सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India

Wastewater Recycle and Reuse

TRAINING MANUAL

NIUA | C3
Climate Centre for Cities

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Supported by:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
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ClimateSmart Cities Assessment Framework
Water Management

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Wastewater Recycle and Reuse
Training Manual

Developed by:
Climate Centre for Cities, NIUA in association with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

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Executive Summary

On one hand, cities are a significant contributor of carbon emissions aggravating climate change and on the other, cities are considerably impacted by climate disasters. The recently released Global Climate Risk Index 2021 ranks India as the 7th most affected country from climate related extreme weather events (storms, floods, heatwaves etc.). Further, studies indicate that poor planning and urban management are expected to cost Indian cities somewhere between $2.6 and $13 billion annually.[1] Cities are increasingly at the forefront of addressing both urbanization and climate change and to strengthen climate-sensitive urban development, a holistic understanding of the urban development from a climate lens is crucial. The ClimateSmart Cities Assessment Framework (CSCAF) launched in 2019 by the Ministry of Housing and Urban Affairs (MoHUA), Government of India aimed to address this gap. This first-of-its-kind assessment with 28 progressive indicators across 5 thematic areas helps cities to benchmark their development, understand the gaps and further prioritize climate relevant development.

With a focus on building local capacities to develop and adopt climate measures, the Climate Centre for Cities (C-Cube) at the National Institute of Urban Affairs (NIUA) initiated a series of training aligned to the thematic areas of CSCAF - Energy and Green Buildings, Urban Planning, Green Cover & Biodiversity, Mobility and Air Quality, Water Management, Waste Management. The focus of the training is to provide a step-by-step approach of conducting studies, assessments and stakeholder consultations, establishing committees, developing action plans and implementing relevant measures that not only makes the cities climate resilient but also helps them progress across the assessment of CSCAF. The training on the 'wastewater recycle and reuse' under the thematic areas of Water Management in the CSCAF.

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[1] *Mani, M. et al., 2018. South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards, Washington D.C, World Bank Group.*

Wastewater recycling and reuse are essential services to be provided in a city. With increasing population and urbanisation, water stress and scarcity of water emerging as one of India's most challenging threats, it is crucial to recycle waste water and reuse it appropriate use. The objective of the module is to

- Present the current water and wastewater related challenges in urban India.
- Understand the performance evaluation approach of the assessment framework and provide guidance on how to perform better.
- Illustrate the approach and technologies applied for wastewater treatment and reuse.
- Provide insight on rules and standards for recycling and reusing waste water along with some of the innovations and best practices adopted by cities.

Who is the training manual designed for?

What is the focus of the training manual?

How to make use of this manual?

What are the Learning outcomes of the training?

Scope and limitations of the training

The training manual is designed for urban local body authorities and decision makers to plan, design and implement of wastewater treatment/ recycling systems. Besides, the module can also be used by training institutes to further the capacity building of ULB authorities, engineers, consultants and others. A pre-requisite for this training is to have a basic knowledge of wastewater and wastewater mechanisms. The training will be conducted in English, so understanding language may be necessary.

This manual gives an outline of the topics covered in training, and the link to further reading. The manual has seven components:

- Current Scenario on wastewater treatment
- Indicator: Wastewater treatment recycling and reuse
- Wastewater management approach and strategies
- Technological options
- Rules and Regulations
- Finance and Budgeting
- Best practices

This manual can be used as a reference note to get insights on wastewater treatment and reuse. It has briefed the topics mentioned above and provides links for further reading. Participants can refer to this document before and after the training sessions to equip themselves with knowledge on the relevant subject. It will also help them engage more effectively during the training sessions and identify any queries that they can ask to the facilitator.

The learning outcome of training includes:

- Appraise participants to a broad overview of the technical and regulatory framework for wastewater recycling
- Introduction to the indicator, 'Wastewater recycle and reuse'. Assess and evaluate their options to enhance wastewater treatment and move forward in CSCAF performance.
- Understand different approaches (centralised vs decentralised) for planning wastewater treatment systems
- Understand the appropriateness of onsite and offsite sanitation systems; and centralised and decentralised sanitation systems.

As this is a short online training, details of all technologies and applications are not covered. The training is intended to serve as an impetus for the CSCAF assessment by increasing the volume of wastewater treated, recycled and reused. Thus, this training provides a broad overview of insights and approaches rather than prescriptive tasks or recommendations on technology.

