सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India

Training Module on
Used Water and Septage Management

Sustainable Cities Integrated Approach Pilot in India

gef

UNIDO
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

NIUA
National Institute of Urban Affairs

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CONTENT

The given module is prepared by compiling information sourced from various knowledge products and training modules prepared by Ministry of Housing and Urban Affairs (MoHUA), National Institute of Urban Affairs (NIUA) and Central Public Health and Environmental Engineering Organization (CPHEEO) for knowledge dissemination and capacity building of municipal officials.

THE FULL MODULE SHOULD BE REFERENCED AS FOLLOWS

NIUA (2022) “Training Module on Used Water and Septage Management”. Text from this report can be quoted provided the source is acknowledged.

**Note- In this module Used Water is referred to as Wastewater*

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BASIC PROJECT INFORMATION

Project Title	Sustainable Cities Integrated Approach Pilot in India
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Project Deliverable	Delivery of tailored training and capacity building activities in 5 pilot cities – Bhopal, Guntur, Jaipur, Mysuru and Vijayawada
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Duration of Project	2 Years
About this Module	This module is a part of the second deliverable for the project to provide training modules for three sectors.

ABOUT THE PROJECT

"Sustainable Cities Integrated Approach Pilot in India" is one of the child projects under GEF's Sustainable Cities Programme in the GEF 6 cycle. The aim of the project is to integrate sustainability strategies into urban planning and management to create a favourable environment for investment in infrastructure and service delivery, thus building resilience of pilot cities. The three main project components comprise- Sustainable Urban Planning and Management, Investment Projects and Technology Demonstration and Partnerships and Knowledge Management Platform.

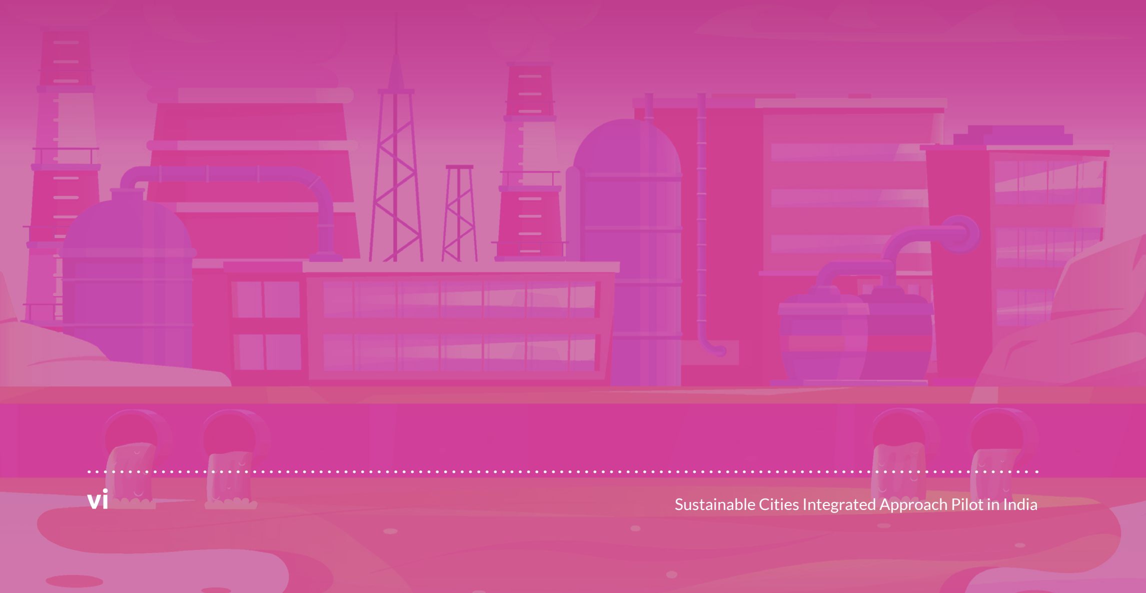
National Institute of Urban Affairs (NIUA) has been engaged to undertake the implementation of Component 3 – Partnerships, Knowledge Management and Capacity Building. As a part of this component of the Project, a Training and Assistance Needs Assessment (TANA) was conducted from February 2020 to August 2020 for the ULBs of five cities - Bhopal, Jaipur, Mysuru, Vijayawada and Guntur to assess and identify the needs of the ULB officials to prepare on-the-job training modules.

ABOUT THE TRAINING MODULE

Based on the results of TANA, training modules on Solid Waste, Wastewater and Water Management have been developed by NIUA. The modules are an outcome of the activity 2 of the project which included the following tasks:

- On the basis of TANA results, training modules were prepared for relevant stakeholders
- For developing the Module & Pedagogy, NIUA has synergized the experience of practitioners and subject experts.
- The modules have been finalized in coordination with experts and officials from cities.

This module on Wastewater Management is a part of the series of modules that would supplement the training activities.



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List of abbreviations and acronyms

ABR	Anaerobic baffled reactor
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BCM	Billion Cubic Meters
BIS	Bureau of Indian Standards
BMC	Bhopal Municipal Corporation
BOD	Biochemical Oxygen Demand
BOT	Build-Operate-Transfer
BSUP	Basic Service for the Urban Poor
BWC	Blue Water Company
CAPEX	Capital Expenditure
CBOs	Community-Based Organizations
CBS	Container-Based Services
CFT	Child Friendly Toilet
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Cental Public Health & Environmental Engineering Organization
CSP	City Sanitation Plan
CSR	Corporate Social Responsibility
DFID	Department for International Development
DRDO	Defence Research and Development Organization
DTMC	Devanahalli Town Municipal Council
DWWM	Decentralized wastewater management
E&T	Emptying and Transport
EC	Electric conductivity
EIA	Environmental Impact Assessment
EPA	Environment Protection Act
EPC	Engineering-Procurement-Construction
ERSU	Emergency Response Sanitation Unit
ETP	Effluent Treatment Plant
FC (MPN)	Fecal coliforms, most probable number
FFC	Fourteen Finance Commission
FSSM	Faecal Sludge and Septage Management
FSTP	Faecal Sludge Treatment Plant
GCSWC	Greater Cairo Sewage Water Company
GDP	Gross Domestic Product

GHG	Greenhouse Gas
GIS	Geographic Information System
GMC	Guntur Municipal Corporation
GoAP	Government of Andha Pradesh
GoMP	Government of Madhya Pradesh
GoR	Government of Rajasthan
HPGF	Horizontal Planted Gravel Filter
ICCC	Integrated Control and Command Centres
ICT	Information and Communications Technology
IEC	Information, Education and Communication
IHHT	Individual Household Toilets
IWRM	Integrated Water Resources Management
JNNURM	Jawaharlal Nehru Urban Renewal Mission
JSSB	Jaipur Supply and Sewerage Board
KLD	Kilo Litre per Day
KUWS&DB	Karnataka Urban Water Supply & Drainage Board
LDA	Leh Development Authority
MBBR	Moving Bed Biofilm Reactor
MBR	Membrane Bioreactor
MCL	Municipal Committee Leh
MDG	Millennium Development Goals
MLD	Million Litres Per day
MoEF & CC	Ministry of Environment, Forest & Climate Change
MoHUA	Ministry of Housing and Urban Development
NAPCC	National Action Plan on Climate Change
NBC	National Building Code of India
NCP	National Commission on Population
NGOs	Non-Government Organizations
NGT	National Green Tribunal
NMC	Nagpur Municipal Corporation
NMSH	National Mission on Sustainable Habitat
NSKFDC	National Safai Karamcharis Finance and Development Corporation
NSS	National Sample Survey
NUSP	National Urban Sanitation Policy
O&M	Operation and Maintenance
ODF	Open Defecation Free
OHS	Occupational Health and Safety
OPEX	Operational Expenditure
OSS	On-site sanitation systems
OTCA	One Time Cash Assistance
PGF	Planted Gravel Filter
PHED	Public Health and Engineering Department
PP	Poly Propylene

PPEs	Personal Protective Equipment
PPP	Public Private Partnership
PRB	Permeable Reactive Barrier
PVC	Poly Vinyl Chloride
RPL	Recognition of Prior Learning
RUIDP	Rajasthan Urban Infrastructure Development Project
RWAs	Resident Welfare Associations
RWH	Rain Water Harvesting
SBM	Swachh Bharat Mission
SBR	Sequencing Batch Reactor
SDG	Sustainable Development Goals
SeTP	Septage Treatment Plant
SHGs	Self-Help Groups
SLB's	Service Level Benchmarks
SOPs	Standard Operating Procedures
SPCB	State Pollution Control Board
SRMS	Self-Employment Scheme for Rehabilitation of Manual Scavengers
SSS	State Sanitation Strategy
STPs	Sewage Treatment Plants
SUY	Swachhta Udyami Yojana
SWM	Solid Waste Management
TC (MPN)	Total coliforms, most probable number
TDS	Total Dissolved Solids
TLBG	Toilet linked Biogas Plants
TS	Total Solids
TSS	Total Suspended Solids
UASB	Up flow Anaerobic Sludge Blanket Reactor
UDDT	Urine Diverting Dry Toilets
UDFT	Urine-Diverting Flush toilet
UGD	Underground Drainage
UIG	Urban Infrastructure and Governance
ULB	Urban Local Body
UNICEF	United Nations International Children's Emergency Fund
UTs	Union Territories
VAR	Vector attraction reduction
VGTM	Vijayawada Guntur Tenali and Mangalgiri
VIP	Ventilated Improved Pit
VSS	Volatile Suspended Solids
WASH	Water, Sanitation and Hygiene
WB	World Bank
WHO	World Health Organization

Chapter

1

Urbanization & Sustainable Sanitation

Summary

Understanding the current status of sanitation at International and National level, and the need for achieving sustainable sanitation.

Training Objectives

- To get an overview of the Urban Sanitation Scenario around the world and in India
- Understanding the need for sustainable sanitation
- Rethinking the current approaches towards sanitation management in India

Training Outcomes

- To understand the importance of Sanitation
- Gain exposure on existing challenges towards achieving sustainable sanitation in India
- Explore various approaches towards Sustainable sanitation management in India

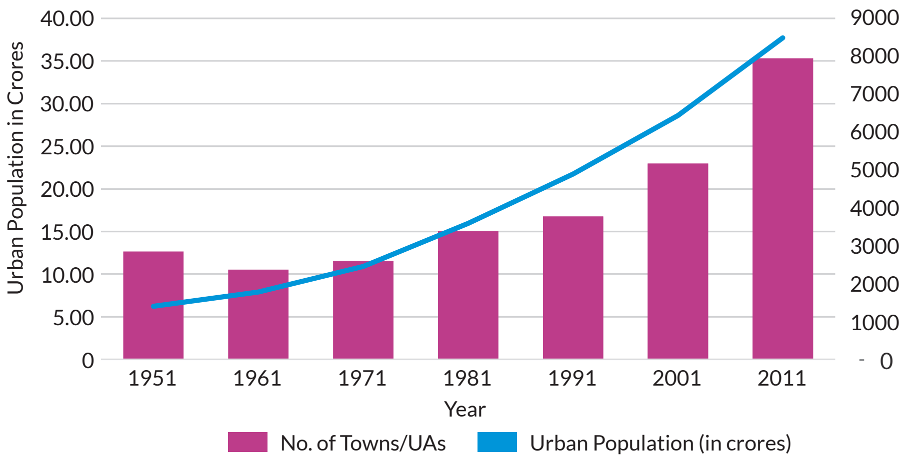
Chapter Contents

1.1 Urbanization and emerging trends

In the year 1950, only about 30% of the world population lived in urban areas, which increased to above 50% in 2012. At present, 55% of the world's population lives in urban areas and is expected to increase to 68% by 2050 (UN DESA, 2018).

India with an urban population increase from 377 million in 2011 to expected 594 million in 2036 – a growth of 57%, is one of the fastest urbanizing nations in the world.[1] By 2050, it is projected that India will have added 416 million urban dwellers.[2]

Figure 1.1: Urban Population Trends India



Source- Adapted from Sadashivam & Tabassum (2016)

According to World Bank, more than 80% of the global GDP is generated in cities (WB, 2019). While the cities are becoming the centre of economic growth and technological development, limited resources and inadequate infrastructure fail to meet the needs of the growing population, posing serious threats to the wellbeing of the humans as well as the environment.

[1]Report of the technical group on population projections (July 2020), National Commission on Population (NCP), Ministry of Health and Family Welfare, Government of India

[2]United Nations|Department of Economic and Social Affairs. 2018. [online] Available at: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Considering the rapid pace of urbanization, it is important for the cities to meet the double challenge of demographic change and the massive transformations taking place in the global economy. It is necessary to commensurate the associated risks emerging from the rapid, unplanned and unsustainable patterns of urban development.

The universal provision of good sanitation facilities and drainage system is a necessary requirement to ensure betterment of community health and hygiene. Urban sanitation infrastructure and management is one of the key concerns associated with the ever-increasing population in the cities.

1.2 Urban Sanitation and Associated Challenges

"Sanitation is defined as safe management of human excreta, including its safe confinement treatment, disposal and associated hygiene-related practices". Sanitation pertains to management of human excreta and associated public health and environmental impacts, it is recognized that integral solutions need to take account of other elements of environmental sanitation, i.e. solid waste management; generation of industrial and other specialized / hazardous wastes; drainage; as also the management of drinking water supply (National Urban Sanitation Policy, 2008).

According to the World Health Organization (WHO), an approximated 2.3 billion people worldwide still do not have access to rudimentary sanitation facilities. Of the world's 7.7 billion population, only 27% use private sanitation facilities with properly connected sewage pipes, and 13% use toilets or latrines where human waste is disposed of in the right manner.

In India, as per the NSS (2019) report, in urban areas, about 96.2 % of the households have access to latrines. About 48.9 % households use septic tank type of latrines, 8.7% twin leach pit/ pit toilets and 39.1% piped sewer system. The vast majority of urban residents are still dependent on on-site sanitation services such as discharging pour flush toilets to leach pits or septic tanks. Untreated wastewater, faecal sludge and septage from septic tanks and pit toilets in the cities is the single biggest source of water resource pollution in India. Human waste has clearly been identified as the leading polluter of water sources in India, causing a host of diseases including diarrhoea, agricultural-produce contamination, and environmental degradation.[3]

[3] *Urban Management Centre, Ahmedabad, 2018. Faecal Sludge & Septage Management (Fssm) Skill Gap Assessment Study. [online] Deendayal Antyodaya Yojana - National Urban Livelihoods Mission. Available at: <https://sscgj.in/wp-content/uploads/2016/05/Concept_note_Faecal_SludgeSeptage_Management.pdf>*

The poor neighbourhoods tend to have the poorest sanitary conditions. This could be attributed to the fact that, in general, toilet construction is regarded as the duty of the owner, but, expenditure in sanitation is often limited by the following problems in the case of poor households:

- Affordability including the cost of sewer networks connectivity;
- Land tenure confusion (fear of expulsion);
- Space restrictions;
- Low Priority- the value of good sanitation practices is not understood by people due to lack of awareness/motivation, etc.

DID YOU KNOW?

Accessing Toilets – Challenge in Slums of Bengaluru city

Mythri Sarva Seva Samithi's (2012) study reveals that 40 percent of the slum population did not have access to toilets. There are cases of one bathroom being shared by 100 people and 200 people share nine toilets (in Tasker Town, Shivajinagar). Besides, due to the lack of maintenance, these toilets tend to become unusable, which is a matter of serious concern.

For further details:
Seshaiah, M., Nagesh, L. and Ramesh, H. (2009) 'Working Paper Series', Accounting & Finance, 24(1), PP. 75–75. DOI: 10.1111/j.1467-629x.1984.tb00054.x.

Even in settings where toilets are available, some are not used or are underused, with family members defecating much of the time outside. This may be because of a number of reasons like for instance, sanitation facilities may be available, but they may be uncomfortable, unpleasant or unkempt. This may be due to poor design or development or management arrangements. Alternatively, people have restricted access or are not comfortable in sharing toilets, or because open defecation is a long-held preference. In some cases, people tend to underuse their toilet because of lack of knowledge about its functioning and maintenance. For example in the case of twin-pit pour flush toilets, some individuals believe that the pits will fill quickly if the toilet is used too often; and they may not realise that once they have been given time to decay, the contents of a full pit may safely be removed manually. Such problems indicate the need for effective communication in sanitation programmes, so that community knowledge, preferences and actions are properly understood and then addressed through information, advice, and hygiene promotion.

In some scenarios, sanitation facilities may be available but they are not linked to any septic tank or existing public sewer. In these situations, no provision can be made for the treatment of waste water or excretions, leading to transfer of waste to another part of the city, where local pollution is caused. Households are mostly worried about the cleanliness of their immediate environment and far less worried about the larger environmental effects.

DID YOU KNOW?

The Issue of insufficient coverage of centralized sewer network in Raipur and the willingness of household to get connected low (2011 status).

The city's sewer network comprises just 11% of urban residents, while the rest of the population depends on open drains or open wastewater disposal areas. At city level, nearly 43 per cent of the city's population lacks a drainage system.

For further details:
Sustainable Sanitation and Water Management Toolbox. 2011. Case Study Raipur. [online] Available at: <https://sswm.info/node/7932> [Accessed 9 September 2021].

Lack of regard for sanitation not only impacts health and environment, but it has drastic effects on education, social well-being and safety as well. Sanitation linked diseases and poor hygienic conditions leads to 1 out of 10 deaths, putting a huge strain on the Indian healthcare sector.

In India, the various challenges associated with different systems of disposal of human waste are discussed as below:

Septic Tank Latrines

As per the NSS report, 48.9 % urban households use septic tank latrines in urban areas. Also, community/ public toilets in urban areas are mostly connected with septic tanks. In un-sewered cities/ towns septic tank system is the preferred option for toilets. There are however, two serious challenges associated with this system. The standard design of CPHEEO, Government of India for the septic tank is rarely followed. Further, cleaning interval of tank is rarely followed. In some households, septage from tank is removed only when there is a sign of backflow or blockage.

Another serious issue with septic tank system is the proper management of septage. Due to lack of effective regulation, septage from the septic tanks, after evacuating (mechanically or manually) is discharged anywhere suitable for the vendors-for instance, in open fields, drains, water bodies etc., without any treatment, leading to serious problems associated with community health, environment and irreversible ground water contamination.

Piped Sewer System

About 39.1% households are connected with sewer system in urban areas. An estimated 61,754 MLD of sewage every day. Talking of Wastewater treatment, the operational treatment capacity of the country at present is 26840.83 MLD with 1095 number of operational STPs. However, just 18439.96 MLD is the actual utilized treatment capacity (CPCB, 2020). As quite evident, there seems to be a huge gap between the generation and treatment capacity of the wastewater in the country.

Even in many cities, the existing treatment capacity remains underutilized due to various challenges leading to sewage being discharged without treatment into the water bodies. Various factors such as adequate and appropriate availability of resources and expertise for proper selection of technologies and equipment for treatment, availability of funds, etc. hugely impact the state of wastewater management.

Leach pit and other toilets

There are about 8.7 % leach pit toilets and small number (around 0.3%) other toilets. Leach pit toilets are low cost technology, mostly found in small and un-sewered towns. Sometimes its proper design is not followed. Such technology is not suitable for the areas having high ground water table, as it can lead to ground water contamination. Ground water contamination not only poses serious threat to the environment but also hugely impacts the health of the community.

Cities must therefore take the responsibility to reduce these risks by managing factors contributing to these emerging issues. A holistic approach must be adopted both at the planning and implementation level, focusing on the entire sanitation value chain, extending from the point of generation to the point of disposal/discharge or reuse.

1.3 Addressing Urban Sanitation

Over the last two decades, effective strategies have been developed to provide affordable sanitation services to the urban populations of all countries.

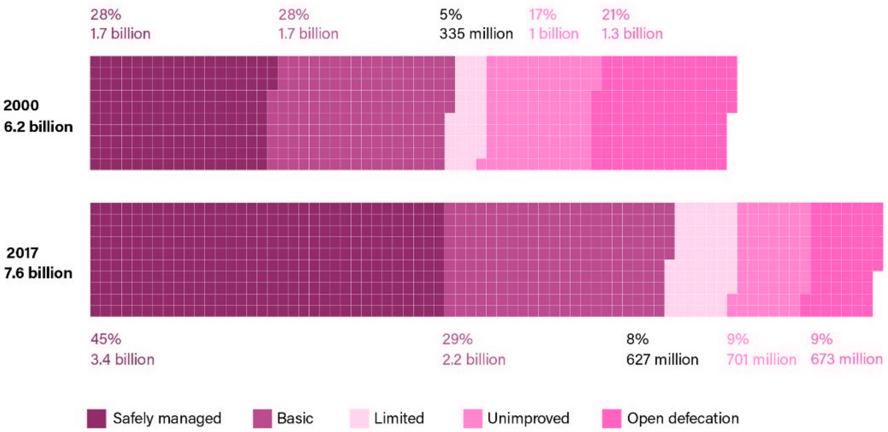
According to World Bank, the Millennium Development Goals (MDG) on global sanitation access missed their target by 700 million people.[4] Although, from 2000 to 2015, the proportion of the global population using at least a basic sanitation service increased from 59% to 68%, however, 2.4 billion people still lacked basic services. About 4.5 billion people worldwide lacked a safely managed sanitation service in 2015, where excreta were safely disposed on site or treated off-site.[5]

In 2015, the Sustainable Development Goals (SDG) were introduced to improve the lives and the environment across the globe, targeting for holistic sustainable development. Out of the 17 SDGs covering various aspects of human habitats and life, SDG 6 focuses completely on water and sanitation. Safe Sanitation is imperative to ensure that we meet the UN sustainable development goals (SDGs), particularly SDG 6, which aims at ensuring availability and sustainable management of sanitation for all. As the global population increased by 1.4 billion in seventeen years, the access to safely managed services has doubled. In 2000 while 1.7 billion out of 6.2 billion (28%) people had access to safe sanitation, it increased to 3.4 billion out of 7.6 billion population (45%). As population with either basic or safely managed sanitation increased from 3.4 to 5.5 billion, the number of people lacking basic sanitation service decreased from 2.7 to 2.0 billion. The population practicing open defecation was reduced by half from 1.3 billion to 673 million (UNICEF and WHO, 2020). The below given diagram explains the changing dynamics of access to sanitation service with population growth from 2000 to 2017.

[4]*World Bank, 2020. Data - World Bank. [Online]*
Available at: https://data.worldbank.org/indicator/
[Accessed October 2020].

[5]*United Nations, 2018. Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation., New York: United Nations.*

Figure 1.2: Global Sanitation Coverage, 2000-2017



SERVICE LEVEL	DEFINITION
Safely managed	Use of improved facilities that are not shared with other households and where excreta are safely disposed of *in situ* or transported and treated off-site.
Basic	Use of improved facilities that are not shared with other households.
Limited	Use of improved facilities that are shared with other households.
Unimproved	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines.
Open defecation	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste.

Note: Improved facilities include flush/pour to piped sewer systems, septic tanks or pit latrines, ventilated improved pit latrines, composting toilets or pit latrines with slabs.

Source: (UNICEF and WHO, 2020)

In India, a few years ago in 2015, nearly half of the population of about 568 million people, due to lack of access to toilets, suffered the indignity of defecating in fields, woods, bodies of water, or other public spaces. However, since 2015, through strategic planning and intense implementation efforts by governing bodies and stakeholders across the nation, India has seen drastic improvement in its water sanitation and hygiene (WASH) sector. With the goal to eliminate the practice of Open Defecation and to provide universal sanitation across the country, nationwide campaign of Swachh Bharat Mission played a critical role. On 2 October 2019, Urban India was declared Open Defecation Free (ODF). Besides the great achievements of the Swachh Bharat Mission towards the goals of embarking urban India on the path of achieving universal sanitation, the Ministry of Housing and Urban Affairs is implementing various other missions like AMRUT, Smart City Mission, NERUDP etc. to address the issues of urban sanitation.

ODF (Open Defecation Free)

A city/ward can be notified /declared as ODF city or ODF ward if, at any point of the day, not a single person is found defecating in the open. (MoHUA)

DID YOU KNOW?

Achievements (SBM-Urban) – Current Status of Access to sanitation facilities in urban areas:

INDIVIDUAL HOUSEHOLD TOILET
Mission Target
58,99,637

Construction Achieved:
62,60,606 (106%)

COMMUNITY & PUBLIC TOILETS
Mission Target
5,07,589

Construction Achieved:
6,15,864 (121%)

OPEN DEFECATION FREE (ODF)
Total Cities
4,316

ODF Declared Cities
4,369 (97%)

Achievements till The Year 2020, Report by Swachh Bharat Mission Urban; Source: (MoHUA) Available at: http://www.swachhbharaturban.gov.in/

Presently, India follows a holistic approach towards its 2030 Sustainable Development Goals (SDGs) by launching various schemes. India's SDG Index Score ranges between 42 and 69 for States and between 57and 68 for UTs. Kerala and Himachal Pradesh are the front runners amongst all the States with a score of 69, Chandigarh and Puducherry are the front runners with a score of 68 and 65 respectively among the UT's.[6]

One of the recent policy initiatives by the Government of India in direction of achieving SDG 6 is the Namami Gange Mission- launched as a priority programme for the period 2015-2020. Major components include sewerage project management, urban and rural sanitation, tackling industrial pollution, water use efficiency and quality improvement, ecosystem conservation and Clean Ganga Fund, among others.

[6] *India follows a holistic approach towards its 2030 Sustainable Development Goals (SDGs) [Online]. Available at: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1577014 (Accessed: November 2020).*

1.4 Moving towards Sustainable Sanitation- Rethinking Current Approaches to Urban Sanitation

With only ten years left until 2030, the rate at which sanitation coverage is increasing will need to quadruple if the world is to achieve the SDG sanitation targets (UNICEF and WHO, 2020).[7] The efforts done so far have positively demonstrated the ability of nations across the globe, with the potential scope of achieving the targets. However, responding to the sanitation needs requires designing systems that are healthy, accessible and usable and sustainable over the long term. This corresponds to 'Sustainable sanitation', which is not a single technology or a particular limited sanitation system design, but rather an approach in which a large range of requirements must be taken into account in order to achieve universal and equal access to services over the long term in a specific context. This requires, for example, the acknowledgment and participation of consumers and organisations responsible for service provision and operation and maintenance in the implementation of more sustainable systems. This could include various efforts to meet user needs, to understand behavioural factors and to determine available financial and technological capabilities.[8]

Sustainable Sanitation system addresses wider environmental concerns as compared to a typical sanitation system. A sanitation system caters to provision of safe and hygienic facilities along with technological options for effective treatment of sanitation waste such that it is safe for disposal into environment. Sustainable Sanitation on the other hand acknowledges that the system must also be socially acceptable and economically viable i.e., it should be suitable for the expected capacity for operation and maintenance, in both technical and financial terms. This aspect is of particular importance as different types of technologies will require varying degree of technical and financial inputs during the life time of the technology to keep it in sustainable operation mode. Sustainable Sanitation System also identifies a management system that ensures maximum recovery of sanitation waste products, utilizes its nutrient cycle thus making them suitable for reuse. In this way, sustainable sanitation is a loop- based approach that differs fundamentally from the current linear concepts of waste water management, as it not only recognizes technology, but also social, environmental and economic aspects along with resource management.

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[7] *State of the World's Sanitation: An urgent call to transform sanitation for better health (UNICEF and WHO, 2020)*

[8] *Andersson, K., Dickin, S. and Rosemarin, A. (2016) 'Towards "sustainable" sanitation: Challenges and opportunities in urban areas', Sustainability (Switzerland), 8(12). doi: 10.3390/su8121289*

Below are the various aspects one must assess while selecting appropriate technology for achieving sustainable Sanitation:[9]

- **Health-** Evaluating differences in risk of infections between various options
- **Environment-** Evaluating differences in emissions into air and water and the use of energy and natural resources; complying the environmental norms, if any.
- **Economy-** Evaluating Capex and recurring costs related to the options
- **Socio-cultural aspect–** Evaluating appropriateness to local cultural context, social acceptance, etc.
- **Technical function-** Evaluating robustness against extreme conditions, maintenance requirements, risk of failure, effect of failure, structural stability and institutional viability.
- **Capacity-** Local capacity for operation & maintenance in technical and financial terms
- **Resource recovery-** Degree of resource recovery and safe reuse of by-products

It should be however noted that the criteria for selecting of appropriate sanitation technology varies from city to city. For example, a technology may be affordable for one ULB but may not be for other. Hence, different technical options should be compared against the above mentioned points and the preferred option must be selected based on the principles of sustainable sanitation system.

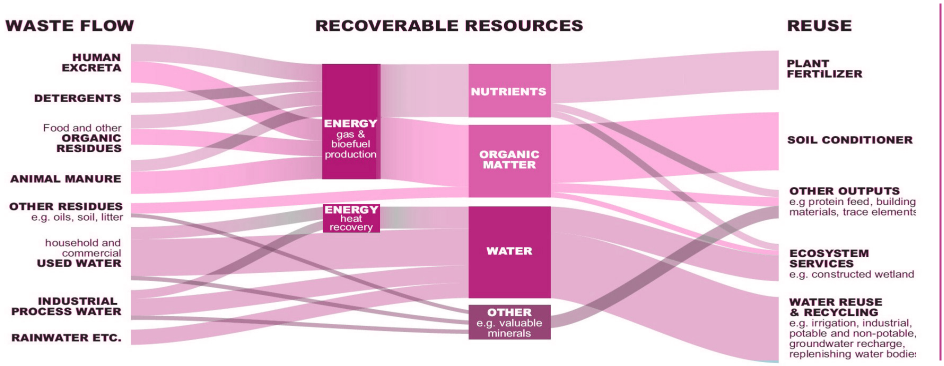
In 2020, the United Nations Water Organisation defined Sustainable Sanitation System as *follows,*

"Sustainable sanitation begins with a toilet that effectively captures human waste in a safe, accessible and dignified setting. The waste then gets stored in a tank, which can be emptied later by a collection service, or transported away by pipework. The next stage is treatment and safe disposal. Safe reuse of human waste helps save water, reduces and captures greenhouse gas emissions for energy production, and can provide agriculture with a reliable source of water and nutrients."

Sustainable sanitation system aims creating win-win situations for diverse sectors including environmental safety, hygienic living conditions, technical innovations, economic viability, diversity of users and their cultural conditions.

[9] Technological options for solid and liquid waste management in rural areas, Ministry of Drinking water and Sanitation, (2015)

Figure 1.3: Sustainable Sanitation Offers Opportunities for Resource Recovery



Source: (Anderson, et al., 2016)

As shown in the above diagram, a major target for sustainable sanitation system is to recover maximum resources from the sanitation cycle, a practice which has been largely overlooked in conventional linear approaches to sanitation disposal methods. A context-specific analysis is needed of the availability and marketability of the resources in a given city, but the figure communicates the various opportunities. Some of these resource recovery systems are already being applied in a variety of cases e.g., wastewater irrigation, while others are less common e.g., excreta-based fertilisers or are still at the experimental stage e.g., protein feed production from insect larvae (Black soldier flies) grown on human faeces, recovery of phosphates from urine etc. Simultaneously, the system can also address other criteria through diverse approaches found suitable as per context-based needs of users.[10]

To achieve "sustainable sanitation" for over a billion Indians, persistent efforts must continue to improve the required sanitation infrastructure to meet the requirements of rapid urbanisation and population growth, for long term perspective.

Cities should develop short-term and long-term targets to meet the sanitation needs. Careful planning of integrated sanitation systems, providing context effective solutions and regular operations and management can ensure wide coverage of sanitation provisions as well as optimising investment costs. Integrated planning of sanitation in a city is necessary for optimal performance and coherent functioning of on-site systems with off-site systems as and when necessity arises. Both the systems address sanitation needs of different spatial extents; hence both must coexist complementing each other.

[10] *Andersson, K., Dickin, S. and Rosemarin, A. (2016) 'Towards "sustainable" sanitation: Challenges and opportunities in urban areas', Sustainability (Switzerland), 8(12). doi: 10.3390/su8121289.*

Rethinking many aspects of the approaches and practices adopted so far can help prepare and plan for the exponential effort to be implemented in the next decade. This perspective applies for all the participating stakeholders from administration to citizens. The focus should be on adopting a holistic approach, which transcends the cultural, economic, social, technical and environmental dimensions in an integrated manner to ensure sustainable sanitation. At the same time, it is necessary to recognize the need to save and manage water, nutrients, organic matter and energy contained in sanitation and other wastewater and organic waste streams. These resources can, and should, be safely recovered and productively reused. With such efforts, city wide sustainable sanitation can be achieved in five to ten years.

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17. World Bank, 2020. Sanitation. [Online] Available at: https://www.worldbank.org/en/topic/sanitation [Accessed Decmber 2020].

Quick Assessment

1. World Toilet Day is celebrated annually on________ to inspire action to tackle the global sanitation crisis and help achieve Sustainable Development Goal 6 (SDG 6), which promises sanitation for all by 2030.
   a. 19th November
   b. 19th December
   c. 30th November
   d. 2nd October

2. Sanitation is the ________ means of promoting health through prevention of human contact with the hazards of waste.
   a. Hygienic
   b. Proper
   c. Better
   d. Perfect

3. The main objective of a ____________is to protect and promote human health by providing a clean environment and breaking the cycle of disease.
   a. Drainage System
   b. Flush System
   c. Toilet System
   d. Sanitary System

4. According to NSS report, 2019, ------------ of household have access to latrines?
   a. 96.2%
   b. 98.7%
   c. 95.2

5. Which of these diseases can happen from drinking contaminated water?
   a. Pneumonia
   b. Small pox
   c. Malaria
   d. Cholera

6. According to WHO________ do not have access to sanitation facilities.
   a. 2.8 billion
   b. 2.3 billion
   c. 8.3 million
   d. 2.49 billion

** For answers please refer Annexure I*

Chapter 2

Enabling Environment– Legislative and Policy Framework

Recap

After understanding the importance of sanitation and gaining the knowledge on the current sanitation status of India, it is necessary to understand the enabling environment governing the sanitation sector, to take necessary actions.

Training Objectives

- To understand the sanitation legislative instruments at the National level
- Understand the state legislative instruments of the selected pilot cities
- Analyze the city legislative instruments of the five pilot cities related to the sanitation sector

Training Outcomes

- Gaining knowledge about the legislative instruments available at National level for improvement of Sanitation sector.
- Understand the State legislative instruments available for achieving the goals of sanitation sector.
- Gaining an overview of the city level legislative instruments through the case of five pilot cities.

Chapter Contents

2.1 Introduction

The regulatory frameworks of a country influence the provisions of basic needs to its citizens through laws, regulations, and standards. The higher judiciary has recognised the right to sanitation as a constitutional right linked to the right to life (GoI, 2020). The responsibility for wastewater is largely split between the Union, States, and local governing bodies (urban municipalities and rural panchayats). The legislative instruments at the National, State, and city levels are explained in the following sections.

2.2 National Legislative Instruments

In India, the wastewater management legislation has taken into account not only waste generators but also the receiving ecosystems. Limits have been set in terms of effluent or emission requirements. Depending on the type of waste generator, the limits for the amount of waste and the characteristics of the waste have been defined. The minimum standards of safety deemed appropriate for the receipt of waste by environments have also been considered. The legislative instruments for wastewater management at the national level are discussed in brief as below:

Acts and Policies governing wastewater and sanitation[1]

1. **Water (Prevention and Pollution Control) Act, 1974,** as amended in 1988.[2]
    - **Objectives:** To provide for the prevention and regulation of water contamination and for the preservation or restoration of water health.
    - **Key Provisions:** The Act lays down a statutory provision for the establishment of Pollution Control Boards, namely the Central Pollution Control Board (CPCB) and the respective State Pollution Control Board (SPCB). Studies show that, while the Act has been significantly effective in alleviating the evils of industrial pollution, regulating household level contamination is still a challenge.

2. **Water (Prevention and Emission Control) Cess Act, 1977,** as amended in 2003.[1]
    - **Objective:** To mandate the consumers engaged in an industry falling within the scope of the provisions, to affix the meters for the purpose of evaluating the quantity of water used.
    - **Key Provisions:** To enact a cessation on the consumption of water by persons carrying on certain industries and local authorities in order to increase the resources of the Central Board and the State Boards for water pollution prevention and control, which were established in accordance with the Water Act, 1974.

[1]NIC, n.d. INDIA CODE| Digital Repository of All Central and State Acts. [Online] Available at: https://www.indiacode.nic.in/handle/123456789/1612

[2]The Water (Prevention and Control of Pollution) Cess Act, 1977|Legislative Department | Ministry of Law and Justice | GoI (no date). Available at: http://legislative.gov.in/actsofparliamentfromtheyear/water-prevention-and-control-pollution-cess-act-1977 (Accessed: November 2020).

The Act gives power to the Central Government to carry out the functions of Levy and collection of cess, affixing of meters, furnishing of returns, Assessment of cess, Rebate, Crediting proceeds of cess to Consolidated Fund of India and application, power to make rules and penalty for not paying the cess. The Schedule II of the Act provides the maximum rates for the water consumed, for any purpose including Industrial purpose, domestic purpose etc.

3. **Environment (Protection) Act, 1986[3],** amended in 1993
   - **Objective:** The Umbrella legislation for protection and improvement of environment. This is a key act enacted by the Ministry of Environment and Forests, which transfers powers to state governments to enact the act.
   - **Key Provisions:** The central government is authorised to the development of new national environmental quality standards and standards for the regulation of pollution and effluent discharges.

The 1993 amendment to the Act sets out national requirements and standards for the quality of treated water with criteria such as pH, turbidity and Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrogen phosphates, and other parameters. The Act applies, in principle, to any establishment, agency or entity that discharges any pollutant into the atmosphere. In practice, ULBs are expected to comply with the discharge requirements for wastewater discharges from wastewater treatment plants. Such discharge norms are regularly reviewed and upgraded time to time by the Ministry of Environment and Forests & Climate Change, Government of India.

4. **The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 1993,** amended in 2013[4]

   Manual scavenging refers to the process of manually washing, storing, disposing or treating in some way, human excreta from dry latrines and sewers. It also requires using the most common equipment, such as buckets, brooms and baskets.
   - **Objective:** Recognizing that manual scavenging infringes the right to dignity, the Act seeks to prohibit the recruitment of individuals as manual scavengers and the rehabilitation of current manual scavengers.
   - **Key provisions:** The Employment of Manual Scavengers and Dry Latrines (Prohibition) Act, 1993 was amended in 2013. The previous act prohibited the use of manual scavengers for the manual cleaning of dry latrines and also for the

[3] The Environment (Protection) Act, 1986|Legislative Department | Ministry of Law and Justice | GoI (no date). Available at: http://legislative.gov.in/actsofparliamentfromtheyear/environment-protection-act-1986 (Accessed: 18 November 2020).

[4] The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013|Legislative Department [Online]. Available at: http://legislative.gov.in/actsofparliamentfromtheyear/prohibition-employment-manual-scavengers-and-their-rehabilitation-act (Accessed: 18 November 2020).

construction of dry toilets, that is to say, toilets which do not flush and operate with dry latrines. It provided for a term of imprisonment of up to one year and a fine to the households who engage manual scavengers. The amended Act added to the aims, to prohibit the dangerous manual cleaning of sewers and septic tanks, and to track and rehabilitate manual scavengers.

Key features of the Act include:

- Infringements could result in years of imprisonment or imprisonment of INR 50,000 or both.
- Offences under the Act are visible and non-compensable.

DID YOU KNOW?

National Survey on Manual Scavengers has been completed in all States except J&K (170 Districts). At national level so far total 38,785 persons have been identified including earlier surveys (25015 as per 2018 survey and 13770 as per 2013 survey). Under the Self Employment Scheme for Rehabilitation of Manual Scavengers (SRMS), One Time Cash Assistance (OTCA) of Rs. 40,000 each has been provided to 24,863 persons; 955 Manual Scavengers have been provided capital subsidy. Under the skill development component, 6361 Manual Scavengers have completed training programmes and 4306 are undergoing training programme, as on 30th Sept. 2018.

- Achievements In The Year 2018-19, Report by NITI Aayog

5. **National Environment Tribunal Act, 1995[5]**

   To provide for the strict responsibility for damages resulting from an accident involving dangerous substances; the act led to creation of a National Green Tribunal (NGT) for the efficient and expeditious disposal of cases arising from such accidents. The Tribunal is responsible for providing appropriate and expeditious remedies in cases relating to the protection of the environment, the conservation of forests and other natural resources and the enforcement of any legal right relating to the environment. NGT is also responsible for reviewing the discharge norms of effluent from sewage treatment plants (STP), Effluent treatment plant (ETP), reviewing of reports of functioning of treatment plants in different states.

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[5] *National Environment Tribunal - The Official Website of Ministry of Environment, Forest and Climate Change, Government of India Ministry of Environment, Forest and Climate Change (no date). Available at: http://moef.gov.in/rules-and-regulations/national-environment-tribunal/ (Accessed: November 2020).*

The EPA (**Environment Protection Act)** through the MoEF&CC notified the latest discharge norms of STP on 2017. However, in April 2019 the NGT made the norms more stringent. Both the norms are tabulated below (**Table 2.1**):

Table 2.1: Waste water discharge standards for STPs by EPA/ MoEF&CC and NGT

Parameters (Units are in mg/ l except pH, FC MPN/ 100 ml.)	EPA/ MOEF&CC notification October 2017		NGT Order April 2019
pH	6.5-9.0		6.5-9.0
Biochemical oxygen Demand	Metro Cities*, all State Capitals except in the State of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Union territory of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and Lakshadweep	20	10 for all
	Areas/regions other than mentioned above	30	
Chemical Oxygen Demand	-		50 for all
Suspended solids	Metro Cities*, all State Capitals except in the State of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Union territory of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and Lakshadweep	50	20 for all
	Areas/regions other than mentioned above	100	
Ammonical Nitrgen	-		-
Total Nitrogen	-		10
Phosphate	-		<1
Faecal coliform	< 1000		Permissible < 230

Source: Author

6. **National Urban Sanitation Policy, 2008**[6]

With growing urbanization, the National Urban Sanitation Policy was established in 2008 mandating the total coverage of sanitation in all Indian cities and towns.

- **Key Provisions**
  - Generate awareness and promote mechanisms for adopting healthy sanitation practises.
  - Ensure 100% maintenance and management of public sanitation facilities in all urban areas.
  - Re-orientation of institutions at all levels and mainstreaming of sanitation.
  - Promoting the proper disposal and treatment of waste as well as the recycling and re-use of treated waste for non-potable uses wherever possible.
  - Strengthening ULBs to provide or cause sustainable sanitation services to be delivered.
  - Urges the states to form State Sanitation Strategy boards to prepare City Sanitation Plans.
  - Sharing the knowledge wealth accumulated during the different phases of preparation of the City Sanitation Plans (CSPs) with practitioners all over India, in order to provide a guideline in the future preparation of CSPs by the local governments.

7. **National Water Policy, 2002**[7]

NWP proposes the recycling and reuse of water, including return flows for the management of demand and the efficient use of water, incentives through efficient pricing of water.

- **Key Provisions:**
  - Water supply bills should contain charges for sewerage.
  - Industries in water-short regions may be permitted either to remove only make-up or to have an obligation to return treated effluent to the specified level back to the hydrological system.
  - Subsidies and incentives should be placed in place to promote recovery of industrial contaminants and recycling / reuse that are otherwise capital intensive.

There is no appropriate focus on massive investment in water infrastructure, not only for storage, given only a few weeks of extreme annual rainfall, but also for treatment, sewers and sewerage treatment plants.

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[6] *Ministry of Urban Development, 2008. National Urban Sanitation Policy. [online] GoI. Available at: http://mohua.gov.in/upload/uploadfiles/files/NUSP_0.pdf*

[7] *MINISTRY OF JAL SHAKTI, 2002. National Water Policy. [online] DEPARTMENT OF WATER RESOURCES, RD & GR. Available at: http://nwm.gov.in/sites/default/files/nwp20025617515534.pdf*

8. **FSSM (Faecal Sludge and Septage Management) Policy, 2017**[8]
   - **Objective:** To set the context, priorities, and direction for, and to facilitate, nationwide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all in each and every household, street, town and city.
   - **Key Provisions:**
     - Ensuring benefits of wide access to safe sanitation to all citizens, through identification of methods and resources, across sanitation value chain
     - Defining roles and responsibilities of the Government entities, agencies and key stakeholders
     - Enable and support synergies among relevant Central Government programmes like SBM, AMRUT, and Smart Cities Mission to realize safe and sustainable sanitation for all
     - Provision for incremental approach towards achieving the strict environmental discharge standards and Mitigate gender-based sanitation insecurity directly related to FSSM.

Missions

1. **JNNURM (Jawaharlal Nehru Urban Renewal Mission), 2005-2014**[9]
   - **Objective:** Infuse infrastructure resources into selected Indian cities as well as introducing a collection of urban reforms.
   - **Key Provisions:** The project centred on 65 selected cities (mostly millions-plus) and included two sub-missions: Urban Infrastructure and Governance (UIG), which focused on infrastructure; and Basic Services for the Urban Poor (BSUP), which focused on housing for the urban poor.

2. **National Water Mission, 2008 under NAPCC (National Action Plan on Climate Change)**[10]
   - **Objective:** To prepare strategies for the goals of comprehensive water data base in public domain and assessment of the impact of climate change on water resource, Promotion of citizen and state actions for water conservation, augmentation and preservation, focused attention to vulnerable areas including over-exploited areas, Increasing water use efficiency by 20%, and Promotion of basin level integrated water resources management.

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[8] *Ministry of Urban Development, 2017. National Policy on Faecal Sludge and Septage Management (FSSM. [online] GoI. Available at: http://amrut.gov.in/upload/newsrelease/5a5dc55188eb0FSSM_Policy_Report_23Feb.pdf*

[9] *2005. Jawaharlal Nehru National Urban Renewal Mission. [online] Available at: http://mohua.gov.in/cms/jawaharlal-nehru-national-urban-renewal-mission.php*

[10] *MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RD & GR. n.d. NATIONAL WATER MISSION. [online] Available at: http://nwm.gov.in/?q=goal-3*

- **Key Provisions:**

  The Goal 3 (Focused attention to vulnerable areas including over-exploited areas) focuses on

  - Enhancing storage capacities in multipurpose hydro-projects and integration of drainage with irrigation infrastructures.
  - Promoting Recycling of Wastewater for meeting water needs of urban areas.

  The Goal 4 (Improving Water Use Efficiency by 20%) included strategies focused on

  - Research in area of increasing water use efficiency and maintaining its quality in agriculture, industry and domestic sector;
  - Incentivize recycling of water including wastewater;
  - Development of Eco-friendly sanitation system;

3. **National Mission on Sustainable Habitat (NMSH), 2010[11] under NAPCC**

   The NMSH Is one of the eight National Missions under the National Action Plan on Climate Change (NAPCC),that aims to encourage the sustainability of ecosystems by enhancing energy efficiency in buildings, urban planning, improving the management of solid and liquid waste including recycling and production of electricity, modal changes towards public transport and conservation.

   It also aims to enhance ecosystem capacity to respond to climate change by enhancing infrastructure resilience. Management of solid and liquid waste, with a specific emphasis on the advancement of technology for generating power from waste.

4. **SBM (Swachh Bharat Mission)-Urban, 2014 – 2025[12]**

   Swachh Bharat Mission (SBM) or Clean India Mission is a country-wide campaign initiated by the Government of India in 2014, aimed to achieve an "open-defecation free" (ODF) India by 2 October 2019. The mission is split into two: rural and urban. The "SBM - Gramin" is financed and monitored through the Ministry of Drinking Water and Sanitation (Now Department of Drinking Water and Sanitation, Ministry of Jalshakti); whereas "SBM - urban" is overseen by the Ministry of Housing and Urban Affairs.

   The objectives of the first phase of the mission also included eradication of manual scavenging, generating awareness and bringing about a behavior change regarding sanitation practices, and augmentation of capacity at the local level. The second phase of the mission aims to sustain the open defecation free status and

[11] Ministry of Housing and Urban Affairs. National Mission on Sustainable Habitat. [online] Available at: http://mohua.gov.in/cms/National-Mission-on-Sustainable-Habitat.php

[12] Ministry of Housing and Urban Affairs. Swachh Bharat Mission. [online] Available at: http://mohua.gov.in/cms/swachh-bharat-mission.php.

improve the management of solid and liquid waste. The mission is aimed at progressing towards target 6.2 of the Sustainable Development Goals Number 6 established by the United Nations in 2015.[13]

Swachh Survekshan 2020

The annual survey of cleanliness, hygiene and sanitation in cities and towns of India. It was launched as part of Swacch Bharat Abhiyan, that aimed to make India clean and free of open defecation by 2 October 2019. The first survey was undertaken in 2016 and covered 73 cities; by 2020 the survey had grown to cover 4242 cities and was said to be the largest cleanliness survey in the world.

WEIGHTAGE OVERVIEW

Service Level Progress	Citizen's Voice	Certifications
Quarter 1: 500 M (21% of 2400M) Quarter 2: 700 M (29% of 2400M) Quarter 3: 1200 M (50% of 2400M)	Feedback: 600M Experience: 300M Engagement: 450M Swachhata App: 350M Inovation: 100M	GFS Star Rating: 1100M ODF/ODF + / ODF++/ Water+ : 700M
Total : 2400 M	**Total: 1800 M**	**Total: 1800 M**

Source: Swachh Survekshan 2021. n.d. Swachh Survekshan 2021. [online] Available at: https://www.swachhsurvekshan2021.org/

5. **AMRUT (Atal Mission for Rejuvenation and Urban Transformation) Mission, 2015-2022[14]**
   - **Objective:** The Mission focuses on the construction of basic urban infrastructure for wastewater and septage management in Mission Cities with the planned outcome of significant improvement in sewer coverage and treatment capacity.
   - **Key provisions:** Sewerage and septage sector initiatives include decentralised or networked underground sewerage systems, sewage treatment plants, renovation of old sewerage systems, treatment plants, recycling and re-use of water for beneficial purposes. Projects related to faecal sludge disposal, mechanical and biological sewage cleaning are also eligible for funding.

[13]Department of Economic and Social Affairs; Sustainable Development. Goals 6 Ensure availability and sustainable management of water and sanitation for all. [online] Available at: https://sdgs.un.org/goals/goal6

[14]Ministry of Housing and Urban Affairs. Atal Mission for Rejuvenation and Urban Transformation -AMRUT. [online] Available at: http://mohua.gov.in/cms/amrut.php.

AMRUT was designed to address the need of all areas with populations over one lakh in contrast with JNNURM, which concentrated solely on cities.

Achievemnets Under AMRUT

National Level Water Provision	National Level Sewerage/ Septage Management Services	Slums & Low-income Habitations
1.39 crore households	**1.45** crore households	Household water tap **79** lakh connections Sewer connections **45** lakh

Achievements till 2020, (Press Information Bureau, Govt. of India)

6. Smart City Mission, 2015-2023[15]

- **Objective:** To promote cities that provide key infrastructure and provide citizens with a reasonable quality of life, a safe and healthy environment through the implementation of Smart Solutions. The emphasis is on sustainable and equitable growth, and the concept is to look at compact areas and create a replicable model that will serve as a beacon for other cities in the future.

- **Key Provisions:**
  - Pan-city initiative in which at least one Smart Solution is applied city-wide, Develop areas step-by-step – three models of area-based developments, Retrofitting, Redevelopment, Greenfield developments.
  - Provisions for Sanitation, through benchmarks and ICT interventions identified for smart sewerage and sanitation facilities in the smart cities.

[15] *Ministry of Housing and Urban Affairs. Smart Cities. [online] Available at: http://mohua.gov.in/cms/smart-cities.php*

DID YOU KNOW?

"47 operational Integrated Control and Command Centres (ICCC) became War-rooms & played an effective role in COVID-19 response"
-Press Information Bureau. 2020. 5TH Anniversary of Urban Missions. [online] Available at: https://pib.gov.in/PressReleseDetailm.aspx?PRID=1634268

(ICCCs) help in tracking the status of the disease spread, tracking hospitals and identifying localized hotspots. Smart cities like Pune, Surat, Bengaluru, etc. are using cameras at ICCC, across the cities, designed for traffic and safety & surveillance, to track the movement of vehicles and people in the lockdown areas."

- Smart Cities Council India. 2020. See how these tech-enabled smart cities are helping fight COVID-19. [online] Available at: https://india.smartcitiescouncil.com/article/see-how-these-tech-enabled-smart-cities-are-helping-fight-covid-19

7. 14th Finance Commission (FCC) by the Ministry of Finance[16]

The FFC recommends basic grants to ULBs with the purpose of providing unconditional support for the delivery of basic services that includes water supply, sanitation including septage management, sewage and solid waste management. Among other services assigned to them under relevant legislature. The 15th Finance Commission was decided to be implemented from April 2020 focussing on Progress made in sanitation, solid waste management and bringing in behavioural change to end open defecation.

Norms and Standards

There are various agencies that are responsible for setting the norms and standards for overall wastewater management to be referred by the various governments and private entities. The following table describes the standards and norms related to wastewater prescribed by these agencies.

[16]*Department of Expenditure. 14TH FINANCE COMMISSION. [online] Available at: https://www.doe.gov.in/14th-finance-commission*

Table 2.2: Norms and Standards governing Wastewater in India

Standards/ norms	Implementing/ Managing Authority	Focus on wastewater and sanitation sector
Discharge Standards for treated wastewater	CPCB[17]	Rules laid down in the Environmental Protection Act, 1986 Schedule VI A: Provide specific standards for a variety of criteria relating to the disposal of waste water / effluent. The requirements include those for colour, pH, BOD, COD, degree of contaminant metals, etc.
Standards for water quality	CPCB[18]	The CPCB prescribes specific standards for quality according to the categories for e.g. Drinking water, Water for Bathing, Water for irrigation industrial cooling etc.
Standards for construction of community / public toilets	CPHEEO[19]	Public toilets to be constructed every 1 km, including in parks, plaza, open air theatre, swimming area, car parks, fuel stations. Toilets shall be disabled-friendly and in 50-50 ratio (Male / Female).
Laboratory protocols and standards	CPHEEO[20]	The Drinking Water Quality Monitoring protocol describes specific requirements for monitoring drinking water quality ensuring provision of safe drinking water to the consumers. It also includes requirements for setting-up laboratories at State, District and Sub-district level and their quality control for regular testing and surveillance of drinking water sources.
Guidelines and manual on wastewater, solid waste, storm water etc.	CPHEEO[21]	As per the guidelines given in manual of sewerage and sewage treatment by CPHEEO, sewage generation has been estimated at 80% of water supply. For urban drainage system, the coefficient of runoff may be calculated for areas with composite land use pattern on the basis of anticipated land use in the new areas and existing land use pattern for the areas already developed. In urban area, runoff coefficient not less than 0.6 may be adopted in absence of adequate details of the areas.

[17] *Central Pollution Control Board. 1986. GENERAL STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS PART-A : EFFLUENTS. [online] Available at: https://cpcb.nic.in/displaypdf.php?id=R2VuZXJhbFN0YW5kYXJkcy5wZGY=*

[18] *Central Pollution Control Board. Water Quality Standards. [online] Available at: https://cpcb.nic.in/wqstandards/*

[19] *MINISTRY OF HOUSING AND URBAN AFFAIRS, 2018. ADVISORY ON PUBLIC AND COMMUNITY TOILETS. [online] Central Public Health and Environmental Engineering Organisation (CPHEEO). Available at: http://cpheeo.gov.in/upload/whatsnew/5c0a08232e7afAdvisory%20on%20public%20toilet.pdf*

[20] *2013. Uniform Drinking Water Quality Monitoring Protocol. [online] MINISTRY OF DRINKING WATER AND SANITATION, GoI. Available at: https://jalshakti-ddws.gov.in/sites/default/files/UniformDrinkingWaterQualityMonitoringProtocol.pdf*

[21] *Ministry of Housing and Urban Affairs, Government of India. n.d. CPHEEO Manuals. [online] Available at: http://cpheeo.gov.in/cms/manual-on-solid-waste-management.php#*

Standards/ norms	Implementing/ Managing Authority	Focus on wastewater and sanitation sector
NGT (National Environment Tribunal) Guidelines[22]	Ministry of Environment, Forest & Climate Change (MoEF & CC)	Jurisdictions include all environmental laws on air and water pollution, EPA, FCA and the Biodiversity act. It orders for the statutory recognition of the principle of no-fault liability, principles of Sustainable development, precautionary principle and polluter pays principle.
Service Level Benchmarks (SLB's)[23]	MoUD, Government of India	SLB framework encompasses 28 performance indicators across four sectors water supply services, sewerage management (sewerage and sanitation), storm water drainage, solid waste management (SWM) services. According to SLB framework, cities have to present their own performance data along with a performance gap analysis and improvement in plans.

Source: (Author)

1. National Building Code, 2005[24]

The Detailed Building Code, the **National Building Code of India (NBC),** is a national instrument that provides guidance on the regulation of building construction activities across the nation. It serves as a model code to be followed by all agencies engaged in construction works, be they the Departments of Public Works, other government construction departments, Local entities or private building companies.

- **Objective:** The Bureau of Indian Standards, in line with the recommendations of the Planning Commission, formulated the National Building Code in 1970 in order to unify the scattered rules and provisions on construction. There have been two significant updates reflecting the condition of the buildings caused by technological advances- growth in population and public safety issues, leading to the new 2005 edition.

- **Key provisions:**
  - The Code includes legislation which may be implemented or enforced without delay for the use of different departments, local authorities and public bodies.
  - The Code also extends to legislation for ventilation, acoustics and plumbing facilities, such as water supply, drainage, sanitation and gas supply.
  - Design, layout, installation and maintenance of drains for foul water , surface water, subsoil water and sewage; along with all ancillary works, such as connections, manholes and inspection chambers used inside the building and connections from the building to a public sewer, a private sewer, a separate

[22] *National Green Tribunal (no date). Available at: https://greentribunal.gov.in/ngt-practise-procedure-rules (Accessed: November 2020).*

[23] *Ministry of Housing and Urban Affairs, Government of India. Service Level Benchmarks. Available at: http://mohua.gov.in/cms/Service-Level-Benchmarks.php (Accessed: November 2020).*

[24] *National Building Code - Bureau of Indian Standards (no date). Available at: https://bis.gov.in/index.php/standards/technical-department/national-building-code/*

sewage-disposal system, a cessation-pool, a soak-up or other permitted points.

Table 2.3: IS Codes of NBC, 2005 governing wastewater

Standards/norms	Focus on wastewater and sanitation sector
Standards for construction of septic tanks in IS Codes of NBC	**IS 2470 (Part 1):1985** – Code of Practice for installation of septic tank: design criteria and construction. **IS 2470 (Part 2):1985** – Code of Practice for installation of septic tank: secondary treatment and disposal of septic tank effluent. **IS 1172:1993** - Basic requirements for water supply, drainage, and sanitation. **IS 12314:1987** - Code of Practice for sanitation with leach pits for rural communities. **IS 9872:1981** — Precast concrete septic tanks. **IS 5611:1987** - Code of Practice for waste stabilization ponds (facultative type). **IS 10261:1982** — Requirements for settling tanks (clarifier equipment) for wastewater treatment. **IS 13496:1992** — General requirements for suction machines for cleaning sewers, manholes and so on.

Source: (BIS)

The guidelines and Bye-laws laid for effective storm water management are discussed in the table as below:

Table 2.4: Standards and Norms guiding the Stormwater Management

Guidelines	Existing Key focus
Development Plans & Implementation, URDPFI guidelines, 2014[25]	Preparing the proposed and use bifurcation for different urban centres
Model Building bye-laws, 2016[26]	Provisions for rainwater harvesting, green buildings, segregated toilets, wastewater reuse and recycle
Storm water Index – National Water Mission on Sustainable Habitat, 2015[27]	Assess and monitor implementation of sustainable stormwater management

Source: (Author)

[25] *2014. Urban and Regional Development Plans Formulation & Implementation Guidelines, 2014. Volume II A. [online] Ministry of Urban Development. Available at: http://www.naredco.in/notification/pdfs/Volume%20II%20A%20Compilation%20of%20Legal%20Instruments%20of%20URDPFI%20Guidelines%202014.pdf*

[26] *2016. Model Building Bye-laws, 2016. [online] Ministry of Urban Development, Government of India. Available at: https://smartnet.niua.org/sites/default/files/resources/mbbl.pdf*

[27] *Manuals and Advisories. [online] Available at: http://mohua.gov.in/publication/manual-on-storm-water-drainage-systems--2019.php*

2.3 State Legislative Instruments

As sanitation is a state subject, various states have come up with their own legal instruments either in the form of State Municipal Acts or Policy measures considering state specific situations. Karnataka Urban Drinking Water and Sanitation Policy, 2003; The Haryana Municipal Corporation Act, 1994; Gujarat Irrigation and Drainage Act, 2013; etc. are some examples for such legal instruments.

The SCIAP project is focused on the five cities, i.e., Guntur-Vijayawada, Mysuru, Bhopal and Jaipur, belonging to the states of Andhra Pradesh, Karnataka, Madhya Pradesh and Rajasthan respectively. Thus, this section shall provide the legal instruments available for sanitation sector in each of the above-mentioned states and further elaborate on the selected pilot cities for the project.

Andhra Pradesh (Pilot cities: Guntur and Vijayawada)

The urban local bodies in Andhra Pradesh are largely steered by Andhra Pradesh Municipalities Act 1965 for the municipalities and Andhra Pradesh Municipal Corporations Act 1955 for Municipal Corporations.

1. Andhra Pradesh Municipalities Act, 1965[28]

- All the powers and functions of the Urban Local Bodies in Andhra Pradesh with respect to drainage, water works etc. are laid out categorically from section 147 to section 159 of the Act which include management, construction, inspection, fine-levying provisions etc.
- Constructing, altering, cleaning and maintaining sewers and drainage networks is obligatory duty of the municipality.
- Before construction of any new building, the interested person must notify the municipality about information required by the bye-laws or demanded by the municipal council regarding the limits, dimension, design, ventilation and materials of the proposed building, and the intended situation and construction of the drains, sewers, privies, water-closets and cesspools and must obtain permission regarding the same.
- Supervision and Execution of Drainage / Sanitary works: A certificate of Supervision and Execution of drainage / sanitary works shall be enclosed in the prescribed Form by the Architect / Engineer / Supervisor as the case may be.

[28] Government of Andhra Pradesh (1965) 'Andhra Pradesh Municipalities Act', 1965(0), pp. 0–12., Available at: http://www.ielrc.org/content/e6503.pdf

The key aspects of the Andhra Pradesh Municipality Act 1965 concerning wastewater management are discussed below:

Table 2.5: Aspects along with the Regulations governing the wastewater management in Andhra Pradesh

Management aspects	Regulations
Maintenance of drainage system & Power to regulate discharge of water	**Public drainage:** • The Municipal Council holds the power to permit, provide and maintain a sufficient system of public drains. • Owners of buildings to pay for clearance of sullage from their buildings by connecting their house-drains with public drains
	Private drainage: All house drains within the municipality shall be under the control of the council. All works to be carried out according to the bye-laws. • Connection of house-drains of private latrines with public drains of underground sewers within specific distance as mentioned in Section-150 of part V. • If owner or occupier fails to comply with the notice specified within fifteen days, shall be recovered in the same manner as property tax by the Commissioner.
Tariff fixation, collection	For discharge of drainage from private premises to the public drains, payment shall be made on the basis of: • Either monthly rent or percentage of capital value of the building as laid down in the bye-laws, or • According to the number of taps allowed. This may be recoverable in the same manner as the property tax by the Municipal Council.
Power to close open discharge and disconnection of services	Commissioner has the power to close or limit the use of existing private drains, on the condition, in providing another for the drainage of the premises and communicating with a public drain or other place aforesaid. The expenses incurred shall be borne by the Council. (refer Section 151)
No permission to build over drains	Without permission of the council, no person shall place or construct or in any way interfere with, any public drain, whether it passes through public or private ground.
Construction of culverts or drain covers	The Commissioner may by notice require the owner or occupier of any building or land adjoining a public street to construct culverts or drains-coverings over the side channels or ditches at the entrances to the said building or land.
Provision of public latrines and urinals	The council may permit, provide and maintain, sufficient number of public latrines and urinals and shall cause the same to be daily cleaned and kept in proper order. (refer Section 156)

Source: (IELRC, n.d.)

Other similar legal instruments which govern sanitation services include AP Building Rules 2012[29], modified in 2017 notified by the State Government under the provisions of Andhra Pradesh Municipalities Act, 1965.

Main provisions of the Act include:

- The act provides that the planning, design, construction and installation of water supply, drainage and sanitation etc. shall be in accordance with the provisions of Water Supply, Drainage and Sanitation, Gas Supply or Plumbing Services, of the latest edition of National Building Code of India.
- For each plot, the Application for Building Permission should be accompanied by services plan, including the drainage and sewerage work plan and a certificate of supervision and execution of drainage / sanitary works to get the approval from the Authority.
- The relevant provisions, standards contained in these Rules and also as given in the NBC shall apply to the type of occupancy/development in addition to requirements mentioned, depending on the type of proposal, e.g., Assembly buildings, Educational buildings, etc. Requirements of Water Supply, Drainage and Sanitation are to be referred from Annexure-5.
- Construction of other facilities like bathrooms, kitchen, water closets etc. is subject to provision of sewer line supply.
- Conditions on construction of septic tanks along with dimensions have been outlined.
- The provisions such as location of sewer lines, submission of sewer and water supply plans for sanction, inspection of sewer lines etc. have been allotted to the municipal authority.

2. Andhra Pradesh State Sanitation Strategy (AP SSS)[30]

The National Urban Sanitation Policy (NUSP) of the Government of India announced in 2008, entrusted state governments to prepare their State Sanitation Strategy (SSS) in line with constitutional provision. The AP SSS recognizes primacy to integral solutions that covers sub sectors of solid waste, waste water (including septage), storm water drainage and drinking water. The National Urban Sanitation Policy (2008) stipulates all Urban Local Bodies (ULBs) to develop their City Sanitation Plans (CSP) as a city level instrument for sanitation sector planning. AP SSS is a major fillip to guide the Municipal Authorities to prepare and operationalize the CSPs.

[29] *Department, M. A. and U. D. (2013) 'AP Building Rules 2012', Available at: http://www.bareactslive.com/AP/ap431.htm*

[30] *Pradesh, A. and Strategy, S. S. (no date) 'Andhra Pradesh State Sanitation Strategy'. Available at: http://www.urbansanitation.org/live/hrdpmp/hrdpmaster/hrdp-asem/content/e30293/e31169/e49811/e65195/FINAL_AndhraPradeshSSS-Releasedversion.pdf*

Key Highlights:

- Ensuring 100 percent hygienically safe and sanitary treatment and disposal
- Achieving Open Defecation Free Cities
- Improved institutional governance and enhanced human resource capacities for city-wide sanitation
- Enhanced awareness and sustained behavioral change
- Technological efficiency and appropriateness
- A draft implementation plan is also attached with broad Measures to be implemented from the AP-SSS and their implementation timelines.

According to the order published in 2001, by the Municipal Administration and Urban Development Department of Andhra Pradesh, Rainwater harvesting has been made mandatory in all new buildings with an area of 300 sqm or more. Tentative for enforcing this deadline was June 2001.[31]

3. Andhra Pradesh Water, Land and Trees Act, 2002[32]

The Act came into force on April 4, 2002 with an objective of promoting water conservation and tree cover, and regulating the exploitation and use of ground and surface water, and protection and conservation of water sources, land and matter connected therewith.

The Act provides the Authority to have functions, for which it may appoint officers and servants. The functions are to:

- Promote water conservation and enhancement of tree cover in the State.
- Regulate the exploitation of ground and surface water
- Make regulations for the functioning of authorities at the District and Mandal Level
- Advise the Government on legislative and administrative and economic measures, from time to time, as incentives or disincentives relating to taxes, levies, fee or other charges to promote conservation of natural resources.
- To advise on strengthening Public Participation in Conservation of Natural Resources.

[31] *2000. Government of Andhra Pradesh[online] Available at: http://www.rainwaterharvesting.org/urban/govt_order1.htm*

[32] *2002. Andhra Pradesh Water, Land and Trees Act and Rules, 2002. [online] International Environmental Law Research Centre. Available at: http://www.ielrc.org/content/e0202.pdf*

Rajasthan (Pilot city: Jaipur)

The following legislation and documents are the bases of the practices adopted by the State Government and agencies therein, for regulating the sanitation sector within the state.

1. Rajasthan Municipalities Act, 2009[33]

According to section 45 of the Act, It shall be the duty of every Municipality to make reasonable provision and proper arrangement for the following matters within the municipal area, namely: -

- Public health, sanitation, conservation, solid waste management, drainage and sewerage, cleaning public streets, places and sewers, and all spaces, not being private property, which are open to the enjoyment of the public, whether such spaces are vested in the Municipality or not, removing noxious vegetation and abating all public nuisances;
- Removing filth, rubbish, night-soil, odour, or any other noxious or offensive matter from privies, latrines, urinals, cesspools or other common receptacles for such matter in or pertaining to a building or buildings;
- Securing or removing dangerous buildings or places and reclaiming unhealthy localities;
- Constructing, altering and maintaining public streets, culverts, municipal boundary marks, markets, slaughter-houses, drains, sewers, drainage-works, sewerage-works, baths, washing places, drinking fountains, tanks, wells, dams and the like;
- Constructing public latrines, privies and urinals;
- Making arrangements for preparation of compost manure from night soil and rubbish;

Under the section 46 of the Act, the other municipal functions of a Municipality may include, having regard to the satisfactory performance of its core functions which shall constitute the first charge on the municipal fund, and subject to its managerial, technical and financial capabilities, undertake or perform, or promote the performance of, any of the following functions, namely: -

- In the sphere of protection of environment (related to sanitation sector)
    - Reclamation of waste lands;
    - Promotion of measures for abatement of all forms of pollution;

- In the sphere of public health and sanitation
    - Reclamation of unhealthy localities;
    - Maintenance of all public tanks and regulating re-excavation, repair and up-keep of all private tanks, wells and other sources of water-supply on such terms and conditions as the Municipality may deem proper; and
    - Advancement of civic consciousness of public health and general welfare by organizing discourses, seminars and conferences;

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[33] *Rajasthan Municipalities Act, 2009. Available at: http://www.bareactslive.com/RAJ/RJ018.HTM (Accessed: December 2020).*

2. **State sewerage and waste water policy, 2016**[34]

The Government of Rajasthan's 'Sewerage and Waste Water Policy' is read in accordance with the most current versions of the following, legislations and documents of the Government of India:

Latest Manual on Sewerage and Sewage Treatment Systems, 2013, Environmental (Protection) Act, 1986, The Environment (Protection) rules, 1986, The Water (Prevention and control of pollution) Act, 1974, The Water (Prevention and control of pollution) cess Act, 1974, The Water (Prevention and control of pollution) Amended rules, 2011, The water (Prevention and control of pollution) Cess rules, 1978, The water (Prevention and control of pollution) Rules, 1975, National Urban Sanitation Policy 2008, National Water Policy 2012, Rajasthan Municipalities Act, 2009, Quality standards suggested by Central Pollution Control Board and Rajasthan State Pollution Control Board, Standards set by Bureau of Indian Standards (BIS), Effluent Quality guidelines for health protection measures in aquaculture use of waste water, Quality guidelines for health protection in using human wastes for aquaculture and Service Level Benchmarks Fixed by Ministry of Urban Development.

- All cities and towns of Rajasthan become totally sanitized, healthy and liveable and to ensure, sustain good public health and environmental outcomes for all their citizens with a special focus on hygienic and affordable sewerage facilities for the urban poor and women. All urban dwellers will have access to and use safe and hygienic sewerage facilities and arrangements so that no one defecates in the open.
- To overcome the shortage of water, for different purposes, use of potable water should mostly be for drinking purposes and re-use of water up to a certain quality after proper treatment of water for non-drinking purpose and last but not the least scientific disposal of the remaining waste is the object behind formulating this policy.

Functions: The policy guides the ULBs in managing their sanitation sector in the following heads-

- On Resource Development
- On Resource Management
- On Wastewater Collection and Treatment
- On Reuse of Treated Effluent and Sludge
- On Pricing, Financing and Investment
- Source of Funds for Sewerage Project
- On Standards, Regulations and Quality Assurance

[34] *Rajasthan, G. of (2016) 'STATE SEWERAGE & WASTE WATER POLICY- 2016'. Available at: https://urban.rajasthan.gov.in/content/dam/raj/udh/lsgs/lsg-jaipur/pdf/Sewerage_and_Waste_Water_Policy_07.09.2016.pdf*

- On Legislation and Institutional Arrangements
- On Public Awareness
- On Service Level Benchmarks & Implementation Plan

3. Rajasthan Urban Development Policy, 2017[35]

The vision of Rajasthan Urban Development Policy is:

"To develop cities and towns which enhanced productivity, liveability, and prosperity for the citizens."

Objectives for Municipal Wastewater Management:

- To ensure 100% coverage of sanitation services with proper collection, transportation, treatment, and disposal.
- To eliminate open defecation by providing sanitation services to the urban poor on a priority basis.
- To incentivise private sector participation for implementing innovative technologies in sanitary waste management focusing on treatment for maximum recycle and reuse of wastewater.
- To implement "polluter pays principle" for management of wastewater

Objectives for Stormwater Management:

- To make storm water management system an integral part of urban planning and development process with the municipal body responsible for compliance of the same.
- To ensure regular maintenance and operations of the drainage system throughout the year, especially during the monsoon season.

4. Faecal Sludge & Septage Management Guidelines for Urban Rajasthan, 2018[36]

These operative Guidelines are formulated by the GoR, drawing from the provisions and specifications for Faecal Sludge and Septage Management from the National Faecal Sludge and Septage Management Policy, 2017; Rajasthan Wastewater and Sewerage Policy, 2016, Primer on Faecal Sludge and Septage Management, 2016; National Building Code, 2005; revised CPHEEO Manual on Sewage and Sewerage Treatment 2012; Advisory Note on Faecal Sludge and Septage Management in Urban India, 2013; and National Urban Sanitation Policy, 2008.

[35] *Local Self Government Department, 2017. Rajasthan: Urban Development Policy. [online] Government of Rajasthan. Available at: https://urban.rajasthan.gov.in/content/dam/raj/udh/organizations/ruidp/MISC/Rajasthan_Urban_Development_Policy_Final_Approved.pdf*

[36] *Local Self Government Department, 2018. Faecal Sludge & Septage Management Guidelines for Urban Rajasthan. [online] Government of Rajasthan. Available at: https://urban.rajasthan.gov.in/content/dam/raj/udh/organizations/ruidp/MISC/Final_State_FSSM_Guideline_upload.pdf*

- **Aim:** to promote a comprehensive and integrated approach to Faecal Sludge and Septage Management covering the attributes of the collection, storage, desludging, transportation, treatment, disposal and reuse, and ensure the compliance with various national-level guidelines and regulations.
- **Objectives:** To be facilitators for all relevant stakeholders for their individual roles and responsibility;
  - To establish a robust institutional and regulatory mechanism at the State and ULB-level to bridge the existing gaps in FSSM value chain;
  - To provide clarity on selections of towns and intervention approaches to kick-start implementation;
  - To provide necessary guidance for planning and implementing FSSM interventions at a town and city-level;
  - To facilitate the adherence to proper design, collection, treatment, disposal and reuse standards in managing faecal sludge/septage with the existing infrastructural capabilities of the ULBs;
- To further strengthen the framework focused on implementing the provisions of the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013.

5. Unified Building Bye-laws, 2017[37]

The state government has made rainwater harvesting mandatory for all public and commercial establishments and all properties in plots covering more than 500 m^2 in urban areas.

If completion certificate for RWH is not submitted to PHED, water supply connection can be terminated.

The section 9.12 of the bye-laws, have made it mandatory for all the liquid waste/sewage pipes to either be connected to the nearest municipal pipelines or have the provision of a septic tank/soak-pit within the plot, constructed according to the NBC 2005.

[37] *Local Self Government Department, 2017. Unified Building Bye Laws. [online] Government of Rajasthan. Available at: https://urban.rajasthan.gov.in/content/dam/raj/udh/uits/uit-kota/pdfs/Unified%20Building%20Bye%20Laws%202017.pdf*

Madhya Pradesh (Pilot city: Bhopal)

1. Madhya Pradesh Municipal Corporation Act, 1956 and M.P Municipalities Act, 1961[38]

The Corporation shall make adequate provision, by any means or measures which it may lawfully use or take, for each of the following matters, namely:-

- Disposing of night soil and rubbish and, if so deemed desirable, preparation of compost manure from night soil and rubbish;
- Constructing, altering and maintaining public streets, culverts and corporation boundary markets, latrines, urinals, drains, sewers and providing public facilities for drinking water; watering public streets and places;
- The erection in proper and convenient situations on municipal land of water closets, closet accommodation, urinals, and other conveniences for the public and the maintenance and the cleansing of the same;
- Matters which may be provided for by corporation at its discretion.
- Establishing and maintaining a farm or factory for the disposal of sewage.

