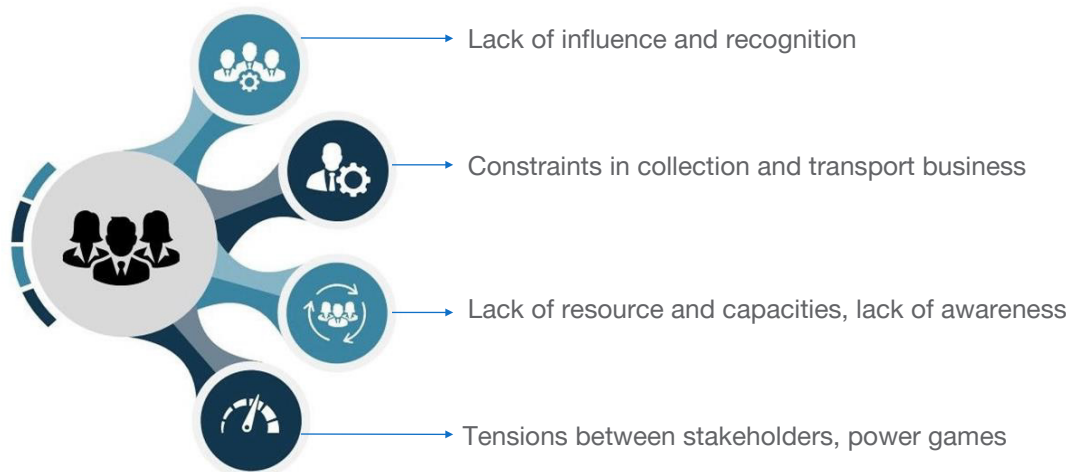
Why is stakeholder analysis important?

- Identify and characterise stakeholders
- Level of a project:
 - Planning
 - Execution
 - Monitoring and evaluation
- Understand social and institutional context
- Planning of stakeholders' participation
- Engage and build trust amongst stakeholders



- To identify who to involve and at which level of participation, at the different stages of the planning and implementation process
- To understand the social and institutional context
- To identify conflicts and interests in between stakeholders.
- To clear the roles and responsibilities of each stakeholder in every stage of the project.

Challenges faced with stakeholders



Lack of participation: i) Lack of influence and recognition; ii) Lack of understanding the official language; iii) Lack of money.

Constraints in the sludge emptying business: i) Costs of sludge transport; ii) Lack of available land for FSM activities.

Lack of resources and capacities: i) Lack of management capacities; ii) Lack of human resources; iii) Laws and regulations are inadequate or not enforced; iv) Poor tax recovery.

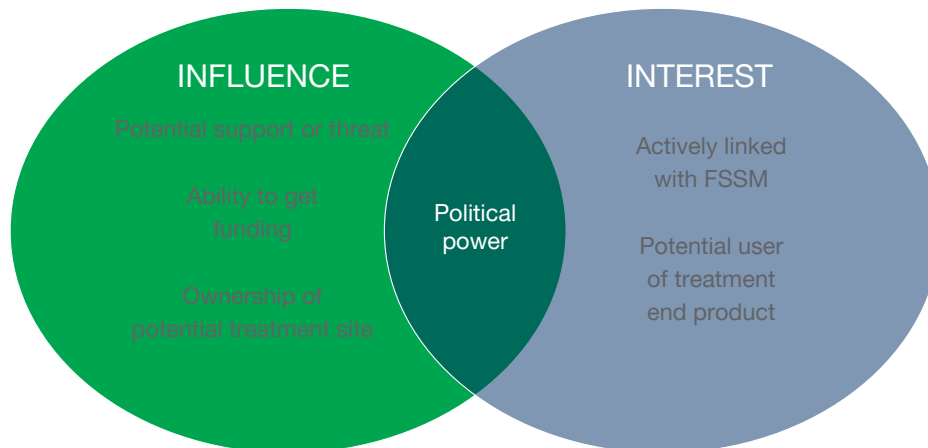
Conflicts in-between stakeholders: i) Power games/competition; ii) Lack of communication and coordination within and between agencies; iii) Tensions in between formal and informal sectors.

Awareness and behaviour: i) Lack of awareness

Characterisation of stakeholders			
Stakeholder	Interest	Opportunities /Threats	Involvements Needs
Urban Local Bodies	Public health Sanitation work Sanitation fees	Power of enforcement through regulatory framework Management of treatment units	Sensitisation, need for capacity building, collaboration Institutional and regulatory framework, enforcement Involvement of financing schemes
Stakeholder B			
Stakeholder C			
...			

- Main interest: Consultation with stakeholders should be carried out in order to determine how each interest can be taken into account in the future FS systems
- Strength: Establish what the process leader can count on
- Weakness: Establish where information, empowerment and capacity building is needed
- Opportunities/threats: Characterize the potential positive (negative) perspective of the project
- Relationship between stakeholders: Hierarchy, friendship, competition or professional link. Good, bad can decide which working groups can be built
- Impacts: Type of impact of the project on the stakeholder determines the measure needed to maximize positive impact and mitigate negative impact
- Involvement needs: The action required, results mainly from identified interest, weakness and potential.

Selection of key stakeholders



Key stakeholders in an IWSM project are those whose interest and influence are most at stake. There are six criteria or attributes which are important for the selection of key stakeholders:

1. Activity linked with IWSM management
2. Political power
3. Potential support or threat
4. Ability to get funding
5. Ownership of a potential treatment site
6. Potential user of a treatment end product.

Influence and Interest matrix

	Low influence	High influence
Low interest	<p>Stakeholders are unlikely to be closely involved in the project and require not more than information sharing aimed at general public.</p> <p>INFORMATION</p>	<p>Stakeholders may oppose the intervention, therefore, they should be kept informed and their views acknowledged to avoid disruption or conflict.</p> <p>CONSULTATION - INFORMATION</p>
High interest	<p>Stakeholders require special efforts to ensure that their needs are met and their participation is meaningful.</p> <p>CONSULTATION - EMPOWERMENT</p>	<p>Stakeholders should be closely involved to ensure their support for the project.</p> <p>CONSULTATION – COLLABORATION – EMPOWERMENT / DELEGATION</p>

Adapted from Reilberger et al. 1988

It is important to differentiate between two different types of opportunities and threats, the influence over the project and the interest in the project. The two concepts can be defined as:

Influence is the power that stakeholders have on the project i.e. to control which decisions are made, facilitate their implementation, or affect the project negatively.

Interest characterises stakeholders whose needs, constraints and problems are a priority in the strategy e.g. desludging service providers, end users, households and sanitation authorities.

Missing key stakeholders in sanitation planning

Sanitation **planning is often done with a fixed mindset**: providing access to toilets, conveying wastewater through sewer network, and treatment prior to disposal

However, **major gaps become evident** when people receive access to any sanitation facility

Main reason is **due to lack of consultation** with key stakeholders like women and children, urban poor, people with disabilities, etc.

Targeting these underserved and/or unserved population is necessary and is highlighted in the following **CWIS principles**:

- *Everybody benefits* from adequate sanitation service delivery outcomes that meet user aspirations and that protect the health of users.
- Activities are included to *target specific unserved and underserved groups*, such as women, ethnic minorities, the urban poor and people with disabilities.

This is an activity session for face to face trainings – Kindly refer Part B: Learning Notes for activity instructions

Exercise: Stakeholders analysis

Groups:

Case A: FSTP Project at ULB

Case B: Co-treatment of FS with STP at Town

Steps to be followed by participants:

- I. Identify the stakeholders
- II. Characterise the stakeholders
- III. Select the key stakeholders
- IV. Influence and Interest Matrix

Exercise:

Instructions for participants:

- Participants will be divided in 4 or 5 groups.
- Each group will be given a case (A or B) to work on. We can create 4 or 5 cases to distribute in the respective group
- Each group will be given a exercise sheet (Size - A3) on which they have to work on. Each sheet will be printed with the tables for stakeholder analysis
- Steps for stakeholders analysis are given as follows,

STEP 1 - In the first stage, each group has to identify stakeholders according to their case

STEP 2 – In this step, participants will have to characterize the stakeholders which they have identified

STEP 3 – In this step, participants will have to understand the inter-relationships between stakeholders and has to select the key stakeholders from it.

STEP 4 – In this step, participants will have to complete the influence and interest matrix according to the stakeholders characterization and selection of key stakeholders

12.2 Stakeholder Engagement



Why is stakeholder engagement important?

- To take into account stakeholder needs and priorities
- To avoid conflicting interest and goals
- To develop an appropriate project design
- To take ownership of the project
- To build consensus on the project framework
- To develop skills, confidence and trust with stakeholders
- To increase sustainability of the project

Thus, resulting in securing the investment in the terms of time and money

Stakeholders engagement or involvement is key for the successful implementation of integrated wastewater or septage management (IWSM) projects. It's a step of planning process where stakeholders are included in order to take into account their needs, priorities and interests to achieve consensus and to address any concerns from opposing groups. It's the key for sustainability of the project.

Participation levels



INFORMATION

- To enable stakeholders to understand:
 - Situation
 - Different options available
 - Implications
- One-way flow of communication
- To engage stakeholders whose involvement is limited

Involvement Tools

- ✓ Personal meetings
- ✓ Workshops
- ✓ Site visits
- ✓ Media Campaigns
- ✓ Advocacy / lobbying

Choosing how to engage a stakeholder means choosing the appropriate participation level. The level of participation depends on what needs to be achieved with the targeted stakeholders.

Information: The objective is to enable the stakeholders to understand the situation, the different options and their implications. This is a one-way flow of communication. All the stakeholders concerned by IWSM need to be well informed in order to understand their role and the objectives of the project. It can be carried out through awareness raising campaigns or informative meetings or related field visits etc.

Participation levels



CONSULTATION

- To obtain stakeholders' feedback on:
 - Situation and options
 - Scenarios and/or decisions
- Two-way flow of communication
- To take into account interest, priorities, needs and concerns

Involvement Tools


- ✓ Personal meetings
- ✓ Focus groups
- ✓ Workshops
- ✓ Site visits
- ✓ Household surveys
- ✓ Mediation
- ✓ Logical framework

Consultation: The objective is to obtain the stakeholders feedback on the situation, options, scenarios, and/or decisions. This is a two-way communication. It allows interests, priorities, needs and concerns to be taken into account (e.g. through interviews carried out with different stakeholders at the beginning of the planning process). However, the stakeholders are not involved in decision making.

Participation levels

COLLABORATION

- To work as partner with stakeholders on various aspects, including:
 - Development of scenarios
 - Identification of the preferred solutions
- Power of taking decisions is shared between stakeholders



Involvement Tools


- ✓ Personal meetings
- ✓ Focus groups
- ✓ Workshops
- ✓ Advocacy/lobbying
- ✓ Mediation
- ✓ Logical framework

Collaboration: The objective is to work as a partner with the stakeholders on various aspects including development of scenarios and the identification of the preferred solution. The power for taking decisions is shared between the stakeholders.

Participation levels

EMPOWERMENT/ DELEGATION

- To build the capacities of stakeholders so that they can:
 - Make informed decisions
 - Take responsibilities for final decision making
 - Take charge of their roles and responsibilities once the project is implemented



Involvement Tools

- ✓ Personal meetings
- ✓ Focus groups
- ✓ Workshops
- ✓ Advocacy/lobbying
- ✓ Mediation

Empowerment/Delegation: The objective is to build capacities of stakeholders so that they are able to make informed decisions, to take responsibilities for final decision making, and to assume their role and responsibilities once the IWSM system is implemented.

Selection of involvement tools

- Selection depends on the goals, personality and capacities of the stakeholders
- Consideration of practical aspects linked with the socio-economic conditions
- Dependent on availability of resources required for conducting involvement programs
- Need good knowledge of the local context
- Minimum level of trust between stakeholders

Once participation levels for each stakeholder have been defined, the involvement tools can be selected. For each participation level, there are number of possible involvement tools. Selection of involvement tool is depending on the goals, personalities and capacities of the stakeholders. It is also dependent on availability of resources required for conducting involvement programs. Stakeholder should have good knowledge of the local context. A minimal level of trust in between stakeholders is also required. Few examples of involvement tools are individual meetings, informal or semi-structured interviews, focus group meetings, workshops, site visits, participatory mapping, surveys, media campaigns, mediation, logical frameworks, etc.

Selection of involvement tools

Political framework	Legal framework	Institutional framework	Social framework
<ul style="list-style-type: none"> • Involvement fits into existing political system • Needs involvement of political leaders 	<ul style="list-style-type: none"> • Involvement conforms to laws 	<ul style="list-style-type: none"> • Involvement matches the institutional framework • Right authorities involved 	<ul style="list-style-type: none"> • Involvement conform to social customs

The selection of involvement tools should be done on a case-by-case basis as it depends on the different aspects of the local context like political framework, legal framework, institutional framework and social framework. Context specific involvement tools are used to make all the different stakeholder groups ready to make informed decisions and reach consensus where necessary.


Milestones in IEC campaign




Milestones

- Initial launching workshop
- Validation workshop of selected options by all stakeholders
- Validation workshop of the action plan

Cross cutting tasks

- Raising awareness
- Training and capacity building



Usually, the level of participation of key stakeholders should increase as the process develops. From information at the very beginning stage, it should move towards collaboration, so that when it comes to implementation and operation, smooth collaboration between stakeholders is secured. The way in which participation levels evolve is context specific. However, the process is marked out by milestones corresponding to the end of phases, where participation levels are formally rethought and where important changes can be decided for the next phase.

In participatory planning framework, there are different phases and milestone events. Three **main milestones** are identified for the involvement strategy of the project. i) initial launching workshop ii) validation workshop of selected options by all the stakeholders iii) validation workshop of the action plan.

In parallel, the planning process is usually marked by two participatory **cross-cutting tasks**: i) Awareness raising to a wide audience (i.e. not limited to key stakeholders and ii) Capacity building, which first aims to enable the key stakeholders to take informed decisions and then prepares the key stakeholders to endorse their role and responsibilities in the implementation and operation of the system.

Exercise: Stakeholder engagement

Groups:

Case A: FSTP Project at ULB-level

Case B: Co-treatment of faecal sludge and septage with sewage at an STP at town-level

Steps to be followed by participants:

- I. Participation levels as considering stakeholders in the project

Exercise:

- Instructions for participants:
- Participants will be divided in 4 or 5 groups.
- Each group will be given a case (A or B) to work on. We can create 4 or 5 cases to distribute in the respective group
- Each group will be given a exercise sheet (Size - A3) on which they have to work on. Each sheet will be printed with the tables for stakeholder analysis
- Each group will continue with the next stakeholders engagement practice after stakeholders analysis

Steps for stakeholders engagement are given as follows,

STEP 1 - In this stage, participants will distribute the stakeholders in participation levels and inter-relationships according to categories i.e. information , consultation, collaboration and empowerment/delegation.

Summary

- Stakeholder analysis is a vital tool for understanding social and institutional context of a project
- Identification and characterisation of stakeholders provides early and essential information about who will be affected by and will influence the project
- Stakeholder engagement plays a vital role in sustainability of the project



Session

13

Faecal Sludge & Septage Treatment

13. Faecal Sludge & Septage Treatment

Learning objectives

- To understand the difference between faecal sludge and septage and its characteristics
- To learn the objectives and stages of treating faecal sludge and septage
- To understand non-mechanised and mechanised treatment units for handling faecal sludge and septage

Contents

- What is faecal sludge and septage?
- Treatment objectives
- Treatment stages
- Treatment units
- FSTPs in India

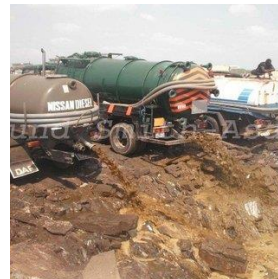
13.1 What is Faecal Sludge & Septage?

What is faecal sludge?

- Contents of pits and vaults accumulating excreta and anal cleaning water
- Very high solid content as compared to wastewater
- Characterised by:
 - fresh and yellowish colour
 - low dewaterability
 - higher BOD
 - needs higher degree of treatment



Source: Eawag/Sandec 2008



Source: Modjinou et. al. (2015)

What is septage?

- Contents of septic tanks and vaults accumulating blackwater
- Very high solid content as compared to wastewater
- Characterised by:
 - well digested and black in colour
 - high dewaterability
 - lower BOD
 - needs lower degree of treatment



Source: Modjinou et. al. (2015)



Source: Eawag/Sandec 2008

Characteristics

	Public Toilet Sludge	Septage	Sewage
Characteristics	Highly concentrated, fresh excreta, stored for weeks or months	Low concentration, more stabilised, stored for several years	Tropical sewage
COD [mg/L]	20 - 50,000	< 10,000	500 - 2,500
COD:BOD ratio	2 - 5	5 - 10	2
NH ₄ - N [mg/L]	2 - 5,000	< 1,000	30 - 70
Total solids [%]	≥ 3.5%	< 3.0%	< 1.0%
Suspended solids [mg/L]	≥ 30,000	≈ 7,000	200 - 700
Helminth eggs (no./L)	20 - 60,000	≈ 4,000	300 - 2,000

Source: Heinss et al. 1998

Depending on the type of the containment system and its design and holding period, the content of the pits (human excreta) undergoes digestion. The containment unit such as pits or under designed septic tank results into faecal sludge, whereas the units such as septic tanks is sludge holding capacity of 2-3 years or anaerobic treatment system such as digester produce septage. The content of septic tank has high TSS and TDS than wastewater. Faecal Sludge as mentioned earlier is fresh yellowish, higher BOD, non settleable solids. Hence, it needs higher degree of treatment. Septage on the other hand, is well digested black in color, higher content of settleable solids and requires lesser degree of treatment.

13.2 Treatment Objectives

Treatment objectives

- Dewatering
- Pathogen removal
- Nutrient recovery
- Stabilisation

Treatment objectives

DEWATERING

- Reduction of design capacities
- Simplifies treatment scheme
- Achieved through gravity settling or filter drying beds
- Adding dry material to increase solid content such as wood chips, saw dust, organic solid waste, etc.
- Liquid fraction obtained after dewatering high in ammonia, salts and pathogens

One of the very important treatment objective of the faecal sludge and septage is dewatering. Dewatering helps to reduce the volume of sludge to be handled and treated using other treatment mechanisms, hence it reduces the CapEx significantly. Separating the solids and liquid stream simplifies the treatment of the faecal sludge and septage and helps to optimise the process. Ex. In case of heat drying, dewatering will save significant amount of energy.

Dewatering can be achieved by gravity settling or filtration. However, it needs to be noticed that dewaterability of faecal sludge is less as compared to septage. Hence, in such cases, stabilisation is recommended before dewatering.

Dewatering can also be achieved by increasing the solid content in the faecal sludge or septage. In case of pyrolysis or incineration, addition of dehydrating agent such saw dust or wood chips is done to increase the solid content as well as the calorific value of the solids.

It needs to be kept in mind that after dewatering, the liquid fraction might contain high amount of ammonia, salts or pathogens.

Treatment objectives

PATHOGEN REMOVAL

- FSS contains large amount of pathogenic microorganisms
- Significant health risk through direct/indirect exposure
- Treatment up to adequate hygienic level
- Reduction or inactivation done by:
 - Starvation
 - Predation
 - Exclusion
 - Desiccation
 - Increasing temperature

The second treatment objective is pathogen removal. Pathogen removal is important from the discharge and reuse point of view of the end products. Faecal sludge and septage is known to contain high amount of pathogens and hence indiscriminate disposal of it may result into cross contamination of the water resources. Reduction of pathogen is achieved by various ways as listed in the slide, and are briefly described below:

- Starvation refers to starving the pathogen to death. Predation refers to introducing or allowing specific types of bacteria to eat (predate) the pathogens.
- Exclusion refers to physical exclusion of pathogens depending on their size using filters.
- Desiccation refers to reducing the moisture content to the level where the cell wall ruptures due to dryness.
- Pathogens are believed to reduced significantly at temperature above 600C.

Treatment objectives

NUTRIENT RECOVERY

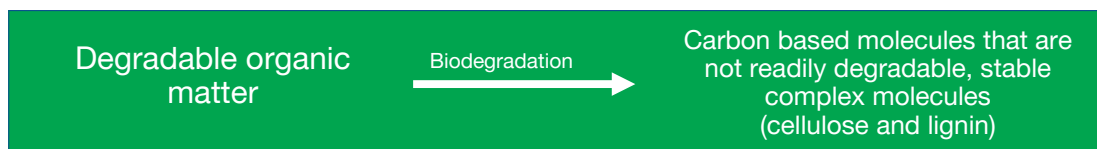
- FSS contains significant concentration of nutrients
- Can supplement synthetic fertiliser:
 - Nitrogen based fertiliser is recovered from fossil fuel
 - Phosphorus is mined from finite resources such as ores
- If not managed properly can lead to:
 - Eutrophication and algal blooms in water bodies
 - Contamination of drinking water sources

Nutrient recovery is a specific treatment objective which is very important when we are intending to use the end products as soil supplements for improving its characteristic. Faecal sludge and septage contain good amount of nutrients. If managed properly these nutrient can be used as supplement to synthetic fertilisers in agriculture. However, if not managed properly, it leads to eutrophication of water bodies and further it may lead to contamination of drinking water resources.