Glossary of Terms

- **Waste:** Waste is any item beyond use in its current form and discarded as unwanted. It can be solid or liquid with respective management methods1.
- **Sanitation:** Sanitation generally refers to providing facilities and services for the safe disposal of human urine and faeces.
- Solid waste is 'Waste' generated by households and of a similar nature generated by commercial and business establishments, industrial and agricultural premises, institutions such as schools and hospitals, public spaces such as parks and streets and construction sites. Generally, it is non-hazardous wastes composed of food waste, garden waste, paper and cardboard, wood, textiles, nappies (disposable diapers), rubber and leather, plastics, metal, glass, and refuse such as ash, dirt and dust (source: https://unstats.un.org/sdgs/metadata/files/Metadata-11-06-01.pdf)
- **Wastewater:** When water is used once and is no longer fit for human consumption or any other use, it is considered liquid waste. Wastewater can be sub-categorised as industrial and domestic:
  - ✓ Industrial wastewater is generated by manufacturing processes and is challenging to treat.
  - ✓ Domestic wastewater includes water discharged from homes, commercial complexes, hotels, and educational institutions. : Wastewater in this manual refers to domestic wastewater generated from toilets, bathing, washing, cleaning, community stand post/hand pumps etc.
- **Grey Water:** Wastewater generated from bathing, washing, general cleaning, laundry, as well as from community stand post, well, hand pumps etc.
- **Black Water:** wastewater generated from toilet/latrine containing faecal matter. Such water contains a very high amount of pathogens compared to greywater.
- **Yellow Water:** Urine with or without flush water is termed as yellow water.
- Night soil: human excreta.
- **Storm Water: S**torm water indicates rainfall runoff from roofs, roads and other surfaces
- **Sludge:** it is the settled solid matter in semi-solid conditions. The term sewage sludge is generally used to describe residuals from wastewater treatment systems, while the term Septage describes the residuals from septic tanks.
- **Effluent:** wastewater that flows out of a treatment system (septic tank in this module). It is partially treated.

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[1]*Sources: CEPT CWAS, UNICEF, CPHEEO, NIUA, CSE, SuSaNa*

- **Faecal sludge:** Faecal sludge is the solid or settled contents of pit latrines and septic tanks.
    - ✓ **Septage:** settled solid matter produced in septic tanks is termed as Septage.
    - ✓ **Scum:** impure matter like oil, hair, grease and other light material that float at the surface of the liquid in a septic tank.
    - ✓ **Faeces:** Faeces refers to (semi-solid) excrement without urine or water.
    - ✓ **Leachate:** is the liquid part of mixed wastewater separated through gravity or filtration from the solid component. It required further treatment prior to disposal
    - ✓ Soak Pit/soakaway/leach pit: It is a covered porous walled chamber that allows liquid waste to infiltrate the surrounding ground.
    - ✓ Septic Tank: An underground tank that treats wastewater by a combining 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.
    - ✓ **Sewer:** is an underground carriage system/network transporting liquid waste from the household level to the disposal/treatment unit. The system carrying only wastewater (black and or greywater) is termed a sanitary sewer system, while that carrying storm water is termed storm water sewer. There is a combined sewer that carries combined waste..
    - ✓ **Ecological sanitation:** It is a form of sanitation that involves re-use of human faecal waste/ wastewater and its nutrient back into the local environment, thus avoiding pollution of land, air and water resources.
    - ✓ **Pathogen:** an organism capable of causing disease.
    - ✓ The aerobic process is the process that relies on microorganisms that thrive under aerobic conditions i.e. where plentiful oxygen is available
    - ✓ Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material without of oxygen.
    - ✓ **Biodegradable:** Any organic material that microorganisms can degrade into simpler stable compounds.
    - ✓ **Non Bio-degradable Waste :** Any waste that micro-organisms cannot degrade into simpler stable compounds.