Table 2.6: Aspects along with the Regulations governing the wastewater management in Madhya Pradesh

Management aspects	Regulations
Power to close open discharge and disconnection of services	Commissioner has the power to close or limit the use of existing private drains, on the condition, in providing another for the drainage of the premises and communicating with a public drain or other place aforesaid. The expenses incurred shall be borne by the Council. (refer Section 193)
No permission to build over drains	Without permission of the Commissioner, no person shall place or construct or in any way interfere with, any public drain, whether it passes through public or private ground.
Construction of culverts or drain covers	The Commissioner may by notice require the owner or occupier of any building or land adjoining a public street to construct culverts or drains-coverings over the side channels or ditches at the entrances to the said building or land.
Provision of public latrines and urinals	The Municipality may permit, provide and maintain, sufficient number of public latrines and urinals and shall cause the same to be daily cleaned and kept in proper order. (refer Section 194 & 195)
Sewage and rain water drains to be distinct	Commissioner may require that there be one drainage for offensive matter and sewage and another drainage for rainwater and uncontaminated sub-soil water, each drainage in separate municipal drains or other places specified by the Drainage Discharge Commissioner, or in the drainage discharge area, or into other suitable places.

Source: (M.P. Municipal Corporation, 1956)

[38] *1956. Madhya Pradesh Municipal Corporation Act, 1956. [ebook] Available at: http://www.janaagraha.org/asics/report/Madhya-Pradesh-Municipal-Corporation-Act-1956.pdf*

2. The M.P. Nagar Tatha Gram Nivesh Adhiniyam, 1973[39]

The government of Madhya Pradesh (GoMP) enacted the M.P. Nagar Tatha Gram Nivesh Adhiniyam, 1973, act for planning and urban development in the state. For giving the enforcement powers and permissions, the GoMP makes the rules under M.P. Bhumi Vikas Rules, 1984. (Department of Housing and Environment, 2020)

Functions: Execution of plans, projects and schemes for the development of the cities of Madhya Pradesh.

3. The M.P. Bhumi Vikas Rules, 1984[40]

In exercise of the powers conferred by Section 85 read with sub-section (3) of Section 24 and Section 31 of the Madhya Pradesh Nagar Tatha Gram Nivesh Adhiniyam, 1973 (No. 23 of 1973), the State Government prepared the MP Bhumi Vikas rules. The rules apply to all of the Madhya Pradesh.

The rules prescribe mandates related to building construction as well as the wastewater infrastructure layout procedures within a plot falling within the Development Authority boundary.

4. Govt. of Madhya Pradesh State Level Policy (2017) for Waste Water Recycle & Reuse and Feacal Sludge Management (FSM)[41]

The Policy, envisions, "All MP State cities and towns become totally sanitized, healthy and liveable and ensure and sustain good public health and environmental outcomes for all their citizens, with a special focus on hygienic and affordable sanitation facilities for the urban poor and women".

The policy specifically endorses the following core principles:

- To promote proper functioning of network-based sewerage systems and ensure connections of household so as to prevent dry weather flow in drains & streets.
- Treatment of sewage and sludge is required prior to discharge into the environment.
- Promote recycling & re-use of treated sewage for non-potable applications.
- To make Sewerage project economical and environmentally sustainable.
- Capacity building for enhanced institutional ability to govern the sector effectively.

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[39] 1973. The M.P. Nagar Tatha Gram Nivesh Adhiniyam, 1973. [online] Available at: http://bareactslive.com/MP/MP539.HTM

[40] 1984. The Madhya Pradesh Bhumi Vikas Rules. Part-I-General. [online] Available at: http://mptownplan.nic.in/Rules/vikasniyam/MPBVN-1984.pdf

[41] Urban Development & Housing dept., 2017. State Level Policy (2017) for Waste Water Recycle & Reuse and Feacal Sludge Management (FSM). [online] Govt. of Madhya Pradesh. Available at: http://www.mpurban.gov.in/Uploaded%20Document/guidelines/8%20StateLevelPolicyV1.pdf

- Establishment of an efficient, effective, affordable and accountable system for managing urban sewerage and septage management.
- Effective monitoring and evaluation of the initiatives intended to improve sewerage and septage management services.
- Coverage of all citizens in the urban areas for service provisioning.
- Adequate sewerage and Septage facility provided to all urban customers
- Ensuring the system's financial sustainability in a progressive manner through improved efficiency, tariff rationalization and corporatized operations there by decreasing dependence on unsustainable resources.
- Improved service levels in a well-defined and phased manner by ensuring interventions in the spheres of infrastructure, institution, autonomy and management, monitoring mechanism and regulatory framework.

Karnataka (Pilot city: Mysuru)

1. **Karnataka Urban Water Supply and Drainage Board Act, 1973[42]**

About the Act

- It provides for the establishment of a Water Supply and Drainage Board and
- Provision of regulation and development of drinking water and drainage facilities in the urban areas of the State of Karnataka.

Functions

All the powers and functions of the Board to provide for Urban Local Bodies in Karnataka with respect to drainage, water works etc. are laid out categorically from section 16 to section 43 of the Act which includes preparing schemes and programmes for drainage, provide for the scheme's finance and power to cut off the connections.

The prohibited actions and penalty procedures are also provided for ULBs to be carried out for the offenders in case of failure to abide to the rules of the Act.

2. **Karnataka Municipal Corporations Act, 1976[43]**

   The urban local bodies in Karnataka are largely steered by Karnataka Municipal Corporations Act 1976 for Municipal Corporations. Sections 221 to 254 in Chapter XIII, describe all the legal provisions for the ULBs, regarding managing wastewater infrastructure in the Act. Some of the key provisions in the act are discussed below:

[42] *1973. Karnataka Urban Water Supply and Drainage Board Act, 1973. [online] Available at: http://www.dpal.kar.nic.in/pdf_files/25%20of%201974%20(E).pdf*

[43] *1976. The Karnataka Municipal Corporations Act, 1976 [online] Available at: http://dpal.kar.nic.in/14%20of%201977%20(E).pdf*

- All sewers alongside or under any public street within the city and all sewage disposal works shall vest in the corporation and referred to as corporation sewers.
- The corporation shall maintain and keep in repair all sewers and sewage disposal works and shall construct as many new drains, and sewage disposal works periodically necessary for effectual sewerage of the city.
- Polluting matters not to be passed into corporation sewers and prohibition of some acts regarding sewerage are identified in these sections.
- Application for permissions by owners and occupiers to drain private sewers into corporation sewer. Rules and Regulations provided for the same.
- Sewage and rainwater drains shall be distinct.
- Identification of places for the emptying of sewers and disposal of sewage(desludging).
- Powers to execute work, affix shafts, for ventilation of sewer or cesspool, examine and test sewers, believed to be defective, lay sewer through land belonging to other persons, regularly inspect sewer lines and related infrastructure.
- The corporation may make bye-laws relating to sewerage to carry out the purposes of sewer infrastructure and maintenance.

3. Karnataka Urban Drinking Water and Sanitation Policy, 2002[44]

The National Urban Sanitation Policy (NUSP) of the Government of India announced in 2008, entrusted state governments to prepare their sanitation policy to manage the sanitation sector.

The Government of Karnataka in partnership with urban local bodies in the State, the Karnataka Urban Water Supply & Drainage Board (KUWS&DB) provides all residents of urban areas of the state, piped water supply and sanitation services at or near their dwellings. The efforts of the Government of Karnataka and its partner agencies is to:

- Ensure universal coverage of water and sanitation services that people want and willing to pay for and ensure a minimum level of service to all citizens.
- The Government of Karnataka, however, will have the responsibility to monitor that ULBs provide quality services in accordance with the standards prescribed at the State level.
- Provides capital investment strategies.

[44] *2002. Karnataka urban drinking water and sanitation policy (2002). [online] Available at: https://www.indiawaterportal.org/articles/karnataka-urban-drinking-water-and-sanitation-policy-2002*

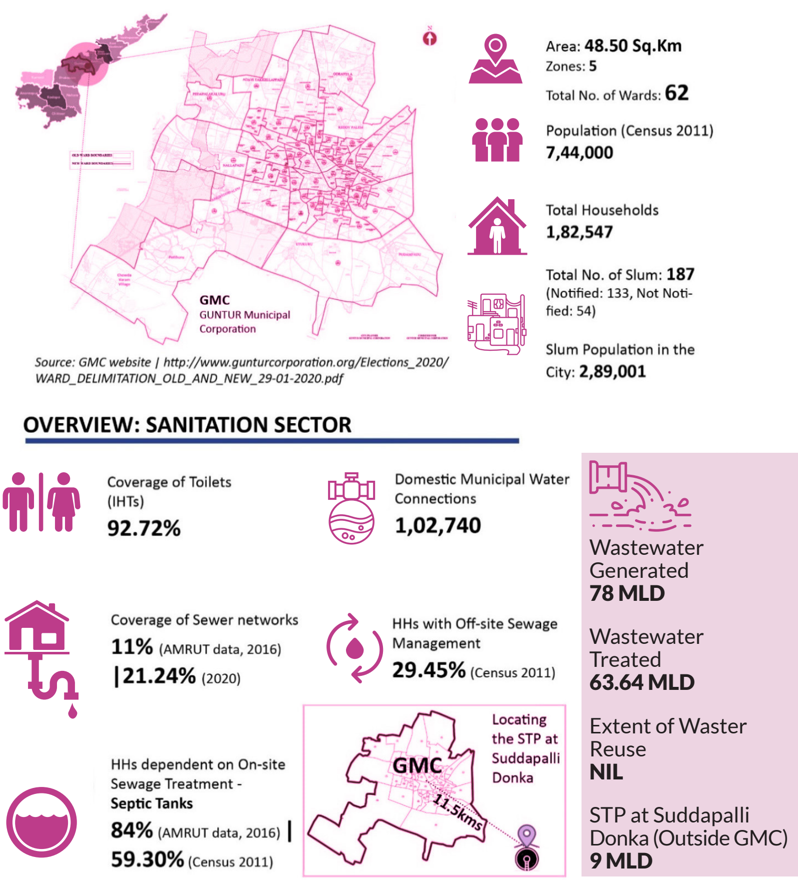
2.4 City Legislative Instruments

Many cities of India have their own regulations for managing their sanitation sector at city level. Thus, this section shall give brief overview of each of the pilot cities and the respective measures taken by the urban local bodies of the respective city for efficient wastewater management.

Guntur

Guntur, an administrative head-quarters of the Guntur District was formed on the 1st October, 1904 after bifurcating Krishna and Nellore Districts. The city has gained prominence in recent decade as it's slated to be part of "Twin Cities" combining the nearby Vijayawada. New capital city for Andhra Pradesh has been proposed in the VGTM (Vijayawada Guntur Tenali and Mangalgiri) jurisdictions adding ample emphasis to the city's growth.

Figure 2.1: Snapshot of sanitation sector, Guntur



Source: Author

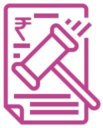
1. Municipal Bye-laws

The city of Guntur follows the Andhra Pradesh Building rules under the Andhra Pradesh Municipalities Act.[45] The Guntur Municipal Corporation is responsible for all the laying, maintenance and operation of the sewerage and sanitation sector of the city.

Guntur has a regional centre for the AP Pollution Control Board and its functions apply to groundwater, air and noise in the city under the Government of India Acts. In addition to parastatal agencies, a number of private agencies operate in the fields of medical waste treatment and septic tank management (Guntur CSP, 2016). According to the GMC, the primary cause of water contamination in the city is that housing layouts do not have a proper sewerage system. Wastewater from the baths, kitchens, and toilets is disposed of in stormwater drains. In view of the fact that the houses are situated at a higher elevation gravity, this discharge to the lakes also aided.

The following table shows the current legislative status of wastewater management in the city:

Table 2.7: Scenario of wastewater management in Guntur, Andhra Pradesh

	Legislation Aspects	Situation in Guntur
	By–laws for construction of septic tanks as per standards	The households have the prescribed toilet technology and are connectwed to individual on-plot septic tanks.
	By–laws for penalty provisions	Penalty in case of failure in construction of Rain Water Harvesting Structures by the Owners. (refer section 155) From 10th August 2020, the GMC has started to put penalties for those who do not hand over garbage to sanitary workers at their doorstep, but prefer to burn it on the roads or throw it in drainage.
	Treatment, Disposal and Monitoring of the services	The 9 MLD STP is located at sudapalli donka which at present is defunct. The coverage of individual household toilets is considerably good. There is no dedicated septage treatment facility or disposal site. At present, septage is being disposed in open land at the outskirts of the city.

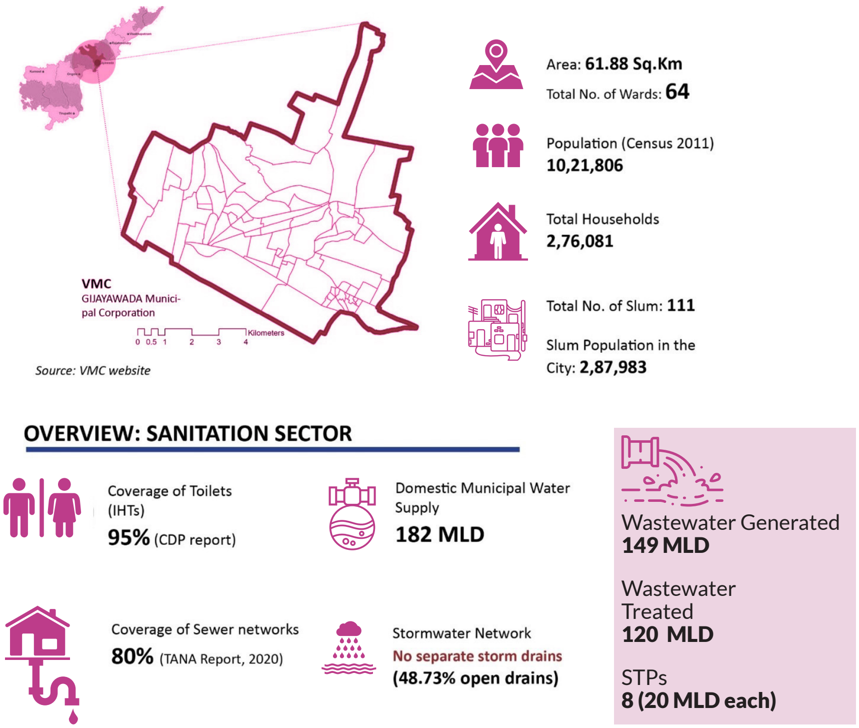
Source: (Government of Andhra Pradesh, A. P. Municipalities Act, 1965)

[45] *1965. Andhra Pradesh Municipalities Act, 1965. [online] Available at: <http://bareactslive.com/AP/ap062.htm> [Accessed 8 September 2021].*

Vijayawada

Vijayawada is the second-largest city of Andhra Pradesh and a suburb of the city of Amravati, the capital city of Andhra Pradesh. It is situated on the banks of the river Krishna. It has a warm and humid climate and an altitude of 20 metres above sea level.

Figure 2.2: Snapshot of sanitation sector, Vijayawada



Source: Author

The Vijayawada Municipal Corporation Act, 1981[46], constituted the Vijayawada Municipal Corporation. In 2016, the Andhra Pradesh Metropolitan Region and Urban Development Authority Act, 2016 (Government of Andhra Pradesh, 2016) was enforced, which overrides all the relevant provisions of the Andhra Pradesh Urban Areas (Development) Act, 1975, Andhra Pradesh Municipal Corporation Act, 1994, (PRS, 1986) and the Vijayawada Municipal Corporation Act, 1981, (Government of Andhra Pradesh, 1981) among others.

[46] *1981. The Vijayawada Municipal Corporation Act 1981. [online] Available at: https://www.indiacode.nic.in/bitstream/123456789/16197/1/act_no_23_of_1981.pdf#:~:text=THE%20VIJAYAWADA%20MUNICIPAL%20CORPORATION%20ACT%201981ACT%20No.%2023,theThirty-second%20Year%20of%20Republic%20of%20India%20as%20follows%3A-*

1. Andhra Pradesh Metropolitan Region and Urban Development Authority Act, 2016[47]

The Metropolitan Region Development Authority undertakes execution of infrastructure projects and schemes; manages and supervises the urban amenities of the areas with more than 1 million population.

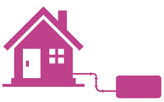
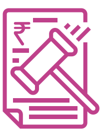
Provides rules for preparing Development Schemes:

- sewerage works - distribution network and sewerage treatment plant;
- storm water drains network

2. Municipal Bye-laws

The following table shows the current legislative status of wastewater management in the city:

Table 2.8: Scenario of wastewater management in Vijayawada, Andhra Pradesh

	Legislation Aspects	Situation in Vijayawada
	By–laws for construction of septic tanks as per standards	The households have the prescribed toilet technology and are connected to individual on-plot septic tanks.
	By–laws for penalty provisions	Penalty in case of failure in construction of Rain Water Harvesting Structures by the Owners. (refer section 155)
	Treatment, Disposal and Monitoring of the services	• The final treated wastewater will be let out in to the Budameru after achieving the desired effluent standards. • Out of the total sewage generated, only 10% of it is treated and disposed. There is no dedicated disposal site. • At present, septage is being disposed in open land at the outskirts of the city.

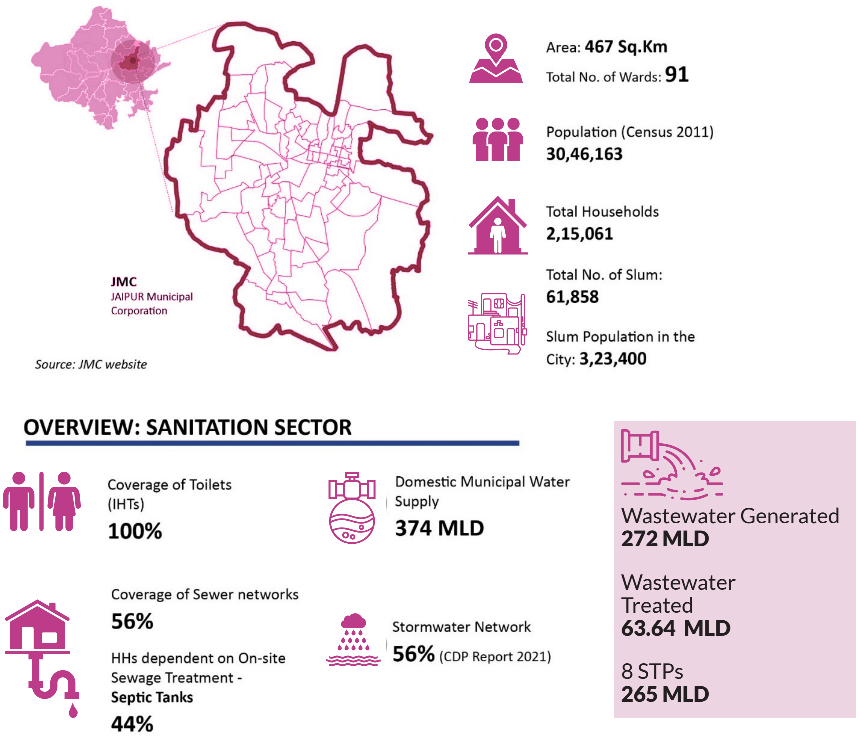
Source: (Government of Andhra Pradesh, 1981)

[47] *Government of Andhra Pradesh, 2016. The Andhra Pradesh Metropolitan Region and Urban Development Authorities Act, 2016. [online] Available at: https://www.indiacode.nic.in/bitstream/123456789/10814/1/metropolitan_region_act_2016_foot_note.pdf*

Jaipur

Jaipur is the capital and the largest city of the Rajasthan state. It is situated in the east-central part of the state, roughly equidistant from Alwar (northeast) and Ajmer (southwest). Jaipur is a tourist city with major attractions like Hawa Mahal, Jantar Mantar, Forts of Amber, Nahar Garh, etc. It is also known as the “Pink City”, due to the dominant colour scheme of its buildings.

Figure 2.3: Snapshot of sanitation sector, Jaipur



Source: Author

1. The Jaipur Development Authority Act, 1982[48]

In Jaipur, the Government has enacted ‘The Jaipur Development Authority Act, 1982’, to act as an establishment authority for the purpose of planning, coordinating and supervising the proper, orderly and rapid development of the Jaipur region and of execution plans, projects and schemes for the development of the city (GoR, 1982). The Act provides for the preparation of infrastructure projects and schemes for Jaipur region.

[48] *1982. The Jaipur Development Authority Act, 1982. [online] Available at: http://www.bareactslive.com/RAJ/RJ573.HTM*

2. Draft Jaipur Water Supply & Sewerage Board Bill, 2017[49]

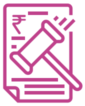
In 2017, a draft of the bill for constitution of the Jaipur Supply and Sewerage Board (JSSB) bill has been prepared by Rajasthan Urban Infrastructure Development Project (RUIDP). The draft proposes cash and imprisonment penalties for those guilty of waste or misuse of water.

An Act to make provision for the management of water supply and sewerage systems in Jaipur Urban Area and matters connected therewith by formation of Jaipur Water Supply and Sewerage Board.

Functions related to sanitation sector:

- Prepare, plan, execute, promote and finance schemes and projects for the development and management of water supply and sewerage systems;
- Construct, operate, maintain and regulate sewerage systems and in this regard lay sewerage sewage treatment works, lay service pipes, close or limit the use of private drains or may place or maintain or construct sewers and sewage treatment works over, under, along or across any immovable property whether within or without the local limits of the Jaipur Urban Area, by acquiring right of user in the property in the prescribed manner.

Table 2.9: Scenario of wastewater management in Jaipur

	Legislation Aspects	Situation in Jaipur
	By–laws for penalty provisions	The Board, under chapter IX of the Bill can impose penalties to be paid by offenders for damage caused by them or for disobeying the Act's legislation.
	Treatment, Disposal and Monitoring of the services	8 STPs with the total capacity of 265 MLD out of which 60% are non-functional Where the sewer lines do not exist, the storm water drains are used for conveyance of silt and sullage. At present, septage is being disposed in open land at the outskirts of the city.

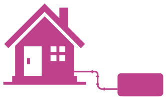
Source: (RUIDP, 2017)

3. Building Bye-laws, Jaipur

The city of Jaipur follows the unified building bye-laws of the state. The following table shows some of the implemented legal aspects in the city.

[49] *2017. Draft Jaipur Water Supply & Sewerage Board Bill, 2017. [online] Available at: https://urban.rajasthan.gov.in/content/dam/raj/udh/organizations/ruidp/MISC/Draft%20Jaipur%20Water%20Supply%20and%20Sewerage%20Board%20Bill%20-%202017.pdf*

Table 2.10: Scenario of wastewater management in Jaipur

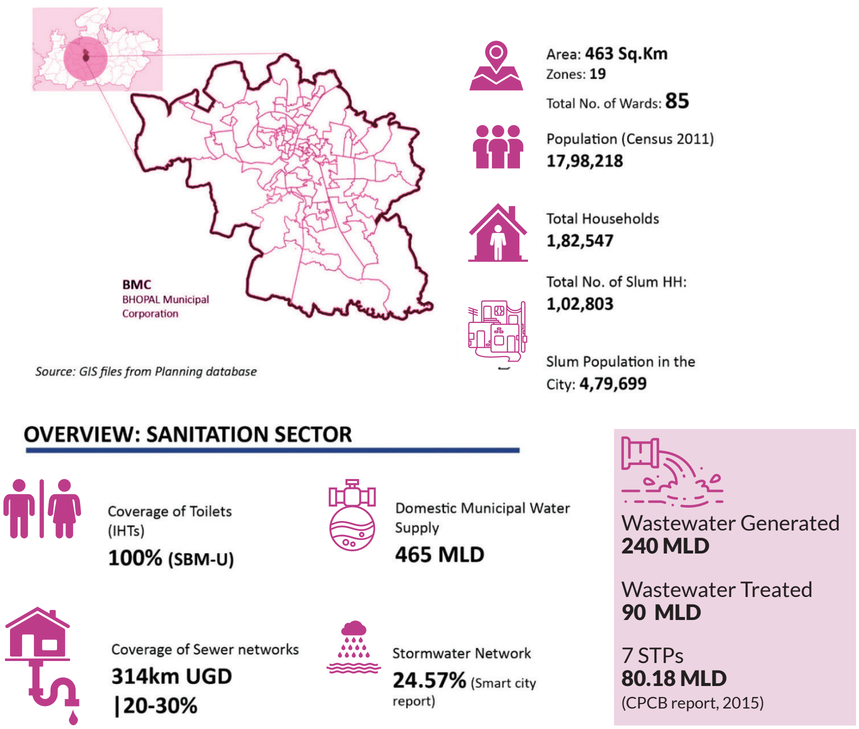
	Legislation Aspects	Situation in Jaipur
	By–laws for construction of septic tanks as per standards	The households have the prescribed toilet technology and are connected to individual on-plot septic tanks or nearby sewer line.
	Green building initiatives by Jaipur Development Authority	Engaging real estate developers and locals to conserve and harvest rainwater through green initiatives. Provision of incentives on green practices through incentive FAR.

Source: (Urban Development & Housing Department, Government of Rajasthan, 2020)

Bhopal

The city of Bhopal is the capital of the Indian state of Madhya Pradesh and the administrative headquarters of Bhopal district and Bhopal division. Bhopal is known as the ''City of Lakes'' for its various natural as well as artificial lakes and is also one of the greenest cities in India. Bhopal, with its central location is very well connected to all the parts of the country. With a municipal area of 463 sq. km, Bhopal stands among 15 largest cities of India. (BMC, 2020)

Figure 2.4: Snapshot of sanitation sector, Bhopal

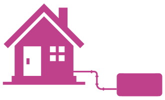


Source: Author

1. Municipal Bye-laws

Bhopal city acts upon the MP Bhumi Vikas Rules of the Act.[50]

Table 2.11: Scenario of wastewater management in Bhopal

	Legislation Aspects	Situation in Bhopal
	By–laws for construction of septic tanks as per standards	The households have the prescribed toilet technology and are connected to individual on-plot septic tanks.
	Treatment, Disposal and Monitoring of the services	Almost 28-30% of the BMC area is covered by sewerage network. A 90 MLD treatment facility available for the population, rest sewer generated is either directly flows in to the open drains and nallahs. At present, septage is being disposed in open land at the outskirts of the city.

Source: (Government of Madhya Pradesh, 1984)

In order to maintain the proper sanitation system, the city has divided into 19 zones (85 wards) and cleaning works are being assigned to the health inspector in each zone. The slum areas which are exempted from regular cleaning system, are cleaned through contractors and proper disposal of garbage is done.

The sewer network in Bhopal executed under various development programs is indicated below:

- – 16 km sewer with 2 pumping stations
- – 24 km sewer line with 5 pumping stations discharging sewage to Patra nallah
- – 108 km sewer with 6 pumping stations
- – 61.7 km sewer with 11 pumping stations
-

2. Stormwater Drainage:

The natural drainage of storm water is reasonably good in Bhopal. In old Bhopal areas, the drainage is provided mainly by Patra nallah which receives flow from number of small channels running across the city, like Gaji Khan ka nallah, Ashoka Garden nallah, Jinsi nallah, Maholi ka nallah, mahamai Bagh ka nallah, kale Bhairon ka nallah etc. Patra nallah after collecting the stormwater from these channels discharges it to the Islamnagar river 18 km from Bhopal, which finally flows in to the Halali river. Large portion of the city in the central region discharges storm runoff to Upper Lake and Lower lake. The entire network of Patra

[50] *1984. The Madhya Pradesh Bhumi Vikas Rules, 1984. [online] Available at: http://mptownplan.nic.in/Rules/vikasniyam/MPBVN-1984.pdf*

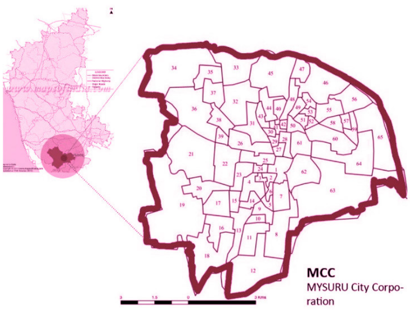
nallah is about 50 kms.

In the New Bhopal area the drainage is provided mainly by katsi nallah, which flows for about 8 km before meeting Shahpura Lake. Three major streams drain Storm Water from Bhopal. On northeastern side river Halali carries the drainage and on southeastern side River Kaliasote carries it, both these rivers drain to the river Betwa. In the southwestern side the drainage is carried by many small nallahs, which ultimately drain in to Kolar River. (BMC)

Mysuru

Mysuru is the third-largest city of Karnataka and second most populated city in the state. It is situated at the foothills of Chamundi Hills, to the Southwest of the capital city of Bengaluru. Mysuru City Corporation received the status of City Corporation from 10 June, 1977.

Figure 2.5: Snapshot of sanitation sector, Mysuru



Source: CDP Report of Mysuru

Area: **128.4 Sq.Km**

Total No. of Wards: **65**

Population **9,20,550**

Total Households **2,15,061**

Total No. of Slum: **83** (Notified:73, Not Notified: 10)

Slum Population in the City: **1,03,390**

OVERVIEW: SANITATION SECTOR

Coverage of Toilets (IHTs) **98.1%**

Domestic Municipal Water Supply **271 MLD**

Coverage of Sewer networks **100%** (TANA Repart, 2020)

Stormwater Network **1200 kms**

Population dependent on On-site Sewage Treatment - **Septic Tanks** **1.6%** (AMRUT data, 2016)

Population with Off-site Sewage Management **96.2%**

Wastewater Generated **200 MLD**

Wastewater Treated **63.64 MLD**

STPs **3**
Vidyranyapuram 67.65MLD
Kesare 30 MLD
Rayanakere 60

Source: Author

1. Municipal Bye-Laws

The city of Mysuru follows the Karnataka Municipalities Model Building bye-laws, 2017 under the Karnataka Municipalities Act, 1964.[51] The Mysuru City Corporation is responsible for all the laying, maintenance and operation of the sewerage and sanitation sector of the city.

Table 2.12: Scenario of wastewater management in Mysuru

	Legislation Aspects	Situation in Mysuru
	By–laws for construction of septic tanks as per standards	The households have the prescribed toilet technology and are connected to municipal sewer lines or individual on-plot septic tanks.
	By–laws for penalty provisions	Penalty in case of failure in construction of Rain Water Harvesting Structures by the Owners. (refer section 155)
	Treatment, Disposal and Monitoring of the services	The final treated wastewater will be let out in to the Budameru after achieving the desired effluent standards. Out of the total sewage generated, only 10% of it is treated and disposed. There is no dedicated disposal site. At present, septage is being disposed in open land at the outskirts of the city.
	Bye-laws for Rainwater harvesting structures	roof of a building to effectively drain water by means of sufficient rain-water pipes of adequate size, wherever required, so arranged, jointed and fixed as to ensure that the rain-water is carried away from the building and rain-water pipes to be connected to a drain or in any other approved manner. (refer section 5.1.16)
	Bye-laws for preserving the natural drainage	No construction is allowed to obstruct the natural drainage through the site. No construction is allowed on wetland and water bodies. (Table 15.1, 15.2, 15.3)

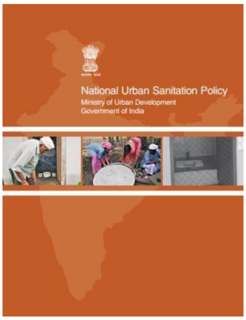
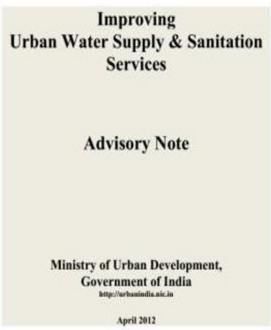
Source: (Government of Karnataka, 1964)

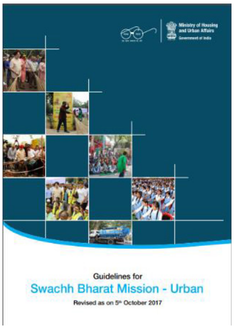
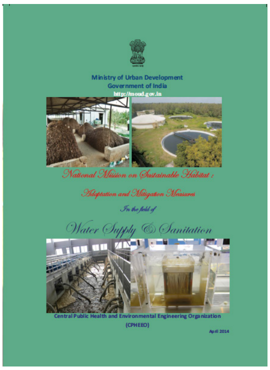
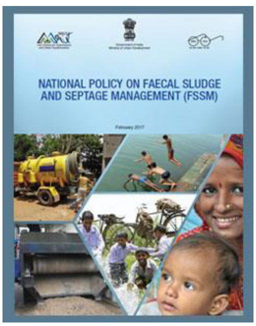
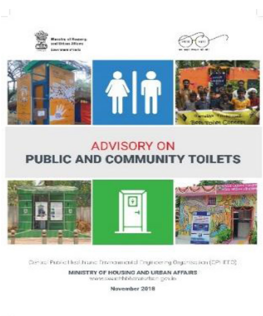
[51] *1964. The Karnataka Municipalities Act, 1964. [online] Available at: <http://dpal.kar.nic.in/.%5C22%20 of%201964%20(E).pdf> [Accessed 8 September 2021].*

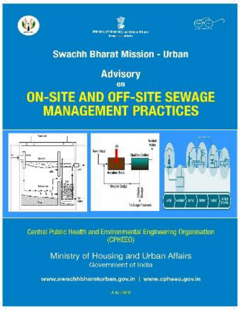
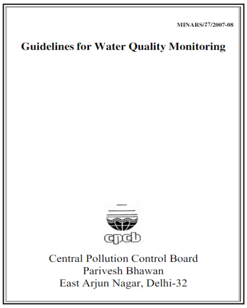
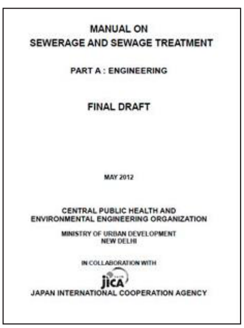
2.5 Compilation of the Advisories for Reference

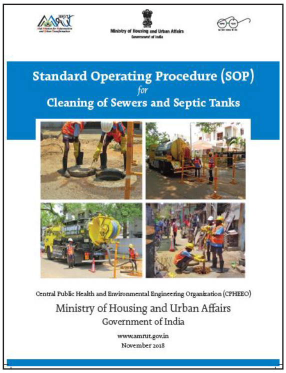
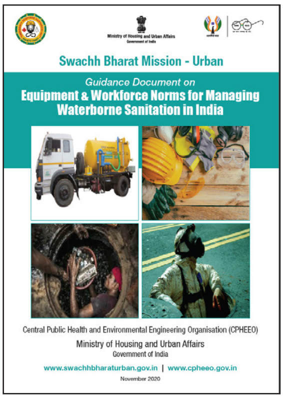
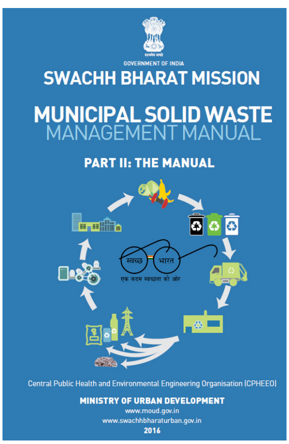
The following table is a compilation of various advisories, i.e., Government and other advisories, relevant for Wastewater Management in India:

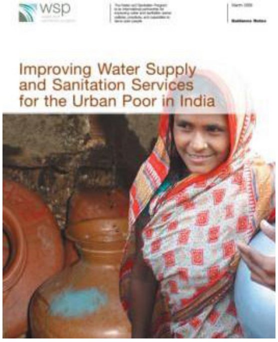
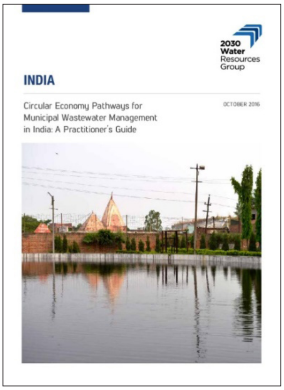
Table 2.13: Advisories prescribed by Government and Other Agencies for Wastewater sector

	Name of document	Link	Remarks
1. Advisory, Policies and Guidelines			
	National Urban Sanitation Policy, 2008 Ministry of Urban Development, Government of India	http://mohua.gov.in/cms/National-Urban-Sanitation-Policy.php	
	Advisory Note, 2012 Improving Urban Water Supply & Sanitation Services Ministry of Urban Development, Government of India	http://cpheeo.gov.in/upload/uploadfiles/files/dvisoryNoteonImprovingUrbanWater SupplySanitationServices.pdf	
	Advisory Note, Septage Management in Urban India, 2013 Ministry of Urban Development, Government of India	http://cpheeo.gov.in/upload/uploadfiles/files/Advisory%20Note%20on%20Septage%20Management%20in%20Urban%20India.pdf	Septage Management

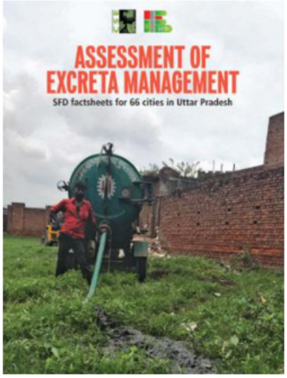
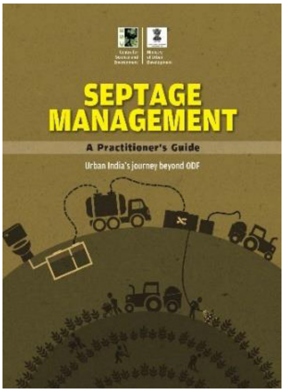
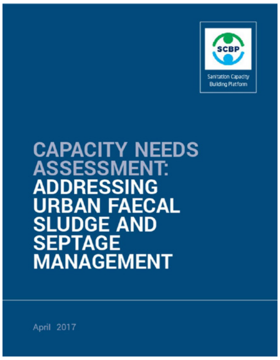
	Name of document	Link	Remarks
	Swachch Bharat Mission Guidelines, 2014 Ministry of Urban Development, Government of India	http://swachhbharat-mission.gov.in/sbmcms/writereaddata/images/pdf/Guidelines/Com-plete-set-guidelines.pdf	
	NMSH Advisory on Adaptation and Mitigation measures in Water Supply and Sanitation, 2014	http://mohua.gov.in/upload/uploadfiles/files/NMSH%20Advisory%20on%20Adaptation%20and%20Mitigation%20Measures.pdf	
	National Policy on Faecal Sludge and Septage Management, 2017 Ministry of Urban Development, Government of India	http://amrut.gov.in/up-load/newsrelease/5a5d-c55188eb0FSSM_Poli-cy_Report_23Feb.pdf	FSSM policy
	Advisory on Public and Community Toilets, 2018 CPHEEO, Ministry of Housing and Urban Affairs	http://cpheeo.gov.in/upload/5d7f529ceed-5eAdvisory%20on%20Public%20Toilet_com-pressed.pdf	FOR Public & Community Toilets

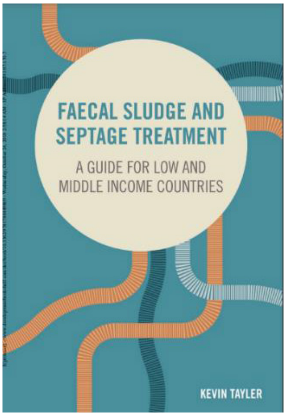
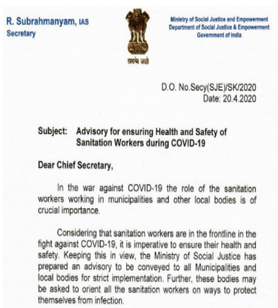
	Name of document	Link	Remarks
	Advisory on On-site and Off-Site Sewage Management Practices, 2020 CPHEEO, Ministry of Housing and Urban Affairs		Sewage treatment systems
2. Manuals and Standards			
	CPCB guidelines on Water Quality		Drinking water and Bathing water quality
	Guidelines for Decentralized Wastewater Management, 2012 by IIT-Chennai for MoUD, Government of India	http://cpheeo.gov.in/upload/uploadfiles/files/Guidelines%20for%20Decentralized%20Wastewater%20Management.pdf	
	Manual on Sewerage and Sewage Treatment 2013 - CPHEEO	http://cpheeo.gov.in/cms/manual-on-sewerage-and-sewage-treatment.php	

	Name of document	Link	Remarks
	Standard Operating Procedures (SOP) For Cleaning of Sewers and Septic Tanks, 2018	http://cpheeo.gov.in/upload/5c0a062b23e94SOPforcleaningofSewersSepticTanks.pdf	
	Equipment & Workforce Norms for Managing Waterborne Sanitation in India	http://swachhbharaturban.gov.in/sbmdocumentfile.aspx?DOCTYPE=9999&DOCID=33	FOR Sanitation Workers
	Manual on Municipal Solid Waste Management - 2016	http://cpheeo.gov.in/upload/uploadfiles/files/Part2.pdf	

	Name of document	Link	Remarks
Other Advisories			
	Guidance notes Improving Water Supply and Sanitation Services for the Urban Poor in India,2009 Water & Sanitation Programme	https://www.wsp.org/sites/wsp/files/publications/SA_GUIDANCE-NOTES.pdf	
	Policy Paper on Septage Management in India, 2011 Centre for Science and Environment, New Delhi	https://www.cseindia.org/policy-paper-on-septage-management-in-india	
	Circular Economy Pathways for Municipal Wastewater Management in India: A Practitioner's Guide. Washington, D.C.: 2030 Water Resources Group, 2016	https://smartnet.niua.org/sites/default/files/resources/Circular-Economy-Pathways-India.pdf	

	Name of document	Link	Remarks
Other Advisories			
	Closing the Water Loop: Reuse of Treated Wastewater in Urban India. Gurugram: PwC India, 2016.	https://smartnet.niua.org/sites/default/files/resources/pwc-closing-the-water-loop-reuse-of-treated-wastewater-in-urban-india.pdf	Re-Use of treated wastewater
	5 Innovative WASH Solutions for an Inclusive Urban India. New Delhi, India: National Institute for Urban Affairs, 2017.	https://smartnet.niua.org/sites/default/files/resources/2017-12-05_v03.pdf	Case Studies related to WASH
	IHUWASH. Innovative Toilet Concepts For Urban India. New Delhi: National Institute of Urban Affairs, 2017.	https://smartnet.niua.org/sites/default/files/innovative-toilet-concepts-for-urban-india.pdf	

	Name of document	Link	Remarks
Other Advisories			
	Assessment of Excreta Management	https://www.cseindia.org/content/downloadreports/9269	SFD factsheets for 66 cities in Uttar Pradesh
	Septage Management – A Practitioner Guide	https://www.cseindia.org/static/mount/recommended_readings_mount/26-septage-management-a-practitioners-guide-update.pdf	
	Capacity Needs Assessment: Addressing Urban Faecal Sludge And Septage Management. New Delhi, India: National Institute of Urban Affairs (NIUA), 2017.	https://smartnet.niua.org/sites/default/files/resources/Capacity%20Needs%20Assessment%20for%20FSSM.pdf	Capacity Building for Sanitation sector

	Name of document	Link	Remarks
Other Advisories			
	Faecal Sludge and Septage Treatment- A guide for low and middle income countries Kevin Tayler, WB & SANTEC & BMGF & GWSP & Practical Action	https://practicalactionpublishing.com/book/693/faecal-sludge-and-septage-treatment	
 R. Subrahmanyam, IAS Secretary Ministry of Social Justice and Empowerment Department of Social Justice & Empowerment Government of India D.O. No.Secy(SJE)/SK/2020 Date: 20.4.2020 Subject: Advisory for ensuring Health and Safety of Sanitation Workers during COVID-19 Dear Chief Secretary, In the war against COVID-19 the role of the sanitation workers working in municipalities and other local bodies is of crucial importance. Considering that sanitation workers are in the frontline in the fight against COVID-19, it is imperative to ensure their health and safety. Keeping this in view, the Ministry of Social Justice has prepared an advisory to be conveyed to all Municipalities and local bodies for strict implementation. Further, these bodies may be asked to orient all the sanitation workers on ways to protect themselves from infection.	Advisory for ensuring Health and Safety of Sanitation Workers during COVID-19	https://drive.google.com/file/d/1DY1Ht3Y5U-8Tm-f2WGOt3sd-SlzFMDml-y/view?usp=sharing	For Sanitation workers during covid

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Quick Assessment

1. Which ministry initiated the Swachch Bharat Mission?
    a. Ministry of Environment and forest
    b. Ministry of Urban Development Housing
    c. Ministry of Urban development
    d. Ministry of Drinking water and Sanitation

2. Do you think that the Manual Scavenging Act of 2013 applies to the manual emptying of septic tanks?
    a. Yes
    b. No

3. The aim of Swachh Survekshan 2020 is to make India clean and free of open defecation?
    a. True
    b. False

4. In which year was the National Urban Sanitation Policy (NSUP) was launched?
    a. 2010
    b. 2012
    c. 2008

5. What are the objectives of NUSP?
    a. To address issues on sanitation & prepare city sanitation plan
    b. To migrate urban inhabitants to safer places
    c. To provide urban people with brooms to clean their houses

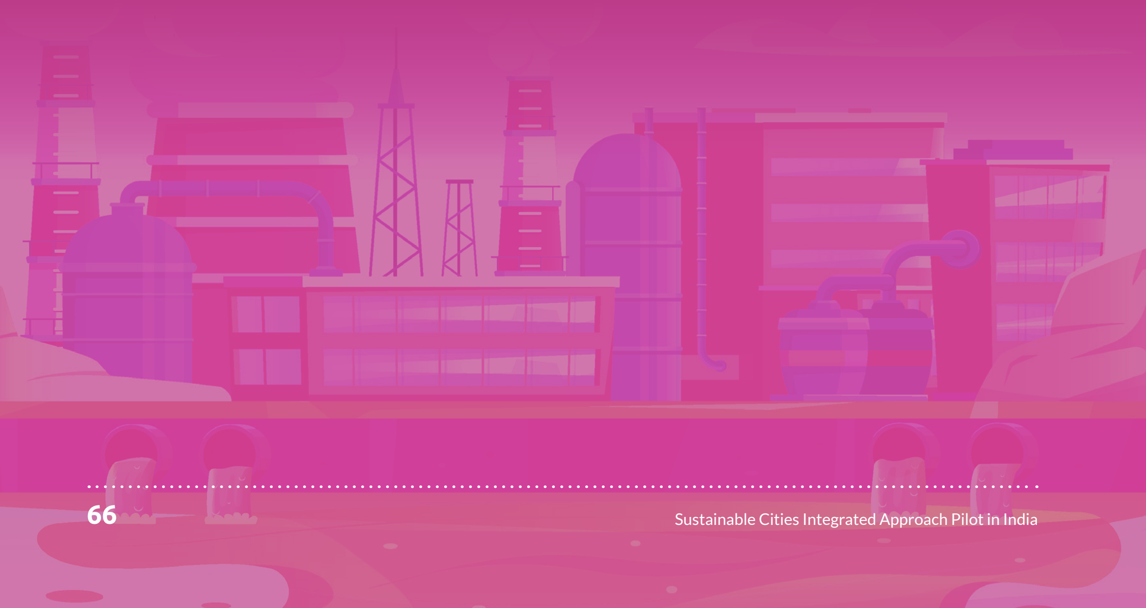
6. Which two aspects do Manual Scavenging and their Rehabilitation Act, 2013 focuses on?
    a. Hazardous cleaning
    b. Promoting manhole cleaning
    c. Manual Scavenging

* *For answers please refer Annexure I*

Chapter

3

Understanding Sanitation & Urban wastewater Management



Recap

The previous chapter gave a brief idea of the current legislative instruments - Acts, Missions, Standards and norms - available at the National, State and city level for the sanitation sector, across the five pilot cities. Moving ahead, this chapter includes topics that are essential for understanding the basics of sanitation and urban wastewater management in the Indian context

Training Objectives

- To get an overview of the domestic wastewater and the waste products
- To understand the various sanitation systems at different levels with their applicability as per the context
- Overviewing the Sanitation value chain along with its components
- Planning of the sanitation systems

Training Outcomes

- To understand the basics of domestic wastewater management
- To get an overview of the Sanitation value chain
- To understand the functional groups of the sanitation value chain
- To gain an understanding on the aspects governing wastewater management, for efficient planning of the sanitation systems.

Chapter Contents

3.1 About Domestic Wastewater and Waste Products

Achieving sustainable sanitation requires safe management and disposal of human excreta/domestic wastewater. The process involves safe collection, safe storage/disposal and recycling/safe reuse of domestic wastewater. Thus, Sanitation covers all four of these technological and non-technical systems, i.e., wastewater management systems, excreta management systems (including wastewater treatment plants), solid waste management systems as well as rainwater drainage systems, also known as storm water drainage systems.

"Storm water in a community settlement is runoff from house roofs, paved areas and roads during rainfall events. It also includes water from the catchment of a stream or river upstream of a community settlement" (EPA).

Wastewater is defined as the used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff/stormwater, and any sewer inflow/infiltration. The characteristics of wastewater vary depending on the source[1].

Domestic wastewater is the used and unwanted water which cannot be used for human consumption or other domestic purpose. The type and amount of liquid waste generated in households is influenced by nature and quantity of water supply, behaviour, lifestyle and standard of living of the population as well as by the governing technical and juridical framework (Mogens Henze, 2001). The domestic wastewater can be categorized as:

1. **Grey Water:** wastewater generated from bathing, washing, general cleaning, laundry, as well as from community stand post, well, hand pumps etc.

2. **Black Water:** Wastewater generated from toilet containing faecal matter. Such water contains very high amount of pathogen compared to grey water.

3. **Brown water:** It 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.

Liquid waste also comprise of Yellow Water (urine with or without flush water). It is separated in certain type of toilet units and reused as fertiliser.

[1] *Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Schertenleib, R. and Zurbrügg, C., 2014. Compendium of Sanitation Systems and Technologies. 2nd Revised Edition. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.*

Once the waste is collected in pit, septic tank etc., it further disintegrates and can be termed as follows:

1. **Faecal Sludge:** 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 from on-site sanitation technologies, like septic tanks, leach pit (single or double pit toilets), aqua privy toilets, Ecosan toilets, UDDT toilets (Urine Diverting Dry Toilets), VIP, VIDP toilets, toilet linked biogas plants (TLBG) etc., in non sewered areas. The physical, chemical and biological qualities of faecal sludge are influenced by the duration of storage, temperature, soil condition, and intrusion of groundwater or surface water in septic tanks or pits, performance of septic tanks, and tank emptying technology and pattern. (MoHUA, 2017) Sewage sludge is the term for the sludge generated during aerobic treatment of domestic wastewater at the sewage treatment plant.

> *Excreta is the mixture of urine and faeces not mixed with any flushing water (although small amounts of anal cleansing water may be included) while 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 (NIUA, 2018)*

2. **Septage:** It is the completely digested sludge collected from on-site sanitation system such as septic tank or ABR etc. Septage is the combination of scum, sludge and liquid that accumulates in septic tanks. Since septage has higher contents of liquid, it is a bit different from other faecal sludge where liquid contents are comparatively very low.

3. **Scum:** Impure matter like oil, hair, grease and other light material that float at the surface of the liquid in septic tank.

Parameters to Characterize Wastewater

Wastewater is mostly water by weight. Other materials constitute only a small portion of wastewater but can be present in large enough quantities to endanger public health and the environment. Because practically anything that can be flushed down a toilet, drain, or sewer can be found in wastewater, even household sewage contains many potential pollutants.

The characteristics of wastewater can be mainly divided into three categories: Physical parameters, Chemical parameters and Biological parameters.

1. **Solids**

   Solids can be classified into various categories depending upon the size of the particles.
   - TS- Total Solids
   - TSS-Total Suspended Solids

Total solids are dissolved solids plus suspended and settleable solids in water.If the particle size is very small and is completely dissolved in the solution, we call it as dissolved solids. If the particle size is in between 0.01 micrometer to 1 micrometer, they are colloidal solids. These colloidal solids are very stable that means they will not settle down in the liquid or water, so it is very difficult to remove them especially from water and wastewater.

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 by 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.

2. Organic constituents

Organic materials are found everywhere in the environment. They are composed of the carbon based chemicals that are the building blocks of most living things. Organic materials in wastewater originate from plants, animals, or synthetic organic compounds, and enter wastewater in human wastes, paper products, detergents, cosmetics, foods, and from agricultural, commercial, and industrial sources.

Organic compounds usually are some combination of carbon, hydrogen, oxygen, nitrogen, and other elements. Many organics are proteins, carbohydrates, or fats and are biodegradable, which means they can be consumed and broken down by organisms. Organic matter is determined by following characteristics:

- BOD- Biochemical Oxygen Demand

It is the most important parameter to assess the pollution level of any sewage waste water. Biochemical oxygen demand (BOD) represents the amount of oxygen required by bacteria and other microorganisms while they decompose organic matters completely under aerobic (oxygen is present) conditions at a specified temperature. Higher the oxygen requirement means higher BOD of wastewater.

- COD- Chemical Oxygen Demand

It is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water. COD can be measured in real-time with our COD analyzers to improve wastewater process control and plant efficiency.

Biodegradable organics are composed mainly of proteins, carbohydrates and fats. If discharged untreated into the environment, their biological stabilization 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 stabilization of the organic matter present, which in turn, can be used to determine the efficiency of wastewater treatment facilities, and to evaluate compliance with wastewater discharge norms.

3. Nutrients

Wastewater often contains large amounts of the nutrient's nitrogen and phosphorus in the form of nitrate and phosphate, which promote plant growth. Organisms only require small amounts of nutrients in biological treatment, so there is typically an excess available in treated wastewater. In severe cases, excessive nutrients in receiving waters cause algae and other plants to grow fast depleting oxygen in the water, causing eutrophication. Deprived of oxygen, fish and other aquatic life die, emitting foul odours.

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.

4. Pathogens

Many disease-causing viruses, parasites, and bacteria also are present in wastewater and enter from almost anywhere in the community. These pathogens often originate from people and animals who are infected with or are carriers of a disease.

For example, greywater and blackwater from typical homes contain enough pathogens to pose a risk to public health. Other likely sources in communities include hospitals, schools, farms, and food processing plants.

- TC (MPN): Total coliforms, most probable number
- FC (MPN): Fecal coliforms, most probable number

Pathogenic organisms present in wastewater can transmit communicable diseases. The presence of specific monitoring organisms is tested to gauge plant operation and the potential for reuse. Coliform bacteria include types that originate in faeces (e.g. Escherichia) as well as the genre not of fecal origin (e.g. Enterobacter, Klebsiella, Citrobacter). The assay is intended to be an indicator of fecal contamination; more specifically of E. coli which is an indicator microorganism for other pathogens that may be present in feces.

The below Table 3.1 showcases the diseases associated with various pathogens:

Table 3.1: Bacterial Pathogens in Human Excreta

S.NO	Bacteria	Diseases	Reservoir
1	Escherichia coli	Diarrhoea	Human
2	Salmonella typhii	Typhoid fever	Human
3	S. paratyphii	Paratyphoid fever	Human
4	Other salmonellae	Food poisoning and other salmonellosis	Human
5	Shigella spp,	Bacilliary dysentry	Human
6	Vibrio cholera	Cholera	Human
7	Other vibrions	Diarrhoea	Human
8	Campylobactor fetus	Diarrhoea	Human, Animals
9	Yarsinia enterocolitica	Diarrhoea and septicimia	Human, Animals

Source: (MoDWS, 2012)

5. pH

The acidity or alkalinity of wastewater affects both treatment and the environment. Low pH indicates increasing acidity, while a high pH indicates increasing alkalinity (a pH of 7 is neutral). The pH of wastewater needs to remain between 6 and 9 to protect organisms. Acids and other substances that alter pH can inactivate treatment processes when they enter wastewater from industrial or commercial sources. Wastewater with an extreme concentration of hydrogen ions is difficult to treat biologically. If the concentration is not altered before discharge, the wastewater effluent may alter the concentration in natural waters, which could have negative effects on the ecosystem.

Alkalinity in wastewater results from the presence of calcium, magnesium, sodium, potassium, carbonates and bicarbonates, and ammonium hydroxides. Alkalinity in wastewater buffers (controls) changes in pH caused by the addition of acids. Wastewater usually is alkaline due to the presence of groundwater (which has high concentrations of naturally occurring minerals) and domestic chemicals. The alkalinity of wastewater is essential where chemical and biological treatment is practiced, in biological nutrient removal and where ammonia is removed by air stripping.

6. Electric conductivity(EC)

The measured EC value is used as a surrogate measure of total dissolved solids (TDS) concentration. The salinity (i.e. 'saltiness') of treated wastewater used for irrigation is also determined by measuring its electric conductivity.

7. Temperature

The wastewater temperature is commonly higher than that of local water supplies. Temperature affects chemical reactions, reaction rates, aquatic life, and the suitability for beneficial uses. Furthermore, oxygen is less soluble in warm than in cold water. The wastewater temperature is commonly higher than that of local water supplies. Temperature affects chemical reactions, reaction rates, aquatic life, and the suitability for beneficial uses. Furthermore, oxygen is less soluble in warm than in cold water. For biological treatment of wastewater under mesophilic condition, a temperature range of 35-370C is optimum.

Characteristics of Main Waste Components

1. **Grey Water:** The composition of grey wastewater depends on sources and installations from where the water is drawn, e.g. kitchen, bathroom or laundry. The chemical compounds present originate from household chemicals, cooking, washing and the piping. In general, greywater contains lower levels of organic matter and nutrients compared to conventional wastewater, since urine, feces and toilet paper are not included. Water consumption in low-income areas with water scarcity can be as low as 20-30 litres per person per day. Greywater volumes are even lower in regions where rivers, lakes or ponds are used for personal hygiene and for washing clothes and kitchen utensils.

   Households in affluent areas with piped water supply may, however, generate several hundred liters per day. In urban and peri-urban areas of low and middle-income countries, greywater is most often discharged untreated into stormwater drains or sewers – provided they exist –from where it flows typically into aquatic systems. This practice may lead to oxygen depletion, increased turbidity, eutrophication, as well as microbial and chemical contamination of aquatic systems.

2. **Urine:** The concentration of nutrients in the excreted urine depends on the nutrient and liquid intake, the level of personal activity and climatic conditions. Urine, rich in nitrogen and phosphorus, can be used as fertilizer for most non-nitrogen-fixing crops after appropriate treatment to reduce potential microbial contamination. The nutrients in urine are present in ionic form, and their plant availability and fertilizing effect compare well with those of chemical (ammonium and urea-based) fertilizers (Pettersson, 1995). Environmental transmission of urine- excreted pathogens is of minor concern in temperate climates. However, faecal cross contamination may create a health risk. In tropical climates, faecal contamination of collected urine poses the primary health risk.

3. **Faeces:** From a risk perspective, exposure to untreated faeces is always considered unsafe because the high levels of pathogens whose prevalence is dependent on the given population. Enteric infections can be transmitted by pathogenic species of bacteria, viruses, parasitic protozoa, and helminths. (WHO 2006). Fecal compost can be applied as a phosphorus-potassium fertilizer or as a soil improver. About 4-70% of the organic matter and some nitrogen content are lost through biological activity and volatilization.

Most of the remaining nitrogen will become available to plants during degradation. The content of organic matter in feces also increases the water-holding and ion-buffering capacity of soils, an essential aspect to improving soil structure and stimulating microbial activity. (WHO 2006).

Table 3.2: Charaterization of Waste Products

	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)	–	104-106	0	107-109

Source- (NIUA, 2018)

3.2 Overview of Sanitation Systems

Sanitation system is a multi-step process in which human excreta and wastewater are managed from the point of generation to the point of treatment for safe reuse or ultimate disposal with minimal human intervention. It is important to understand that sanitation can act at different levels, protecting the household, the community and society. Poor design or inappropriate location of the sanitation system may lead to migration of waste matter and contamination of local water supplies putting the community at risk.

Objectives of the sanitation systems:

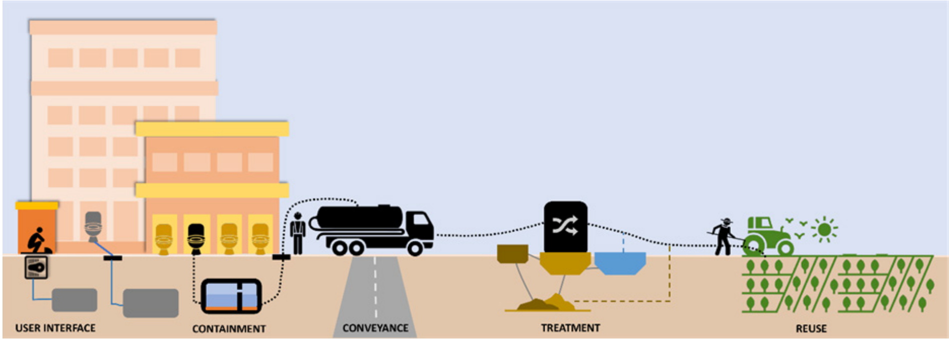
- Safe sanitation systems should keep a barrier between disease-carrying wastes and insects from people, both at the site of the toilet, in nearby homes and in the neighbouring environment.
- It should avoid air, soil, water pollution, return nutrients/resources to the soil, and conserve water and energy.
- The system must be operational with locally available resources (human and material). Where technical skills are limited, simple technologies should be favoured.
- Total costs (including capital, operational, maintenance costs) must be within the users' ability to pay.
- It should be adapted to local customs, beliefs and desires.
- It should address the health needs of children, adults, men, and women.

Sanitation systems can be broadly classified as on-site and off-site depending on disposal systems of waste.

a. On-site sanitation (Non-sewered): Such system aims to contain wastewater at the point of generation. The solids are stored in the containment unit and the liquid effluent is disposed into the ground using soak pits or soak away. After a duration of a few years, the contents of the containment unit as called septage or faecal sludge, are emptied and transported for treatment for their safe reuse or disposal. Since this conveyance of solids is done by mechanised equipment such as vacuum trucks and not by a pipe network, this type of sanitation system is also called as non-sewered sanitation.

Faecal Sludge and Septage Management i.e. FSSM refers to the approach towards building a sustainable and environmentally safe infrastructure from containment to end use or disposal of faecal sludge from on-site sanitation systems (OSS). This includes the safe storage, collection, transport, treatment and end-use or disposal of faecal sludge through Non-Sewered methods.

Figure 3.1: FSSM Value Chain



Source: (NIUA, 2020)

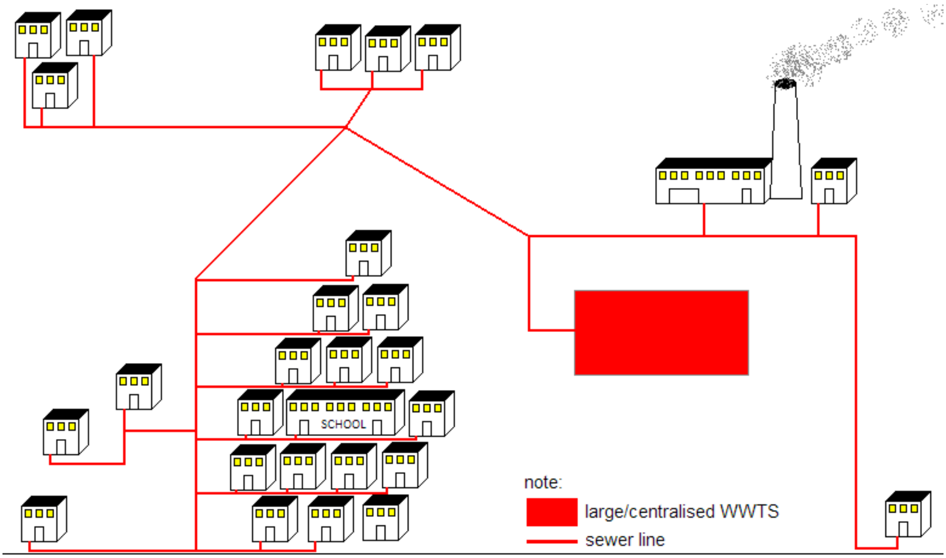
The FSSM value chain includes regular emptying of septic tanks (as per the CPHEEO norms of 2 years intervals), through the emptier having proper safety norms (as per The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act 2013 and Standard Operating Procedure for Cleaning of Sewers and Septic Tanks, by the CPHEEO, Ministry of Housing and Urban Affairs, 2018), conveyance through leak proof and spill proof tractor mounted tank and adequately treated through sustainable technologies for maximum resource recovery in the form of solid and liquid manure for reuse in agriculture. Objective of FSSM will be adversely affected if any of the stages of the chain are not properly followed.

b. Off-site sanitation (Sewered): Systems which require transportation of wastewater to another location for treatment, disposal or reuse are termed as off-site sanitation systems. The off-site sanitation can be centralized (at single point in city) or decentralized (at communal level at multiple points).

Centralized systems

Centralized systems are usually planned, designed and operated to collect and treat large volumes of wastewater for the entire communities/ ULBs. This system requires pipe sewer network such that the waste from every household or building is collected and conveyed to a single Sewage Treatment Plant (STP) in the city. Conventional centralised sewerage systems require a sophisticated infrastructure and large amounts of water to transport the wastes or excreta away. Conventional centralized sanitation systems are expensive to operate. They require energy, skilled labour, infrastructure and maintenance. In efforts to reduce the cost and complexity of waste treatment, decentralised treatment units have been developed.

Figure 3.2: Centralized System

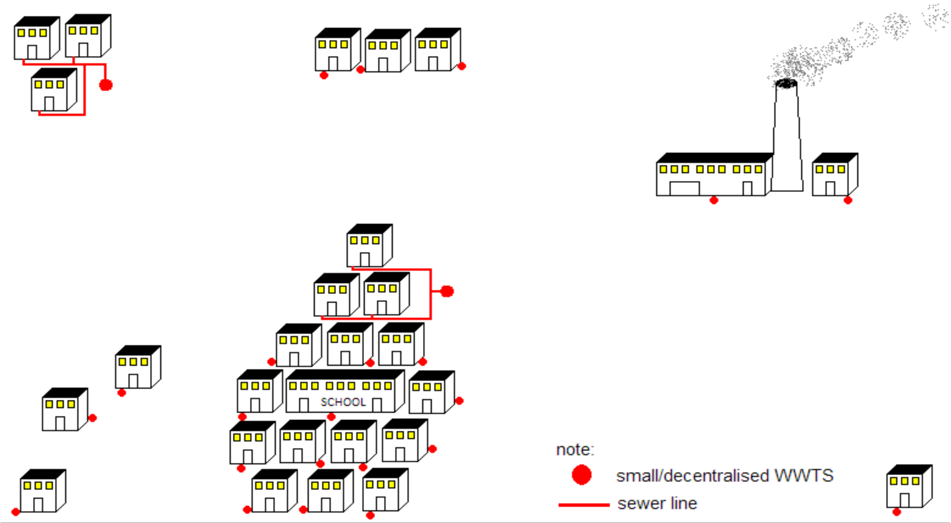


Source: (NIUA, 2017)

Decentralized wastewater management (DWWM) systems

Decentralized wastewater management (DWWM) systems treat wastewater of individual houses, apartment blocks or small communities at the same location where it is generated or is transported through a drainage system and is treated within a short distance of its generation. In decentralized approach, more than one, small capacity of treatment plant can be set up across the city. It could be in the cluster of residential areas, in commercial areas, at the individual scale or in the industrial areas. Decentralised systems can be installed wherever centralised sewered services are unreachable, infeasible or unaffordable. Typically, the decentralized system is a combination of many technologies within a given geographical boundary, namely, onsite systems, low cost collection systems and multiple locations for treatment facilities.

Figure 3.3: Decentralized System



Source: (NIUA, 2017)

Advantages of Decentralized Wastewater Treatment Systems

1. **Cost efficient**
   - The requirement for the underground sewer system is completely eliminated or partially required (within the settlement area from the household to the decentralised treatment system).
   - Lower capital cost and O&M costs, due to absence of complex mechanical as well as electrical systems associated.

2. **Environment Friendly**
   - Complete absence or lower electric consumption and hence power saving.
   - Due or absence of underground sewer system, negligible possibility of ground water contamination.
   - Odorless, hence can be built within a living habitat also.
   - Depending on the technologies applied, it can easily meet the discharge norms of effluent.

3. **High user acceptance**
   - Minimal O&M needs and costs like lower human resources capacity levels needed, makes it easily acceptable by community
   - Easy and efficient user involvement and participation (e.g. in decision making and O&M).

4. **Flexibility in scale**
   - Can be built easily at remotest places, even by skilled labour.
   - Can be built for a scale fit for a household, cluster as well as community level or a town level.
   - Suitable even for hilly /uneven topography of the areas where sewer system is not feasible.

Comparing the Centralized and Decentralized Systems

1. **Centralized System**

In a centralized approach, the ULB has to bear the capital and operation & maintenance cost of the infrastructure. However, taking into consideration the efficiency of collection of taxes in Indian cities, maintaining the infrastructure and providing required services becomes more of a burden, and due to paucity of fund, ULBs find unable to operate the system effectively.

By using valuable drinking water as the transport medium, this system is wasteful of water and plant nutrients that could otherwise be easily treated and reused in agriculture. A centralized wastewater management system reduces wastewater reuse opportunities and increases the risk to humans and the environment in the event of system failure.

Effective level of treatment of waste water through STPs is always a challenging task for the ULBs. Depending on the types, the CAPEX and OPEX of the STPs varies. CAPEX can be arranged from different schemes of the Government of India. Due to lack of own required fund for OPEX, most of the STPs in small ULBs are not operating satisfactorily causing severe problems to community health and environment.

In the past, conventional thinking favoured centralized systems since they are easier to plan and manage than decentralized treatment units. This belief is partly true if municipal administration systems are centralized. However, experience reveals that centralized systems have been particularly poor at reaching peri-urban areas and informal settlements. Centralized treatment systems are usually much more complicated and require professional and skilled operators.

2. **Decentralized System**

Decentralized system of installation, operation and maintenance appears suitable and cost effective for wastewater treatment at community level. However, even where policy makers accept the decentralized approach, they may lack the capacity to plan, design, implement, and operate decentralized systems, thus leading to severe constrains in ensuring its widespread implementation. Most developing countries have no suitable institutional arrangements for managing decentralized systems and lack an appropriate policy framework to promote a decentralized approach. There is a risk that decentralisation will lead to fragmentation and failure to address overall problems adequately. Without technical assistance and other capacity building measures, problems of institutional capacity existing under a centralised operation are simply passed on to the new structures.

Without a formal institutional framework within which decentralized systems can be located, efforts to introduce decentralized management are likely to remain fragmented and unreliable. Decentralization therefore requires greater coordination between the government, private sector and civil society. Decentralized systems must be compatible with the knowledge and skills available at local level, as even the simplest technologies often fail in practice for lack of attention to operational and maintenance requirements. Comparative analyses of advantages and limitations of both the systems are presented in the table below Table 3.3.

Table 3.3: Centralized and Decentralized Sanitation Systems

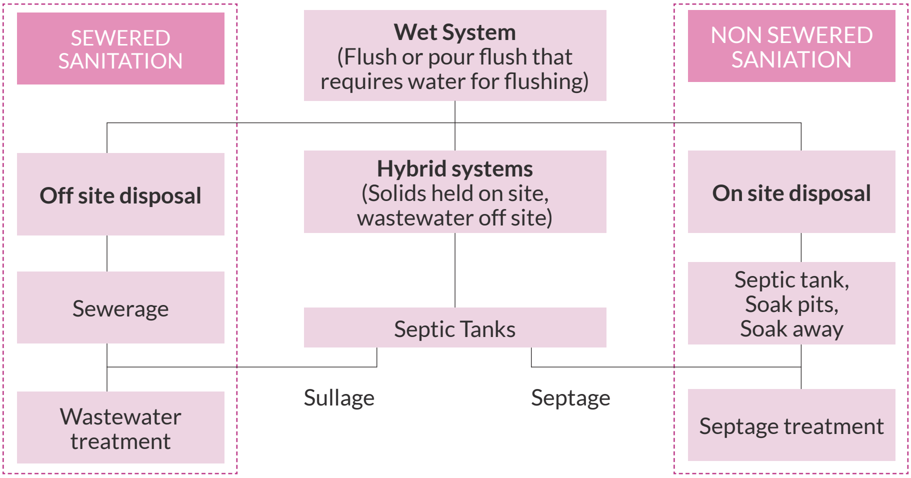
Centralized	Decentralized
Suitable for dense cities—but difficult to scale as city grows	Suitable for population of 5-20,000—single home to entire neighbourhood
Require adequate water for effective operations	Enables maximum local re-use of water, reducing fresh water needs
Expensive to build and maintain—CapEx Rs 20,000- 25,000 per capita	Much less expensive—CapEx Rs 4,000-6,000 per capita
Estimated effectiveness only 30-50% - due to power cuts, mixing of sewage with storm water	Flexible and modular design for clusters
Extensive excavation along roads and private property	Comparatively less excavation required, easier to connect toilets
More chances of failure—several cases of unsuccessful projects	Less complex, requires basic skills to construct, operate and manage
Chances of safe reuse of treated effluent is less treated effluent can be safely reused locally by farmers as there is chance of mixing of industrial wastes containing heavy metals and toxic elements. Further, to carry such effluent to agriculture lands more infrastructure is required	Treated effluent can be safely reused locally by farmers

Decentralized systems are not intended to replace but rather to complement centralised systems. The approach focuses on reducing the pressure on centralized treatment plant thereby making city sanitation infrastructure adaptable to grow systematically as the city grows.

It may be noted that any city or town can have a combination of centralized, decentralized and on-site wastewater management systems, to meet the overall city sanitation. (MoUD, 2012).

In India, a hybrid system exists in most of the ULBs, where in the human wastes are contained in the septic tank at the household level and the sullage/ effluent is either stored in leach pit or disposed into the surface drains outside the houses. The network of drains thus collects the sullage/effluent from all the households and by gravity brings it to the treatment plant if available or low land areas. The septage from the septic tank is emptied after few years and transported by vacuum trucks for either treatment through co-composting with STPs or independent FSTP (Faecal sludge treatment plant), if available or direct disposal on open land, drains or low land areas. This system cannot be classified as completely sewered or non sewered sanitation system and thus is referred to as hybrid sanitation system.

Figure 3.4: Sanitation Systems



Source: (NIUA, 2020)

3.3 Overview of Sanitation Value Chain

A sanitation value chain is made of: **User Interface – Containment – Emptying and Transportation – Treatment – Reuse or Disposal.** These five steps are identified as functional groups of sanitation value chain. Sanitation System also includes the management, operation and maintenance (O&M) required to ensure that the system functions efficiently and waste is reused/discarded safely. It is important to understand that sanitation can act at different levels, protecting the household, the community and society. Thus, the stakeholders and management methods vary at every stage of the sanitation

Every functional group has different key parameters it must address in order to achieve optimum functional performance.

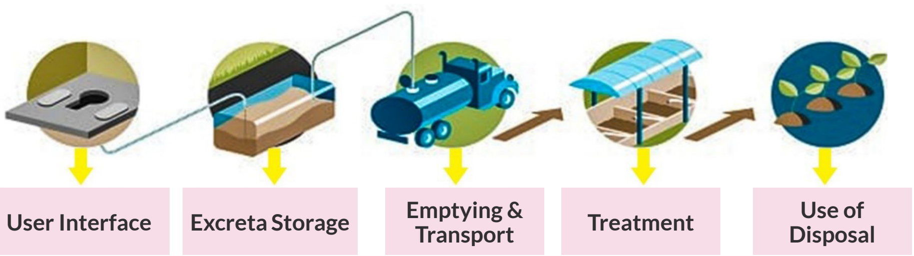
FSSM (Faecal Sludge and Septage Management) or the FSM stage in the Sanitation value chain has become increasingly relevant because only a small proportion of households are linked to sewer systems in urban areas and most households have on-site sanitation systems (such as septic tanks, pits and large holes) (MoSPI, 2018).