Treatment objectives

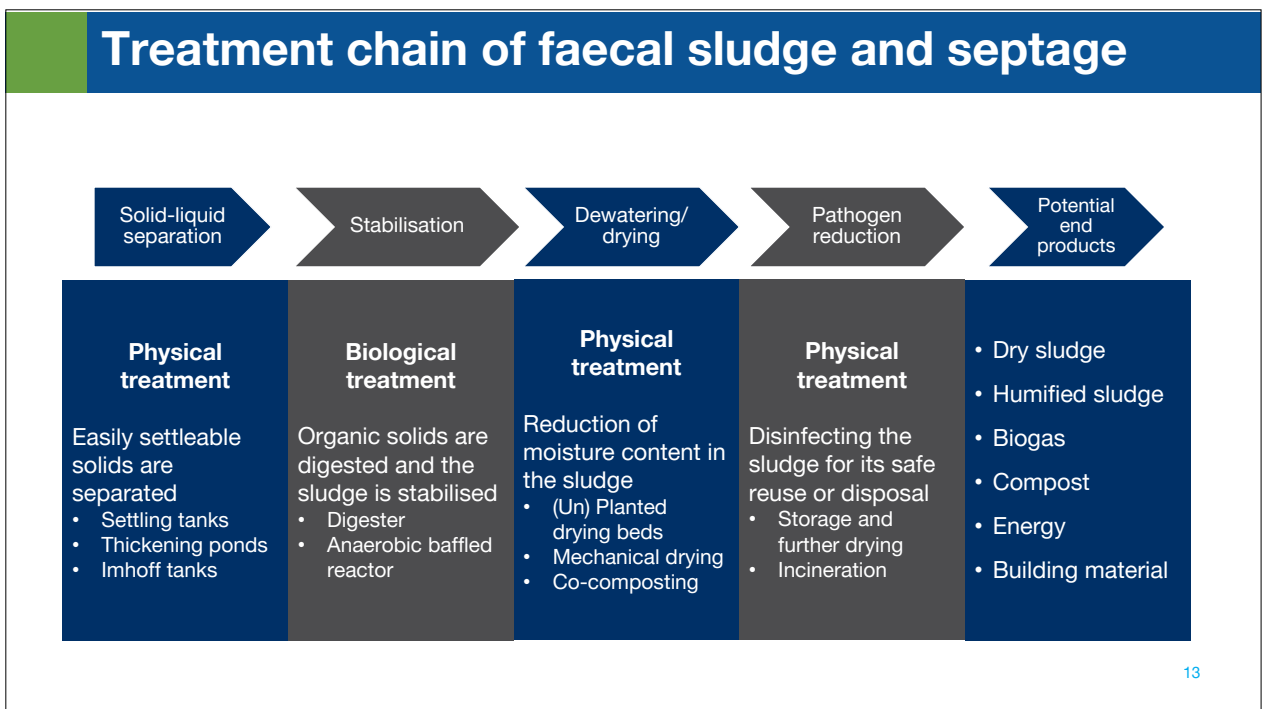
STABILISATION

- Faecal sludge has high oxygen demand
- Depletion of oxygen in surface water bodies
- Stabilisation = Digestion
- Indicators of stabilisation: TVS, BOD, COD



Faecal sludge contains more organic solids which needs stabilisation before it can be discharged into the environment. Stabilisation reduced the oxygen demand of the liquid fraction of the faecal sludge. The need of stabilisation can be assessed using parameters such as volatile solids, BOD and COD.

13.3 Treatment Stages



Treatment facilities are combination of different treatment mechanisms. Each treatment mechanisms has a specific treatment objective. Faecal sludge and septage treatment plants can be divided into four stages. At least three stages are put together to achieve complete treatment of faecal sludge and septage. Pre treatment of septage such as screening is always recommended before starting with actual treatment processes.

Solid liquid separation- This stage refers to separation of easily settleable solids. Septage is known to have higher content of unbiodegradable particulate COD. This COD can be reduced significantly by separating the solids from the liquid fraction. Solid liquid separation is based on physical treatment and can be achieved by settling thickening tanks or geo tubes.

Stabilisation- This stage refers to the stabilisation of organic solids in the sludge. Faecal sludge is known to have higher content of slowly biodegradable COD. Reduction of COD in such cases can be achieved using biological treatment in the form of anaerobic treatment. Anaerobic digestion provides stabilisation of the difficult to digest solids. The process reduced the odour and increases the dewaterability of the sludge.

Dewatering/ Drying- This stage refers to reduction of water content in the sludge. This can be achieved by treatment mechanisms such as evaporation, evapotranspiration, heat application. Treatment units such as planted, unplanted drying beds or mechanical dewatering equipment is suitable to achieve adequate reduction in the water content.

Pathogen reduction- This stage refers to reduction in the pathogens in the sludge. The same can be achieved by various ways, however, the most common way is to store the solids for longer duration (starvation) or to expose the solids to temperature up to 700C or application of heat to drive away the moisture (desiccation).

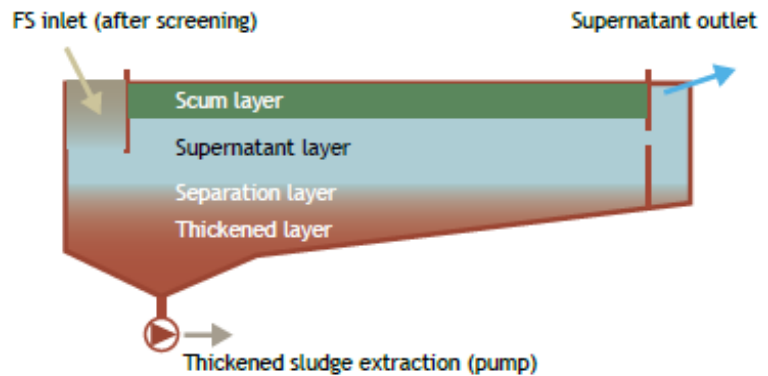
Depending upon the treatment units selected for forming the treatment chain, end products such as sry sludge, humified sludge, biogas, energy etc is produced.

13.4 Treatment Units- Non-Mechanised



Settling thickening tank

- Most commonly employed method
- Based on specific gravity of the particles, suspended solids concentration and flocculation
- Settling mechanisms:
 - discrete particle
 - flocculent
 - hindered
 - compression



Source: Faecal Sludge Management: System approach for implementation and operation

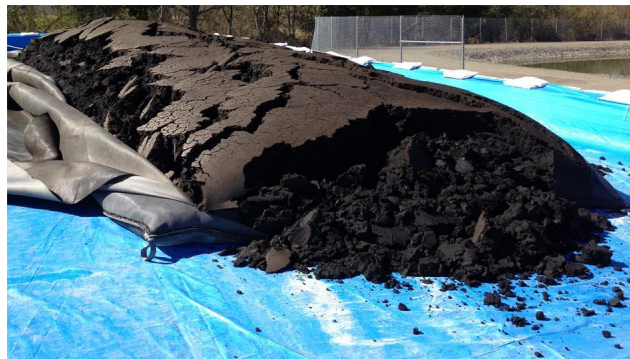
Settling thickening tanks are the simplest kind of treatment unit. It is the most commonly used treatment unit for solid-liquid separation in case of faecal sludge and septage treatment. The separation takes place due to difference in the specific gravity of the solids and their masses. The fat – oil – grease which has lower specific gravity tends to float up on the surface of the water. Hence, in the settling thickening tank, the incoming sludge is given appropriate hydraulic retention time, where in the solids and the FOG separate and the liquid effluent comes out from the outlet. The settled sludge then undergoes compaction due to hydraulic pressure from the top, resulting into thick dense layer suitable for pumping. Concentration of solids is up to 12%.

Geotubes

- Non-woven geotextile is used to create long tubes
- Stitching or use of adhesive
- **Application:** fully digested sludge, increasing efficiency of SDB
- **Advantages:** Low cost and ease of operation
- **Limitation:** One-time use



Source: ESF/Dhawal Patil

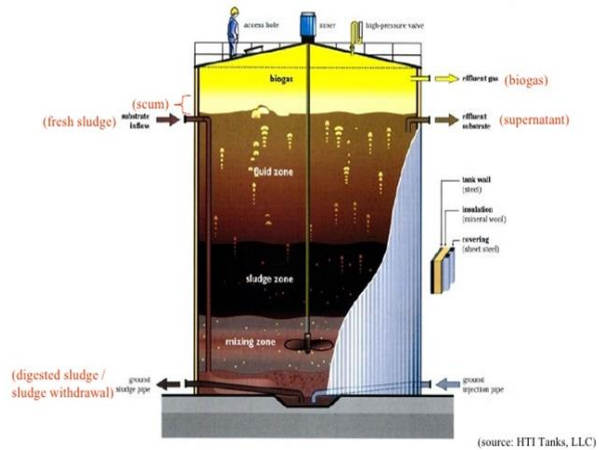


Source: cementingproductsinc.com

Geotubes are long, relatively narrow flexible bags fabricated from high-strength permeable textiles. The only opening in the bag is a connection to allow sludge to be discharged into it. Once sludge has been pumped into a geotube, solids are retained in the bag while free water drains out through the permeable walls of the bag. Geotubes are available in a variety of sizes. They must be removed and replaced when they are full, and therefore have an operational cost, which reduces its viability as a dewatering option.

Anaerobic digester

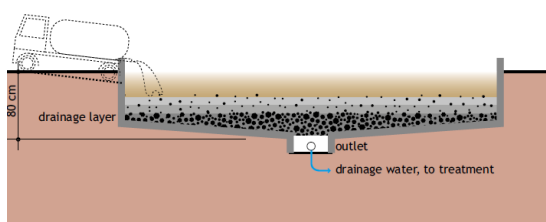
- Organic matter: Biogas (methane and CO₂) and digestate
- **Advantages:** Production of biogas, reduction of sludge volume and odours
- **Limiting factor:** High level of skilled operation and monitoring



Anaerobic digester is used for stabilisation of solid in faecal sludge. Faecal sludge has higher content of slowly biodegradable COD. Hence, to stabilise these solids and bring down the COD, an anaerobic digester with retention time of 20-30 days is designed. The advantage of this is the production of methane gas which can be used for generating energy. Digestion also results in reduction in sludge volume and odour.

Unplanted drying beds

- Shallow filters with sand and gravels with under drain to collect filtrate
- **Application:** Climatic factor and types of sludge
- **Advantages:** Low cost and ease of operation
- **Limitation:** Large footprint and odour problems



Unplanted drying beds are shallow filters with filter bed made out of combination of gravels and sand. The beds have under drain to collect the filtrate which is collected in filtrate sump by gravity. The free water in the sludge drains out of the filter bed and the bound water is removed from the sludge by evaporation. The design of the sludge drying bed is based on the evaporation rate which is determined by the average temperature and humidity. The operational cycle of unplanted sludge drying beds ranges into weeks depending upon the local conditions. The sludge drying beds have relatively low CAPEX and since they are easy to operate and low on OPEX. The biggest limitation of drying beds is their area requirement is quite high and if not operated properly the odour can be a nuisance.

Planted drying beds

- Unplanted drying bed with emergent macrophyte
- **Application:** Climatic factor
- **Advantages:** Low cost and ease of operation
- **Limitation:** Large footprint and odour problems

Planted drying beds are similar to the unplanted drying beds having macrophyte such as cattail, typha etc. In this case the bound water is removed by evapotranspiration. The difference between the planted drying bed and unplanted drying bed is the way they are operated and stabilization of sludge. Unlike unplanted drying beds, the operational cycle of planted drying beds is in months. Each bed is used for months before it is made non-operational. Since the sludge stays in the beds for a long time, mineralisation of the sludge also occurs. The nutrients are taken up by the plants leaving behind mineralised solids behind.

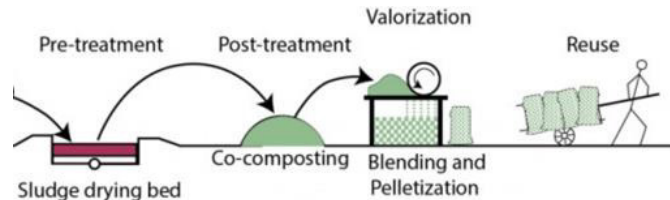
In most of the cases the planted drying beds are made dysfunctional, however there are cases where the filter media has been removed, washed and reinstalled. The application criteria, advantages and limitations are similar to unplanted drying beds.

Co-composting

- C:N Ratio= 20-30:1, oxygen concentration: 40-60%, particle diameter < 5 cm
- **Advantages:** Thermophilic condition = pathogen inactivation
- **Limiting factors:** Technical and managerial skills required



Source: www.wmicgjar.com



Source: www.wateratleeds.com

Co-composting can be performed on the dewatered sludge. Sludge is rich in nitrogen and if mixed with organic solid waste to achieve C: N ratio of 30 then aerobic composting can be achieved. Thermophilic conditions are required for pathogen inactivation and hence care needs to be taken to achieve optimum temperature and maintain oxygen concentration between 40% - 60%. The advantage of co-composting is that it performs drying and pathogen reduction simultaneously and generates a high value end product.

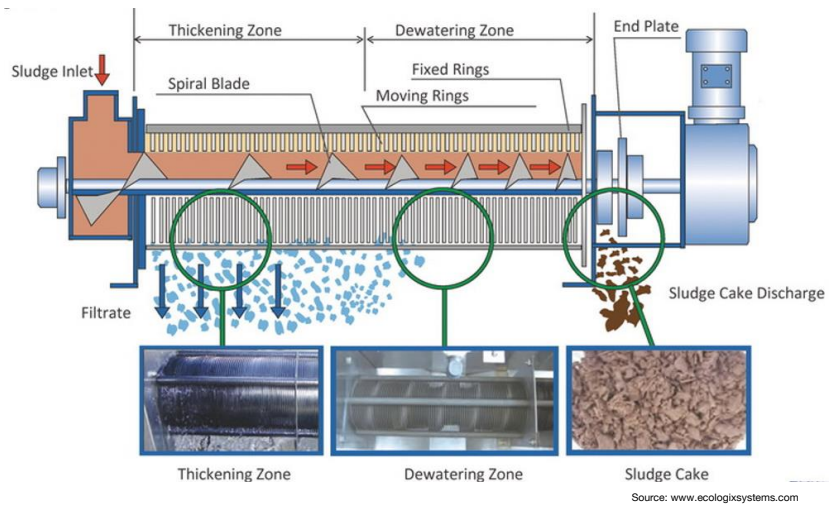
13.5 Treatment Units - Mechanised

Mechanised treatment units

Screw press, Belt press
Paddle Dryer, Rotary Dryer
Belt Dryer

Screw press

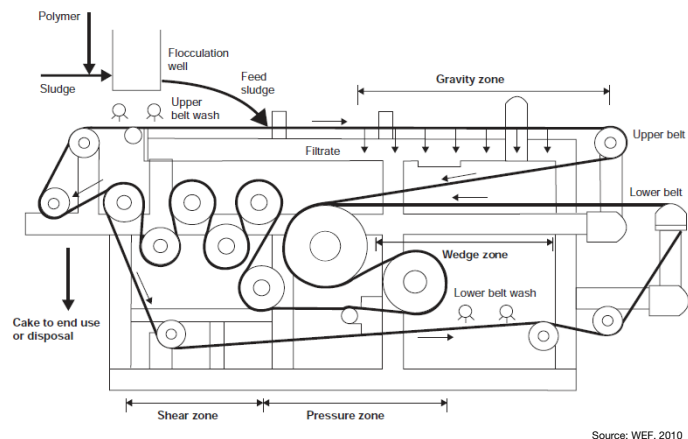
- Work with low solid content: <1%
- Outlet solid content: 15-25%
- Less sensitive to non homogenous sludge characteristics



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 sludge is squeezed into a progressively smaller space. 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.

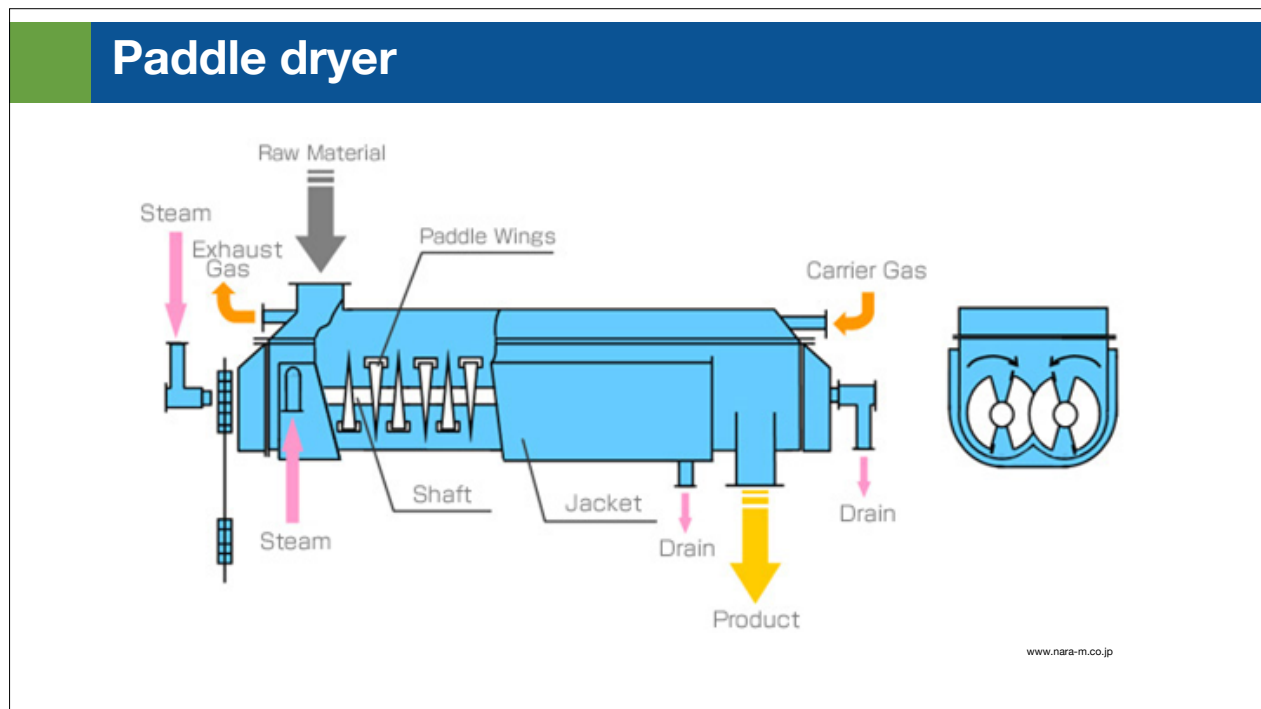
Belt press

- Preconditioning
- Gravity drainage
- Low-pressure linear compression
- High-pressure roller compression and shear
- Work with inlet solids: < 0.5%
- Outlet solids: 15-25%



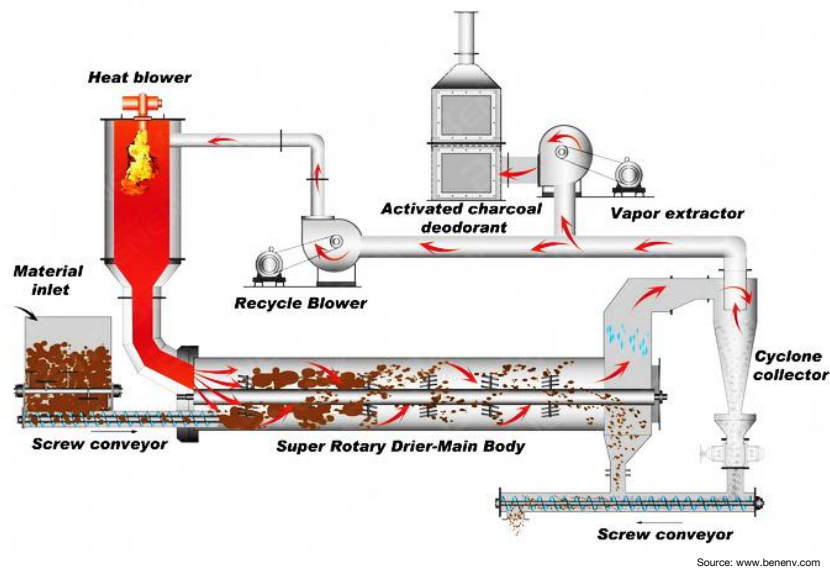
Belt filter presses separate liquid from solids, using gravity and applied pressure between fabric belts. The process typically involves four steps: preconditioning, gravity drainage, low-pressure linear compression, and high-pressure roller compression (and shear). After preconditioning, sludge passes 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.