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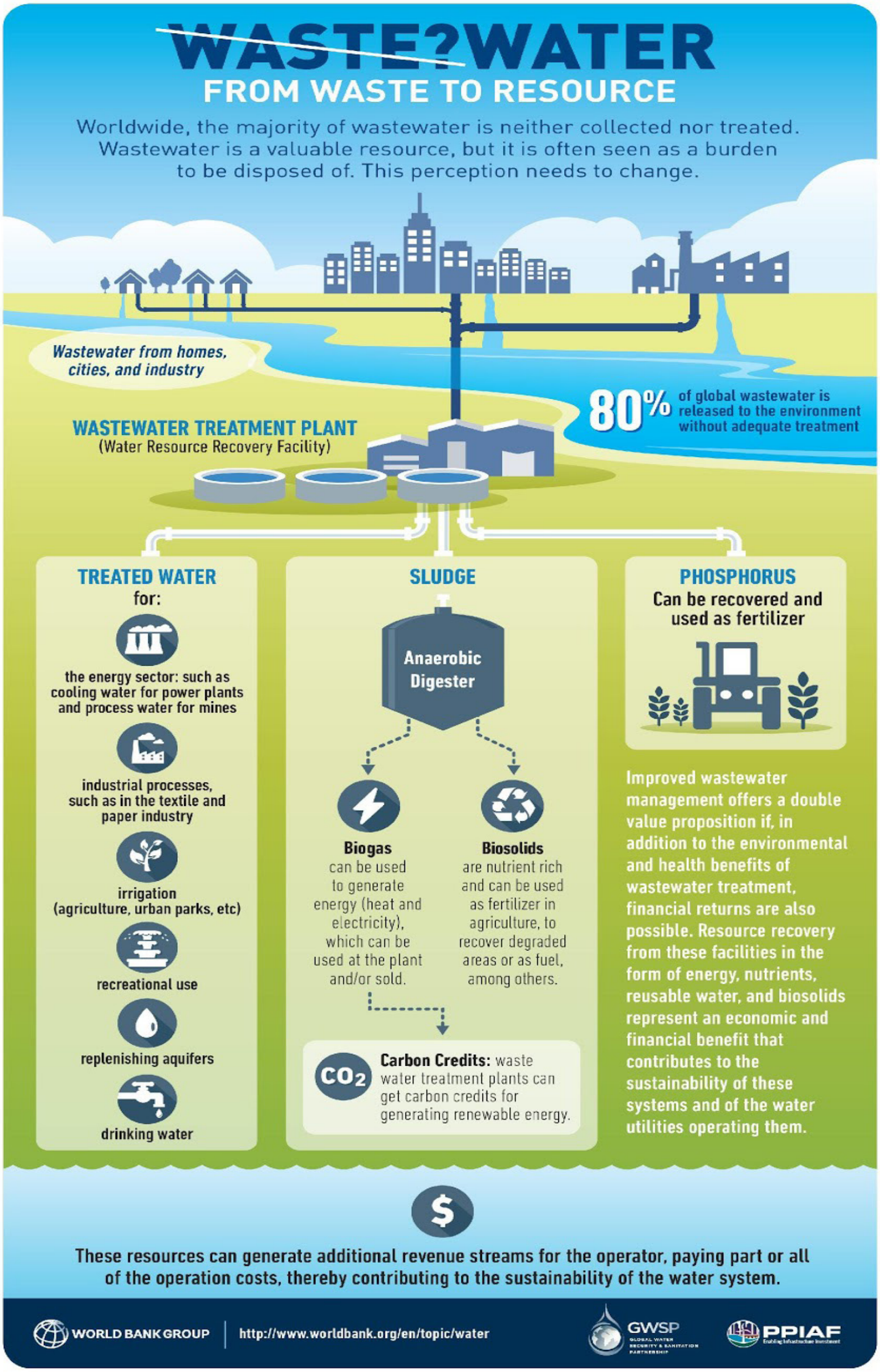
Abbreviations

ASP	Activated Sludge Processes
BCM	Billion Cubic Metre
BOD	Biological Oxygen Demand
CMD	Chennai Metropolitan Development
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CSCAF	ClimateSmart Cities Assessment Framework
CSR	Corporate Social Responsibility
DEWATS	Decentralized Wastewater Treatment System
DeLWM	Decentralized Liquid Waste Management
DeSWM	Decentralized Solid Waste Management
DeWaM	Decentralized Waste Management
FIRE	Financial Institution Reform and Expansion
FRP	Fibre Reinforced Plastic
GHG	Green House Gas
HH	House Hold
HRIDAY	National Heritage City Development and Augmentation Yojana
JJM	Jal Jeevan Mission
Mg/l	Milligram/Litre
MLD	Million Litres per Day
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
NAPCC	National Action Plan on Climate Change
NGO	Non-Governmental Organisation
O & M	Operation & Maintenance
PMAY	Pradhan Mantri Awas Yojana
PPP	Public Private Partnership
PVC	Poly Vinyl Chloride
RCC	Reinforced Cement Concrete
RDF	Refuse Derived Fuel
RWA	Resident Welfare Association
SBM (U)	Swachh Bharat Mission (Urban)
SHG	Self Help Group
SPCB	State Pollution Control Board
SUDD	State Urban Development Department
SUWSSB	State Urban Water Supply and Sewerage Board
TDS	Total Dissolved Solids
TNUIFSL	Tamil Nadu Urban Infrastructure Financial Services Limited
TSS	Total Suspended Solids
ULB	Urban Local Body
WSSB	Water Supply and Sewerage Board