The following section explains the various functional groups across the entire sanitation value chain:

Functional Groups of Sanitation Value Chain

In Sanitation value chain, there are five different functional groups from which technologies can be chosen to build a system. By selecting a technology for each product from each applicable functional group, one can design a logical sanitation system. The five functional groups that forms a sanitation system are:

Figure 3.5: Functional groups of sanitation value chain



Source: Author

1. **User Interface:** any type of latrine or tank which is used to capture and store faecal sludge (only excreta and black/yellow water and wash water is captured and not grey water generated from domestic sources)

2. **Excreta Storage:** any type of device used to empty waste collected in latrines and urinals;

3. **Emptying and Transport:** physically moving the sludge from the storage device to the treatment plant. Toilets with septic tanks and leach pit constitute major on-site sanitation systems that need septage collection and treatment. Properly designed twin leach pit toilets, Ecosan and UDDT toilets don't need septage collection and treatment as human excreta in these cases turn into dried manure- suitable for use in agriculture.

4. **Treatment:** treating sludge so that it is safe to disposed of or, ideally, reused;

5. **Reuse or Disposal:** Resource recovery from the septage and treated wastewater by making the plant nutrient contents available for agriculture etc.

Figure 3.6: The technologies and sanitation option for all functional groups (Maharashtra Jeevan Pradhikaran (MJP), 2012)

User Interface	Collection & Storage	Conveyance	Treatment	Reuse/ disposal
Dry/compost toilet	Pit (single or double)	Small Bore Grey Water Drainage System	Sewer Tank	**Treated Water** Reuse (in Agriculture, Irrigation, Aquaculture, Domestic Flushing), surface/ ground water disposal
Pour Flush Toilet	Septic Tank	Simplified Sewer System	Aerobic & Anaerobic Filter/tank	**Treated Sludge** resuse as compost in Agriculture, land application
Pit toilet		Conventional Piped Sewer System	Baffled Reactor	**Semi treated sludge** surface disposal
		Septage transport through mechanical equipment	Root Zone Treatment unit	**Use of bio gas for cooking**
			Polishing Chamber	
			Stabilization & oxidation Pond	
			Bio Gas Plant	
			sludge dewatering/ sludge stabilisation/ slude drying beds	

Source: (Maharashtra Jeevan Pradhikaran (MJP), 2012)

Besides choosing appropriate technologies under each of the functional group as per the needs of the city, various other aspects have to be considered for effective wastewater management. The following section highlights a few of such aspects.

3.4 Aspects for Effective Wastewater Management

The implementation of sanitation system is very slow and tedious process. A few aspects to be considered for the financial sustainability of the wastewater management projects include:

1. Idle Volumes and Time

Invariably, the sewers as a convention are designed for the ultimate projected population till next 30 years (except the pumping stations which are generally designed for 15 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 merely become defunct with time and eventually go into repair. This is a non-productive expenditure, implying that the investment could have been utilized elsewhere like in decentralised treatment systems.

2. House Service Connections

The investment on provision of sewerage is usually met out of capital grant funding, the cost of house service connections is to be met by the house owners when they occupy the property. Repeated road cuts become a perpetual affair over a long time which costs higher for single connection. As and when the houses are built, service connection requests arise. An approach that has been tried out is the provision of house service connection sewers even in the beginning itself and blank it at the property boundary and connect it only when the house gets built up and the applicant pays up 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

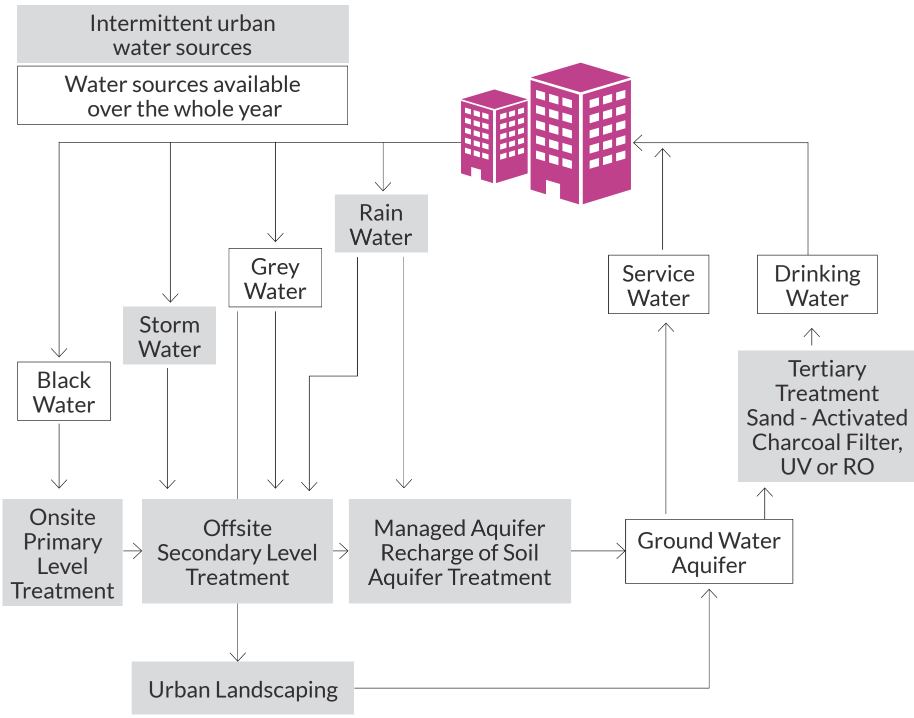
3. Recovery of Costs

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 too meagre to break even in the local administration accounts, let alone increasing the reserve funds. When an unwieldy coverage of a conventional sewerage is implemented, the problem gets compounded all the more 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.

4. The Multi-Barrier Approach

The multi barrier approach focusses more on integration of natural water treatment technologies in the urban scape. These technologies treat perennial and intermittent water sources with special emphasis on resource recovery and reuse. This holistic approach minimises the urban water footprint and enhances the water security of the area, as the water cycle is closed at a local level. It also minimises the pollution of ecosystems and water sources for downstream users, as almost minimal amounts of freshwater get polluted and polluted water is treated and reused locally.

Figure 3.7: Representation of the Multi-Barrier Approach



Source: (NaWaTech)

3.5 Planning of Sanitation Systems

For planning of sanitation systems, a great deal of data collection, analysis of the ground conditions and understanding of the constraints is required. Key determinants of planning are:

1. **Settlement:** Population density and population size. Population density plays a very important role in planning of sewered sanitation. It is very crucial to understand the level or type of habitat while planning wastewater management in order to assess various variables like 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, etc. There are different levels or types of habitat like URBAN, PERI-URBAN, RURBAN or RURAL.

   "**URBAN** habitats usually have very high population density and areas with high rise buildings." Generally, urban administrations and urban population have high affordability of implementing and maintaining these environmental services but there is problem of lack of space or land for development of utility infrastructure. In URBAN case, it has suitability of centralised system i.e. household connections with sewerage system and wastewater transferred in centralised treatment system for treatment which is further disposed of into the surface water bodies after treatment.

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

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

RURAL habitat has scattered hamlets with low population density and areas with 1-2 story buildings. Generally, local administration people have very less affordability for developing and maintaining the environmental services. In RURAL case, it has on-site sanitation system i.e. households 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 soaks away zones. In this case, the wastewater is managed at individual household level with primary treatment. In some cases, toilets are connected with biogas systems which are in farmland premises or household premises.

2. **Physiographical Parameters:** Soil type, topography, altitude, terrain, and ground water table. All these parameters need to be considered in order to select the right option in containment units, conveyance units and disposal mechanisms. The cost of the treatment units also is largely influenced by these parameters.

3. **Land Availability And Social Acceptance:** These parameters play an important role in selection of user interface. Land availability in case of urban landscapes becomes a major constraint while deploying user interface linked to a containment unit such as soak pits or septic tank.

4. **Geographic Information System (GIS):** tools are mostly used for planning of sanitation systems in large cities. In case of large habitats, the complexity of the systems is high. Thus, a computer based application such as GIS transforms all the data points into visual data using heat maps etc. This helps to analyse large data sets and derive meaningful inferences from it. Visual illustrations also help to see the impact of certain parameters on the other. Use of GIS is not only limited to planning but can also be used in operation and monitoring of the system.

   For smaller cities, the same type of work can be done developing logic diagrams. Logic diagrams are based on the inferences drawn from the analysis of the data collected. The logic diagrams are simple to understand and communicate and help the decision maker to make informed decision when the parameters change.

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Quick Assessment

1. Sludge treatment aims at reducing sludge weight and volumes.
   a. True
   b. False

2. The wastewater and sludge from toilets contain valuable resources such as water and nutrients
   a. True
   b. False

3. Most of the urban household toilets are connected to:
   a. Underground sewers
   b. Septic tanks
   c. Dry Latrines

4. Solids removal can reduce sludge volume.
   a. True
   b. False

5. ________ of the sample must be measured on site
   a. BOD
   b. COD
   c. Temperature
   d. TDS

* *For answers please refer Annexure I*

Chapter
4

Approaches & Technologies: User Interface

Recap

The previous chapter provides brief explanation on Urban wastewater management, it's needs, objectives and approaches by stressing on the Sanitation value chain and the functional groups of the chain. This chapter explains in detail various approaches and technologies for user interface.

Training Objectives

- Overview of approaches and Technologies across the User Interface
- Understand Criteria for choosing appropriate technologies
- To understand the types of User Interface with the help of case studies

Training Outcomes

- Understand various types of User Interfaces
- Understand Criteria for choosing appropriate technologies

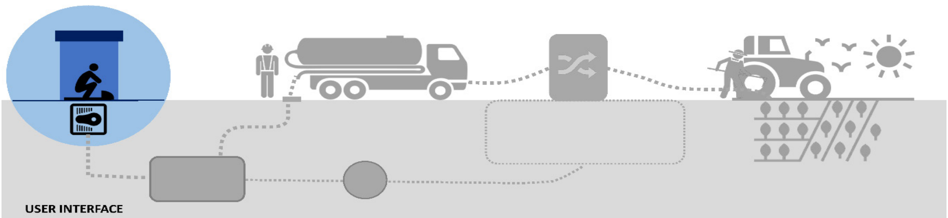
Chapter Contents

4.1 Introduction

The sanitation value chain must be suitably adaptive to the diverse living conditions across the globe. All the stages of the value chain have been addressed differently in different physical setups as per need. These include technology, operations and management, environmental conditions, population and resource availability, to name a few. In this section of the report, various approaches practised for the functional groups of User Interface have been briefly discussed.

4.2 User interface Technologies

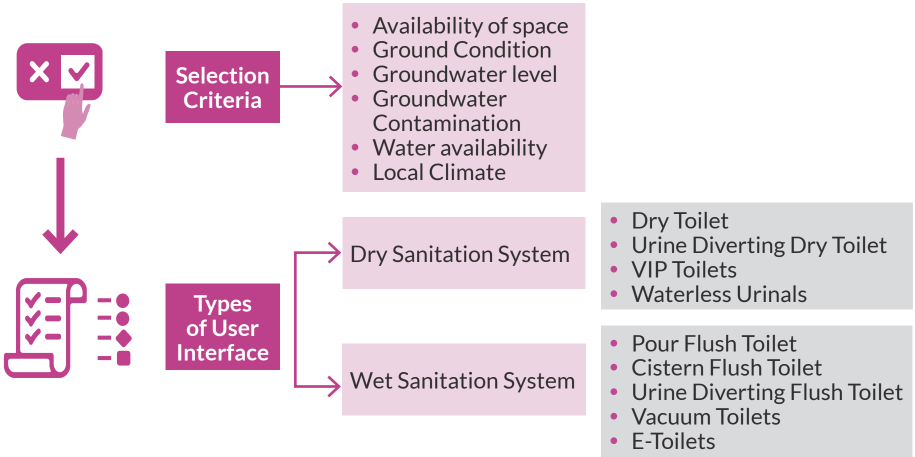
Figure 4.1: User Interface in Sanitation Value Chain



Source: Author

The user interface must guarantee that the disposal of human excreta is practised in a clean facility and that the waste is hygienically separated from human contact to prevent exposure to faecal contamination. The user interface is how the sanitation system is accessed.

Figure 4.2: Selection criteria for choosing appropriate user interface technology for a site



Source: Author

Selection Criteria for User Interface

Selection of user interface depends on both technical and physical criteria. It begins with the space available for constructing the toilets, followed by the ground water level condition, which determines the structure's foundation and depth of collection units. Groundwater level and contamination must be examined for determining the release of primarily/ partially treated waste. Water availability must be checked for identifying dry and water-based cleaning methods. Climatic conditions influence the choice of the building materials, structure, user comfort and unit design-based decisions.

4.3 Types of User Interface

User Interface technologies are commonly classified based on cleansing methods for disposals. Waterless cleaning materials and technology, using alternatives as substitutes to water are identified under dry sanitation systems. Those using water to flush waste are identified under wet sanitation systems.

Dry Sanitation Systems

Dry sanitation is defined as the disposal of human waste without the use of water as a carrier. The collected and stored by-products, i.e., decomposed solids and urine, are then used as fertilizer after one year of storage. Dry sanitation systems were initially designed for use in remote areas for practical and environmental reasons. There has been an increasing environmental awareness which has led to people using them as an alternative to conventional systems. In developing countries, they can be a low cost, environmentally acceptable, hygienic alternative in areas with water scarcity or having no access to sewer connections. The benefits of dry sanitation systems are:

- Works without the use of water and therefore produces no wastewater
- Can easily be used within nutrient-retrieval systems (closing the nutrient loop)
- Removes the chances of ground water contamination

Some of the disadvantages of this system are discussed as below:

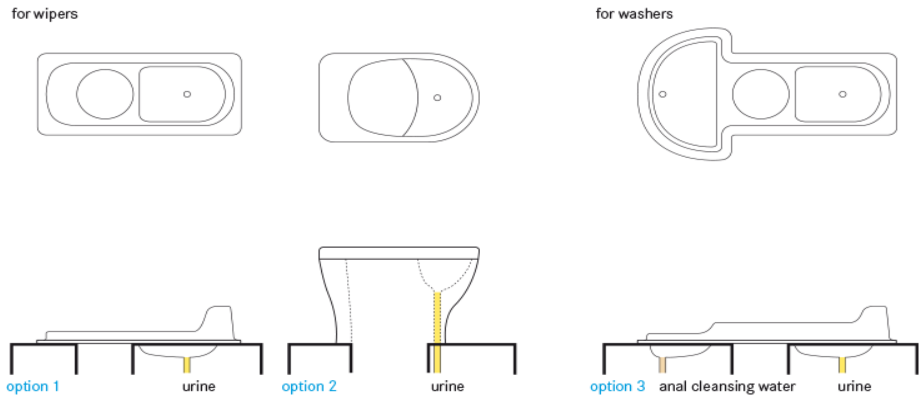
- In Indian conditions, cultural aspect does not appear suitable for dry sanitation system in most of the communities. Moreover, cost of the such toilets is much higher than the pit toilets. More awareness and motivation is required to make these toilets acceptable at community level.
- Due to the lack of water seal in the system, there is odour problem when not properly designed and operated. This also makes people hesitant in adopting the technology.

Urine Diverting Dry Toilets (UDDT)

A urine-diverting dry toilet (UDDT) is a toilet that operates without water and has a divider so that the user, with little effort, can divert the urine away from the faeces. The two toilet sections must be well separated to ensure that a) faeces do not fall into and clog the urine collection area in the front. b) urine does not splash down into the dry area of the toilet. There are also 3-hole separating toilets that allow anal cleansing water to go into a third, dedicated basin separate from the urine drain and faeces collection. A pedestal and a squat slab can be used to separate urine from faeces depending on user preference.

Urine tends to rust most metals; therefore, metals should be avoided in the construction and piping of the UDDT. All connections (pipes) to storage tanks should be kept as short as possible to limit scaling. Wherever they exist, pipes should be installed with at least a 1% slope, and sharp angles (90°) should be avoided. A pipe diameter of 50 mm is sufficient for steep slopes and where maintenance is easy. Larger diameter pipes (> 75 mm) should be used elsewhere, especially for minimum slopes, and where access is difficult. An odour seal should be installed at the urine drain to prevent odours from coming back up the pipe.

Figure 4.3: Types of UDDT



Source- (Tilley, et al., 2014)

The structure of a UDDT collects urine and drains it from the front area of the pan, while faeces fall through a large chute (hole) in the back. Depending on the collection and storage treatment technology, drying material such as lime, ash, or earth should be added into the same hole after defecating. UDDT is simple to design and build, using materials like concrete and wire mesh or plastic.

Applicability: This model is a suitable option in areas with a lack of water availability and where providing sewered connections is a challenge. It is also a preferable option for cases where urine and faeces are intended to be collected separately. UDDT design can be altered to suit the needs of specific populations (i.e., smaller for children, people who prefer to squat).

Table 4.1: Merits and Constraints of UDDT

Merits	Constraints
No need for water	Its use may be difficult for some people (heavy, old and young)
Since faeces are dry and urine is separated, smells are minimal, though a lid should be used	Faeces can be accidentally deposited in the urine section and lead to clogging and cleaning problems
Economical	Urine pipes/fittings can become blocked with time. Excreta are visible.
	Pre-fabricated modules not available everywhere
	Men need additional urinal attached to system for the need to stand and urinate.

Source: (NIUA, 2019)

Case Study: Ecosan Toilets

Technology Highlights	
Name	Ecosan Toilets
Components	UDDT-pan or seat with segregated urine and faces collectors, collection pit or unit
Material Used	Varies as per model, local materials
Input Products	Urine, Faeces, dry cleansing material
Output Products	collected dry faeces and urine after periodic storage
Cleaning method	Dry cleansing materials: sand, ash, lime, sawdust

Source: *(IESNI, 2006)*

What is Ecosan?

Ecological sanitation, or Ecosan, is this new paradigm in sanitation that recognises human excreta and water from households not as a waste but as resources that can be recovered, treated where necessary and safely used again. Tailored to local needs, ecological sanitation systems, ideally, enable the complete recovery of nutrients in household wastewater and their reuse in agriculture. In this way, they help preserve soil fertility and safeguard long-term food security whilst minimizing the consumption and pollution of water resources (IESNI, 2006).

Ecosan encourages adopting UDDT based on-site sanitation methods which do not need water for cleansing and provide cost-effective infrastructure for storage, treatment and reuse.

For further reading, refer: (IESNI, 2006)

Figure 4.4: Ecosan toilets in Bangalore, Dhanduka (Ahmedabad) and Rayka (Vadodara)

Source- (IESNI, 2006)

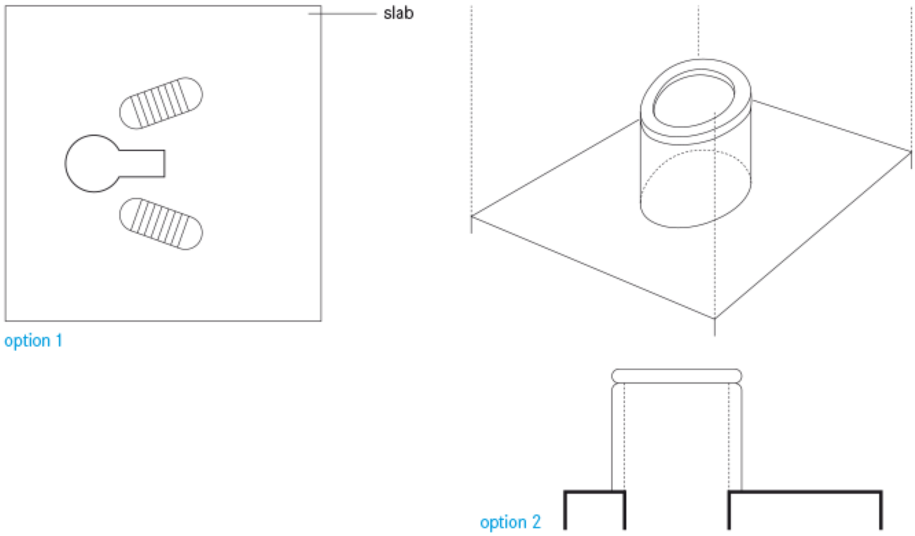
Dry Toilets

A dry toilet operates without freshwater. The toilet may be a raised pedestal on which the user can sit. Alternatively, it can be a squat pan. In both cases, urine and faeces fall through a drop hole. In this report, a dry toilet refers precisely to the device over which the user sits/ squats. In other literature, it may refer to a variety of technologies or combinations of technologies.

The dry toilet is usually placed over a constructed pit. Two holes are used, the pedestal or slab should be designed in such a way that it can be lifted and moved from one pit to another. The slab or pedestal base should be well sized to the pit so that it is both safe for the user and prevents stormwater from infiltrating the pit (which may cause it to overflow). The hole is being closed with a lid to prevent unwanted intrusion from insects or rodents. Pedestals and squatting slabs can be made locally with concrete (if sand and cement are available).

Applicability: This model is suitable in areas facing scarcity of potable water for daily purposes. It can be used in areas where sewered connection are not available or a challenge to provide. E.g., rural, peri-urban and congested areas like slums.

Figure 4.5: Dry Toilets



Source- (Tilley, et al., 2014)

Table 4.2: Merits and Constraints of Dry Toilets

Merits	Constraints
No need of water for waste disposal. Dry materials can be used to cover waste	Since dry toilets do not have a water seal: odour usually is noticeable even if the vault or pit used to collect excreta is equipped with a vent pipe
Urine and faeces discharge through the same hole. So, it is easier to use compared to UDDT.	Social acceptance can take some time.
Suitable for sitters, washers, wiper, squatters. Adaptable design for children.	Foul smell and insects a problem if discharge hole is not sealed well.
Can be made with locally available materials	Excreta is visible and misuse could possibly lead to faecal clogging.
Byproducts obtained after treatment from storage are useful for various purposes.	Safety concerns for children, disabled, elderly
No groundwater contamination.	

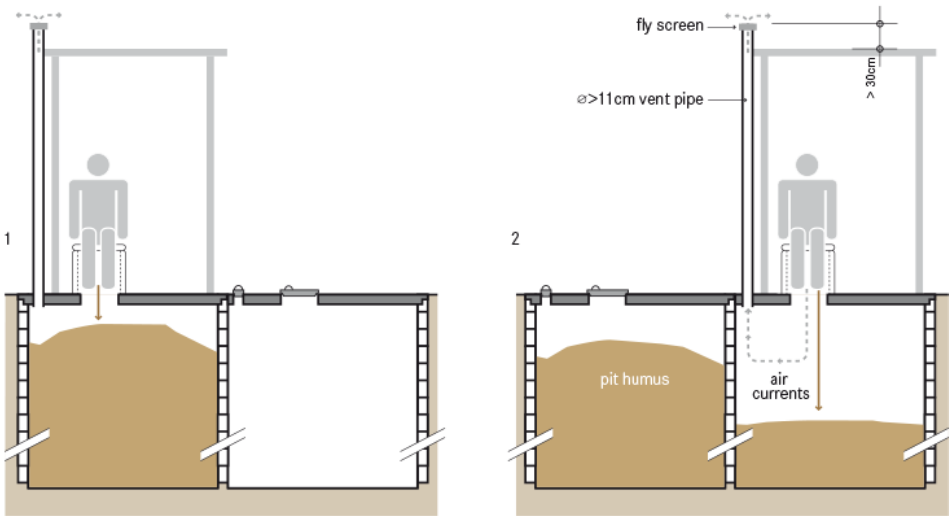
Source: : (NIUA, 2019)

VIP Toilets

The Ventilated Improved Pit (VIP) is an advanced model of the simple dry pit latrine. The modifications are about improving the ventilation inside the user interface unit to prevent foul odour, pathogens and flies from entering the unit and collection systems. Accordingly, a vent pipe is installed into the pit which is covered by a fly trap on the top outlet. The openings to the built around the toilet are provided in the windward direction, such that there is sufficient ventilation inside the interface. The roof is often kept non-opaque to allow sunlight to enter, which helps in eliminating bacteria. The human waste disposal system is the same as found in dry toilets or UDDT as per preference.

Applicability: This option is often used as an upgraded model of pit toilets, as a replacement on the same location. It is preferred in rural, peri-urban areas or areas where sewered connection is not available. The soil condition however, must be favourable to dig deep pits for collection purposes.

Figure 4.6: Schematic diagram of double VIP Toilets



Source- *(Tilley, et al., 2014)*

Table 4.3: Merits and Constraints of VIP Toilets

Merits	Constraints
Improved ventilation system ensures odour free user experience	The foul smell cannot be prevented on days of no wind and sunlight.
Can be built using local materials	Vent pipe and filter should be regularly maintained and cleaned.
Flies and odour, not a problem if maintained well.	Slightly higher maintenance due to lack of water, and separation of faecal and urine waste.
Easy to maintain and clean	Pre-fabricated modules not available everywhere

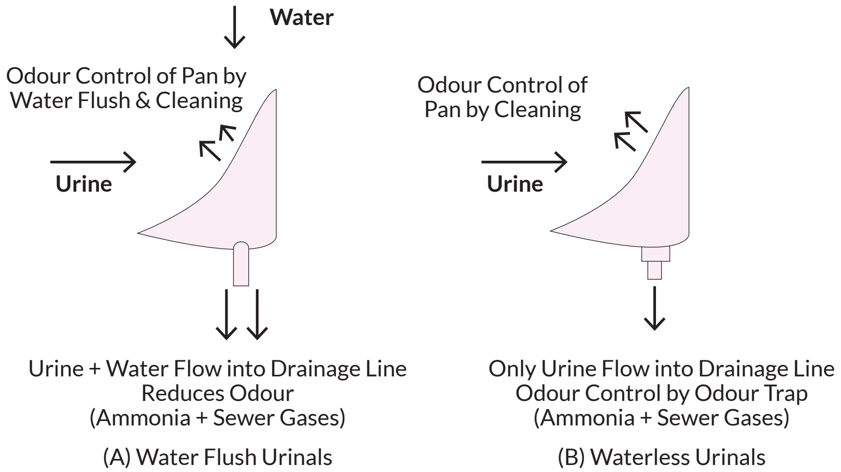
Source: (NIUA, 2019)

Waterless Urinals

New technologies are being developed to dispose of urinary waste without water, thus reducing the need for urinals' freshwater usage. These urinals save as much as 2000-10,000 litres of water fresh water every day. Waterless urinals do not need water and expensive plumbing accessories usually required for flushing. Also, the dry operation of waterless urinals and touch-free operations reduce the spreading of communicable diseases. Odour trap mechanisms using sealant liquid, microbial control, membrane and curtain valve fitted to waterless urinals help prevent odour developed inside the drainage lines connected to urinals (Chariar & Sakthivel, 2009).

Applicability: It is a very viable option in mass use restrooms in airports, institutes, hospitals, public toilets to save freshwater consumption for flushing.

Figure 4.7: Procedure of waterless urinal cleaning



Source- (Chariar & Sakthivel, 2009)

Table 4.4: Merits and Constraints of waterless urinals

Merits	Constraints
Waterless disposal and hygiene maintaining.	Maintenance procedure involves many steps. It is methodical and involves training very systematically.
Suitable for significant freshwater use in large scale buildings	Not feasible in the absence of regular cleaning.

Source: (NIUA, 2019)

Dry Toilets for Indian Cities

Waterless toilets were initially identified as alternatives to conventional sewer connected water use based toilets for water-scarce regions where potable water and sewer networks were challenging. However, in recent times, they have gained recognition as a conscious, cost-effective choice even in urban areas to reduce water consumption and re-use the collected excreta matter for agricultural purposes. These options can also be adopted in Indian cities for the same purposes and more.

Wet Sanitation Systems

Wet sanitation system involves the use of water as a carrier of waste products for disposal. These are the most commonly used sanitation systems in India as water is preferred for disposal, cleansing purpose. Sanitation waste collected from the user interface is conveyed to Sewage Treatment Plant (STP) by sewered, non sewered or hybrid sanitation systems.

Pour Flush Toilet

A pour flush toilet is like a regular flush toilet, and the user pours in the water. When the water supply is not continuous, any cistern flush toilet can become a pour flush toilet. Just like a cistern flush toilet, the pour flush toilet has a water seal that prevents odours and flies from coming back up the pipe. Water is poured into the bowl to flush the toilet of excreta; approximately 4 to 6 L is usually sufficient. The quantity of water and the force of the water (pouring from a height often helps) must be sufficient to move the excreta up and over the curved water seal. Both pedestals and squatting pans can be used in the pour flush mode. Due to demand, local manufacturers have become increasingly efficient at mass-producing affordable pour-flush toilets and pans.

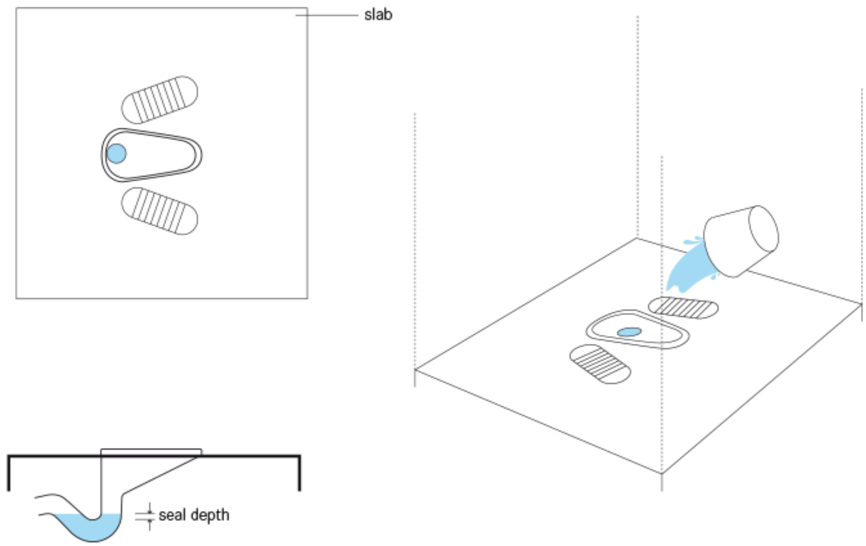
Applicability: This is one of the most preferred user interface options in India as it is suitable for squatting position and incorporates water for cleansing purposes.

Table 4.5: Merits and Constraints of Pour Flush Toilets

Merits	Constraints
The water seal effectively prevents odour	Requires a constant source of water (can be recycled water or collected rainwater)
The excreta of one user have flushed away before the next user arrives	Requires materials and skills for production that are not available everywhere
Suitable for all types of users (sitters, squatters, wipers and washers)	Coarse dry cleansing materials may clog the water seal
Low capital costs; operating costs depend on the price of water	

Source: (NIUA, 2019)

Figure 4.8: Details of Pour Flush Toilet



Source- *(Tilley, et al., 2014)*

Cistern Flush Toilet

The cistern flush toilet is made of porcelain and is mass-produced. The cistern is integrated into the toilet. The toilet consists of a water tank supplying water for flushing excreta and a bowl into which the excreta are deposited. Excreta are flushed away with water stored in the cistern (depending on the type between 6 to 12 litres per flush). Cistern-flush toilets provide a high level of convenience for the user, but their installation can result in a significant increase of the freshwater consumption and increase of wastewater to be collected and treated. Dual flush toilets (with a smaller flush-volume for urine), low-flush toilet and urine-diverting toilets are available in order to reduce the amount of generated blackwater.

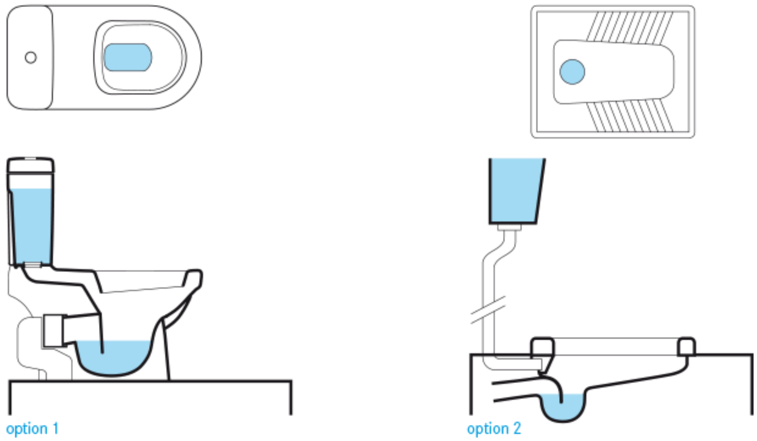
Applicability: This is a preferred user interface option in India as an alternative for squatting position-based toilets, and incorporating water for cleansing purposes.

Table 4.6: Merits and Constraints of Cistern Flush Toilets

Merits	Constraints
The excreta of one user have flushed away before the next user arrives	High capital costs; operating costs depend on the price of water
No real problems with odours if used correctly	Requires a constant source of water
Suitable for all types of users (sitters, squatters, wipers and washers)	Cannot be built or repaired locally with available materials

Source: (NIUA, 2019)

Figure 4.9: Details of Pour Flush Toilet



Source- (Tilley, et al., 2014)

Innovations to the flush toilets: Best Practices in India

During the Swachh Bharat Mission, innovations in technology and management practices implemented across cities and villages in were recognized with many of them being awarded by government as well. Here are a few of them developed using the pour-flush and cistern toilets.

Case Study: Portable Public Toilets

Technology Highlights	
Name	Namma Toilets
Location	Across various Indian cities and railway stations
Designed by	IIT Bombay
Components	Male, Female and physically challenged users' toilets with sanitary disposal units, grab bars, overhead tank, solar panel
Material Used	Fibreglass sandwiched composite material
Storage Capacity	Overhead tank can store 2000 litres of water
Unit dimensions	1.3m*2.7 m (5 units)
Input Products	Urine, Faeces, wash water
Output Products	Excreta, wash water
Cleaning method	Water from supply source like borewell
Source of energy	The solar panel mounted overhead
Unit Cost	13 lakhs INR with 24,000 INR/ month O&M

Source: Case Studies (SBM-U), Innovative Toilet Concepts for Urban India (NIUA, 2018)

Recipient of "National Best Practices" award, the first Namma toilet was installed at the Tambaram suburb in Chennai in February 2013. Namma toilet has been designed, keeping in mind the specific requirements of the Indian sanitary practices, which meets the needs of male, female, and physically challenged users. The module for female has a sanitary disposal unit. The toilet section for physically challenged has a ramp for a wheelchair, wide doors, and grab bars.

Figure 4.10: Portable Public Toilet, Chennai

Source: Case Studies (SBM-U), Innovative Toilet Concepts for Urban India (NIUA, 2018)

Figure 4.11: Views of Installations in public spaces

Source: Case Studies (SBM-U, n.d.), Innovative Toilet Concepts for Urban India (NIUA, 2018)

This toilet's superstructure is made of composite fibreglass sandwiched material to increase durability and strength for withstanding harsh conditions and high footfall. The material used is retardant, acid, and alkali proof, water and termite resistant, and has high strength. Due to its robust, modular, and easy to install the superstructure, this model is useful in public places with high footfall areas, provided they have a continuous water supply. Cost-effectiveness, through its life cycle, makes it favourable to be adopted in the urban areas.

Case Study: Women Friendly Toilets

Technology Highlights	
Name	Sunidhi Toilets
Location	Dindigul, Madurai in Tamil Nadu
Designed by	WASH Institute (NGO)
Components	Female toilets, sanitary napkin vending machines, changing room and an incinerator to dispose of sanitary pads
Material Used	Ferro cement
Installation Time	One day
Input Products	Urine, Faeces, wash water, Menstrual waste, used napkins in an incinerator
Output Products	Excreta, wash water
Cleaning method	Water
Source of energy	Electricity by Municipal Corporation
Unit Cost	85,000 INR for installation, transportation, masonry charges

Source: Innovative Toilet Concepts for Urban India (NIUA, 2018)

Sanitation needs for women include facilities for menstrual cleaning needs and disposal of sanitary napkins. They also include changing rooms along with toilets. Safe disposal of napkins is crucial for hygiene purposes. Women need such facilities available in public spaces.

Sunidhi toilet is a modular unit with a specially designed user interface system for females. It is prefabricated using moulds and transported to the required location for easy installation. These toilets are located in busy public places that have a high floating population of women. The toilet locations were chosen, keeping in mind areas frequently visited by women who would be needing appropriate sanitation facilities. The O & M costs include a caretaker's salary, water and electricity supply charges and underground drainage connection charges. Since its inception, the demand for Sunidhi toilets has risen, especially by urban local bodies to be installed in public spaces like markets, bus stands, temple spaces, fairs to state a few.

Figure 4.12: Sunidhi Toilet installed in public space

Source: Innovative Toilet Concepts for Urban India (NIUA, 2018)

Figure 4.13: Step by Step Installation Process of Sunidhi Toilet

Source: Innovative Toilet Concepts for Urban India (NIUA, 2018)

Case Study: Children Friendly Toilets

Technology Highlights	
Name	Children Friendly Toilets (CFT)
Location	Tiruchirappalli, Tamil Nadu
Designed by	S. Damodaran, founder of Gramalaya (NGO)
Components	Toilets pans for children, water-efficient fixtures, biogas plant
Material Used	WC and footrest with Poly Propylene (PP), Poly Vinyl Chloride (PVC), concrete slabs and floor tiles and cuddapa slabs for cubicle separation
Installation Time	One week for 8-unit community toilet including CFT
Input Products	Urine, Faeces, wash water
Output Products	Excreta, wash water
Cleaning method	Water
Unit Cost	2.50 Lakh INR/unit and 1000 INR/month for Operations

Data Source: Innovative Toilet Concepts for Urban India (NIUA, 2018)

Gramalaya NGO has initiated the practice of encouraging children friendly-CFT toilets in the country. The founder designed the CFT model to provide separate sanitation facilities for children in community toilets in the slum areas, as well as educate them to use toilets, maintain personal hygiene.

The eight community toilets in slums of Tiruchirappalli have separate toilets for men, women and an additional block called Child-Friendly Toilet (CFT). The toilet cubicles have piped water facilities in 'press and use' mode to ensure judicious use of water. 8'' PVC pipes are cut it into semicircles and used as pans. These are connected through a pipeline and finally with the underground drainage. The toilet pans were further modified to match with high slope WC. The toilets are connected to biogas tanks and an incinerator for disposal of sanitary napkins. The NGO has helped form women self-help groups (SHG) in the slums which would take care of maintaining the toilets.

Figure 4.14: Children Friendly Toilet at Viragupetti Slum, Tiruchirappalli

Source: Innovative Toilet Concepts for Urban India (NIUA, 2018)

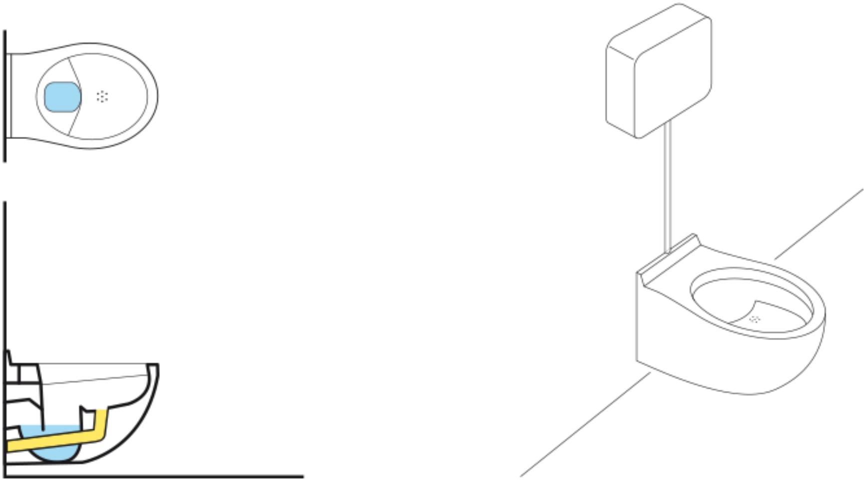
Figure 4.15: Children Friendly Toilet Model in Community Toilet at Karuvattupettai slum

Source: Innovative Toilet Concepts for Urban India (NIUA, 2018)

Urine Diverting Flush Toilets (UDFT)

The urine-diverting flush toilet (UDFT) is similar in appearance to a cistern flush toilet except for the diversion in the bowl. The toilet bowl has two sections so that the urine can be separated from the faeces. Both sitting and squatting models exist.

Figure 4.16: Details of UDFT



Source- (Tilley, et al., 2014)

Urine is collected in a drain in the front of the toilet, and faeces are collected in the back. The urine is collected without water, but a small amount of water is used to rinse the urine-collection bowl when the toilet is flushed. The urine flows into a storage tank for further use or processing, while the faeces are flushed with water to be treated (onsite pre-treatment and treatment in septic tanks, biogas settlers, anaerobic baffled reactors; semi-decentralised treatment units, e.g. DEWATS systems; centralised sewage treatment plants).

Urine water can rust metal. Hence it should not be used in the construction of this system. All pipes to storage tanks should be of the shortest possible length to avoid scaling, with the provision of at least 1% slope. Sharp angles must be avoided. While 50 mm diameter pipes usually are sufficient for steep slopes, pipes with a greater diameter (> 75mm) must be used where access is difficult. Odour seals should be added to the urine drain to prevent foul smells coming from the back of the pipe. Applicability: This option is suitable in cases where urine and faeces are intended to be collected separately. It is recommended in areas facing water scarcity as water consumption is lesser in this technology.

Table 4.7: Merits and Constraints of UDFT Toilets

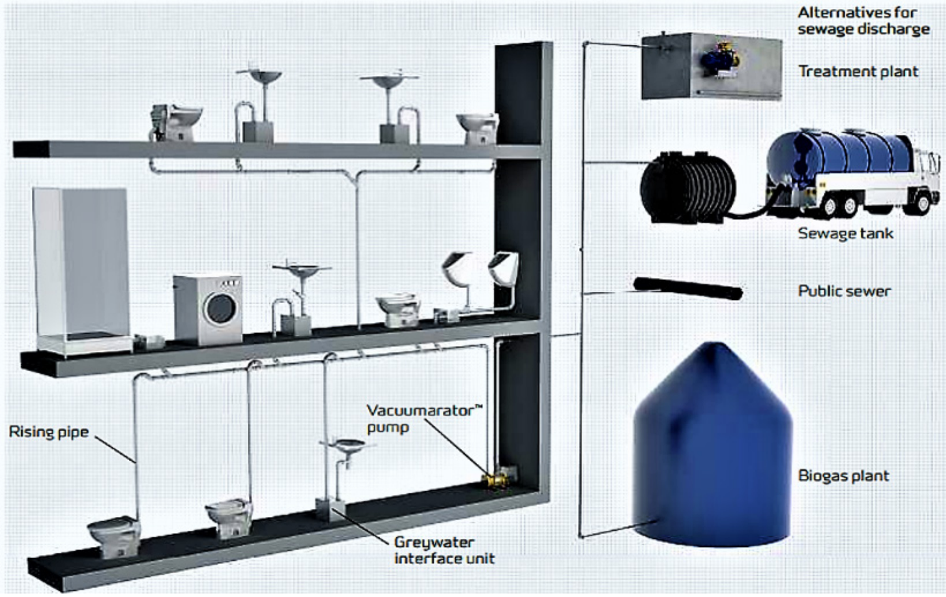
Merits	Constraints
Requires less water than a traditional flush toilet	Limited availability; cannot be built or repaired locally
No real problems with odours if used correctly	Labour-intensive maintenance
Looks like, and can be used almost like, a cistern flush toilet	High capital and low to moderate operating costs (depending on parts and maintenance)
	Requires training and acceptance to be used correctly
	Is prone to clogging and misuse
	Requires a constant source of water
	Men usually require a separate urinal for optimum collection of urine

Source: (NIUA, 2019)

Vacuum Toilets

The use of vacuum toilets provides a similar level of comfort as traditional flush toilets, but they use much less water due to air sucked into the toilet when flushing, thereby producing a vacuum. It results in a minimal requirement of water (0.5 to 1.5 litre) for the transport of faeces and urine. The system is completely closed. Since 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 anaerobic digestion treatment for biogas production. Urine diversion bowls can be applied to minimize the water consumption of a vacuum toilet even more. Vacuum toilet systems are applicable both in large and small buildings, trains, ships and aeroplanes.

Figure 4.17: Vacuum Toilets sanitation system



Source: (JETS, 2009)

Applicability: This option is recommended in areas with water scarcity as water consumption is lesser in this technology.

Table 4.8: Merits and Constraints of Vacuum Toilets

Merits	Constraints
Saving significant quantities of water (only 0.5 to 1 litre required per flush) and allows considerable flexibility for on-site treatment (independent of large sewer collection systems).	High capital costs; needs expert design

Source: (NIUA, 2019)

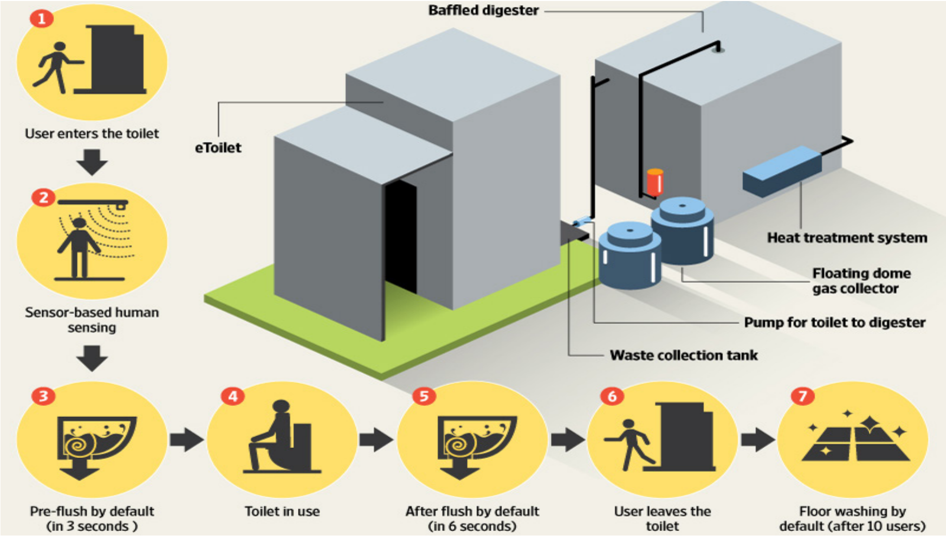
Self-Flushing E-Toilets

This innovation involves non-human based operations and thus ensures easy and continual operation while minimizing maintenance costs. The toilets are built of stainless steel or mild steel enclosures and have electronic systems for enhancing user experience. The essential features include automated access control systems, sensor-enabled water minimization and self-washing & floor wash mechanisms. The toilets have ample natural ventilation and offer privacy and safety.

These sleek and modular, self-cleaning etoiles have simple user interfaces. The integrated a comprehensive maintenance plan ensures that the e-Toilets are clean and hygienic for every user. The e-Toilet has a facility of pre-flushing before entering, automatic flushing once usage is done, in-built water tanks, sensors for water and electricity conservation and automatic platform cleaning and power back-up with coin-operated entry.

Applicability: This option is suitable in areas with high footfall, thus needing public restrooms and higher maintenance. This model requires minimal human intervention for maintaining. During the Swachh Bharat Mission, many cities have opted this technology in public places.

Figure 4.18: Sanitation system of E-Toilets



Source: (ESS)

Reducing water consumption in wet toilets: Forthcoming vision for Indian Cities

Emerging technologies that reduce water consumption have been a growing trend in the Indian market of the sanitation-wares sector. However, the facility is currently available to a niche section of the users. Lack of awareness and comparatively higher costs than conventional toilet pans/urinals could be a few reasons. At the background of the ongoing enthusiasm among citizens and administrators for the Swachh Bharat mIssion, this is an excellent opportunity to mainstream these technologies at affordable costs and propagate awareness at large scale.

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Quick Assessment

1. After flushing the toilet, where does the water and waste go?
   a. into a holding tank
   b. into a sewerage system
   c. both of the above
   d. None

2. Sewage is mainly generated from which of these?
   a. Houses
   b. Factories
   c. Offices
   d. Hospitals

3. Dried _______ is used as manure.
   a. Sewage
   b. Sludge
   c. Both of them
   d. None

4. Wastewater released by houses is called _________
   a. Sewage
   b. Sludge
   c. Both of them
   d. None

5. There are________ types of user interface
   a. 3
   b. 4
   c. 6
   d. None

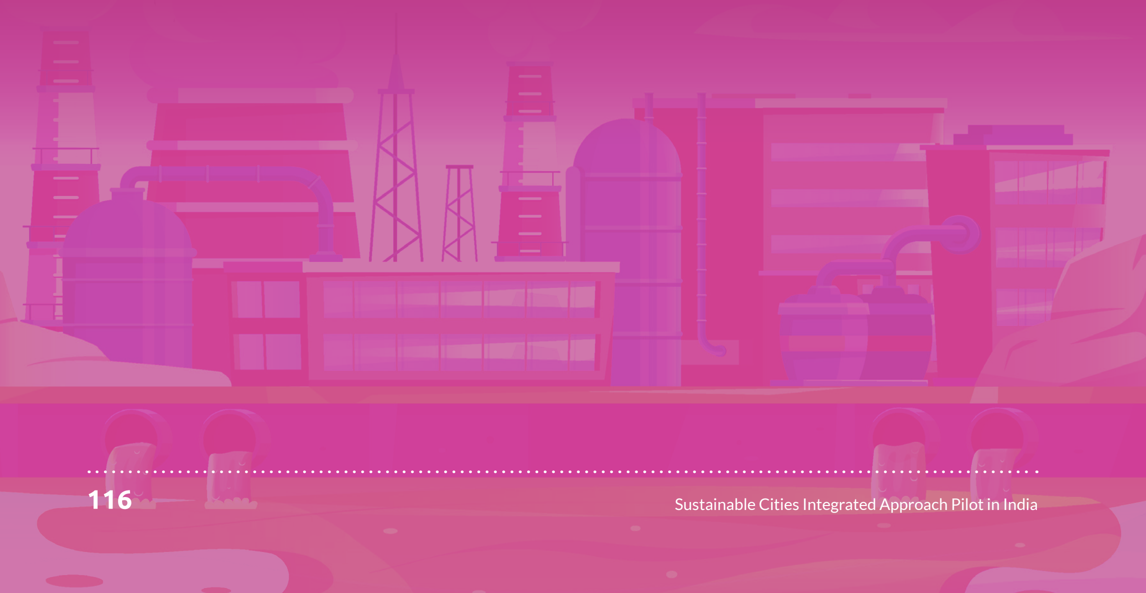
6. Which are the types of Conveyance technologies?
   a. Anaerobic Baffle reactor
   b. Bio-Digester systems
   c. Single pit
   d. All of the above

* *For answers please refer Annexure I*


KAM-AVIDA

Chapter
5

Approaches and Technologies: Collection & Conveyance



Recap

The previous chapter provides explanation on the first stage of Sanitation Value chain, i.e., User Interface. The approaches and technologies for Collection and Conveyance are discussed in this chapter.

Training Objectives

- To understand the various approaches and technologies with respect to conveyance of waste water and the selection criteria
- To overview various available desludging services

Training Outcomes

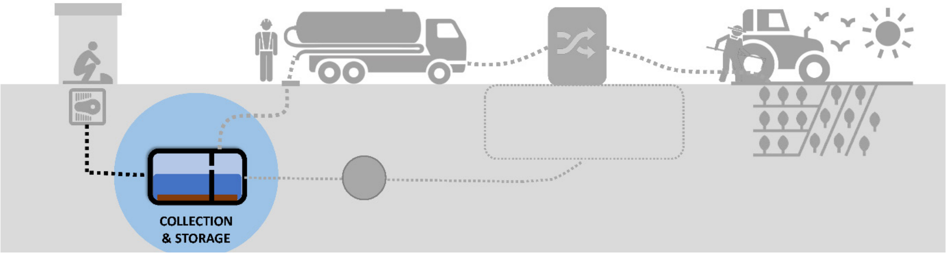
- Understand the selection criteria and types of Collection Approaches
- Understand the selection criteria of Conveyance Approaches and technologies

Chapter Contents

5.1 Introduction

The disposed waste products from user interface can be collected, stored and primarily treated through on-site sanitation, off-site sanitation or a system which is a hybrid of both. Generally, the hybrid sanitation system is considered as an off-site sanitation system as it involves the use of sewer systems which collect and convey the waste to a location within closer proximity to origin source.

Figure 5.1: Functional Group of Collection insanitation Value Chain



Source: Author

5.2 Types of Collection Technologies

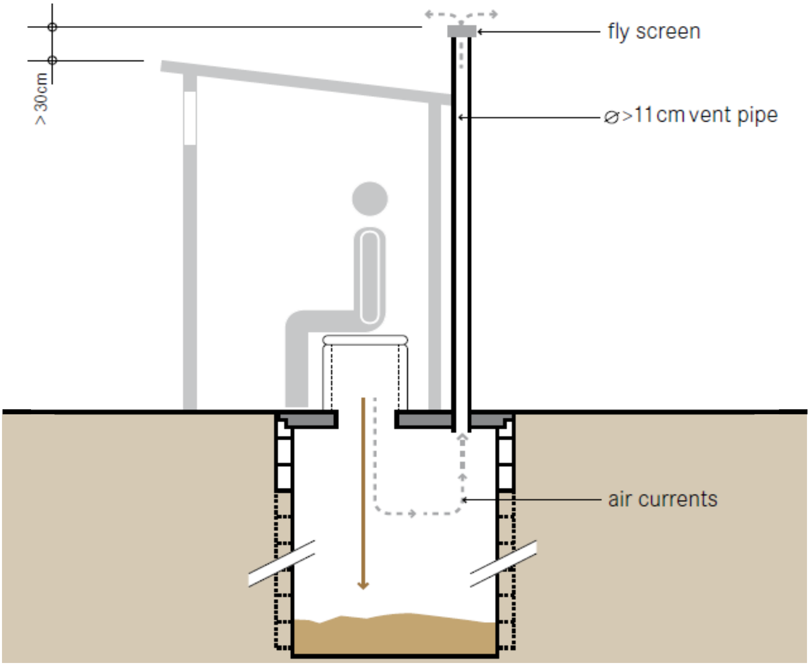
In a non-sewered system, waste is collected in a containment system and may or may not be treated on site. OSS systems may comprise a primary sanitary facility, such as single pit and twin-pit latrines, to a treatment system that connects a septic tank with a soak pit or a bio-digester toilet (aerobic and anaerobic). Offsite or sewered collection methods carry the wastewater collected from the toilet to a single point of collection and treatment or outlet to water bodies. In cases where buildings are far from the main central treatment plant, the approach of providing intermittent collection and treatment infrastructure nearby is considered.

Collection and Coveyance Methods/Technologies for Non-sewered sanitation System

Single Pit

It consists of a superstructure and a pit. Faecal matter is deposited into a pit. Urine and water percolate into the soil through the bottom of the pit and wall, while microbial action degrades part of the organic fraction. Pathogenic germs are absorbed to the soil surface. In this way, pathogens can be removed before contact with groundwater.

Figure 5.2: Diagram illustrating the single pit technology



Source: (Tilley, et al., 2014)

Applicability: Single pits are ideal for rural and peri-urban areas. They are often hard to empty or have inadequate space for infiltration in densely populated areas. Single pits are particularly suitable where water is scarce, and the groundwater table is low. They are not ideal for rocky or compacted soils (which are difficult to dig) or regularly flooded areas.

Table 5.1: Merits and Constraints of Single Pit Collection

Merits	Constraints
Can be built and repaired with locally available materials	Flies and odours are generally noticeable
Low (but variable) capital costs depending on materials and pit depth	Low reduction in BOD and pathogens with possible contamination of groundwater
Small land area required	Costs to empty may be significant compared to capital costs
	Sludge requires secondary treatment or appropriate discharge

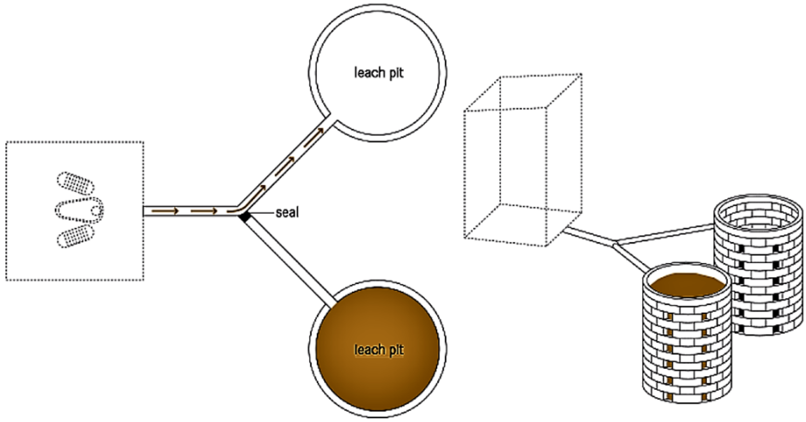
Source: (NIUA, 2018)

Twin Pit for Pour Flush

It consists of a superstructure (pour-flush toilet) connected to two alternating pits (two chambers). Blackwater is collected in the pits and allowed to infiltrate into the surrounding soil slowly. Only one pit is functional at a time while the other is allowed to rest as the liquid leaches out of the pit. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel. The filled pit can be conveniently emptied after one-and-half years when most of the pathogens die. The sludge, also called pit humus, can safely be used as manure.

The twin pits for pour flush technology can be designed in various ways; the toilet can be located directly over the pits or at a distance from them. The superstructure can be permanently constructed over both pits, or it can move from side to side depending on which one is in use. No matter how the system is designed, only one pit is used at a time. While one pit is filling, the other full pit is resting.

Figure 5.3: Diagram illustrating the twin pit technology



Source: *(Tilley, et al., 2014)*

As liquid leaches from the pit and migrates through the unsaturated soil matrix, pathogenic germs are absorbed onto the soil surface. In this way, pathogens can be removed before contact with groundwater. The degree of the removal varies with soil type; distance travelled, moisture and other environmental factors. As this is a water-based (wet) technology, the full pits require a longer retention time (two years is recommended) to degrade the material before it can be excavated safely.

Applicability: Twin pits for pour-flush are a permanent technology appropriate for areas where it is not possible to build new pit latrines continuously. If water is available, this technology is appropriate for almost every type of housing density.

Table 5.2: Merits and Constraints of Twin Pit Toilet Collection

Merits	Constraints
Because double pits are used alternately; their life is virtually unlimited	Manual removal of pit humus is required
Excavation of humus is easier than faecal sludge	Clogging is frequent when bulky cleansing materials are used
Potential for the use of stored faecal material as a soil conditioner	Higher risk of groundwater contamination due to more leachate than with the waterless system
Flies and odours are significantly reduced (compared to pits without a water seal)	
Can be built and repaired with locally available materials	
Low (but variable) capital costs depending on materials; no or low operating costs if self-emptied	
Small land area required	

Source: (NIUA, 2018)

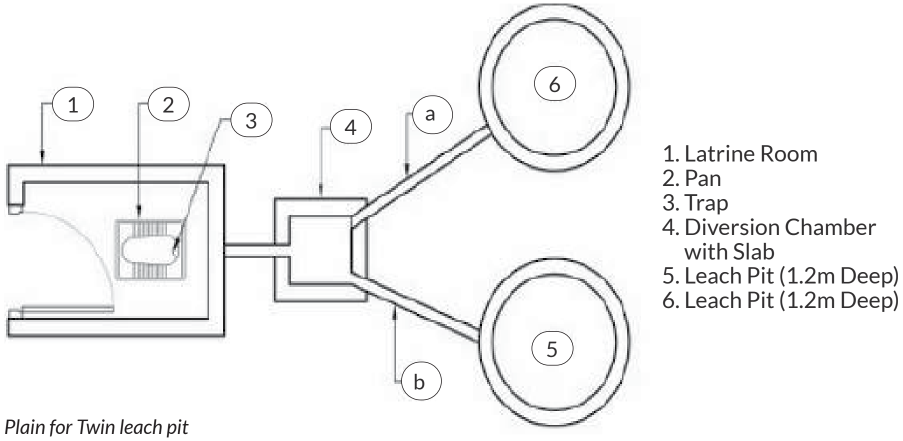
Case Study: Permeable Reactive Barrier Toilets (PRB)

Technology Highlights	
Name	Permeable Reactive Barrier Toilets
Location	Mulbagal, Kolar District, Karnataka
Designed by	Prof. Sudhakar Rao, A. Lydia, Nitish V. M. (IISC Bangalore)
Components	Latrine Room, Pan, Trap, Diversion Chamber, Leach Pit x 2 Nos.
Material Used	Sand, Bentonite Clay or Cow Dung & Concrete
Storage Capacity	Overhead tank can store 2000 litres of water
Input Products	Urine, Faeces, wash water
Output Products	Excreta, wash water
Cleaning method	Water from the supply source
Source of energy	Electricity
Unit Cost	18750 INR with 4,750 INR/ month O&M

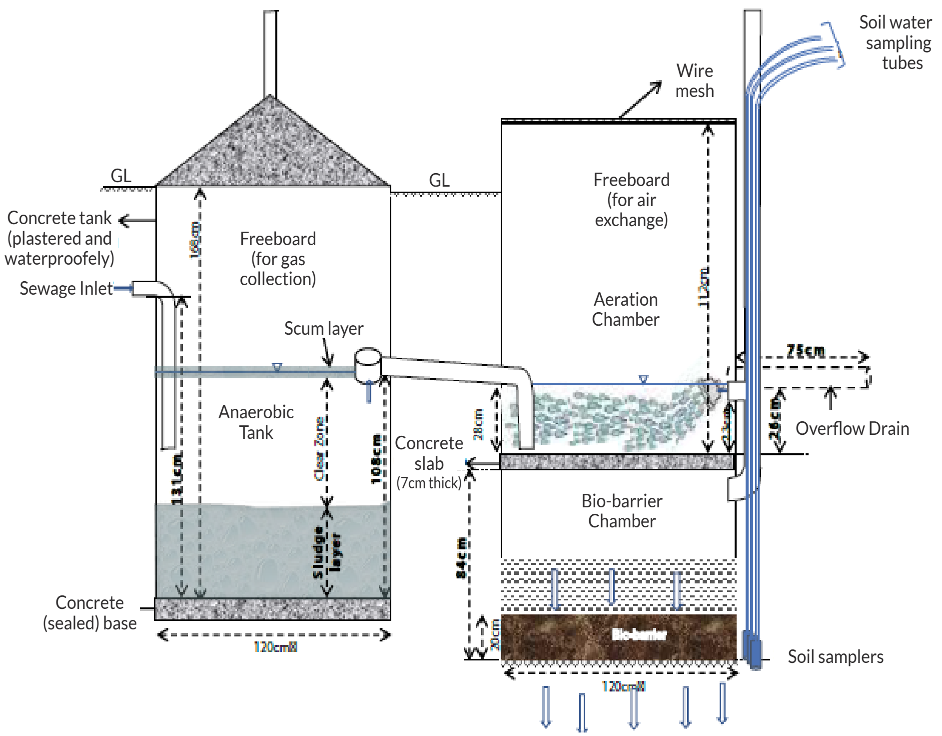
Source: (NIUA, 2018)

A viable upgraded alternative to the conventional Twin pit latrines, the PRB technology relies on a refuse-collection pit and use a mixture of sand and bentonite clay. The clay regulates the flow of leachates by swelling when in contact with water. The groundwater in most of the urban and peri-urban areas in India have high nitrate concentration in almost all hydrogeological formations which leads to excess nitrates in drinking water. This innovative technology devised by the team at IISC Bangalore helps in dealing with reducing excess nitrates in groundwater. The technology used in Permeable Reactive Barrier (PRB) toilets helps in preventing groundwater contamination by providing in-situ anaerobic, aerobic, denitrification, and anammox process that utilizes indigenous microbes to reduce organic load, nitrate load, and pathogen load in pit toilet sewage.

Figure 5.4: A schematic diagram of a PRB Twin Pit

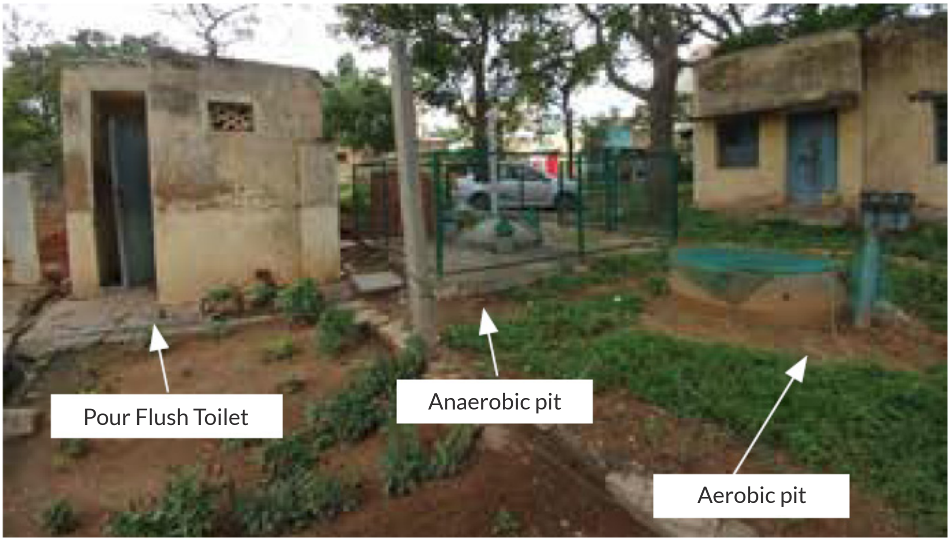


Plain for Twin leach pit



Source: (NIUA, 2018)

Figure 5.5: A PRB Twin pit toilet at Mulbagbal Town, Karnataka



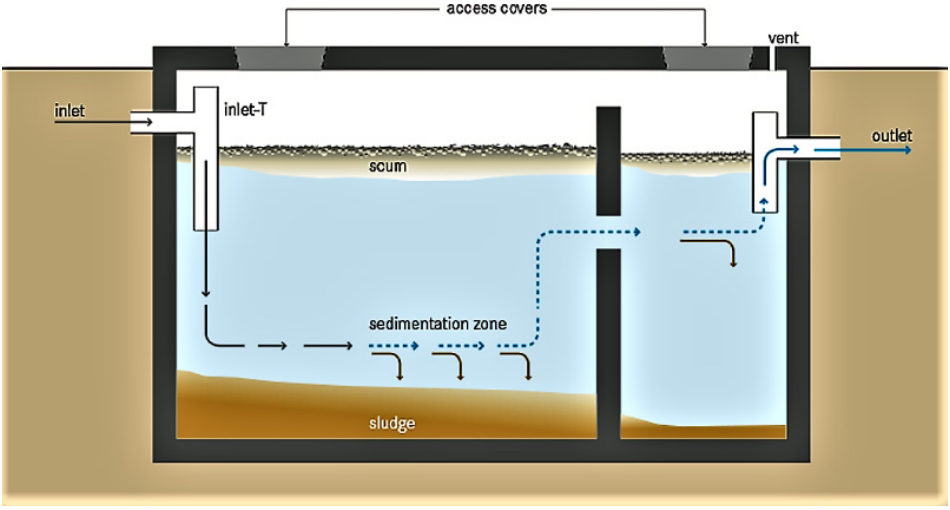
Source: (NIUA, 2018)

Septic Tank

A septic tank is a water-tight, single-storied tank made of concrete, fibreglass, PVC or plastic in which sewage is retained long enough to permit sedimentation and digestion. It is an underground tank that treats sewage by a combination of solids settling and anaerobic digestion. Liquid flows through the tank, and heavy particles sink to the bottom, while scum (mostly oil and grease) floats to the top. Over time, the solids that settle to the bottom are degraded anaerobically. Bureau of Indian Standards provides a Code of Practice for Installation of Septic Tanks (IS-2470 Part-B, 1985).

However, the rate of accumulation is faster than the rate of decomposition, and the accumulated sludge and scum must be periodically removed. The effluent from the septic tank must be dispersed by using a Soak Pit or Leach Field or transported to another treatment technology via a Solids-Free sewer connection.

Figure 5.6: Diagram illustrating the septic tank



Source: (Tilley, et al., 2014)

The design of a septic tank depends on the number of users, the amount of water used per capita, the average annual temperature, the desludging frequency and the characteristics of the wastewater. The retention time should be 48 hours to achieve moderate treatment. The retention time should be 48 hours to attain moderate treatment. This technology is most commonly applied at the household level. Larger, multi-chamber septic tanks can be designed for groups of houses and public buildings (e.g., schools).

A septic tank is appropriate where there is a way of dispersing or transporting the effluent. If septic tanks are used in densely populated areas, onsite infiltration should not be used. Otherwise, the ground will become oversaturated and contaminated, and wastewater may rise to the surface, posing a severe health risk. Instead, the septic tanks should be connected to some Conveyance technology, through which the effluent is transported to a subsequent Treatment or Disposal site. Even though septic tanks are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding.

Because the septic tank must be regularly de-sludge, a vacuum truck should be able to access the location. Often, septic tanks are installed in the home, under the kitchen or bathroom, which makes emptying difficult.

Table 5.3: The recommended size of the septic tank up to 20 users

No. of users	Length (m)	Breadth (m)	Liquid depth (m) (Cleaning interval)	
			Two years	Three years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Source: (NIUA, 2017-18)

Table 5.4: The recommended size of the septic tank up to 300 users

No. of users	Length (m)	Breadth (m)	Liquid depth (m) (Cleaning interval)	
			Two years	Three years
50	5.0	2.00	1.0	1.24
100	7.5	2.65	1.0	1.24
150	10.0	3.00	1.0	1.24
200	12.0	3.30	1.0	1.24
300	15.0	4.00	1.0	1.24

Source: (NIUA, 2017-18)

Applicability: This technology is most commonly applied at the household level. Larger, multi-chamber septic tanks can be designed for groups of houses and public buildings (e.g., schools). A septic tank is appropriate where there is a way of dispersing or transporting the effluent. If septic tanks are used in densely populated areas, onsite infiltration should not be used. Otherwise, the ground will become oversaturated and contaminated, and wastewater may rise to the surface, posing a severe health risk. Instead, the septic tanks should be connected to some conveyance technology, through which the effluent is transported to a subsequent Treatment or Disposal site. Even though septic tanks are watertight; it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding.

Table 5.5: Merits and Constraints of Septic Tanks

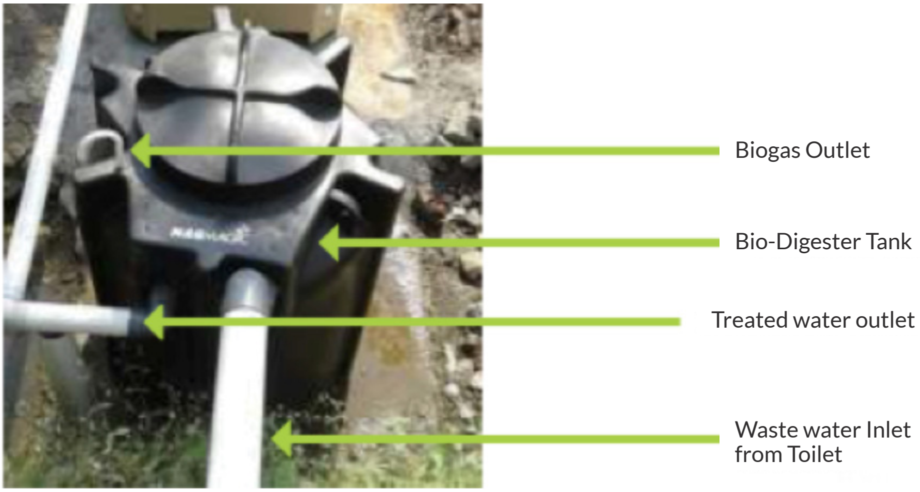
Merits	Constraints
Simple and robust technology	Low reduction in pathogens, solids and organics
No electrical energy is required, long service life	Regular desludging must be ensured
Low operating costs. Small land area needed (can be built underground)	Effluent and sludge require further treatment and appropriate discharge

Source: (NIUA, 2017-18)

Bio-digester tank system

A bio-digester toilet is an anaerobic multi-compartment tank with inoculum (anaerobic bacteria) which digests organic material biologically. This system converts faecal waste into usable water and gases in an eco-friendly manner. This technology has been developed by the Defence Research and Development Organisation (DRDO) and advocated in SBM. The toilet tank consists 3-4 chambers where flow of waste is spiral. Each chamber contains plastic/ nylon sheet that helps grow bacteria. It is a prefab structure made up of HDPE. Complete structure is enclosed and properly covered. These toilets are widely used for 80% treatment of black water from individual and cluster households or institutional buildings where there is no sewerage network.

Figure 5.7: A DRDO Biotoilet



Source: (NAGMAGIC)

Applicability: The reactor may be constructed above or below ground, depending on the soil, location and size required (even below roads). Small biogas reactors can be built on rooftops or in courtyards for more urban applications. The reactors should be located close to where the gas will be used to reduce distribution losses.

Table 5.6: Merits and Constraints of Bio-Digestor Tank

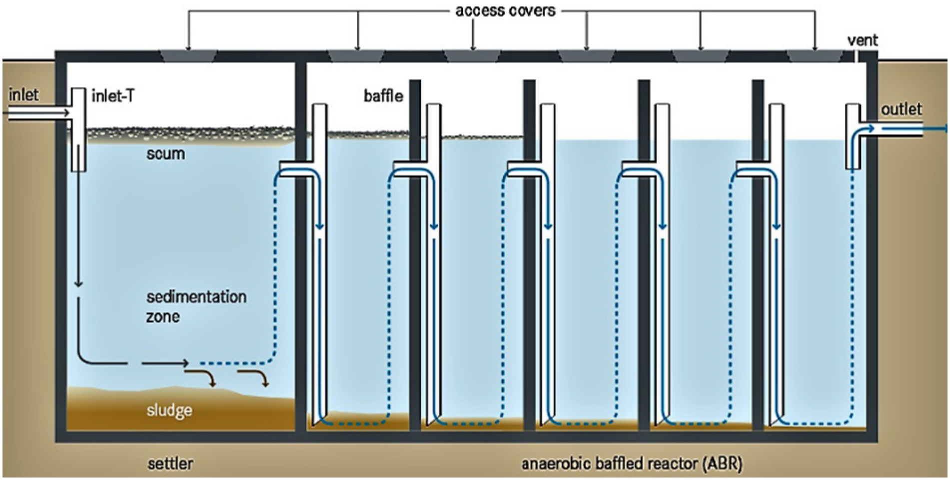
Merits	Constraints
Wide applicability	Requires expert design and skilled construction.
Effluent water recyclable	Each day, the bio-digester effluent needs to be removed from the effluent tank.
Pathogen reduction: > 99%	Function poorly in colder climates unless an external heat source is applied.
Maintenance Free, since only one-time cultue/inoculum addition and no de-sludging for the lifetime of the system	Biogas provides much less energy compared to fuels such as propane and natural gas
	Since it is a prefab structure manufactured by some authorised company (having TOT from the DRDO), its cost is higher than other technologies. Also, in smaller ULBs such manufacturers are normally not available

Source: (NIUA, 2017-18)

Anaerobic Baffle reactor

An anaerobic baffled reactor (ABR) is mainly a small septic tank (settling compartment) followed by a series of anaerobic tanks (at least three). Most of the solids are removed in the first and largest tank. Effluent from the first tank then flows through baffles and is forced to flow up through activated sludge in the subsequent tanks. Each chamber provides increased removal and digestion of organics: BOD may be reduced by up to 90%. Increasing the number of chambers also improves performance. (Tilley, 2008). The majority of settleable solids are removed in a sedimentation chamber in front of the actual ABR. Small-scale stand-alone units typically have an integrated settling compartment, but primary sedimentation can also take place in a separate Settler or another preceding technology (e.g., existing Septic Tanks). Designs without a settling compartment are of particular interest for Semi-Centralized Treatment plants that combine the ABR with other technologies, or where prefabricated, modular units are used.

Figure 5.8: Diagram illustrating the ABR technology



Source: *(Tilley, et al., 2014)*

Applicability: This technology is easily adaptable and can be applied at the household level, in small neighbourhoods or even in more significant catchment areas. It is most appropriate where a relatively constant amount of blackwater and greywater is generated. A semi-centralised ABR is applicable when there is a pre-existing Conveyance technology, such as a Simplified Sewer. This technology is suitable for areas where land may be limited since the tank is most commonly installed underground and requires a small area. However, a vacuum truck should be able to access the location because the sludge must be regularly removed (mainly from the settling compartment).ABRs can be installed in every type of climate, although the efficiency is lower in colder climates. They are not efficient at removing nutrients and pathogens. The effluent usually requires further treatment.