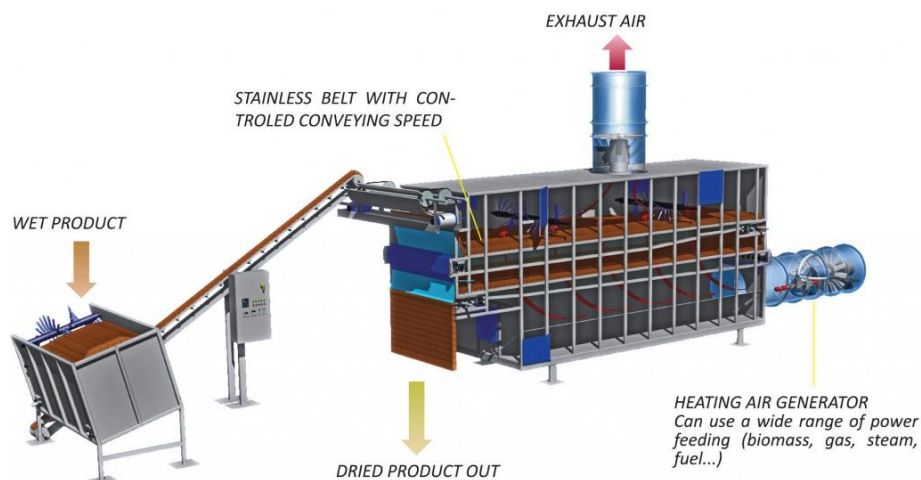
Paddle dryer has paddle wings which are hollow from inside so that steam can be circulated from it. The paddle system is also encompassed into a jacket which is fed by steam. When raw material is introduced into the paddle dryer, the heat is transferred from the paddles to the sludge. The sludge moves 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.

Rotary dryer



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.

Belt dryer



Belt dryers operate at lower temperatures than rotary drum dryers. The heat from the furnace is transferred to a thermal fluid, which heats the air in the dryer. The dewatered cake that is to be dried is distributed onto a slow-moving belt, which exposes a high surface area to the hot air.

Pyrolysis

- Burning of sludge at temperature 850°C-900°C
- **Advantages:** Volume and pathogen reduction
- **Limiting factors:** Emission of pollutants, high skilled operator and maintenance staff, high capital and O&M cost

Source: www.carbonizationfurnace.com

Pyrolysis is the thermal decomposition of material at high temperatures in the absence of oxygen. It may be classified as fast, intermediate, or slow. Fast and intermediate pyrolysis require that the material undergoing decomposition remains in the reactor for seconds or minutes with temperature in between 700 – 900 0C. In slow pyrolysis, the main focus here, requires a retention time measured in hours and a temperature up to around 700°C. Pyrolysis differs from combustion in that little or no carbon dioxide is released during the process. Organic material instead undergoes carbonization, or conversion into carbon in the form of hard porous charcoal. This material, which is called biochar, can be used as a soil supplements or as a fuel source.

Selection of treatment mechanisms

Treatment performance	Local context	O&M requirements	Costs
Effluent and solids quality according to the discharge / reuse standards	<ul style="list-style-type: none"> • Characteristics of sludge (dewaterability, solids concentration, stabilisation, spread ability) • Quality and frequency of the sludge to be received at treatment facility • Climate • Land availability and its cost • Interest in the end-use 	<ul style="list-style-type: none"> • Availability of skilled persons for operation-maintenance and monitoring • Availability of spares locally in case of mechanical equipment 	<ul style="list-style-type: none"> • Investment costs covered (land acquisition, infrastructure, human resources, capacity building and training) • O&M costs • Affordability for households and ULB

The selection of the treatment mechanisms depends on various factors which are listed in the slide, i.e., treatment performance, local context, O&M requirements and costs.

13.6 FSTPs in India



Case study - videos

- [Faecal Sludge Management – Jhansi](#)
- [Faecal Sludge Treatment Plant - Bhubaneswar](#)
- [Faecal Sludge Management – Devanhalli](#)
- [Faecal Sludge Management – Wai](#)

Summary

- Characterisation of faecal sludge and septage plays an important role in selection of a treatment objective
- FSS treatment facility consist of upto four stages, each having a specific treatment objective
- FSS treatment facility consists of multiple components to achieve the desired treatment objectives
- Defining the right treatment objective is key to selection of appropriate treatment components for FSS treatment facility

Session

14

Financial Aspects of Faecal Sludge & Septage Management

14. Financial Aspects of FSSM

Learning objectives

- To look at different financial aspects related to infrastructure projects such as setting up of a FSTP
- To understand different financial models for operating FSSM at a city level

Contents

Financing FSSM

- Capital expenditure
- Operational expenditure
- Income and revenue
- Annualised cost

Financial flow models

- Discrete model
- Integrated model
- Sanitation tax model
- License model
- Incentivised model

14.1 Financing FSSM



Capital expenditure

- Land & site preparation
- Civil structures (life span of 30 years)
- Plumbing and electrical components (life span of 15 years)
- Electromechanical components (life span of 10 years)
- Planning and supervision costs
- Costs for site investigation and sampling
- Transportation costs and overheads

Capital expenditure (CapEx) refers to one-time expenditures incurred to setup the treatment facility such as an FSTP. The percentage contribution of each component changes depending upon the selection of treatment modules. For example, in case of treatment using settling thickening tank, sludge drying beds and DEWATS, the civil costs will form a majority of the total cost of the project. However, in case of mechanised dewatering and drying, the cost of electromechanical components will be on the higher side.

Operational expenditure

Direct costs

- Expenditure to be borne in treating faecal sludge and septage received at the treatment plant
- Cost of material for operation
- Cost of power for operation
- Cost of chemicals (if required)

Indirect costs

- Expenditure to be borne even if faecal sludge and septage is not received at the treatment plant
- Human resource costs

Operational expenditure (OpEx) is the cost incurred to operate the treatment plant to treat and manage the sludge at the FSTP. This cost can be divided into two heads: direct and indirect costs. Direct cost refers to the cost which needs to be borne for actual operation and will vary depending upon the quantity of the sludge received at the FSTP. Indirect cost, on the other hand, refers to the cost to be borne irrespective of the quantity of the sludge received at the plant, such as the human resource cost and land lease (in case the land is procured on lease for constructing FSTP).

Income and revenue

Discharge fee

- Fee collected from the collection and transport company to discharge faecal sludge and septage at the treatment plant

Purchase price

- Revenue generated from selling the end products such as soil conditioner, solid/liquid fuel, building material etc.

Budget support

- Financial support provided by a government authority (ULB) to the company operating and maintaining the treatment plant

There are various streams of recuperating costs incurred for operating an FSTP. Standard streams are listed on the slide.

Discharge fees refers to the tipping fee to be given by the desludging operator to the FSTP operator for taking responsibility of the sludge for treatment and further disposal. Purchase price refers to the revenue generated by sale of the treated products. However, it needs to be understood that from these two streams, it is impossible to meet all the operational expenditure of the FSTP and hence budgetary support is needed. Budgetary support refers to the financial support provided by the government to the company which is operating and maintaining the plant.

Annualised cost

$$\text{Annual CapEx} = \text{CapEx} \times \frac{(1+r)^N \times r}{(1+r)^N - 1}$$

$$\begin{aligned} \text{Annualized Cost} \\ = \text{Annual CapEx} + \text{OpEx} - R \end{aligned}$$

Where;

CapEx: Capital expenditure

r: Rate of interest (bank rate – inflation rate)

N: life span of the component

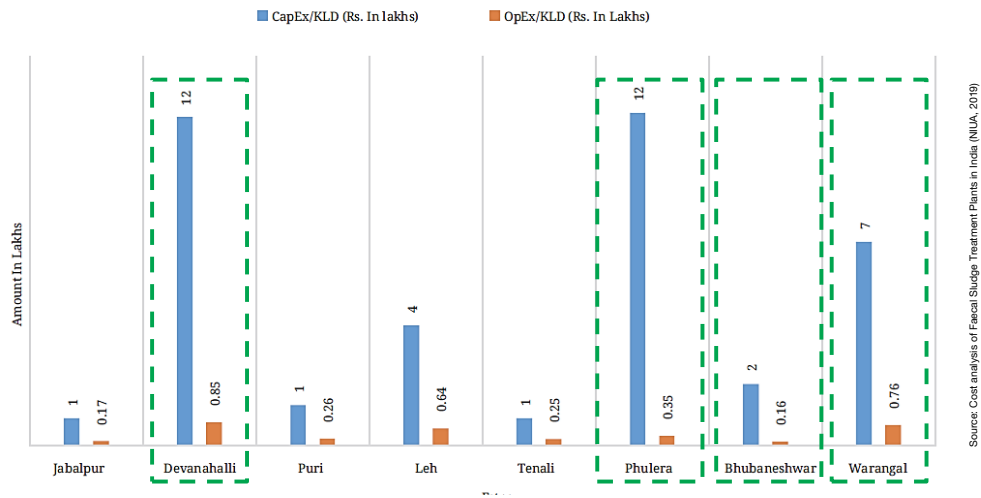
Where;

OpEx: Operational expenditure

R: Revenue

Annualised cost method is a method of life cycle analysis of infrastructure projects such as treatment plants. This method aggregates operation and maintenance cost, revenues and capital expenditure of the project into one single cost. It factors in the life of the civil, electromechanical and plumbing, and electrical components based on their life spans. The O&M cost is factored in using a standard rate of inflation. Hence the method annualizes all costs and gives one cost which can be compared for all the technologies in order to choose the suitable technology.

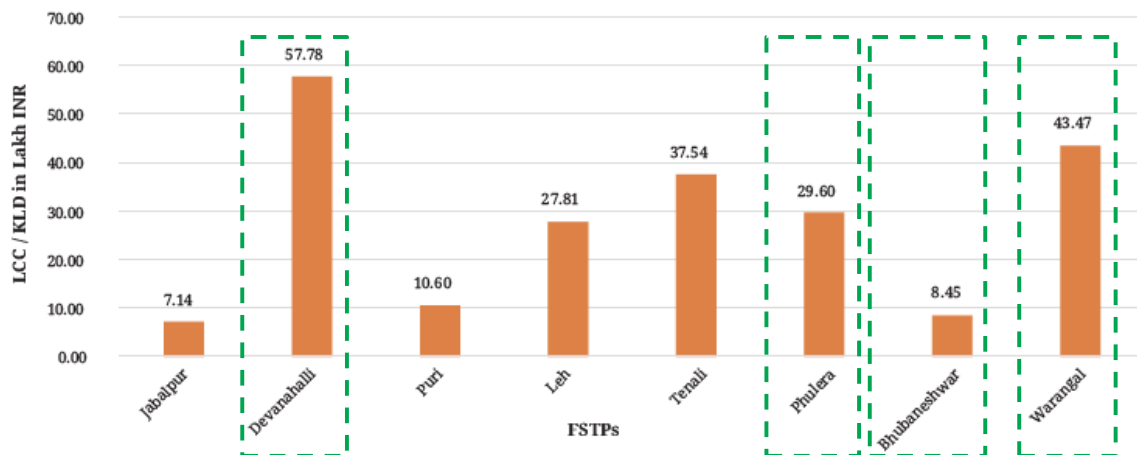
Cost analysis of FSTPs in India



Source: Cost analysis of Faecal Sludge Treatment Plants in India (NIUA, 2019)

The slide compares cost analysis of various FSTPs in India. The plants marked in green are the plants which cater to both liquid and solid treatment completely. The blue bar shows the capital cost of the technology whereas the orange bar gives the O&M costs. Devanahalli and Phulera plants are based on DEWATS module, with feeding tank, stabilization unit, unplanted drying beds and co-composting for treatment of solids, whereas for liquid treatment AS, ABR, AF and PGF have been installed. Bhubaneswar is also based on DEWATS model, however, settling thickening tank is used for separation of solids and liquid. At Warangal the treatment units are screw press followed by thermal drying and pyrolysis of the sludge. Liquid after dewatering is also treated separately.

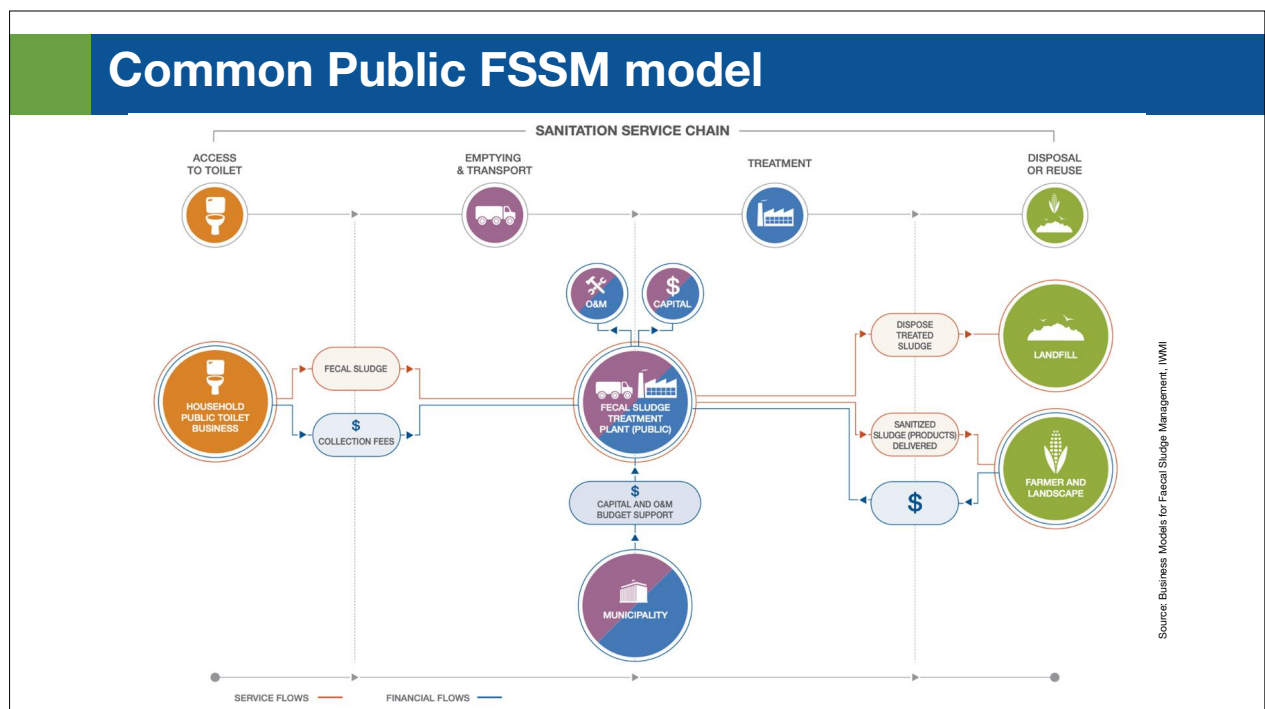
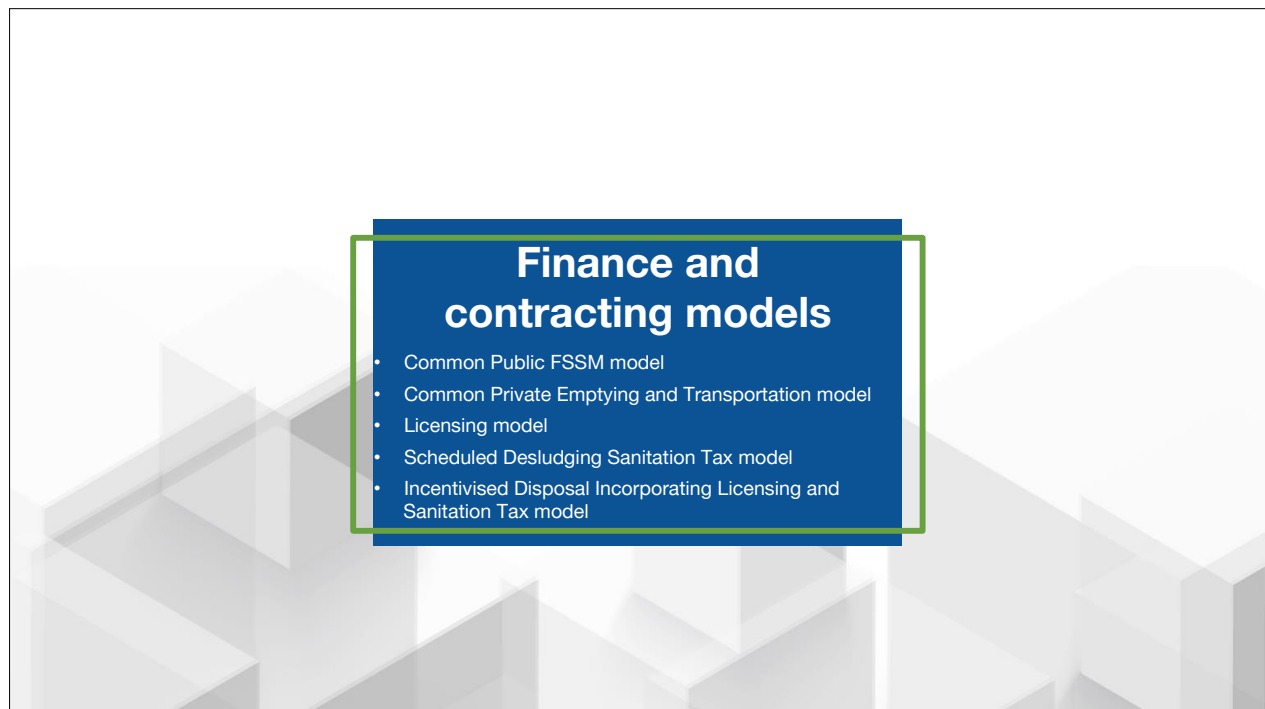
Life-cycle cost (LCC) analysis of FSTPs in India



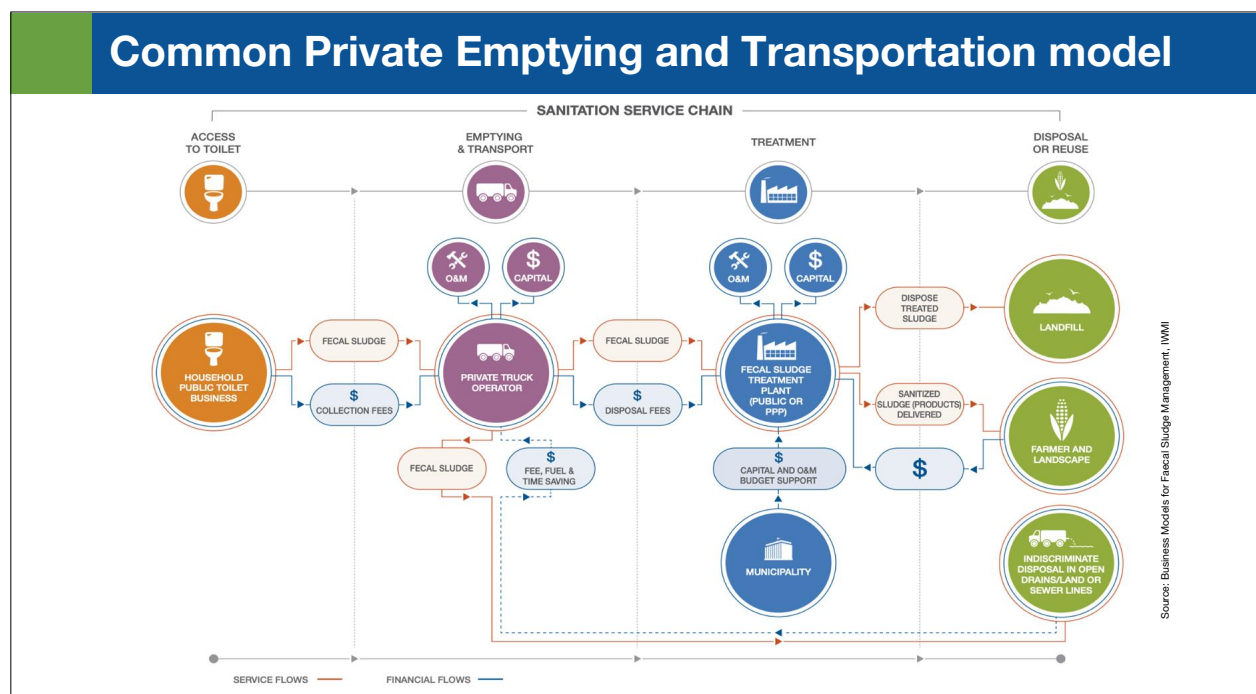
Source: Cost analysis of Faecal Sludge Treatment Plants in India (NIUA, 2019)

The life cycle cost of these plants is shown in the slide above. It can be observed that cost of Bhubaneswar plant is far less as compared to other three plants. Hence it can be seen that appropriate selection of the treatment units is necessary for optimising the cost of treatment. In LCA, the design capacity of the treatment plant can have an impact on the life cycle cost. It is also important to explore other options to manage septage for smaller capacities instead of having a full scale FSTP.