Figure 1 Wastewater Recycle and Reuse, World Bank Group



1

Wastewater recycling and reuse

The consistent increase in the growth rate of India's population and unprecedented urbanization has led to an increase in the demand for water.[1] The Asian Development Bank projects that by 2030, India will have a water deficit of 50%.[2] Currently, as per Central Public Health and Environmental Engineering Organisation (CPHEEO), the average water supply in urban local bodies is 69.25 LPCD against the service benchmark of 135 LPCD. This indicates a vast gap between the demand and supply of water in the urban areas.

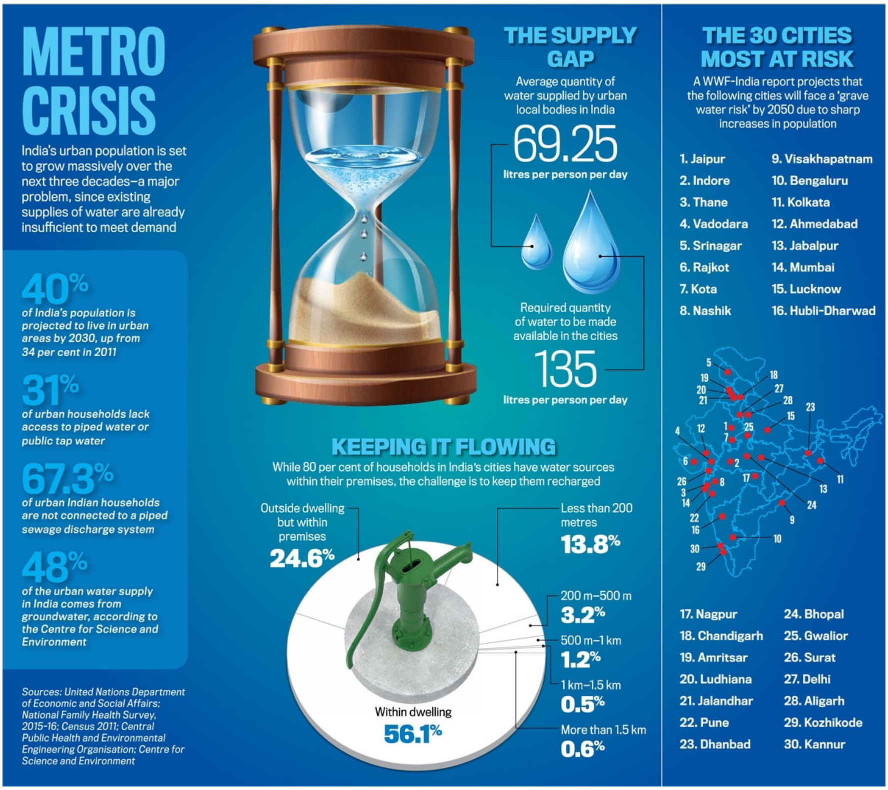
The problem of access to safe drinking water and sanitation facilities in urban areas of India is also a significant concern. In this context, appropriate reuse of treated wastewater can support in meeting the water demands to an extent.[3] However, there is a lack of wastewater treatment facilities to treat the wastewater of a growing population. The lack of sufficient infrastructure, services and funds to support the water and wastewater treatment facilities required for an urban area exacerbate the problem. Moreover, the drainage and solid waste collection services are not adequate in most urban areas. The systems are poorly planned and designed or operated without inadequate maintenance. The use of natural capacities of soil and vegetation (green infrastructure) can be applied to absorb and treat wastewater. Natural systems are more cost- effective and require low building, labour and maintenance costs.