Table 5.7: Merits and Constraints of ABR Technology

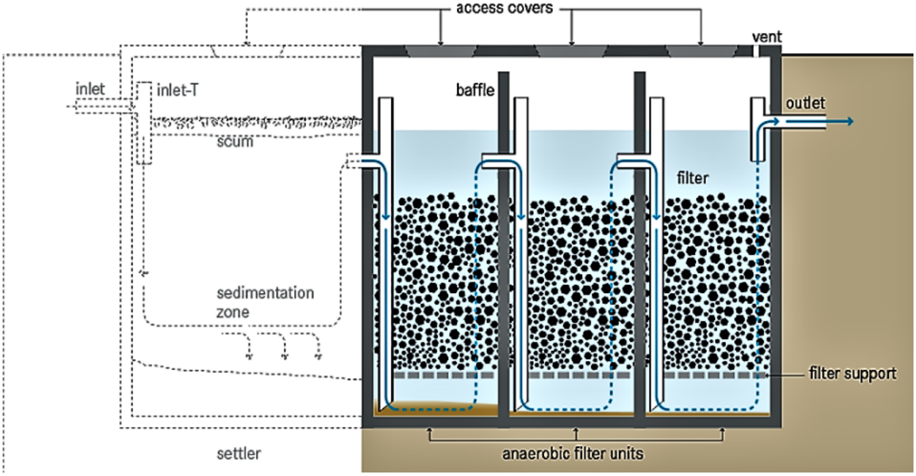
Merits	Constraints
Low cost when divided among members of a housing cluster or small community	Requires expert design and skilled construction; partial construction work by unskilled labourers
Minimum operation and maintenance	Requires secondary treatment and discharge
Resistant to organic and hydraulic shock loads	
Reliable and consistent treatment	

Source: (NIUA, 2017-18)

Anaerobic up-flow filter

An anaerobic up-flow filter is a fixed-bed biological reactor with one or more filtration chambers in series. As wastewater flows through the filter, particles are trapped, and organic matter is degraded by the active biomass that is attached to the surface of the filter material. With this technology, suspended solids and BOD removal can be as high as 90% but is typically between 50% and 80%. Nitrogen removal is limited and usually does not exceed 15% regarding total nitrogen (TN).

Figure 5.9: Diagram illustrating the Anaerobic up-flow filter technology



Source: *(Tilley, et al., 2014)*

Pre and primary treatment is essential to remove solids and garbage that may clog the filter. The majority of settleable solids are removed in a sedimentation chamber in front of the anaerobic filter. Small-scale stand-alone units typically have an integrated settling compartment, but primary sedimentation can also take place in a separate Settler or another preceding technology (e.g., existing Septic Tanks). Designs without a settling compartment are of particular interest for Semi-Centralized Treatment plants that combine the anaerobic filter with other technologies, such as the Anaerobic Baffled Reactor (ABR).

The microbial growth is retained on the stone media, making possible higher loading rates and efficient digestion. Materials commonly used include gravel, crushed rocks or bricks, cinder, pumice, or specially formed plastic pieces, depending on local availability. The connection between the chambers can be designed either with vertical pipes or baffles. Accessibility to all chambers (through access ports) is necessary for maintenance. The tank should be vented to allow for controlled release of odorous and potentially harmful gases. BOD removals of 70% can be expected. The effluent is clear and free from odour.

Applicability: This technology is easily adaptable and can be applied at the household level, in small neighbourhoods or even in more significant catchment areas. It is most appropriate where a relatively constant amount of blackwater is generated. The anaerobic filter can be used for secondary treatment, to reduce the organic loading rate for a subsequent aerobic treatment step, or polishing. This technology is suitable for areas where land may be limited since the tank is most commonly installed underground and requires a small area. Accessibility by vacuum truck is essential for desludging.

Table 5.8: Merits and Constraints of Anaerobic up-flow filter technology

Merits	Constraints
No electrical energy is required	Requires expert design and skilled construction
Low operating costs, Long service life	Low reduction of pathogens and nutrients
High reduction of BOD and solids	Effluent and sludge require further treatment and appropriate discharge
Low sludge production; the sludge is stabilized	Risk of clogging, depending on the pre-and primary treatment
Moderate area requirement (can be built underground)	Removing and cleaning the clogged filter media is cumbersome

Source: (NIUA, 2017-18)

Innovation in collection technologies

New technological models of on-site collection systems focus on making the collection segment of sanitation easy and less hazardous to handle as well as reduce the storage unit size by improving the treatment methods used in storage units. These methods exclude the need for septic tanks as waste is stored and treated in the in-built units along with user interface vessels.

Case Study: Bio-Digestor Toilets

Technology Highlights	
Name	Bioloo
Location	Across various Indian cities
Designed by	DRDO India
Components	Toilet Pan and treatment chamber
Material Used	FRP
Installation time	8-10 hours
Unit Dimensions	6 ft* 10 ft space needed for 1 unit
Unit Cost	35,000 INR for one household unit (10 users)
Input Products	Urine, Faeces, water
Output Products	Odour + solid free waste (0% reduced organic matter)

Source: (NIUA, 2018)

The bio-digester is a consortium of anaerobic bacteria, adapted to work at temperatures as low as -5°C and as high as 50°C. It is composed of four clusters of bacteria of hydrolytic, acidogenic, acetogenic and methanogenic groups with high efficiency of biodegradation. These convert the organic waste into water, methane and CO2. The anaerobic process inactivates the pathogens responsible for water-borne diseases. Bio-digesters serve as reaction vessels for bio-methanation and provide anaerobic conditions and the required temperature for the bacteria.

This system consists of an easy-to-install super-structure, a multi-chambered bio-tank that holds the bacterial culture and enables the treatment of human waste. The system does not need any external energy for treatment, instead emits pathogen-free effluent water that is good for gardening and similar purposes; and bio-gas that could be used for cooking or heating (in case of large institutions). The system meets all regulatory and environmental compliances and enhances the socio-environmental fabric. This technology completes the onsite treatment process in its treatment tank that reduces the cost of further treatment, which exists in a septic tank.

Figure 5.10: Bioloo toilets in a school in India

Source: (NIUA, 2018)

An emerging trend in collection methods: Container-Based Sanitation (CBS)

Since the early 2010s, Container-Based Services or CBS models have emerged as an alternative service approach in circumstances where existing sanitation solutions were deemed inadequate or unfeasible.

CBS consists of an end-to-end service that collects excreta hygienically from toilets built with sealable, removable containers and strives to ensure that the excreta is safely treated, disposed of, and reused. Households benefit from having a toilet in their own homes or nearby (with associated benefits of convenience and privacy) without having to provide upfront financing for investing in infrastructure (such as a latrine), which in many cases they cannot afford.

Rather than building a sanitation facility, households (or public toilet operators) can sign up for a service. They are usually provided with a light, portable toilet that is independent of any superstructure. The CBS service provider conducts regular visits to empty the facilities. The toilets contain sealable excreta containers (also referred to as cartridges) that are safely sealed and removed, without exposing residents or workers to the excreta, and taken to a treatment or resource recovery centre for processing and cleaning. The service provider provides the customer with an empty, clean container when the full one is removed. Transport methods can vary (and may involve tuk-tuks, motorcycles, hand carts, and donkey carts) to adapt to a variety of space and logistical constraints.

CBS service providers may manage the entire sanitation service chain themselves or partner with other groups or local authorities to implement other parts of the chain. Some of the CBS service providers build and operate resource recovery facilities, taking advantage of the high nutrient content of the relatively "fresh" and undiluted excreta to produce biogas, solid fuel, fertilizers, or other products.

Source: (World Bank, 2019)

Case Study: GroSan Toilets

Technology Highlights	
Name	GroSan Toilet
Location	Across various Indian cities
Designed by	Sanitation First, a UK-India based NGO
Components	Toilet Pan and Waste Container
Material Used	Ceramic for toilet pan, Aluminum Composite Panels for toilet unit
Storage Capacity	90 kg or seven days/ container, emptied after 21 days
Unit cost	83,000 INR catering to 40 users.
Input Products	Urine, Faeces, wash water, dry cleansing material
Output Products	Urine, Faeces with cleansing material, wash water
Cleaning method	Dry materials like sawdust, ash or soil
Source of energy	Electricity for light connections

Source: (NIUA, 2018)

Gro San is an upgraded model of the static twin chambered EcoSan (UDDT) Toilet. It is a low-tech model comprising of semi-permanent and portable four container system. Aluminium composite panels are used to construct a unit to sustain disintegration from natural forces in coastal and flood-prone areas, making it a viable option for Guntur. Pans are made of ceramic to avoid rusting. Each storage container is filled in 7 days and rotated. It is removed after 21 days through the specially designed lid and tools to avert human contact. The waste is transported to a yard where it is kept for 150 days, later being sold to the agriculture market. Each toilet caters to 40-45 users per day.

This model is suitable for individual households and community toilets. Its compact size, self-contained feature, minimal water, less maintenance has led to more than 5000 units being installed across India since the project inception in 2009. Education and Motivation are imparted to identified locations. After installation, periodic monitoring and operations are carried out NGO.

Figure 5.11:

(a) A user entering a GroSan unit

(b) Removal of the container after completion of the 21-day cycle

(c) Survey to identify the location and post-installation monitoring

Source: Container-Based Sanitation for Urban Slums, (Sanitation First)

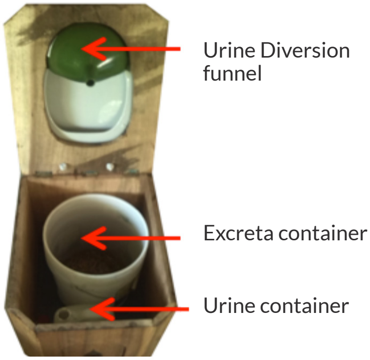
Case Study: EkoLakay Sanitation services

Technology Highlights	
Name	EkoLakay ecological sanitation services
Location	Port-au-Prince and Cap-Haitian, Haiti
Managed by	Sustainable Organic Integrated Livelihoods-SOIL, a US-based NGO
Inception year	2006
Services	Urine Diverting Toilets, Collection Units, Transportation and weekly replacement of collection units
Unit Capacity	20L container for faeces, 3L for Urine
Service cost	22$ and 50 $ for toilet unit, 4-5 a unit/month for services
Input Products	Urine, Faeces, dry cleansing material
Output Products	Excreta with a cleansing material
Cleansing material	Bonzode- a carbon-based material to cover the odour

Source: SOIL Publications, (Cherrak, et al., 2016)

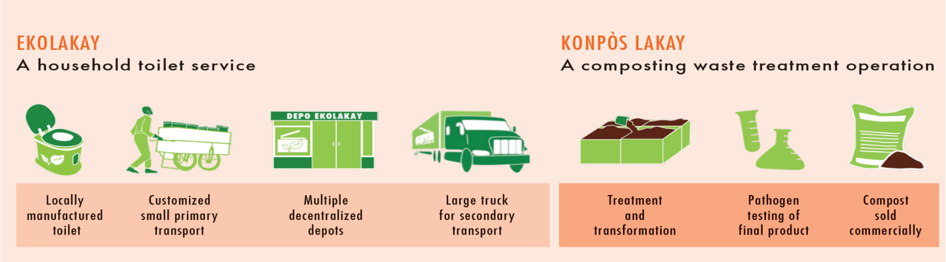
SOIL is a Haiti based NGO providing CBS services in highly dense settlement areas with no sewered connections. Customers sign up for the service for a feasible monthly payment. It includes the installation of the toilet, weekly collection of filled containers, providing a carbon cleansing material, and treatment at a SOIL composting waste treatment facility. Processed through a carefully monitored thermophilic composting process, all material is converted into nutrient-rich compost (suitable for use as per WHO standards). The end product, a nutrient-rich organic compost, is sold to recover costs of the waste treatment process partially. Since its inception in 2006, the service has covered more than 4000 users in both areas. As per a survey done by SOIL, it was found a heightened willingness among low-income households to pay for their services in order to have safe and hygienic facilities for waste collection.

Figure 5.12: Components of an EkoLakay CBS Toilet



Source: (Cherrak, et al., 2016)

Figure 5.13: Two Services of SOIL cycle



Source: (SOIL, 2020)

Figure 5.14:

(a) A EkoLakay CBS Toilet

(b) Figure: Container Collection Depot

Source: Annual Report 2020 (Soil, 2020)

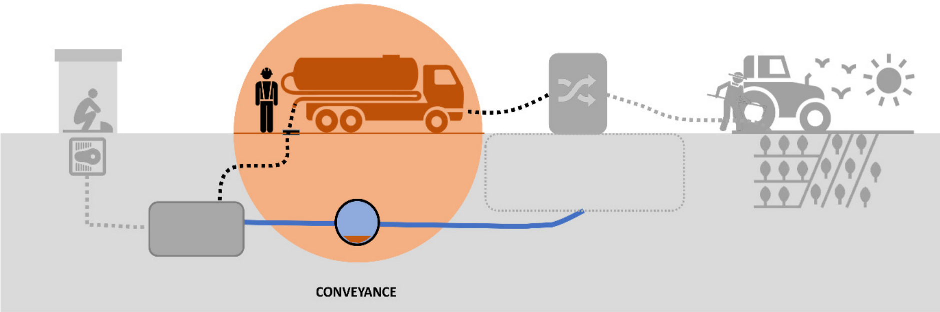
Non-Sewered collection technology and management options for Indian Cities

Innovations during the Best practices of Swachh Bharat Mission were frequently observed to improving the collection methods and discharge of faecal sludge and urine water. Common approaches included making collection methods hassle-free, reducing groundwater and soil pollution by discharge from pits, and gaining maximum nutrient recovery from collected and stored waste. Stakeholders in Indian cities have also been showing a positive response towards these innovations. With this encouragement, more innovations in technology and management can be adopted by Indian cities to address challenges of treatment infrastructure for the growing population.

5.3 Conveyance System and Technologies

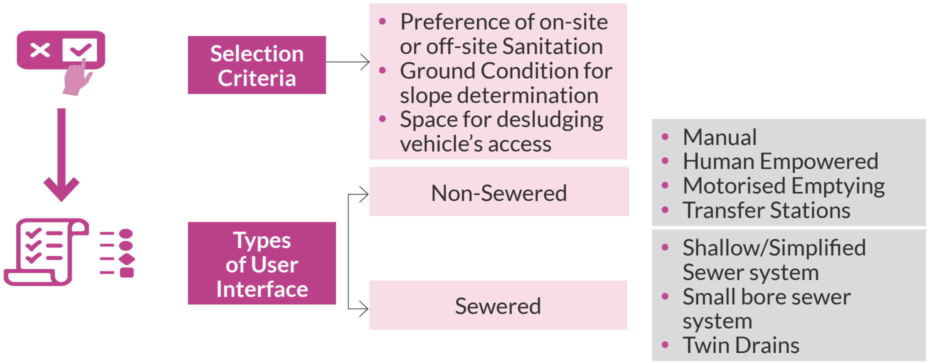
Sanitation waste collected in storage unit needs to be regularly emptied from the collection unit to avoid leakage into groundwater and soil. The Conveyance system is adapted to transport the sanitation waste products from containment units to the treatment units to prevent the leakages.

Figure 5.15: Conveyance in Sanitation Value Chain



Source: (NIUA, 2017-18)

Figure 5.16: Criteria for choosing appropriate conveyance technology for a site



Source: Author

Selection Criteria for Conveyance systems

In areas with sewered network, conveyance methods of conventional or non-conventional (small bore or simplified) sewer network are selected for conveyance to centralized or decentralized STP. The ground condition must be taken into account to provide inclination appropriate for smooth conveyance from the containment unit to the intercepting unit or STP. In areas where sewer network is not available or accessible, conveyance equipment or vehicles are opted for periodical emptying of the collection unit on site. Space availability for access to desludging equipment and vehicles determines the choice of desludging method selected.

Methods/ Technologies for Conveyance and Transportation of Wastewater

In non-sewered methods and technologies, sanitation workers along with conveyance vehicles and equipment visit individual collection units periodically to desludge them. After that, collected sludge is conveyed to transfer stations or FSTP. In Sewered methods, collection units are connected to intercepting tanks, either on-site or near the site, or directly conveyed to STP through sewers. The waste from interceptor tanks to STP is conveyed through sewered networks. In both approaches, regular maintenance of storage and conveyance infrastructure is necessary through regular desludging and other related cleaning activities.

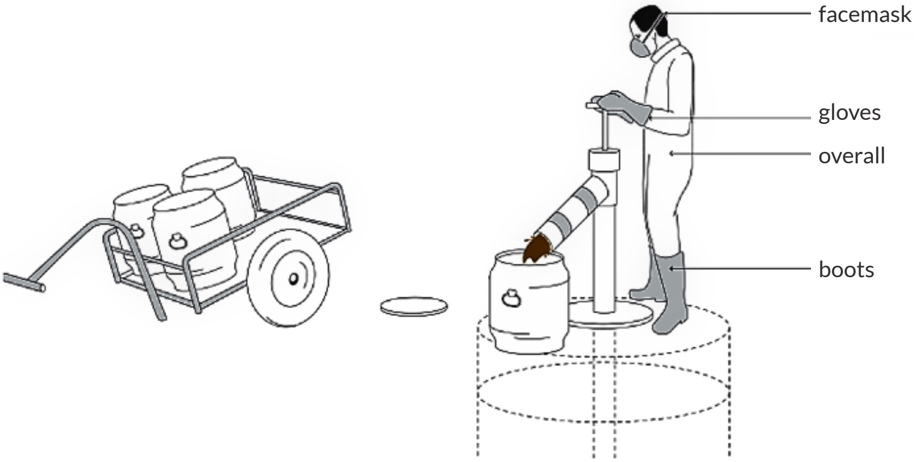
Conveyance Methods/Technologies for Non-Sewered Sanitation System

Desludging is the process of periodic emptying and cleaning of septic tanks, Interceptor tanks and sewer pipes. In urban scenarios, desludging services are managed by Urban Local Bodies. They provide the desludging service or hire private contractors for the same. In Indian cities, desludging services are recommended to be provided as per the CPHEEO standards.

- **Desludging equipment options:** There are desludging equipment available for various sizes and volumes that are portable considering the locations of containment units. Small to moderate volumes of collection tanks can be cleaned with manually operated equipment like shovel, buckets, gulpers, diaphragms, etc . For large volumes of desludging, vacuum trucks are a viable option provided there are access provisions for them to reach the tank.
- **Infrastructure for desludging:** Desludging infrastructure includes transfer stations for vacuum trucks to empty the collected waste. For sewered networks, pumping stations are provided at proximity to cluster of buildings. Waste from all buildings is collected in the pumping station and further sent to the treatment plant.
- **Area-based desludging options:** Choice of desludging method is dependent on the access to the collection unit. In dense areas like slums, non-vehicular equipment like gulpers, diaphragm pumps can have easier access. Similarly, access to higher terrain areas or low lying areas also needs specific desludging options.

Manual and Human-powered emptying

Figure 5.17: Manual and human empowered desludging



Source: *(Tilley, et al., 2014)*

Human-powered emptying and transport refer to the different ways in which people can manually empty and transport sludge and solid products generated in on-site sanitation facilities. Human-powered emptying of pits, vaults and tanks can be done in one of two ways:

- Using buckets and shovels, or
- Using a portable, manually operated pump specially designed for sludge (e.g., the Gulper, the Manual Diaphragm Pump or the MAPET).

Manual sludge collection falls into two general categories, namely 'cartridge containment' and 'direct lift'. Cartridge containment and direct lift methods can be practised safely when operators perform their tasks with the proper equipment following appropriate procedures. For instance, descending into pits as currently practised in several areas of our country is not safe and legally banned through manual scavenging act.

Dumping of Faecal Sludge directly into the environment rather than discharging at a transfer or treatment site must also be avoided. Besides, local government can help promote hygienic Faecal Sludge collection by highlighting best practices, imposing restrictions on unsafe practices, and providing incentives such as training, capacity building, and licensing. Formalising the informal sector through training and licensing will drive the demand for improved services, will improve hygiene, and enable business development and job creation.

Gulper

The Sludge Gulper was developed in 2007 by the London School of Hygiene and Tropical Medicine (LSHTM). It is a low-cost, manually driven positive displacement pump that operates along with the same principles as that of direct-action water pumps. The Gulper has a simple design and can be built using locally available materials and fabrication techniques generally common in low-income countries. It consists of a PVC riser pipe containing two stainless steel 'non-return' butterfly valves. One valve, the 'foot' valve, is fixed in place at the bottom of the riser pipe and a second valve, the 'plunger' valve, is connected to a T-handle and puller rod assembly.

Figure 5.18 Gulper operated desludging

Source: (HUFFPOST, 2015)

As the handle is moved up and down, the two valves open and close in series and sludge is lifted the riser pipe to exit the pump via a downward angled spout. The sludge can be collected in barrels, bags or carts, and removed from the site with little danger to the operator. Hand pumps can be locally made with steel rods and valves in a PVC casing. A strainer is fitted to the bottom of the riser pipe to prevent non-biodegradable material from entering and blocking the pump.

Table 5.9: Performance details of desludging by a gulper

Performance	Purchase/operating cost	Constraints
Suitable for pumping low viscosity sludges	Capital Cost: INR 3000 – INR 90,000 (depending on design)	Difficulty in accessing toilets with a small superstructure
Average flow rates of 30 L/min	Operating Cost: Unknown	Clogging at high non-biodegradable material content
Maximum pumping head is dependent on design		PVC riser pipe prone to cracking
		Splashing of sludge between the spout of the pump and the receiving container

Source: (NIUA, 2019)

Diaphragm Pumps

Figure 5.19: Diaphragm Pumps based operation

Source: (Pumpindia)

Manually operated diaphragm pumps are simple, low-cost pumps capable of extracting low viscosity Faecal Sludge that contains little non-biodegradable materials. They typically consist of a rigid, disc-shaped body clamped to a flexible rubber membrane called a diaphragm. An airtight seal between the diaphragm and the disc forms a cavity. To operate the pump, the diaphragm is alternately pushed and pulled, causing it to deform into concave and convex shapes in the same way a rubber plunger is used to unblock a toilet. A strainer and non-returning foot valve fitted to the end of the inlet pipe prevents non-biodegradable material from entering the pump and stops backflow of sludge during operation respectively.

Table 5.10: Performance details of desludging by Diaphragm pumps

Performance	Purchase/operating cost	Constraints
Suitable for pumping low viscosity sludges	Capital Cost: INR 20,000 – INR 60,000 (depending on design)	Clogging at high non-biodegradable content
Average flow rates of 100 L/min	Operating Cost: Unknown	Difficult to seal fittings at the pump inlet resulting in the entrainment of air
Maximum pumping head Of 3.5m-4.5m		Pumps and spare parts currently not locally available

Source: (NIUA, 2019)

The merits and constraints of opting for Human empowered desludging options are discussed in the Table below:

Table 5.11: Merits and Constraints of human empowered desludging

Merits	Constraints
Potential for local jobs and income generation	Spills can happen which could pose potential health risks and -generate offensive smells
Simple hand pumps can be built and repaired with locally available materials	Time-consuming: emptying pits can take several hours/days depending on their size
Low capital costs; variable operating costs depending on transport distance	Garbage in pits may block the pipe
Provides services to areas/communities without sewers	Some devices may require specialized repair (welding)

Source: (NIUA, 2017-18)

Motorized Emptying

Motorized emptying and transport refer to a vehicle equipped with a motorized pump and a storage tank for emptying and transporting faecal sludge and urine. Humans are required to operate the pump and manoeuvre the hose, but sludge is not manually lifted or transported.

Vacuum Trucks

A truck is fitted with a pump connected to a hose that is lowered down into a tank (Septic Tank) or pit. Sludge is pumped up into the holding tank on the vehicle. This type of design is often referred to as a vacuum truck. Conventional vacuum tankers are typically fitted with either a relatively low cost, low-volume sliding vane pump or a more expensive liquid ring pump. The former is appropriate for low-capacity vacuum tankers where high vacuum and low airflow sludge removal techniques are used. Vacuum conveyance techniques work best for removing low-viscosity sludge such as that found in septic tanks. The type of desludging vehicle or emptier truck that would need to be procured would depend on the volume of septic tanks to be emptied and the number of trips of an emptier truck. Suction-based vacuum trucks or emptier trucks with varying capacities of tanks are available in the market. The capacity of an emptier truck typically varies from 2,000 litres to 20,000 litres. The cost of the truck varies depending upon its capacity.

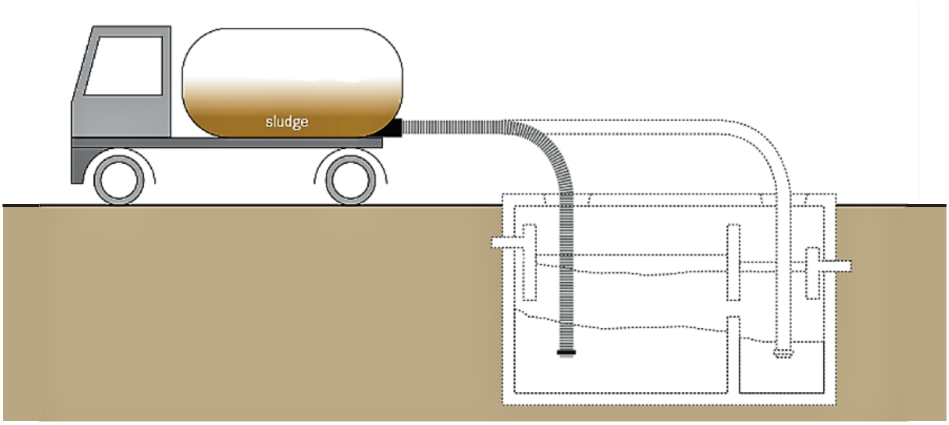
Figure 5.20:

(a) Vacutug

(b) Vacuum trucks

Source: (Tilley, et al., 2014)

Figure 5.21: Schematic diagram of motorized desludging by a vacuum truck



Source: (Tilley, et al., 2014)

While deciding the procurement of emptier trucks, ULBs should consider the following factors:

- Average road width of the areas from where the septic tanks need to be dislodged – road widths and weight constraints.
- Typical volume of the tanks or vaults that will be serviced.
- Characteristics of septage and size of septic tanks: to assess the amount of septage that can be desludged at a time which will consequently affect the number of trips
- Distance to the treatment site, access to the site, traffic congestion: to comprehend the number of trips that can be made in a day.
- Availability and budget.
- Skill level of the operators.

- Considerations for OPEX – fuel requirements.
- Financial budget for emptying services: to assess feasibility before planning for conveyance system.

Depending on the Collection and Storage technology, the sludge can be so dense that it cannot be efficiently pumped. In these situations, it is necessary to thin the solids with water so that they flow more quickly, but this may be inefficient and costly. Garbage and sand make emptying much more complicated and clog the pipe or pump. Multiple truckloads may be required for large septic tanks.

The merits and constraints that should be considered while opting for mechanized methods is discussed as below:

Table 5.12: Merits and Constraints of vacuum trucks

Merits	Constraints
Fast, hygienic and effective sludge removal	Cannot pump thick, dried sludge (must be thinned with water or -manually removed)
Efficient transport possible with a large vacuum trucks	Garbage in pits may block the hose
Potential for local job creation and income generation	Cannot empty deep pits due to limited suction lift
Provides an essential service to non-sewered areas	Very high capital costs; variable operating costs depending on use and maintenance
	Not all parts and materials may be locally available
	May have difficulties with access

Source: (NIUA, 2017-18)

Ensuring Periodic desludging for all households

As per the CPHEEO recommendations, residential septic tanks should be desludged once in every 3-5 years. This practice should be facilitated for all households in the city with septic tanks. Pre-determined scheduling of desludging services is the only way of keeping regular monitoring on status of septic tanks, and accordingly determine the need for conveyance and treatment facilities. ULB should do the management. There should be a penalty and regulations-based approach to desludging instead of a complaint-based facility for desludging services. Complaint based facility is not practised systematically among citizens due to lack of sufficient knowledge on the need for desludging.

Case Study: Desludging management by WAI Municipal Corporation, Maharashtra

Management Highlights	
Name	Scheduled Desludging service
Location	Wai, Maharashtra
Managed by	Wai Municipal Corporation
Target	Pre-Scheduled desludging of septic tanks/3 years
Conveyance	4 Vacuum trucks for desludging 4000 trucks annually
Fees Regulation	Sanitation tax

Source: C-WAS, (Mehta, 2019)

In 2018, Wai Municipal Corporation became the first city in India to begin scheduled desludging services in the city. The city was divided into three sanitation zones. Route plans were prepared for each zone. Household owners were informed a day before cleaning, to open the lids to septic tanks. The collected waste was transported to the treatment plant through vacuum trucks. A systematic record of all the steps was kept for every household. Additionally, awareness was generated among citizens through pamphlets, SMS and video clips. Instead of the desludging charges levied after the optional choice of service, the new service levied sanitation tax which cost lesser than the earlier facility.

Five months since its inception, the corporation managed to desludge more than 350 tanks at the rate of 7 to 8 tanks per day. 2.2 Million litre septage was delivered to a treatment facility. The practice has been very positively received by household owners with more than 90% acceptance rate.

Figure 5.22: Desludging Service in households in Wai

Source: (C-WAS, 2019)

Case Study: Innovative GIS-based Scheduled Desludging Services

Management Highlights	
Location	Hai Phong, Vietnam
Service area	Four urban districts
Managed by	Hai Phong Sewerage and Drainage One member state Company limited (Hai Phong SADCO)
Target	The desludging interval for household septic tanks once in 5 -6 years, and for communal apartments once in 1 -2 years
Technology Value	GIS-based data available for more than 86000 septic tanks across four urban districts
Conveyance	Vacuum trucks
Regulation	City budget and 15% wastewater surcharge on water bill

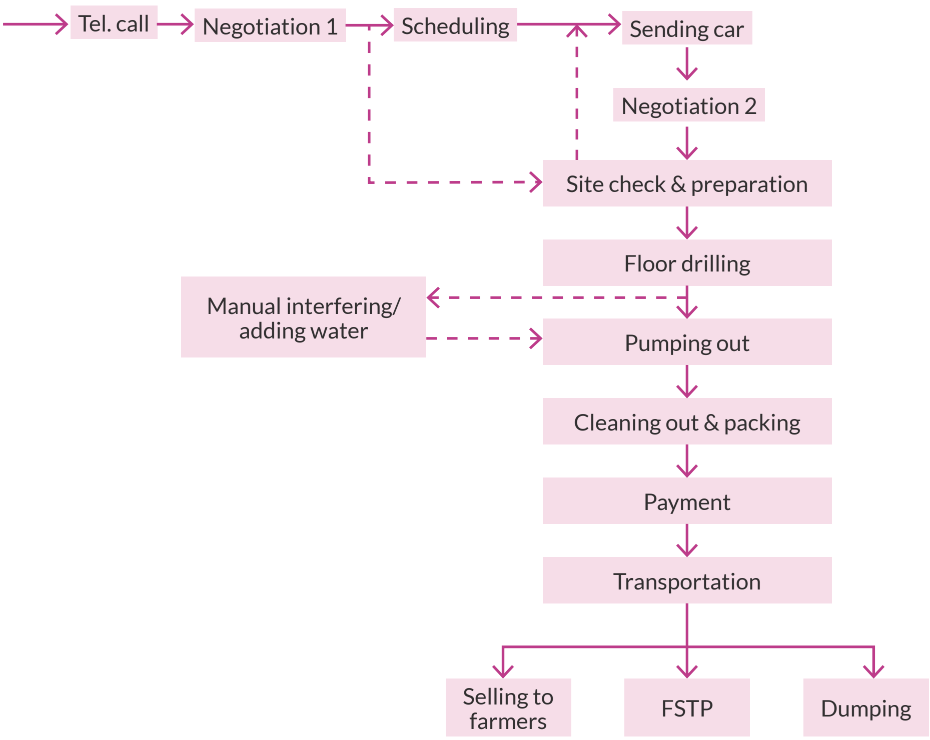
Source: C-WAS, (Mehta, 2019)

A GIS and telephone service-based management of desludging activities provides benefits due to technological access. Some of them are easy updating of services, real-time monitoring of household and communal cleaning periods across the region, storage and analysis of significantly extensive sanitation data collection, improved interactive facilities between service providers and citizens. This technology helps in effectively managing the services across larger urban areas reducing cumbersome manual data collections and updating needs.

Figure 5.23: Desludging truck

Source: C-WAS, (Mehta, 2019)

Figure 5.24: FSM service chart



Source: (Nguyen, 2011)

Vacutug

Vacutug is a smaller version of the trailer-mounted type of vacuum truck which carries a small sludge tank and a vacuum pump and can negotiate narrow pathways. The need for 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 vacuum truck. The vacutug can be as small as 300 L to 2000 L. The vacutug should be developed, keeping in mind that it should be easy enough to pull it by persons or small vehicle. In Bangladesh Vacutug is being used at larger scale in many areas. In India its performance has been evaluated, supported by the UN HABITAT during 2005-06. Under favourable circumstances, small vehicles like the vacutug can recover the operating and maintenance costs. However, the capital costs are still too high to run a profitable business sustainably. The Vacutug can be a useful tool in sludge management. Some of the features of vacutug are:

- Many vacutug models have a small footprint and can access sites that are hard to reach.
- A support tool for larger vacuum trucks to reduce the trips
- It works efficiently and hygienically.
- It is relatively inexpensive to operate.
- It needs minimal maintenance. Spare parts are inexpensive and readily available at many local markets.
- Offering a vacutug service is a potentially viable micro-enterprise.
- Vacutug operators wearing protective clothing throughout the process will not come into direct contact with sludge.

Table 5.13: Merits and Constraints of motorized emptying

Merits	Constraints
Fast, hygienic and effective sludge removal	Cannot pump thick, dried sludge (must be thinned with water or -manually removed)
Efficient transport possible with large vacuum trucks	Garbage in pits may block the hose
Potential for local job creation and income generation	Cannot empty deep pits due to limited suction lift
Provides an essential service to non-sewered areas	Very high capital costs; variable operating costs depending on use and maintenance
	Not all parts and materials may be locally available
	May have difficulties with access

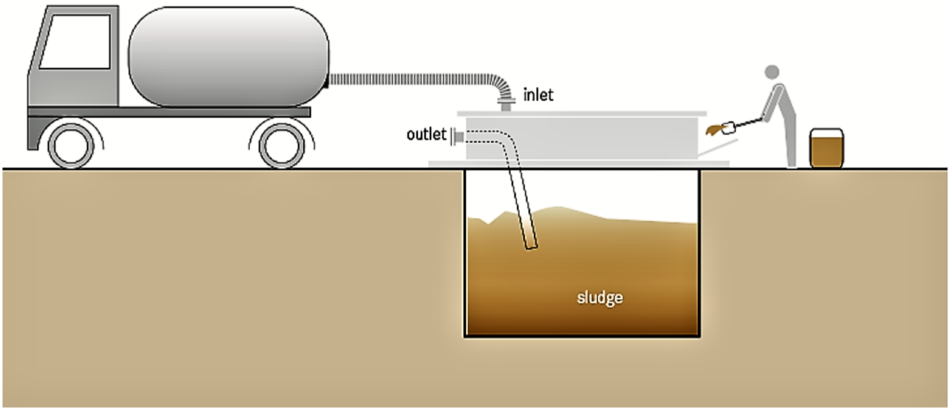
Source: (NIUA, 2017-18)

Transfer Stations

Transfer stations or underground holding tanks act as intermediate dumping points for faecal sludge when it cannot be easily transported to a Faecal Sludge or Septage Treatment facility. A vacuum truck is required to empty transfer stations when they are full. Operators of human-powered or small-scale motorised desludge vehicles discharge the sludge at a local transfer station rather than illegally dumping it or travelling to discharge it at a remote treatment or disposal site. When the transfer station is full, a vacuum truck empties the contents and takes the sludge to a suitable treatment facility.

In urban settings, transfer stations have to be carefully located. Otherwise, odours could become a nuisance, especially if they are not well maintained. A transfer station consists of a parking place for vacuum trucks or sludge carts, a connection point for discharge hoses, and a storage tank. The dumping point should be built low enough to minimise spills when labourers manually empty their sludge carts. Additionally, the transfer station should include a vent, a trash screen to remove large debris (garbage) and a washing facility for vehicles. The holding tank must be well constructed to prevent leaching and surface water infiltration.

Figure 5.25: Transferring of sludge at a transfer station



Source: (Tilley, et al., 2014)

Table 5.14: Merits and Constraints of desludging in transfer stations

Merits	Constraints
Makes sludge transport to the treatment plant more efficient, mainly where small-scale service providers with slow vehicles are involved	Requires expert design and construction
May reduce the illegal dumping of faecal sludge	Can lead to odours if not properly maintained
Costs can be offset with access permits	
Provides an essential service to non-sewered areas	
Potential for local job creation and income generation	

Source: (NIUA, 2017-18)

Increasing the practice of regularized desludging services in Indian Cities

ULB of cites like Wai, Ladakh, Sinnar in India have already strong standards and demonstrated promising results by implementing regularised desludging services throughout the city. They have successfully proved that these services are adaptable to surrounding conditions and can be practised efficiently through strategic management. More and more cities continue to plan on introducing these services in the city.

Sewered Conveyance Methods/Technologies

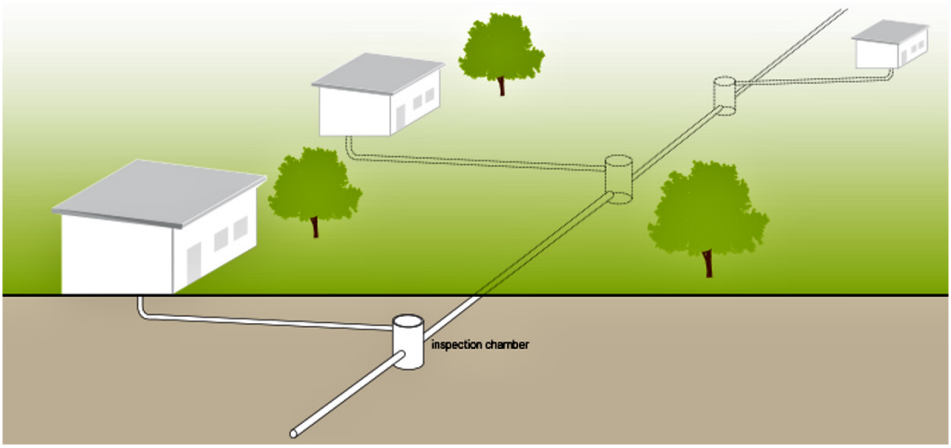
Conventional and non-conventional sewer systems are conceptually the same, with later one focussing on eliminating unnecessary conservative design features and matching design standards to the local situation. The whole idea is to simplify the design and reduce the costs of laying the sewer system. Non-conventional sewer systems are cost-effective alternative approaches to overcome the challenges of implementing conventional sewer systems. These mainly pertain to costs in laying sewer lines, installation challenges and after that maintenance issues. Two approaches under the ambit of non-conventional sewer systems are discussed as below:

Shallow/Simplified Sewer System

Also referred to as simplified sewerage, it conveys both blackwater and greywater from a household to an offsite location through sewer lines laid at shallow depth for treatment and safe disposal. The design and implementation of this system mainly involve applying simplified sewers' design principles coupled with consultations with users, planning and implementation agencies. The successful implementation of these systems is mainly dependent on the local community's participation since sewer lines need to cross private property boundaries.

A shallow sewer system follows the hydraulic theory of conventional sewerage; however, its design assumptions are less conservative. Smaller diameter pipes are used, and minimum earth cover could be as low as 0.2 m if less traffic volume expected. Such systems are designed with a planning horizon of 30 years. The maintenance requirements for the system mainly includes individual households maintaining their interceptor tanks and grease traps, periodical cleaning of inspection chambers and avoiding grit and stormwater entering in the collection system.

Figure 5.26: Shallow / Simplified Sewer System



Source: (Tilley, et al., 2014)

The main feature of this system is that sewers are routed through private land (either in back or front yards of the property). Shallow sewers are usually laid in the front or back yards of the house plots (suited for neighbourhoods with challenging topography or urbanization patterns) or under the pavement (sidewalk).

The system is suitable for:

- high density and squatter settlements
- newly planned settlements where currently there is no option to dispose of household wastewater through a conventional sewer system
- adverse ground conditions and where on-site disposal is not possible and,
- for sullage disposal and where the minimum rate of water consumption is 25 lpcd.

Table 5.15: Merits and Constraints of shallow sewer systems

Merits	Constraints
Smaller diameter pipes and shallow inspection chambers resulting in lower CAPEX and OPEX compared to conventional system	Requires expert design and construction supervision
The system can be built with locally available materials and repaired locally	Suitable only where the adequate ground slope available
Can be incrementally expanded as per need	Frequent clogging of sewers requires frequent cleaning as solids likely to get deposited becauseof flat
Cost of construction could be 30 to 50% lower than conventional sewerage depending on local conditions	Reluctance by households to allow the laying of sewers through their properties

Source: (NIUA, 2017-18)

Case Study: Simplified Sewer as an affordable Wastewater facility option

Management Highlights	
Location	Ramagundam, Telangana
Service area	Selected locations in the city
Managed by	Ramagundam municipality
Target	Introduce the concept of off-site sanitation in of the low-income group-based communities to encourage safe and hygienic sanitation practice
Technology Value	Decentralization of Sewer systems to smaller settlement clusters, reducing expenditure on infrastructure encouraging residents to be able to afford to contribute in expenses
Conveyance	Sewer Lines
Regulation	Fully funded by authority, or 40% contribution by household owners and rest by funding organization

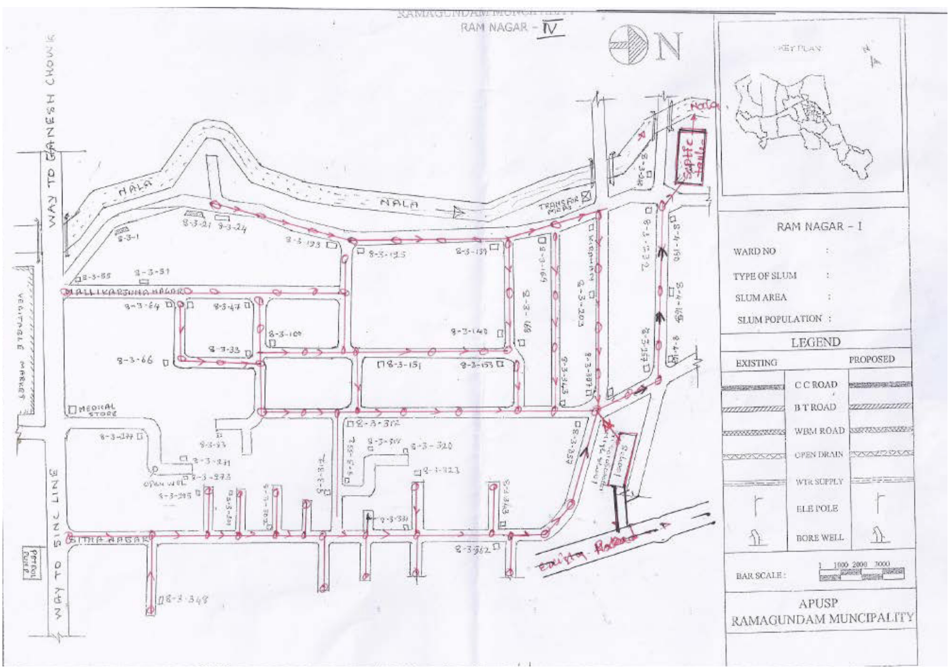
Source: (Nema, 2013)

Under the aegis of Department for International Development-UK (DFID), the program 'Andhra Pradesh Urban Services for the Poor' launched the first project of wastewater management through simplified sewer network in the country at Ramagundam.In its pilot case, the municipality identified a resettlement colony of 300 lower-middle-income families for a pilot project wherein each family agreed to construct an individual household latrine at its own cost and contribute towards a 40% cost of the sewer network (Nema, 2013).

Figure 5.27: Simplified sewer with shallow chambers in a housing colony

Source: (Nema, 2013)

Figure 5.28: Map of the Simplified Sewerage Network in Ramnagar Slum (APUSP Program)



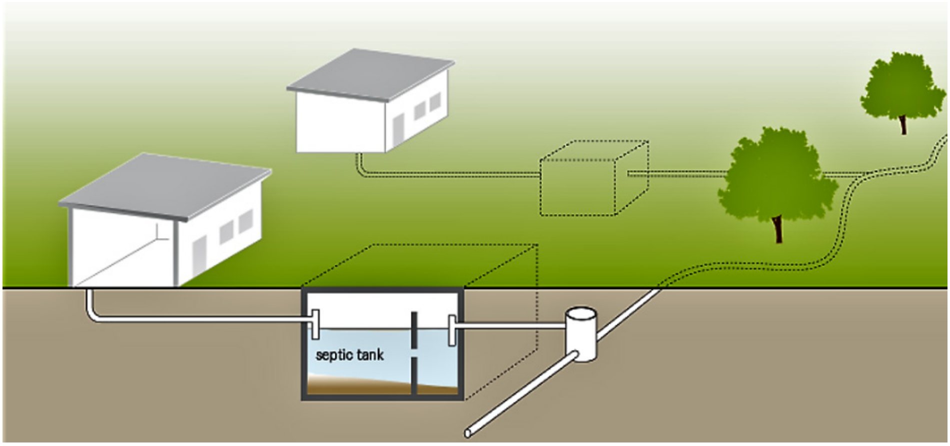
Source: (Nema, 2013)

Each house connection includes a raised chamber at the front of a property. The sewers are of 150 mm diameter and are laid relatively shallow, with invert between 150-200 mm below ground. The combined sewage from three hundred houses gets discharged into a typical large septic tank which then overflows into a stormwater drain. The municipality manages the repairs and maintenance aspects while the community supports through timely reporting of blockages and nominal sharing costs. These simplified sewerage networks are found to be working well, and the community is satisfied with the level of service(Nema, 2013). The program has resulted in substantial behaviour change with leaving practices of Open defecation and improvement in environmental sanitation within the community.

Small Bore Sewer System (Solid free/ Settled Sewer System)

The system is designed to collect only the liquid portion of the domestic wastewater (blackwater & greywater) and transport to an on-site or off-site location for treatment and safe disposal. The solids are retained in septic tanks or interceptor tanks at the household level before it enters the sewer system. Since the system collects only settled wastewater, the water requirements for transporting the solids and self-cleansing velocities are less.

Figure 5.29: Shallow Settled Sewer System



Source: (Tilley, et al., 2014)

The system is suitable for the following conditions:

- Where there is no possibility of on-site/off-site effluent disposal from toilets and bathrooms/kitchens.
- An area where interventions for improvements are incrementally planned by the provision of small-bore sewer system first, followed by gradual up-gradation to a full-scale conventional system.
- Where ground and soil conditions do not allow for effluent from on-site systems to be discharged locally.

The minimum diameter of the sewer pipe is 100 mm. The system does not require to maintain strict gradients for self-cleansing velocities. The sewer may be constructed with any profile provided the hydraulic gradient is maintained below the levels of interceptor tanks. The optimal functioning of this system to a large extent depends on households getting their septic tanks and interceptor tanks cleaned regularly. Flushing of sewers is recommended once a year as part of the regular maintenance regardless of their performance.

Table 5.16: Merits and Constraints of small-bore sewer systems

Merits	Constraints
reduced water requirements for transportation of solids	regular cleaning of septic/interceptor tanks
lesser excavation and construction material cost as compared to a conventional system	requires a well-planned maintenance system
treatment requirements are less since solids are already retained on-site	mixed experience with the system (limited experience)
reduced maintenance requirements	possibility of solids entering the sewer system due to illegal connection

Source: (NIUA, 2017-18)

Decentralizing sewer based conveyance in Indian Cities

As our cities grow, providing sewer infrastructure across all the settlements in the city becomes a growing challenge. Decentralized separate sewer systems can be identified as viable solutions in areas where conventional sewer systems cannot provide. These technologies have been implemented in India for two decades, albeit for particular situations and places (flood-affected areas, slums etc., as discussed in the case study on Ramagundam). These solutions are not alternative but supportive complementing technologies that help conventional sewer infrastructure of city function with better efficiency.

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Quick Assessment

1. In a Non-sewered system, waste is collected in a containment system and may or may not be treated on site.
   a. True
   b. False

2. How does a pit toilet or latrine work?
   a. By separating sludge and scum from the liquid wastewater
   b. By holding faeces' and urine in a pit or tank until it can be removed for further treatment
   c. By allowing faeces and urine to flow directly to a drain field for bacteria to continue their work
   d. By mixing in air to speed up the breakdown of liquid wastewater

3. What happens to sludge in a septic tank?
   a. It dries out and form clumps that have to be shoveled out every few years B. it floats on top of the liquid wastewater in the tank and needs to be pumped out every few years
   b. It collects at the bottom of the tank and needs to be pumped out every few years
   c. It flows through pipes in the septic tank to the drain field

4. What happens to liquid wastewater in a septic tank?
   a. It evaporates through holes in the top of the septic tank
   b. It is converted to sludge over time
   c. It flows through pipes in the septic tank to the drain field
   d. It drains through the bottom of the septic tank

5. What is the installation time for a Bio-Digestor Toilet?
   a. 2-3 hours
   b. 5-6 hours
   c. 1-2 hours
   d. 8-10 hours

6. Anaerobic Baffle Reactors(ABRs) can be installed in every type of climate, although the efficiency is lower in colder climates.
   a. True
   b. False

** For answers please refer Annexure I*


LEACHATI SUMP
AND
PUMPING SYSTEM

Chapter 6

Urban Wastewater Treatment and Technologies

Recap

The previous chapters provide explanation on the stages of Sanitation Value chain, i.e., User Interface, Collection and Conveyance. The approach and technologies for Wastewater treatment are discussed in this chapter.

Training Objectives

- To understand the objectives of wastewater treatment
- To understand various available wastewater treatment Technologies and processes

Training Outcomes

- Understand the importance of wastewater treatment
- Understand the different types of treatment processes & Technologies
- Get an overview of components of Sewage Treatment Plants

Chapter Contents

6.1 Need for Wastewater Treatment

Municipal sewage has many types of impurities such as floating objects, suspended solids, dissolved solids, dissolved gases and microorganisms. Along with human organic waste, detergents, pesticides and pharmaceuticals also get added to it. Wastewater, therefore, can also be called water of different form where, if the concentration of impurities is reduced, can have applications similar to that of freshwater. Municipal wastewater treatment is the process of ejecting the harmful pollutants from wastewater.

Objectives of Wastewater Treatment

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 industries 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.

Treatment Processes

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 it's the specific gravity or the size of the constituent which assists the separation from the water. Most of these methods are based on physical forces, e.g. screening, mixing, flocculation, sedimentation, flotation, and filtration.
- **Biological** processes rely on the microorganisms to carry out digestion of the organic matter in anaerobic or aerobic conditions. Biological processes are the main heart and soul of any wastewater treatment plant.
- **Chemical** processes rely on the use of chemicals either to treat the water (e.g. Ozonation-to kill pathogens) or to assist the physical or biological processes (e.g. Alum or ferric chloride to coagulate the sludge).
- **Photolytic** processes rely on the photon in the light to treat the wastewater directly (e.g. UV to kill pathogens) or indirectly (e.g. Photosynthesis help to uptake the nutrients from the wastewater in case of constructed wetlands).

Design Parameters

The different type of design parameters used to design wastewater treatment units are listed as below. The importance of the design parameters may increase or decrease from case to case basis.

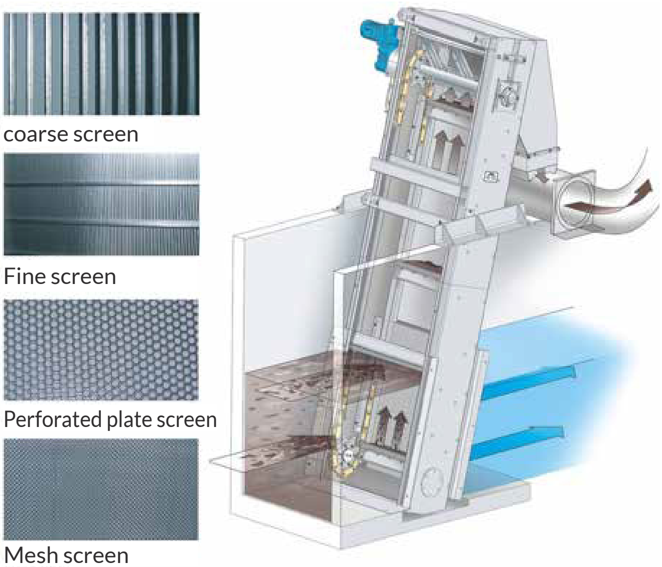
- Organic loading (kg BOD/day, kg COD/day),
- Volumetric loading rate (m^3/d)
- Temperature (°C)
- Hydraulic retention time (HRT) (hours or days)
- Sludge age (d)
- Biomass yield (kg VSS/ kg COD)
- Up flow velocity (m/s)
- Specific surface area (m^2/m^3)

6.2 Components of Sewage Treatment Plants

Screens

Screening is essential for the removal of floating materials which are mainly sachets, plastic sheet bits, leaves, fibres, rags, etc. If these are not removed, they will get into the pumps and entangle in the impellers. Screens are used ahead of pumping stations, meters and as a first step in all STPs. A screen is a device with openings generally of uniform size. The screening element may consist of parallel bars, rods, gratings or wire mesh or perforated plates and the openings may be of any shape, although generally they are contrived from circular or rectangular bars.

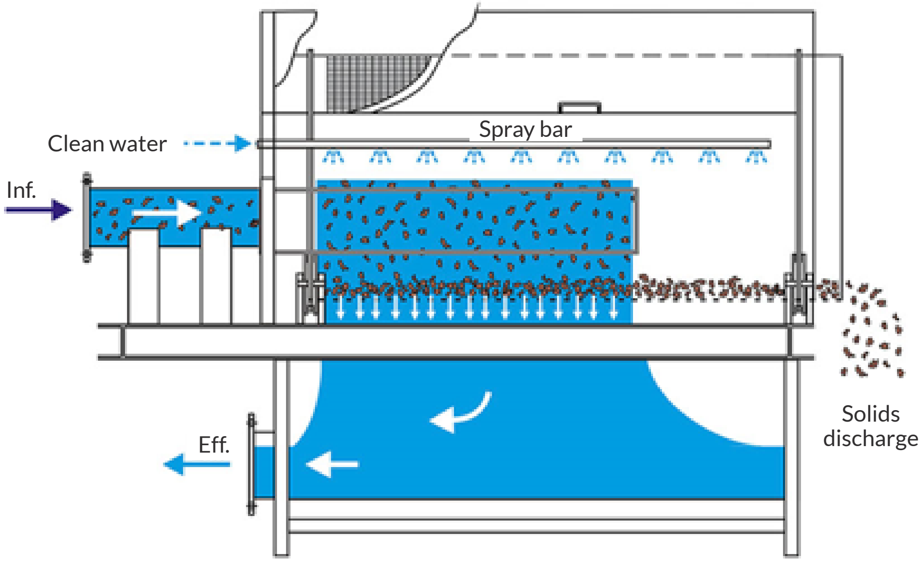
Figure 6.1 Schematic diagram of a mechanized bar screen



Source: (Huber Technology Waste Water Solutions)

Rotary drum screens- Where the incoming sewage to the STP is at a higher elevation than ground level, the use of horizontal rotary screen is advantageous as it avoids the need for manual scraping and the complicated forward and backward mechanical rakes. The inlet sewage skims over the rotating screen and the screenings are intercepted and rotated forward to be scraped onto the conveyor belt. The screened sewage goes through the slots and fall downward and gets collected in a bottom trough. The sticky screenings are released to the circular screen in the downward rotation while the screenings float up for the screening on the upward movement. The screened sewage at the bottom can be collected in a channel and taken out in any suitable direction for downstream units. Their design criteria are generally as per the chosen manufacturer's design standards.

Figure 6.2: Schematic diagram of rotary drum screens



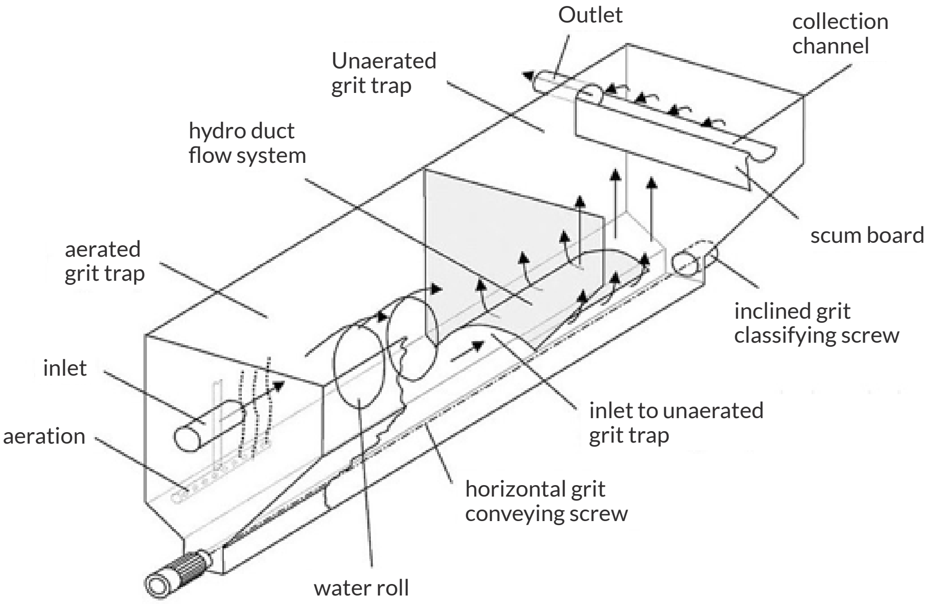
Source: (HUBER TECHNOLOGY Waste Water Solutions)

Grit removal

Grit removal is necessary to protect the moving mechanical equipment and pump elements from abrasion and accompanying abnormal wear and tear. Removal of grit also reduces the frequency of cleaning of digesters and settling tanks. It is desirable to provide screens or commuting device ahead of grit chambers to reduce the effect of rags and other large floating materials on the mechanical equipment, in case of mechanized grit chamber.

Aerated grit chamber- An aerated grit chamber is a special form of grit chamber consisting of a standard spiral-flow aeration tank provided with air-diffusion tubes placed on one side of the tank, 0.6 to 1 m from the bottom. The grit particles tend to settle down to the bottom of the tank at rates dependent upon the particle size and the bottom velocity of roll of the spiral flow. This is in turn controlled by the rate of air diffusion through the diffuser tubes and the shape of the tank. The heavier grit particles with higher settling velocities drop down to the floor whereas the lighter organic particles get carried with the roll of the spiral motion and eventually out of the tank.

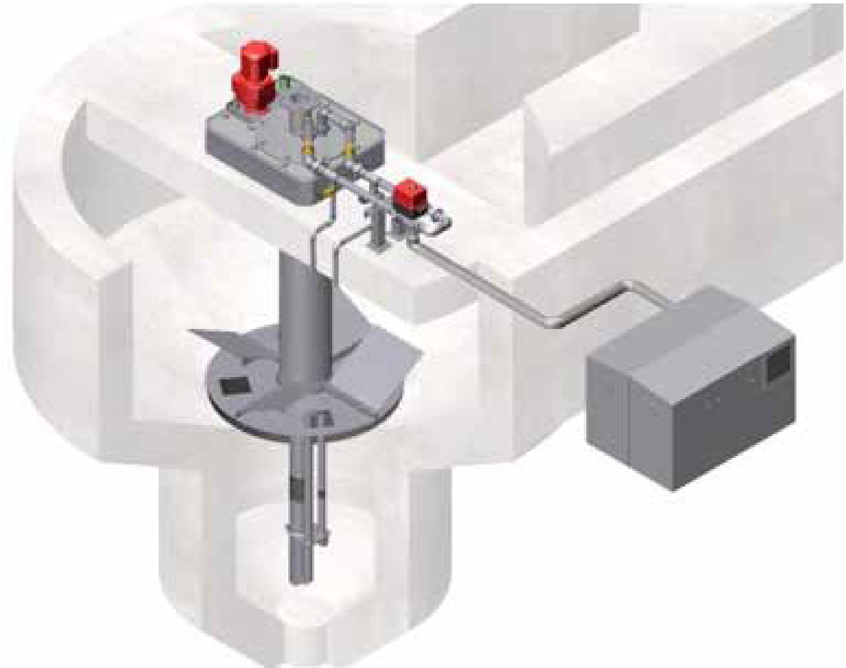
Figure 6.3: Aerated grit chamber



Source: (HUBER TECHNOLOGY Waste Water Solutions)

Vortex grit chamber- The sewage is fed tangentially to induce a vortex type of flow, which will funnel the grit towards the centre, and hence be drawn down at the bottom chamber. An auxiliary agitator at this location keeps the grit in suspension and hence it is washed free of organics. The rim flow of the vortex is the degritted sewage to downstream units. The grit at the bottom can be either drained onto a grit filter bed by gravity or pumped to the beds depending on the levels. The filtrate is returned to the raw sewage.

Figure 6.4: Vortex grit chamber



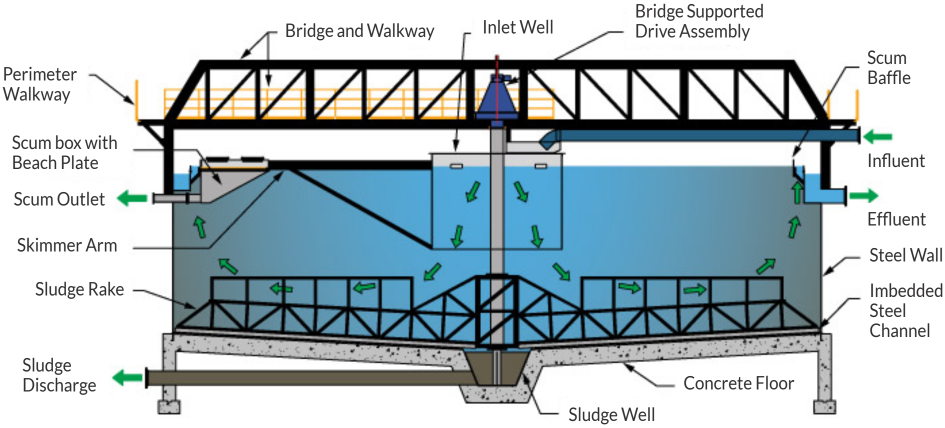
Source: (SPIRAC Solid Handling Solutions)

Primary treatment

Primary clarifier- The primary clarifier generally removes 30 to 40% of the total BOD and 50 to 70% of suspended solids from the raw sewage. The flow through velocity of 1 cm/sec at average flow is used for design with detention period in the range of 90 to 150 minutes. This horizontal velocity will be generally effective for removal of organic suspended solids of size above 0.1 mm.

Primary sedimentation tanks can be circular or rectangular tanks designed using average dry weather flow and peak flow condition. The numbers of tanks are determined by limitation of tank size. The diameter of circular tank may range from 3 to 60 m (up to 45 m typical) and it is governed by structural requirements of the trusses which supports scrapper in case of mechanically cleaned tank. Rectangular tank with length 90m is in use, but usually length more than 40 m are not preferred. The depth of mechanically cleaned tank should be as shallow as possible, with minimum 2.15 m. The average depth of the tank used in practice is about 3.5 m. The floor of the tank is provided with slope 6 to 16 % (8 to 12 % typical) for circular tank and 2 to 8% for rectangular tanks.

Figure 6.5: Schematic diagram of a primary clarifier



Source: (Monroe Environmental)

Secondary treatment

The main objective of secondary treatment is removal of organic matter. Organic matter is present in the following forms:

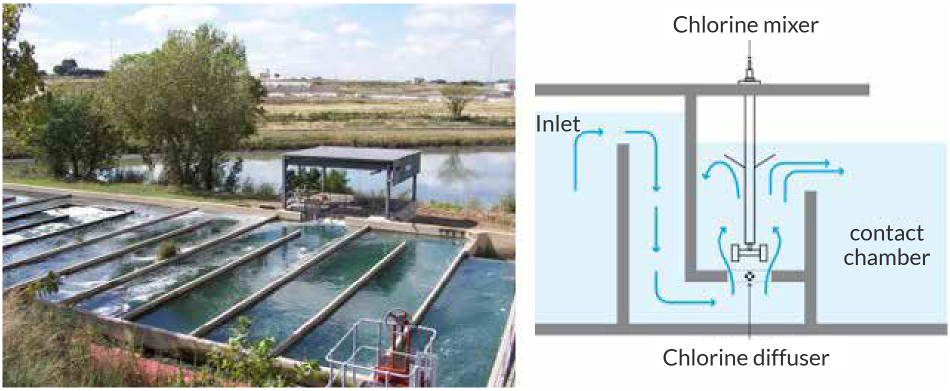
- Dissolved organic matter (soluble or filtered BOD) that is not removed merely by physical operations such as sedimentation that occurs in primary treatment.
- Organic matter in suspension (suspended or particulate BOD) which is largely removed in the occasionally existing primary treatment, but whose solids with slower settleability (finer solids) remain in the liquid mass.

The essence of secondary treatment of sewage is the inclusion of a biological stage. While preliminary & primary treatments have predominantly physical mechanisms, the removal of the organic matter in the 2nd stage is carried out through biochemical reactions, undertaken by micro-organisms.

Tertiary treatment

Chlorination- The destruction, inactivation, or removal of pathogenic microorganisms can be achieved by chemical, physical, or biological means. Due to its low cost, high availability and easy operation, chlorine has historically been the disinfectant of choice for treating wastewater. Chlorine oxidizes organic matter, including microorganisms and pathogens. Concerns about harmful disinfection by-products (DBP) and chemical safety, however, have increasingly led to chlorination being replaced by alternative disinfection systems, such as (UV) radiation and ozonation (O3).

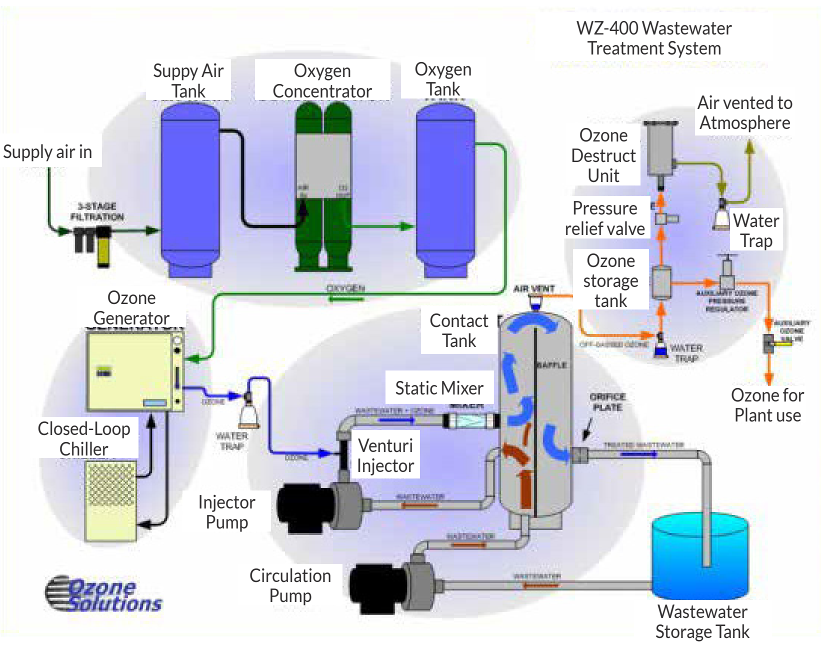
Figure 6.6: Chlorination Basin & Schematic Diagram of Chlorine Dosing & Mixer



Source: (NIUA, 2021)

Ozonation- Ozonation is an efficient treatment to reduce the amounts of micropollutants released in the aquatic systems by wastewater treatment plants. Although no residual by-products are generated by ozone itself, some concerns are raised regarding oxidation by-products when water containing both organics and ions, such as bromide, iodide and chlorine ions, are treated with ozonation. A typical ozonation system consists of an ozone generator and a reactor where ozone is bubbled into the water to be treated.

Figure 6.7: Schematic diagram of ozonation



Source: (Ozone Solutions, 2008)

6.3 Wastewater Treatment Technologies

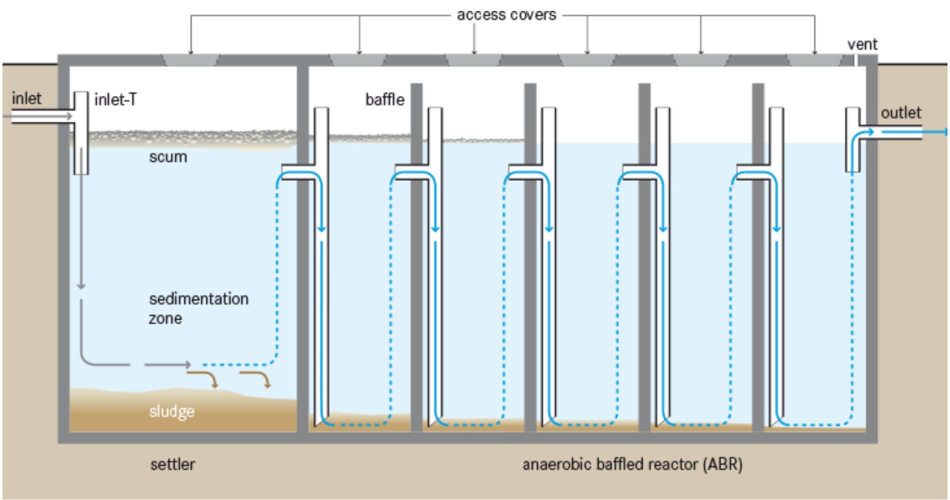
The treatment units can be broadly classified based on degree of mechanization required to treat the wastewater into two categories:

- Non-mechanized treatment systems, and
- Mechanized treatment systems.