14.2 Finance & Contracting Models



A commonly occurring scenario observed is the ownership and management of FSSM by the public sector for collection, transportation and treatment. Users of OSS systems approach local authorities, which are usually the municipality or the state-run water and sewerage companies, to provide emptying services. The service is provided for a prefixed price. The sludge collected is transported to a treatment plant or landfill site which is also owned and operated by a public utility or the local municipality.



A commonly occurring scenario observed is the ownership and management of FSSM by the public sector for collection, transportation and treatment. Users of OSSs approach local authorities, which are usually the municipality or the state-run water and sewerage companies, to provide emptying services. The service is provided for a prefixed price. The sludge collected is transported to a treatment plant or landfill site which is also owned and operated by a public utility or the local municipality.

FINANCIAL IMPLICATIONS

- Benefits for emptying operations (N)
- Reduces emptying cost to households (N)
- Requires subsidy (Y)
- Improve cost recovery of FSSM (N)

REGULATORY AND MONITORING IMPLICATIONS

- Requires close monitoring for regulatory compliance (N)
- Modification of sanitation codes and policy (N)

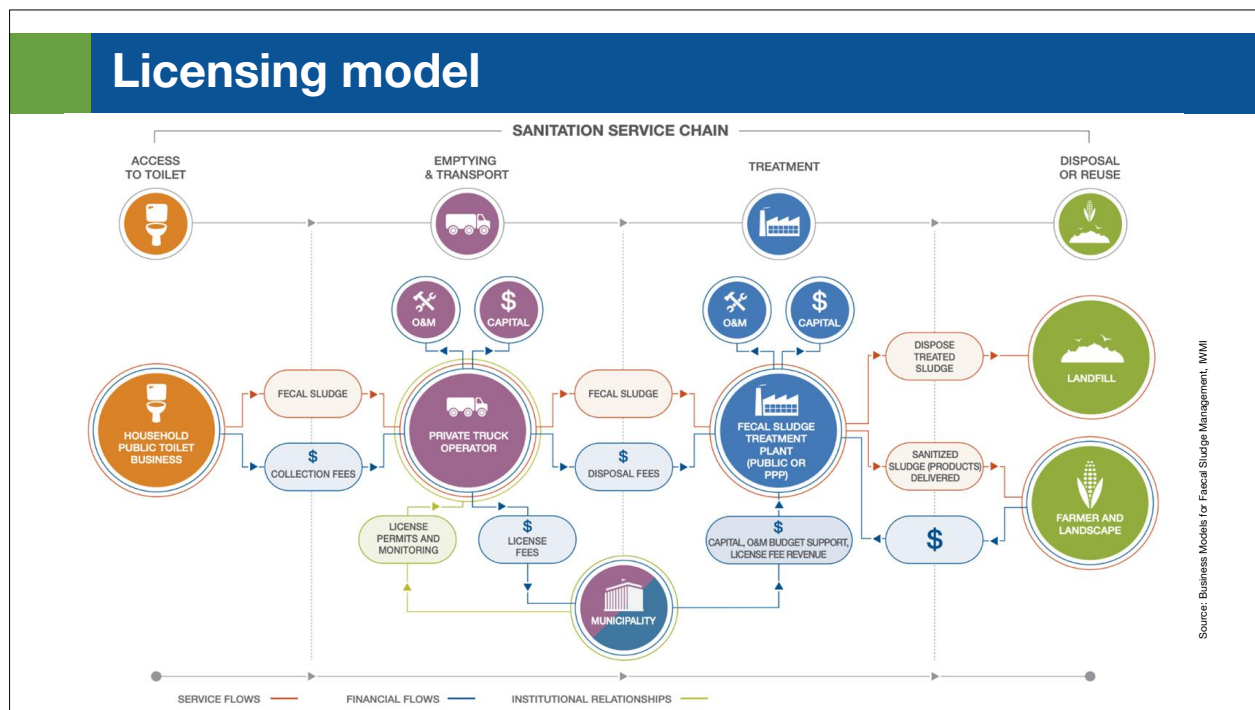
INSTITUTIONAL IMPLICATIONS

- Requires public sector involvement (Y)
- Requires private sector involvement (N)

ENVIRONMENTAL AND HEALTH IMPLICATIONS

Reduces indiscriminate disposal of sludge (Y)
 Concerns of public health and environmental safety (N)

Y – Yes, P – Possible, N – No, NA – Not applicable



In a commonly occurring scenario, when an emptying business is initiated by a private entity (mechanical or manual emptying), the households or businesses with on-site sanitation systems contact the private entity to provide emptying services on a fixed agreed tariff. Ideally, the private entity is required to transport and safely dispose the FS either to a treatment plant or to a designated disposal site, typically a landfill.

FINANCIAL IMPLICATIONS

Benefits for emptying operations (N)
 Reduces emptying cost to households (P)
 Requires subsidy (N)
 Improve cost recovery of FSSM (N)

REGULATORY AND MONITORING IMPLICATIONS

Requires close monitoring for regulatory compliance (Y)
 Modification of sanitation codes and policy (N)

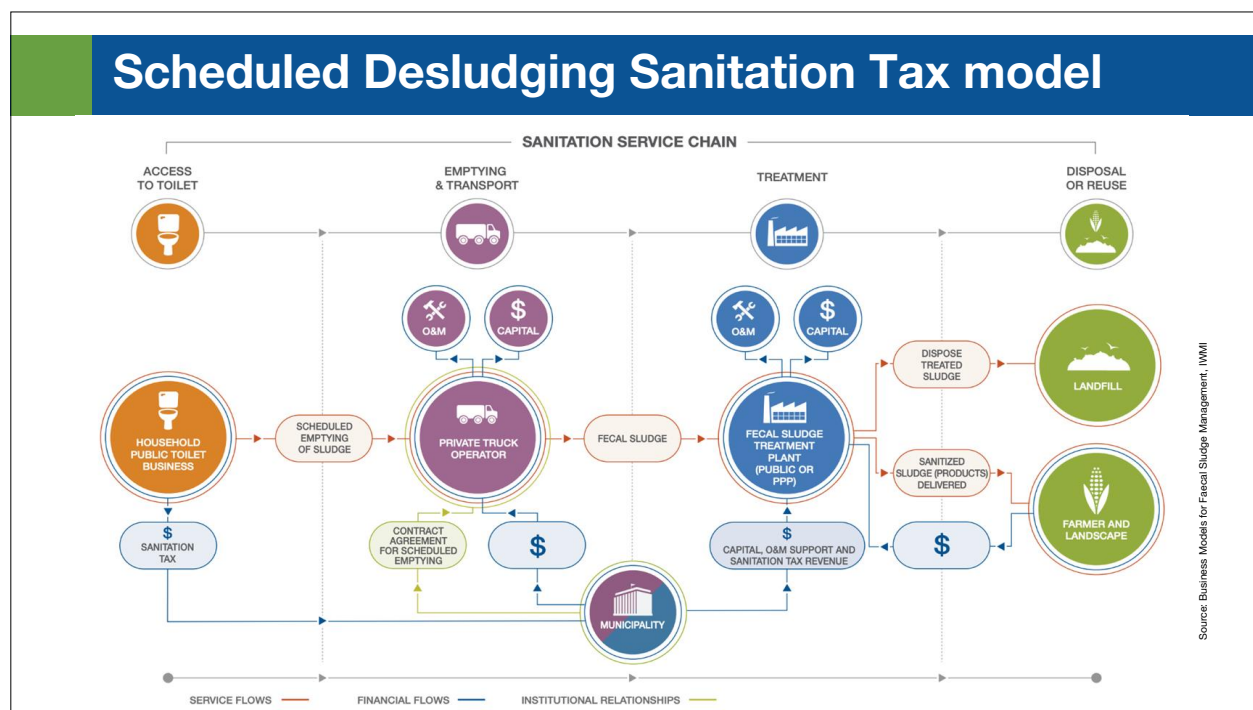
INSTITUTIONAL IMPLICATIONS

Requires public sector involvement (P)
 Requires private sector involvement (Y)

ENVIRONMENTAL AND HEALTH IMPLICATIONS

Reduces indiscriminate disposal of sludge (N)
 Concerns of public health and environmental safety (Y)

Y – Yes, P – Possible, N – No, NA – Not applicable



This business model is similar to the commonly occurring private emptying and transportation model. The key difference lies in the issuing of license/permits to the private truck operators by relevant public authorities to operate emptying businesses. Licensing helps in accounting for all emptying businesses in the city, and can potentially track these businesses to prevent illegal disposal of FS. The license/permit could be either a one-time fee or fees paid annually by the truck operators. The public authority issuing the license provides basic “dos and don’ts” to the truck operators, and they need to monitor for regulatory compliance by tracking the operations of private truck operators. The license is revoked, if the truck operator is found to be violating any regulations, especially engaging in the illegal disposal of FSS.

FINANCIAL IMPLICATIONS

Benefits for emptying operations (N)
 Reduces emptying cost to households (P)
 Requires subsidy (P)
 Improve cost recovery of FSSM (N)

REGULATORY AND MONITORING IMPLICATIONS

Requires close monitoring for regulatory compliance (Y)
 Modification of sanitation codes and policy (Y)

INSTITUTIONAL IMPLICATIONS

Requires public sector involvement (Y)

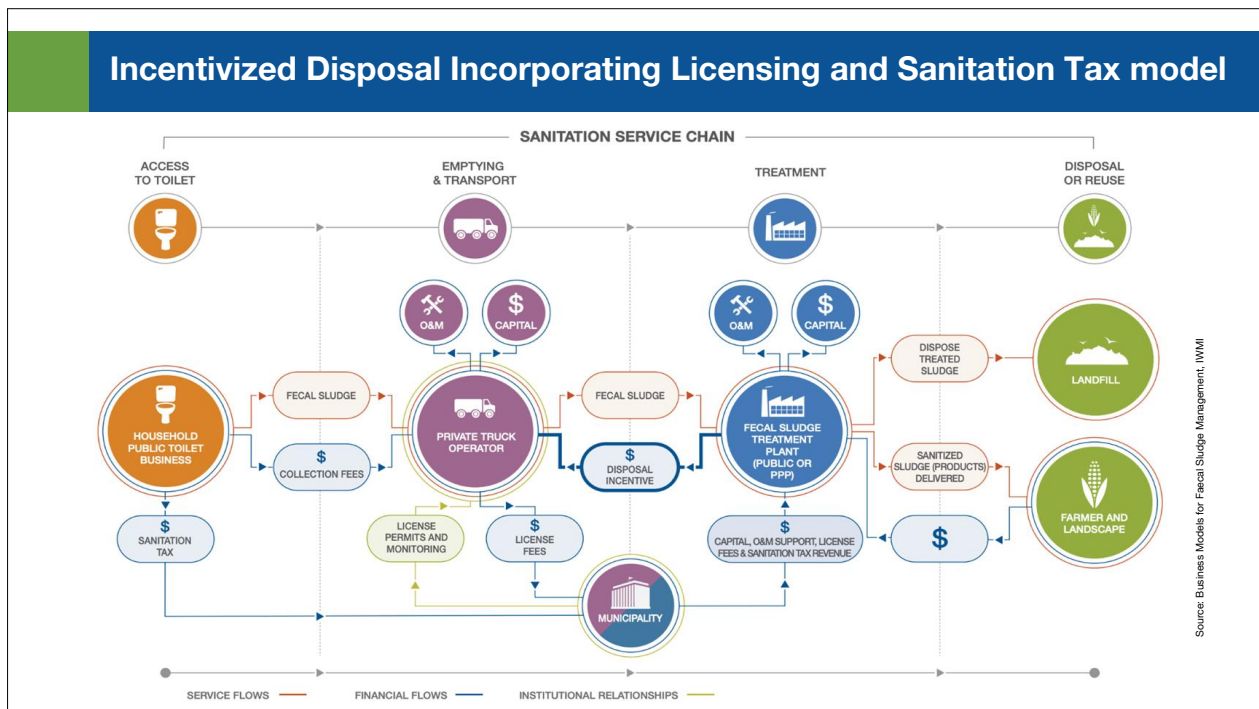
Requires private sector involvement (Y)

ENVIRONMENTAL AND HEALTH IMPLICATIONS

Reduces indiscriminate disposal of sludge (Y)

Concerns of public health and environmental safety (N)

Y – Yes, P – Possible, N – No, NA – Not applicable



This business model is similar to the commonly occurring private emptying and transportation model. The key difference lies in the issuing of license/permits to the private truck operators by relevant public authorities to operate emptying businesses. Licensing helps in accounting for all emptying businesses in the city, and can potentially track these businesses to prevent illegal disposal of FS. The license/permit could be either a one-time fee or fees paid annually by the truck operators. The public authority issuing the license provides basic “dos and don’ts” to the truck operators, and they need to monitor for regulatory compliance by tracking the operations of private truck operators. The license is revoked, if the truck operator is found to be violating any regulations, especially engaging in the illegal disposal of FSS.

FINANCIAL IMPLICATIONS

Benefits for emptying operations (N)

Reduces emptying cost to households (P)

Requires subsidy (P)

Improve cost recovery of FSSM (N)

REGULATORY AND MONITORING IMPLICATIONS

Requires close monitoring for regulatory compliance (Y)

Modification of sanitation codes and policy (Y)

INSTITUTIONAL IMPLICATIONS

Requires public sector involvement (Y)

Requires private sector involvement (Y)

ENVIRONMENTAL AND HEALTH IMPLICATIONS

Reduces indiscriminate disposal of sludge (Y)

Concerns of public health and environmental safety (N)

Y – Yes, P – Possible, N – No, NA – Not applicable

Summary

- There are multiple types of cost which need to be considered during setting up an FSTP
- Selection of technology should be done after analysing the LCC of a project
- There are multiple transfers which needs to be considered during operationalising of an FSSM plan
- Selecting an appropriate contracting and a financial transfer model is key to sustainability of an FSSM plan

Session

15

Operation & Maintenance Cost of Faecal Sludge & Septage Management

This is an exercise session – Kindly refer Part C: Workbook

Session

16

Conceptualising Sewage Treatment Plant (STP)

This is an activity session for face to face trainings – Kindly refer Part B: Learning Notes for activity instructions



Session

17

Wastewater Treatment Principles

17. Wastewater Treatment Principles

Learning objectives

- To define and understand the objectives of wastewater treatment
- To learn the underlying processes and their design parameters
- To understand different stages of treatment with focus on preliminary, primary and tertiary treatment

Contents

Objectives of wastewater treatment

Treatment processes and stages

- Primary
- Secondary
- Tertiary

Components of a sewage treatment plant (STP)

Layout of an STP

17.1 Objectives

Objectives of wastewater treatment

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



Reduce eutrophication of surface water bodies



Reuse in industry where reasonable quality process water is required



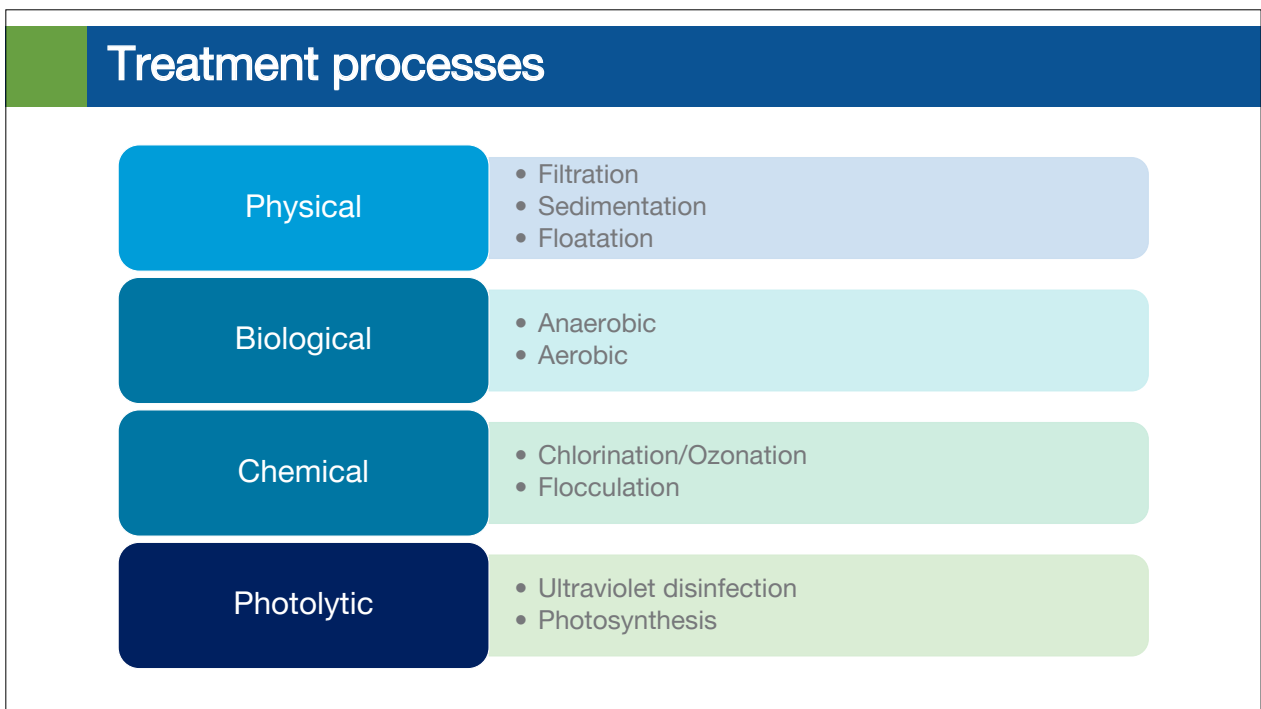
Reuse in agriculture areas not covered under irrigation schemes



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, in some cases 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 reduce the eutrophication of 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
- Wastewater Treatment- Processes & Stages

17.2 Wastewater treatment: processes and stages



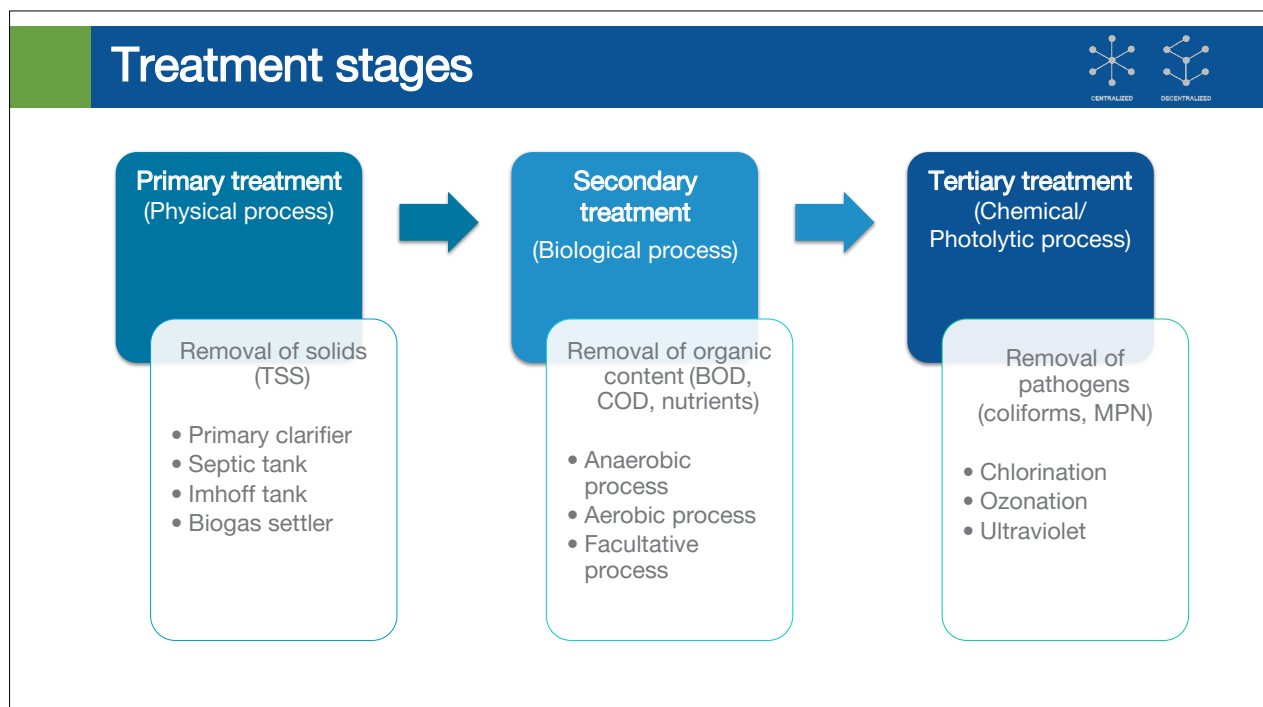
Wastewater treatment processes are of different types: Physical, biological, chemical and photolytic. Physical processes are based on the physical characteristic of the wastewater constituents, mainly the specific gravity of the constituent which assists the separation from the water. Biological processes rely on the microorganisms to carry out digestion of organic matter in anaerobic or aerobic conditions. Biological processes are the heart and soul of any wastewater treatment plant. Chemical processes rely on the use of chemicals either to treat the water (for example, ozonation, to kill pathogens) or to assist the physical or biological processes (for example, alum or

ferric chloride to coagulate the sludge). Photolytic processes rely on photons in light to treat the wastewater directly (for example, UV to kill pathogens) or indirectly (for example, photosynthesis helps to uptake the nutrients from the wastewater in case of constructed wetlands).