[1] *Nathaniel B Dkhar and Qazi Syed Wamiq Ali, India's rampant urban water issues and challenges, The Energy and Resource Institute (TERI), 2018*

[2] *https://www.governancenow.com/views/think-tanks/india-would-have-water-deficit-50-cent-2030-adb#:~:text=Asian%20countries%2C%20including%20India%2C%20are,said%20in%20its%20latest%20report.*

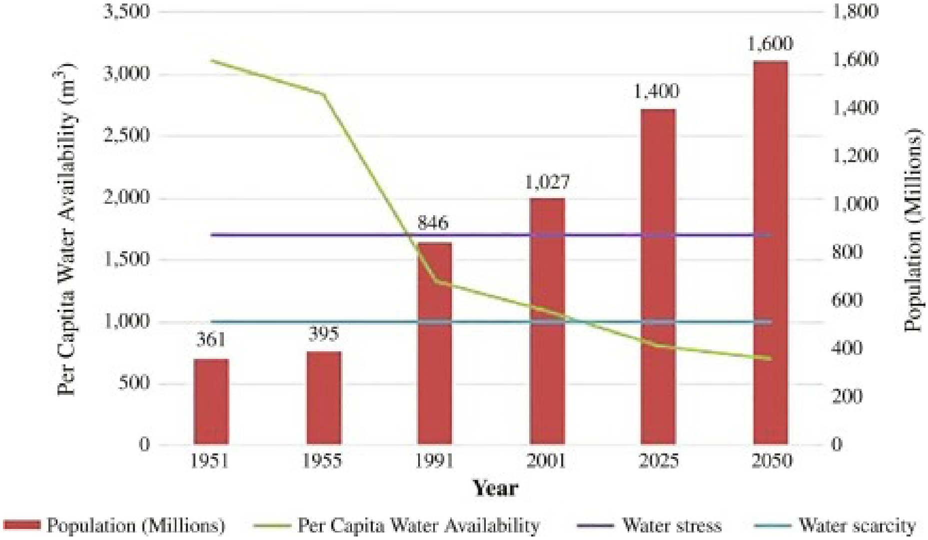
[3] *Arun Kumar and Kirti Goyal, Wastewater Treatment and Reuse in India: Current Perspective and future potential, Science Direct, 2020*

Figure 2 Water Scenario in India[4]



[4]Kaushik Deka, India's Urban Water Crisis: Cities at risk of running out of water, India Today - https://www.indiatoday.in/magazine/nation/story/20210329-the-cities-of-woe-1781275-2021-03-20

Figure 3 Water scarcity and stress projection in India[4]



1.1. Existing scenarios and gaps

Low provision of facilities for wastewater treatment, ineffective treatment of wastewater and existing treatment facilities working below par contribute to the discharge of partial or untreated wastewater and are responsible for more than 80% pollution in surface waters in India (CPCB, 2007).[5] Only 200 cities/towns in India have a partial sewerage network; only 32.7% of the urban population (25.78 of the total 78.9 million households) have access to sewer despite investments over 11 plan periods up to 2012 (Census, 2011). Sewage treatment capacity is 30% of what is required in class I and class II cities.[6] It is further exacerbated because existing treatment capacity is underused, with capacity utilization estimated to be about 66% of existing sewage treatment facilities (ibid).

Decreasing per-capita water availability and increasing pollution of fresh-water resources are enormous challenges as India continues to grow economically. In urban areas especially, water resources are under significant pressure due to high water-demand patterns. The situation is worsening with rising demand due to increasing urbanisation. Almost 80 per cent of water supply to municipalities flows back into the ecosystem as untreated wastewater, which is a critical environmental and health hazard. An estimated 38354 million litres per day (MLD) sewage is generated in major cities of India, but

[5]Water and Sanitation Programme, Approaches to Capital Financing and cost Recovery in Sewerage Schemes implemented in India: Lessons Learned and approaches for Future Schemes, March 2016

[6]Performance Evaluation of Sewage Treatment Plants under NRCD. CPCB. 2013. (https://cpcb.nic.in/openpdffile php?id=UmVwb3J0RmlsZXMvMjlfMTQ1ODExMDk5Ml9OZXdJdGVtXzE5NV9TVFBfUkVQT1JULnBkZg)

the sewage treatment capacity is only 11786 MLD. Similarly, only 60% of industrial wastewater, primarily large scale industries, is treated.