Non mechanized treatment system

Anaerobic baffled reactor

Figure 6.8: Schematic diagram of anaerobic baffled reactor



Source: (Tilly et al, 2014)

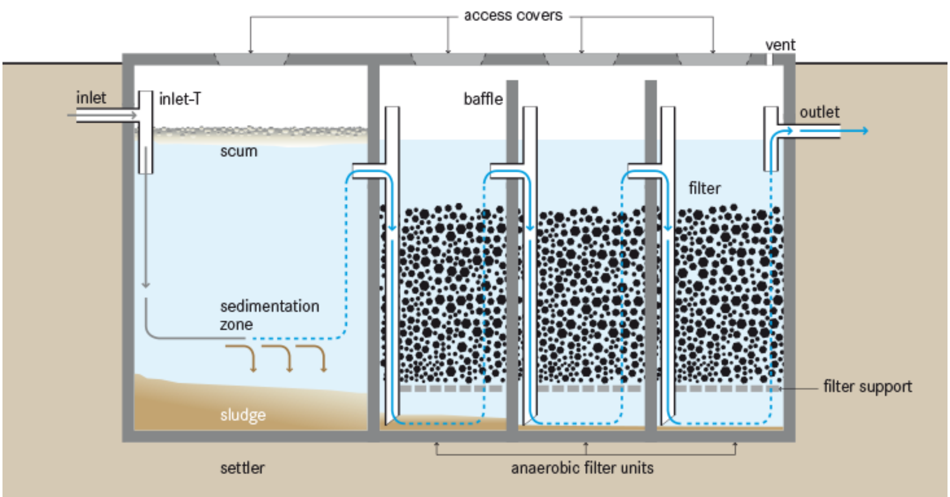
Table 6.1: Anaerobic baffled reactor

Working Principle	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; at least 1 sedimentation chamber and 2–5 up-flow chambers
Capacity/Adequacy	Community (and household) level; For pre-settled domestic or (high-strength) industrial wastewater of narrow COD/BOD ration. Typically integrated in DEWATS systems; Not adapted for areas with high ground-water table or prone to flooding
Performance	70- 95% BOD; 80% - 90% TSS; Low pathogen reduction. HRT: 1 to 3 days
Costs	Generally low-cost; depending on availability of materials and economy of scale
Self-help Compatibility	Requires expert design but can be constructed with locally available material
O&M	Should be checked for water tightness, scum and sludge levels regularly; Sludge needs to be dug out and discharged properly (e.g. in composting or drying bed); needs to be vented
Reliability	High resistance to shock loading and changing temperature, pH or chemical composition of the influent; requires no energy
Main strength	Strong resistance; built from local material; biogas can be recovered
Main weakness	Long start-up phase

Source: (NIUA, 2017-2018)

Anaerobic filter

Figure 6.9: Anaerobic filter



Source: (Tilly et al, 2014)

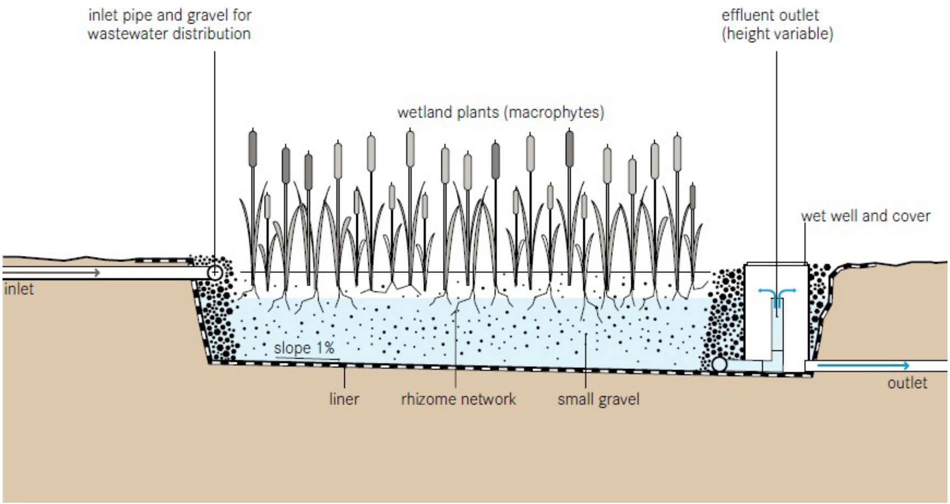
Table 6.2: Anaerobic filter

Working Principle	Dissolved and non-settleable solids are removed by anaerobic digestion through close contact with bacteria attached to the filter media
Capacity/Adequacy	Household and community level; as secondary treatment step after primary treatment in a septic tank or an anaerobic baffled reactor; effluents can be infiltrated into soil or reused for irrigation; not adapted if high ground- water table or in areas prone to flooding.
Performance	BOD: 50 to 90%; TSS: 50 to 80 %; Total Coliforms: 1 to 2 log units. HRT: about 1 day
Costs	Generally low-cost; depending on availability of materials and frequency of back flushing and desludging.
Self-help Compatibility	Requires expert design but can be constructed with locally available material
O&M	Regularly backflush to prevent clogging (without washing out the biofilm); desludging of the primary settling chambers; needs to be vented if biogas not recovered.
Reliability	Reliable if construction is watertight and influent is primary settled; Generally good resistance to shock loading.
Main strength	Resistant to shock loading; High reduction of BOD and TSS.
Main weakness	Long start-up phase

Source: (NIUA, 2017-2018)

Horizontal Flow Constructed Wetland

Figure 6.10: Schematic diagram of horizontal flow constructed wetland



Source: (Tilly et al, 2014)

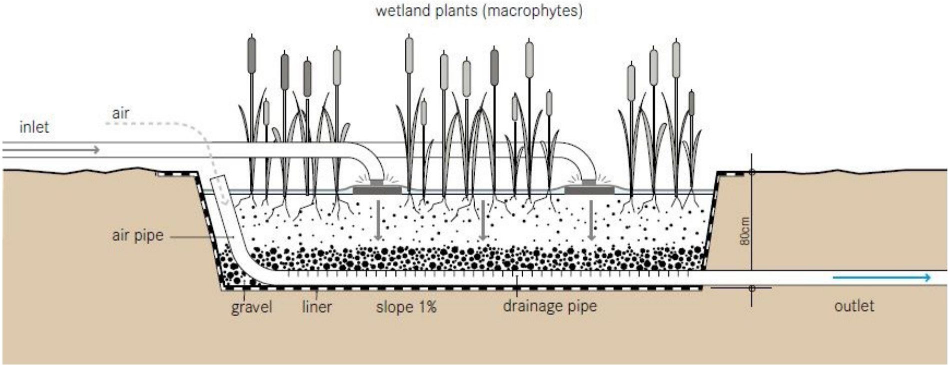
Table 6.3: Horizontal Flow Constructed Wetland

Working Principle	Pre-treated grey or blackwater flows continuously and horizontally through a planted filter bed. Plants provide appropriate environments for microbiological attachment, growths 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
Capacity/Adequacy	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water
Performance	BOD = 80 to 90 %; TSS = 80 to 95 %; TN = 15 to 40 %; TP = 30 to 45 %; FC ≤ 2 to 3 Log; LAS > 90 %
Costs	The capital costs of constructed wetlands are dependent on the costs of sand and gravel and also on the cost of land required for the CW. The operation and maintenance costs are very low
Self-help Compatibility	O&M by trained labourers, most of construction material locally available, except filter substrate could be a problem. Construction needs expert design
O&M	Emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/outlet systems
Reliability	Clogging of the filter bed is the main risk of this system, but treatment performance is satisfactory
Main strength	Efficient removal of suspended and dissolved organic matter, nutrients and pathogens; no wastewater above ground level and therefore no odour nuisance; plants have a landscaping and ornamental purpose
Main weakness	Permanent space required; risk of clogging if wastewater is not well pre-treated, high quality filter material is not always available and expensive; expertise required for design, construction and monitoring

Source: (NIUA, 2017-2018)

Vertical Flow Constructed Wetland

Figure 6.11 Schematic diagram of vertical flow constructed wetland



Source: (Tilly et al, 2014)

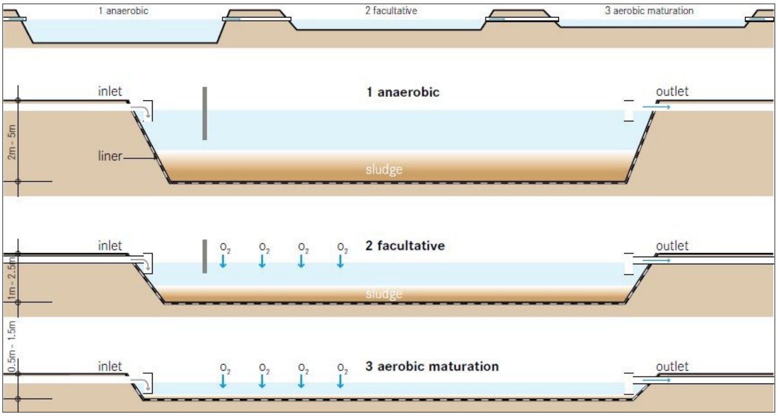
Table 6.4: Vertical Flow Constructed Wetland

Working Principle	Pre-treated grey- or blackwater is applied intermittently to a planted filter surface, percolates through the unsaturated filter substrate where physical, biological and chemical processes purify the water. The treated wastewater is collected in a drainage network
Capacity/Adequacy	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water
Performance	BOD = 75 to 90%; TSS = 65 to 85%; TN < 60%; TP < 35%; FC ≤ 2 to 3 log; MBAS ~ 90%
Costs	The capital costs of constructed wetlands are dependent on the costs of sand and gravel and also on the cost of land required for the CW. The operation and maintenance costs are very low
Self-help Compatibility	O&M by trained labourers, most of construction material locally available, except filter substrate could be a problem. Construction needs expert design. Electricity pumps may be necessary
O&M	Emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/ outlet systems
Reliability	Clogging of the filter bed is the main risk of this system, but treatment performance is satisfactory
Main strength	Efficient removal of suspended and dissolved organic matter, nutrients and pathogens; no wastewater above ground level and therefore no odour nuisance; plants have a landscaping and ornamental purpose
Main weakness	Even distribution on a filter bed requires a well-functioning pressure distribution with pump or siphon. Uneven distribution causes clogging zones and plug flows with reduced treatment performance; high quality filter material is not always available and expensive; expertise required for design, construction and monitoring

Source: (NIUA, 2017-2018)

Waste stabilization pond

Figure 6.12 Schematic diagram of waste stabilization pond



Source: (Tilly et al, 2014)

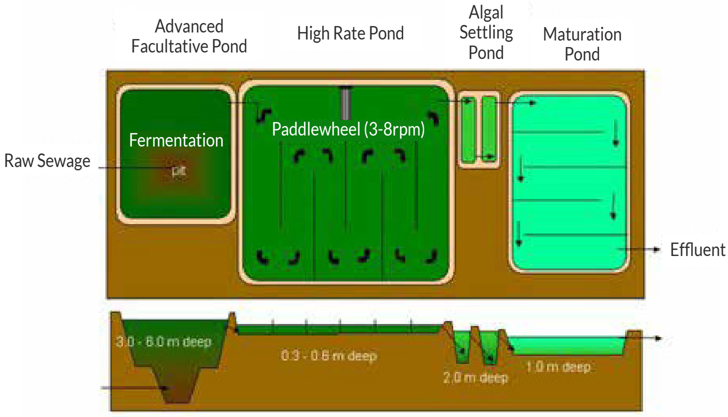
Table 6.5: Waste stabilization pond

Working Principle	In a first pond (anaerobic pond), solids and settleable organics settles to the bottom forming a sludge, which is, digested anaerobic by microorganism. In a second pond (facultative pond), algae growing on the surface provide the water with oxygen leading to both anaerobic digestion and aerobic oxidation of the organic pollutants. Due to the algal activity, pH rises leading to inactivation of some pathogens and volatilization of ammonia. The last ponds serves for the retention of stabilized solids and the inactivation of pathogenic microorganisms via heating rise of pH and solar disinfection.
Capacity/ Adequacy	Almost all wastewaters (including heavily loaded industrial wastewater) can be treated, but as higher the organic load, as higher the required surface. In the case of high salt content, the use of the water for irrigation is not recommended
Performance	90% BOD and TSS; high pathogen reduction and relatively high removal of ammonia and phosphorus; Total HRT: 20 to 60 days
Costs	Low capital costs where land prices are low; very low operation costs
Self-help Compatibility	Design must be carried out by expert. Construction can take place by semi- or unskilled labourers. High self-help compatibility concerning maintenance.
O&M	Very simple. Removing vegetation (to prevent BOD increase and mosquito breath) scum and floating vegetation from pond surfaces, keeping inlets and outlets clear, and repairing any embankment damage
Reliability	Reliable if ponds are maintained well, and if temperatures are not too low
Main strength	High efficiency while very simple operation and maintenance
Main weakness	Large surface areas required and needs to be protected to prevent contact with human or animals

Source: (NIUA, 2017-2018)

Advanced integrated ponds

Figure 6.13: Schematic diagram of advanced integrated pond



Source: (Tilly et al, 2014)

Table 6.6: Advanced integrated ponds

Working Principle	In a primary advanced facultative pond (AFP) containing a digester pit on its bottom, solids and organic are trapped and degraded via anaerobic digestion and aerobic degradation. In a high rate alga pond (HRP) BOD is further aerobically degraded and taken up by growing microalgae. In the next step, algae are settled in the algal settling pond (ASP) and can be harvested (and used as fish fodder or fertilizer). A final maturation pond (MP) enhances pathogen abatement
Capacity/Adequacy	Due to the complexity of the system it is adapted for community or large-scale application, but almost every wastewater can be treated
Performance	90 to 100 % BOD; 90 to 100 % TSS; 60 to 90 % nitrogen; 90 to 100 % ammonia; 60 to 100 Phosphorus; 6 log units E. coli
Costs	Compared to the high BOD, TSS and pathogen removal, AIWPS are cost-effective. However, investment costs are high and expert skills for design and construction are required
Self-help Compatibility	Presently, no clear guidelines for the design are available and planning and construction supervision. Operation and maintenance need to be carried out by technical experts; the community may contribute during construction
O&M	Large objects and coarse particles need to be screened; The algal settling pond needs to be desludged once to twice a year. HRPs are sensitive and require skilled maintenance
Reliability	High reliability and good resistance to shock loading
Main strength	High removal efficiency and almost no sludge produced
Main weakness	Not well experienced yet and expert skills required since the system is somehow complicated

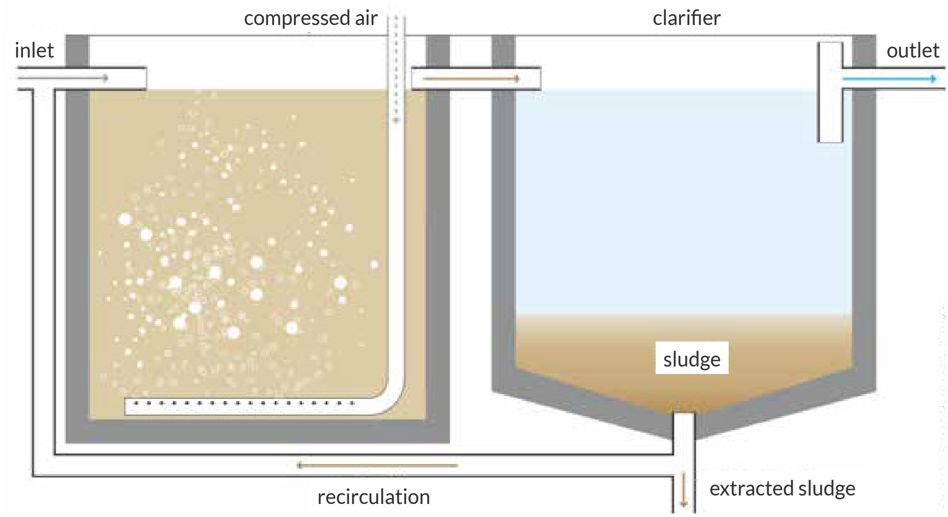
Source: (NIUA, 2017-2018)

Mechanized treatment system

Activated sludge process

Aerobic suspended growth systems are of two basic types, those which employ sludge recirculation, viz., conventional activated sludge process and its modifications and those which do not have sludge recycle, viz., aerated lagoons. In both cases sewage containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the soluble and suspended organic matter. Part of the organic matter is synthesized into new cells and part is oxidized to carbon dioxide 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 clarifiers. A part of this activated sludge is recycled to the aeration basin and the remaining form waste or excess sludge. In aerated lagoons the microbial mass leaves with the effluent stream or may settle down in areas of the aeration basin where mixing is not sufficient.

Figure 6.14: Schematic diagram of activated sludge process



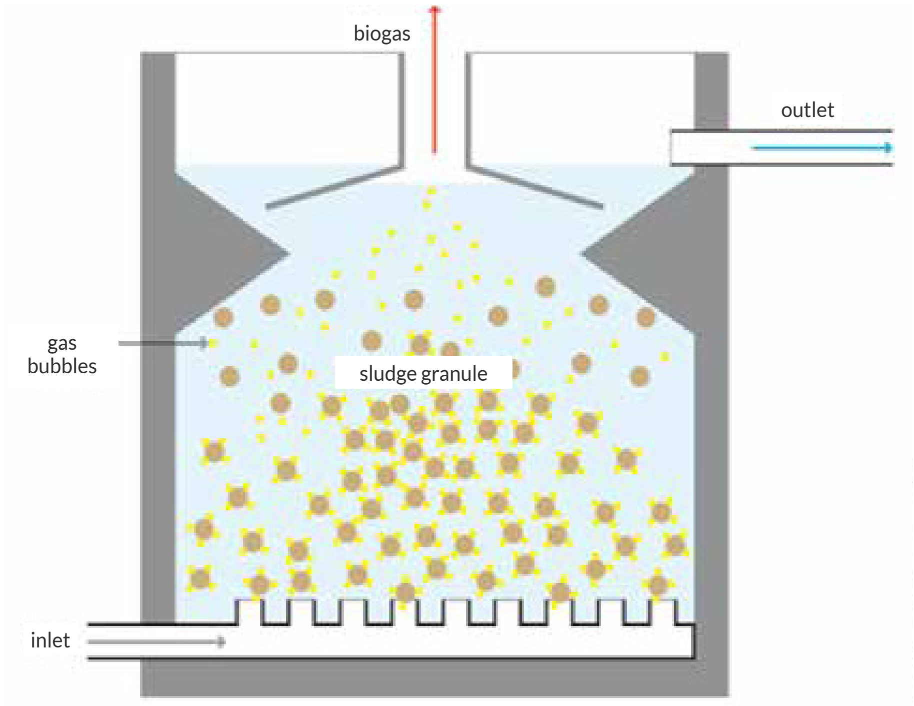
Source: (Tilly et al, 2014)

The suspended solids concentration in the aeration tank liquor, also called mixed liquor suspended solids (MLSS), is generally taken as an index of the mass of active micro-organisms in the aeration tank. However, the MLSS will contain not only active micro-organisms but also dead cells as well as inert organic matter derived from the raw sewage. The mixed liquor volatile suspended solids (MLVSS) value is also used and is preferable to MLSS as it eliminates the effect of inorganic matter. The Conventional system is always preceded by primary settling. The plant itself consists of a primary clarifier, an aeration tank, a secondary clarifier, a sludge return line and an excess sludge waste line leading to a digester. The BOD removal in the process is about 85% to 92%.

UASB Reactor

The Up flow Anaerobic Sludge Blanket Reactor (UASB), maintains a high concentration of biomass through formation of highly settleable microbial aggregates. The sewage flows upwards through a layer of sludge. At the top of the reactor phase, separation between gas-solid-liquid takes place. Any biomass leaving the reaction zone is directly recirculated from the settling zone. The process is suitable for both soluble wastes and those containing particulate matter. The process has been used for treatment of municipal sewage at few locations and hence limited performance data and experience is available presently.

Figure 6.15: Schematic diagram of up flow anaerobic sludge blanket reactor

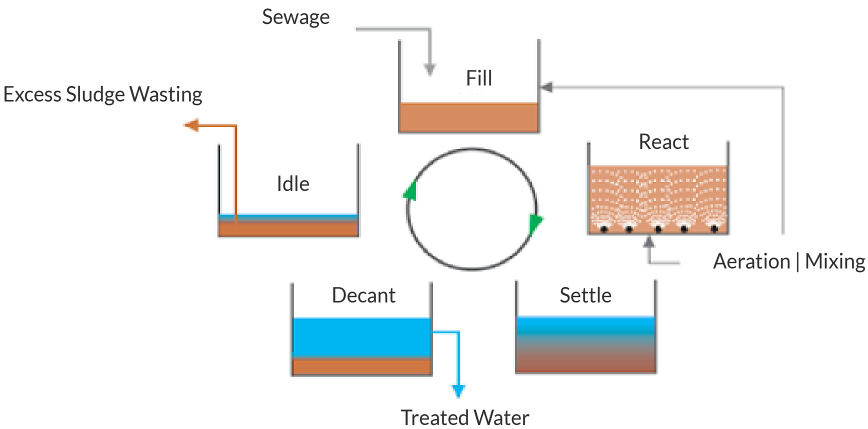


Source: (Tilly et al, 2014)

Sequencing batch reactor

In its functional process scheme, a Sequencing Batch Reactor (SBR) is the same as the activated sludge process. The only difference is in the activated sludge process, the sewage flows through a primary clarifier, an aeration tank and then through a secondary clarifier continuously whereas in the SBR, the aeration and settling are carried out in batch mode one after the other in the same tank. Primary clarifiers do not seem to be provided. Consequently, at least two SBR basins are needed in parallel so that when one is in aeration, the other can be in settling and decanting of the supernatant. In fact, the activated process can be referred to as continuous flow reactor. For this reason, the footprint on like to like basis of this type of SBR will be higher. SBRs are typically configured and operated as multiple parallel basins. It aims to provide process and equipment performance, and variously include an instrumental control system that regulates timed sequences for filling, reaction, settling and effluent decanting. All these are referred to as one cycle of process control operation. It is the time duration between successive decanting sequences during which the liquid level moves from a lower water depth (bottom water level) to its fill depth (top water level) and back to its lower water depth (bottom water level). This volume progression takes place in repetitive sequences that permit reactive filling to be followed by solids liquid separation.

Figure 6.16: Schematic diagram of sequential batch reactor



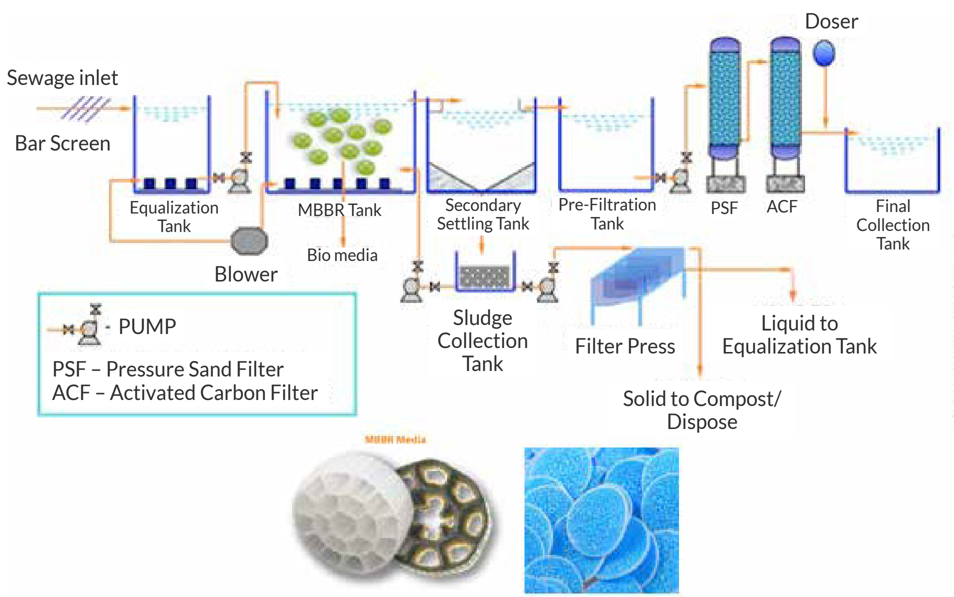
Source: (Ethics Infinity Pvt.Ltd.)

Moving bed biofilm reactor

The moving bed biofilm reactor (MBBR) is based on the biofilm carrier elements. Several types of synthetic biofilm carrier elements have been developed. These biofilm carrier elements are floated in the mixed liquor in the aeration tank and are kept floating by the air from the diffusers. They have a tendency to accumulate at the top zones. Hence wall mounted mixers propel the media downwards so that they again float and are in circulation in the mixed liquor. They are retained by suitably sized sieves at the outlet.

This process is intended to enhance the activated sludge process by providing a greater biomass concentration in the aeration tank and thus offer the potential to reduce the basin volume requirements. They have also been used to improve the volumetric nitrification rates and to accomplish the denitrification in aeration tanks by having anoxic zones within the biofilm depth. Because of the complexity of the process and issues related to understanding the biofilm area and activity, the processes design is empirical. There are now more than 10 different variations of the processes in which a biofilm carrier material of various types is suspended in the aeration tank of the activated sludge process. There are many examples of such activated sludge treatment process with suspended biofilm carrier in the world.

Figure 6.17: Schematic diagram of moving bed biofilm reactor

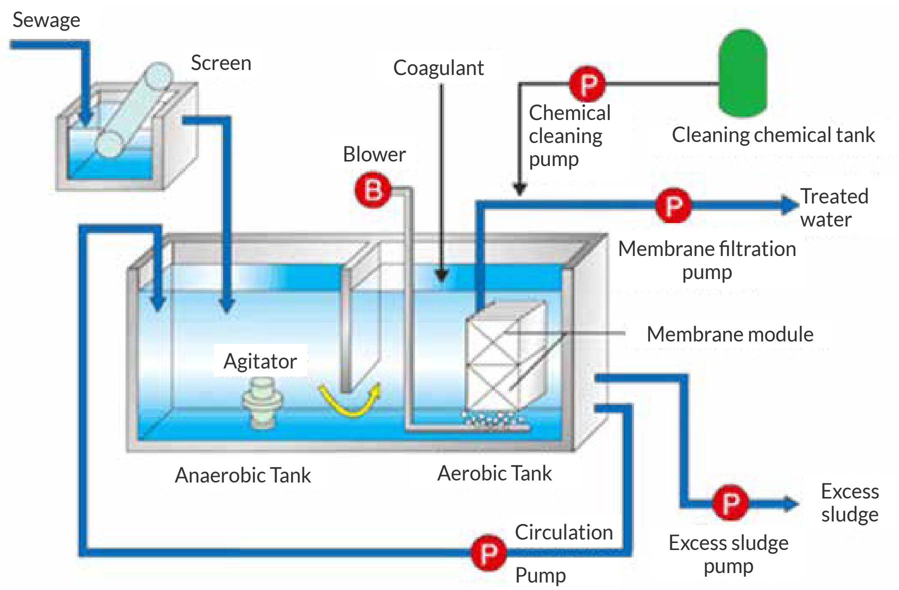


Source: (EcoMENA Echoing Sustainability in MENA)

Membrane bio reactor

The membrane bioreactor (MBR) process is a combination of activated sludge process and membrane separation process. Low pressure membranes (ultrafiltration or microfiltration) are commonly used. Membranes can be submerged in the biological reactor or located in a separate stage or compartment and are used for liquid-solid separation instead of the usual settling process. Primary sedimentation tank, final sedimentation tank and disinfection facilities are not installed in this process. The reaction tanks comprise an anoxic tank and an aerobic tank, and the membrane modules are immersed in the aerobic tank. Pre-treated, screened influent enters the membrane bioreactor, where biodegradation takes place. The mixed liquor is withdrawn by water head difference or suction pump through membrane modules in a reaction tank, being filtered and separated into biosolids and liquid. Surfaces of the membrane are continuously washed down during operation by the mixed flow of air and liquid generated by air diffusers installed at the bottom of the reaction tank. The permeate from the membranes is the treated effluent.

Figure 6.18: Schematic diagram of membrane bio reactor



Source: (Ecologic Systems, 2021)

6.4 Case-studies

Sewage Treatment Systems/Plants

East Kolkata Wetlands

The wetland is largely human made, comprising inter tidal marshes, with significant wastewater treatment areas like sewage farms, settling ponds, oxidation basins. Successfully managed by the local fishers for the past 100 years, East Calcutta Wetlands has been designated as a Ramsar Site in November 2002. Wetlands in West Bengal constitute about 31% of the total freshwater resources. Back in the day when the city began to grow faster, the British authorities started to engineer an advance drainage system. In 1860, a health officer of the Calcutta corporation started sewage farm & in 1930 regulated proportions of sewage water began to be used for fisheries. The nutrients present in the water are used for aqua culture. The wastewater is also used for plantation & livestock farming.

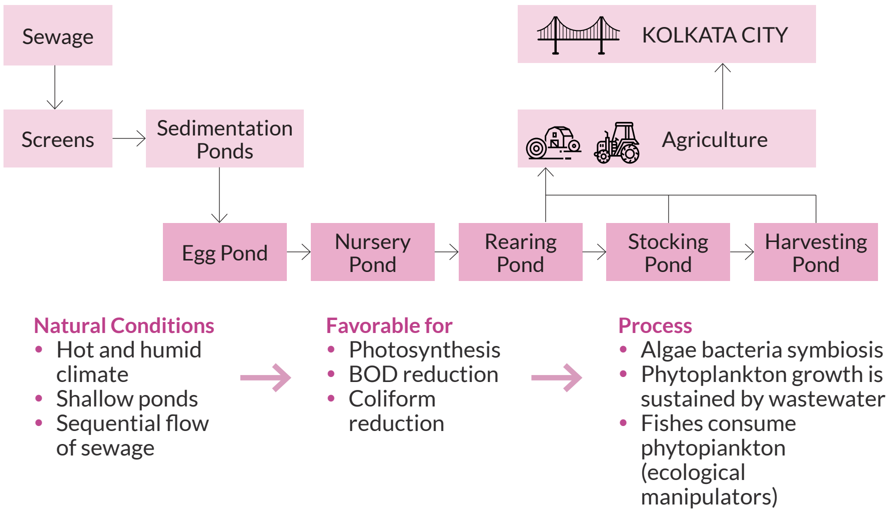
The wetlands to the east of Kolkata are the shock absorbers of all life activities of the city. A unique example of a man made and man managed wetland in which untreated sewage of the city is utilized extensively for fish culture. Treating the waste water from the city by these waste lands saves Kolkata from constructing and maintaining a wastewater treatment plant

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 passes 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 bio curtains or bio-filters for the passive remediation of wastewater.

The wetlands are managed by the community of local fisherman who also earn their living through this eco system. East Kolkata Wetlands is a perfect example of ecological sanitation where in the water loop as well as the nutrient loop is closed by integrated a high value product such as fishes.

Figure 6.19: East Kolkata Wetlands

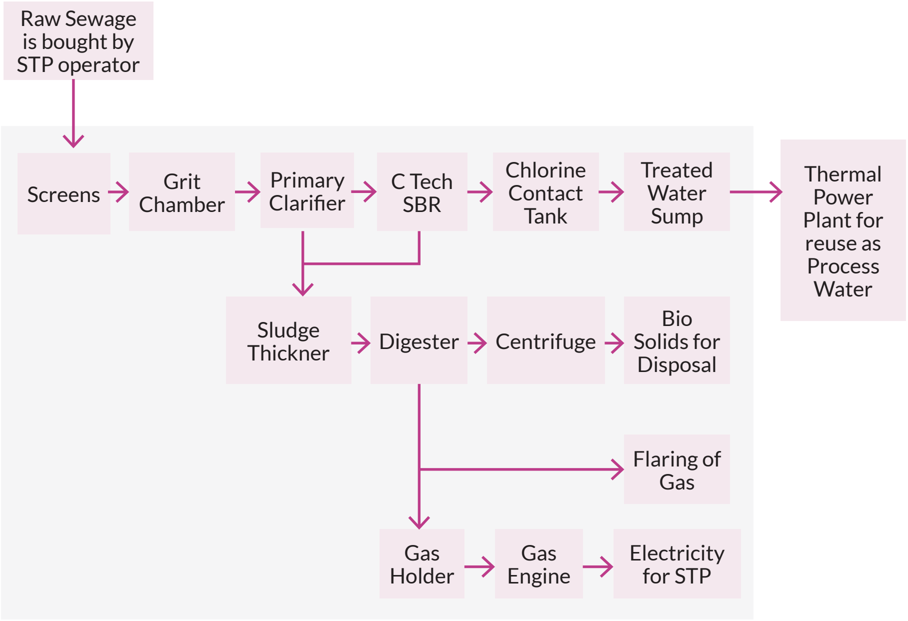


Source (NIUA, 2021)

Sewage Treatment Plant, Bhandewadi, Nagpur

This STP is designed & commissioned by SMS Ltd. This unique, state-of-the-art, fully automated & one of the largest sewage reuse plants in India is spread over 12.5 acres which takes in 130 MLD of sewage water from Nag river in Nagpur. The entire process is monitored through the administrative building. It is the nerve centre of the project & houses state-of-the-art equipment and control panels. An electrical 33 KV indoor sub-station houses the control mechanisms. The entire facility is powered by 5000 kilowatts of energy as regulated by a powerhouse in the premises.

Figure 6.20: Sewage Treatment Plant at Bhandewadi, Nagpur



Source: (NIUA, 2021)

Water from the Nag river is brought to the facility through pipeline into the intake structure where floating material up to sizes of 6mm is removed by fine screens. The water then passes through the mechanical detritus which removes the sand & grit from sewage water. After primary cleaning, the water is sent to primary clarifiers for partially removing BOD & TSS by adding alum at partial flume location. HRT of 30 mins is given at primary clarifiers for settling purpose. After passing through primary clarifier, the water overflows through the launder and through. An underground duct passes to the sea-tech basin for secondary treatment. The water flows to 8 sea-tech basins for aerobic digestion of biological impurities in presence of oxygen supplied by the 24 blowers.

The water is now subjected to sequential filling & aeration, sedimentation & decanting mode for secondary cleaning. The decanted water now passes through the chlorine contact tank for addition of chlorine to treated water for treatment of balanced bacteria. The water after processing with chlorine is passed to a sump where it's shifted to tertiary treatment plant. Using 8 vertical turbine pumps in tertiary treatment, water is passed through a multi-bed media filter comprising of anthracite sand & pebbles for final cleaning to achieve the desired parameters. The treated water is then transferred to the thermal power station.

This case study shows the planning process needs to be started from the last point i.e. reuse of the treated wastewater. In this case, the choice of technology and the integration of various treatment units was done in order to meet the standards of water to be used at the thermal power plant. Also, the integration of anaerobic digester which generates methane gas plays a crucial role in lowering the operation costs of the plant. The system seems to be complex, but with right aim and objectives, integration of the units becomes easy. If the whole system is designed well, the operation and maintenance can also be simplified.

Decentralized Wastewater Treatment System, CoEP, Pune

The College of Engineering, Pune is one of the most popular education institutes in Maharashtra. It has a large campus, which is divided in to four parts, two of which belong to the academic buildings, one is the hostel campus and the last is the sports campus. The following picture shows the layout of the college.

The hostel campus caters to 2000 persons consisting of students and staff who reside there during the academic year. There are ten students block out of which 7 are reserved for males and 3 are for females.

Figure 6.21: Layout of College of Engineering, Pune

Source: (NIUA, 2021)

The details of the water and wastewater at the hostel campus are given in the picture below;

Figure 6.22: Details of the water consumption and wastewater generation at the CoEP hostel campus, Pune

Source: (NIUA, 2021)

There are three systems installed to manage the different kinds of wastewater generated at the campus.

System A caters to the blackwater generated from the 3 hostel blocks of girls where black and grey water segregation has been done. System consists of anaerobic treatment system consisting of anaerobic settler, anaerobic baffled reactor and anaerobic up flow filter. The secondary treated water is discharged into the sewer.

System B caters to the grey water produced in these blocks. This system consists of grease trap followed by vertical flow constructed wetland. The secondary treated water is further treated using sand filter and UV. The reclaimed water is thus used for land scaping and toilet flushing in one of the hostel blocks.

System C caters to the rest of the seven blocks where segregation is not possible and hence wastewater is generated. The wastewater is first treated in anaerobic treatment system consisting of settler, baffled reactor and up flow filter. The anaerobically treated water is further treated aerobically in vertical flow wetlands. The secondary treated water is further clarified using charcoal and sand filter. Final disinfection is provided using UV lamp. The treated water is mostly used for toilet flushing and landscaping purpose all around the campus.

Figure 6.23: Decentralized wastewater treatment system, CoEP Hostel Campus

System A
Design capacity: 40 KLD
Influent: Blackwater

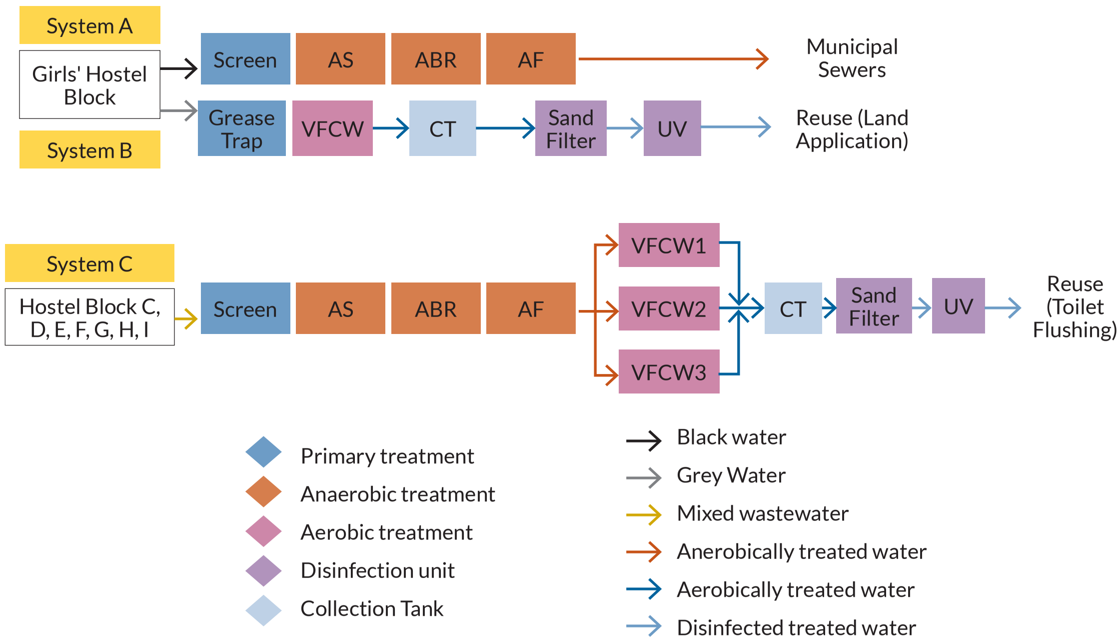
System B
Design capacity: 40 KLD
Influent: Greywater

System C
Design capacity: 100 KLD
Influent: Domestic Wastewater

Reclaimed Water

Volume: 150 KLD

Reuse volume: Toilet flushing & Landscaping



Source: *(NIUA, 2021)*

The details of the three systems are given in the picture below. The key takes away message from this case study is that integrating the natural wastewater treatment systems in the urban landscape is key to reducing the water footprint of the residential apartments. Thus, providing treated water at right at the point of generation at a cheap cost.

Faecal sludge and Septage Treatment Plants

Co treatment Facility, Puri

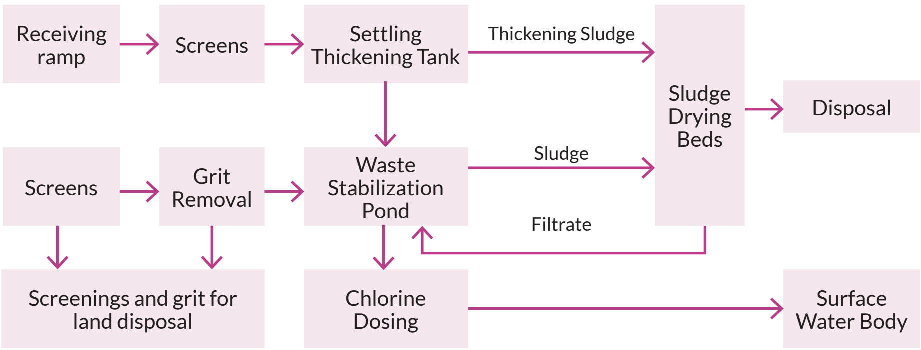
A Septage Treatment Plant (SeTP) having the capacity of 50 KLD (Kilo Litre per Day) was constructed by OWSSB (Odisha Water Supply and Sewerage Board) in 2017. The plant was constructed under the AMRUT (Atal Mission for Rejuvenation and Urban Transformation) scheme and is one of its kind in the nation as it uses co-treatment technology for the treatment of septage. The settling-cum-thickener tank of SeTP allows heavier particles of the unloaded septage to settle down to the bottom of tank while the lighter part of septage (i.e. water & oil) remains above. The settled solids (sludge) get thickened in the settling-cum-thickener tank and removed by pumping at regular interval to the sludge drying bed for removal of moisture content. The leachate from sludge drying bed is collected in a leachate sump which is pumped to the pre-treatment unit of Sewage Treatment Plant (STP) which is co-located with the Septage Treatment Plant (SeTP) for further treatment and disposal.

The Municipality has 6 number of cesspool vehicle out of which 4 were procured by the OWSSB and handed over to ULB while the other 2 were procured by ULB. The 4 newly procured vehicle are of 3000 L capacity and have been handed over to the professional agency under the contract.

Details of FSTP: 50 KLD Capacity

Details of STP: 15 MLD, Present flow: 12 MLD, Technology: Aerated Lagoon

Figure 6.24: Treatment Flow chart - Co-treatment Facility, Puri

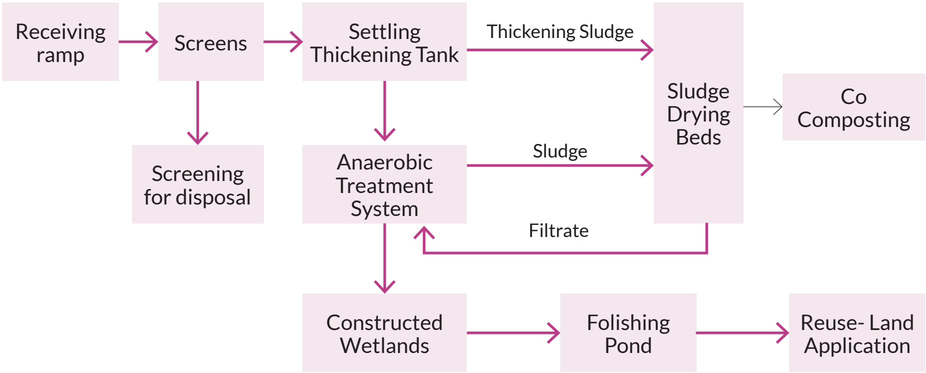


Source: (NIUA, 2021)

Septage Treatment Plant, Bhubaneshwar

The city of Bhubaneshwar is planning for sewered 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 figure given below. 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.

Figure 6.25: SeTP Treatment Flowchart, Bhubaneshwar



Source: (NIUA, 2021)

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 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 is disinfected and kept aerated using cascade aeration.

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Quick Assessment

1. _______ is essential for the removal of floating materials mainly sachets, plastic cheets, leaves, fibers, rags, etc. from the wastewater ahead of pumping stations, meters and as a first step in all STPs.
    a. Screens
    b. Aerated Grit Chamber
    c. Vortex Grit Chamber
    d. Primary Clarifier

2. Chlorination is a part of Primary treatment of Wastewater.
    a. True
    b. False

3. MBBR stands for____________

4. The BOD removal percentage in the Activated Sludge Process is:
    a. 20%-30%
    b. 55%-62%
    c. 42%-50%
    d. 85%-92%

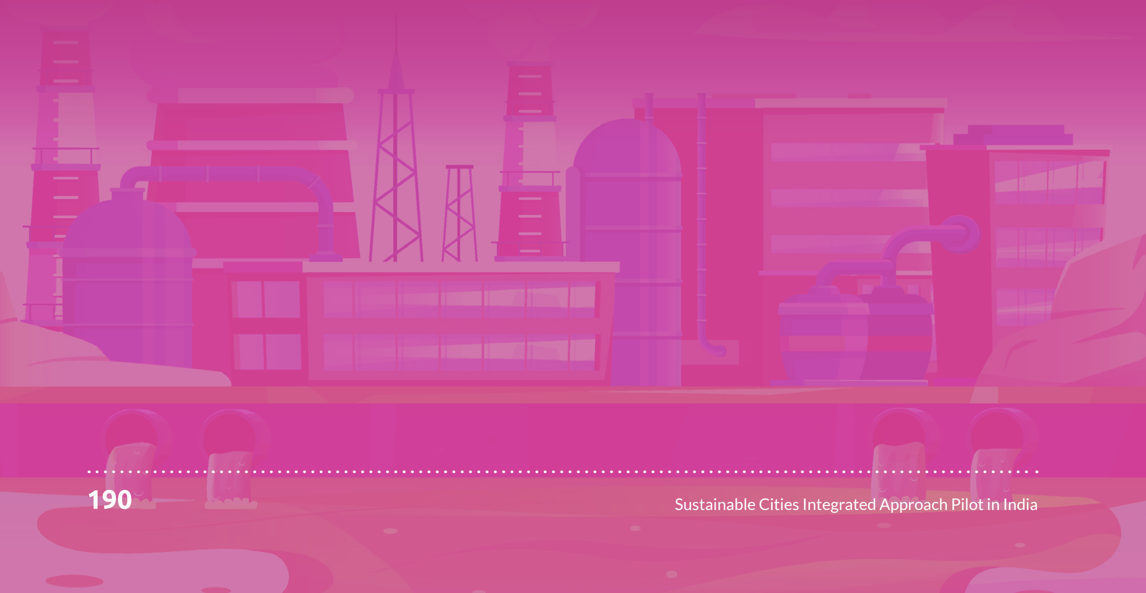
5. The percentage of suspended solids removed from raw sewage through Primary Clarifier is:
    a. 50%-70%
    b. 20%-30%
    c. 80%-90%
    d. 30%-40%

6. UASB stands for____________

* *For answers please refer Annexure I*

Chapter 7

Business Ecosystem Models for reuse of treated Wastewater



Recap

The previous chapter discussed about various wastewater treatment approaches and technologies. The given chapter tries to explain the relevance and importance of wastewater recycling through various business models and relevant case studies

Training Objectives

- To understand various business models for reuse of treated wastewater in India and abroad

Training Outcomes

- Understand the benefits of wastewater recycling
- Understand various models for reusing treated water
- Analyze the complexity in scaling up reuse

Chapter Contents

7.1 Introduction

Urban India faces significant challenges in terms of availability of adequate water supply and sanitation infrastructure. Water supply in most cities and towns is often insufficient to meet the growing demand for water by all economic sectors. Wastewater generated in urban India is often discharged in the open leading to unhygienic conditions and environmental pollution. Wastewater treatment and management, whether on site, decentralized or off site, are part of the full sanitation cycle and influence public health and the environment; it is very important to recognize that both central government and state governments must work together to tackle this issue. Recycling and reuse of treated wastewater are an important part of the sanitation cycle and critical in an environment of decreasing freshwater availability and increasing costs for delivering acceptable quality water supply to cities for multiple uses. Recycling and reuse of treated wastewater reinforce the economic benefits arising from the public good of achieving the total sanitation cycle.

Collection, treatment and reuse of municipal wastewater provides an opportunity for not only environmental rehabilitation, but also meeting the increasing water needs of different economic sectors. In addition to recycled wastewater becoming an additional and valuable water source, there are opportunities to recover nutrients and energy from wastewater. It is estimated that if 80% of urban wastewater could be collected and treated by 2030, there would be a total volume of around 17 billion m3 (BCM) per year; an increase of around 400% in the volume of available treated wastewater. This 17 BCM of treated wastewater resource, if captured, treated safely and recycled, is equivalent to almost 75% of the projected industrial demand in 2025 (MoWR 2006) and almost a quarter of the total projected drinking water requirements in the country.[1]

7.2 Benefits of wastewater recycling

Many cities in India encourage wastewater recycling but, with few exceptions, there are no clear incentives or mandate from the respective metropolitan administrations for wastewater recycling. There is a natural advantage to wastewater recycling, and this note discusses this in detail. Some of the key benefits of wastewater recycling are summarized below.

1. **Use of Recycled wastewater as an additional source of water**
    - Recycled wastewater and its allocation to industrial customers frees up freshwater hitherto used, which could be reallocated to other users with greater net benefits. This option is less expensive compared to other options to augment existing water

[1] CGIAR Research Program on Water, Land and Ecosystems, 2016. Recycling and Reuse of Treated Wastewater in Urban India: A Proposed Advisory and Guidance Document. RESOURCE RECOVERY & REUSE SERIES 8. [online] International Water Management Institute (IWMI). Available at: http://www.iwmi.cgiar.org/Publications/wle/rrr/resource_recovery_and_reuse-series_8.pdf

supplies from distant water sources or expensive treatment such as desalination. Use of treated wastewater can provide industries with a reliable source of water supply, and in most cases, a supply that is cheaper than freshwater. This can result in significant cost savings for industrial enterprises given that the water tariffs for industrial use are steep and rising consistently.

- Recycled wastewater also plays an important role in providing a reliable source of water for agriculture. Several countries use treated wastewater to varying degrees to meet agricultural water demand. The practice of using treated or untreated wastewater for agriculture has also been historically prevalent in India; however, there is a need to understand the economic, environmental, social and health implications of using untreated wastewater and mitigating any deleterious effects from its use. In coastal areas, reclaimed wastewater (discharged to the sea) is an additional resource to meet irrigation demand, and in upstream locations, use of reclaimed water in agriculture frees up freshwater for domestic and industrial consumption. In India, the urban wastewater generated (estimated currently at about 38,000 million liters a day [MLD]) would provide 14 Billion cubic metres (BCM) of irrigation water, which could safely irrigate (if treated) an area ranging between 1 and 3 million hectares (ha), depending on the type of crop cultivated and its irrigation requirement. This wastewater irrigation (WWI) potential (taken at 2 million ha) is 44% of the major and medium potential created and nearly three times the surface water-based minor irrigation potential created in the 10th five year plan (FYP). This is also significant when considering our national circumstances as 70% of India's population relies on agriculture for sustenance and agriculture, and is heavily reliant on rain-fed irrigation in large parts of the country.

2. **Source of revenue for utilities**
   - Utilities, with well-functioning STPs, are in a position to sell the treated effluent to industrial customers depending on the need and availability of other water sources. Utilities may charge these industrial customers for this recycled wastewater based on the required level of treatment provided and quality of wastewater. Being industrial customers, it is possible to charge these customers the actual cost incurred for the treatment and provision of water, allowing the utility to recover a significant share of O&M costs. Revenue from sale of secondary treated wastewater can cover the O&M costs of STPs. It is desirable therefore, that cities, whenever possible, should promote the use and sale of recycled wastewater to industrial customers, even making this practice mandatory through changes in state/local regulations. By 2030, treated wastewater from Class I and II cities has the potential to meet about a quarter of the current industrial water demand (17 BCM including the water demand for energy production in the country).[1]

3. **Nutrient recycling through wastewater recycling**
    - In addition to being a water resource, wastewater also contains valuable nutrients (nitrogen, phosphorus and potassium [NPK], among others), which aid in crop growth and could reduce the need for synthetic fertilizers in India by up to 40%. Wastewater, a valuable source of plant nutrients, needs to be viewed as an economic resource by the planning authorities at national, state and local levels.

4. **Reduction in ground water pumping requirement:**
    - The use of treated wastewater for irrigation also has potential to reduce ground water irrigation, and hence pumping and the associated energy requirement and associated costs.
    - Conservation of energy as a result of using wastewater for irrigation has a concomitant benefit of reducing harmful greenhouse gas (GHG) emissions that would have been generated during the production of an equivalent amount of electricity. These GHG emissions can be avoided through adoption of wastewater irrigation which reduces ground water pumping requirements.
    - Estimates in this advisory suggest that the avoided ground water pumping due to wastewater irrigation has the potential to reduce about 1.75 million MWh of electricity, which is equivalent to reducing about 1.5 million tonnes of CO_2e (tCO_2) GHG emissions.[1]

7.3 Why business model approach to Reuse?

While treated wastewater presents potential economic and environmental benefits to consumers (industrial, agricultural), city governments and states–an assured and reliable water supply, the nutrients present in the wastewater, and avoided costs of ground water pumping – utilities and state/ city governments will need to develop more sustainable business models. These models should aim at different user categories – industry, agriculture, institutions/commercial establishments–which in collaboration with partner agencies ensure financial viability, follow water allocation rules and support peri-urban agriculture. Thus by deriving an economic value for the treated products from a STP or wastewater treatment facility and linking it to back to the sustainability of the facility will not only ensure that such treatment units are thriving and expanding, but will also make sure that quality of treated water is maintained.

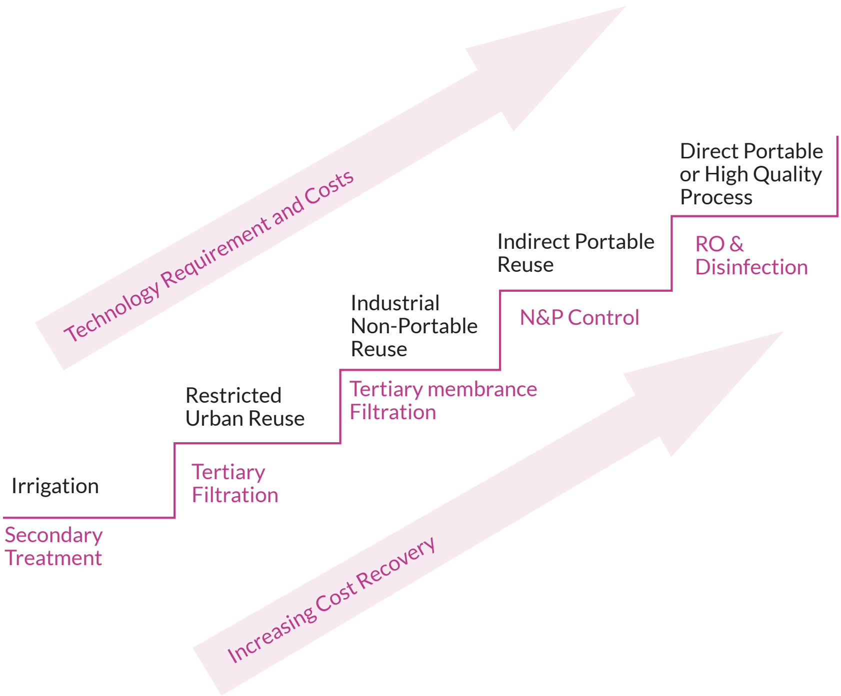
Choosing the right treatment technology based on reuse needs

Treatment of wastewater can be classified under the following stages- primary treatment, secondary treatment or tertiary treatment. Primary treatment essentially consists of removing the suspended solids present in the wastewater through physical sedimentation or coarse screening methods. Secondary treatment involves some form of biological treatment which removes the organic matter lowering the bio-chemical oxygen demand (BOD) of the wastewater. Tertiary treatment provides the most advanced level of treatment, reducing BOD and the total dissolved solids (TDS) levels to very low levels and can also be effective in removing dissolved impurities and nutrients such as nitrogen and phosphorus that may be present in the water. The type of advanced treatment (nutrient removal/ reverse osmosis/advanced disinfection) will depend on the type of reuse application, and is usually significantly capital-intensive along with high O&M costs compared to conventional secondary treatment alone. Of particular interest are anaerobic treatment systems with still lower energy demands

Choosing to provide a level of treatment which treats water to a quality beyond that required for its safe use for a particular application will burden the service provider with higher capital costs and higher O&M costs, with not enough revenue realization in the absence of demand for this high quality water.

The choice should be based on sound financial assessment of the investment required, the appetite for treated wastewater in the region, and customer profiles and their willingness to pay for the treated water.

Figure 7.1: Treatment Technology based on the reuse needs



Source: (CGIAR Research Program on Water, Land and Ecosystems, 2014)

Transitioning policy and regulatory environment

A number of policies and bye-laws emerged since mid-2000s that substantially influenced recycling and reuse of treated wastewater in India.

Table 7.1: Transitioning policy and regulatory Environment

Year	Policy	Key point
2006	National Environment Policy	Emphasizes recycling sewage and used water from municipal and industrial sources, before discharge to water bodies.
2008	National Urban Sanitation Policy	Recommends recycle and reuse of treated wastewater
2010	Service level benchmarks	Mandate the extent of reuse and recycling of sewage for gardens and parks in urban areas as 20%
2012/ 2020	National Water Policy/ Revised National Water Policy	Embraces the imperative of recycling and reuse
2016	Ministry of Power, Tariff policy	Requires thermal power plants located within 50 km radius of a sewage treatment plant (STP) of a ULB to mandatorily use treated used water (Treated water)
2016	National Building Code guidelines	Guidelines of National Building Code 2016 , emphasizes the reuse of treated sewage and sullage in commercial or residential multi-storeyed complexes for flushing of toilets, horticulture and fire-fighting purposes
2019	Central Ground Water Board notification	Regulate and control groundwater requires that, where viable, treated water is used rather than groundwater for purposes like toilet flushing, for irrigating green areas, and use in residential buildings, and infrastructure requiring more than 12.5 m^3/d of groundwater.

Source: Author

7.4 Business models with case studies

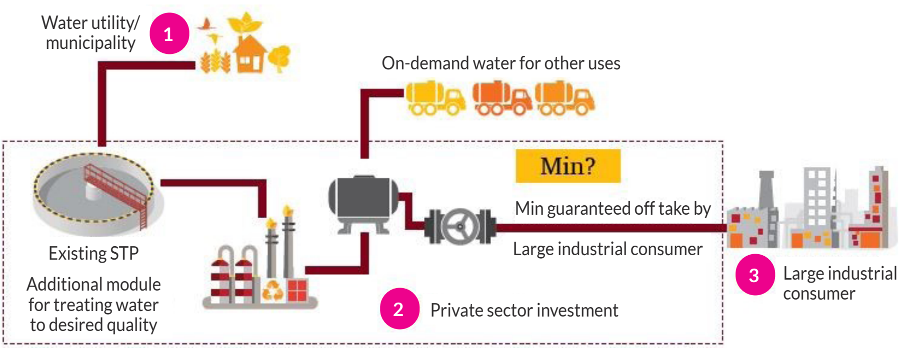
There are six different categories of business models with the case studies are described below:

1. Industries
2. Agriculture & agroforestry
3. Aquaculture
4. Inter-sectoral water exchange
5. Onsite reuse of treated water
6. Corporate social responsibility model

1. Industries

- **Minimum guarantee and fixed price model:** The implementing agency enters into a long-term contract with an industry or industrial zone for bulk consumption of treated water at an agreed price. The implementing agency can set up a tertiary treatment unit and operate it on its own. Alternatively, if the implementing agency enters into a PPP arrangement for design, build and operations of the tertiary treatment unit to a private entity, they will be responsible to monitor compliance by the private entity to supply the agreed quantity of treated water to the bulk consumer. The implementing agency makes a net annuity payment to the private entity to ensure a guaranteed minimum revenue. The private entity responsible for treatment can sell additional water to other consumers.

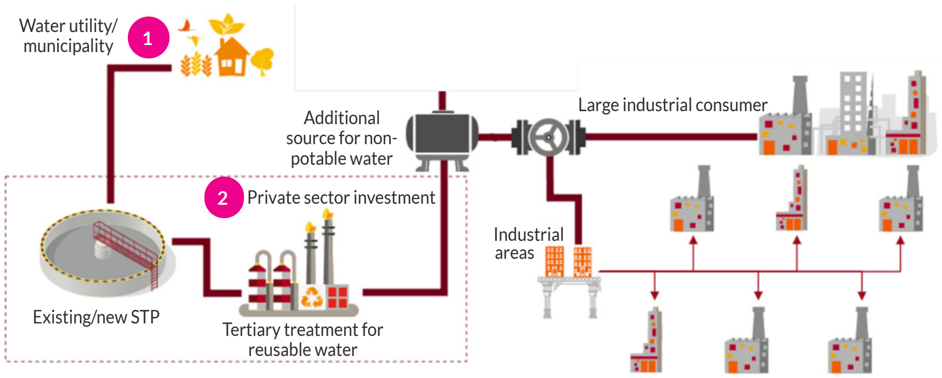
Figure 7.2: Minimum guarantee and fixed price model



Source: Author

- **Reuse buy-back model:** An alternative arrangement is for the implementing agency to enter into a PPP arrangement with a private entity to develop and operate a tertiary treatment unit. The implementing agency pays a fixed O&M cost to the private entity and provides full buy back guarantee for treated water. The implementing agency is responsible to deliver water to the industries at a price fixed or as agreed with the industries.

Figure 7.3 Reuse buy-back model



Source: Author

Case Study: The Water Reuse Project, Nagpur

The water reuse project, which came into operation in 2015, reuses municipal treated wastewater from Nagpur for cooling purposes in the new power plant (the Koradi Thermal Power Plant) built and operated by MahaGenCo (Maharastra state power generation company). MahaGenCo and Nagpur Municipal Corporation (NMC) signed a Memorandum of Understanding in 2008 "Construction and Operating Agreement of Treatment and Transmission Facilities for Reclaimed Water Usage". The partnership took the form of a build-operate transfer (BOT) end-user contract with a 30-year concession, with the option for extension. NMC agreed to provide the raw wastewater, and MahaGenCo agreed to be in charge of the transportation and treatment needed to be able to reuse the wastewater effluent from the NMC sewerage system. The contract was developed to ensure a regular source of water to the power plant (the raw wastewater) while providing NMC with a constant stream of revenue from MahaGenCo (in the form of raw wastewater fees). The city would also reap the environmental, health and social benefits from the extra wastewater treatment. The investment project included a raw wastewater intake facility with a pumping station of 130 million liters per day, a 2.3-kilometer pipeline to the wastewater treatment facility, a wastewater treatment plant with secondary and tertiary treatment to meet MahaGenCo's water quality requirements, a 16.2-kilometer pipeline from the wastewater treatment plant to the power plant, and a one-day reservoir of treated wastewater at the Koradi Thermal Power Plant for back-up. The capital cost of the project was about INR 195 crore (US$28 million), excluding the cost of land, which NMC agreed to provide. NMC also agreed to cover part of the capital cost with a grant of INR 90 crore from JNNURM.

MahaGenCo agreed to finance the rest and to assume cost overruns. MahaGenCo committed to build, operate, and maintain the wastewater treatment plant and pay NMC a fixed amount of INR 15 crore (US$ 2.25 million) a year for the raw wastewater (110 million liters a day). For flows that exceeded the contracted amount, MahaGenCo agreed to pay NMC INR 2.03 per cubic meter of raw wastewater. The benefits of the deal to MahaGenCo are the cost savings of using wastewater rather than freshwater to meet its water requirements. The treatment and provision of water through this arrangement cost MahaGenco about INR 3.4 (US$0.05) per cubic meter. Its costs would have been significantly higher if it had sourced fresh water from another municipal or irrigation project (about INR 9.6 (US$0.13) per cubic meter for recent projects).

SOURCE: CGIAR Research Program on Water, Land and Ecosystems, 2014. Recycling and Reuse of Treated Wastewater in Urban India: A Proposed Advisory and Guidance Document. RESOURCE RECOVERY & REUSE SERIES 8. [online] International Water Management Institute (IWMI). Available at: http://www.iwmi.cgiar.org/Publications/wle/rrr/resource_recovery_and_reuse-series_8.pdf

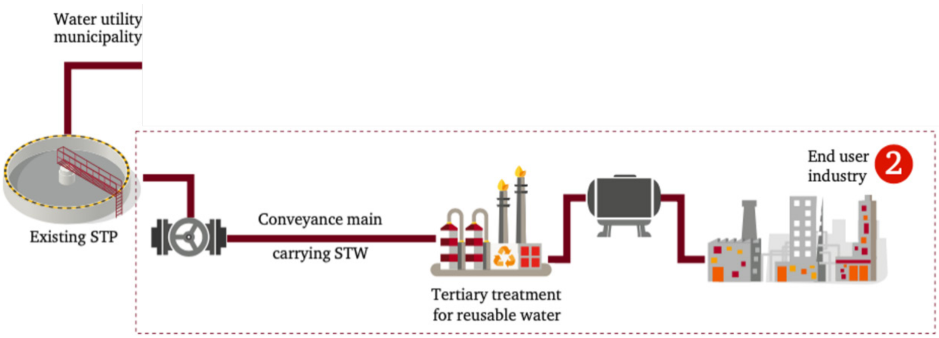
- **Reuse PPP model – investment by end user:** In this approach, the industry or industrial board purchases secondary treated water from the implementing agency. The industry or the industrial board is responsible for setting up the infrastructure for tertiary treatment and conveyance of the treated water at an agreed price to participating industries. Alternately, the industry could contract operation and management of tertiary treatment unit to an agency and pay them a fixed O&M fee.

2. Agriculture & Agroforestry

The business model has high application to treatment plants located at the peri-urban part of a town or city with agriculture in the vicinity or where sufficient land is available for afforestation or for treatment plants in rural areas. The business model is most promising where no alternative water sources are available for agriculture or agroforestry.

- **Agriculture reuse:** The institutional arrangement across the sanitation-agriculture interface is important with involvement of departments of agriculture or local universities, farmer groups or civil society organisations working with the farmers. The model requires a high level of participatory planning and trust building for the recipients of the treated water as well as their customers in its safety. Guidance should be provided to farmers on types of crops cultivated which are safe for consumption and have high demand or provide revenue that meets farmers' expectations. The reuse revenue to the treatment plant comes from sale of treated water to the farmers. The treatment plant operator can also sell treated sludge (biosolids) to farmers that can serve as a soil ameliorant.

Figure 7.4: Reuse PPP model – investment by end user



Source: Author

Case Study: The Greater Cairo Sewage Water Company (GCSWC)

The Greater Cairo Sewage Water Company (GCSWC), Egypt operates the El Berka wastewater treatment plant in the north-eastern part of Greater Cairo. Although the bulk of its wastewater is discharged back into the environment, about 5% of its secondary treated wastewater is used for irrigating lemon trees, cactus and trees for wood production, such as Khaya senegalensis, and, on pilot basis, industrial oilseeds including Jojoba and Jatropha. In addition, about 1,500 tenant farmers renting government land use approximately another 12% of the treated wastewater to irrigate about 1,000 hectares (ha) to support their livelihoods. This activity is informal and no fees are charged. The majority of the entity's revenue comes from household wastewater fees levied on around 1 million connected households, helping achieve a high cost recovery for the treatment of the wastewater. However, only about half of the households pay regularly resulting in USD 3.6 million revenues. The plant also raises revenue of about USD 0.6 million from selling one third of the generated sludge for composting and to the construction sector.

- **Agroforestry reuse:** The institutional partnership between treatment plant operator, implementing agency and the forest department is key in this model. The reuse revenue to the treatment plant is from sale of treated water to the forest department.

In both agriculture and agroforestry end uses, there should be assured commitment from the treatment plant operator on the quantity and quality of treated water supplied. For the conveyance of the treated water, financial contribution from treatment plant, implementing agency and end user of treated water can be explored.

3. Aquaculture

The business model is highly applicable for treatment plants with a pond-based system or where secondary treated used water is discharged to ponds or lakes. The model is applicable to both urban and rural treatment plants.

In the case of pond-based treatment system, aquaculture can be integrated in the treatment system and the treatment plant operator enters into a partnership with a private entity involved in sales and marketing of fish. In this case, the treated water can be released safely in the environment or reused for irrigation as per the agriculture reuse business model.

In the case where treated water is discharged to a pond or lake, the ULB can contract a private entity to undertake aquaculture and the revenue from this contract can be allocated for used water treatment works. In both scenarios, the institutional arrangement requires a partnership with the department of fisheries or research institution experienced in aquaculture to provide guidance and monitor any contaminant accumulation in the harvested fish.

4. **Inter-sectoral Water Exchange**

- **Inter Water Swap Model:**

  This business model addresses the increasing demand for urban water and to manage scarce urban water resource especially during severe periods of drought as an adaptation strategy. With the Jal Jeevan Mission providing drinking water through individual tap connections, this model will increasingly be applicable to rural areas. The model looks at reallocating freshwater from agriculture and/or industries (including construction) to urban or rural domestic use in exchange for treated water within the same basin, and it may help optimize water allocations with sector specific water quality requirements.

  The main contract is between the implementing agency and the irrigation department, farmers or farmers group that have access to water rights or with access to canal water in the case of end use in agriculture, or the industry association or relevant industry development board in the case of end use in industry. The model is complex in terms of engagement with multiple partners to get their buy-in and especially ensuring end users of treated water understand the underlying rationale. Water-swap model requires incentivizing end users of treated water to participate in the arrangement and release their surface-or groundwater for urban or rural domestic consumption. The model may require additional treatment infrastructure to address the water quality aspects as required by the end user. In addition, investments in water conveyance will be required. Contracts can be structured either for the entire year for urban and rural areas which face water scarcity and hence address freshwater supply deficit or it can be seasonal which can be invoked in times of severe drought. The additional freshwater gained through this arrangement can then be sold at a higher price to urban consumers and the obtained revenues can support cost recovery of treatment and conveyance treated water.

Case Study: Integrated Water Resources Management

This business case presents an example of integrated water resources management (IWRM) in support of a voluntary water exchange between local farmers and the Catalonian Water Agency (ACA) in the Llobregate River basin delta. The inter-sectoral water transfer builds on a flexible approach which allows negotiation between the parties involved to adapt to the intensity of seasonal drought and priority water needs. In this European Union co-funded project, the ACA treats urban wastewater to different, reuse defined levels. The main clients are farmers who are obliged to stop using surface water in times of drought. In exchange for accepting treated wastewater the city obtains the protected freshwater for aquifer recharge. This is in large a social responsibility business model, which allows on one hand (i) ACA to deliver on its water supply mandate also in times of extreme water shortage; and on the other hand (ii) gives farmers a reliable water supply to cope with drought or to go beyond (low revenue) rainfed farming; while (iii) the city gains in terms of drinking water, environmental health, aquifer protection and more resilient short food supply chains. From an economic perspective, the investment costs are marginal compared to the direct and indirect costs of a severe drought as experienced in 2007–2008. The case also realizes an often demanded paradigm shift where the degree of water treatment and allocation differ between types of reuse to optimize the overall returns on investment.

- **Rural-Urban Water Exchange through Managed Aquifer Recharge:**
  Treated used water can be reused for landscaping, parks, rejuvenation of wetlands, lakes and ponds to improve the bio-diversity within and around urban and rural centres. When reuse of treated water is for wetlands, lakes and ponds, the distance from the treatment plant to the location will require conveyance of the treated water. One option is for the conveyance to utilize unlined open irrigation channels. Natural filtration processes take place during conveyance in open channels and seepage into the soil leading to aquifer recharge. Over time, surface and ground water reservoirs around such a system will improve. This now becomes a source of renewed fresh water for the urban and rural area. It becomes the responsibility of the ULB to ensure appropriate management of this source of water which can be harnessed in drier periods.

5. On-site reuse of treated wastewater

An objective for a treatment plant along with public and environment outcomes relates to providing a visual appeal and to meet odour standards. Landscaping by lawns and trees should be a critical feature of any treatment plant. Treated water can be used to meet the water requirement for maintaining the landscape. Treated water can also be used onsite for cleaning of vacuum and suction trucks, cleaning of sewers and desludging of onsite sanitation systems.

In gated colonies, apartment complexes and institutions that are required to have treatment plants, treated water can be used for landscaping and for flushing toilet water by implementing dual plumbing systems. Where dual plumbing systems are incorporated, the planning norms for per capita use of water in the building can be divided into two parts, one to be delivered by freshwater and the other by treated water.

Case study: On-site reuse of treated wastewater

A residential apartment of 100 flats has succeeded in breaking a great psychological barrier: They have pioneered in using recycled water for drinking. Unlike other apartments where treated water is being used for non-potable purpose, this apartment has installed 11 filters to get clean water and has also won the confidence of the inmates by conducting a blind test. Just like any other apartment society in Bengaluru, TZED Apartment was facing a serious water shortage problem. The society was buying 10 tankers of water each day around three years back. Even after buying so much water, the apartment had to resort to water rationing to make sure there was sufficient water to use. The apartment shut water from 11 am to 4 pm, and from 1 am to 4 am. Desperate to get a solution for the problem, two residents decided to track the whole cycle of water that comes to their apartment. It is found out that the water their apartments got is from Varthur Lake. But the water from the Sewage Treatment Plant (STP) in their apartment also goes to the same lake. The duo then started working on a method through which they could create a closed loop system for the water flow within their society - basically, they wanted to create the same cycle within the society instead of allowing it to go to the lake and then receive the water from there. Earlier the RO plant was in place to purify the tanker water before consumption. Water from the STP was being used to water the gardens, wash cars etc. The treated water was then channelled through the RO plant along with 11 different kinds of filters to purify the water. Finally, the treated was fit to be used for drinking purposes." The total cost to the society to set up the project was Rs 2,50,000 which came to Rs 2,000 per family. However, the bigger challenge was now to convince the members that this is just as good as normal drinking water. The apartment saves on an average 4000 Rs per day during months of summer. raises revenue of about USD 0.6 million from selling one third of the generated sludge for composting and to the construction sector.

6. Corporate Social Responsibility (CSR) model

With the implementing agency constrained in financing of treatment infrastructure, they could approach the private sector to drive CSR models to fill the required gap. In water scarce regions, private sector CSR could invest in treatment infrastructure. Industries investing in-house treatment infrastructure for high quality treated water, may be encouraged to provide a portion of treated water for environmental purposes or to improve green spaces in the urban areas under their CSR programs.

In the reuse of treated water for agriculture, the implementing agency could engage private companies to train farmers on practices as part of CSR so as to ensure safety of harvested goods for end consumers. The implementing agency can engage with the CSR programmes of supermarket chains to buy back crops from farmers safely cultivating products using treated water. Wholesalers, traders or supermarkets can support this process through contracts with farmer cooperatives which allow them to secure a reliable crop supply while offering inputs, training or credit.

7.5 Challenges in up-scaling reuse

- **Public perception and awareness:** Although the policy does not encompass direct potable use of treated water, the discharge of treated water into natural water bodies ultimately sees a proportion of the used water re-enter the water cycle into water supply treatment and distribution systems, albeit in a diluted form. For some, it may still challenge cultural norms and raise questions about public safety. Similarly, treated water in certain agricultural, industrial and municipal settings may also raise concerns. Overcoming negative perceptions on treated water and encouraging support for circular economy solutions will require a program of consistent and targeted messaging to end users and the public through water communication programs of the central and State Governments.

- **Financing and viability:** Achieving treated water targets requires an alignment of interests and incentives amongst the key stakeholders, identifying areas of demand and supply, selecting the most appropriate business model where risks are shared equitably, and designing support programs that are efficient in time and resources.

- **Compliance with standards:** Significant efforts will be required to ensure prevailing standards are met thus reducing risks to public health and the environment. Treated water introduces an additional layer of processes for which compliance has to be assured. A range of approaches is needed including improving the financing and capacity of compliance institutions, introducing transparent self-monitoring systems into business models with sufficient checks and balances, and engaging stakeholders in the process. Food safety is of paramount importance for public health nationally and for export trade. Past international experience has demonstrated the economic impact of non-compliance with food safety standards in relation to foregone export potential. National norms for water safety planning and risk management will be key to expansion of sustainable treated water in India.

- **Integration and coordination:** Treated water is one step in the circular economy approach for water supply and sanitation. Other policy elements exist, such as for the recovery and reuse of faecal sludge from septic tanks under the FSSM Policy. Others are gaining attention including campaigns to promote recovery and reuse of sludge from STPs for use in power generation or agriculture. In the near future, it is expected that treated water will form part of a wider integrated waste recovery and reuse system. As demand for treated water escalates, competition amongst end-users may arise as in the case of freshwater, requiring an allocation system that prioritizes reuse according to locally relevant economic, social and environmental criteria.

- **Managing the transition:** The scale of the challenge to reach universal sewage treatment and high levels of safe reuse is considerable and will require states to develop and adopt a strategy and action plan that focuses both on realizing early gains where sources of supply and demand are aligned, in parallel with medium term programs to introduce an enabling regulatory and pricing environment that provides incentives for change. In managing the transition, safeguards are also required to consider pre-existing uses of used water (formal and informal) and ensure the needs of prior users are addressed.

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Quick Assessment

1. What are the advantages of recycling water?
   a. Treated water can be used for agriculture offsetting the need for surface and fresh water
   b. Treated water can offset industrial water requirement for fresh water
   c. Recycling water can generate revenue for treatment
   d. All of the above

2. What is the key point covered by National Urban Sanitation Policy 2008 with regards to reuse?
   a. Mandate the extent of reuse and recycling of sewage for gardens and parks in urban areas as 20%
   b. Emphasizes the reuse of treated sewage and sullage in commercial or residential multi-storeyed complexes for flushing of toilets, horticulture and fire-fighting purposes
   c. Recommends recycle and reuse of treated wastewater
   d. Regulate and control groundwater requirements

3. Which policy emphasized on recycling sewage and used water from municipal and industries sources before discharging to water bodies?
   a. National Urban Sanitation policy
   b. National Water Policy
   c. National Environment Policy

4. Treated water from onsite treatment can be reused for which of the following applications?
   a. Car washing
   b. Irrigating landscapes
   c. Flushing
   d. Drinking
   e. All of the above

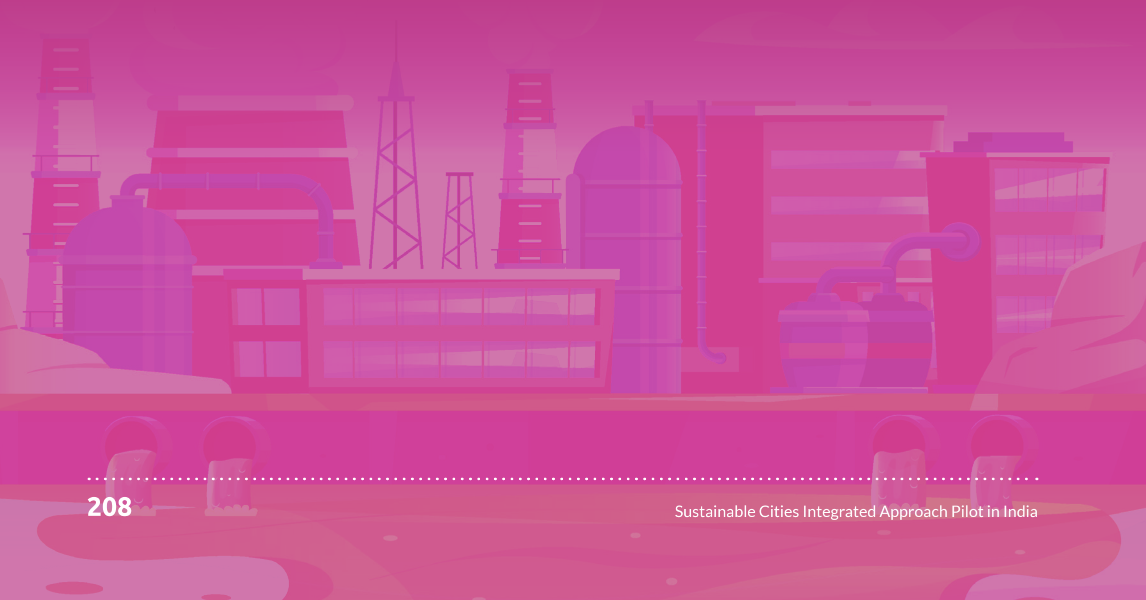
5. Which of the following is not regarded as a challenge to scale up reuse?
   a. Availability of treatment technologies
   b. Public perception
   c. Coordination with various stakeholders/departments
   d. Compliance with standards

* *For answers please refer Annexure I*

Chapter

8

Faecal Sludge & Septage Management



Recap

The previous chapter covers various aspects of urban wastewater treatment and management. The current chapter focuses on the faecal sludge and Septage management sector in India.

Training Objectives

- To understand the concept of faecal sludge and septage.
- To understand various parameters relevant for faecal sludge characterisation and methods of faecal sludge quantification.
- To understand the various treatment stages and acknowledge the treatment Units as per the Non-mechanised and Mechanized criteria.
- To overview the various approaches implemented in different Faecal Sludge Treatment Plants across the country.

Training Outcomes

- Acknowledge the difference between Faecal Sludge and Septage along with the stages and mechanisms of Faecal Sludge and Septage treatment.
- Understand Faecal Sludge characterization and quantification
- Understand different Non-Mechanized and Mechanized treatment units with their criteria for selection

Chapter Contents

8.1 Need for FSSM

A sanitation system deals with human excreta from the time it is generated until it is used or disposed of safely. While commendable success has been achieved through Swachh Bharat Mission in providing improved sanitation services to the people, providing a complete sanitation solution still poses serious question on achieving the end objectives of the mission.

It is well known that centralized sewerage systems with vast underground pipelines, pumping stations and huge treatment plants are capital intensive, involve complex engineering and require continuous power, large amount of water and extensive electro-mechanical maintenance with skilled operators. As a result, in many cities, sewerage networks extend only to the core area while the peripheral areas or the outgrowths still remain unserved, making households dependent on On-site Sanitation systems. As per Census 2011, only 32.7% of the 81.4% urban households having access to toilet facilities were connected to sewer systems, while 38.2% were dependent on septic tank or On-site sanitation systems (OSS). Although through Swachh Bharat Mission (SBM-U) toilet coverage has increased to 100% with the construction of about 61 lakh individual household toilets and 5.82lakh community/public toilets facilities, around 60 % of urban households are still dependent on On-site sanitation systems and the remaining 40% are serviced with the sewerage system (CPHEEO, 2020). As per the latest National Sample Survey (NSS) report (2019), percentages of households having septic tanks in urban areas is 48.9%. In terms of treatment of wastewater or Faecal Sludge, only 64% of the listed STPs in India are operational (as of 2015), while 10% are non-operational, 18% under construction and 8% are proposed on paper. The treatment capacity that is available is only for 37% of the total 62,000 MLD (million litres per day) of human waste that is generated in urban India (GoR, 2018).

Thus, considering the current scenario with many households still dependent on onsite sanitation systems, effective containment, conveyance, treatment along with reuse or responsible disposal of the treated product is essential to achieve a sustainable sanitation ecosystem and meet the objectives of the Swachh Bharat Mission.

On-site sanitation systems as discussed in the previous chapters requires proper containment, conveyance and treatment systems at place. Improper containment can lead to unsafe sanitation practices causing negative health outcomes. For example, improper construction of on-site containment units like septic tanks, can lead to frequent failures and leakages leading to soil and ground water contamination. Also, since the septic tanks are not constructed as per standard specifications, they tend to fill up quickly, requiring frequent emptying. However, due to high cost of desludging, many households only avail the septic tank cleaning services when the tank is overflowing or on the verge. The frequency of desludging therefore typically exceeds the prescribed interval of 2-3 years as recommended by CPHEEO (MoHUA, 2013). Constraints like physical access to households for desludging, availability of appropriate equipment and vehicles for desludging and trained and skilled labour for safely carrying out the cleaning services, are some of the other issues associated with emptying and cleaning the containment units.