Design parameters

- Organic loading (kgBOD/d, kgCOD/d)
- Volumetric loading rate (m³/d)
- Temperature (°C)
- Hydraulic retention time (HRT) (hours or days)
- Sludge age (d)
- Biomass yield (kgVSS/ kgCOD)
- Up flow velocity (m/s)
- Specific surface area (m²/m³)

The slide shows different type of design parameters used to design wastewater treatment units. The importance of these design parameters may increase or decrease on a case-to-case basis.




A waste treatment facility consist 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 removes the BOD and COD using the digestion process carried out by anaerobic and aerobic micro organisms. In the tertiary stage, chemical or photolytic treatment process is used to disinfect the wastewater.


17.3 Components of Headworks

Components of headworks



Preliminary stage of wastewater treatment



CENTRALIZED




DECENTRALIZED





Primary treatment | Screens


- Removal of coarse solids in wastewater
- Different sizes and configurations
- Manually or mechanically cleaned
- Velocity through openings during peak flow: 0.6 – 1.2 m/s




Coarse Screen



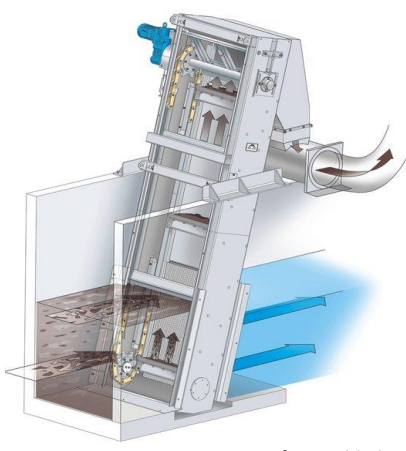
Fine Screen



Perforated Plate Screen



Mesh Screen



Source: www.huber.de

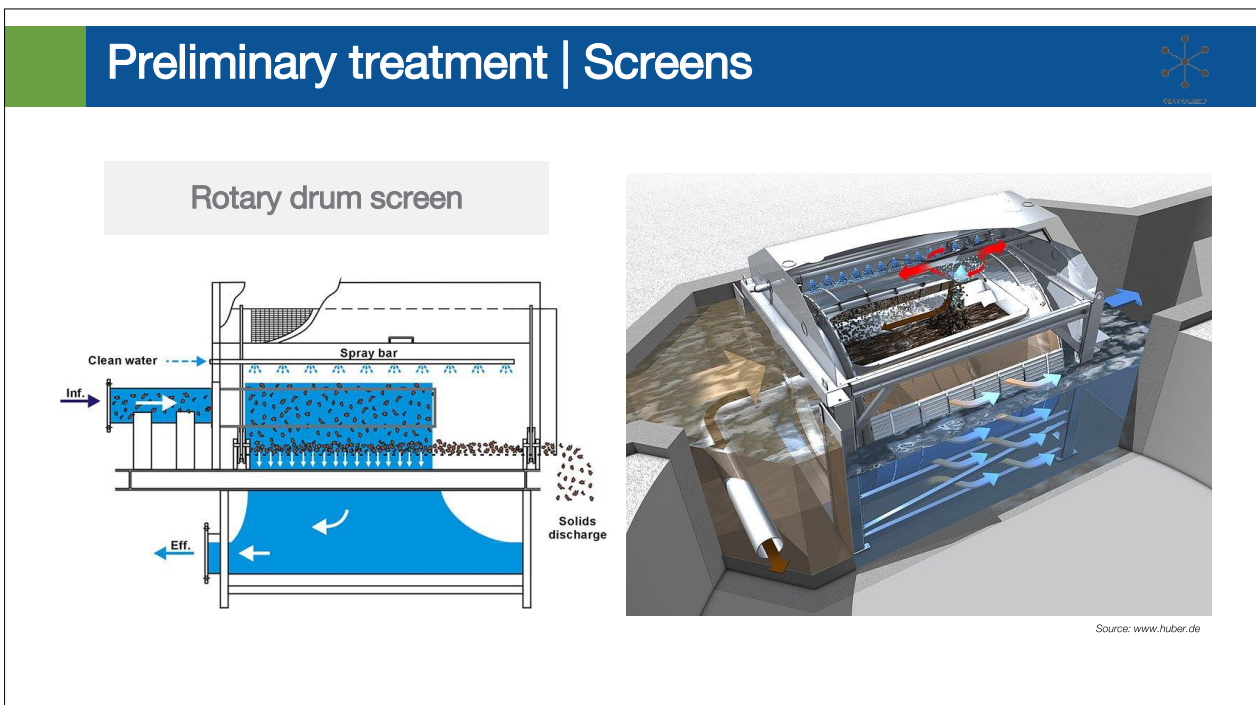
Screens are used to remove solid waste from the wastewater. Different sizes and configurations of screens are available. They are either manually cleaned or mechanically cleaned using a raking system as shown in the slide.

Preliminary treatment | Screens

Operation	Size of opening (mm)	Moisture content (%)	Specific weight (kg/m ³)	Volume of screening (L/1000 m ³)	
				Range	Typical
Coarse screen	12.5	60-90	700-1100	37-74	50
	25	50-80	600-1000	15-37	22
	37.5	50-80	600-1000	7-15	11
	50	50-80	600-1000	4-11	6
Fine screen	12.5	80-90	900-1100	44-110	75
Rotary drum screen	6.25	80-90	900-1100	30-60	45

Source: Metcalf and Eddy, 2003

Screens are available in different types like coarse screen, fine screen or rotary drum screen. The specifications and design criteria are given in the above slide.



In rotary drum screen, the screening or straining medium is mounted on a cylinder that rotates in a flow channel. The construction varies, principally with regard to the direction of flow through the screening medium. The wastewater flows either into one end of the drum and outward through the screen with the solids collecting on the interior surface, or into the top of the unit and passing through to the interior with solids collecting on the exterior. Drum screens are available in various sizes, from 0.9 – 2m in diameter and 1.2 – 4m In length.

Preliminary treatment | Grit chamber



- Removes inert settleable solids
- Types of grit chamber:
 - Horizontal flow
 - Aerated type
 - Vortex flow
- Aeration improves the separation of particles
- Oil & grease skimmed off from the top surface



Source: www.huber.de

Grit chambers are used to remove the inert, easily settleable solids. Grit chambers are available in two types: longitudinal flow and circular or vortex flow. In some cases, the grit chambers are also aerated to improve the separation of the solids from the wastewater. Grit chambers also remove the FOG – fat oil grease – from the wastewater which is skimmed and stored separately from the grit. Grit chambers are provided to:

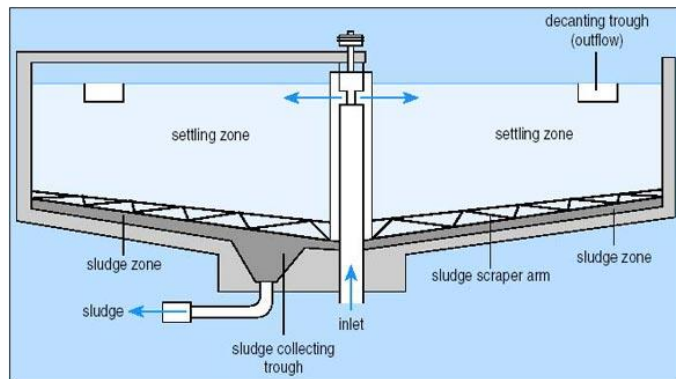
- Protect moving mechanical equipment from abrasion.
- Reduce formation of heavy deposits in pipelines, channels and conduits.
- Reduce the frequency of digester cleaning caused by excessive accumulations of grit.

Preliminary treatment | Grit chamber



Horizontal flow: circular grit chamber

- Horizontal velocity: 0.25 – 0.4 m/s
- Removal of grit: 95% of 0.15 – 0.21mm
- Cleaned mechanically



Source: <http://sewagetreatment.us>

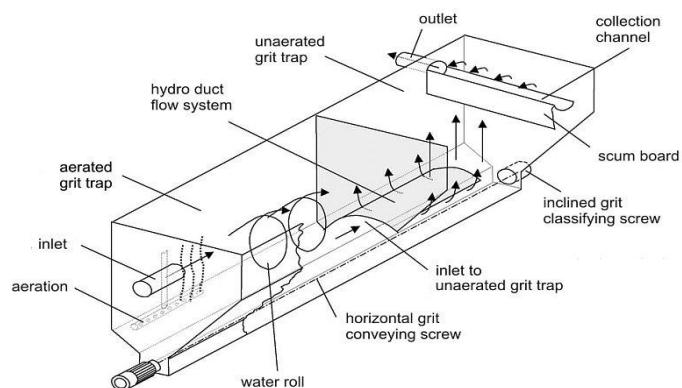
Horizontal Flow Circular Grit Chamber: In the horizontal flow circular type, the flow passes through the chamber in a horizontal direction and the straight-line velocity of flow is controlled by the dimensions of the unit, an influent distribution gate and a weir at the effluent end. The units are designed to maintain the horizontal velocity in between 0.25 – 0.4 m/s. These are normally designed to remove 95% of the 0.15mm diameter particle at peak flow.

Preliminary treatment | Grit chamber



Aerated grit chamber

- Spiral flow pattern
- Detention time at peak flow rate: 2 to 5 min
- Grit quantities: 0.004 – 0.20m³/10³ m³



Source: www.huber.de

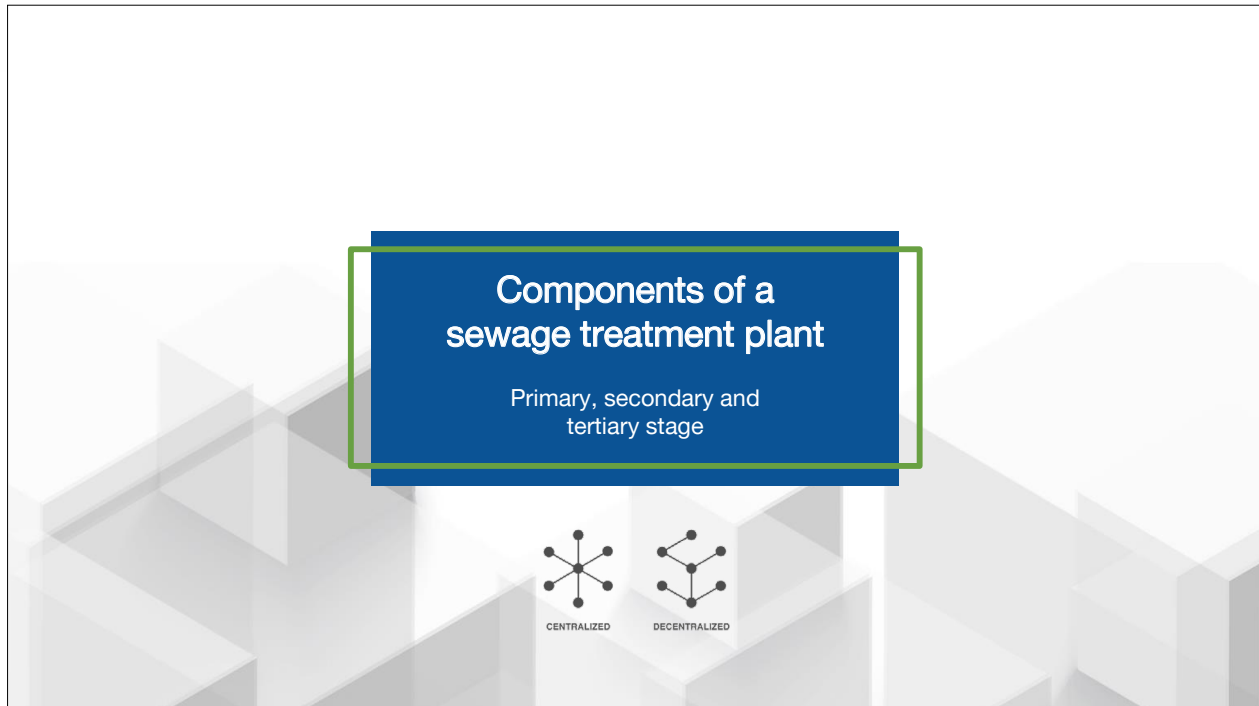
Aerated grit chamber: In aerated grit chambers, air is introduced along one side of a rectangular tank to create a spiral flow pattern perpendicular to the flow through the tank. The heavier grit

particles that have higher settling velocities settle at the bottom of the tank. Lighter, principally organic particles remain in suspension and pass through the tank. These chambers are normally designed to remove 0.21mm diameter or larger with 2 – 5min detention periods at peak hourly rate of flow.



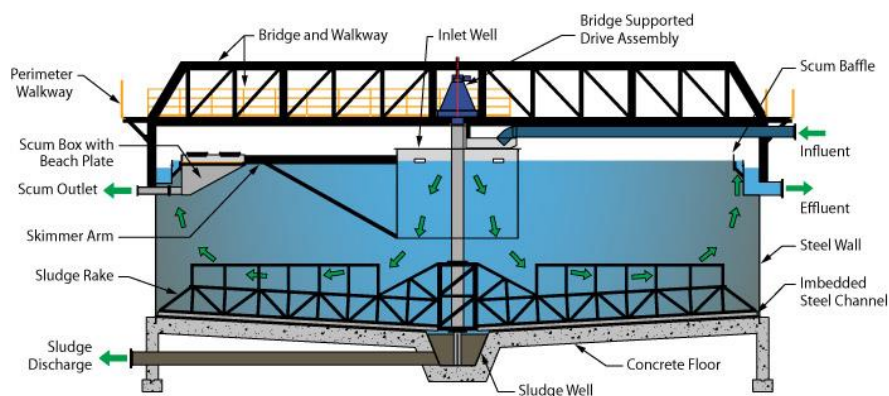
Vortex Grit Chamber: In the vortex grit systems shown in the slide, the wastewater enters and exits tangentially. These are designed to capture/arrest grit or other similar matter; with a Specific Gravity ≥ 2.65 . The rotating turbine maintains constant flow velocity and its adjustable pitch blades promote separation of organics from the grit. The grit settles by gravity into the hopper in one revolution of the basin's contents. Solids are removed from the hopper by grit pump or an airlift pump. These types of chambers are designed to handle peak flowrates up to 0.3 m³/s per unit

17.4 Components of a sewage treatment plant



Primary treatment | Primary clarifier

- Removes suspended solids
- Reduces organic load on secondary stage
- Mechanically cleaned
- Detention time upto 4 hrs
- TSS removal: 50-70%
- BOD removal: 25-40%



Application of Primary Clarifier:

- Inorganic suspended solids or grit if it is not removed in grit chamber described earlier
- Organic and residual inorganic solids, fat oil and grease and other floating material
- Chemical flocs produced during chemical coagulation and flocculation
- Mechanically cleaned tanks of standardized circular or rectangular design.

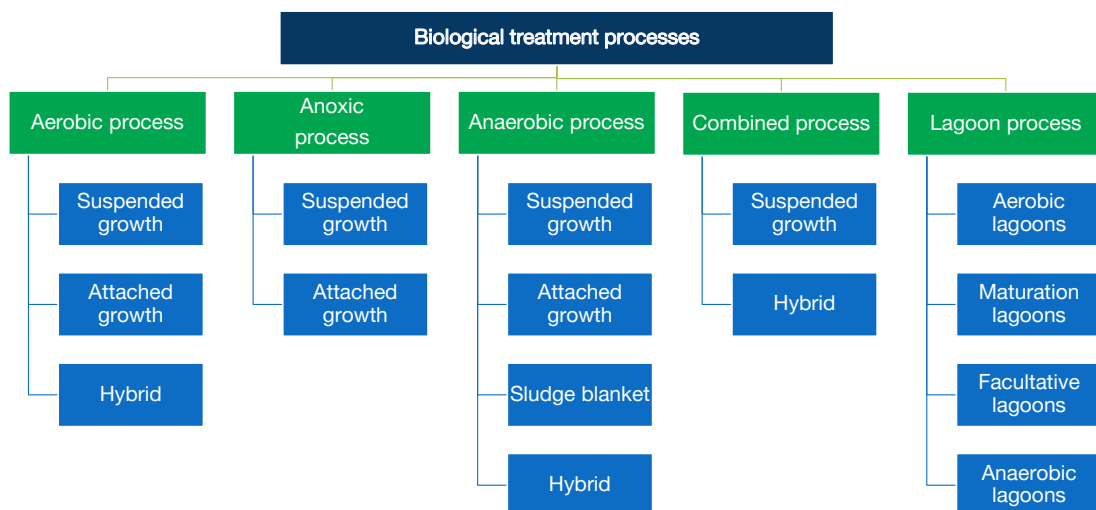
Secondary treatment



- Oxidises dissolved and particulate biodegradable constituents
- Capture suspended and non-settleable colloidal solids in biofloc or biofilm formation
- Remove nutrients such as nitrogen (N) and phosphorus (P)
- Remove trace organic constituents and compounds

The key objective of secondary treatment of wastewater is to oxidise the dissolved and particulate biodegradable constituents into acceptable end products. It also captures and incorporates the suspended and non-settleable colloidal solids into biological floc or biofilm form. In this treatment stage, we can transform or remove nutrients such as nitrogen & phosphorus and specific trace organic constituents and compounds.

Secondary treatment



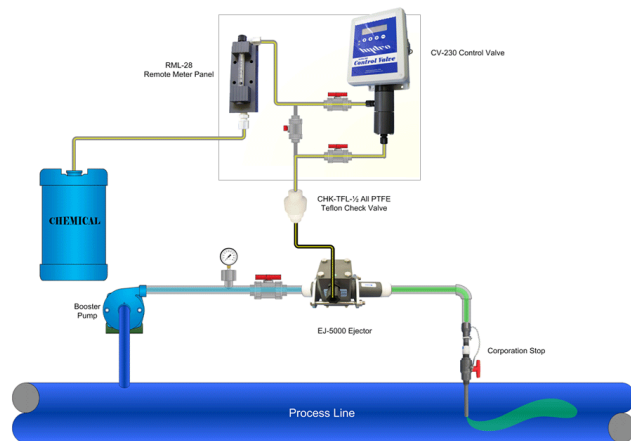
Benefits of Biological Treatment Processes:

- 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 stabilisation.**
- Combined processes provide carbonaceous BOD removal, nitrification, denitrification & **phosphorus removal.**

Tertiary treatment | Chlorination



- Provides prolonged treatment effect
- Eliminates obnoxious odour
- Residual chlorine is toxic to aquatic life
- Highly corrosive, hence, storage, shipping and handling of chlorine poses a health risk



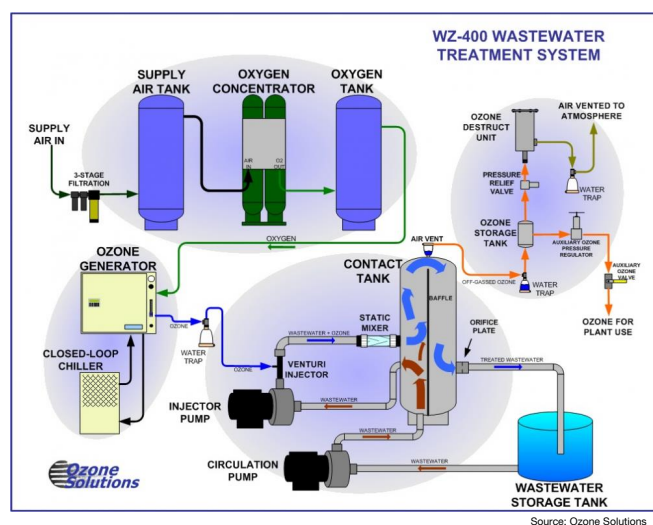
Chlorination is by far the most common method of wastewater disinfection and is used worldwide for the disinfection of pathogens before discharge into receiving streams, rivers or oceans. Chlorine is known to be effective in destroying a variety of bacteria, viruses and protozoa, including Salmonella, Shigella and Vibrio Cholera. Chlorination plays a key role in the wastewater treatment process by removing pathogens and other physical and chemical impurities.