Figure 4 Wastewater generated and treated in major cities

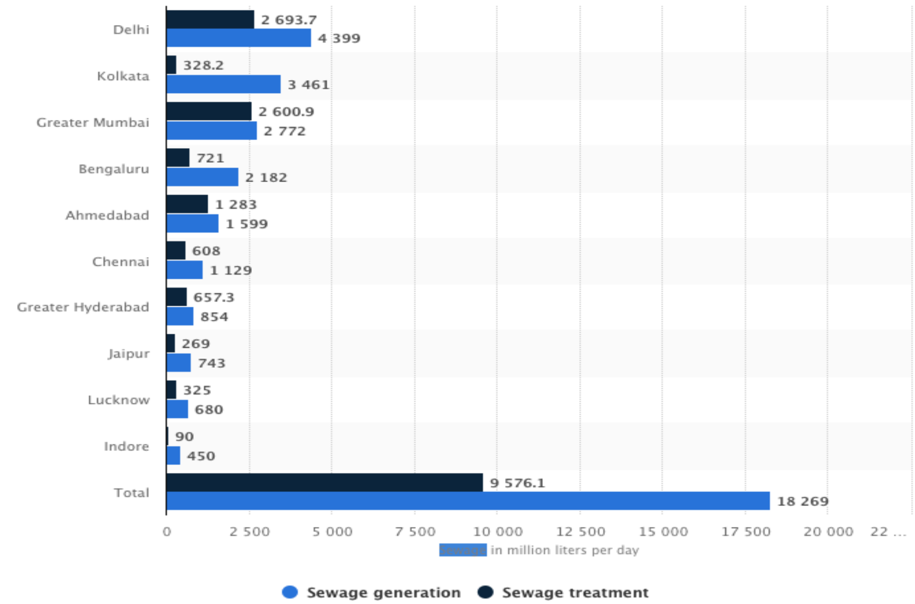


Figure 4 shows that there is a wide gap in terms of treatment infrastructure across all the cities. As of August 2017, Delhi generated nearly 4400 million litres of sewage per day. The Indian capital territory produced more sewage than any other city in the country that year. Among all the municipal corporations across the most populated cities, the sewage generation exceeded the treatment capacity. As this training is focused on helping ULBs to move forward in CSCAF ranking, the module is mainly designed to;

1. Understanding approaches and strategies to plan and design wastewater treatment facilities, including sewerage network; and
2. Understanding the essential functions of different technologies and their suitability in application in different scenarios.

1.2. Aligning with the ClimateSmart Cities Assessment Framework

The importance of wastewater recycling and reuse as an indicator is emphasized because freshwater resources are depleting rapidly, and climate change has impacted the availability and replenishment of water sources. This indicator stresses the conservation of existing water resources and opportunities to tap into recycling and reuse potential.

The assessment for this indicator is based on the percentage of wastewater that is being recycled and reused, adhering to CPCB standards. The higher the percentage of wastewater treated by the city (against the baseline), the higher the performance.

Formula:

$$\frac{\text{Treated wastewater recycled and reused in Million litres per day (or) month}}{\text{0.80 X water supplied to the city in Million litres per day (or) month}} \times 100$$

Unit: %

Maximum Score: Total score for the indicator is 100. Cities will be marked in 5 levels with scores ranging from 0 to 100.

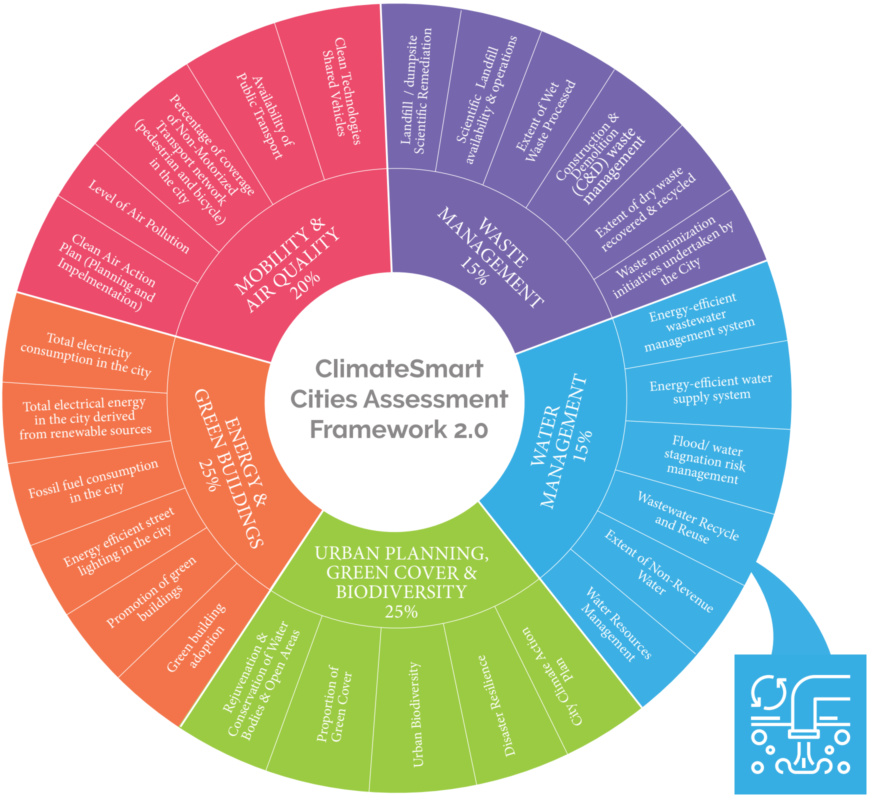
Based on this formula the performance evaluation levels may be derived using following table.