Once the faecal sludge and septage is collected from the households, it should be taken to an FSTP or an STP for proper treatment before disposal if such STPs can take extra load of organic matters. In case of absence of proper disposal point, the septage is indiscriminately disposed-off in to the surface water bodies or on to the land. Since, the solid content in faecal sludge and septage is significantly high as compared to wastewater, indiscriminate disposal of it possesses a bigger health hazard compared to open defecation and environmental pollution. Thus, such practices should be completely stopped and dedicated measures should be taken to resolve these issues.

Table 8.1: Challenges in FSSM

Components of Services Value Chain	Challenges
User Interface	• Availability of the space to construct sanitation facilities • Affordability of the construction and operation cost • Non-availability or limited access of water and electricity • Less operation and maintenance of sanitation facilities • Quality of the material used for the construction of the sanitation facilities
Collection	• Access for the on-site systems, congested locations for the movement of the desludging trucks • No provisions for secondary effluent disposal units in the form of piped sewer network, leach pits or drain fields, thus directly discharging septic tank effluent into drains • Most of the septic tanks present are not constructed as per the standard specifications by the CPHEEO, leading to varying sizes, partial lining, frequent failures, leakages/ contamination of ground and surface water bodies or soil, etc.
Conveyance	• Most households only call for septic tank cleaning services when the tank is overflowing or on the verge. The frequency of desludging typically varies from 5-10 years due to irregular sizes and usage pattern, which far exceeds the prescribed interval of 2-3 years as recommended by CPHEEO (MoHUA, 2013) • Unsafe handling of faecal sludge by the private operators • Desludging operators and service providers are not properly trained and do not use safely equipment during operations.
Treatment	Requirement of Scientific Treatment Facilities
Disposal	Private operators practice the direct discharge of desludged faecal sludge/septage in the open drains, open land, SWM landfill sites etc.

Source- (NIUA, 2020)

8.2 Shifting Paradigm towards FSSM

While the efforts to expand the sewerage network in cities through the flagship missions like AMRUT, to achieve the vision of 100% sewerage universalization are ongoing, the Government of India recognized the gaps in sanitation coverage and the need to manage the faecal sludge and septage. In view of this, the Ministry of Housing and Urban Affairs (MoHUA) launched the National Policy on Faecal Sludge and Septage Management (FSSM) in February 2017 to facilitate nationwide implementation of FSSM in India.

Faecal Sludge and Septage Management is the process of safe collection, conveyance, treatment and disposal/ reuse of faecal sludge and septage from on-site sanitation systems such as pit latrines, septic tanks, etc., i.e. the management of the mixture of human waste (solid and liquid) that is not conveyed by a centralized sewerage system.[1]

Figure 8.1: Schematic Diagram of FSSM Operation

ACESS TO TOILET

Access to Hygienic Toilet to all houseolds

EMPTYING & TRANSPORT

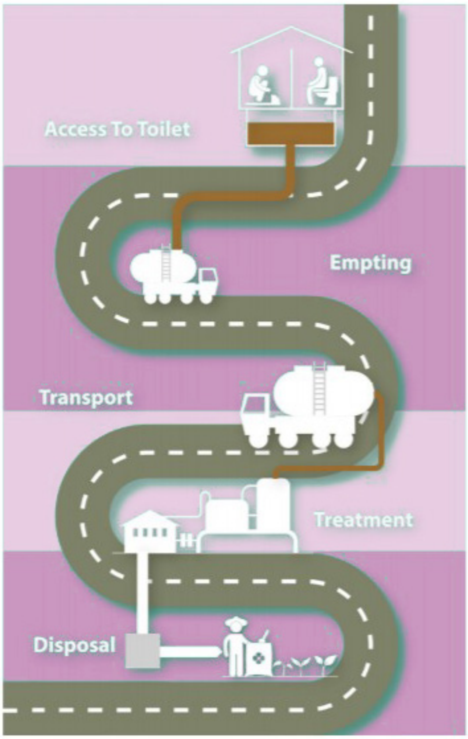
Desludging of septic tanks by suction machines and transportation to Treatment Plant

TREATMENT

Treatment at centralized or decentralized treatment plants

DISPOSAL/REUSE

Reuse of treated effluents for agricultural or other uses, or disposal at designated site



Source: (NIUA, 2020)

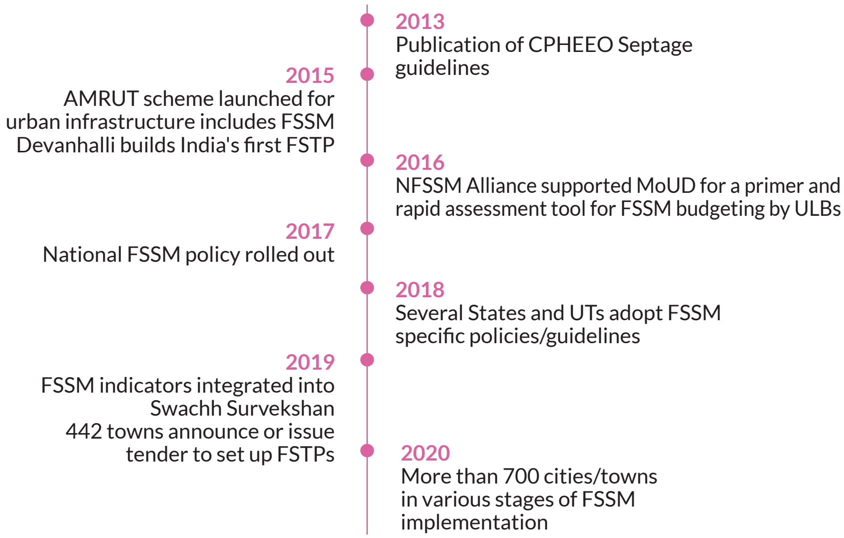
[1]*Government Of Rajasthan, 2018. Draft Policy Faecal Sludge & Septage Management (FSSM). Government of Rajasthan, P.15.*

The National Policy addresses the specific issues and challenges of FSSM and acts as a guiding document by setting the context, priorities and direction for states and cities to ensure proper implementation of FSSM in a holistic manner across urban India.

As per the FSSM policy, each state is expected to develop and issue an FSSM Implementation strategy and plan guideline. In accordance with state policy and plan, the guidelines should provide an overall state level framework, objectives, timelines and implementation plans to the ULBs.[2] Since the States have the responsibility of the implementation of this policy, and for the fact that a number of factors, constraints and opportunities with respect to sanitation, climate, physiographic factors, economic, social and political parameters, and institutional variables are peculiar to specific situation of states and cities, considerable flexibility is granted to states to develop their own models to further the cause of FSSM.[3]

The Government has continued to show its commitment towards FSSM through the launch of ODF+ and ODF++ protocols, an emphasis on FSSM in Swachh Survekshan, as well as financial allocations for FSSM across AMRUT and NMCG missions.

Figure 8.2: Timeline of FSSM adoption- India making rapid strides towards 100% safely managed sanitation



Source- (NITIAYOG, 2021)

[2] *Government of India Ministry of Urban Development, 2017. National Policy on Faecal Sludge and Septage Management (FSSM). Ministry of Urban Development, p.22*

[3] *Government of India Ministry of Urban Development, 2017. National Policy on Faecal Sludge and Septage Management (FSSM). Ministry of Urban Development, pp.4-5.*

Some of the other steps taken towards FSSM by the government through various regulatory frameworks are discussed in the following section.

Regulatory Framework

Some of the existing national and state level framework in terms of legislation, policy, programmes, standards, guidelines, etc. related to FSSM have been presented below in Table 8.2. To know more about the existing legislative framework with respect to wastewater management in India, refer to Chapter 2 Legislative and Policy Framework.

Table 8.2: Legislations, Policies and Standards governing FSSM in India

Legislations	Brief
The Employment of Manual Scavengers and Construction of Dry Latrines (prohibition) Act, 1993	Ban on dry latrines, i.e., latrines with no water-seal or flushing mechanism, and the employment of persons for manually carrying human excreta
Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013	It intends to empower "District level survey committee" & "State level survey committee" towards the complete abolition of manual scavenging without certain obligations. "Hazardous cleaning" in relation to sewers and septic tanks is banned and that manual cleaning of sewers and septic tanks, if necessary, may be carried out only in very controlled situations, with adequate safety precautions, and in accordance with specific rules and protocols for the purpose.
Municipal Solid Waste (MSW) Rules, 2016	Disposal and treatment of faecal sludge and septage, before or after processing, at landfills and for use as compost; and final and safe disposal of post-processed residual faecal sludge and septage to prevent contamination of ground water, surface water and ambient air.
Policies, Missions & Guidelines	**Brief**
National Urban Sanitation Policy, 2008	It intends to make all Indian cities and towns become totally sanitized, healthy and liveable and ensure and sustain good public health and environmental outcomes for all their citizens with a special focus on hygienic and affordable sanitation facilities for the urban poor and women.
National Mission on Sustainable Habitat (NMSH), 2010	National Mission on Sustainable Habitat (NMSH) is a component of the action plan for climate change that focus on waste recycling.
Guidelines for Swachh Bharat Mission (Urban), 2014	It intends to eliminate open defecation, eradication of manual scavenging and to effect behavioural change regarding healthy sanitation practices in urban areas.

Atal Mission for Rejuvenation and Urban Transformation	Improving basic services (water supply, sewerage & septage, urban transport) in cities through reforms in urban governance, augmentation of basic infrastructure and establishing a sound institutional framework for effective delivery, through an incremental approach.
Standards, Manuals & Advisories	**Brief**
National Building Code of India (NBC) 1983 & 2005	Code governs the design, installation and maintenance of toilets, septic tanks, and sewers. It gives an overview of size of drainage, sewerage including design of septic tanks, sewers, toilets, and other sanitation devices. The NBC also suggests that use of septic tanks without follow-up treatment is not permitted.
Indian Standard - 2470	Code of practice for installation of septic tanks.
Manual on Sewerage and Sewage Treatment, CPHEEO in collaboration with JICA, 2013	Guidelines for – design, planning and providing advice on the selection of technology options for urban sanitation (for on-site, off-site sanitation and both decentralized & centralized treatment options); operation and maintenance of sanitation systems & resource mobilization; management, administration, project delivery, etc.
Standards, Manuals & Advisories	**Brief**
Advisory on Septage Management in Indian Cities, MoUD, 2013	Outlines the contents and steps of developing a septage management sub-plan (SMP) as a part of the city sanitation plans (CSP) being prepared and implemented by cities which supplement the NUSP. Septage here refers not only faecal sludge from septic tanks but also from pit latrines and on-site toilets.
Primer on Faecal Sludge and Septage Management, MoUD, 2016	Supplementary document to the advisory on septage management in Indian cities, 2013. Stresses the need for state-wide operative guidelines, City level toolkits, operational manual, management/ financing/ operating FSSM, and FSSM plan for the city.
National Urban Faecal sludge management policy, MoUD, GoI, Feb 2017	The draft document mainly outlines need of FSM, awareness generation, national declaration, central laws and rules, and implementation approach.

Source- (GoR, 2018)

The States of Maharashtra, Odisha and Tamil Nadu have already released state level Septage Management policies to ensure proper FSSM in their respective cities. Table 8.3 showcases various existing State-level guidelines to provide good examples for other States to prepare their own set of guidelines.

Table 8.3: State level regulatory guidelines and frameworks for FSSM

State	FSSM Framework
Andhra Pradesh	• Faecal Sludge and Septage Management: Policy and Operative Guidelines for Urban Local Bodies in Andhra Pradesh • Andhra Pradesh Government Order 134, March 2017
Maharashtra	• Guidelines for Septage Management, 2016 • Government resolution to move beyond ODF to ODF+/++, 2017 • Maharashtra State FSSM Strategy • Government resolution on co-treatment of Faecal Sludge at STPs, 2018 • Government resolution on setting up independent FSTPs at scale, 2019
Odisha	• Odisha Urban Sanitation Strategy • Odisha Urban Sanitation Policy (2016) & ULB's regulation (2018)
Rajasthan	• Draft Policy on FSSM, 2017 • State FSSM guidelines for urban Rajasthan, 2018
Tamil Nadu	• Tamil Nadu Septage Management Operative Guidelines, 2014
Telangana	• The 2018 State Faecal Sludge and Septage Management (FSSM) Policy
Uttar Pradesh	• Guidelines for FSSM in Uttar Pradesh, 2018 • Draft State FSSM Policy, 2019

Source- (GoR, 2018)

Figure 8.3: Several states have rolled out FSSM programs at scale with only modest capital outlays due to cost-effective nature of FSSM

Co-treatment in existing STPs-69	Co-treatment in existing STPs-50	Co-treatment in existing STPs-2	Co-treatment in existing/Proposed STPs-28	Co-treatment in existing STPs in Hyderabad-(12 No.s)
Independent FSTPs (Co-located at SWM plant) 327 All towns covered	Independent FSTPs 59 Population covered 2.5Cr (75% urban pop; 600 towns)	Independent FSTPs 98 Cities covered All	Independent FSTPs 77 All towns covered	Independent FSTPs 71 (PPP-HAM) +70 (EPC) All towns covered
Total investment 45 Cr	Total investment 200 Cr	Total investment 298 Cr	Total investment 259 Cr	Total investment 250+ Cr

Source- (NITIAyog, 2021)

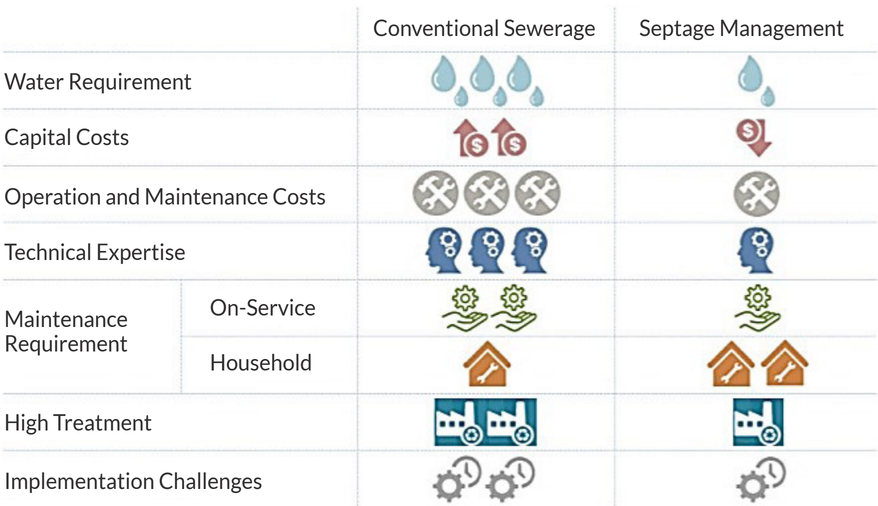
Apart from the regulatory push, coordinated action on behaviour change, through the Malasur campaign, has also been rolled out by the MoHUA and several States.[5]

Figure 8.4: Launch of Malasur Campaign

Source- (BBC, 2020)

Considering the fact that many households are still dependent on on-site sanitation systems, focusing on Faecal Sludge and Septage Management (FSSM) can help bridge the gap in achieving the target of providing complete sanitation solution to all. Besides resolving the sanitation issues of areas yet to be covered through sewer networks, FSSM has a lot of associated advantages as compared to conventional sewerage management. Figure 8.5 below tries to compare the conventional sewerage system with FSSM on various aspects.

Figure 8.5: Advantages of Septage Management over Conventional Sewerage System



While FSSM presents an opportunity to rapidly deliver safely managed sanitation to all, it should not be seen as a means to cover network or conventional sewerage system (including treatment plants) of wastewater/sewage management. Cities should come up with strategies that are a combination of on-site and off-site (decentralised and centralised) systems to meet the growing demands of the ever expanding urban centres. The Table 8.4 below tries to highlight various aspects where FSSM complements the existing sanitation infrastructure of any city.

Table 8.4: Sanitation Scenarios across the country and how FSSM can complement

Sanitation System In City/ Town	Applicability Of FSSM
Complete sewer coverage with adequate STP capacity	FSSM required only in growth areas
Partial sewer coverage with adequate STP capacity	FSSM to complement sewerage with co-treatment and FSTPs
No sewer coverage	FSSM with stand-alone or clustered FSTPs

Source: (NITI Aayog, 2021)

8.3 Understanding Faecal Sludge and Septage

Faecal sludge is referred to the sludge obtained from the containment unit such as a line pit (pit latrine) or any on-site sanitation system. It is generally fresh and yellowish in colour. This is due to the fact that the contents of the pits do not undergo digestion and the pits need to be frequently emptied. The water content of faecal sludge is relatively low as compared to other forms of sludge. As a result, it has higher solid content and corresponding BOD concentration than faecal sludge. It requires higher degree of treatment.

Septage is referred to the sludge obtained from the on-site containment units such as septic tanks or holding tanks. It is well digested and blackish in colour as it has undergone digestion over a period of time before being emptied. The water content of septage is higher than that of faecal sludge (sometimes as high as above 95%). As a result of this, it has lower solid content and corresponding BOD concentration. It requires less degree of treatment.

Figure 8.6:
Faecal Sludge being emptied at a FSTP

Figure 8.7:
Septage emptied at a FSTP

Source- (NIUA, 2019)

Characteristics of Faecal Sludge and Septage

Assessment of faecal sludge and septage treatment requirements must start from an understanding of the main sanitation options and the ways in which they influence subsequent links in the sanitation chain. It is important to understand that Faecal sludge and Septage characteristics differ widely according to location (from household to household and from city to city) in terms of consistency, quantity, and concentration. A basic distinction can usually be made between sludges, which are upon collection still relatively fresh or contain a fair amount of recently deposited excreta (e. g. sludges from frequently emptied, un-sewered public toilets) and sludges, which have been retained in on-plot pits or vaults for months or years and which have undergone biochemical degradation to a variable degree (e.g. sludge from septic tanks – septage). Moreover, varying amounts of water or wastewater, which have accumulated in vaults or pits, are collected alongside with the solids. The various factors affecting the characteristics of Faecal sludge are discussed as below:

- **Origin of the sludge-** The total solids concentration of Faecal Sludge is highly dependent on factors like dry versus flush toilet, volume of flush water used, cleansing method ('washers' versus 'wipers'), and inclusion or exclusion of grey water from bathing or cooking.

- **Type of containment unit-** The emptying frequency of septic tanks varies greatly by the type of the containment unit. If the containment units are not designed as per the specific standards, various underlying issues can lead to delayed emptying. For instance, the permeability of the containment systems is dependent on whether the containment systems are unlined, partially lined, completely lined, connected to drain fields or soak pits, and the quality of construction. If systems are permeable, the amount of inflow and infiltration of leachate into the environment from the system and / or ground water would be more, resulting in a thicker Faecal Sludge.

- **Duration for which the sludge is stored in the containment unit:** The storage duration of the Faecal sludge in the containment unit depends on the type of technology, quality of construction, toilet usage, and inflow and infiltration. The longer duration Faecal Sludge is stored in the on-site containment systems before being collected and transported, the more the characteristic of the Faecal sludge will change due to the digestion of organic matter. For instance, the Faecal sludge that has been stored in any containment unit for a period of years will have undergone more stabilisation than Faecal Sludge collected from the public toilets.

- **The Faecal Sludge collection method:** when the containments units are not cleaned frequently, the faecal sludge at the bottom of the containment systems becomes thick and needs to be either manually emptied with shovels or flushed with water to decrease the viscosity and enable pumping. The faecal sludge that has been removed by pumping is generally more dilute and less viscous than faecal sludge that is manually collected, thereby impacting the sludge characteristics.

- **Climate:** Climate hugely impacts the faecal sludge characteristics. Since the biological degradations are highly dependent on variations in temperature and moisture, variations in the same can hugely influence the Faecal sludge characteristics.

Sewage which is usually collected and conveyed using sewerage system reaches the treatment facility in few hours from the point of generation. The quantum of water used for flushing the waste and the turbulent flow in the pipes and pumping stations, makes sewage a homogenous mixture by the time it reaches the treatment facility. Hence, the characteristics of faecal sludge and septage varies significantly from sewage and require a higher degree of treatment. The following Table 8.5 gives an overview of the characteristics of faecal sludge, septage and sewage.

Table 8.5: Overview of the characteristics of Faecal Sludge, Septage and Sewage

Parameters	Faecal Sludge	Septage	Sewage
Characteristic	Highly concentrated, Fresh excreta, Stored for weeks or months	Low concentration, more stabilized, Stored for several years	Tropical sewage
COD [mg/L]	upto 50,000	< 10,000	500 - 2,500
COD:BOD Ratio	2 – 5	5 – 10	2
NH4 – 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: (NIUA, 2021)

8.4 Treatment of Faecal Sludge and Septage (FSS)

Before choosing the appropriate treatment mechanism for faecal sludge and septage, one must understand the various aspects associated with the treatment process. The following sections shall discuss various such aspects, that should be considered before choosing appropriate treatment mechanism.

Treatment Objectives

The specific objectives of faecal sludge and septage treatment are briefly discussed as below:

1. **Dewatering or thickening of FSS** to reduce the water content of the sludge, making it easier to treat separately. Separating the solids and liquid stream simplifies the treatment of the faecal sludge and septage and helps to optimise the process. FS has different dewatering characteristics compared to septage and wastewater sludge. Faecal sludge tends to foam upon agitation, and resist settling and dewatering mostly due to bound water. The duration of on-site storage, and the age of sludge also affects the ability to dewater the sludge. Empirical evidence shows that 'fresh' or 'raw' sludge is more difficult to dewater than older, more stabilised sludge. The dewatering, or thickening process can also include adding dry materials such as sawdust to increase the solids content, this is a common practice in processes such as composting where the sawdust also increases the carbon to nitrogen (C:N) ratio. The liquid stream that is produced during dewatering also requires further treatment, as it can be high in ammonia, salts, and pathogen.

2. **Stabilisation of organic matter and nutrients** to reduce the oxygen demand and suspended solids of the liquid fraction that is discharged to the environment to the point at which discharging it to watercourses will not deplete oxygen levels. Untreated FSS has a high oxygen demand due to the presence of readily degradable organic matter that consumes significant amounts of oxygen during aerobic respiration. If FSS is discharged to the environment, it can result in depletion of oxygen in surface waters. The process of stabilisation results in FSS containing organic, carbon-based molecules that are not readily degradable compounds, and which consists of more stable, complex molecules (e.g. cellulose and lignin). Stabilisation is achieved through the biodegradation of the more readily degradable molecules, resulting in FSS with a lower oxygen demand. Common indicators of stabilisation include measurement of Volatile Suspended Solids (VSS), BOD, and COD. In addition, stabilisation ensures that organic forms of nutrients present in treatment end-products are stable, and can be more predictably and reliably used. Stabilisation also reduces foaming of FSS, leading to better dewatering.

3. **Pathogen reduction** from the liquid effluent and solids so as to allow safe disposal or end use FSS contains large amounts of microorganisms, mainly originating from the faeces. These microorganisms can be pathogenic, and exposure to untreated FSS constitutes a significant health risk to humans, either through direct contact, or through indirect exposure. Hence, pathogen removal is important from the discharge and reuse point of view of the end products. Reduction of pathogen is achieved by various ways such as – starvation, predation, exclusions, desiccation, exposing to high temperature.

4. **Nutrient recovery from** FSS is very important if we intend to have beneficial resource recovery in terms of plant's macro and micro nutrients. If managed and treated properly, these nutrients 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. Environmental impacts from nutrients include eutrophication and algal blooms in surface waters and contamination of drinking water.

Faecal Sludge Quantification

Quantification and characterization of Faecal Sludge is an important aspect when required to meet the treatment objectives. As discussed in the earlier section, the quantity and characteristics of faecal sludge collected is dependent on various factors that vary hugely within cities, and within the same type of containment technology in different locations. In such scenario, determining the exact quantity and characteristic of Faecal Sludge generated is very difficult. While the factors impacting the characteristic of the Faecal sludge collected have been discussed in the previous section, the following section explains the various methods that can be adopted to estimate the quantity of the Faecal sludge generated.

Quantification of faecal sludge

Accurate estimate for the volume of the Faecal sludge produced is important to derive the proper sizing of the infrastructure required for collection and transport networks, discharge sites, treatment plants, and end use or disposal options. Two approaches can be adopted for estimating the volume of the Faecal Sludge Produced:

- Sludge Production Method
- Sludge Collection Method

The approaches can be chosen based on the fact that whether the objective is to determine the total sludge produced or the expected sludge received at the treatment plant. However, irrespective of the method of quantification chosen, many assumptions still have to be made due to lack of available information.

Sludge Production method

Sludge production method is useful in case of scheduled desludging and starts at the household level with an estimate of excreta production (i.e. faeces and urine), the volume of water used for cleansing and flushing and in the kitchen, and accumulation rates based on the type of on-site containment technology. This method takes into account the number of people and the standard sludge production rate. This is similar to estimating the wastewater production where 80% of the water utilized by the person is taken as quantity of wastewater produced. According to the IS 2470 Code of practice for Installation of Septic Tanks (part 1: Design criteri d construction) 1985, volume of digested sludge in the septic tank is given as 0.00021 m3/cap/d. The US EPA handbook on Technology Transfer for Septage Treatment and Disposal mentions the average per capita septage generation as 230 L/cap/annum (EPA, 2008). It has also been mentioned that his number is highly variable and will change depending on a number of factors discussed in the next session.

While a lot of data is required to obtain a good estimate of Faecal sludge production, collection of these data can be very challenging. For instance, there is no official record of how many, or what type, of on-site sanitation systems exist on a city-level scale. Also, while the ultimate goal is for all FS to be delivered to a treatment plant, it is not realistic to assume that all of the FS produced will initially be collected and transported for discharge at a FSTP.[4] Thus, to avoid overestimating the quantity of FS to be delivered to treatment plants, one must take into account that all vacuum trucks do not always empty the contents of the entire sanitation containment system.

Sludge collection method

The sludge collection method needs to be adopted for quantification of FSS in case of demand desludging. In most of the cases of Indian cities, not all the waste which is generated at the household level is usually collected, be it solid of liquid. Hence, sludge collection method is much more reliable estimate of quantification of FSS in a city. In this method structured interviews need to be conducted with important stakeholders such as desludging operators, ULB official such as sanitary inspectors and households. Depending upon the responses and statistical analysis of the data collected, inferences are drawn to arrive at the quantity of FSS to be managed in a city. Estimates can be based on the number of collections made each day, the volume of FS per collection, the average emptying frequency at the household level, and the estimated proportion of the population that employ the services of collection and transport companies (Koanda, 2006). In this method, to avoid under estimating the quantity of the Faecal Sludge produced, activity of informal or illegal collection should also be taken into account, as the volumes collected can be quite significant.

Criteria and considerations for quantification

Seasonal and monthly variations need to be taken into account while quantification. Especially in cities which experience inflow of floating population (due to pilgrimage or tourism) on an annual basis needs to take into consideration the variation and peaking factor. Peaking factor is necessary to calculate the peak load which the treatment facility might have to handle in a month. The peaking factor in case of FSS can range from 1.5 to 4. (NIUA, 2021)

Approaches of FSSM

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:

1. **Deep Row Entrenchment:** It refers to the method where FSS is fed to an excavated pit. Once the pit is fed with FSS, 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

[4] *Lopez-Vazquez, C., Dangol, B., Hooijmans, C. and Brdjanovic, D., 2014. Co-treatment of Faecal Sludge in Municipal Wastewater Treatment Plants. In: L. Strande, M. Ronteltap and D. Brdjanovic, ed., Faecal Sludge Management- Systems Approach for Implementation and Operation. [online] IWA Publishing. Available at: <https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/EWM/Book/FSM_Book_LowRes.pdf>*

the solids can be stabilized over a period of time. 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 of 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. Selection of appropriate site for practicing DRE is the most important stage. DRE should not be practiced in low lying areas and region where ground water table is high.

2. **Co-treatment at STP:** 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
    - At the manhole chamber before the inlet of STP
    - At the inlet of screens of the STP
    - At the sludge management process of the STP

    Co-treatment with STP should be done when such STP can take extra load of organic matters without affecting its performance.

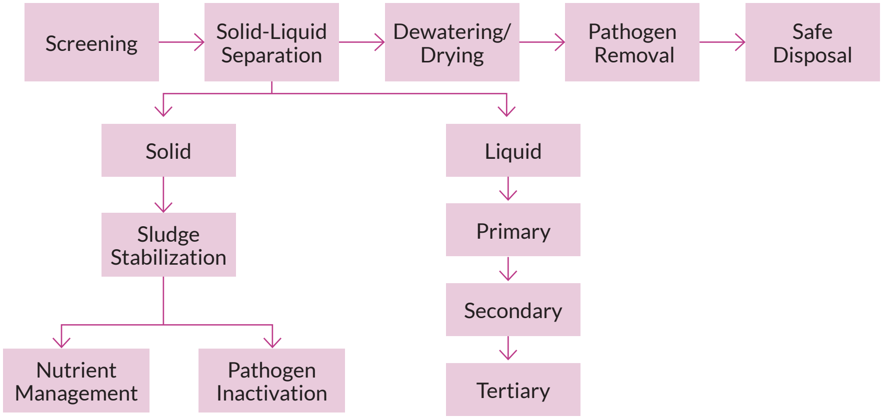
3. **Co-treatment in MSW management facility-** There are two different approaches in co-treatment at MSW plant:
    - **Composting-** In case of co composting, the dewatered solids with a solid content of up to 40% can be mixed with carbon rich organic waste. The dewatered sludge helps to achieve the C:N ratio which is required for optimum composting of the waste. In ideal conditions, the temperature during composting reaches above 60˚C for couple of days, which also results into reduction of pathogen, making the compost safe and hygienic for reuse in agriculture.
    - **Combustion-** The dry solids content should be at least 80% and preferably higher. This ensures that there is little energy consumption for evaporation of the moisture from the solids. Thus, it helps to maintain the temperature of the reactor at a constant level. The precise requirements of dry solid content will depend on the process used to burn the sludge.
4. **Faecal sludge and Septage treatment plant (FSTP)- The treatment stages in an FSTP are discussed in the following sections.**

8.5 Treatment Stages And Mechanisms

Treatment Stages

There are multiple stages of FSS treatment and each stage has a specific treatment objective. Treatment for faecal sludge can be broadly classified in the following stages:

Figure 8.6: Faecal Sludge and Septage Treatment Stages



Source: Author

1. **Screening:** removal of solid waste, trash and grit from the incoming faecal sludge
2. **Solid-liquid separation/dewatering:** the faecal sludge into solid and liquid streams
3. **Solid and Effluent (Liquid) treatment:** treatment to meet the discharge or re-use standards
4. **Dewatering/Drying:** removal of moisture content of the sludge

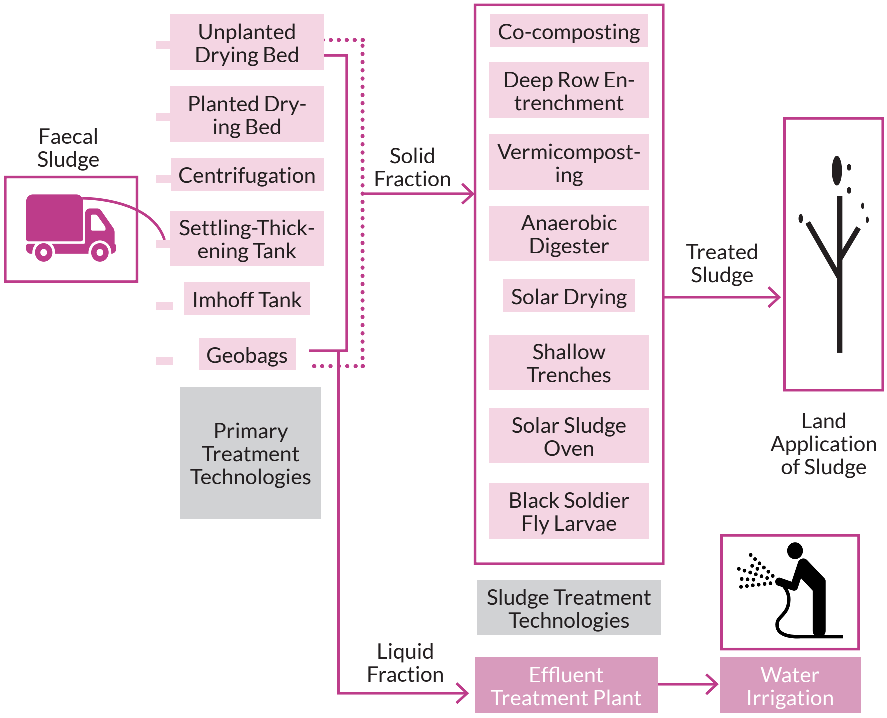
An FSTP must have technologies catering to functions in each of these stages. Different combinations of these modules are possible and are welcomed. Newer technical approaches may be added to these specifications once demonstrated to be effective and feasible.

Table 8.6: Faecal Sludge Treatment Options

<table>
<tr><th>Solid/Liquid Separation</th><th>Dewatering</th><th>Stabilisation/Further Treatment</th><th>End Product/ End Use</th></tr>
<tr><td>Imhoff Tanks</td><td>Mechanical Dewatering</td><td>Co-Composting</td><td>Soil Conditioner</td></tr>
<tr><td>Settling/ Thickening Tanks</td><td>Unplanted Drying beds</td><td>Deep row entrenchment</td><td>Irrigation</td></tr>
<tr><td></td><td></td><td>Lime/ Ammonia addition</td><td></td></tr>
<tr><td></td><td></td><td>Sludge incineration/ Pyrolysis</td><td>Building Material</td></tr>
<tr><td></td><td></td><td>Anaerobic Digestion</td><td>Biofuel</td></tr>
<tr><td></td><td></td><td>Black Soldier Flies/ Vermicomposting</td><td>Proteins</td></tr>
<tr><td></td><td></td><td>Co-treatment with wastewater upto 3% FS of current STP Load</td><td></td></tr>
<tr><td></td><td colspan="2">Thermal Drying</td><td></td></tr>
<tr><td></td><td colspan="2">Solar Drying</td><td></td></tr>
<tr><td></td><td colspan="2">Planted Drying beds</td><td></td></tr>
</table>

Source: (MoHUA)

Figure 8.7: Overview of technology options for faecal sludge treatment



Source- (Singh, et al., 2016)

Treatment Mechanisms

To achieve the treatment objectives as discussed in the earlier section, various mechanisms can be adopted across these stages. These can be physical mechanisms, biological mechanisms and chemical mechanisms.

1. **Physical Mechanisms:** Physical mechanisms are usually used in faecal sludge and septage treatment for reducing the water content of it. Water is present in faecal sludge and septage in mainly two forms- bulk(free) and bound form. Understanding the difference between the two forms helps in choosing the right treatment mechanism. Bulk water is the majority of water in untreated sludge and is fairly easy to remove compared to the bound water using dewatering technologies such as settling or filtration. Bound water includes interstitial, surface, and intracellular forms of bound water. (Interstitial water also referred to as capillary water is in pore spaces, but bound to solids through capillary forces. Surface water also referred to as colloidal water is bound to solids and micro-organisms by adsorption and adhesion. Intracellular water is contained within micro-organisms, and is only removed by treatment mechanisms that result in the lysing of

cells, thus releasing the liquid)[5]. Bound water is therefore difficult to remove than bulk water and requires the addition of chemicals or the use of centrifugation, pressure or evaporation.

The various treatment processes under physical mechanism include:

- Gravity separation
- Filtration
- Evaporation and evapotranspiration
- Centrifugation
- Belt filter,
- Frame filter press,
- Screw press
- Heat drying
- Screening

2. **Biological mechanisms** can be used for stabilization of organic matter and nutrients to reduce the oxygen demand, produce stable and predictable characteristics, reduce odours, and allow for easy storage and manipulation. Biological mechanisms can be either aerobic, anaerobic or anoxic. The various treatment processes under biological mechanism include:
    - Metabolism
    - Temperature
    - Types of microorganisms
    - Aerobic treatment
    - Composting
    - Anaerobic treatment
    - Nitrogen cycling
    - Pathogen reduction

3. **Chemical mechanisms** refer to use chemicals to either enhance the performance of physical mechanisms, to inactivate the pathogens or to stabilise the faecal sludge. The objective of chemical mechanisms is to partially digest the sludge and reduce the pathogens. Chemical mechanisms can also be used to condition the sludge for mechanical dewatering. Since chemicals used in liquid treatments are quite expensive, a proper cost benefit analysis is required before resorting to the use of chemical mechanisms. The various treatment processes under chemical mechanism include:
    - Alkaline stabilisation
    - Ammonia treatment

[5] *Strande, L.; Ronteltap, M.; Brdjanovic, D. (2014): Faecal Sludge Management (FSM): Systems Approach for Implementation and Operation. London: IWA Publishing*

- Coagulation and flocculation
- Conditioning
- Disinfection of liquid effluents

Treatment Units

Treatment Units – Non-Mechanised

Physical Mechanisms

Screening

Screening of faecal sludge and septage is necessary to arrest the solid waste which might be disposed-off in the toilet. Solid waste such as sanitary pads, diapers, condoms and plastic bags are commonly found waste in septage. It is important to remove this waste from the sludge as it may clog the pipes or pumps or disrupt the treatment processes. The velocity of the faecal sludge – septage should be between 0.3 m/s and 1.0 m/s. The velocity of 0.3 m/s ensures self-cleansing velocity in the channel leading to the screens whereas the velocity of 1.0 m/s ensures that the solid waste is not pulled through the bars due to the strength of flow. Usually coarse screens are usually used for screening, however, second fine screen can be used in certain cases where deemed necessary.

Figure 8.8: Bar screen at Niayes faecal sludge treatment plant, Dakar, Senegal

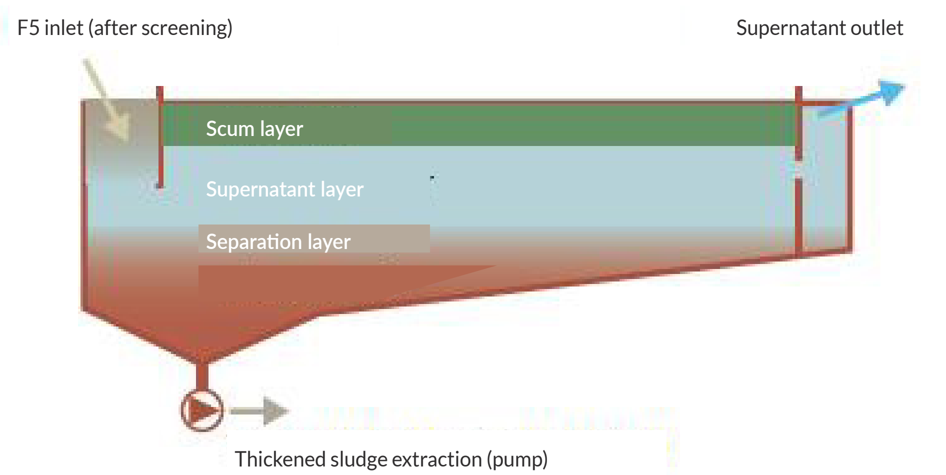
Source- (Bassan, et al., 2014)

Gravity Separation- Settling thickening tanks

Gravity separation is based on the fact that solids in the faecal sludge and septage have different specific gravity when compared to water. Oil grease fats also gets separated because they have less specific gravity as compared to water. Hence when the water is retained, gravity separation occurs naturally.

Settling thickening tank are sedimentation tanks which are designed based on the settling velocities of the suspended particles in the FSS. The difference in the specific gravity aids the settling process. The FOG has lower specific gravity as compared to the water and hence, floats on the top of the tank. The solids which settle down in the tank and further compressed and thickened by the hydrostatic pressure from the water above. The HRT of the settling thickening tank is in hours, however, sludge retention time (SRT) can be ranging from 10-30 days. The properly designed and well operated settling thickening tank thicken the FSS of solid content as low as 0.5% to up to 12%.

Figure 8.9: Schematic diagram of a settling thickening tank



Source- (NIUA, 2021)

In settling-thickening tanks the suspended solid (SS) particles that are heavier than water settle out in the bottom of the tank through gravitational sedimentation. The types of settling that occur are:

- discrete, where particles settle independently of each other;
- flocculant, where accelerated settling due to aggregation occurs; and
- hindered, where settling is reduced due to the high concentration of particles

Discrete and flocculant settling happen rapidly in the tank. Hindered settling occurs above the layer of sludge that accumulates at the bottom of the tank, where the suspended solids concentration is higher. These combined processes result in a reduction of the solids concentration in the supernatant, and an accumulation of solids at the bottom of the tank. Particles with a greater density settle faster than particles with lower densities. Based on the fundamentals of settling the distribution of types and shapes of particles in FS (and their respective settling velocities) could theoretically be used to design settling-thickening tanks. Although this theory is important in understanding the design of settling-thickening tanks, the reality is that when designing a settling tank, empirical values are determined and used for the design based on the characteristics of the FSS in specific conditions.

Geotubes

Geotubes are long, relatively narrow, flexible bags fabricated from high-strength permeable textiles. The only opening in a 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. The geotubes are available in a variety of sizes and geotubes must be removed and replaced when they are full. This suggests that the permeable geotube option has an operational cost, which reduces its little viability as a dewatering option.

Figure 8.10: Use of Geotubes for Solid Liquid Separation

Source- (NIUA, 2020)

Filtration

It is a process based upon the physical size of the solids when compared to that pores in the filter media. Physical exclusion can be achieved using different filtration media such as membrane (geotubes) or granular (sludge drying beds). Filtration can be classified as slow, rapid and pressurized depending upon the environment in which filtration is achieved. Usually in case of faecal sludge and septage, slow filtration is used since, in the other two types of filtration processes, there are high chances of clogging when used for septage. The most common types of filtration types used for Faecal sludge and septage are unplanted and planted drying beds. These processes use filter media to trap solids on the surface of the filter bed, while the liquid percolates through the filter bed and is collected in a drain, or evaporates from the solids[6].

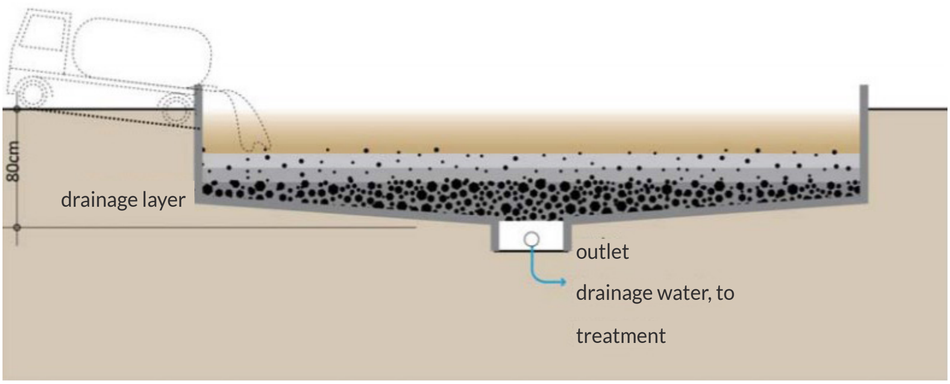
[6] *Strande, L.; Ronteltap, M.; Brdjanovic, D. (2014): Faecal Sludge Management (FSM): Systems Approach for Implementation and Operation. London: IWA Publishing*

Unplanted drying beds

Unplanted sludge drying beds are constructed in multiple number (usually between 8-12 beds) and are operated over a period of weeks before the dried solids are taken out from the bed. The sludge loading and drying cycle depends on the TSS content of the sludge and local climatic conditions such as temperature, humidity and air flow.

Most design guidelines for sludge drying beds specify the allowable solids loading on the bed in kilograms of total solids per square metre per year (kg TS/m2 year). A solid loading rate of 120–150 kg dry solids/m2 year for primary sewage-works sludge and 90–120 kg dry solids/m2 year for sludge from humus tanks is recommended. These figures are intended for use in temperate climates. Referring to conditions in tropical countries, solid loading rates typically vary between 100 and 200 kg TS/m^2 year. In practice, various researchers have reported loading rates higher than 200 kg TS/m^2 year.

Figure 8.11: Schematic diagram of unplanted drying bed



Source- (NIUA, 2017)

The height of solids on the surface of the beds should not be greater than 300 mm. As this slows the drying process significantly and inadequately dried sludge also does not ensure removal of pathogens by desiccation process.

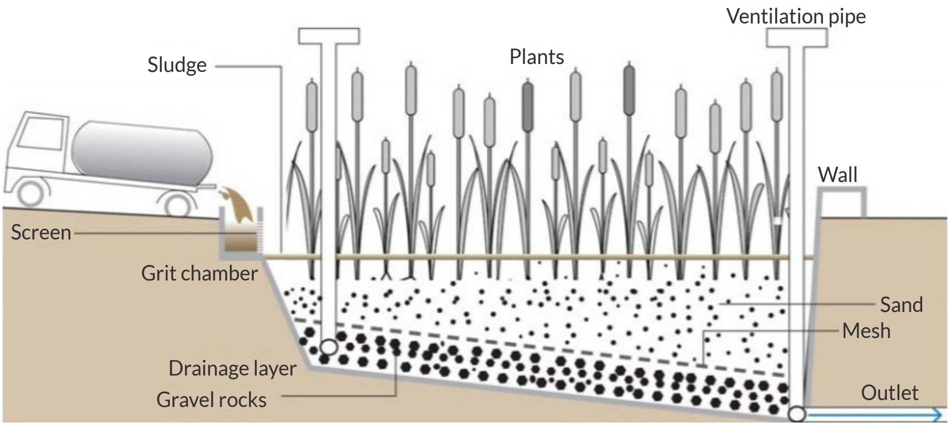
Planted drying beds

The treatment of sludge in PDBs is achieved through a combination of physical and biochemical processes. In wet, rainy climates, macrophytes play an essential role in almost all processes, and are responsible for the higher levels of treatment in terms of stabilization and pathogen removal in PDBs compared to unplanted drying beds. Macrophytes therefore play an essential role in the following:

- Stabilizing the beds to prevent media erosion and clogging, and improving the drainage;
- Increasing moisture removal rate (through evapotranspiration, in contrast to only evaporation in unplanted drying beds);

- Providing a surface area for microbial growth within the sludge layer;
- Transferring oxygen to the sludge layer (i.e. within the rhizosphere); and
- Absorbing heavy metals and nutrients.

Figure 8.12: Schematic diagram of planted drying bed



Source- (NIUA, 2017)

However, while PDBs, and their ability to wick away moisture via transpiration, make them an applicable technology in humid or rainy climates, the macrophytes of a PDB could wilt and die off in a climate that is too hot and dry, especially if the sludge does not provide sufficient moisture. However, if the PDB can be operated to induce 'ponding', i.e. keeping a certain amount of water in the beds by turning off the drainage outlet valve of the ponds or by adjusting the level of the outlet valve, then PDBs can be operated efficiently, even in a very dry climate.

Commonly used macrophytes in India:

1. **Canna Indica**

   Canna Indica, also known as Vaijanti, is a perennial flowering plant growing to between 0.5 m and 2.5 m. depending on its variety. It forms branched rhizomes up to 60 cm long that are divided into bulbous segments. It is effective for the removal of high organic load, colour and organic compounds.

2. **Typha angustifolia**

   Typha angustifolia, also known as its Indian name, Reed Mace, Elephant grass, Lesser Cattail or its Hindi name, Patera. This plant is a perennial suitable for trearing organic matters through providing media for bacterial growth and aeration for biodegration of organic materails.

Figure 8.13: Typha angustifolia

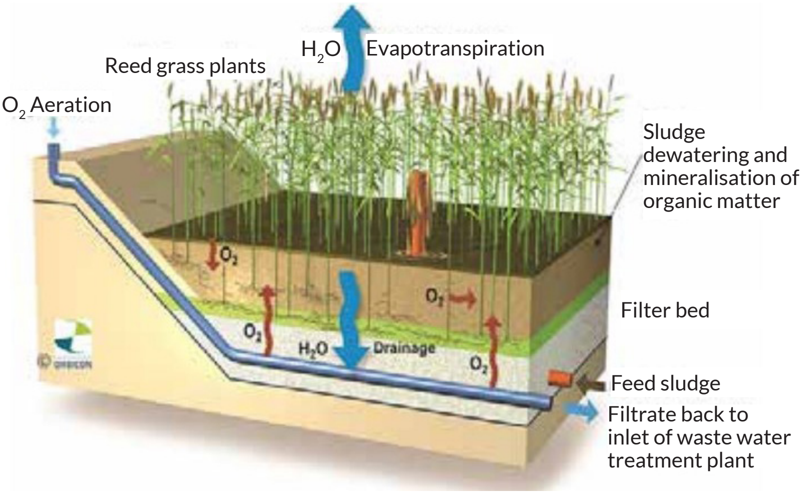
Figure 8.14: Canna indica

Source: (NIUA, 2017)

Evaporation and Evapotranspiration

Evaporation and Evapotranspiration is used for reducing the bound water of the sludge. In case of unplanted drying beds and geo tubes, evaporation is achieved by exposing the solids to sunlight or by forced evaporation using solar drying houses. In case of planted drying beds, the same is achieved using evapotranspiration. Planted drying bed also stabilize the sludge to some extent when designed and operated properly. The rate of evaporation and evapotranspiration is largely dependent on climate, heat, moisture content and wind speed at the treatment facility.

Figure 8.15: Schematic Diagram of Planted Drying Bed



Source- (NIUA, 2020)

Heat Drying

Heat drying refers to application of heat to reduce the water content of the sludge. Usually heat application is done after dewatering i.e. after freeing the sludge from bulk water. Heat drying achieves significant volume as well weight of the sludge. Heat application can be done using conduction, convection, radiation of combination of these processes. The quantity of heat that needs to be applied depends on the specific heat capacity of the sludge or in simple words the water content of the sludge. Specific heat capacity is measured in kJ/kg/oC. Specific Heat Capacity of Water at 250C is 4.18 kJ/kg/ºC. For wastewater sludge it is reported to be 1.95 kJ/kg/ºC.

Biological Mechanisms

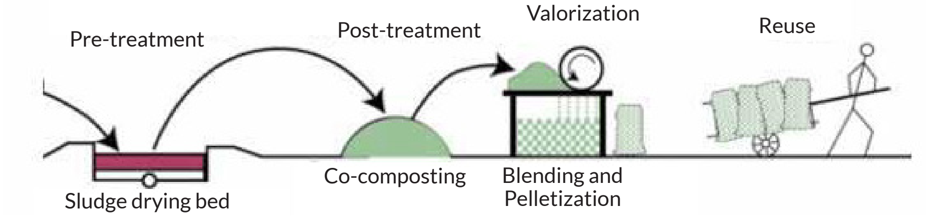
Aerobic treatment

Aerobic treatment consists of aerobic degradation of organic solids. Aerobic digestion of the solids needs supply of external oxygen and since solubility of oxygen in FS is low, hence aeration can be energy intensive. Aerobic digestion of the organic solids is usually used in wastewater treatment and is not recommended for stabilisation of faecal sludge and septage. Aerobic treatment processes in wastewater treatment are activated sludge, sequencing batch reactors, trickling filters etc.

Co-composting:

Composting is a biological process that involves microorganisms that decompose organic matter under controlled predominantly aerobic conditions. The resulting end product is stabilised organic matter that can be used as a soil conditioner. It also contains nutrients which can have a benefit as a long-term organic fertiliser. There are two types of composting systems, open and closed, of which open systems are lower in capital and operating costs but typically require more space. In an open composting system, raw organic matter is piled up into heaps (called windrows) and left for aerobic decomposition. To increase space efficiency, the heaps of waste can also put into walled enclosures which is called box composting. If untreated waste feedstock is placed in a closed container this is called in-vessel or closed drum composting and is considered in the category of closed systems.

Figure 8.16: Co-composting of dewatered faecal sludge and septage with organic waste



Source: (NIUA, 2020)

In a properly operated composting heap, the temperature rises rapidly to 60-70°C as heat is released when carbon bonds are broken down in an exothermic process. Pathogen die-off is highest during this time of high temperature. After approximately 30 days, the temperature drops down to 50°C. During the maturation phase the temperature is around 40°C, and the process ends once ambient temperature is reached. The whole composting process (including maturation) takes a minimum of six to eight weeks.

Anaerobic treatment

It refers to anaerobic digestion of organic solids. Anaerobic digestion happens in three stages. Anaerobic digestion is of different types such as –

- Psychrophilic
- Mesophilic and
- Thermophilic.

Mesophilic anaerobic digestion is appropriate for Indian context as it demands operating temperature of 20 0C – 40 0C with SRT of 20-30 days.

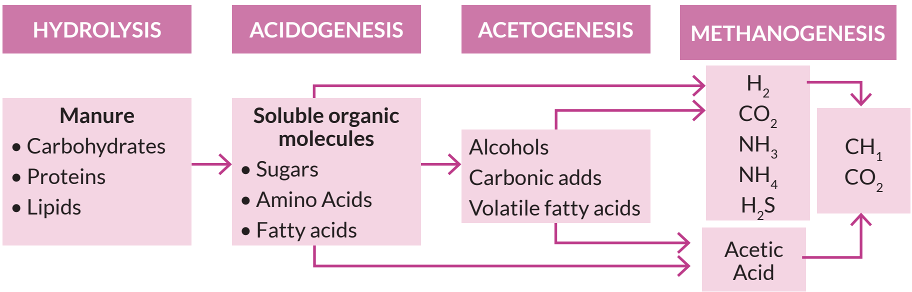
Anaerobic digestion takes place in four stages and a state of balance needs to be maintained in this process. The four stages of anaerobic digestion are –

Hydrolysis of slowly biodegradable contents such has fats, cellulose and proteins,

- Acidogenesis,
- Acetogenesis and
- Methanogenesis

The first stage is called hydrolysis where complex organic material breaks down into soluble compounds. These compounds are then converted into different types of acids by two processes called acidogenesis and acetogenesis. Further in the fourth stage the acids are transformed into stable compounds such as methane, carbon dioxide and water by a process called methanogenesis. Anaerobic digestion is recommended in sludge stabilisation as it is more economical as compared to aerobic digestion.

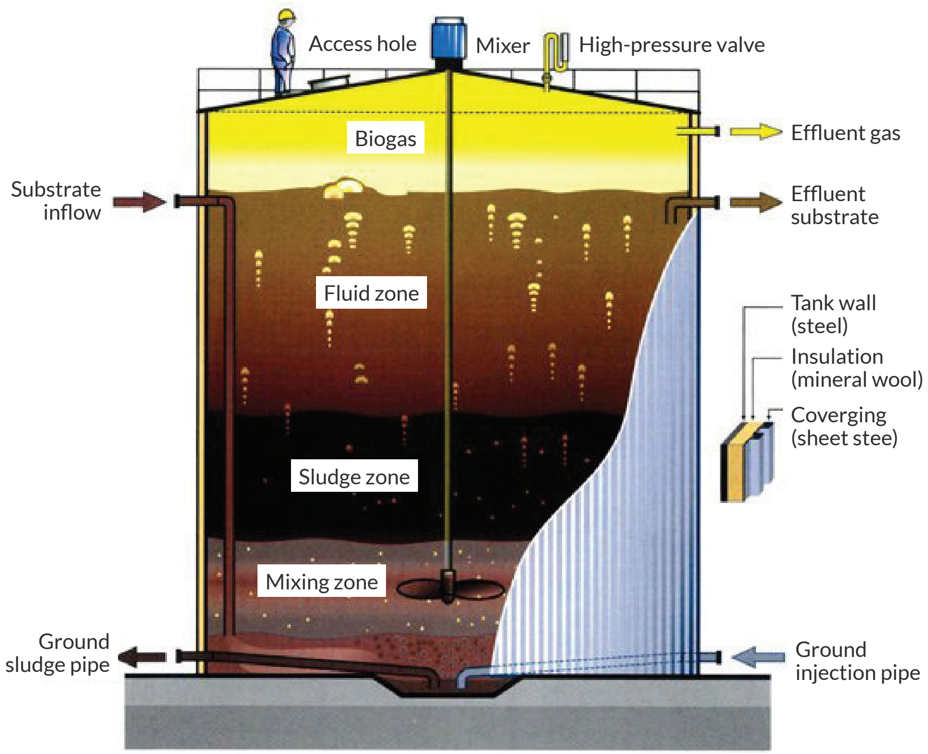
Figure 8.17: Stages of Anaerobic Digestion



Source: (Nour & Nour, 2017)

The second and third stage results into organic acids which lowers the pH of the reactor, however the fourth stage is sensitive to pH and slow. Hence, if there is increase in production of acids, the pH lowers below the favourable limit and souring of digester takes place. On the other hand, if organic loading is not maintained properly, then the microorganisms scavenge each other killing the activity rate of digester. In both cases, recommissioning of anaerobic digester may be needed.

Figure 8.18: Schematic diagram of a high rate anaerobic digester



Source- (Rycroft, 2016)

Chemical Mechanisms

Alkaline Stabilisation

Alkaline stabilisation as the name suggests helps to stabilise the faecal sludge and septage. It can be achieved using lime or quicklime. When lime is mixed with faecal sludge or septage, it raises the pH of the mixture to 12. The pathogens do not survive in such extreme alkaline conditions. This process not only stabilises the sludge but also reduced odour and increases the settleability of the solids.

When quick lime is mixed with faecal sludge or septage, it rapidly reacts with the water. This is an exothermic process which raises the temperature of the moisture upto 600 degree Celcius. This also results in reduction in pH of the mixture. Both these factors lead to not only stabilisation but also pathogen reduction. In cases where pH drops below the desired values, addition of lime is required.

Coagulation and flocculation

Coagulation and flocculation refers to the chemical treatment mechanism where in chemical is used to achieve flocs of sludge which are then easy to remove using gravity settling or mechanical dewatering process. The commonly used chemicals for coagulation and flocculation are ferric chloride, alum or lime. Now-a-days a complex mixture of polymers is also available which are highly effective in coagulation of sludge. These are mostly used in cases where direct dewatering of septage is done using mechanical dewatering equipment.

Treatment Units- Mechanized

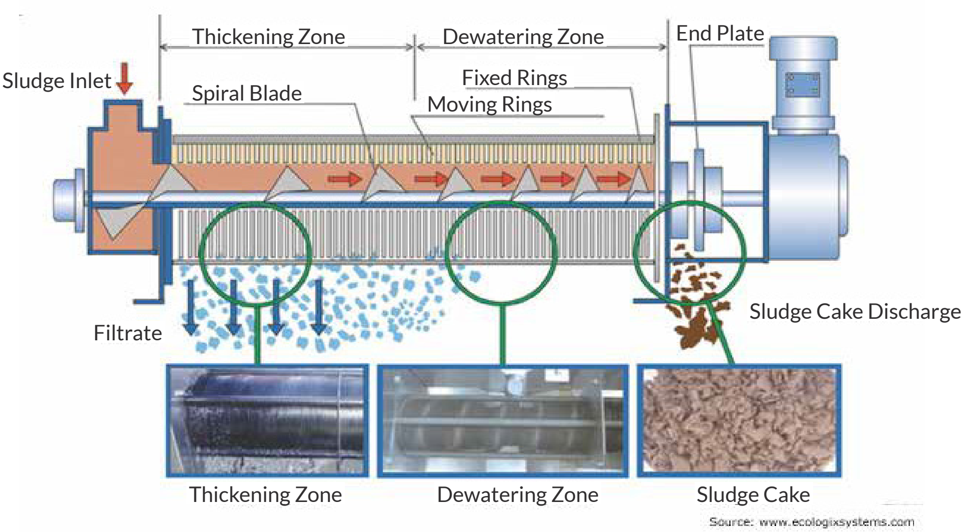
Mechanized Dewatering Units

Mechanized dewatering units have been used for dewatering of sewage sludge in the STP's. The mechanical dewatering units are mainly of two types: centrifuge & press. Mechanical centrifuge is quite efficient & mostly appropriate for STP whereas the mechanical press is more suitable for faecal sludge & septage. The mechanical presses are of 2 types: screw press and belt press filter.

Screw Press

Screw presses separate liquid from solids by forcing sludge through a screw or auger contained within a perforated screen basket. The screw diameter increases with distance along the shaft while the gap between its blades decreases so that the gap between basket, shaft, and flights continuously decreases and sludge is squeezed into a progressively smaller pace. 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.

Figure 8.19: Schematic diagram of a screw press

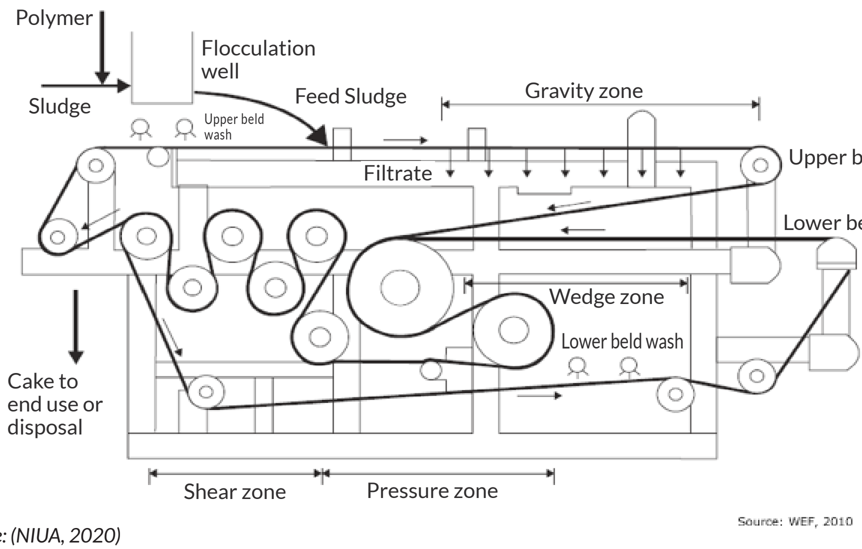


Source: (NIUA, 2020)

Belt Press

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. 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 wash water after each pass.

Figure 8.20: Schematic diagram of a belt press



Source: (NIUA, 2020)

Following table describes the brief difference between a screw press & a belt filter press:

Table 8.7: Mechanized Dewatering: Screw Press vs Belt Filter Press based on Operation & Performance

Technology	Operation	Maintenance
Screw press	• Intermittent medium pressure wash water (<10% sludge flow rate at 4 bar pressure) • Simpler operation • Enclosure keeps surrounding environment clean and safe • Low Energy consumption	• Fewer parts to monitor and maintain • Less inventory to maintain
Belt filter press	• Continuous wash water (50-100% sludge flow rate at 8 bar pressure) • Unenclosed units are messy to operate and present health hazard; however, allow visibility of process performance	• Simple equipment to maintain (rollers, • bearing, belt) • More parts to monitor- inspect and maintain
Technology	• Dewatering Performance	• Cost
Screw press	• Can receive sludge with low solid content (<1%) • 15-25% final dry solids • Less sensitive to non-homogenous sludge characteristics	• Higher capital costs • Slightly lower operation cost
Belt filter press	• Can receive sludge with solid content < 0.5% • 15-25% final dry solids • Can be provided with greater capacity for single unit	• Lower capital cost • Slightly higher operating cost

Source: (NIUA, 2020)

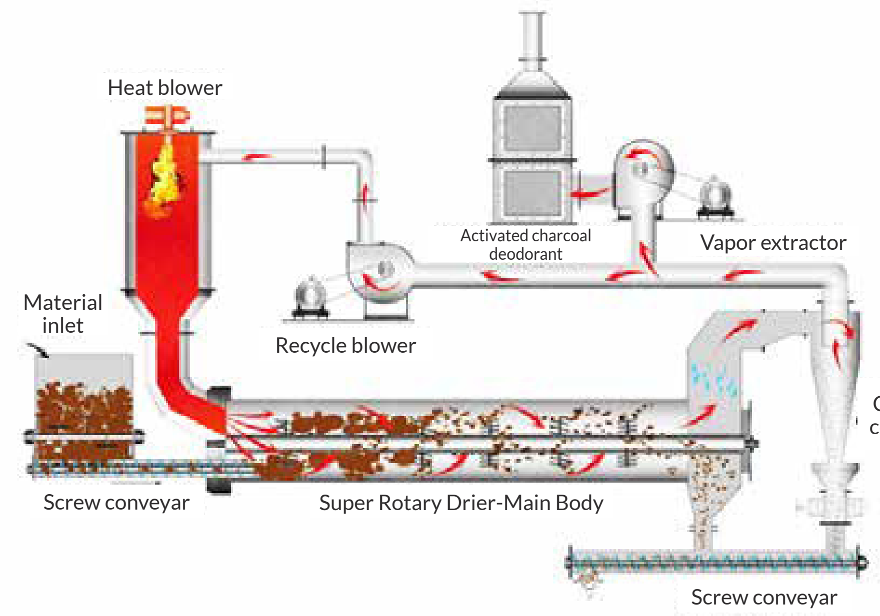
Mechanized Drying Units

Thermal dryers have high energy requirement, since tremendous amount of energy is required to heat the water and there by vaporise it. However, thermal dryer requires significantly less area for processing the sludge. In optimised operation, efficiency of the dryer is more than 80% consistently. Health and safety consideration such as production of dust should be taken into account. Operators need to be trained properly and persons with skills and expertise are required for operating such equipment.

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.

Figure 8.21: Schematic Diagram of a Rotary Drum Dryer



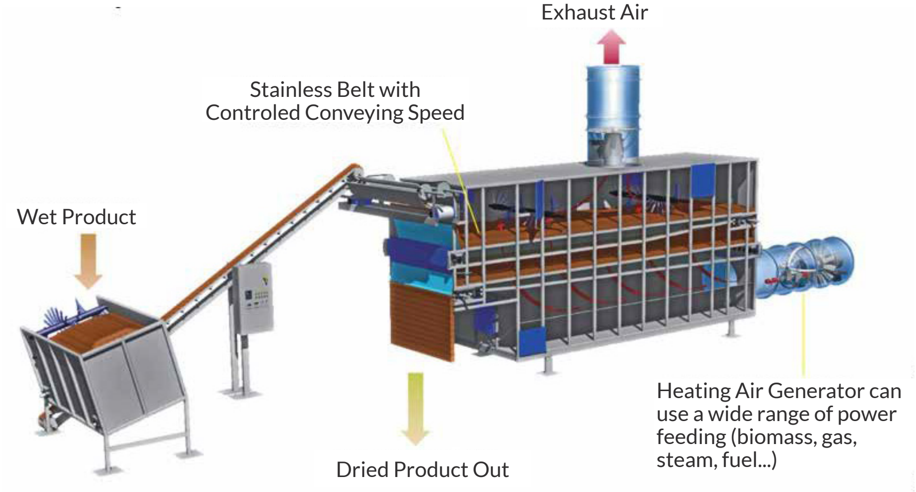
Source: (NIUA, 2020)

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 Dryers

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. Alternatively, electrical heating coils are also used to heat 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.

Figure 8.22: Schematic Diagram of a belt dryer

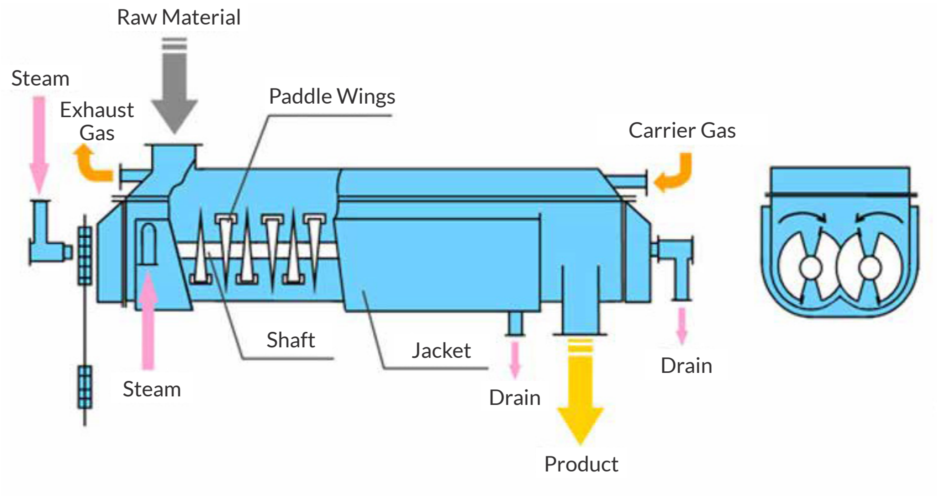


Source- (NIUA, 2020)

Paddle Dryers

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.

Figure 8.23: Schematic Diagram of a Paddle Dryer

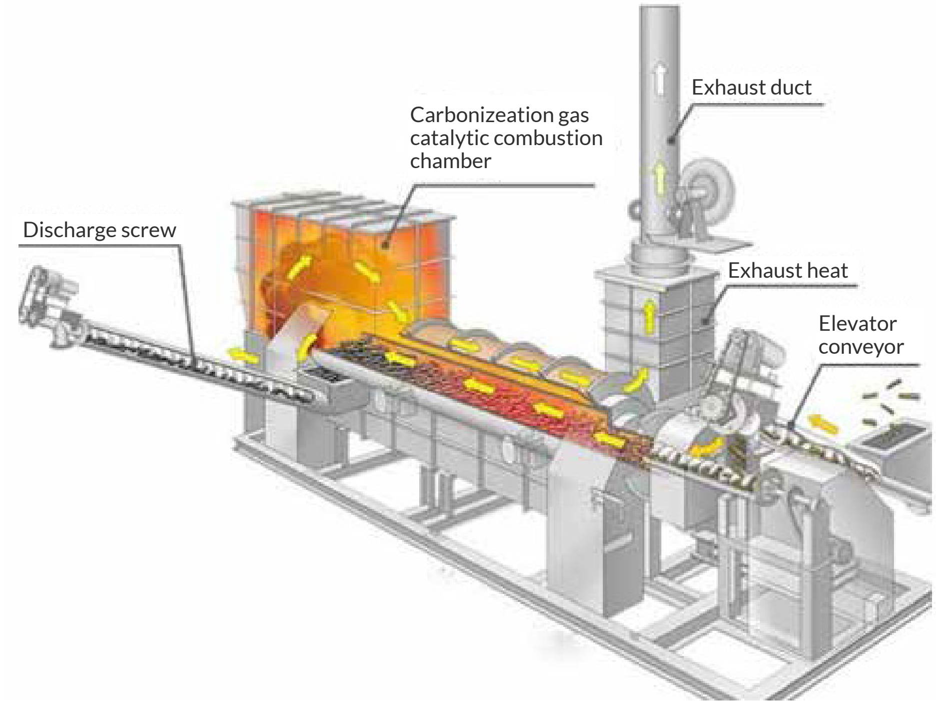


Source- (NIUA, 2020)

Pyrolysis

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. The slow pyrolysis, the main focus here, requires a retention time measured in hours and a temperature more, 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 amendment or as a fuel source.

Figure 8.24: Schematic Diagram of a Pyrolizer



Source- (NIUA, 2020)

Selecting Appropriate Treatment Mechanism

The selection of the treatment mechanisms is governed by certain criteria which are listed in the figure below. However, it needs to be understood that these criteria are not inclusive and there can be other criteria as well.

Table 8.8: Selection Criteria for Treatment Mechanism

Treatment Performance	Local Context	O&M Requirements	Costs
Effluent and solids quality according to the discharge/ reuse standards	• Characteristics of Sludge (Dewaterability, solids concentration, stabilisation, spread ability) • Quality of the frequency of the sludge to be received at treatment facility • Climate • Land availability and its cost • Interest in the end use	• Availability of skilled persons for operation, maintenance and monitoring • Availability of spares locally in case of mechanical equipment	• Investment costs covered (land acquisition, infrastructure, human resources, capacity building and training) • O&M costs • Affordability for households and ULBs

Source- (NIUA, 2020)

1. **Treatment performance:** The default criteria is that the treatment facility should be able to produce end products meeting the standards of discharge/ end use.
2. **Local context:** Most important criteria is the local context. The characteristic of the sludge and its characterisation ratios determine the degree of stabilisation and dewaterability etc. The frequency of desludging affects the quality of the sludge. Hence, if the frequency of the desludging is high, there is possibility of having faecal sludge. In that case, stabilisation of sludge becomes important. Climate plays important role in case of all-natural treatment mechanisms such as evaporation, evapotranspiration and stabilisation.
3. **Land availability and its cost of acquisition must also be considered before finalising the treatment mechanisms:** In cases where the land is not available and acquisition of it is costly or time consuming, it is advisable to go for treatment mechanisms demanding less area. If there is interest in the use of end products of treatment, then treatment mechanisms suitable to produce those end products in demand should be chosen. Ex: In cases where there is demand for biochar, pyrolysis will be suitable treatment mechanisms for pathogen reduction.
4. **O&M requirement:** Availability of the resources such as skilled persons, spares etc. at local level is very important. In absence of local availability of the resources, no treatment technology is going to economically viable in spite of it producing very high-quality end product.
5. **Costs:** The CAPEX and OPEX of the technology are also one of the criteria which is thought as the only criteria. Affordability of the complete project to the ULB or the end beneficiaries such as households should also be checked

Various Approaches for Faecal Sludge and Septage Management

Approach 1: Anaerobic Digestion and Unplanted Drying Bed based FSTP[7]

In this process, the faecal sludge is first passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand and silt. The screened faecal sludge/septage is then stabilised (reduction of volatile solids) through an anaerobic process. This process also aids in solid-liquid separation. The partially dewatered sludge is further dried in the drying beds. The dried sludge removed from the drying beds must not contain more than 60% moisture.

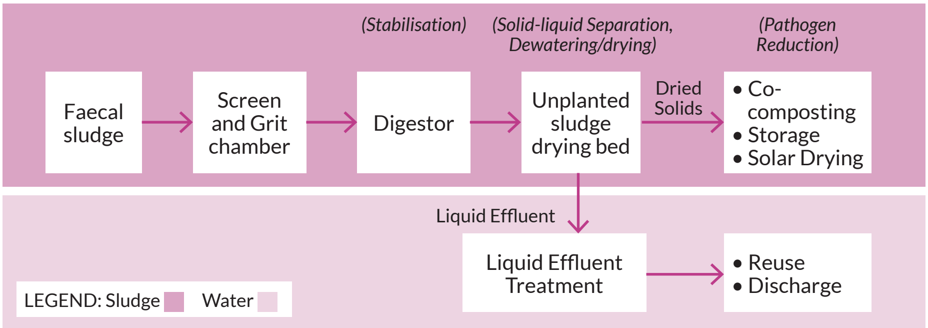
This sludge is then further treated for pathogen reduction by any of the following methods:

- co-composting,
- storage for periods in excess of 12 months
- solar drying or any other process prescribed for pathogen reduction.

[7] *Velidandla, S., Rao, K., Parekh, R. and Nagaraja, P., 2020. Quality in Faecal Sludge Management. 1st ed. WASH Institute, NFSSM Alliance.*

The supernatant from the digester and the percolate from the drying beds are collected and further treated to reduce organic content and pathogens to achieve liquid discharge standards.

Figure 8.25: FSTP Process Modules in Anaerobic Digestion and unplanted Drying Bed based FSTP



Screening	Screen and grit chamber
Solid-liquid separation	Unplanted drying bed
Solid treatment - VAR	Digestor
Solid treatment - Pathogen reduction	Co-composting, storage, solar drying

Source- (Velidandla, et al., 2020)

Approach 2: Planted Drying Bed based FSTP[8]

In this process, as depicted in Figure 7- 13, first the faecal sludge is passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand, and silt. The screened faecal sludge/septage is disposed in planted drying beds. Unlike regular drying beds, in planted drying beds, the sludge is applied in layers and allowed to dry over very long periods of time.

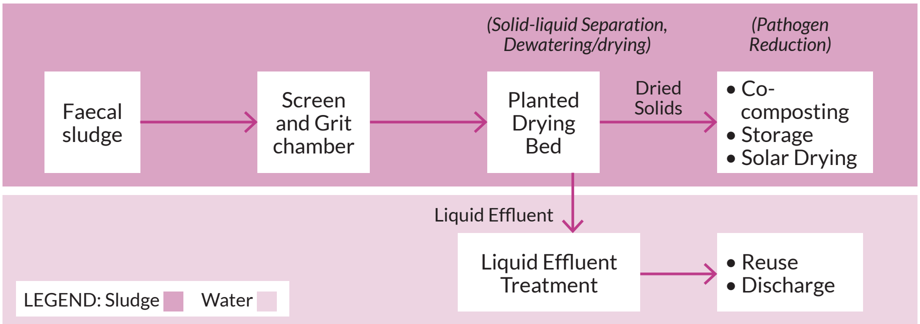
During these long accumulation periods, the sludge undergoes stabilisation and mineralisation. Thus, planted drying beds aid in both solid liquid separation and VAR. The dried solids from planted drying beds are further treated for pathogen reduction by following any of:

- co-composting,
- storage for periods in excess of 12 months
- solar drying or any other process as prescribed for pathogen reduction.