Chlorine's important benefits to wastewater treatment are listed as follows: (a) Disinfection, (b) Controlling odour and preventing septicity, (c) Aiding scum and grease removal, (d) Controlling activated sludge bulking, (e) Controlling foaming and filter flies, (f) Stabilizing waste activated sludge prior to disposal, (g) Foul air scrubbing, and (h) Ammonia removal.

Tertiary treatment | Ozonation



- Infusion of ozone
- Sophisticated technical setup of equipment is required
- High efficiency of disinfection
- Relatively, high O&M cost
- Expensive than disinfection using chlorine



Source: Ozone Solutions

Disinfection of water using ozone is advantageous compared to more traditional methods, such as chlorine or UV disinfection. Ozone effectively breaks down the lipid layers in the cell membrane. Further, ozone is more effective at deactivating viruses and bacteria than any other disinfection treatment, while at the same time requiring very little contact time.

Tertiary treatment | Ultraviolet disinfection

- Cheapest disinfection option
- Does not involve handling of chemical/gases
- Least effective as it does not provide oxidation of certain contaminants

An ultraviolet (UV) disinfection system transfers electromagnetic energy from a mercury arc lamp to pathogenic organism’s genetic material (DNA and RNA). When UV radiation penetrates the cell wall of a pathogenic organism, it destroys the cell’s ability to reproduce. The effectiveness of the UV disinfection is depending on the characteristics of wastewater, the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation and the reactor configurations.

17.5 Layout of STP

Case study:

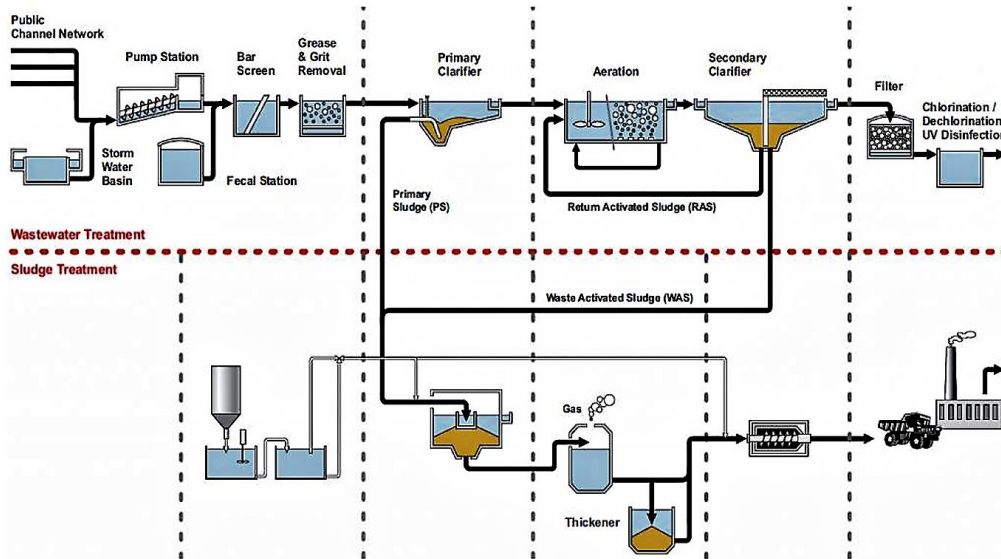
Process flow diagram of STP

Case study I: Activated Sludge Process (ASP)

Case study II: Trickling filter

Case III & IV: Decentralised wastewater treatment system and constructed wetlands

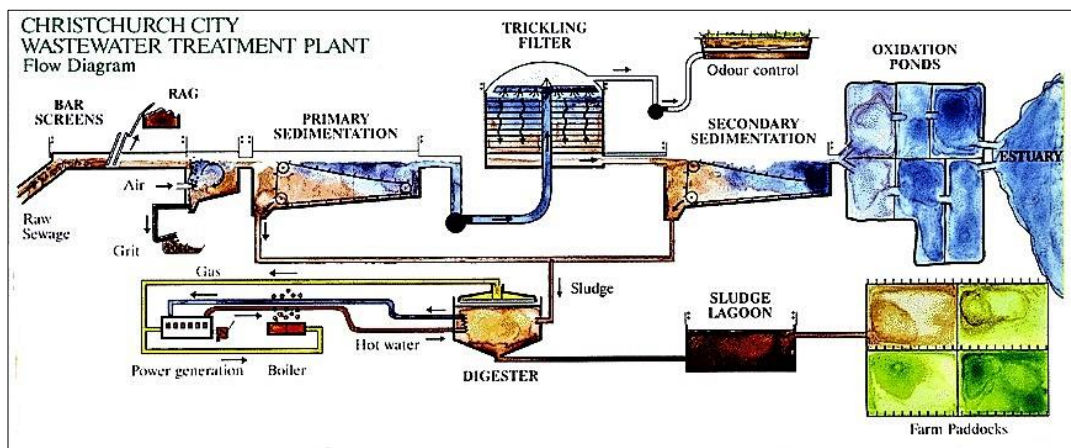
Activated Sludge Process (ASP)



Source: ENDRESS+HAUSER (2002)

The slide represents the flow diagram for activated sludge process-based sewage treatment plant. The upper part refers to the treatment of the wastewater and the lower half shows the treatment of sludge.

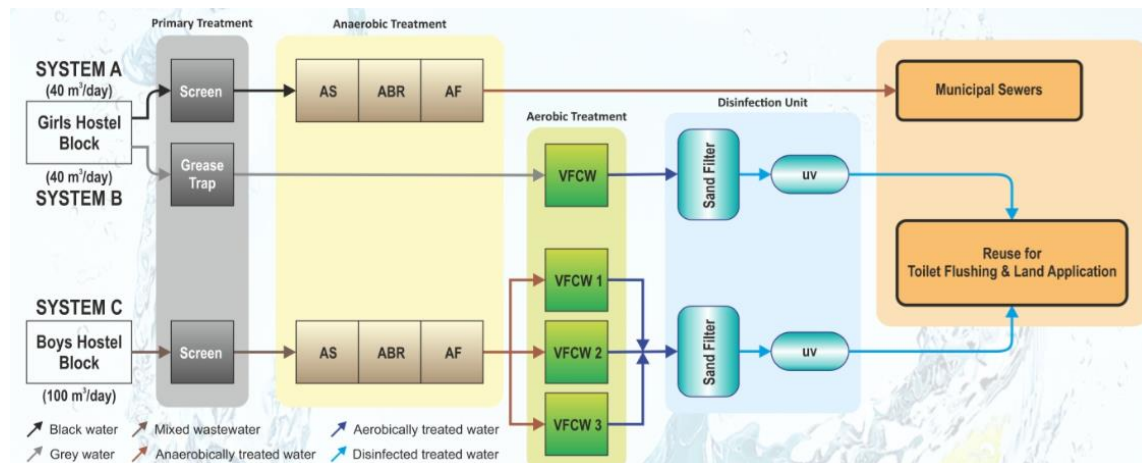
Trickling filter



Source: TOPRAK (2000)

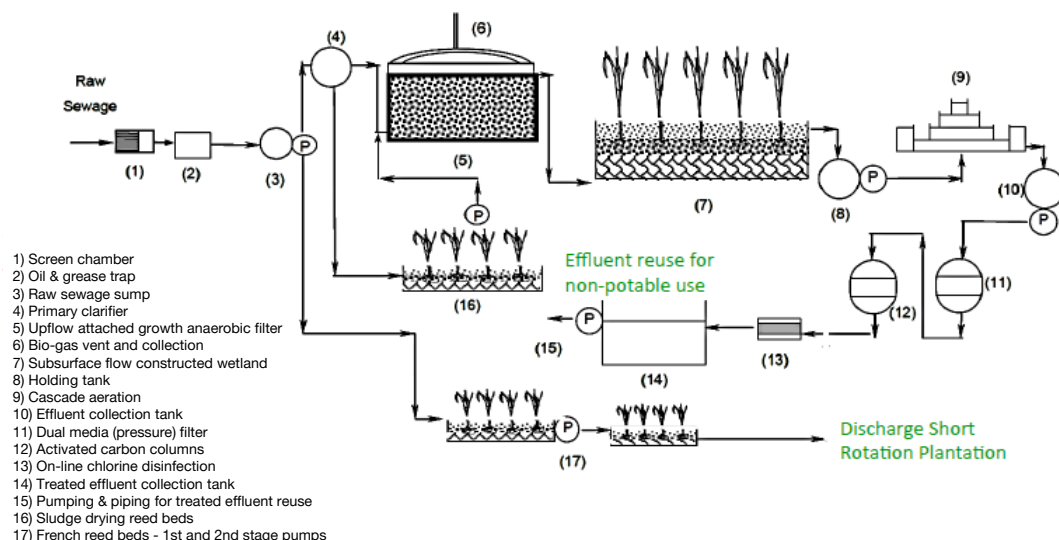
The slide represents the flow diagram for trickling filter-based sewage treatment plant. The upper part refers to the treatment of the wastewater and the lower half shows the treatment of sludge.

Decentralised Wastewater Treatment System (DWTS)



The slide here represents a decentralised wastewater treatment system (DEWATS). In this case there are three smaller sub systems. System A caters to blackwater. After anaerobic treatment consisting of anaerobic settler, anaerobic baffled reactor and anaerobic filter, the wastewater is disposed into the municipal sewers. System B caters to grey water using a vertical flow constructed wetland. After treatment the wastewater is disinfected using dual media filter followed by UV. System C caters to the sewage and is given anaerobic and aerobic treatment. Post disinfection, the water from systems B and C is reused for toilet flushing and gardening.

Constructed wetlands



The slide represents another decentralised wastewater treatment system of design capacity 100 KLD based on anaerobic up flow growth reactor and French reed bed system for treating the raw sewage directly. The sludge produced in the anaerobic treatment was treated using planted drying beds. A decentralised wastewater treatment system hence can be mechanised with pumps, blowers etc., and does not essentially mean DEWATS which is completely natural without requiring electricity for treatment.

Summary

- Objectives of wastewater treatment should be clearly understood before considering different options for treatment
- Wastewater treatment technologies consist of different components
- In case of an FSTP, design of secondary treatment units need to be tweaked individually for liquid effluent treatment
- Nitrification, denitrification and aerobic treatment is needed order to achieve high standards of treatment



Session

18

Wastewater Treatment Technologies

18. Wastewater Treatment Technologies

Learning objectives

- To have a detailed understanding of the secondary treatment stage in a wastewater treatment system, its types, and working of each type
- To understand the selection criteria for wastewater treatment technologies

Contents

Secondary treatment

Non-mechanised treatment systems

- DEWATS
- Waste stabilisation pond
- Advanced integrated pond
- Soil bio-technology (SBT)

Selection criteria

Mechanised treatment systems

- Activated sludge process (ASP)
- Upflow anaerobic sludge blanket (UASB) reactor
- Sequential batch reactor (SBR)
- Moving bed biofilm reactor (MBBR)
- Membrane bioreactor (MBR)

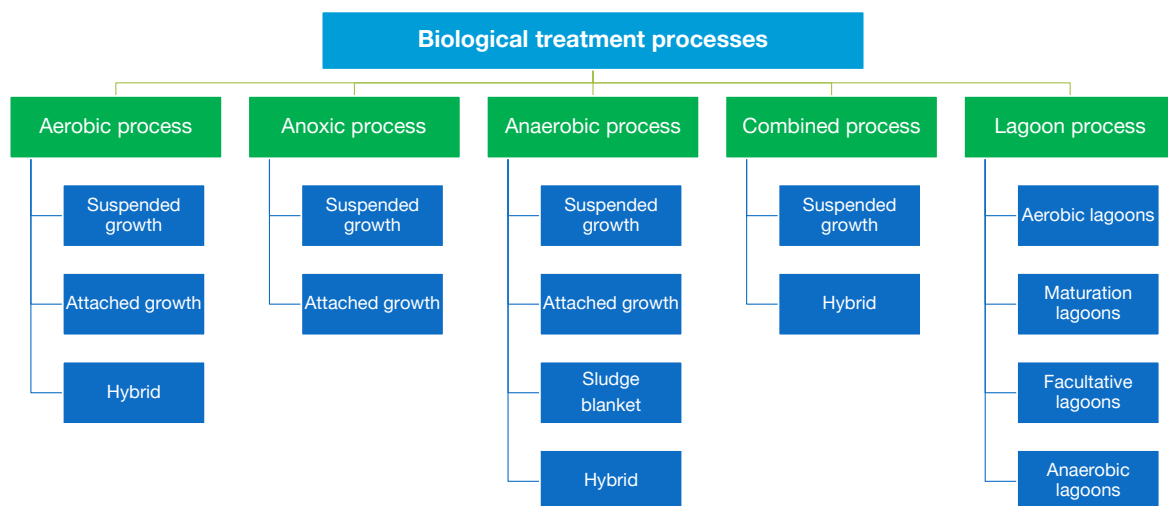
Objectives of secondary treatment

- Transform (oxidise) dissolved and particulate biodegradable constituents into acceptable end products
- Capture and incorporate suspended and non-settleable colloidal solids into biological floc or biofilm
- Transform or remove nutrients such as nitrogen (N) and phosphorus (P)
- Remove specific trace organic constituents and compounds

The key objective of secondary treatment of wastewater is to oxidise the dissolved and particulate biodegradable constituents into acceptable end products. It also captures and incorporates the suspended and non-settleable colloidal solids into biological floc or biofilm form. In this treatment stage, we can transform or remove nutrients such as nitrogen & phosphorus and specific trace organic constituents and compounds.

18.1 Secondary Treatment

Secondary treatment



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 stabilisation.
- Combined processes provide carbonaceous BOD removal, nitrification, denitrification & phosphorus removal.

Selection of appropriate 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 stabilisation
- Combined processes provide carbonaceous BOD removal, nitrification, denitrification and phosphorus removal

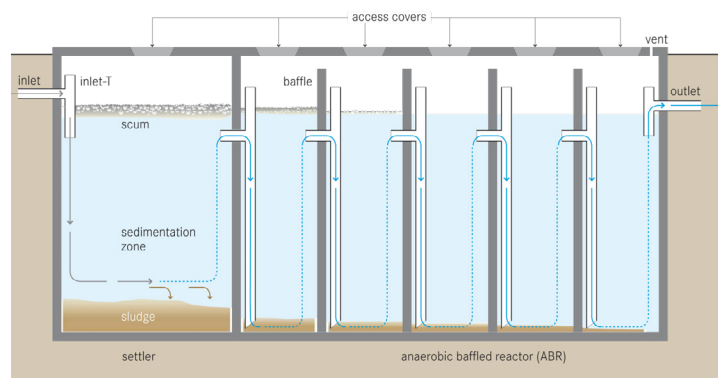
18.2 Non-mechanised Treatment System



Anaerobic Baffled Reactor (ABR)

ANAEROBIC SUSPENDED GROWTH BIOLOGICAL PROCESS

- Contact between wastewater and resident sludge
- BOD removal: 70 - 95%
- TSS removal: 80 - 90%
- Low pathogen reduction
- HRT: 1 to 3 days



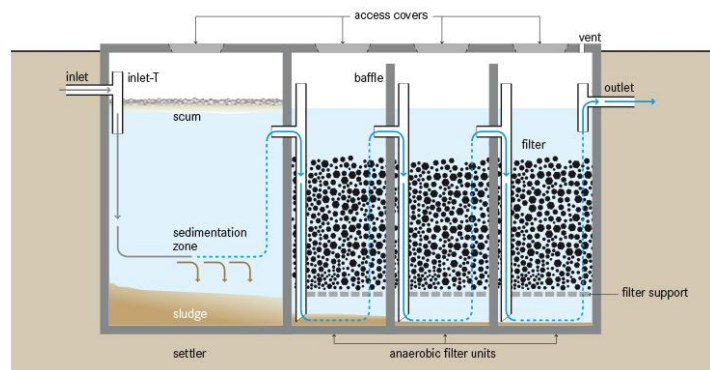
Source: TILLEY et al. (2014)

ABR is an improved version of the septic tank with multiple chambers having baffle pipes. Vertical baffles in the tank force the pre-settled wastewater to flow under and over the baffles guaranteeing contact between wastewater and resident sludge and allowing an enhanced anaerobic digestion of suspended and dissolved solids. It has at least 1 sedimentation chamber and 2–5 up-flow chambers.

Anaerobic Filter (AF)

ANAEROBIC ATTACHED GROWTH BIOLOGICAL PROCESS

- Reduces dissolved and non-settleable solids
- BOD removal: 50 - 90%
- TSS removal: 50 - 80%
- Reduction in total coliforms: 1 to 2 log units
- HRT: about 1 day



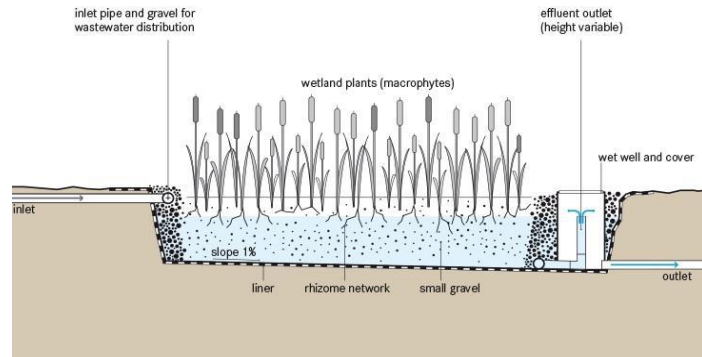
Source: TILLEY et al. (2014)

Anaerobic Filter (AF) consists of multiple chambers where baffle walls or pipes force the water to the bottom of the chamber and the water flows upwards while passing through the filter. AF is based on the attached growth micro-organisms. Dissolved and non-settleable solids are removed by anaerobic digestion through close contact with bacteria attached to the filter media.

Constructed wetlands

ATTACHED GROWTH HYBRID BIOLOGICAL PROCESS

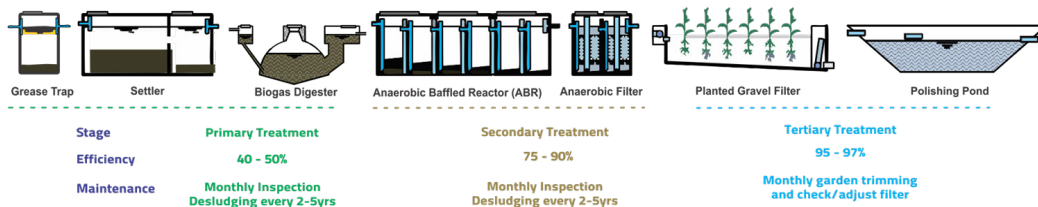
- Treatment through filtration and degradation
- Microbiological attachment, growth and transfer of oxygen.
- BOD removal = 80 - 90%
- TSS removal = 80 to 95%
- TN & TP removal = 15 - 45%
- Reduces fecal coliform to about ≤ 2 to 3 log



Source: TILLEY et al. (2014)

Constructed wetlands are where pre-treated grey or blackwater flows continuously and horizontally through a planted filter bed. Plants provide appropriate environments for microbiological attachment, growth and transfer of oxygen to the root zone. Organic matter and suspended solids are removed by filtration and microbiological degradation in aerobic, anoxic and anaerobic conditions. Constructed wetlands can be classified based on the flow of wastewater in the bed.