Table 1 Progression Level in CSCAF

Progression Level	1	2	3	4	5
Evidence	No Reuse	< 5% Treated wastewater recycled and reused	5 to <10% Treated wastewater recycled and reused	10 to < 20% Treated wastewater recycled and reused	>= 20% Treated wastewater recycled and reused
Score	0	25	50	75	100

Hence, this module will focus on enhancing the capacity of ULBs to treat and reuse wastewater by addressing the challenges and guiding enabling measures to achieve desired objectives.

Figure 5 ClimateSmart Cities Assessment Framework



2

Institutional framework

2.1. Legal provisions and Acts

While there are no specific legal provisions relating to urban sanitation, there are several provisions relating to sanitation services. The responsibility for the planning and delivering of urban services, including sanitation, lies with urban local bodies under local municipal laws and the 74th Constitutional Amendment Act, 1992. The 12th Schedule of the Act sets out a list of critical issues for the urban local bodies, including amongst other things:

1. Urban Planning
2. Regulation of land-use and construction of buildings;
3. Water supply for domestic, industrial, and commercial purposes;
4. Public health, sanitation, conservancy, and solid waste management;
5. Protection of the environment and promotion of ecological aspects; and
6. Slum improvement and upgrading.
7. Municipal Bylaws

These enable local bodies to discharge their functions and typically include, for example, a requirement for property owners to discharge wastewater without causing a nuisance; and an obligation to discharge wastewater into sewers where available. There are, however, no specific provisions for the safe removal, cartage, and disposal of septage in urban areas.[1]

Water (Prevention & Control of Pollution) Act, 1974 is comprehensive legislation regulating agencies responsible for checking on water pollution and ambit of pollution

[1]*A Guide to Decision making: Technology Options for Urban Sanitation in India, Ministry of Urban Development (Now Ministry of Housing and Urban Affairs), Government of India, 2007*

control boards both at the centre and states. Under Water Act 1974, Sewage or pollutants cannot be discharged into water bodies, including lakes, and the state pollution control board must intervene and stop such activity.

The Environment (Protection) Act, 1986: This Act applies in principle to every establishment, agency, or individual discharging any pollutant into the environment. 'Pollutant' includes treated or untreated sewage. In principle, municipalities must to comply with discharge norms for effluent released from sewage treatment plants and pay water cess under the Water Cess Act, 1977.

2.2. Policies and Guidelines

The National Environment Policy (NEP), 2006 builds on the various earlier policies that had addressed the environment's challenges and need for sustainable development prior to this policy. One of the objectives of the policy is to protect and conserve critical ecological systems and resources.

Atal Mission for Rejuvenation and Urban Transformation (AMRUT): Aimed to provide basic services (e.g., water supply, sewerage, and urban transport) to households and build amenities in cities to improve the quality of life for all, especially the poor and the disadvantaged.

National Urban Sanitation Policy (NUSP), 2008: Aimed to transform all urban areas into community-driven, totally sanitised, healthy, and liveable city and town, ensuring and sustaining good public health and environmental outcomes for all citizens.

The Manual on Sewerage and Sewage Treatment (CPHEEO), 2013: The Manual on Sewerage and Sewage Treatment of the Central Public Health and Environmental Engineering Organization, Ministry of Housing and Urban Affairs (formerly known as, Ministry of Urban Development (MoUD)), sets out technical norms for best practice in on-site sanitation and wastewater management. The manual covers planning, design, and construction aspects for various technical options; it also includes operation and maintenance aspects and safeguards to prevent water pollution under different soil and groundwater conditions.