[8]*Velidandla, S., Rao, K., Parekh, R. and Nagaraja, P., 2020. Quality in Faecal Sludge Management. 1st ed. WASH Institute, NFSSM Alliance.*

The percolate from drying beds is treated in appropriate liquid treatment system to reduce organic content and pathogens to achieve liquid discharge standards.

Figure 8.26: FSTP Process Modules in Planted Drying Bed based FSTP



Screening	Screen and grit chamber
Solid-liquid separation	planted drying bed
Solid treatment - VAR	planted drying bed
Solid treatment - Pathogen reduction	Co-composting, storage, solar drying

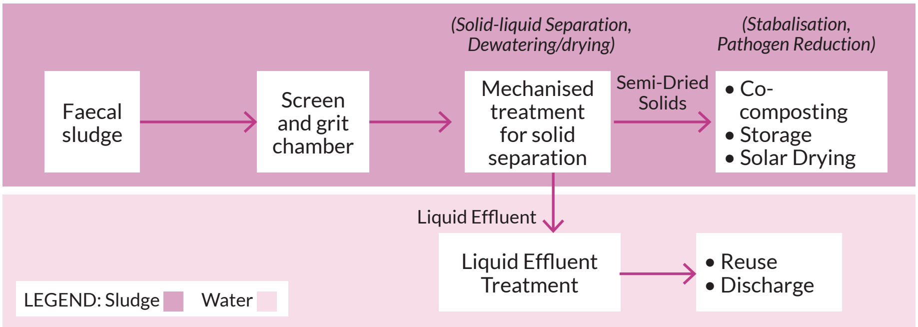
Source- (Velidandla, et al., 2020)

Approach 3: Mechanical Solid-Liquid Separation based FSTP[9]

In this process, as depicted in Figure 8.27, first the faecal sludge is passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand and silt. The screened faecal sludge is stabilised through anaerobic processes as prescribed for VAR under standards for biosolids. The stabilised sludge, which also has improved dewatering capabilities, is dewatered using mechanical device such as volute screw press. The solids from the screw press are further treated for pathogen reduction through any processes prescribed in the biosolids standards guidelines. The supernatant from the digestor and the filtrate from the screw press is collected and treated in liquid treatment modules to achieve effluent discharge standards.

[9]*Velidandla, S., Rao, K., Parekh, R. and Nagaraja, P., 2020. Quality in Faecal Sludge Management. 1st ed. WASH Institute, NFSSM Alliance.*

Figure 8.27: FSTP Process Modules in Mechanical Solid-Liquid Separation based FSTP



Screening	Screen and grit chamber
Solid-liquid separation	planted drying bed
Solid treatment - VAR	planted drying bed
Solid treatment - Pathogen reduction	Co-composting, storage, solar drying

Source- (Velidandla, et al., 2020)

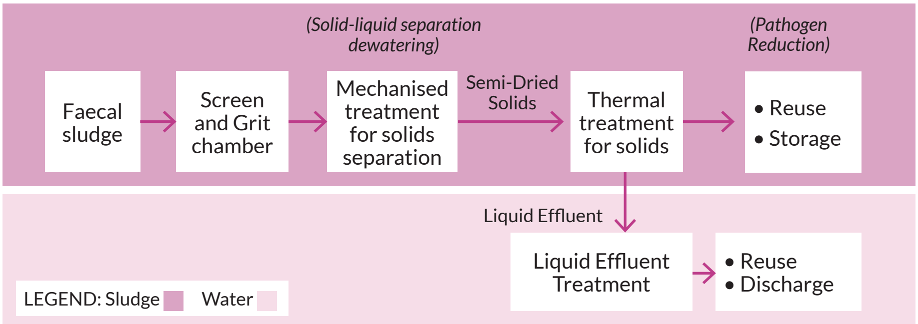
Approach 4: Thermal Solids Treatment based FSTP[10]

In this process, as depicted in Figure 8.28, first the faecal sludge is passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand and silt. The screened faecal sludge is dewatered using mechanical devices such as volute press. The dewatered solids are further dried in a sludge heater. The heater considerably reduces the moisture in the solids, preparing them for incineration. The dry sludge is then incinerated in combustion chambers. The drying and combustion process ensures reduction of pathogens and vector attraction potential.

Depending on the quantity of air supplied, the combustion can be complete or partial (pyrolysis), based on which the end product varies as ash or bio-char. The liquid from various streams is collected and further treated to achieve effluent standards. Stack for exhausts from thermal treatment of bio-solids must be designed considering local wind velocity and direction.

[10] *Velidandla, S., Rao, K., Parekh, R. and Nagaraja, P., 2020. Quality in Faecal Sludge Management. 1st ed. WASH Institute, NFSSM Alliance.*

Figure 8.28: FSTP Process Modules in Thermal Solids Treatment based FSTP



Screening	Screen and grit chamber
Solid-liquid separation	Volute screw pressed
Solid treatment - VAR	Dryer
Solid treatment - Pathogen reduction	Incinerator/Pyrolysis reactor

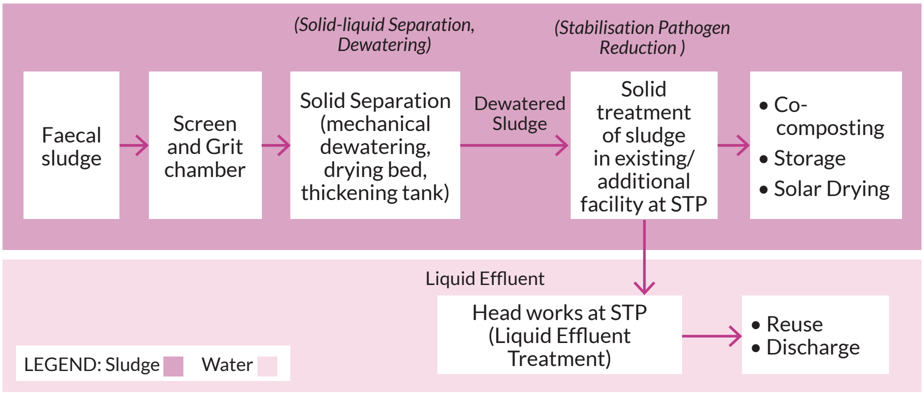
Source- (Velidandla, et al., 2020)

Approach 5: Co-treatment of Faecal Sludge in Sewage Treatment Plants

In cities, towns or districts with access to a sewage treatment plant (STP) with spare capacity, the feasibility of co-treatment of sewage and faecal sludge should be assessed. Given the high solid and organic content of faecal sludge, its direct loading into the STP is not recommended. Faecal sludge must, therefore, undergo preliminary treatment such as solid-liquid separation to render the components of faecal sludge suitable for further treatment in an STP. Solid-liquid separation can be added to the infrastructure at the STP facility (or pumping stations) or can be achieved using existing units meant for sewage sludge.

This process, as depicted in Figure 8.29, separates faecal sludge into liquid effluent (supernatant, percolate or filtrate) and solids. The effluent can be treated in the STP. The solids have to undergo further processes (in existing or newly created infrastructure) for pathogen and VAR reduction before being reused or disposed.

Figure 8.29: Co-treatment of Faecal Sludge in STPs



Source- (Velidandla, et al., 2020)

8.6 Case Studies on various approaches for FSSM

Co-treatment Facility, Puri

Facility Highlights	
Technology	Co-treatment in STP; Aerated Lagoon
Working Principle	Treatment of Faecal sludge and septage in Sewage Treatment Plant (STP) with pre-treatment facilities for Faecal sludge.
Year of Construction	Commissioned in 2017
Status	Operational
Capacity	50 KLD
Area Requirement	20 sq.m./KLD
CAPEX	Rs. 3.5 lakh/KLD
OPEX(per annum)	Rs. 35000/KLD

Source: (NIUA, 2018)

A Septage Treatment Plant (SeTP) having the capacity of 50 KLD (Kilo Litre per Day) was constructed by OWSSB (Odisha Water Supply and Sewerage Board) in 2017. The plant was constructed under the AMRUT (Atal Mission for Rejuvenation and Urban Transformation) scheme and uses co-treatment technology for the treatment of septage.

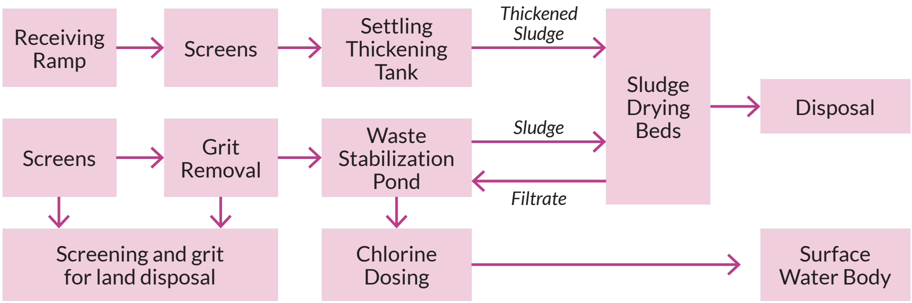
The septage is first unloaded into the settling-cum-thickening tank of the SeTP. In the settling-cum-thickening tank, settling of the heavier particles takes place. The lighter particles (i.e. water & oil) float above while the heavier particles settle down to the bottom of tank. The settled solids (sludge) at the bottom of the tank get thickened and are removed by pumping at regular intervals and are then sent to the sludge drying bed for removal of moisture content. The leachate from the sludge drying bed is collected in a leachate sump which is further pumped to the pre-treatment unit of Sewage Treatment Plant (STP), co-located with the Septage Treatment Plant (SeTP) for further treatment and disposal.

Table 8.9: Merits and Constraints

Merits	Constraints
Faecal sludge and sewage be treated at single location minimizing the maintenance requirements	The regulated flow to the STP needs to be engineered and changes to this can affect the entire performance of the STP
No separate infrastructure required for Faecal sludge treatment with reduced capital cost	STP capability to handle faecal sludge is governed by (i) quantity of Faecal sludge (ii) aeration capacity and solids handling capacity of the plant
	The ability of the STP to co-treat faecal sludge depend on STP type, design capacity and faecal sludge pre-treatment facilities as faecal sludge is 50 times higher strength than sewage

Source: (NIUA, 2018)

Figure 8.30 Treatment Flow Chart- Co-Treatment Facility, Puri



Source: (NIUA, 2018)

Faecal sludge and Septage Treatment Plant, Wai

Facility Highlights	
Technology	Pyrolysis
Working Principle	The working principle of pyrolysis is the thermochemical decomposition of organic material at elevated temperatures in the presence of controlled oxygen (pyrolysis) to efficiently convert sludge to biochar without external power.
Year of Construction	-
Status	Operational
Capacity	70 KLD
Area Requirement	19,602 sq.ft.
CAPEX	Rs 8 lakh/KLD
OPEX(per annum)	Rs. 65,000 to 1,00,000/KLD

Source: (NIUA, 2018)

Wai municipal council has setup the pyrolysis technology based faecal sludge treatment facility. The system comprises of grit removal, pasteurization, 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.

The counter flow heat exchanger recovers the heat generated from pyrolysis and is reused back within the system. No external heat source is required enabling sustained operations. The system is equipped with online temperature monitoring systems optimizing the energy consumption and ensuring the pasteurization. The biochar and pasteurized liquid are the products from the process.

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.

Applicability/Replicability/Scalability: Applicable for treatment of Faecal sludge, STP sludge or sludges with organic content. The modular system is easily scalable as it can be deployed fast with very low footprint.

Table 8.10: Merits and Constraints

Merits	Constraints
Automated system with no direct contact with faecal sludge	Varied septage characteristics pose depend for external thermal energy needs
Suitable for all weather conditions	
The products from the process including dewatered effluent are bio-safe for reuse including food nursery	

Source: (NIUA, 2018)

Faecal Sludge Management, Leh, J&K[11]

Facility Highlights	
Technology	Planted Drying Beds – Biological
Working Principle	This is a biological system with combination of sludge treatment and liquid treatment by the natural process. Planted drying bed is an extension of unplanted drying bed (Faecal Sludge Treatment Technology 02), but has the added benefit of transpiration and enhanced sludge treatment due to the plants. Filters do not need to be desludged after each feeding/drying cycle. The liquid is further treated in plated gravel filter.
Year of Construction	-
Status	Operational
Capacity	12KLD
Area Requirement	60 sq.m./KLD
CAPEX	Rs. 4.5 lakh/KLD
OPEX(per annum)	Rs. 83000/ KLD

Source: (NIUA, 2018)

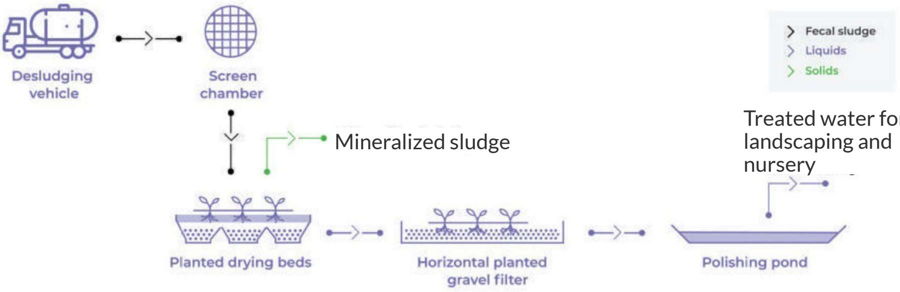
Leh is a high-altitude, cold desert municipality in Jammu & Kashmir with a high dependence on groundwater. While the city plans to increase the coverage of sewer networks, currently most of the households are dependent on on-site sanitation systems. With most septic tanks not built as per standards and high underground water table, water contamination was observed in the city in 2017. A need was therefore felt by the Municipal Committee of Leh (MCL) for an FSTP to treat and reuse the sludge safely.

In April 2017, BORDA was requested to support in creating an effective system to manage faecal sludge in Leh. Blue Water Company was identified as the BOT (Build Operate and Transfer) contractor to finance the FSTP, with payment for return financial arrange. FSTP construction was undertaken in May-July 2017 and was inaugurated in August 2017.

[11] *NITI Aayog (2021) 'Faecal sludge and septage management in urban areas', (January).*

The technology comprises of Screen Chamber, Planted Gravel Filter (PGF), Horizontal Planted Gravel Filter (HPGF) and Polishing Pond. The planted drying beds are used for solids and liquid separation, and the planted gravel filter and polishing pond are used for liquid treatment. Till December 2020, more than 6 million litres of Faecal Sludge has been treated, serving approximately 7,100 people.

Figure 8.31: Treatment Process Faecal Sludge Treatment Plant Leh, J&K



Source: (NITIAYOG, 2021)

Applicability/Replicability/Scalability: The technology is suitable for all organic wastewater and can be replicated in similar climatic conditions.

Table 8.11: Merits and Constraints

Merits	Constraints
Low operation and maintenance cost	The rate of biological degradation during extreme cold weather takes longer for treatment duration
No skilled labour required	The biosafe character of the process outputs need to be ascertained.
No human contact with waste	The pathogens removal in the sludge requires inactivation through chemicals or destruction using heat. The gravel filtration of liquid can only reduce the count and would not remove completely.

Source: (NIUA, 2018)

Further Readings

1. Kevin Tayler (2018); Faecal sludge & septage treatment- A guide for low income countries
2. Technical Note on Shallow and Deep Trenches for Faecal Sludge or Septage by Water, Sanitation and Hygiene Institute, 2019
3. EAWAG/SANDEC (2008): (Sandec Training Tool 1.0, Module 5). Duebendorf: Swiss Federal Institute of Aquatic Science (EAWAG), Faecal Sludge Management (SANDEC)
4. Strande, L.; Ronteltap, M.; Brdjanovic, D. (2014): Faecal Sludge Management (FSM): Systems Approach for Implementation and Operation. London: IWA Publishing
5. Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph. and Zurbrügg, C., 2014. Compendium of Sanitation Systems and Technologies. 2nd Revised Edition. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland
6. To facilitate implementation of various initiatives, knowledge products available to benefit Municipal Corporations are shared as below.
7. Model Concession Agreement and Model RFP Documents for liquid waste management by NITI Aayog
(Link: https://niti.gov.in/sites/default/files/2020-09/Bidding-Documents-for-PPP-in-Integrated-Solid-Waste-Management-and-Integrated-Liquid-Waste-Management.pdf)
8. Standards, specifications and benchmarks for FSSM
(Link: https://www.washinstitute.org/quality-assurance-fsm.php)
9. PPP models under HAM, DBFOT, DBOT formats
(Link: https://www.niua.org/scbp/?q=content/tender-document-andhra-pradesh-rfp-and-concession-agreement-establishment-fstps)
10. Model tenders specific to FSSM
(Link: https://www.washinstitute.org/model-tenders-fsm.php)
11. Business and service delivery models for various FSSM implementations (along with cost benchmarks)
(Link: https://www.iwmi.cgiar.org/publications/resource-recovery-reuse/series-18/)
12. Quality Assurance for FSSM – checklists, templates, SOPs, practitioner manuals
(Link: http://fssmquality.org/)
13. Monitoring and Evaluation processes – at various levels e.g.: Database of existing FSTPs for ready reference, FSTP monitoring protocols
(Link: https://www.cseindia.org/mount/home)
14. Training modules for orientation to advanced training on FSSM
(Link: https://www.niua.org/scbp/?q=training-modules)
15. BCC and IEC materials to drive positive FSSM behaviours
(Link: https://nfssmalliance.org/events/)
16. Guidance Document for Design of FSTP based on Drying Bed Technologies
(Link: https://cddindia.org/wp-content/uploads/FSTP-guidance-document-2021.pdf)

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2. Bassan, M. et al., 2014. Faecal Sludge Management Systems Approach for Implementation and Operation. s.l.:IWA.
3. EPA, 2008. Handbook: Septage Treatment and Disposal. [Online] Available at: https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=NRMRL&dirEntryID=37973
4. IWA, 2014. Faecal Sludge Management Systems Approach for Implementation and Operation. London: IWA Publishing.
5. MoHUA, 2013. Advisory Note: Septage Management in urban India, s.l.: s.n.
6. MoHUA, n.d. Primer on Faecal Sludge and Septage Management. [Online] Available at: https://smartnet.niua.org/sites/default/files/resources/primer_on_faecal_sludge_septage_management.pdf
7. National Institute Of Urban Affairs, Delhi, 2019. Cost Analysis Of Faecal Sludge Treatment Plants In India Life Cycle Costing & Contracting Models Of Fstps. New Delhi: National Institute Of Urban Affairs.
8. Nitiayog, 2021. Faecal Sludge and Septage Management in Urban Areas: Service and Business models, New Delhi: NIUA.
9. NIUA, 2017. Faecal Sludge and Septage Management: orientation module. s.l.:s.n.
10. NIUA, 2017. Handbook on Decentralized Wastewater Treatment Module,2017. New Delhi: National Institute of Urban Affairs.
11. NIUA, 2018. Faecal Sludge Treatment Technologies in India -Compendium, s.l.: s.n.
12. NIUA, 2019. Faecal Sludge Treatment Systems Design Module. S.l.:S.n.
13. NIUA, 2020. Integrated Wastewater and Septage Management — A Planning Approach (Part: B Learning Notes). New Delhi: National Institute of Urban Affairs.
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16. Rycroft, M., 2016. Biofuel and energy crops for electricity production. February.
17. Singh, S., Mohan, R. R., Rathi, S. & Raju, N. J., 2016. Technology options in FSM in developing countries: Benefits and revenue, s.l.: s.n.
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Quick Assessment

1. The National Policy on Faecal Sludge and Septage Management(FSSM) was launched in:
   a. 2015
   b. 2014
   c. 2008
   d. 2017

2. The COD: BOD ratio of Septage is:
   a. 5:10
   b. 3:5
   c. 6:7
   d. 5:13

3. The water content of septage is higher than that of Faecal sludge.
   a. True
   b. False

4. The properly designed and well operated settling thickening tank thicken the FSS of solid content as low as :
   a. 0.1%-0.3%
   b. 15%-20%
   c. 0.5%-12%
   d. 20%-30%

5. Name the three stages of Anaerobic digestion?

** For answers please refer Annexure I*

Chapter

9

Business Ecosystem Models for Across Faecal Sludge and Septage Management

Recap

The previous chapter gave an overview of Faecal Sludge and Septage Management. The given chapter discusses the context and relevance of business models in FSSM value chain.

Training Objectives

- To get an overview of various business models in Faecal Sludge and Septage Management in India
- To understand the applicability of various business models with respect to the given context

Training Outcomes

- To understand the business environment of emptying, transportation and treatment operations.
- To gain exposure on various elements of successful business model
- To differentiate various typologies of business models in FSSM

Chapter Contents

9.1 What is a business model?

"A business model is defined by who your customers are, which markets you operate in, who your partners are, what costs you have, where your revenues come from, which activities you engage in, and how is value created and delivered to your customers".

The term 'business model' is used as a tool to articulate FSM solutions – their costs, potential for revenue generation for cost recovery, partnerships and engagement between diverse stakeholders (government, donors, entrepreneurs, technology providers, community-based organizations [CBOs], and non-governmental organizations [NGOs]).

Why business models are important in faecal sludge management?

The provision of sanitation is like waste management, traditionally a public service to maintain public health and budgeted as such by municipalities. The sanitation value chain appears so far to be prone to market failures due to external effects, imperfect information, disadvantages of monopolies, and destructive competition among many actors – resulting in sanitation goods and services that are not provided in sufficient quantity and quality, both on the demand and supply sides despite an increasing share of enterprises providing toilets as well as Emptying and Transport (E&T) services.

The market failures in sanitation are addressed typically through subsidies to influence investment decisions, defining and enforcing regulations and standards to alleviate public health and environment externalities, and supporting market-based solutions by facilitating finance, dissemination, or provision of business support. In India, the government uses each of these mechanisms to address the market failures, making it still the most important stakeholder in any business model for sanitation service provision.

A business model is a framework within which local governments can plan and implement a set of measures which includes regulatory, financial incentives/dis-incentives, behaviour change to align the interest or actions of actors/stakeholders involved in the fecal sludge management value chain to the overall sanitation vision of the city.

Who are the stakeholders in FSSM value chain?

Managing fecal sludge at the city level in an efficient and sustainable way requires the involvement and support of all the concerned actors across the value chain. These actors are also called key stakeholders, in short they are the people who matter. Neglecting the needs, priorities and interest of people as well as their cultural and economic reality is one of the major causes of failure for sanitation interventions. Stakeholders in FSM planning process can be classified in eight categories as detailed below. This list is not exhaustive, but only indicative and can be used as a guideline in selecting and categorising the stakeholders.

1. **Municipal authorities:**
    - Elected representatives
    - Executive body
    - Technical staff
    - Monitoring and enforcement departments

2. **State and national authorities:**
    - State and national level directorates/ministries related to sanitation, public health, water resource, public utility, agriculture, housing and urban affairs, rural development, etc.

3. **Utilities:**
    - Public, semi-private (parastatal) or private (commercialized)

4. **Traditional authorities and influential leaders:**
    - Religious and ethnic leaders
    - Political and public figures
    - Public influences (role models, mass media, social media)

5. **Small scale businesses:**
    - Empty and transportation service providers
    - FSM and civil contractors
    - Service providers association
    - Waste management enterprises

6. **Organizations active in sanitation:**
    - Local NGO's
    - Universities and research institutions
    - Community based organizations

7. **Potential end users:**
    - Farmers , farmer associations and institutions helping farmers
    - Industries - fuel consumers

8. **Household:**
    - Users
    - Owners (landlords in the case of tenant housing)

9.2 Financing the FSSM Value Chain

Within a FSSM system, money is exchanged for different activities (e.g. emptying, transport, processing), at different orders of magnitude (e.g. small service payments, massive construction costs), and with different frequency (e.g. daily transfer frees, annual taxes). To achieve a financially sustainable business model, a prudent selection of the transfer types must be implemented. A brief summary of the most common financial transfers, applicable to FSSM, is presented below.

1. **Budget support:** It is the name given to cash transfers between stakeholders to partly or fully cover one stakeholder's operating budget. Typically provided by central and state governments to the local government as either program expenditure (SBM, AMRUT, etc.) or as part of finance Commission devolutions.

2. **Capital investment:** These are costs that are paid once, at the beginning of the project to cover all materials, labour and associated expenses needed to build the facilities and associated infrastructure. Examples of capital investments could include the purchase of land for the design and build of a faecal sludge treatment plant (FSTP), the purchase of a vacuum truck for Emptying and transportation (E&T) and other such investments.

3. **Discharge fee:** It is a fee charged in exchange for permission to discharge Faecal Sludge (FS) at some type of facility. The fee is paid with the intention of transferring responsibility to a stakeholder who has the legal and technical ability to safely process and/or transfer FS to another responsible stakeholder.

4. **License fee:** It is a financial instrument used to control the number and quality of E&T enterprises that are allowed to discharge FS at the FSTP. The license, in theory, is given out depending on proven quality of the service that the stakeholder is able to provide.

5. **Emptying fee:** It is the fee that is charged at the household level for removing FS from the onsite sanitation technology where it is collected and stored.

6. **Operation and maintenance (O&M):** These are expenses that must be paid regularly and continually until the service life of the infrastructure/equipment has been reached. Equipment like pumps, trucks, hoses, etc., will wear down with use and the frequency of replacement will depend on the operating conditions and how often the parts are maintained.

7. **Sanitation tax:** It is a fee collected either once, or at regular intervals, and which is paid in exchange for environmental services such as a water connection, a sewer connection / removal of FS, or any combination of these services.

9.3 Cost and revenue functions in Emptying and transportation

It is important to understand the expenses incurred by a private operator on a regular basis. A driver's salary ranges between Rs. 8,000-10,000 and worker/helper salary ranges between Rs. 6,000-8,000. In addition, some operators paid a daily allowance of Rs. 100-200 for each day of work. Temporary worker/helper may be paid a daily wage of Rs. 200-250.

Diesel expenses on average are Rs. 500-1,000 per day but would depend on the customer location served. Maintenance expenses vary widely from Rs. 3,000-5,000 depending on age and condition of the vehicle. Cost of pump lubrication oil forms major part of frequently incurred expenses apart from cleaning costs. Other expenses on an annual basis include taxes paid to state transport authorities, vehicle insurance and repairs for wear and tear.

Table 9.1: Cost in Emptying and Transportation

S.No	Expense Components	Amount
1	Driver Salary	Rs. 8,000 to 10,000 per month
2	Worker	Rs. 6,000 to 8,000 per month
3	Daily allowance	Rs. 100 to 200 per day
4	Diesel	Rs. 500 to 1,000 per day
5	Maintenance	Rs. 3,000 to 5,000 monthly depending on condition of vehicle

Source: (TNUSSP, 2017)

Private desludging operators offer tariff on a per load basis as well. An example from Trichy, for an average distance of 10 kms to customer location, the rate varies from Rs. 1,000–2,000 based on tanker size.

There were four primary factors reported by operators that influence the tariff are mentioned below:

- Distance to customer location
- Labour wages employed
- Length of hosepipe used

9.4 Business Models in Emptying and Transport of Fecal Sludge

With more than 100 million toilets constructed under SBM, the need for mechanical emptying of pits will grow several fold across urban and rural India. There is evidence to suggest that the affordability and ability to empty an OSS is a key concern for households, and it influences their toilet-use behaviours.

A research study carried out in 2019 indicates that private sector is the majority service providers of fecal sludge emptying and transportation service. Among this sole proprietorship is the most commonly found model. Typical capital investment is below INR 25 lakhs, with a little more than 1/3 of the trucks bought being pre-used.

Factors influencing business models:

- **Nature of the market -** In areas where there is limited supply of E&T as a service and where there are not sufficient government owned trucks, the quality of the service, waiting period and cost are determined by the private operators. In areas where there are more than one service provider, which can also include government owned trucks, the above aspects are decided in a more competitive manner.
- **Operations -** The time needed to desludge an on-site sanitation system and the distance to empty also influence the cost functions.
- **Infrastructure -** The condition and the type of the emptying in transportation vehicle can also largely influence the cost functions

The E&T models offer the following value propositions:

- Timely and safe emptying of OSS in households, businesses, and institutions
- Safe transportation of FS to designated disposal sites

The models covered focus on provision of timely, affordable desludging services for OSS users while enabling the municipality to regulate E&T services to ensure the safety of public health and the environment. They also improve the business environment for increased private sector participation in sanitation. The models are applicable in municipalities without sewer networks and where there is a demand for E&T services.

The following business models are explained in this section:

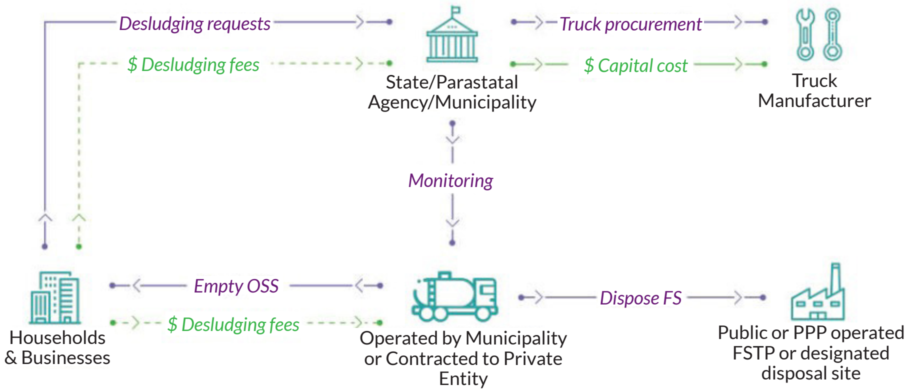
- Government-owned E&T
- Privately-owned and operated E&Tz

9.5 Different Government and privately owned Business Models

Government owned Emptying & Transportation

In this model, desludging vehicles are procured by the municipality, which can undertake desludging operations or outsource operations to a private entity. Households submit desludging requests to the municipality and pay desludging fees in advance if the municipality operates the business. When the private entity operates the business, desludging requests are submitted either to the municipality or the private entity. The municipality is expected to operate a toll-free number or a call center to register desludging requests and customer grievances. FS collected from households and businesses is transported to the FSTP or designated disposal site. In the case of a private entity operating the trucks, the municipality must monitor operations and ensure the safety of public health and the environment by verifying that the private entity is following standard operating protocols and disposing FS at designated sites. The relationships among the various stakeholders in the business model are shown in figure 9.1 below:

Figure 9.1: Business Model of Government owned Emptying & Transportation



Source: Author

Capital cost: Desludging vehicles are procured by the municipality from state or national government programs for improving urban infrastructure or municipality funds, if available.

Operating cost: If the municipality is the desludging operator, the municipality finances the operating cost through collection of desludging fees.

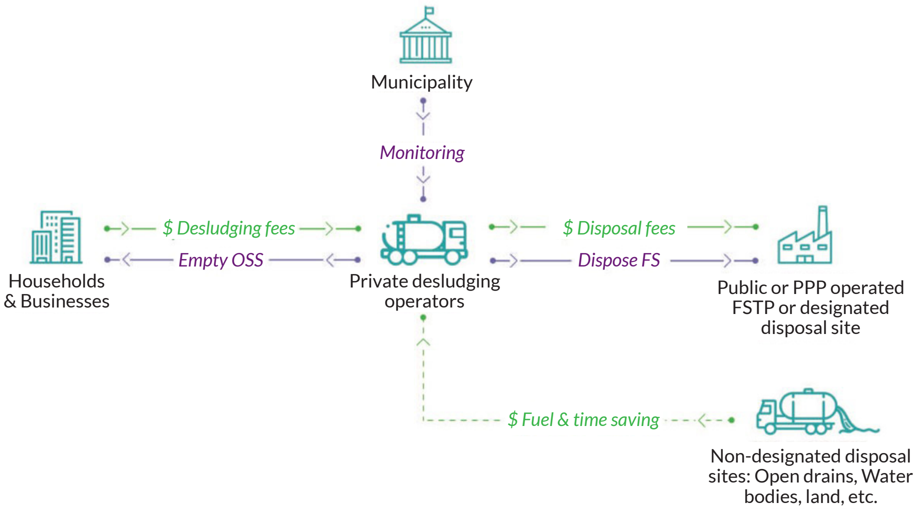
If the private entity is the desludging operator, the municipality pays the operator based on the bid price submitted on a per trip basis and number of service requests undertaken on a monthly basis; fines are levied for not following safety and operation protocols. The private entity is paid based on the number of trips made to the designated disposal site and submission of disposal forms signed by the municipality's desludging request center operator, household, and designated disposal site operator. The municipality should ensure a guaranteed minimum number of trips on a monthly basis for the private operator.

Relevance: High applicability for small towns where private entities are non-existent in the desludging sector due to low demand for desludging or lack of access to finance for investing in desludging vehicles. To make this business model inclusive, a differentiated tariff structure should be implemented for desludging fees based on location or other suitable parameters to make desludging affordable for the poor.

Privately-owned and Operated Emptying & Transportation

This is a market-driven business model. Households engage the services of the private entity, which markets its services through word of mouth, local plumbers funnelling orders for a commission, and bills/stickers on electric poles with telephone numbers. FS collected from On-site Sanitation System is transported to a disposal point – a municipality-designated point, treatment plant. The private entity charges desludging fees to the customer, which are based on market pricing and the containment system (type, number of trips required to empty it, length of pipe required to desludge it and distance from the disposal point). The relationships among the various stakeholders in the business model are shown in figure 9.2 below.

Figure 9.2: Business Model of Privately owned and operated Emptying & Transportation



Source: Author

Capital cost: The private entity finances it through personal financial resources, a personal loan from a friend, family member, or moneylender,

Operating cost: The desludging fees charged to the households and the minimum number of households serviced monthly should cover the operating cost.

Relevance: Applicable for towns with sufficient demand for desludging. This is the most common model across the country, which has evolved organically in response to local conditions.

Case Study: Warangal Desludging licensing

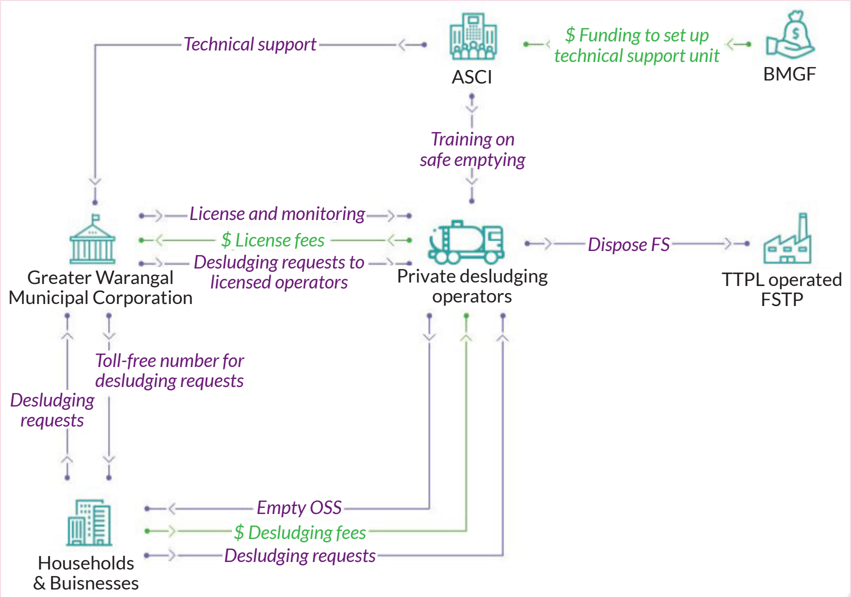
Warangal (The Greater Warangal Municipal Corporation) became the first city in the country to issue FSSM regulations and management guidelines. One of the key aspects of the regulations mandated licensing of private desludging operators and tracking of FS disposal, as there were many private E&T businesses operating in the city. The goal of licensing private desludging operators and tracking FS disposal is to ensure safe E&T of FS to protect public health and the environment.

To obtain the license, private operators must ensure the following:

- Vehicles meet the approved standards
- Workers are equipped with uniforms and required PPE and tools
- GPS devices are installed on their vehicles

GWMC maintains a list of licensed operators on its website to provide customers ease of access to information and has a toll-free number for sanitation queries from citizens. Any desludging request submitted to the GWMC is passed on to licensed operators. Trainings were provided to desludging operators on desludging standards and procedures, including usage of Personal Protective Equipment (PPE). The private operators are required to inform the GWMC about every desludging undertaken through the FSM tracker mobile application. The relationships between the various stakeholders are depicted in Figure below

Figure 9.3: Relationship between various Stakeholders



Source: Author

9.6 Cost Functions for Faecal Sludge Treatment Plants

1. Capital expenditure (CapEx)

Faecal sludge treatment project CapEx refers to the cost of the initial investment in materials, planning, construction, engineering, electrical and mechanical equipment. Some literature may include the cost of land acquisition, and there is generally a 15 – 20% contingency included to account for uncertainty. The type of treatment system being considered will, to a large extent, determine the CapEx distribution profile.

The location of the potential site can have a large influence over several areas of cost. For example, the distance to suppliers, availability of labour, access to utilities (water, electricity, gas) will vary by location, and will inevitably affect cost. The cost of civil works can rise depending on the site topography and soil geology.

2. Operation and Maintenance Expenditure (OpEx)

Although the type of technology chosen will generally dictate OpEx distribution, it is the location of the treatment plant that will ultimately determine the type of treatment technology that should be used. This is based on the predication that the most appropriate system will be chosen for a given location.

Typical OpEx profiles are dominated by three main cost components:

- Energy
- Chemicals, and
- Labour

Depending on the system type, these three cost elements can account for up to 90% of the total OpEx in electro-mechanical systems.

9.7 Business Models for Operating Treatment Plants

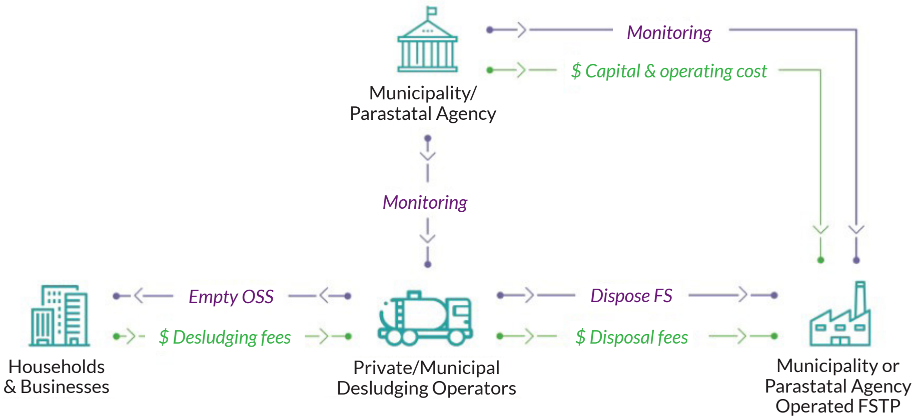
Business models in this section cover the treatment for disposal or reuse component in the sanitation value chain. The models offer the value proposition of treatment of FS for a healthy community and environment.

The simplest form of FS treatment is where an existing STP with excess capacity can accept the FS for co-treatment with sewage. In the absence of STPs, various business models are emerging for the implementation of standalone FSTPs. The government has traditionally provided sanitation services, and it is but natural that municipalities are managing FSTPs with the support of parastatal agencies. On the other hand, FSM being an emerging sector, PPPs allow for municipalities to share risk by sourcing private funds and technology.

Government-managed FSTP

The government finances, designs, constructs, and manages the operations of the FSTP. FS is collected by municipal or private desludging operators and transported to the FSTP. The municipality or parastatal agency conducts self-regulation and monitors FSTP operations. The model depends on the financial and technical skills of the local and/or state government to implement the FSTP. The relationships among the various stakeholders are shown in figure 9.4 below:

Figure 9.4: Model for Government managed FSTP



Source: Author

Owner and operator: The business model is implemented by the state government or the municipality. The municipality or a parastatal agency owns and operates the FSTP.

Capital cost: This is covered by funds from state or central government programs for improving urban infrastructure. Sometimes a donor may provide a grant to the municipality to build the FSTP.

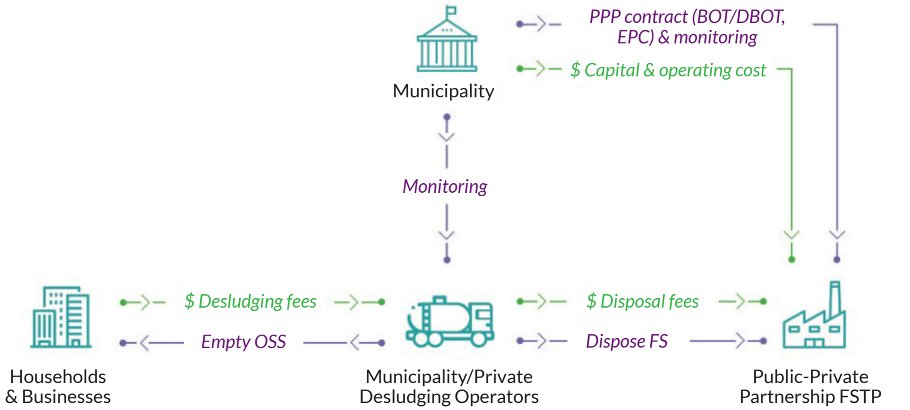
Operating cost: The state or municipality typically finances this cost through a combination of local taxes and state and central government financial assistance. The FSTP could generate revenue from the disposal fees charged to desludging operators and from sales of FSTP by-products.

Relevance: Highly applicable for small towns where private entities may not find it viable to undertake O&M of FSTPs.

3. Public-Private Partnership FSTP

This model engages the private sector in the provision of sanitation services. Limited technical capacity and sometimes financial capacity of the municipality are key reasons to engage the private sector. In this model, the municipality contracts some or all components of the project cycle (planning and design, implementation, construction, and operations) for establishing an FSTP with a private entity. The contract, which can be BOT, DBOT, DFBOT, or EPC (engineering-procurement-construction) dictates the engagement level of the private entity. It is the responsibility of the municipality to ensure delivery of FS to the FSTP when engaging the private sector only for the treatment component of the value chain. The relationships among the various stakeholders are shown in figure 9.5 below:

Figure 9.5: Model for Public-Private Partnership FSTP



Source: Author

Owner and operator: The business model is implemented by the municipality through a PPP contract. The municipality is the owner, and if the PPP contract has an operations component, the private entity is the operator. If the funding comes from a donor through a grant, typically it is given to the municipality either directly or through an institution. In such a case, the owner and operator structure is contingent on the project structure.

Capital cost: This is mostly covered by either funds from state or national government programs for improving urban infrastructure or grants from donors. Depending on project viability, the private entity can finance part of the capital cost, which is recovered from the revenue generated.

Operating cost: The municipality, private entity, and/or donor finance the FSTP operating cost. Donor finance is limited to the first few years after commissioning of the FSTP. The municipality typically funds it through a combination of local taxes and state and national government financial assistance. The municipality can generate revenue from licensing fees and FS disposal fees charged to desludging operators. The private entity funds the cost through a fixed O&M fee from the municipality. The private entity could raise revenue from the sale of reuse products.

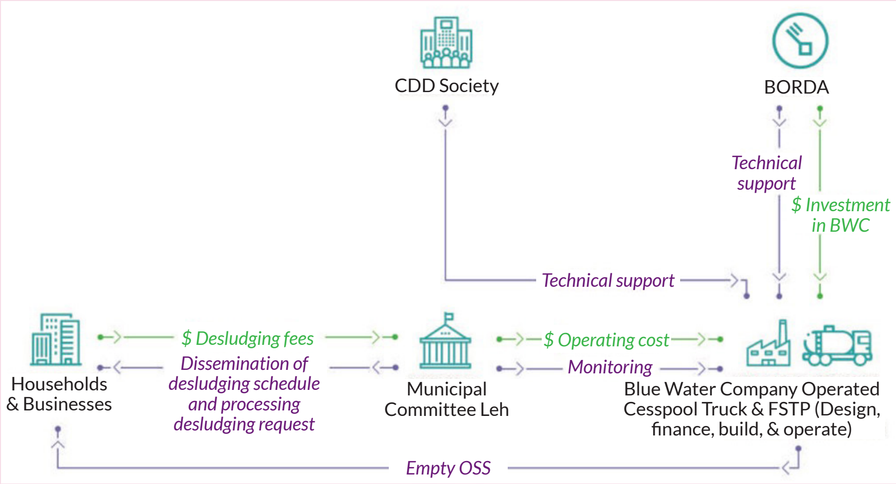
Relevance: Applicable when the municipality seeks to leverage private sector technical expertise and finance.

Case Study: Leh Public-Private Partnership in FSM, Jammu and Kashmir

Leh is a high-altitude, cold desert municipality with a high dependence on groundwater. Most of the local population uses eco-san toilets (no desludging required) whereas water flush toilets are provided for tourists. A PPP between BWC (Blue water company) and MCL (Municipal Committee Leh) for a five-year DFBOT contract was signed. The LDA (Leh Development Authority) allocated land for the FSTP, which was financed by the BWC.

According to the contract, the BWC is responsible for managing FSTP operations, along with provision of scheduled and demand-based desludging services. The MCL provided one existing desludging vehicle. The BWC prepares the schedule for desludging, which is shared with the MCL, who notifies customers of the desludging dates. Scheduled desludging is undertaken twice a week. The remaining days in the week are reserved for on-demand desludging. The MCL collects desludging fees from the hotels and home stays at the time of renewal of the yearly license to operate. Once the desludging service has been provided, the BWC is paid 90% of the revenue (INR 3,500 for each trip) upon submission of documentary evidence of service provision. The municipality monitors desludging and FSTP operations. The relationships among the various stakeholders in the value chain are shown in Figure 9.6 below:

Figure 9.6: Relationship between various stakeholders



Source: Author

9.8 Models linking Emptying, Transport and Treatment

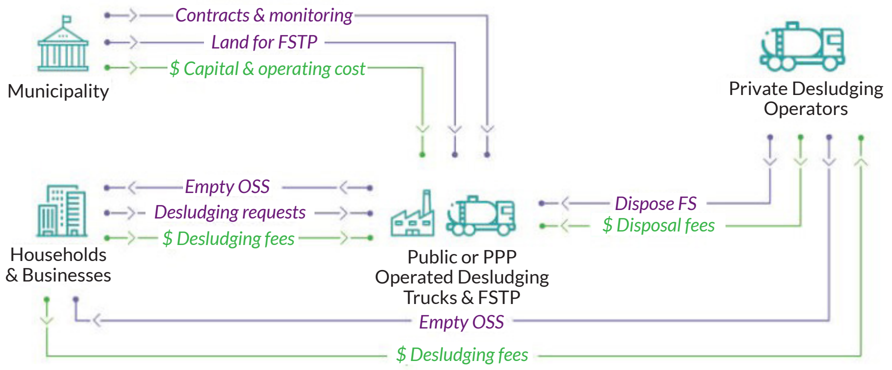
The models offer the following value propositions:

- Timely and safe emptying of OSS in households, businesses, and institutions
- Safe transportation of FS to designated disposal sites
- Treatment of FS for a healthy community and environment

The models in this section link the E&T and treatment components and, in the process, build a mechanism for reducing the monitoring burden on the municipality to ensure disposal of FS at treatment sites.

One entity, either the municipality or a private entity, is responsible for managing desludging and FSTP operations. The entity provides the desludging service and collects fees from OSS users and disposes of the FS at the FSTP that it manages. The municipality monitors FSM service provision. The relationships among the various stakeholders are shown in figure 9.7 below:

Figure 9.7: Model linking Emptying, Transport and Treatment



Source: Author

This model enables implementation of performance linked payments for the entire value chain. This, when coupled with incentives to promote reuse, creates the ideal FSM business model. Integrated business models are a tempting option for local governments, who can solely focus on monitoring while service provision is handled entirely by a private entity.

Capital cost: This is mostly covered by grants from donors and/or funds from state or national government programs for improving urban infrastructure. Depending on the project viability, a DFBOT (Design-finance-build-operate-transfer) contract can be implemented based on the availability of private finance to partially or fully invest.

Operating cost: The financing of the operating cost is dependent upon the PPP (public private partnership) contract. For the integrated model with scheduled desludging, the municipality pays the private entity on a pay per trip model that compensates for E&T and FSTP O&M costs. However, in the case of demand-based desludging, a similar payment mechanism with a minimum guaranteed number of trips is preferred.

The municipality finances the cost through multiple sources – user fees charged for desludging services, local tax collection, and state and central government financial assistance. The municipality can incentivize the private operator to generate additional revenue by selling treated sludge or other FSTP by-products, thus encouraging reuse.

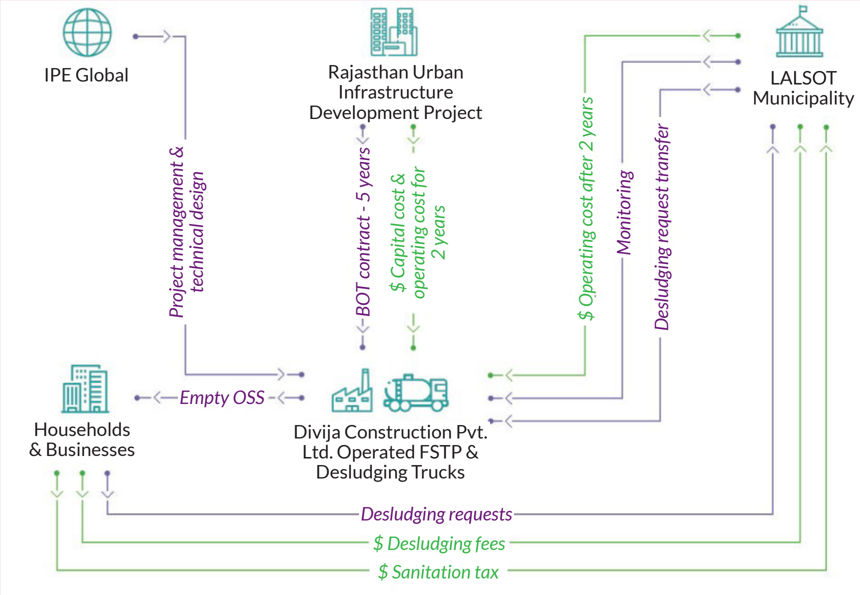
Relevance: The model is applicable to any town where the government predominantly provides emptying services, and limited or no private service providers exist. While this model enables direct linking of performance to pay, it requires specific interventions to assure universal coverage and inclusivity

Case Study: Lalsot Integrated E&T and FSTP, Rajasthan

CLalsot, a small town in Dausa District with a population of about 45,000, is one of the selected FSM pilot sites in Rajasthan. The town has neither private nor government desludging operators; households rely on operators from nearby towns such as Dausa, Gangapur, and Tonk to provide desludging services, resulting in high desludging costs. To address both desludging and treatment of FS, an integrated FSM model was planned for Lalsot

RUIDP (project management unit, Government of Rajasthan) and Lalsot Municipality issued a five-year BOT (build-operate-transfer) contract to Divija Construction Private Limited (Divija) for FSTP O&M and provision of desludging services. RUIDP provided capital funds and O&M funds for the first two years of operations, after which it is the responsibility of the municipality. Households will place desludging requests with the Lalsot municipality, which will set up a system to process customer requests, collect desludging fees, and coordinate with Divija to provide the desludging service. According to the contract, Lalsot municipality will ensure a minimum number of desludging trips for Divija, and Divija will be paid based on the number of trips made to the FSTP each month. Lalsot municipality will cover the cost of spare parts for the desludging truck. The municipality will pay fixed fees for FSTP O&M. After the first two years of operations, the municipality will cover the O&M cost of the FSTP through user fees for desludging and collection of sanitation tax, either through a sanitation surcharge on water bills collected by the Public Health Engineering Department (PHED) or sanitation cess on the solid waste management fee collected by Lalsot municipality. The relationships between the various stakeholders in the value chain are depicted in Figure below:

Figure 9.8: Relationship between the various stakeholders in the value chain



Source: Author

9.9 Models Emphasizing reuse at the end of the value chain

Business models in this section cover the treatment and reuse components in the sanitation value chain. Models for cost recovery through FS reuse are emerging as the FSM sector develops. The reuse models offer the following value propositions:

- Treatment of FS for a healthy community and environment
- Recovering nutrients from FS to produce high-quality compost as a soil ameliorant
- Recovering energy from FS to generate renewable energy for heating or electricity

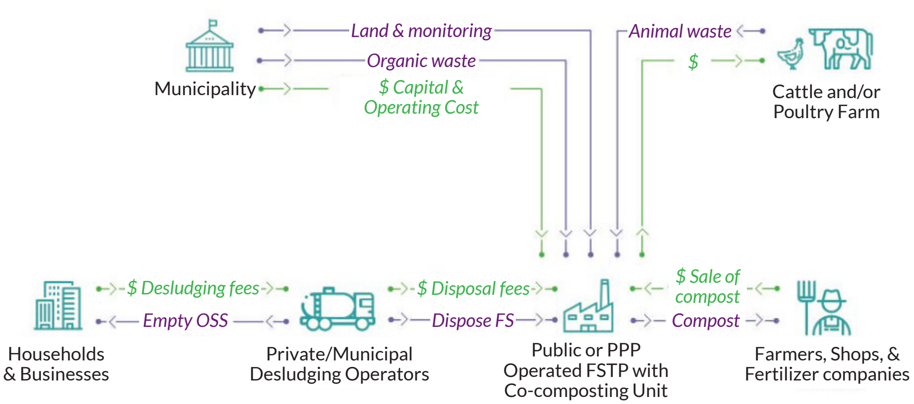
The reuse business models offer scope for reduced dependency on subsidies through increased operational cost recovery. These business models require a shift in approach, from the operator being a sanitation service provider to the operator becoming a seller of a product. The models require greater focus on market development through identification of appropriate customer segments, so that the cost of delivery of reuse products is minimized. Reuse models enhance energy or food security, promote the circular economy, and contribute to the reduction of GHG emissions.

1. Co-composting model

FS is collected from OSS by municipal or private desludging operators and transported to the FSTP. Organic solid waste is sourced from the municipality or collected by the private entity from households and markets. The dried and dewatered FS is co-composted with the organic waste.

The co-compost produced can be sold to multiple customer segments – farmers, farmer producer organizations, landscapers, nurseries, fertilizer companies and their distributors, and to the agro-forestry. The co-compost can be enriched with natural (e.g., rock phosphate) or industrial fertilizer and/or sold in a pelletized form for ease of transport. The relationships among the various stakeholders are shown in figure 9.9 below:

Figure 9.9: Composting Model



Source: Author

Market development is one of the key aspects of any compost-based model, especially in regions where a supply chain for fertilizer and/or compost does not exist. The compost should be marketed to the customer segment with the lowest cost of distribution. Alternately, targeting networks of farmers through farmer producer organizations can be a cost-effective delivery mechanism. Bulk purchasers such as agro-forestry, landscapers, and plantations have year-round demand in comparison to individual farmers, whose demand is seasonal.

Owner and operator: The business model is implemented by any of the following entities: public, private, or a PPP. For PPP, the municipality will enter into a contract with a private entity that can include design, construction, and operation of the treatment plant or only operation.

Capital cost: This has been largely covered by grants from donors and funds from state or national government programs for improving urban infrastructure. The business model has potential for a private entity to partially or fully invest.

Operating cost: The state or municipality typically finances this cost through a combination of local taxes and state and central government financial assistance. The FSTP could generate revenue from the disposal fees charged to desludging operators and from sales of co-compost. In a PPP setup, to encourage reuse, the municipality could, in the initial years, cover the operating cost until the market for compost is established; thereafter, operational costs funded by the municipality could be recovered through a percentage of the co-compost sold.

Relevance: The model is highly recommended for regions where farmers have high willingness and ability to pay for compost. It is also recommended for regions with poor soil health – i.e. low carbon content in the soil. It is most suitable for a municipality that wants to address management of both solid waste and FS in one facility. Municipalities that have implemented segregation of waste at the household level can implement the model within the FSTP by diverting organic waste to it.

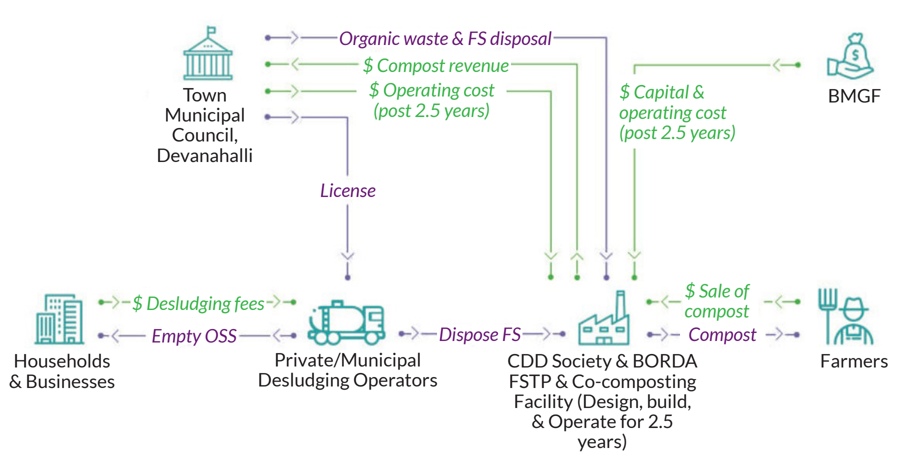
Case Study: Devanahalli FSTP and Co-Composting Unit, Karnataka

Devanahalli Town Municipal Council (DTMC) provided land and approvals for construction and raised funds for the FSTP (grants from CDD Society and BMGF). The DTMC was responsible for operating its desludging vehicle on a fee for service basis, issuing licenses to private desludging operators, and ensuring FS was disposed of at the FSTP. Once the co-composting facility was set up, the DTMC was also required to deliver organic waste to the plant. DTMC has been providing funds for desludging and FSTP operations, including the co-composting unit. The DTMC awarded an O&M contract to the consortium of Kam-Avida Enviro Engineers Private Limited, the CDD Society, and Cube Bio Energy Private Limited.

The co-compost produced is sold to farmers, who procure it from the FSTP's co-compost facility. The consortium collects payment for the co-compost and transfers it to the DTMC at the end of the month (after covering incidental costs for maintenance, if any, with the DTMC's approval). The municipality facilitates identification of clients for the co-compost. The treated water is used for landscaping within the FSTP. The relationships among the various stakeholders in the value chain are shown in Figure below

The capital cost of the FSTP, including the co-composting unit, is approximately INR 8.7 million. Since 2018, the DTMC has allocated an annual budget of INR 2.42 million for O&M of the FSTP, co-composting unit, and municipal desludging vehicle. The FSTP and co-composting project costs and revenue are summarized in figure 9.10 below:

Figure 9.10: FSTP and Co-Composting Project Costs and Revenue



Source: Author

Table 9.2 FSTP and co-composting project costs and revenue

Items	Cost in INR*
Capital Cost (FSTP & co-composting unit)**	8,704,000
Annual FSTP & Co-Composting Expense (estimated)***	
Labor for FSTP	328,865
Labor for co-composting	322,660
Provident fund & employee state insurance for FSTP & co-composting labor	119,620
Labor for overall operations management	500,000
Utilities for the FSTP	18,000
Utilities for co-composting	15,000
Raw materials (filter material) for the FSTP	18,000
Raw materials & consumables for co-composting	45,000
Tool repair/replacement	49,533
Service charges/incidentals	138,455
Total Expense	**1,555,133**
Annual FSTP & Co-Composting Revenue (estimated)	
O&M contract fee	1,555,133
Sale of co-compost****	87,281
Total Revenue	**1,642,414**

Source: Author

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Quick Assessment

1. Business models in FSSM are only effective when complemented with appropriate rules and regulations?
   a. True
   b. False

2. Pick the "key stakeholder" who have to be consulted while preparing a FSSM business model
   a. Political leaders
   b. Local police
   c. Resident welfare associations
   d. All of the above

3. Which of the following are the primary factors that influence the tariffs: for a private desludging operator while fixing the tariff?
   a. Distance to customer location
   b. Labour wages employed
   c. Access to the household – length of pipe, etc.
   d. None
   e. All of the above

4. Even if private E&T operators are available and provide a decent service to users, governments should still procure and operate E&T trucks
   a. True
   b. False

5. Operations of a faecal sludge treatment plant is outsourced to private operators for which of the following reasons
   a. Private operators bring in expertise of O&M
   b. It is easy to monitor the performance of a private operator
   c. It is cheaper for the private operator to manage the facility
   d. Option A and B
   e. Option B and C

** For answers please refer Annexure I*

Chapter 10

Health and Safety of Sanitation Workers

Recap

After understanding the functional group wise sanitation systems in the previous chapters, it is essential to ponder and understand the role of the key players in Sanitation value chain, those are the Sanitation workers. This chapter shall focus on the government initiatives towards their health and safety.

Training Objectives

- To overview the role of sanitary workers and understand the various risks faced by them.
- To understand the legislations and initiatives taken by the government for the sanitation workers.
- To overview the protective gears and equipment provision for the workers with the additional initiatives by few ULBs.

Training Outcomes

- To be able to understand the importance of sanitary worker's role in the sanitation sector
- To get the understanding of current government initiatives for the sanitation workers
- To gain knowledge of the prevalent legislations governing the health and safety of the workers
- To understand the role of ULBs for ensuring the health and safety of sanitation workers
- Understanding the various protective gears and equipments provision with additional initiative cases

Chapter Contents

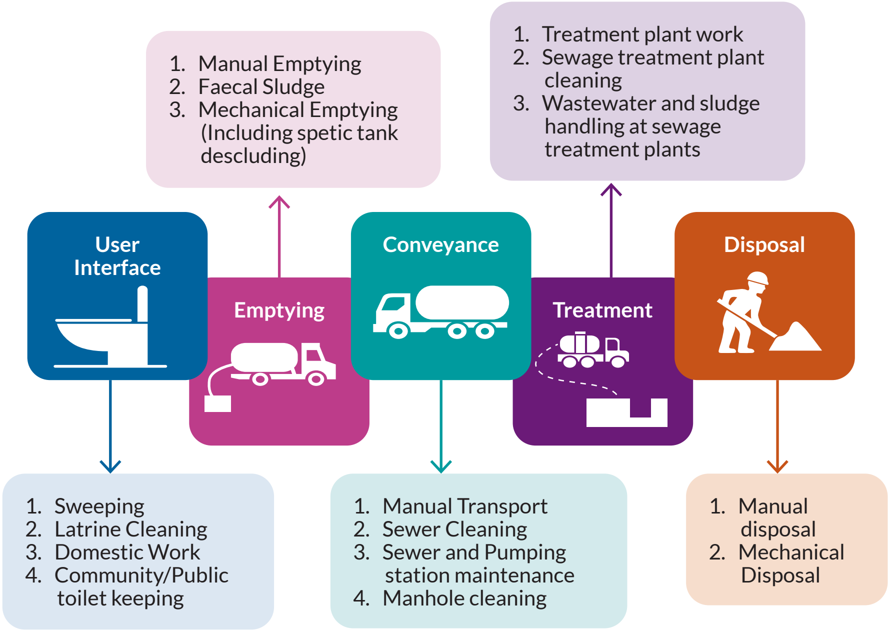
10.1 Context and Rationale

Significant sanitation services are provided by sanitation workers. This is also at the detriment of their safety, health and working conditions. The size of sanitation workers is unknown, and sanitation workers are among the most unseen and ignored in society. It is only when these vital facilities collapse, when society is faced with faecal waste in ditches, highways, rivers, and beaches, or with occasional media coverage of sanitation workers' deaths that the everyday practise and condition of sanitation workers comes to light. It has therefore become important for the country to protect these informal workers by granting them their deserved rights. (Bank, et al., 2019)

Who are Sanitation Workers?

The term sanitation workers refers to all people—employed or otherwise—responsible for cleaning, maintaining, operating, or emptying a sanitation technology at any step of the sanitation chain. This includes toilet cleaners and caretakers in domestic, public, and institutional settings; those who empty pits and septic tanks once full and other fecal sludge handlers; those who clean sewers and manholes; and those who work at sewage and fecal waste treatment and disposal sites (see Figure 10.1) (Bank, et al., 2019).

Figure 10.1: Different kinds of Sanitation Work



Source: Author

10.2 Status and Challenges faced by Sanitation Workers in India

Millions of sanitation workers are surrounded and threaten by hazardous working conditions. They are unconsciously jumbled between a tiny blockage of life and death. In India between 2017 and late 2018, one sanitation worker died every five days (Root, 2019). It is also estimated that five million people in India are engaged in sanitation work, of which two million are likely to be engaged in 'high-risk' work such as cleaning sewers and septic tanks[1]. Crucially, sanitation workers and their families remain trapped in a critical situation in which they are forced to perform de-humanising and unsafe practices, in spite of huge associated risk with it. This is India's foremost sanitation challenge addressing this issue in a comprehensive manner should be the cornerstone of India's next sanitation policy. On World Toilet Day, ILO, Water Aid, the World Bank and the WHO report (Bank, et al., 2019) emphasised on more concentrated and focused efforts by all sectors to improve working conditions. The issue hasn't been taken so seriously and greater need to become our priority to achieve SDGs.

"Without [sanitation workers], we won't be able to live in cities or even villages in a clean and healthy way."

— Anahitaa Bakshi, Dalberg

Figure 10.2: Highlights of the status of Sanitation Workers in India

Sanitation worker dies hours after vaccination in Vadodara

TNN | Updated: Feb 1, 2021, 10:28 IST

A- A+

Five sanitation workers killed while cleaning sewer in Ghaziabad, UP CM announces financial assistance

Five sanitation workers had died while cleaning a sewer in Nandgram area of Ghaziabad on Thursday morning

Delhi: Sanitation worker dies cleaning sewer in Shahdara, another critical

The incident took place at the CBD ground in Karkardooma, near the BSES office. Over five workers under a private contractor were pressed into service to clean a 15-feet-deep sewer.

In India, a sanitation worker dies every 5 days. Here's how to change that.

By Rebecca Root // 19 November 2019

DELHI NEWS

Sanitation worker dies in Delhi hospital sewer; 10th death in over a month

At least nine sanitation workers have died in sewers in a little over a month. Only last week, two brothers died in similar circumstances after they went in to clean a clogged sewage tank in Shahdara.

By HT Correspondent | New Delhi, Hindustan Times

UPDATED ON AUG 21, 2017 11:49 AM IST

Two sanitation workers in Odisha choke to death in manhole

In a tragic incident, two sanitation workers of a family died of suffocation while cleaning a sewer line of Public Health Engineering Organisation at IRC village on Wednesday.

Published: 18th May 2017 06:27 AM | Last Updated: 18th May 2017 06:27 AM

Source: Author (referred by newspaper articles)

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[1]Singh,Arkaja & Dasgupta, Subhagato (2019) "Safe and Dignified Sanitation Work: India's Foremost Sanitation Challenge", CPR, New Delhi https://cprindia.org/news/7910#:~:text=It%20is%20estimated%20that%20five,cleaning%20sewers%20and%20septic%20tanks.

Key challenges and risks faced by the Sanitation workers[2]

The following are the key challenges and risks faced by sanitation workers that can be categorized in four dimensions:

Operational and Environmental Health and Safety[3]

The sanitation workers, who aren't protected by adequate and appropriate health and safety measure, are exposed to different types of occupational and environmental hazards like injuries, chemicals contacts, infections, accidents and direct contact with fecal sludge and wastewater and working in dangerous and confined spaces, etc. (see Figure 10.3). The hazards can be classified into Diseases and Accidents and are mentioned below in detail:

1. Disease

Workers for sewerage and on-site systems face the risk of various health problems by virtue of their occupation since they are exposed to a wide variety of chemicals, micro-organisms and decaying organic matters that are present in sewage. Table 10.1 shows the types of diseases and its causes.

Table 10.1: Types of diseases and their causes

S.No	Diseases	Causes
1	Infections: • Leptospirosis • Hepatitis • Tetanus • Dipyheria	Pathogens present in sewers or sewage
2	Dermatitis	Chemicals, minerals oil and tar
3	Respiratory Symptoms	Endotoxins, Bio- aerosols

Source: Rajnarayan, 2008

2. Accidents

Workers for sewerage systems and on-site systems are exposed to the risk of accidents during work. They are exposed to different kinds of accidents which usually take place in a confined place in sewers and STPs, which are listed and explained below:

- **Confined space hazards:** Confined space hazards include risk of oxygen deficiency, hydrogen sulphide poisoning and risk of combustible gases.

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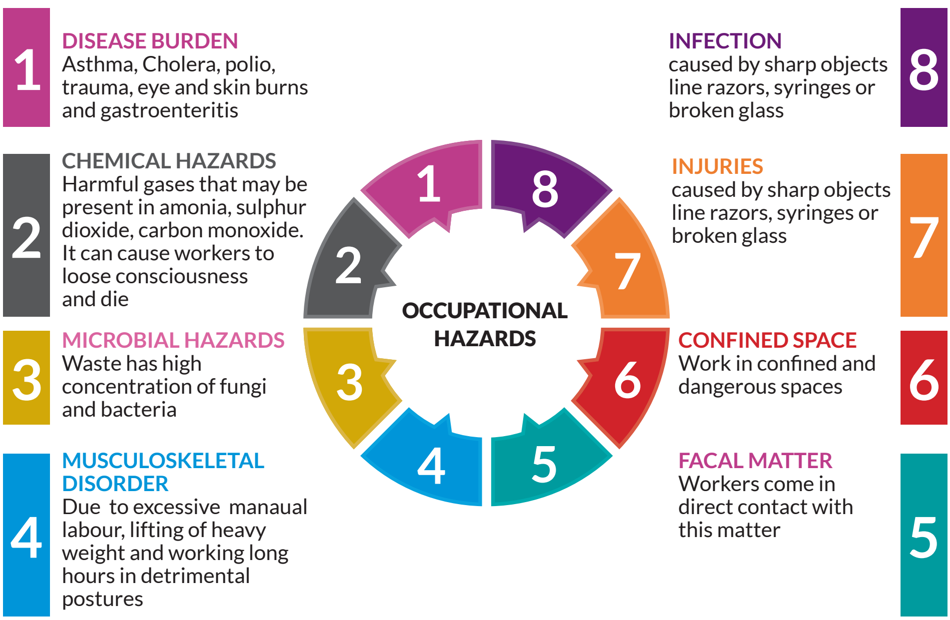
[2] *World Bank, ILO, WaterAid, and WHO. 2019."Health, Safety and Dignity of Sanitation Workers: An Initial Assessment." World Bank, Washington, DC. https://www.who.int/water_sanitation_health/publications/health-safety-dignity-of-sanitation-workers.pdf*

[3] *This section has been refereed from CPHEEO guidebook* (CPHEEO, n.d.)

- **Chlorine poisoning:** It is a yellowish green gas and has a specific weight that is 2.49 times heavier than air. At a concentration of 30 to 60ppm, if you are exposed for 30 minutes it can result in death.
- **Fall:**These accidents usually occurs while climbing/ descending ladders or while working at high elevations.
- **Slip:** Slippery surfaces can lead to slip while working in STPs and sewers.
- **Electric shock:** These can occurs due to absence of insulated protective gear, getting in direct contact with live parts.
- **Fire:** It can be very painful and can serious injuries. The structural damage can be very costly.

Many informal and temporary sanitation workers operate with little to no formal training on the occupational risks of their work. Multiple factors cause poor occupational health and safety (OHS). It is clear that mitigating the OHS hazards along the sanitation service chain (whether manual or mechanized) needs to be addressed systemically. Where sanitation workers are predominantly from lower-income segments of society, their occupational hazards tend to be compounded by living in overcrowded, low-income settlements, with poor water and sanitation and, many times, in flood-prone environments. These conditions increase the environmental health risks.

Figure 10.3: Different kinds of Occupational Hazards



Source: CPHEEO

Legal and Institutional Challenges

Sanitation workers often suffer because of weak legal protection and lack of enforcement of existing rules. Many countries either lack laws and regulations that protect sanitation workers or the laws in place are not enforced or are not enforceable in practical terms. Manual emptying, often the riskiest sanitation work, is often characterized by informality. Efforts to prohibit manual emptying have not necessarily curtailed the practice but instead have forced it underground. By contrast, in South Africa, manual work is formally recognized as part of the sanitation services package, with workers being provided training and occupational health mitigation measures being in place.

Regulation Protecting Sanitation Workers (CPHEEO)

In South Africa, since the 1994 political transition from apartheid, new labor laws have been established to protect vulnerable workers. Three main regulations governing sanitation work attribute responsibilities to both the employer and the employee. The Basic Conditions of Employment Act (1997) offers protections to workers. The National Occupational Health and Safety Act (1993) puts employers in charge of protecting worker health and safety by minimizing and mitigating risks in the working environment, as well as providing training and precautionary measures to protect the health and safety of their workers. The Regulations for Hazardous Biological Agents (2001) mandate that any person who may be exposed to a biohazard must comply with the employer's instructions, such as wearing personal protective equipment, reporting accidents, and completing training or medical examinations.

Financial insecurity

Sanitation workers, especially those employed on temporary or informal terms, are poorly and irregularly paid. The extent to which sanitation markets are formal or informal varies significantly between countries. In India, some manual workers reported that they have been paid in food rather than money. Tight financial margins in the formal private sector can also compromise the conditions for workers; the investment and maintenance of PPE, mechanization, or both may not be considered financially viable.

Social Stigma and Discrimination

Low-grade, unskilled sanitation workers often face social stigma and discrimination. This is true when sanitation is linked to a caste-based structure and often allocated to castes perceived to be lower in the caste hierarchy, such as in India, where sanitation work is perceived to belong to the Dalit caste. This stigma compounds the social ostracizing and limitations on social mobility that workers face and often results in intergenerational discrimination, where children of sanitation workers often struggle to escape the vicious cycle of limited opportunities and sanitation work. More generally, however, low income, financial stress, informality and the social stigma attached to handling feces can form a multigenerational poverty trap for many low-grade sanitation workers. These factors manifest in implicit or explicit discrimination, which hinders workers' social inclusion, their opportunities to shift careers, and social mobility. Furthermore, alcoholism and drug addiction to evade the working conditions are common among some sanitation workers. To protect their families' safety and well-being, the sanitation workers prefer hiding profile and their occupation from their communities.

10.3 Legislations

It is estimated that five million people in India are engaged in sanitation work (that is, work relating to the cleaning and management of toilets and human excreta), of which two million are likely to be engaged in 'high-risk' work such as cleaning sewers and septic tanks (Singh & Dasgupta, 2019). The legal framework in India recognizes the right to sanitation and the rights of workers in hazardous employment. The following are the various regulations taken up by the Government of India till 2020 to curb the practice of manual scavenging.

Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act, 2013

The Act has already been discussed in Chapter 2 of the module. PEMSRA Act*, 2013 deals with two distinct aspects – (a) manual scavenging, and (b) hazardous cleaning. According to the Act, the manual cleaning, carrying, disposing of, or otherwise handling, human excreta in an insanitary latrine or in an open drain or pit has been banned. But the Section 2(1)(d) of the Act on Hazardous cleaning prescribes, Manual cleaning of a sewer or a septic tank without the protective gear, cleaning equipment, and observance of safety precautions prescribed under the Rules.

Rule 4 of Manual Scavenging Rules states that:
Any person engaged to clean a sewer or a septic tank shall be provided by his employer, protective gear and safety devices including, PPE items, safety gears items and other machinery. The equipments are described in detail in the next section.

Safaimitra Suraksha Challenge (MoHUA, 2020)

To abolish the manual scavenging practice, the Government launched the Safaimitra Suraksha Challenge and provides for the evaluation of the cities' performance through certain parameters.

Aim of the Challenge

To save the lives of formal/informal workers engaged in septic tank/sewer cleaning i.e., All informal workers to be identified by the city to integrate them with formal mechanism in place for cleaning septic tanks/sewer lines.

Objectives

- Thrust on mechanized cleaning of sewers and septic tanks, to minimize necessity of human entry
- Availability of proper protective gears and equipment in case manual entry is unavoidable.
- Creation of conducive eco-system through:
  - trained workforce,
  - large scale citizen outreach,
  - 24x7 helpline,
  - enforcement mechanisms

National Safai Karamcharis Finance and Development Corporation (NSKFDC) (MoHUA, 2020)

NSKFDC under its Swachhta Udyami Yojana (SUY) provides financial assistance for procurement and operation of sanitation related equipments/vehicles with a view to promote mechanised cleaning.