Decentralised wastewater treatment system

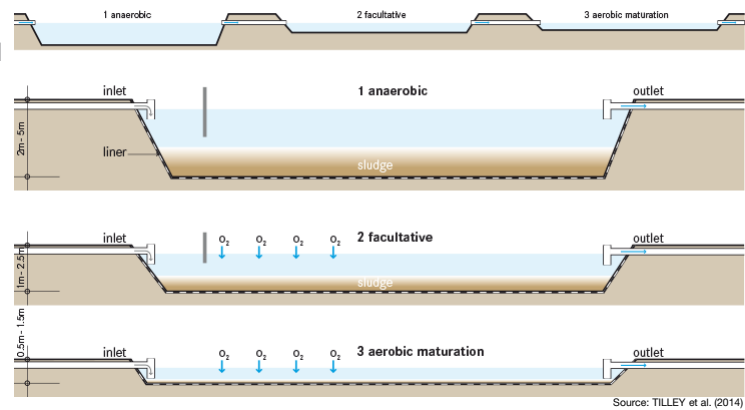


- An approach, rather than just a technical hardware package
- Suitable for treatment 1 – 500 KLD of wastewater
- Reliability, longevity and tolerance towards inflow fluctuation
- No sophisticated control and maintenance required
- Works without energy; cannot be switched off
- Guarantees permanent and continuous operation
- Not the best solution everywhere!
- Suitable where skilled and responsible operation and maintenance cannot be guaranteed

Waste stabilisation ponds

LAGOON BIOLOGICAL PROCESS

- Treatment through physical (sedimentation) and biological processes
- High pathogen reduction and relatively high removal of nitrogen as NH_3 and phosphorus
- BOD & TSS removal: 90%
- HRT: 20 to 60 days



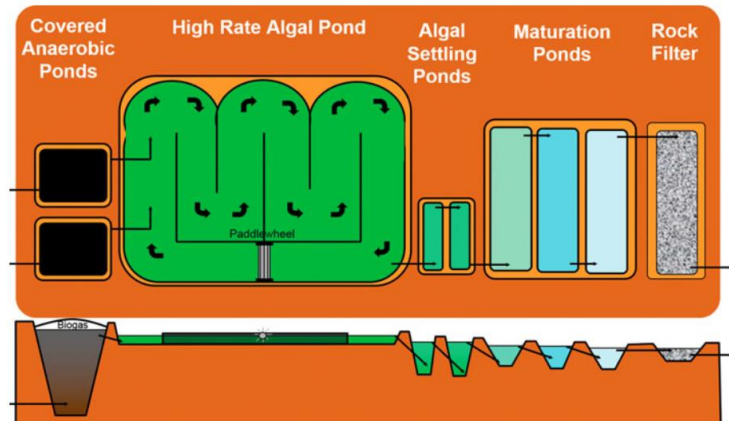
Waste stabilization ponds (WSPs) are large man-made basins in which greywater, blackwater or faecal sludge can be treated to an effluent of relatively high quality and which is apt for reuse in agriculture or aquaculture. For the most effective treatment, WSPs should be linked in a series of three or more with effluent being transferred 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 man-made lake is anaerobic. Solids and BOD removal occurs by sedimentation and through subsequent anaerobic digestion inside the accumulated sludge. 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 at the bottom of the pond. The aerobic and anaerobic organisms work together to achieve BOD reductions of up to 75%.

Advanced integrated ponds

COMBINED HYBRID BIOLOGICAL PROCESS

- Biogas recovery is possible
- Algae is used for fertiliser recovery
- BOD, TSS & NH₃ removal: 90 to 100%
- N removal: 60 to 90 %
- P removal: 60 to 100 %
- Reduction in *E. coli*: 6 log units



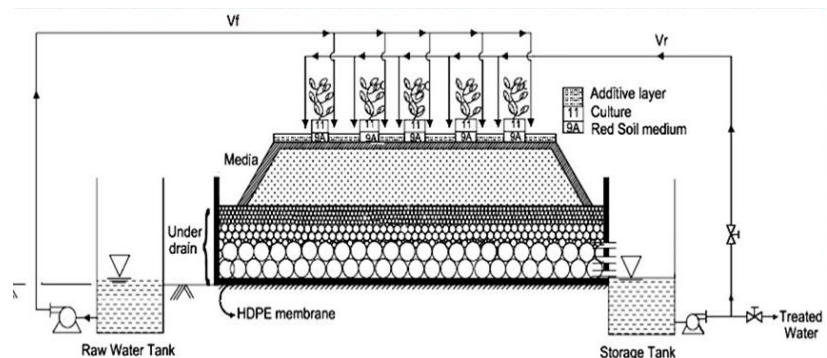
Source: Craggs et al. (2014)

Advanced integrated wastewater pond systems (AIWPS), advanced integrated pond systems (AIPS) or advanced integrated ponds (AIPs) are an adaptation of waste stabilisation pond (WSP) systems based on a series of four advanced ponds: (1) An advanced facultative pond (AFP) containing a digester pit, which functions much like an anaerobic pond; (2) A high rate pond (HRP) covered with algae, similar to the facultative pond, which provide oxygen to aerobic bacteria for BOD oxidation and take up nutrients and further organics; (3) An algal settling pond (ASP); (4) A maturation pond (MP) for solar disinfection and pathogen abatement. The effluent from the MP can be reused for agriculture or aquaculture and the nutrient rich algae can be applied as fertilizer or used as animal feed.

Soil bio-technology

COMBINED HYBRID BIOLOGICAL PROCESS

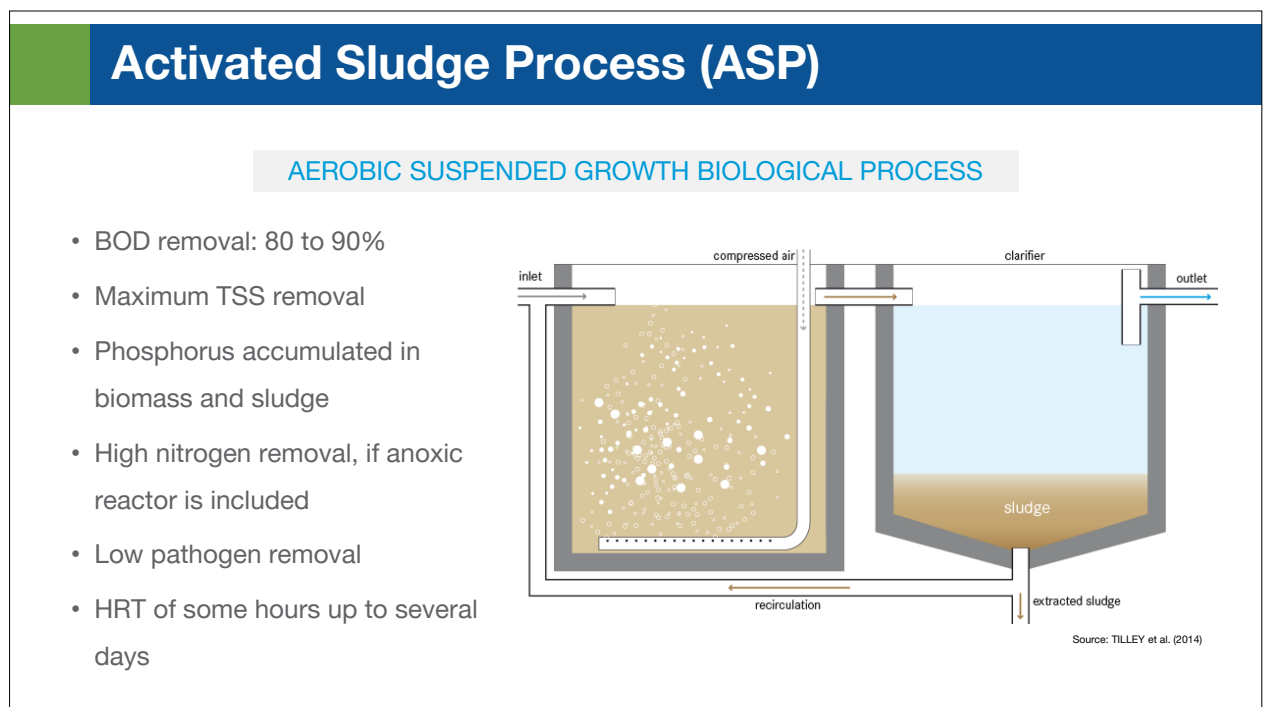
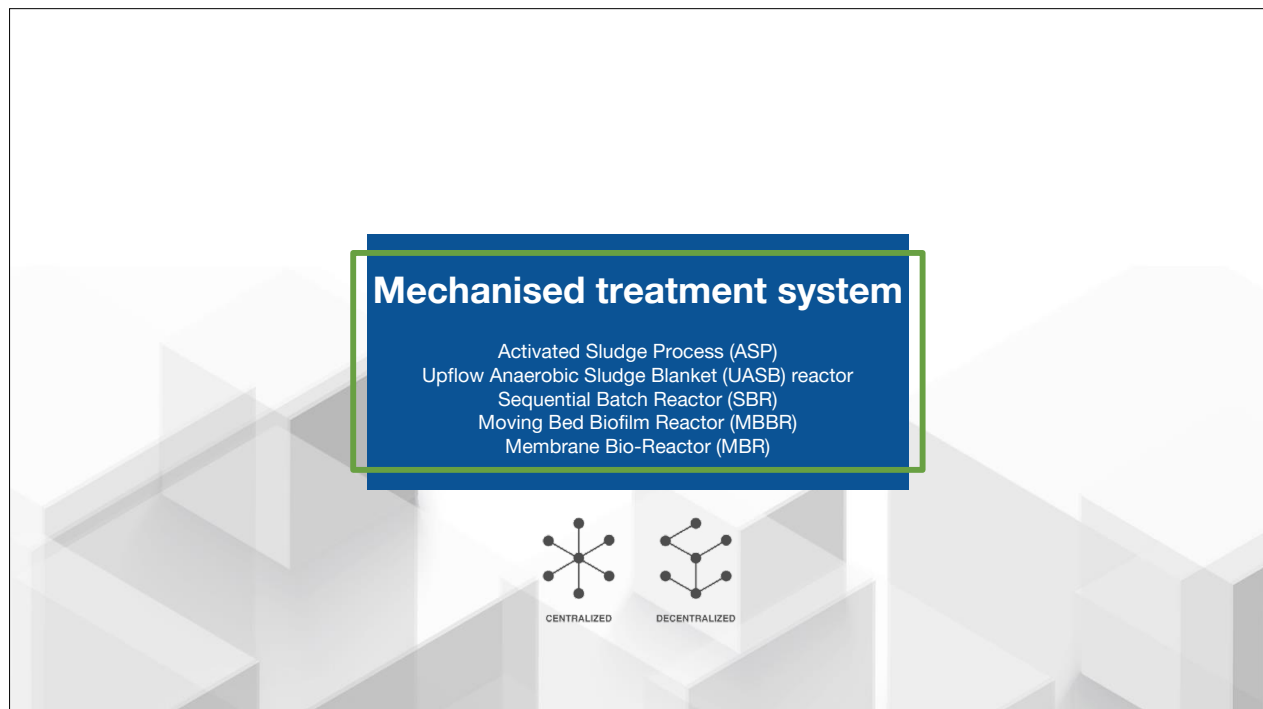
- Treatment through filtration and degradation processes
- Microbiological attachment, growths and transfer of oxygen.
- After treatment
COD < 50 mg/L
BOD < 10 mg/L
TSS < 10 mg/L



Source: www.sugam.in

Soil bio-technology is a terrestrial system for wastewater treatment which is based on the principle of trickling filter. In this system, combination of physical processes like sedimentation, infiltration and biochemical processes are carried out to reduce the suspended solids, organic and inorganic contents of the wastewater. Suitable mineral constitution, culture containing native micro-flora and bio-indicator plants are the key components of the system. It is also known as Constructed Soil Filter (CSF). SBT systems are constructed from RCC, stone-masonry or soil bunds.

18.3 Mechanised Treatment System

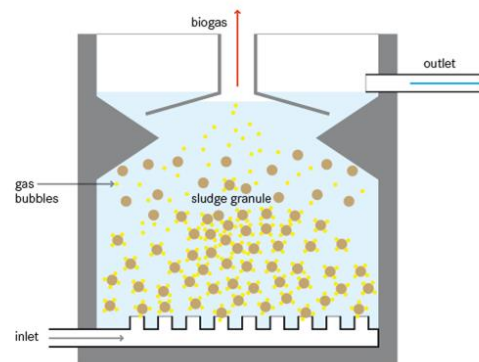


An activated sludge process is where wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of the organic matter is synthesized into new cells and a part is oxidized to CO₂ and water to derive energy. In activated sludge systems, the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks. A part of this settled biomass, described as activated sludge, is returned to the aeration tank and the remaining forms waste or excess sludge.

Upflow Anaerobic Sludge Blanket (UASB) reactor

ANAEROBIC SUSPENDED GROWTH BIOLOGICAL PROCESS

- Recovery of biogas.
- Needs continuous and stable water flow and energy.
- BOD & COD: 60 to 90%
- TSS: 60 to 85%
- Low pathogen reduction and minimal removal of nutrient
- HRT: Min 2 hrs, 4 - 20 hrs



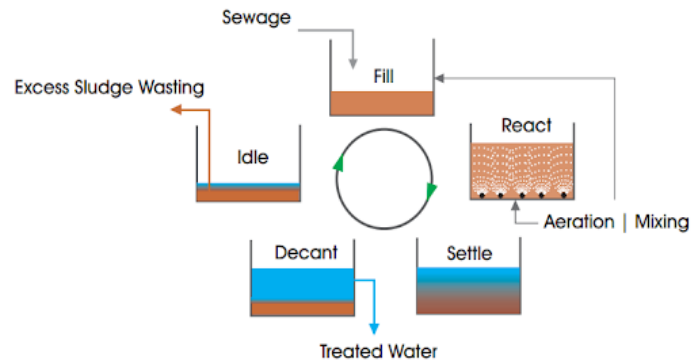
Source: TILLEY et al. (2014)

Industrial wastewater or blackwater flows into the bottom of an anaerobic upflow tank. Accumulated sludge forms granules. Micro-organisms living in the granules degrade organic pollutants by anaerobic digestion. The sludge blanket is kept in suspension by the flow regime and forms gas bubbles. A separator at the top of the reactor allows recovery of biogas for energy production, nutrient effluent for agriculture and to retain the sludge in the reactor.

Sequential Batch Reactor (SBR)

AEROBIC SUSPENDED GROWTH BIOLOGICAL PROCESS

- Batch process consisting of 4 to 5 steps
- Flexibility of treatment
- BOD, COD and TSS removal is up to 90%
- Nitrogen removal is possible, if anoxic reactor is integrated
- Phosphorus removal is high



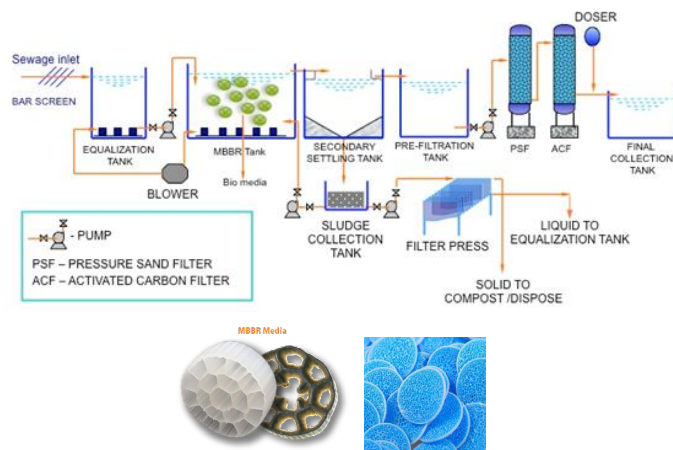
Source: Ethics Infinity Pvt. Ltd.

A sequencing batch reactor is a fill-and-draw activated sludge system for wastewater treatment. Oxygen is bubbled through the wastewater to reduce biochemical oxygen demand (BOD) and chemical oxygen demand (COD), producing a high-quality effluent with a low turbidity and nitrogen levels. The SBR accomplishes equalisation, aeration, and clarification in a timed sequence in a single reactor basin. By varying the operating strategy, aerobic, anaerobic, or anoxic conditions can be achieved to encourage the growth of desirable micro-organisms.

Moving Bed Biofilm Reactor (MBBR)

AEROBIC ATTACHED GROWTH BIOLOGICAL PROCESS

- Biological treatment with floating media and aeration
- Specific surface area of media: 300 to 4000 m²/m³
- Suitable for treatment of weak strength of wastewater
- BOD and P removal: 80 - 90%
- Low pathogen removal




Source: www.ecomena.org/

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

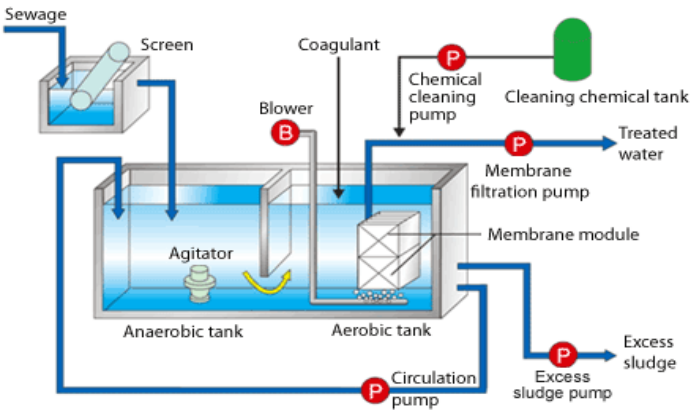
increased surface area for the biological microorganisms to attach and grow. The increased surface area reduces the footprint of the tanks required to treat the wastewater. The treatment process can be aerobic and/or anaerobic and operates at high volume loads.

Membrane Bio-Reactor (MBR)



AEROBIC SUSPENDED GROWTH BIOLOGICAL PROCESS

- Biological treatment coupled with membrane filtration
- Minimal area requirement
- High O&M cost
- High performance efficiency and consistency
- BOD, COD, TSS, nutrients removal: > 90%



Source: www. ecphubconsult.com

The Membrane Bioreactor or MBR is based on the conventional wastewater process, but the separation of micro-organisms is performed by filtration with membranes. The MBR has some distinctive advantages compared with the conventional treatment systems: (1) Very compact design, (2) High quality effluent, and (3) Low sludge production.

18.4 Selection Criteria

Selection criteria

Checklist for selection
 Technology comparison
 Life cycle cost of wastewater treatment

Checklist for 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

In this slide, the parameters or factors are listed which have to be considered for the selection of appropriate wastewater treatment technology.

Technology comparison

Technology	Land area (m ² /KLD)	Energy requirement (KWh/KL)	CAPEX	OPEX
DEWATS	4.0	-	High	Low
Waste Stabilisation Ponds	12.0	-	Moderate	Low
Activated Sludge Process (ASP)	3.5	0.25	Moderate	High
Trickling Filter	5.0	0.20	Moderate	Moderate
UASB Reactor	2.5	0.02	Moderate	Moderate
Moving Bed Biological Reactor (MBBR)	2.0	0.20	Moderate	High
Sequential Batch Reactor (SBR)	1.5	0.20	Moderate	High
Membrane Bio-Reactor (MBR)	1.0	0.30	High	Moderate

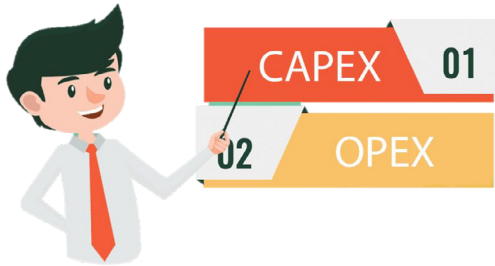
Source: Majumdar A. (2018)

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 mechanised treatment technologies.

Other parameters

Focus on life cycle cost of the project derived in terms of cost of treated water over the period of its design life period.

Sewage treatment plants are usually designed for 15 years of continuous operation.



- When you pay too much, you may lose a little money
- If you pay too little, you may lose everything

Spend a bit more money up front to reduce the operating and maintenance costs

This slide includes the other parameters which needs to be considered while selection of the technologies like capital expenditure, operational expenditure and life cycle cost of the project.

Summary

- Secondary treatment stage is the most important stage in wastewater treatment
- Various combinations of treatment processes take place in the secondary stage for achieving the discharge or reuse standards
- Non-mechanised and mechanised options are possible for wastewater treatment
- Capital cost of the project should not be the driving principle for selection of wastewater treatment technology

Session

19

Case Studies of Sewage Treatment Plants & Faecal Sludge Treatment Plants in India

19. Case Studies of STPs & FSTPs in India

Learning objectives

- In this session participants will be introduced with different case studies of STPs and FSTPs in India and gather key takeaway messages
- Gather information regarding the components and treatment units adopted in STPs and FSTPs in India

Contents

Case studies in India

- Sewage treatment plants (STP)
- Faecal sludge treatment plants (FSTP)

19.1 STP in India

STP in India

- COEP Hostel Campus, Pune (Decentralised)
- Ordinance Factory, Nagpur (Decentralised)
- Sewage Treatment Plant, Erandwane, Pune (Centralised)

COEP Hostel Campus, Pune

Type of project

Greywater segregation, wastewater treatment and reuse for toilet flushing and gardening

Beneficiaries served

Approx. 2000 students + personnel

Plant capacity

140 KLD wastewater & 35 KLD greywater

Executing institution

Ecosan Services Foundation, Pune

Type of project:

Greywater segregation, wastewater treatment and reuse in an urban area (College of Engineering, Pune Hostel Campus) with anaerobic treatments and constructed wetlands, full-scale demonstration project.

Project period:

- Start of construction: May 2014
- End of construction: June 2015
- Start of operation: June 2015
- Ongoing monitoring period planned for: 6 months
- Project end: December 2015

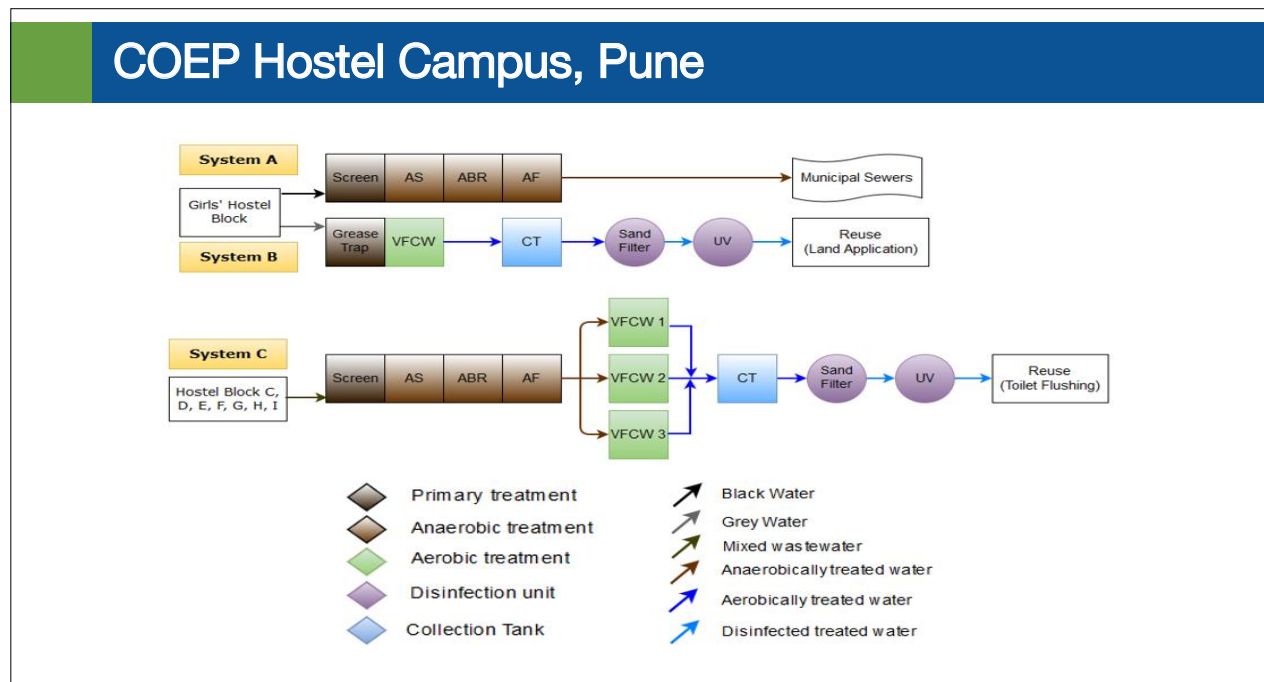
Project scale:

- Number of people covered: max. 1500 students + personnel
- Size of treatment plant: 175 m³
- Plant capacity: 140 m³ of wastewater, 35 m³ of greywater
- Total investment (in EUR): 160,000 (about Rs. 1.4 crore)

Address of project location: COEP Hostel Campus, Pune, Maharashtra, India

Planning institution: NAWATECH consortium (www.nawatech.net)

Executing institution: College of Engineering Pune (COEP)



The slide here represents a decentralised wastewater treatment system (DEWATS). In this case there are three smaller sub systems. System A caters to black water. After anaerobic treatment consisting of anaerobic settler, anaerobic baffled reactor and anaerobic filter, the wastewater is disposed into the municipal sewers. System B caters to greywater using a vertical flow constructed wetland. After treatment the wastewater is disinfected using dual media filter followed by UV. System C caters to the sewage and is given anaerobic and aerobic treatment. Post disinfection, the water from systems B and C is reused for toilet flushing and gardening.

COEP Hostel Campus, Pune



Anaerobic Treatment



Vertical Wetland



UV + Disinfection

Ordinance Factory Colony, Nagpur

Type of project

Wastewater treatment with sludge drying reed bed for sludge mineralisation

Beneficiaries served

Approx. 1000 P.E.

Plant capacity

100 KLD

Executing institution

NEERI, Nagpur

Type of project:

The NaWaTech project aims to optimise the use of different urban water flows by treating each of these flows via modular natural systems appropriated to urban and peri-urban areas of India. The system considered in this case study is located in the Ordnance Factory Ambajhari (OFAJ), Nagpur, in the state of Maharashtra, India. It provides sewage management for at least 1,000 population equivalent (PE). It consists of a main treatment line (anaerobic pre-treatment and horizontal flow constructed wetland (HF-CW) as well as a sludge drying reed bed for sludge mineralization generated from the primary clarifier) and a pilot line with a French type constructed wetland system and a short rotation plantation (SRP). It provides water for a multipurpose lawn to prevent the use of fresh water in gardening.

Project period:

- Start of construction: September 2014
- End of construction: November 2015 (estimated)
- Start of operation: December 2015 (estimated)
- Ongoing monitoring period planned for: Seven months
- Project end: June 2016

Project scale:

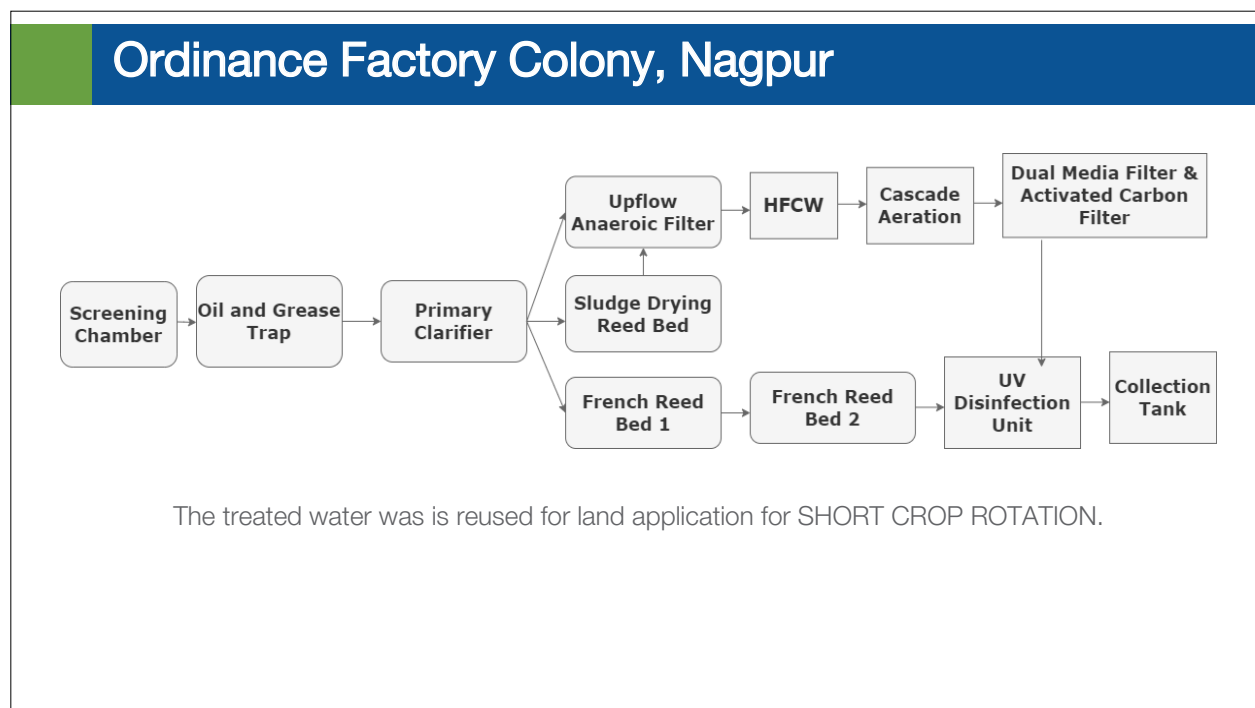
- Number of people covered: 1,000 PE
- Water flow: 100 m³/day
- Total investment (in EUR): 94,900 € for capital and O&M for one year (about Rs. 80 lakh)

Address of project location: Ordnance Factory Ambajhari (OFAJ), Nagpur, Maharashtra, India

Planning institution: NaWaTech consortium (www.nawatech.net)

Executing institution: National Environmental Engineering Research Institute (NEERI, Nagpur)

Supporting agencies: Department of Science and Technology (DST), Government of India; Ordnance Factory Ambajhari (OFAJ), Nagpur, Govt. of India; European Commission (7th Framework Programme).



The slide represents a decentralised wastewater treatment of design capacity 100 KLD based on anaerobic up flow growth reactor and French reed bed system for treating the raw sewage directly. The sludge produced was treated using planted drying beds. A decentralised wastewater treatment system hence can be mechanised with pumps, blowers etc., and does not essentially mean DEWATS which is essentially completely natural without requiring electricity for treatment.

Ordinance Factory Colony, Nagpur



This slide includes the photos of the wastewater treatment system at the project location, Nagpur.

STP – Decentralised Amanora Township, Pune

Type of project

Wastewater treatment and reuse for toilet flushing and gardening with MBR and SBR technologies

Beneficiaries served

Approx. 300 P.E.

Plant capacity

SBR - 10 KLD and MBR - 30 KLD

Executing institution

ESF, Pune

- Number of people covered: 200-300 population equivalent (PE)
- Size of treatment plant: 52 m² of land footprint (including housing for the equipment)
- Wastewater is treated in a SBR (10 m³/day) and in an MBR (30 m³/day)
- Type of reuse: gardening and flushing
- Energy supply: 380 V/3 Phases/50 Hz

Erandwane STP, Pune

Type of project

Centralised Wastewater treatment system with Activated Sludge Process (ASP) Technology

Beneficiaries served

Approx. 5 Lakh P.E. (Erandwane, Kothrud Area)

Plant capacity

ASP - 50 MLD

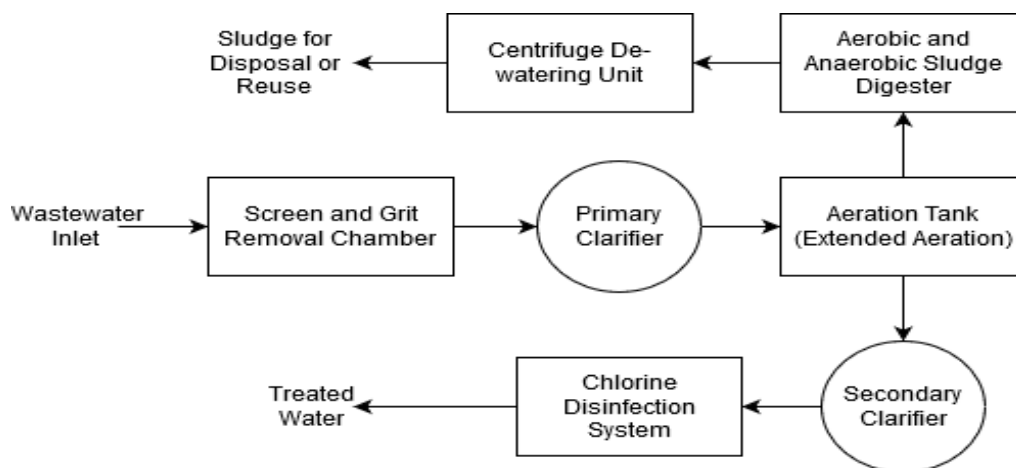
Executing institution

Pune Municipal Corporation, Pune

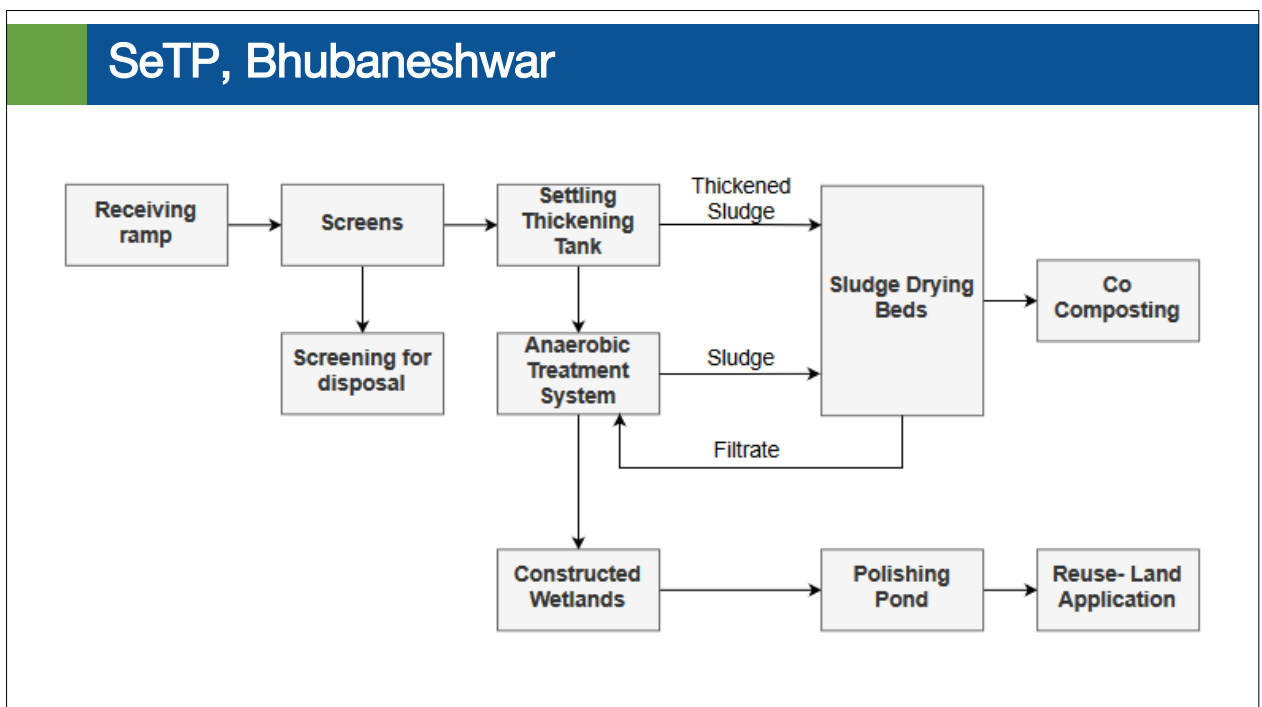


- Number of people covered: 200-300 population equivalent (PE)
- Size of treatment plant: 52 m² of land footprint (including housing for the equipment)
- Wastewater is treated in an SBR (10 m³/day) and in an MBR (30 m³/day)
- Type of reuse: Gardening and flushing
- Energy supply: 380 V/3 Phases/50 Hz

Erandwane STP, Pune



19.2 FSTP in India



The city of Bhubaneshwar has planned for sewerage sanitation system, however, until the sewerage network and STP is developed, Odisha Water Supply and Sewerage board installed a SeTP with design capacity of 75 KLD. The treatment chain is elaborated in the slide above. The plant treats the solids and liquid completely and has been designed as a zero liquid discharge plant. The bio-solids are reused for plantation around the plant and the liquid is also completely utilised in and around the plant to maintain the green spaces.

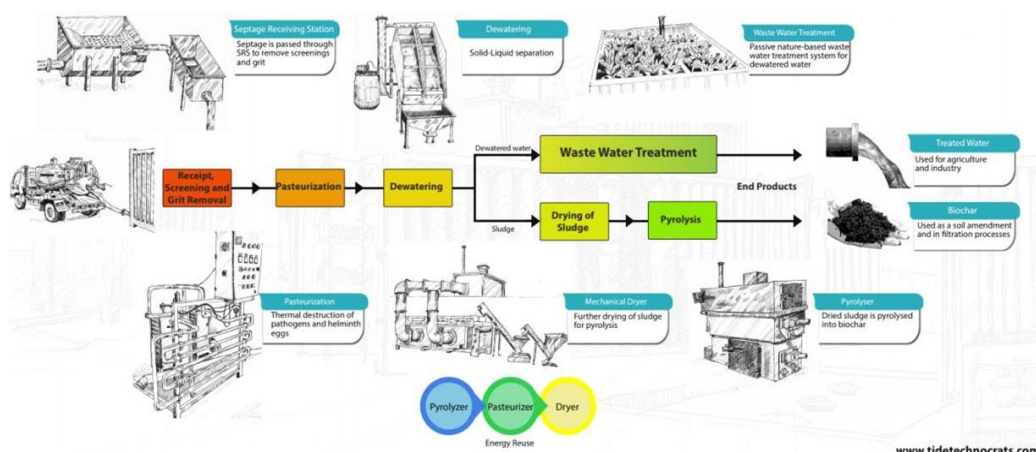
SeTP, Bhubaneswar



Source: Dhawal Pati, ESF

After the receiving ramp, the septage is emptied into the screen chamber, which segregates the solid waste from the septage. The septage then flows into the settling thickening tank (STT) where the solid-liquid separation happens and the sludge undergoes thickening process. The thickened sludge is then pumped to the sludge drying beds for further dewatering and drying. The dried solids are then co-composted with the organic waste (dry waste from the lawn and plants in the SeTP premise). The liquid from the STT flows under gravity to the anaerobic treatment (anaerobic settler, anaerobic baffled reactor and anaerobic up flow filter) followed by aerobic treatment in constructed wetlands. Finally, the clarified water comes to polishing pond where it is disinfected and kept aerated using cascade aeration.

FSTP, Wai



- Capacity: 70 KLD
- Area of installation: 19,602 sq.ft.
- Inlet: Faecal Sludge and Septage (FSS)
- Outlet: Treated water and biochar
- Year of Installation: 2018
- Capital investment: Rs. 1.8 Crores
- Scale of service: City-wide coverage of 8500 HH approx. within municipal boundary
- Treatment time: 12 hrs
- C.O.D. (outlet): 34-80 ppm
- B.O.D. (outlet): 18-24 ppm

System description

In Wai, septic tanks of household toilets are emptied by a private contractor (Sumeet Facilities Pvt. Ltd.), and septic tanks of community and public toilets are emptied by WMC's vacuum tankers. The collected faecal sludge and septage is taken to the 70 KLD treatment facility consisting of the following components:

- Septage receiving station
- Holding tank
- Dewatering unit
- Pasteurization unit
- Dryer and pyrolysis unit
- Wastewater treatment unit

Pyrolyzation of septage with a limited oxygen supply destroys all pathogens present in excreta, and provides fast volume and mass reduction, a net energy output (heat and electricity) and a usable end product in the form of biochar is produced. Biochar provides excellent soil enrichment when used with compost. The treated liquid from the treatment plant is used for landscaping within the premise and for washing vacuum tankers and solid waste collection vehicles.



FSTP – Narsapur



The faecal sludge management plant in Narsapur is being developed as a sanitation resource park on 1 acre of land which was gifted to the municipality by one of its residents. The plant on its own stands on 0.4 acres of land.

Key Features of the treatment plant:

- 15 KLD Capacity
- Remote monitoring capability
- Bio-safe process in a modular/ scalable configuration
- Quick setup
- All weather systems
- Process Output: Treated Water for agriculture, urban greening and industry. Biochar can be used as a soil supplement and in filtration process.

FSTP – Warangal



Source:-cdn.cseindia.org

FSTP at Warangal was commissioned in 2017 having a capacity of 15 KLD. Different subsystems are integrated together to treat the faecal sludge which includes both civil and electromechanical components. The system comprises of components such as septage receiving station with screenings and grit chambers, pasteurization unit, solid-liquid separation, dryer, pyrolizer, heat exchanger and dewatered effluent treatment system. These different subsystems integrated together form a complete plant that can process faecal sludge to biochar.

Case Study - Videos

- [Faecal Sludge Management – Jhansi](#)
- [Faecal Sludge Treatment Plant - Bhubaneshwar](#)
- [Faecal Sludge Management – Devanhalli](#)
- [Faecal Sludge Management – Wai](#)

- [Sewage Treatment Plant, Sarai-Haridwar](#)
- [Energy Neutral Waste Water Treatment Plant -Kodungaiyur, Chennai](#)

Download our latest reports, research briefs
and training modules at:

scbp.niua.org

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.



National Institute of Urban Affairs

National Institute of Urban Affairs

1st Floor, Core 4B, India Habitat Centre, Lodhi Road, New Delhi - 110003

Phone: 011-24617517, 24617543, 24617595, Fax: 011-24617513

E-mail: niua@niua.org • Website: www.niua.org, scbp.niua.org

Integrated Wastewater and Septage Management- Planning Module

Part A: Presentation Slides