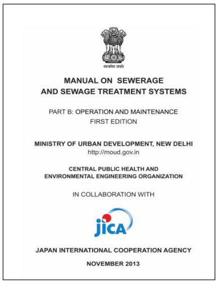
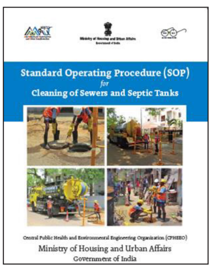
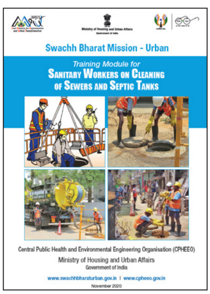
Swachhta Udyami Yojana

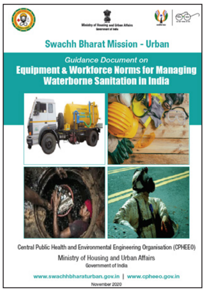
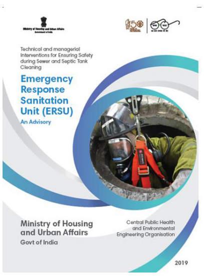
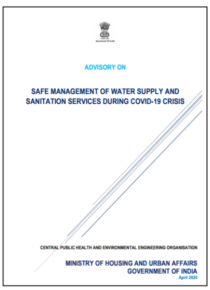
The purpose of the SUY scheme is to prevent manual hazardous cleaning and to promote mechanised cleaning. Two broad implementation models of SUY are as under:

For Target Group	For Urban Local Bodies (ULBs)
• Loans up to Rs. 15 Lakhs for mechanised cleaning equipments through channelizing agencies • 4% rate of interest with upto 10 years repayment period • 1% interest rebate for women and 0.5% for timely repayment • Provision of Capital Subsidy upto 3.25 Lakhs per unit	• Direct loans to ULBs for mechanised cleaning equipments costing up to Rs. 50 Lakhs per unit • 4% rate of interest with 1% rebate for timely repayment • Repayment period of up to 10 years

Source: (MoHUA, 2020)

Table 10.2 Manuals prescribed for ULBs to implement the Manual Scavenging Act

Government Guidelines and Advisories			
Name of document	**Name of document**	**Link**	**Remarks**
	Chapter 9: Occupational Health Hazards and Safety Measures – CPHEEO Guidelines	http://cpheeo.gov.in/upload/uploadfiles/files/operation_chapter9.pdf	Prescribes using protective devices to avoid accidents
	Safaimitra Suraksha Challenge-Toolkit	http://swachhbharaturban.gov.in/sbmdocumentfile.aspx?DOCTYPE= 9999& DOCID=34&id=e6g2sh8m3b6g24bb	Toolkit for ULBs
	IS 11972, CPHEEO manual and Standard Operating Procedure for Cleaning of Sewers and Septic Tanks by MoHUA	http://cpheeo.gov.in/upload / 5c0a062b 23e94SO PforcleaningofSewersSepticTanks.pdf	Training and provision for Sanitation workers
	Training Module for Sanitary Workers on Cleaning of Sewers and Septic Tanks	https://niua.org/scbp/sites/default/files/Training_Module_for_Sanitary_Worker_on_Cleaning_of_Sewers_and_Septic_tank.pdf	

Government Guidelines and Advisories			
Name of document	**Name of document**	**Link**	**Remarks**
	Guidance Document on Equipment & Workforce Norms for Managing Waterborne Sanitation in India under SBM-U	http://swachhbharaturban.gov.in/sbmdocumentfile.aspx?DOCTYPE=9999&DOCID=33&id=e6g2sh8m3b6g24bb	Managing Waterborne Sanitation in India is prepared keeping in view the Safai-mitra Suraksha Challenge, 2021.
	Emergency Response Sanitation Unit – An Advisory by MoHUA	https://static.pib.gov.in/WriteReadData/userfiles/SBM%20ERSU%20Book_Final.pdf	Campaigns to educate on the Act, legal provisions against defaulters
	Safe Management of Water supply and Sanitation Services during COVID-19 Crisis by MoHUA	https://drive.google.com/open?id=12eMDn-9GsXUuPKkx8bjcJzdT8ph2AnMY	PPE gear provision and usage
	SBM and DAY-NULM Convergence Guidelines, 2018	https://nulm.gov.in/PDF/NULM_Mission/SBM_NULM_Convergence_Guideline.pdf	Provisions for informal workers at all levels (Center, State, city and ward/slum level)

Source: Author

10.4 Safety Measures for Sanitation workers (CPHEEO)

Below are the detailed measure and steps to be taken with respect to above mentioned occupational hazards (see section 1.2.1)

Confined Spaces

The potential for build-up of toxic or combustible gas mixture and/or oxygen deficiency exists in all confined spaces. The following things need to keep in mind before entering into a confined space:

1. **Measurement Method:** Before measuring the confined space atmosphere, make sure to perform the zero error correction of the device in fresh air. Measurement should be taken at three levels- top, middle and bottom, since the oxygen level differs in different spaces. Keep record of the results on confined space entry checklist.

2. **Ventilation Method:** If the measured results indicate any hazards make sure to ventilate the location before starting any work. Operate the ventilation equipment's continuously to ensure the safety atmosphere during the work. Bring the blower outlet end close to the workplace and continue to blow air at the rate of 10 m^3/ minute per person or greater.

3. **Evacuation Provision:** The worker should make following provision:
   - Keep prepared breathing apparatus, ladder, rope, seat belt and other gear for use in evacuating or rescuing workers in case of a crisis.
   - Inspect protective gear before start of work and ensure that they are ready for use at all times. Repair or replace gear and equipment that are defective.
   - Bear in mind that gas protection mask or dust protection mask is ineffective against anoxia.
   - Non-spark tools should be used in confined spaces.

4. **Stationing Safety Guard:**
   - The work supervisor should station a security gatekeeper to recognize irregularity at an early phase and to make a prompt and appropriate action.
   - The safety guard should be stationed outside the opening if the situation inside the confined
   - space can be monitored from the outside.
   - The safety guard should check access to the workplace of the workers engaged in the work.

Instructions and duties before entering into a confined space

Figure 10.4: Instructions and duties before entering into a confined space

Precautions against Gas Hazards

Precautions against Infections

Precautions while working near Vehicular Traffic

Source: (CPHEEO)

Operating Guidelines (CPHEEO) for safety measures

Requirements for Duties into Confined Space

Not Requiring Entry

Routine medical examination shall be made. Those with the following disabilities shall not be selected as any of the disease involves risks to the health and safety of both the prospective employee and/or other employees:

- History of fits, blackouts, fainting attacks;
- Chronic skin disease
- Meiners disease or diseases involving loss of balance.

Requiring Entry

Persons considered for employment in confined spaces shall be physically fit and capable of understanding training given. Those with the undernoted disabilities shall not be recruited for this type of work and those who contract these should cease to be employed in this capacity:

- A history of fits, blackouts or fainting attacks;
- A history of heart disease or disorder;
- High blood pressure;
- Asthma, bronchitis or a shortness of breath on exertion;
- Deafness;
- Meiners disease or disease involving giddiness or loss of balance;
- Claustrophobia or nervous or mental disorder;
- Back pain or joint trouble that would limit mobility in confined spaces;
- Deformity or disease of the lower limbs limiting movement;
- Chronic skin disease;
- Serious defects in eyesight; and
- Lack of sense of smell.

Employees should be medically re-examined at reasonable intervals, taking into account the person's age and duties.

Chlorine Poisoning

The chlorine containers should be kept away from direct sunlight or heating units and should be stored in a cool and dry place. It is approximately two and half times heavier than air, vents should be provided at floor level. Also wearing a face shield should be a must while changing the chlorine containers.

Fall

To prevent the workers falling into a manhole following precaution needs to be followed by the work supervisor:

- Ensure that nobody falls from ladders (including metal rungs) and that tools are not dropped from ground level.
- Wear uniform suitable for the work and wear the necessary protective gear.
- Check that the ladder to the manhole is not corroded or worn out.

Slip

- Special anti-skid shoes with metal cladding over the "toe" should be provided by the employer for the workers. These shoes should be used by the workers only within the STP.
- Construct anti-skid floors and keep them free from oil and grease.

Electric shock

- Methods for safe handling of electric equipment should be drilled into the workers and inspection and maintenance methods for electric equipment should be established.
- Special precautions should be taken to prevent electric shocks at locations where sewage is likely to accumulate (grit chamber, pumping room and in pipe gallery).
- Rubber-soled shoes may be used to prevent electric shocks.

Fire

Every facility should develop a fire prevention plan with input from the local fire officers, fire chief and insurance company.

The plan may be very simple or very complex, depending on the specific facility needs. Some items, which may be included in any plan, are:

- Regulate the use, storage and disposal of all combustible materials/substances.
- Provide periodic clean-up of vegetation in and around the plant.
- Develop written response procedures for reacting to a fire situation to include evacuation.
- Provide required service on all fire detection and response equipment (inspection, service, hydrostatic testing).

- Routinely inspect fire doors to ensure proper operation and free access.
- Immediately repair, remove or replace any defective wiring.
- Restrict the use of any equipment, which may provide a source of ignition in areas where
- Combustible gases may exist.
- Maintain clear access to fire prevention equipment at all times.

Safety Signs

To warn and protect workers and visitors against any danger, safety signs should be displayed in all STPs and hazardous places as shown in Figure 10.5 for better security and safety of the workers.

Figure 10.5: Safety signs for Prohibition, Warning and Mandatory for workers

WARNING SMART SIGN

Source: (Safetysignindia)

10.5 Personal Protection and Protective Devices

For proper functioning of the sanitation systems, the workers play a vital role. They come into direct contact with hazardous waste and are exposed to occupational and environmental hazards. One of the key factors for occupational hazards is the lack of proper and adequate use of personal protective equipment (PPE). The importance of PPE provisioning and usage has been amplified by National and State Governments alike for permanent, contract and private service providers. (ASCI, 2020). According to the Rules the various protective gear and safety devices including, PPE items, safety gears items and other machinery provision for Sanitation workers prescribed are:

Figure 10.6: Sanitation Worker

Source: ASCI, 2020

Figure 10.7: PPE, Safety Gears and other machinery provision for sanitation workers

PPE Items	Safety Gear Items	Other machinery
• Reflecting Jacket • Safety helmet • Normal face mask • Hand gloves (pair) • Safety Gumboots(pair) • Safety body clothing	• Safety Tripod Set • Nylon Rope ladder • Blower with Air Compressor • Gas Monitor (4 Gases) • Full body Wader Suit • Gas Mask • Breathing Apparatus • Safety body Harness • Air Line Breathing Apparatus	• Sewer Inspection Camera Apparatus • Hydro Jetting Machines • Power Bucket machine • Power Rodding Apparatus • Hydraulic Sewer Root cutters

Source: (ASCI, 2020)

Personal Protective Equipment (PPE)

According to CPHEEO guidelines for Standard Operating procedures
Personal protective equipment refers to protective barriers / device or clothing that is worn by a worker in order to prevent any part of his or her body and that of the clients from coming into contact with a hazard(s) present at the place of work. Selection of PPE's will be done according to the risk assessment for specific work areas.

General guidelines for using PPE

- Assess the risk of the exposure to a hazard
- Select appropriate PPE
- Fit the PPE to the person
- Use the right PPE for the right purpose
- Avoid any contact between contaminated PPE and services or people outside the work area
- Discard the PPE appropriately
- Do not share PPEs
- PPE should never be carried home and should be cleaned within work area.

Figure 10.8: Safety kits for Sanitation workers

Safety Helmet (unisex): Road sweeping/drain cleaning/ desludging/FSTP

Safety Goggles: Desludgers and FSTP workers

Nose Mask with valve: For all sanitation workers

Face shield attachable to helmet: Only for FSTP operators

Gum boots: For all drain and CT/PT cleaners and desludgers

Half face air purifier respirator with cartridge: Only for FSTP operators

Gloves: CT/PT Cleaning, Desludging

Jacket: Road sweeping/drain cleaning/ desludging/FSTP

Safety shoes (steel toe): For SWM, road sweeping and FSTP workers

LED Flashlight: To be used for security or maintenance purpose when visibility is

Raincoat: To be used for security or maintenanc e purpose during heavy rains.

First Aid Kit: It includes all basic first aid items (compress, bandages, antiseptic wipes, non-latex gloves, scissors, sterile gauze, tweezers, aspirin tablets, etc.).

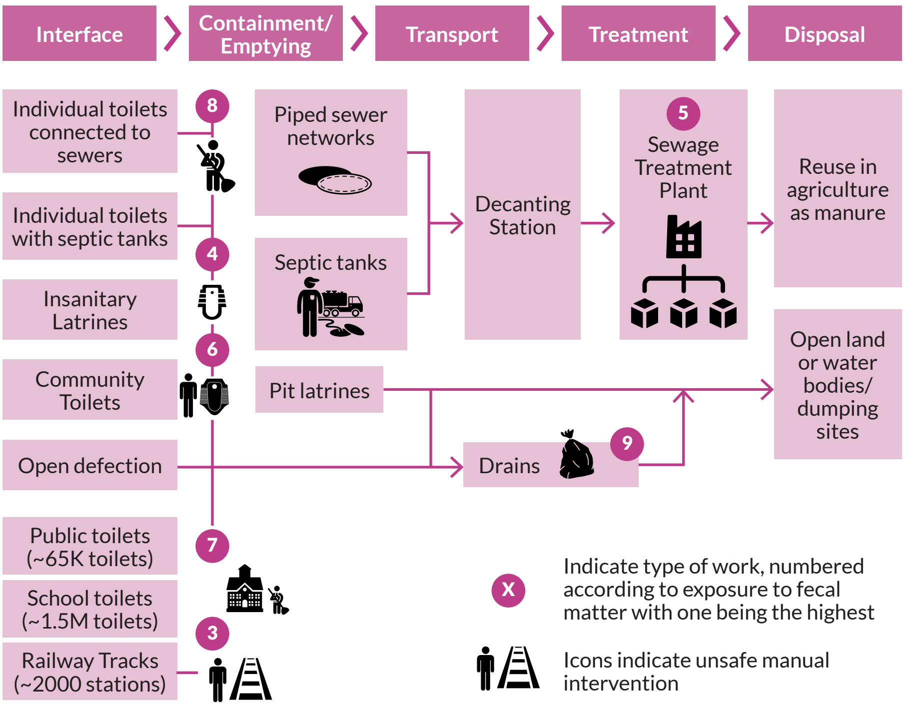
Barrier cone & Caution board: To be used during roadside sewer works.

Image source: CWAS

Job specific PPEs for Workers

Sanitation workers are broadly understood to be a single nebulous category, but there exists nine types of work across the value chain (see Figure 17). Based on the CPHEEO guidelines varied PPEs are prescribed based on the sanitation roles workers play in their day-to-day lives (see Figure 10.9). Below is the detailed categorization of sanitation workers roles, responsibility and PPEs assigned to the workers.

Figure 10.9: Sanitation role workers play in their day-to-day life



Source: (Dalberg, 2017)

Note: Icons indicate unsafe manual intervention; interface use: insanitary latrines include without slab, night soil serviced by humans/ animals; open defecation figures include night soil disposed into open drains; latrines with slabs/ improved pits and flush latrines connected to other system.

Figure: 10.10: Job specific categorization of PPEs for Sanitation worker

Street Sweepers and door-to-door waste collectors		
 Safety Goggles with or without strap.	 Nitrile Gloves– 18” in length	 Particulate Mask with a nose clip
 PVC water proof apron	 Comfortable shoes without steel toe	 High visibility reflective jacket

Community/Public Toilet		
 Particulate Mask with a nose clip	 Nitrile Gloves– 13” in length	 PVC water proof apron
 Comfortable shoes without steel toe	 High visibility reflective jacket	 Cotton sun hat

Open Drain Cleaners

 Particulate Mask with a nose clip	 Nitrile Gloves– 18” in length	 Safety helmet
 Thigh waders with attached boots	 High visibility reflective jacket	 Safety goggles with straps

Sewage treatment plant/Faecal sludge treatment plant operators

 Safety helmet	 Nitrile Gloves– 18” in length	 Particulate Mask with a nose clip
 PVC water proof apron	 Gumboots without steel toe	 High visibility reflective jacket

Desludgers (Mechanical)		
 Respirator	 Nitrile Gloves– 18” in length	 Safety helmet
 Gumboots without steel toe	 High visibility reflective jacket	 Safety goggles with straps

Source: (UMC, 2020)

10.6 Areas of Action (WorldBank, 2019)

Decent toilets and safe working conditions are human rights. Sanitation workers provide a vital public service that is essential for a country’s health and development. The world will never end poverty until everyone, everywhere has access to decent toilets, but this provision must go hand in hand with protecting the life, health and dignity of those who work to bring us these essential services. Many of the challenges sanitation workers face stem from their lack of visibility in society. Improving the lives of sanitation workers will take action from many different parts of the society such as:

- Governments should put in place laws that recognise the work of the sanitation workforce and ratify relevant international labour standards.

- They must put an end to manual scavenging, and offer rehabilitation and alternative livelihoods for those affected, especially women.
- Formalising sanitation work by providing workers with decent working conditions and social protection, and by enforcing regulations.
- Governments and human rights organisations should support sanitation workers' efforts to organise and realise their rights, including through unions and associations.

The prime responsibilities of the government and various other development agencies and donors should ensure that the rights and the welfare should be embedded into all programs related to urban sanitation. There is a greater need to aware and visualise the community and public to support the vital work being carried out by the sanitation workers which benefits all the citizens.

Recommendations for uplifting Sanitation Workers[4]

1. Adequate provisions for Personal Protective Equipment (PPEs)

The frontline workers working in hospital and health facilities, faces acute shortage of PPEs (Dev, 2020). Hence, the need of the hour should be to provide the workers with the adequate and appropriate PPEs including masks, rubber gloves, soap etc. For benefitting the sanitation workers, in India various cities has made tremendous efforts such as Maharashtra, the city has delegated ULBs to utilize the Fourteen finance (PRS) commission funds to purchase appropriate PPEs and to allow workers to work in shifts. In Telangana, self-help groups have been roped in to produce masks for sanitation workers (Sridhar, 2020).

2. Financial Support

Financial support can be provided at individual or at organizational levels. For protecting the salary of the workers MoHUA has issued an advisory stating to protect the salaries of the workers, if they fail to report to duty due to lockdown. Also Ministry of corporate affairs has declared that CSR may utilize funds for COVID19 related activities including preventive measures, sanitation and disaster management. While such efforts by government at national, state, and city levels are welcome, they do not reach all the five million sanitation workers in India.

[4] *Akhilesh, Abhinav et al. 2020 "How can we support sanitation workers during COVID-19", idr https://idronline.org/how-can-we-support-sanitation-workers-during-covid-19/*

3. Offer support at a local level

Resident Welfare Associations (RWAs) should ensure that sanitation workers who work in their localities should have proper PPEs. If required, funds can be collected at a local level to ensure that workers have proper safety gear. RWAs can also support the sanitation workers' organizations to ensure that all sanitation workers are provided health insurance and regular health checks. MPs, MLAs, and municipal councilors have annual funds available for development in their respective constituencies and can be encouraged to allocate amounts from these for the welfare of sanitation workers.

4. Provide access to food and boarding facilities

In Chennai, sanitation workers are provided free meals at Amma Canteens (Muralidharan, 2020). Local communities could also pool resources to ensure that sanitation workers have access to food and other supplies. This will ensure that they do not have to worry about providing for their families while they are at their jobs. In terms of helping they self-isolate, to keep their families safe, state governments should explore the option of providing sanitation workers with boarding in designated hostels and residential facilities. The Delhi government has undertaken a similar step, wherein hotel rooms have been rented for doctors who do not want to go home for the fear of infecting their families with COVID-19 (ET, 2020).

It is important to raise the profile of sanitation workers and pay them their due respect, acknowledging their importance as frontline warriors. Because, just as the nation's health workers tirelessly work to save lives, our sanitation workers have also been working in every ward and *mohalla* to ensure that we remain safe and healthy.

Role of Urban Local Bodies for ensuring the safety of the Workers

The urban local bodies play a vital role in ensuring a safe working environment for all the sanitation workers. They are the critical stakeholder responsible for ensuring health, safety and dignity of all the workers. The following are the defined roles a ULB can play to ensure and uplift the safety of the workers in their respective areas:

Figure 10.11: Roles of ULBs for ensuring the safety of sanitation workers

1 Regulation of Sanitation Work	2 Training	3 Provision of Entitlements	4 Enablers
1. Enumeration of workers 2. Empanelment of private service providers 3. Adoption of standard operating procedures 4. Mechanization of Sanitation work 5. Prohibtion of Manual scavenging 6. Setting up an ERSU	1. Training of sanitation workers 2. Capacity building of ULB staff	1. Service level benefits 2. Health and safety 3. Social security benefits for workers and their families	1. Grievance redressal system 2. Sensitizing Citizens 3. Recoginition of sanitation workers

Source: (JUNEJA, et al., 2020)

1. Regulation of Work

- **Enumeration of sanitation Work -** ULB should maintain records of all sanitation workers engaged in their jurisdiction either directly or via contractors or engaged informally.To know the actual number of the sanitation worker currently engaged in the city, ULB should conduct surveys and assess the extent of linkages to the government schemes. All the workers should be registered with their ULBs. Registering them will aid the ULBs in planning for PPE provision such as what type of PPEs that should be provided to each sanitation worker category, the sizes and numbers of each PPE to be provided, replenishment of PPEs plan etc. In order to carry out the survey and registration process, ULBs can reach out to sanitation workers by either their own sanitation staff or by engaging:
    - NULM teams stationed at the state departments
    - Self-help groups/ common interest groups formed under NULM program in their cities
    - Local organizations working with sanitation workers

- **Empanelment of private service providers:** All sanitation work should be regulated by the ULB or through agencies empaneled by the ULB. For empanelment, following steps should be followed:
    - **Publish notice** asking all private contractors to register/empanel with the ULB- The ULB should issue a public notice asking all private contractors engaged in desludging of septic tanks and emptying of soak pits to register themselves with the ULB. Such registration is mandatory for carrying out operations in the city. Unregistered contractors should be penalized.

- ULB should issue details, terms & conditions of empanelment on their portals- When empaneling contractors, ULBs should ensure that the contractor has adequate staff and equipment for carrying out the work. ULB should specify the validity of registration of private contractors upon empanelment and contractors should re-register after the specified period.
- Training for de-sludging and emptying of septic tanks and soak pits- The ULB should ensure that all staff engaged by them directly or through private contractors is adequately trained in standard operating procedures and safety related aspects.

To ensure the safety of sanitation workers, a typical contract by ULB should include the following:

1. **Scope of work**
   - Provide required equipment & devices
   - Use of safety devices and equipment
   - Safe transport and disposal of solid and liquid waste

2. **Provision of cleaning equipment and vehicles:**
   - The contractor will be required to provide for, and operate cleaning equipment and vehicles and also provide all the necessary materials for maintenance of these.

3. **Capacity building**
   - Orientation on their rights and entitlements
   - Training on SOPs
   - Training on use, O&M and safe disposal of PPE

4. **Access to entitlements**
   - Registration/ ID card
   - Paid leaves
   - Regular health check-up
   - Facilitating linkage with existing schemes

5. **Provision of safety equipment for staff**
   - No worker will come into physical contact with the fecal sludge, during emptying or otherwise.
   - Each worker should be given, and be wearing, safety equipment. For instance:
     - Safety googles or glasses with side splash protection
     - Dust mask that fits over nose and mouth
     - Clean rubber gloves
     - Dedicated body suit
     - Footwear like gumboots or safety shoes
     - Battery operated torch
   - The Contractor also needs to provide workers access to clean water, soap, disposable paper towels, and a first aid kit in the workstation.

- **Adoption of standard operating procedures:** ULBs should adopt standard operating procedures for all sanitation jobs. The ULB staff and the sanitation workers should be trained to follow the standard procedures while performing their tasks.

- **Mechanization of Sanitation work:** The foremost step towards safety in sanitation work is elimination of risk by limiting the need of human contact with fecal matter. ULBs should procure machines to eliminate manual cleaning of septic tanks and sewers. Along with desludging, there have been numerous innovations like Bandicoot, Sewer croc, jetting machines for cleaning of public conveniences to reduce direct contact of workers with fecal matter. ULBs should consider the following selection criteria for procurement or renting of the appropriate vehicle:
    - Criteria for selection of appropriate vehicle
    - Road widths/ condition/ terrain
    - Quantity of fecal sludge and septage generated (required no. of vehicles can be estimated
    - Financial resources available
    - Availability of skilled human resources to operate and maintain the vehicles
    - After sale service/ skill for repair of the vehicle
    - Method of desludging –(will affect the number of vehicles)

- **Prohibition of Manual Scavenging:** Under the section 7 of Prohibition of Employment as Manual Scavengers & their Rehabilitation Act, 2013 -'No person, local authority or any agency shall engage or employ, either directly or indirectly any person for hazardous cleaning of a sewer or a septic tank.' In 2014, the Supreme Court has ordered ULBs to provide compensation of Rs. 10 lakh each to families of all deceased manual scavengers since 1993. MoHUA had issued a notification to set up ERSU (2019), it directs to file FIR against employers in cases of hazardous cleaning of sewer/septic tanks (where hazardous cleaning is manual cleaning without using PPEs and under no supervision).

- **Setting up an Emergency Response Sanitation Unit:** The main objective of the Emergency Response Sanitation Unit (ERSU) is to provide professional, well trained, motivated and appropriately equipped workforce for the maintenance and management of sewers and septic tanks, thereby eliminating the deaths caused by entry of workers into sewers and septic tanks without proper PPEs & training and non-adherence to security protocols. The ULBs should set up an ERSU with the following members to ensure that only authorized sanitation workers enter sewer/ septic tank under the supervision.

2. **Training**
    - Training of sanitation workers:
        - Training of workers is essential to ensure that they practice the safety guidelines as per standards.
        - ULBs should conduct trainings periodically and prepare a training calendar for sanitation workers to enhance the capacity of sanitation workers. The training calendar will guide the ULB to conduct training in an organized manner and enable the workers to participate in an effective manner.
        - ULBs should organize training workshops to help and encourage the workers to upgrade their skill sets. They may engage NGOs having credible experience of working with and training sanitation workers.
        - Certification of existing skills through Recognition of Prior Learning* (RPL) program. They should organize RPL training programs to promote certification of existing skills of the sanitation workers. It is usually a training program of 2-5 days wherein participants receive certification upon completion.
    - **Capacity Building of ULB staff:** Capacity building of ULB staff is crucial to understand the safety measures that should be practiced and can ensure compliance of the same. They should mandate its staff to take up 3 e-courses per quarter[5]. SBM e-learning platform has a total of 179 modules on various aspects of sanitation.

3. **Provisions of Entitlements**
    - Service level benefits for workers
        - **Provisions of PPEs:** PPEs should be procured based on the requirement for different categories of sanitation work. The workers should be trained on the use and maintenance of PPEs. ULBs should ensure that there are changing and bathing facilities where the workers can wear and remove PPEs and they can ensure their personal hygiene. Lockers for storing PPEs should also be provided.
        - **Procurement of PPEs for different sanitation jobs:** Each sanitation job requires protection against different set of risks and hazards. The Prohibition of Employment as Manual Scavengers & their Rehabilitation Rules 2013, CPHEEO guidelines and advisory prescribe various PPEs. ULBs should ascertain total number of sanitation workers under each category of sanitation work and procure relevant PPE accordingly.

[5] *Refer: SBM E-Learning Portal for e-courses- https://swachhbharat.azurewebsites.net/#/*

- **Training for use and maintenance of PPEs:** If the PPEs are not used properly, they will be ineffective in protecting users from likely accidents or infections. Improper use can make the users prone to accidents and hinder work speed. To prolong the life of PPE and avoid frequent wear and tear, PPEs should be cleaned and stored properly. PPE should also be safely disposed so that they do not lead to any contamination of surrounding environment. Thus, it is essential that all sanitation workers are trained in the following.
    - How to wear PPEs?
    - How to remove PPEs?
    - Do's and Don'ts of using PPEs
    - How to disinfect PPEs after work?
    - How to store and maintain PPEs?
    - How to safely dispose damaged PPEs?
- **Provisions of Hand wash station:** Sanitation workers do not have acess to handwashing and changing facilities at their workstation. In the absence of it:
    - They are not able to maintain their personal hygiene
    - They do not have access to water and soap to clean their PPEs after work
    - Especially female sanitation workers do not have access to changing rooms after their shifts.

Why is PPEs Essential?

PPE safeguard health of workers by minimizing their exposure to hazards that can cause serious workplace injuries and illness. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. PPE include items such as gloves, safety glasses, safety shoes, helmets, masks or respirators, or coveralls, vests and full body suits

Who is responsible for providing PPEs to Workers?

As per the Prohibition of Employment as Manual Scavengers & their Rehabilitation Act 2013, it is the duty of the employers, either ULB or a private agency, to provide PPEs to sanitation workers. The ULBs should provide PPEs to sanitation workers engaged by them irrespective of modality of engagement. They should also ensure that private contractors provide PPEs to the sanitation workers engaged by them. To facilitate enforcement of Prohibition of Employment as Manual Scavengers & their Rehabilitation Act 2013 and smooth monitoring of private agencies, the ULB should empanel all private service providers and ascertain adoption of standard operating protocols to ensure safety of sanitation workers.

ULBs should ensure there are facilities of washing and changing for the sanitation workers at their workplace. There should be provisions for lockers for workers to store their PPEs. ULBs could make these provisions at the muster station/ward offices where the sanitation workers typically go to mark their attendance or certain PTs near their workplace.

Figure 10.12 Low- cost portable foot-operated hand washing facility

Source: (Bank, et al., 2019)

- **Periodic replenishment of PPEs:** Different PPEs last for different time duration depending on their quality, usage, maintenance etc. The ULB should maintain a register of PPE distribution and ensure PPEs are periodically replenished or provided timely in case of damage, either by ULB or by private employer. ULBs can follow the advised replenishment frequency* as mentioned in the adjacent table.

Table 10.4: Frequency of PPEs Replenishment

S.No	PPEs	Frequency of replenishment
1	Gloves	At least once in 2 months
2	Shoes	At least twice a year
3	Eyewear	At least twice a year
4	N95 Mask	At least once in 7 days
5	Apron	At least twice a year
6	Helmet	At least once a year
7	Wader suit	At least once a year
8	Gumboots	At least twice a year

Source: (CPHEEO)

**Note: The replenishment frequency is suggestive and will vary across various categories and models of PPEs*

- **Health and safety of sanitation workers (CPHEEO):**
  - Provide regular health check-ups (At least twice a year and this should be frequent in COVID-19 pandemic context)
  - If necessary, provide vaccinations against tetanus, leptospirosis fever and so on.
  - Tie up with Primary Health Centers and maintain health records for all sanitation workers.
  - Mental well-being to be checked
  - Ensure the mental well-being of workers through periodical check-ups organized by the ULBs.

- **Social security benefits for sanitation workers and their family**
  - ULBs should map the sanitation workers against the government schemes they are eligible for. This has also been encouraged by the Swachh Survekshan 2021
  - Based on the eligibility of the workers, ULBs should link sanitation workers to existing schemes so that they are able to access their entitlements.

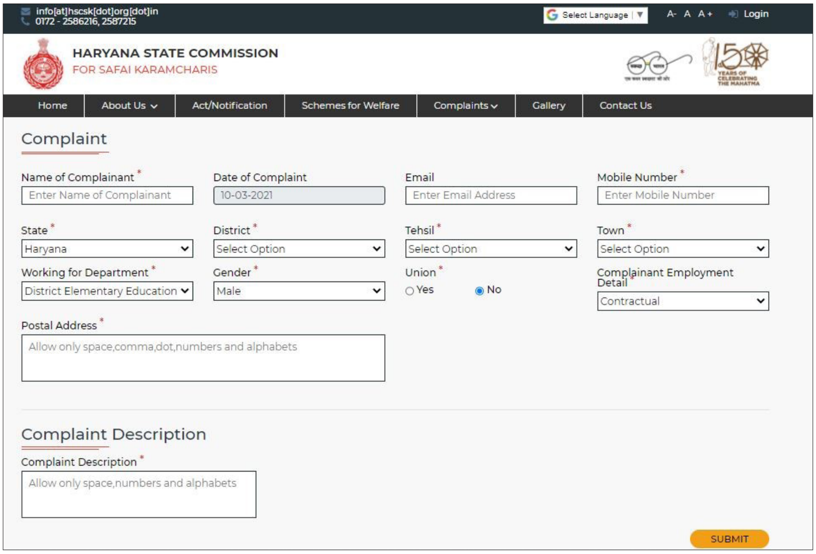
4. Enablers

- **Grievance redressal system for sanitation workers:** Under the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013, State governments are required to designate an authority for taking up grievances of sanitation workers and ensuring their rights are protected. Currently 8 states have SafaiKaramchari Commissions to safeguard the interests of sanitation workers such as Haryana State Commission for SafaiKaramcharis has launched an online portal in June 2020 for resolving grievances and complaints of sanitation workers. The commission works with various bodies including the urban local bodies and public health department to ensure sanitation workers get their entitlements like ex gratia payment, EPF etc. ULBs should ensure that there is a platform for sanitation workers to raise their issues and that their grievances are redressed in a time bound manner

- **Sensitizing citizens:** Citizen participation is essential in ensuring delivery of safe sanitation work.
  - ULBs should sensitize citizens to take services from only registered service providers
  - ULBs should take up IEC campaigns to sanitize citizens about the hazardous nature of sanitation work
  - There should be a dedicated enquiry number for all sanitation services
  - Citizens should have a platform to report any unsafe sanitation work being practiced in the city
  - ULBs should use several media platforms to spread awareness about registered desludging services being provided in the city.

- Put information of all the registered service providers on the ULB website.
- Put information of all the registered service providers on the ULB website.
- Provide contact information of the local registered sanitation provider at the back of the bills –property tax, water tax etc.

Figure 10.13: Safaikaramcharis portal for resolving grievances and complaints of sanitation workers

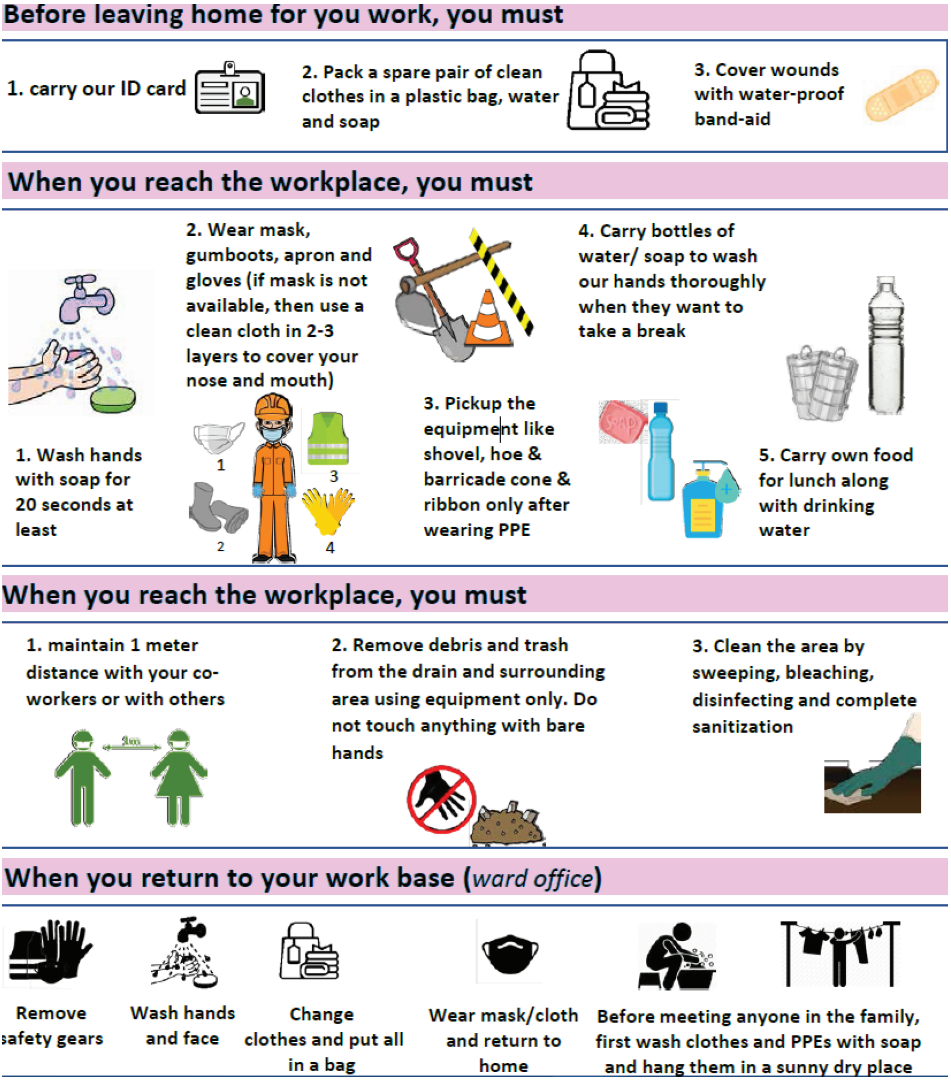


Source: (GoH, 2020)

- **Recognition of sanitation workers:** Often, sanitation work goes unnoticed by the public. ULBs should acknowledge the importance of sanitation workers and the services they provide. Providing appreciation to the best performing sanitation workers can boost the morale of sanitation workers and create a better working condition.
  - ULBs should set the criteria of performance assessment: They should set the criteria of performance assessment and inform the sanitation workers to build a healthy competition among them. It can include:
    - Punctuality
    - Regular use of PPEs
    - Delivery of quality work within deadline
  - ULBs should incentivize performance: They can incentivize performance of workers by giving them cash rewards, vouchers, awards or displaying the names of well-performing sanitation workers on appreciation boards.

Cases of additional Initiatives taken by ULBs

Figure 10.14: Drain cleaners' poster by UMC, Ahmedabad

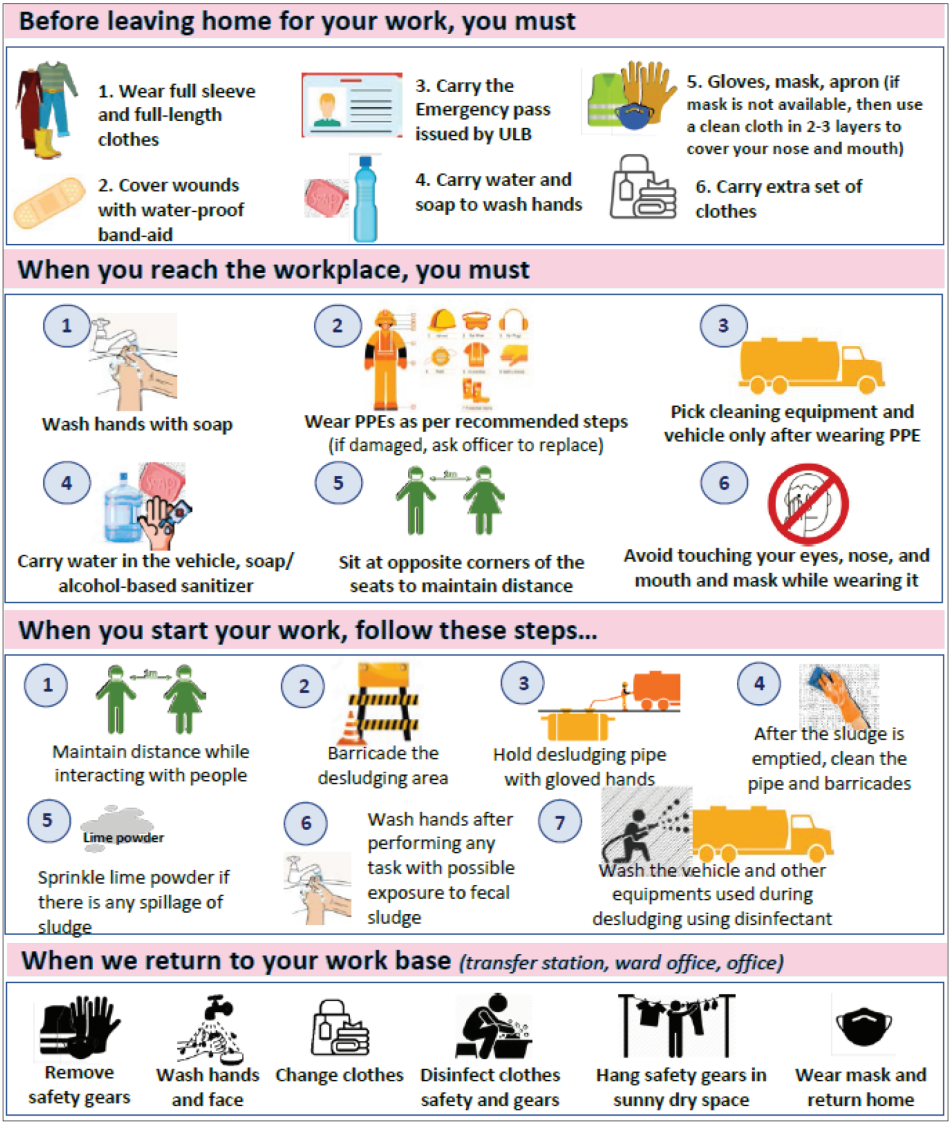


Source: (NIUA)

Figure 10.15: Community toilet (CT) caretakers' poster

Source: (NIUA)

Figure 10.16: Desludging operators' poster



Source: (NIUA)

Figure 10.17: FSTP Operators' poster

Source: (NIUA)

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Quick Assessment

1. Many informal and temporary sanitation workers operate with little or no formal training on the occupational risk during the work
   a. True
   b. False

2. When was the National Occupational Health and Safety Act was enacted?
   a. 1994
   b. 1993
   c. 1997
   d. 2001

3. What does NSKFDC stands for?
   a. National Safai Karamcharis Finance & Development Corporation
   b. National Safai Karami Finance & Development Company
   c. National Safai Karamcharis Finance & Developed Company

4. To protect the workers and visitors against any danger, safety signs should be displayed in all the STPs and hazardous places
   a. True
   b. False

5. Supreme court has ordered ULBs to provide compensation 0f ________ each to families of all deceased manual scavengers since 1993
   a. 25 lakhs
   b. 15lakhs
   c. 10lakhs
   d. 20lakhs

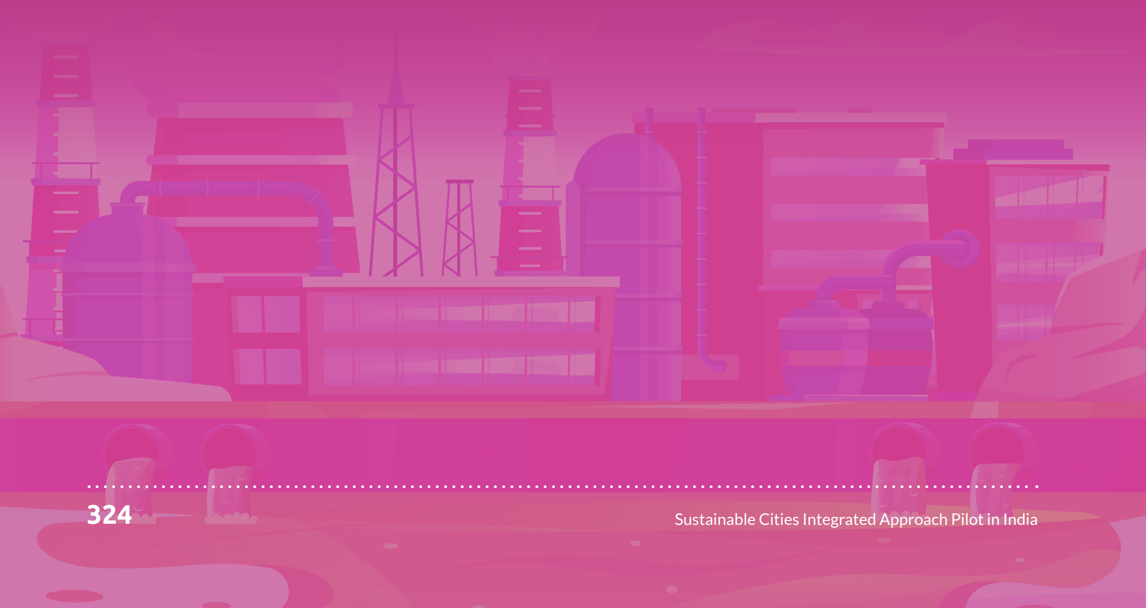
6. Who is responsible for providing PPEs to workers?
   a. ULBs
   b. Private agency
   c. All of the above
   d. None

** For answers please refer Annexure I*

Chapter

11

Project Management



Recap

The previous chapter focused on various aspects with respect to the occupational health and safety of the frontline workers engaged in the wastewater management sector. The current chapter covers various aspects of Project Management ranging from Operation and maintenance of STPs, DPR Preparation and Appraisal for setting up the STPs.

Training Objectives

- To discuss various aspects of DPR Preparation
- To understand various parameters for appraising DPRs
- To discuss various aspects of operation and maintenance of sewage treatment technologies in STPs.

Training Outcomes

- Understand the various aspects of DPR Preparation and Appraisal.
- Understand operation and maintenance related aspects of various technologies used in STPs
- Understand the various aspects of DPR Preparation and Appraisal.
- Understand operation and maintenance related aspects of various technologies used in STPs

Chapter Contents

11.1 How to Prepare Detailed Project Report (DPR)

Detailed project report (DPR) for a Sewage Treatment Plant scheme is a base document for implementing the project. It is a document which should fit into the city sanitation plan. Before undertaking any DPR for wastewater treatment there should be thorough socio-economic, demographic survey and the status of sanitation coverage of the ULB should be assessed.

ULB is responsible for preparing DPR for wastewater treatment. During preparing DPR, ULBs should take into account all the information required for the appraisal of the DPR. For such appraisal checklist of MoUD/ CPHEEO must be followed. Such checklist contains several points including basic information about the ULB, water supply status, topography, technical details of the proposed STP, O&M, effluent quality and capacity building of ULBs etc.

The DPR should be formulated as per the Manual on Sewerage and Sewage Treatment, (CPHEEO, 2018). For preparing a DPR the main steps are as follows:

- **Existing scenario:** Existing scenario for wastewater treatment in the ULB should be explained.
- **Need for project:** The need for such project for the ULB should be explained.
- **Scope of project:** The Scope of the project should be clearly specified and the following aspects must be included:
  - Sewage collection
  - Sewage conveyance
  - Sewage pumping
  - Sewage treatment
  - Sewage reuse where ever possible
  - Sludge management
  - Methods of procurement
  - Human resources development
  - Tariff for sustainable O&M
  - Levies as taxes and charges
- **Outcome:** Outcome in terms of improvement of health, economy should be explained.
- **Location of the project:** It should include map and sketch of the project area.
- **Site investigation details:** It should include Soil properties, Geotechnical report, recommendations from Geography, Topography, Rainfall and climate, ground water, Survey details (Contours, Levels based on requirement) etc.

The various aspects as discussed above have been discussed in detail in the following sections.

Approach and methodology

- Calculation of wastewater generation and capacity determination: Sewage generation should be as per the standard formula – 80% of the volume of water supply and accordingly capacity can be evaluated.
- Quality analysis of Influent wastewater to determine characteristics such as BOD, COD, TDS, TSS, Total Coliform etc. (to be analyzed through a NABL approved or State government laboratory in the state)
- Detailed description of complete treatment process (primary, secondary and tertiary)
- Justification for choice of the technology of STP by comparison with different technologies such as Activated Sludge Process, UASB, SBR, WSP, MBBR. The Justification should highlight how the chosen technology is the most appropriate technology, suiting to the local conditions and financial status of the ULBs. While carrying out the techno economic analysis, life cycle cost should be worked out for all these technologies taking into account the capital cost and O&M cost for a specified period, land cost, financial capability of the ULBs, etc. Other parameters such as influent quality, effluent quality standards, effluent quality for reuse, resource recovery (gas/electricity generation etc.) should also be considered.
- Final achievable wastewater characteristics: Final achievable effluent should meet the criteria of effluent discharge of the State Pollution Control Board and accordingly a letter of Consent of operation should be procured from the SPCB.

Engineering design

- **Flow diagram for the proposed plant:** A complete flow diagram of the plant should be depicted.
- **Detailed design of all units:** There are different units in the treatment system like screening chamber, settling chamber, aeration/ treatment chamber, clarifier etc. Detail design of all the units should be clearly mentioned.
- List of civil structures, mechanical and electrical with detailed specification of all the components should be included.
- **Conveyance network:** Sewerage system of the area should be completely explained through drawings and maps.
- Sewage pumping station (SPS) with capacity, number and locations on map should be properly explained
- **Sludge management plan:** There should be proper sludge management plan explained in the DPR.
- **Reuse proposal for treated water:** Safe reuse of treated water should be properly explained. In case of disposal of treated water, it should also be explained properly

Cost estimates

- **Estimate report:** It should be detailed out technically. For the purpose of estimation of the STP, detailed cost estimate may be prepared either based on the schedule of rates or the recently awarded cost of similar capacities of STPs (average cost of different STPs) based on these technologies in the concerned State.
- Detailed estimate for civil works including plumbing with detailed measurements in CPWD specification as per prevailing DSR
- Detailed estimate for mechanical items
- Detailed estimate for electrical items
- Abstract Estimate
- Rate analysis for market rate items for civil works
- **Time schedule:** It should mention the start date and phase wise completion date
- Gantt chart showing construction and commissioning of treatment plant
- Minimum three quotations for justifying market rate for mechanical components

Operation and maintenance plan

- **Power requirement of the Treatment Plant:** There should be written assurance from the power authority for uninterrupted required power supply to operate the system
- **Cost Estimate for O&M Charges:** Operation and management of the system should be clearly defined
- **Operations and maintenance cost for 10 years:** O&M cost for 10years should be clearly defined.

Procedure for submission of DPR

After the DPR is prepared by the ULB, it needs to get technically sanctioned by the ULB committee chaired by the competent authority. It is then sent to the Department of Urban Development, State Government to be placed before the SLNA/ SLSC for technical recommendation. SLNA/ SLSC, normally headed by the Chief Secretary of the State, reviews the proposal technically and financially. If any clarification is required, it may send back to the concerned ULB with observation for any rectification. SLNA/ SLSC recommend the DPR after all the points in checklist are fully completed and then send it to the Ministry of Housing and Urban Affairs (MoHUA) along with the Appraisal report for sanction by the Ministry.

11.2 Appraising DPRs

There is detail guideline for DPR appraisal for sewerage and sewage treatment plants (MoHUA). DPR shall be technically recommended by the Competent Authority of the State Govt./ULB before forwarding it to the Ministry.

General Components for DPR Appraisal

- **Name of the Scheme with Geographic Details:** Geographical details of the ULB along with map should be there is DPR.
- **Appraisal report by State Level Nodal Agency (SLNA) /State level Sanction Committee (SLSC):** Such report is sent by the SLNA/ SLSC along with the recommendation to the MoHUA, Government of India.
- **Administrative approval of the scheme:** Such approval is submitted by the SLNA/ SLSC.
- **Project formulation justification:** In the introductory chapter of the DPR such justification is clearly mentioned.
- **Land use pattern as per approved Master Plan:** Taking into consideration the Master Plan of the ULB, land use pattern should be clearly explained.
- **Clearance for setting up of STP by the State Pollution Control Board:** Approval of SPCB should be included in the DPR.
- **Commitment from electricity department for uninterrupted power supply:** Letter from the electricity department for its commitment for electric supply for the site should be in DPR
- **Topographic map of the project area:** DPR should include topography map of the area.

Engineering Components

Existing and projected population and their distribution in the project area: The design population should be estimated by paying attention to all the factors governing the future growth and development of the project area in the industrial, commercial, educational, social, and administration spheres. Special factors causing sudden immigration or influx of population should also be predicted as far as possible. Projected population should be calculated for 30 years as per the standard methods.

- **Details of sewage generation and STP capacity:** Sewage generation is 80% of the water supply, accordingly capacity of the STP should be selected.
- **Design details of proposed sewerage infrastructure:** select the appropriate technology from the technology matrix and provide design detail in the DPR.
- **Modular approach for STP:** Is there any design/ method for increasing of efficiency and reliability, improvement of the STP'S life cycle, low maintenance, etc. the same should be mentioned in the DPR.
- **Sewage characteristics certificate by the competent authority:** Get the sewage sample tested by the SPCB laboratory / recognized laboratory.
- **Conformation to effluent standards notified by the competent authority:** Mentions expected discharge quality and meeting the norms of effluent discharge.
- **Hydraulic flow diagram and layout plan for STP:** Layout plan of STP should include in DPR.

- Maps of proposed sewer network and L-section of pumping main and transmission main.
- **Allocation of site for STP/MPS as per Master Plan:** Letter from the competent authority for such allocation should include in the DPR.
- **Provision for land acquisition for water supply infrastructure:** Availability of required land for the purpose should be well defined and included in the DPR.
- Bill of quantities and cost estimates of individual components by latest schedule of rates.
- Detailed drawings and cost estimates for ancillary works. Details of BOQs and latest estimates as per the SR should be included in the DPR.

Some additional aspects for appraisal

- Whether the DPR including the design, drawings, cost estimates, analysis of rates has been authenticated by Competent Authority of State Govt./ ULB and Quasi-Technical sanction of DPR / Technical & Financial Verification Certificate has been attached with DPR?
- Whether the proposals for setting up STP received clearance / consent from the State Pollution Control Board?
- Whether the provision for separate electric feeder line to the sewage treatment plant and pumping stations (to take care of frequent power failure and voltage fluctuation problem) from HT line and an agreement between Electricity Department and Urban Local Bodies (ULBs) has been furnished in the DPR
- Whether the Topographic map of the city/town/project area to the scale has been given in DPR/Zone wise maps to scale showing all streets.
- Whether Contour map of the project area has been annexed with the DPR.
- Area of the town/city (municipal limit): Sq. km
- No. of Households (as per 2001 and 2011 census)
- Whether population projection has been made as per CPHEEO Manual and given in DPR
- City population
- Whether the population projection has been made in consonance with the Developmental Master Plan

Engineering components

- Per capita sewage generation considered in the DPR (80% of water supply) - LPCD
- Sewage Generation (City / town) (specify treated industrial effluent if any)
    - Initial stage (MLD)
    - Net capacity of Sewage Treatment Plant required:
        - Initial stage (MLD)
        - Intermediate stage(MLD)
        - Ultimate stage(MLD)

- Sewer Network
  - Total length of road of city/town (KM)
  - Total length of road in project area (KM)
  - Total length of sewer network in the town (KM)
  - Total length of sewer network in the project area (KM)

- Pumping Stations
  - Total nos. and Capacity (MLD) nos.

- Sewage Treatment Plant
  - Design period (15 years as per CPHEEO Manual)
  - Capacity of STP (existing & proposed) MLD-

- Proposed Technology
  - Name of the technology (select appropriate technology from technology matrix)
  - Whether Life-cycle cost assessment of treatment technologies has been furnished in DPR
  - Whether treated sewage shall conform to the effluent standards notified by the respective SPCB/CPCB/ NGT.
  - Whether a detailed note on performance of existing STP (if considered in the proposal) has been furnished in DPR
  - Whether the Service Level Benchmark as discussed in Table 11.1 as shared below has been furnished in the DPR

Table 11.1: Service Level Benchmarks to be assessed for Appraisal

Indicators	Benchmark	After implementation of the project
Coverage of Toilets	100%	
Coverage of Sewerage Network	100%	
Collection efficiency of sewerage Network	100%	
Adequacy of sewerage	100%	
Treatment Capacity Quality of sewerage treatment	100%	
Extent of reuse and recycle of sewage	20%	
Extent of cost recovery in waste water management	100%	
Efficiency in redressal of customer complaints	80%	
Efficiency of collection of sewage water charges	90%	

- Discharge/ reuse of effluent
    - Percentage of treated effluent reuse in agriculture
    - Percentage of effluent discharge in river etc.
    - Use of settle sludge- Expected income from sale to farmers or disposal procedure

All the above points should be clearly explained in the DPR before submitting to the proper authority for approval.

Training and Capacity building

ULB needs to organize adequate training and capacity building for its staff for proper, monitoring of the system and its operation and maintenance. In case of lack of such program there is chance of failure of operation and maintenance of the system. DPR should include detail schedule of such training / capacity building program.

Documents to be annexed with the DPR

- Lab report of tested wastewater
- Detailed plan, section and elevation drawings of individual tanks with clear dimensions
- Structural details (reinforcement detailing)
- Quotations for items with market rate
- Geotechnical investigation Soil report
- Structural Stability Certificate

11.3 Formulating Request for Proposal

A Request for a Proposal (RFP) is a document formulated by the ULBs to obtain bids from the service vendors for projects specified in the DPR. A well written RFP is essential in ensuring well costed, innovative bids from the suppliers. A good RFP is crucial for effective project management as it enables the service vendors to understand the project and facilitates them to write a proposal or a bid explaining how they can meet the requirements for the project. An RFP clearly describes the deliverables of the project and various assumptions and assessments by the authority in relation to the project.

RFP is issued to the selected bidders who got selected from Expression of Interests (EOI). Whole system for bidding is as follows:

- Preparation of expression of interest (EoI), Request for proposal (RFP), and concessionaire agreement
- Obtaining approval from concerned authority
- Issue of notice for pre-qualification or EoI
- Short-listing of firms
- Issue of RFP to the shortlisted firms
- Conducting pre-bid meeting
- Receiving technical and financial bids in separate packets in response to the RFP and opening of technical bids

- Evaluation of the technical bid document received
- Opening of financial bids of the bidders
- Evaluation of financial bids
- Selection of most preferred bidder
- Negotiation and signing of agreement
- Award of contract

11.4 Tendering Process

The tendering process can either be a single stage process or a two stage process. In a Single stage bidding process, technical and financial bids are submitted simultaneously in response to a RFP. Whereas the two stage selection process includes an initial pre-qualification stage, followed by RFP stage, which is applicable only to pre-qualified bidders. The bidding schedule for the two tendering process are as follows:

Schedule for Bidding – Two Stage Process

Stage 1: Pre-Qualification Stage (Minimum: 3 months)

- Sale of request for qualification (RFQ): zero date
- Submission of query by the perspective applicants: +15 days
- Pre-bid meeting: +20 days
- Authority response to queries: +30 days
- Bid submission due date: +60 days
- Opening of technical qualification bids: +60 days
- Acceptance of technical qualification evaluation report by Tender Committee: +80 days

Stage 2: Bid Stage (Minimum: 6 months)

- Sale of request for proposal (RFP) short-listed applicants: +90 days
- Submission of query by the perspective applicants: +105 days
- Pre-bid meeting: +110 days
- Authority response to queries: +130 days
- Bid submission due date: +150 days
- Opening of bids: +150 days
- Letter of Intent (LOI): within 30 days of bid opening date
- Contract signing: +30 days of award of LOI

Notes: 1. The bidding process takes 6 months minimum. However, depending upon the urgency and requirement of the project execution the bidding process could be done within 60 days. 2 + "x" days means time duration from the zero date, i.e., date of publication of RFP

Schedule for Bidding: Single Stage Process

- Sale of bid or request for proposal (RFP) to short-listed applicants: zero date
- Submission of query by the perspective applicants: +15 days
- Pre-bid meeting: +20 days
- Authority response to queries: +30 days
- Bid submission due date: +60 days
- Opening of technical bids: +60 days
- Acceptance of technical evaluation report by Tender Committee: +80 days
- Financial bid opening: +90 days
- Letter of intent (LOI): within 30 days of bid opening date
- Issue of letter of award to bidder: +30 days of issue of LOI

11.5 Operation & Maintenance of STPs

Operation and maintenance of any STP is one of the most important factors to achieve the objectives of wastewater management by any ULB. O&M needs at all stage of treatment right from screening chamber to treatment plant and sludge drying beds. The following sections covers the O&M related aspect of various units used across the STPs.

Screening Chamber

- **Regular Cleaning:** There should be regular cleaning of screen, frequency of such cleaning should depend on the volume of sewage and deposition of unwanted materials.
- **Disposal of Screenings:** There should be proper disposal / reuse of such materials
- **Washing of Bar Screens:** Bar screen should be properly washed to avoid any blockage
- **Washing sludge layer from walls using water jet:** Walls needs to be properly washed to avoid any sludge layer.
- **Desilting of wet well once a year:** There should be annual desilting of well. Silting of well may cause reduction of its volume and consequently less settling of sludge.

Receiving Chamber & Fine Screens

- Should be scoured minimum once in a week.
- Fine Screens should be kept clean of all obstructions.
- Receiving Chamber & Fine Screens adjusted such that a mat is always on the screen.

Grit chambers

- There should be (1W + 1S) grit channels for peak flow.
- Should be used one at a time, alternatively every day.
- Should be cleaned every day.
- Proper & efficient removal of silt in grit channel will improve the functioning of treatment.

O&M aspects of various treatment technologies

Moving Bed Biofilm Reactor (MBBR)

- The biofilm layer accumulates on the bio media. It needs to be removed regularly.
- The smell of sludge should not be foul. Foul smell is the indication of anaerobic condition. Proper aeration needs to be checked.
- When starting the plant initially, the air blowers should be operated for passing the air through diffusers and run continuously, otherwise the desired parameters will not be achieved.
- Fill both aeration tanks to the normal operating sewage depth, thus allowing the aeration equipment to operate at maximum efficiency.
- Using all of the aeration tanks will provide the longest possible aeration time.
- The effluent end of the aeration tank should have a dissolved oxygen level of at least 1.0 mg/L. DO in the aeration tank should be checked every two hours. Generally, the DO is approx. above 4 in aerated sewage.

Sequence Batch Reactor (SBR)

- There should be 2 in nos. (Parallel & in series).
- The walls, walkway and the railing to be washed daily using water jet.
- The problem of foam can be solved using water jet.
- Reactors should be de-sludged every day to maintain proper MLSS
- The purpose of Fill-React operation is to add substrate (raw sewage) to the reactor. The addition of substrate or filling is controlled by a timer to a set time period. The filling operation is also controlled by level transmitter to limit filling volume up to maximum level. Usually, SBR tanks are designed to take flow as it comes into STP with all variations from peak flow to minimum flow without necessitating any equalization tank.
- The Settling process is controlled by time and is usually fixed between 30 minutes to an hour so that the sludge blanket remains below the withdrawal mechanism during the next phase.
- The purpose of Decantation is to remove the clarified, treated water from the reactor. When starting the plant initially, the diffuser should be operated first and run continuously, otherwise the desired] parameters will not be achieved.
- The precaution needed is to make sure that power supply is available continuously. If power supply fails, immediately bring the genset on-line.
- COD to BOD ratio indicates the bio-degradability of the sewage. Normally, sewage will have COD to BOD ratio between 1.5 to 2. If the ratio is more than 2, entry of industrial effluents into sewer network is a possibility.
- The daily tests shall be COD, TSS, pH, Dissolve oxygen, Ammonia and dissolved phosphate. BOD can be a weekly test.

Sludge Sump & Sludge Drying Beds

- Sludge from the sump should be regularly pumped out.
- Generally, the Sludge Drying Beds are empty without any sludge shows that plant is not running. It needs to be checked regularly.
- Dried sludge cakes should be removed regularly from Sludge Drying Beds.

Clarifier

- The treated water flow should be uniform over the entire length of the launder. It would ensure aeration also.
- There should be no scum over the surface.
- Bridge should be kept running.
- Sludge should be continuously removed.
- Launders should be kept clean.

Activated Sludge Process

- The activated sludge process is biological in nature and usually requires the addition of dissolved oxygen to the wastewater.
- Aerobic organisms are usually used in activated sludge plants, produce little odor, and require a proper amount of dissolved oxygen (DO) to function properly.
- Facultative organisms can grow with or without dissolved oxygen (DO) but are less efficient that aerobic organisms and often produce foul-smelling products.
- Secondary clarifiers remove microorganisms and solids from treated wastewater.
- Returned Activated Sludge (RAS) is settled sludge taken from the bottom and the clarifier tank and returned to the aeration tank. RAS provides an important source of microorganisms needed for the treatment process.
- Caution has to be taken when increasing RAS rates because hydraulic overloading of the activated sludge system can occur. Increasing the RAS rates increases the volume in the aeration tank and in turn decreases the hydraulic detention time.
- Waste Activated Sludge (WAS) is removed from the treatment process and disposed of or "wasted" to prevent an excessive build-up of solids in the treatment process.
- Sludge age is a measure of the time a particle of suspended solids has been retained in the activated sludge process, with changes in sludge age changing the dynamics of the organisms in the activated sludge process.
- Influent wastewater is usually monitored for BOD, pH, alkalinity, flow rate, and toxic substances since all of these can affect the plant operation efficiency.
- Biological activity decreases considerably when temperatures drop below 5 degrees Celsius.
- The three basic types of activated sludge plants are:
  (i) High Rate (Modified Aeration)
  (ii) Conventional
  (iii) Extended Aeration

- Plant efficiency is affected by both the quality of the wastewater influent as well as changes in the plant processes.
- Low DO levels in the aeration tank can allow the growth of undesirable filamentous and facultative bacteria.

The transfer rate of oxygen increases as the temperature of the liquid decreases and the size of the air bubbles decreases, and vice versa. This means that finer bubbles and colder water results in optimal saturation of dissolved oxygen.

General suggestions

- Screens and grit channels should be properly cleaned.
- Both Grit channels should run simultaneously where as it should be one running & to be used alternatively every day.
- Sludge should be removed from reactors & clarifier.
- Dried sludge should be removed from Sludge Drying Beds.
- D.G. set should be available in case of power failure.
- Industrial wastes should be avoided.
- Samples should be tested in laboratory daily.
- Quantity of bio- media should be checked.

Records to be maintained by contractor during O&M

- Attendance of O&M Staff engaged by the contractor.
- Quantity of raw sewage/ treated sewage water.
- Quality of incoming/ treated sewage water based on laboratory testing to be maintained.
- Diesel consumption of generating set based on hour meter.
- Running hours of each prime mover.
- Total power consumption.
- The contractor shall maintain and submit statements for consumption of diesel quantity & quality of treated sewage water & shall get the treated sewage samples duly tested for submission to SPCB for NOC/ Consent & shall submit consolidated monthly statement at the time of claiming payment.

Tests to be conducted by the operator during O&M

- **Inlet chamber** - Measurement of flow, BOD, pH, SS, temp., COD and oil & grease, TDS
- **Outlet chamber** - BOD, suspended solids, pH, COD and oil & grease, TDS
- **Inlet of the reactor** - MLSS, Dissolved Oxygen and pH.
- **Outlet of reactor** - Dissolved Oxygen, Sludge volume Index and pH.
- **Outlet of the secondary** - BOD, SS, pH, COD and oil & grease treatment units.
- **Outlet of the SBR** - BOD, Suspended solids, pH.
- **Excess sludge** - Volatile suspended solids, total solids, specific gravity.

Further Readings

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Quick Assessment

1. The DPR consists of how many components?
   a. One
   b. Two
   c. Three
   d. Four

2. The first step in the detail checklist of DPR is _________
   a. Executive summary
   b. Background
   c. Roadway features
   d. General details of the project

3. RFP Stands for_________
   a. Request for Proposal
   b. Request for Process
   c. Request for Product
   d. Request for Prediction

4. The activated sludge process is chemical in nature and usually requires the addition of dissolved oxygen to the wastewater
   a. True
   b. False

5. The tendering process can either be a single stage process or a two stage process
   a. True
   b. False

* *For answers please refer Annexure I*

Annexure-I

Answer Sheet - Quick Assessment

Chapter 1

Q. No.	Answer	Q. No.	Answer
1	a	5	d
2	a	6	b
3	d		
4	a		

Chapter 2

Q. No.	Answer	Q. No.	Answer
1	d	5	a
2	a	6	a and c
3	a		
4	c		

Chapter 3

Q. No.	Answer	Q. No.	Answer
1	a	5	c
2	a		
3	b		
4	b		

Chapter 4

Q. No.	Answer	Q. No.	Answer
1	c	5	b
2	a	6	d
3	b		
4	a		

Chapter 5

Q. No.	Answer	Q. No.	Answer
1	a	6	a
2	b		
3	b		
4	c		
5	d		

Chapter 6

Q. No.	Answer	Q. No.	Answer
1	a	6	Up-flow Anaerobic Sludge Blanket Reactor
2	b		
3	Moving Bed Biofilm Reactor		
4	d		
5	a		

Chapter 7

Q. No.	Answer	Q. No.	Answer
1	d	5	a
2	c		
3	c		
4	a,b & c		

Chapter 8

Q. No.	Answer	Q. No.	Answer
1	d		
2	a		
3	a		
4	c		
5	Psychrophilic, Mesophilic, Thermophilic		

Chapter 9

Q. No.	Answer	Q. No.	Answer
1	a	5	d
2	d		
3	e		
4	a		

Chapter 10

Q. No.	Answer	Q. No.	Answer
1	a	5	c
2	b	6	c
3	a		
4	a		

Chapter 11

Q. No.	Answer	Q. No.	Answer
1	c	5	a
2	a		
3	a		
4	b		

Glossary

Activated Sludge Process - In the process, large quantities of air are bubbled through wastewaters that contain dissolved organic substances in open aeration tanks. Bacteria and other types of micro-organisms present in the system need oxygen to live, grow, and multiply in order to consume the dissolved organic "food" or pollutants in the waste. After several hours in a large holding tank, the water is separated from the sludge of bacteria and discharged from the system. Most of the activated sludge is returned to the treatment process, while the remainder is disposed of by one of several acceptable methods.

Aerobic Wastewater Treatment - Oxygen dependent wastewater treatment requiring the presence of oxygen for aerobic bacterial breakdown of waste.

Anaerobic Digestion - The degradation and stabilization of organic compounds by microorganisms in the absence of oxygen, leading to production of biogas

Anaerobic Wastewater Treatment - Wastewater treatment in the absence of oxygen, anaerobic bacteria breakdown waste.

Blackwater - "Blackwater" is the mixture of urine, faeces and flushwater along with anal cleansing water and/or dry cleansing materials. Blackwater contains the pathogens of faeces and the nutrients of urine that are diluted in the flushwater

BOD - Biochemical Oxygen Demand - Since oxygen is required in the breakdown or decomposition process of wastewater, its "demand" or BOD, is a measure of the concentration of organics in the wastewater.

Chlorination - The application of chlorine to water, sewage, or industrial wastes, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

COD - Chemical Oxygen Demand - The amount of chemical oxidant required to breakdown the wastes, also an indicator of the concentration of organics.

Desludging - a process of cleaning or removing the accumulated domestic septage from septic tanks;

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).

Digestion - The breaking down of sludge and other waste biologically by microorganisms. Results in byproducts such as methane gas, carbon dioxide, sludge solids and water. Aerobic digestion requires oxygen, anaerobic digestion the absence of oxygen.

Effluent - "Effluent" is the supernatant liquid that flows out of a treatment system or is discharged from the treatment systems

Facultative Ponds - Wastewater ponds with some form of aeration for oxygen replenishment. Can also use algae and other plants for oxygen replenishment.

Faecal Sludge - "Faecal Sludge" is raw or partially digested, in a slurry or semisolid form, the collection, storage or treatment of combinations of excreta and blackwater, with or without grey water. It is the solid or settled contents of pit latrines and septic tanks. Faecal sludge (FS) comes from onsite sanitation systems. Examples of onsite technologies include pit latrines, non-sewered public ablution blocks, septic tanks, aqua privies, and dry toilets.The physical, chemical and biological qualities of faecal sludge are influenced by the duration of storage, temperature, soil condition, and intrusion of groundwater or surface water in septic tanks or pits, performance of septic tanks, and tank emptying technology and pattern.

Flocculation - The process whereby a chemical or other substance is added to wastewater to trap or attract the particulate suspended solids into clusters or clumps of floc or flocculent, wooly looking masses.

Grey water - "Greywater" is 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.

Grit Chamber - Usually in municipal wastewater treatment, a chamber or tank in which primary influent is slowed down so heavy typically inorganic solids can drop out, such as metals and plastics.

Inflow and infiltration - Inflow and infiltration is relatively clean water that enters the sanitary sewer system, mainly as a result of a rainfall event or snow melt. Inflow enters the system from the top – for example roof leaders that drain into the sewer system. Infiltration enters the system from below the ground, for example through leaky pipes or house sump pumps.

Interceptors - Large sewer lines that control the flow of wastewater to the treatment plant. These pipes generally follow the natural slope of land allowing gravity to transport wastewater. This type of pipe is similar to a force main, except that it is typically gravity-fed, not pressurized by pump stations.

Maturation Pond - An aerobic pond with algal growth and high levels of bacterial removal; usually the final type of pond in a waste stabilization pond system

Membrane Bio Reactor (MBR) - aerobic biological wastewater treatment process that utilizes membrane filtration (rather than clarification) for solids / liquid separation. The membrane filters (ultra filters) can be either submerged or external to the biological mixed liquor tanks.

Moving Bed Bio Reactor (MBBR) - aerobic biological wastewater treatment process that utilizes the fixed film (media) process. High surface area media is suspended in biological mixed liquor and bacteria grow on the media (attached growth) surface. A clarifier is typically used downstream of the MBBR for solid / liquid separation.

Pit latrine - Latrine with one or two pits for collection and decomposition of excreta and from which liquid infiltrates into the surrounding soil.

Pour-flush latrine - Latrine with rural pan that depends for its operation of small quantities of water, poured from a container by hand, to flush away feces from the point of defecation.

Primary Wastewater Treatment - The first process usually associated with municipal wastewater treatment to remove the large inorganic solids and settle out sand and grit.

Retention time in septic tanks - The length of time (hours or days) that septic effluent remains in the septic tank before moving out to the treatment or absorption system.

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.

Secondary Wastewater Treatment - Second biological process of digestion with bacteria

Sedimentation Tanks - Provide a period of quiescence during which suspended waste material settles to the bottom of the tank and is scraped into a hopper and pumped out for disposal. During this period, floatable solids (fats, oils) rise to the surface of te tank and are skimmed off into scum pipes for disposal.

Septage - Septage" is the liquid and solid material that is pumped from a septic tank, cesspool, or such onsite treatment facility after it has accumulated over a period of time. Usually, septic tank retains 60% - 70% of the solids, oil, and grease that enter it. The scum accumulates on the top and the sludge settles to the bottom comprising 20% - 50% of the total septic tank volume when pumped. Offensive odour and appearance are the most prominent characteristics of Septage. It is a host of many disease-causing organisms along with the contamination of significant level of grease, grit, hair, and debris. Septage is the combination of scum, sludge, and liquid that accumulates in septic tanks.

Septic tank - An underground tank that treats wastewater by a combination of solids settling and anaerobic digestion. The effluents may be discharged into soak pits or small-bore sewers, and the solids have to be pumped out periodically.

Sewage - "Sewage is defined as the wastewater containing human body waste matter (faeces and urine etc.), either dissolved or undissolved, discharged from toilets and other receptacles intended to receive or retain such human body wastes. The effluent coming out of septic tanks or any such facility is also sewage

Soak Pit - A porous-covered chamber that allows wastewater to soak into the ground. It is also known as a soak-away or leach pit.

TDS - Total Dissolved Solids - Total Dissolved Solids (TDS) is the combined total of all dissolved solids in wastewater, both organic and inorganic and very fine, such as colloidal minerals. Generally particles must be smaller than two micrometers to be considered a dissolved solid. For example, salt dissolved in water is a dissolved solid. Therefore TDS will "survive" screening or other coarse filtration.

Tertiary Wastewater Treatment (Advanced) - Biological or chemical polishing of wastewater to remove organics, solids and nutrients. Tertiary wastewater effluent limits are generally 10 mg/1 BOD5 and 10 mg/1 TSS.

TSS - Total Suspended Solids - As the name implies, the total solid particles that are suspended (as opposed to dissolved) in the wastewater. TSS must be filtered out, flocculated, digested and so on for removal in the treatment of wastewater. Though not necessarily pollutants TSS is considered to be a measure of pollutants in water by the EPA in the US.

Up-flow anaerobic sludge banket reactor - high-rate anaerobic unit used for the primary treatment of domestic wastewater. Water is treated during its passage through a sludge layer (the sludge "blanket") composed of anaerobic bacteria. The treatment process is designed for the removal of organic matter (biological oxygen demand)

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

Wastewater - "Wastewater" consists of domestic blackwater (excreta, urine and faecal sludge) and greywater (kitchen and bathing wastewater) from households and also the effluent from the on-site sanitation systems

Waste Stabilization Pond - Shallow basins that use natural factors such as sunlight, temperature, sedimentation, biodegradation, etc., to treat wastewatre or faecal sludges. Waste stabilization pond treatment systems usually consist of anaerobic, floculative and maturation pond linked in series.

Notes:

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