2.3. Standards

Besides these Acts and statutory provisions documents, there are many relevant Indian Standards and Codes of Practice notified by the Bureau of Indian Standards that guides the planning, design and implementation of various components of the value chain of wastewater recycling and reuse. The most relevant include the following:

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

In addition, MoHUA (then MoUD) prepared a document entitled 'Technical Guidelines on Twin-Pit Pour-Flush Latrines' in 1992, which broadly follows the lines of IS 12314:1987 on leach pit construction in rural areas.

All Indian Standards' codes represent a standard of good practice and therefore take the form of recommendations. They are not mandatory unless made so under contract conditions, and some are routinely ignored, for example, the recommendation for the construction of soakaways, dispersion trenches, and biological filters to deal with the outflow from septic tanks; and for the regular desludging of septic tanks using specified equipment.

Credits: Timothy L Brock on Unsplash

3

Implementation strategies

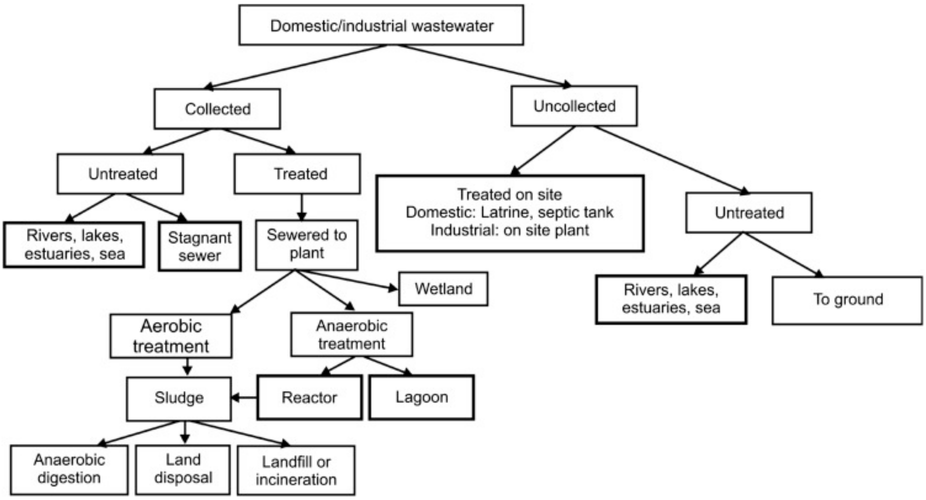
3.1. Concept in practices

Typically, the uncollected wastewater is either treated with onsite sanitation systems like a septic tank or disposed-off in lakes, rivers or even on the ground without any treatment. Figure 6 showcase a typical process of handling wastewater in India. However, collected wastewater may undergo primary or secondary treatment where the Sewage Treatment Plant (STP) facility is available. In a few instances, treated water may be reused after secondary treatment or subject to tertiary treatment. Often, collected water may also be disposed of without treatment in the absence of such a facility within the city.

A typical process involves primary and secondary wastewater treatment, which is shown below (Figure 6). Different systems employ primary or up to secondary treatment methods. For advanced use of treated water (like disposal in water bodies or domestic and drinking water use), tertiary and advanced purification treatment can be adopted.

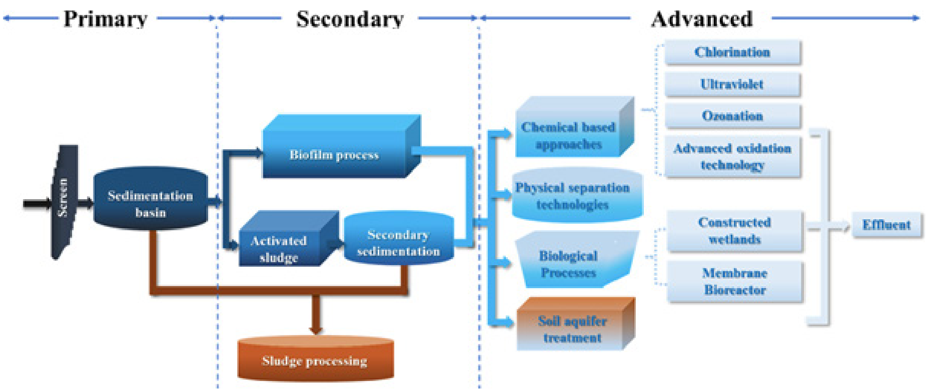
The primary treatment involves screening and sedimentation to remove large solid particles from wastewater. Secondary treatment may use physical, biological and chemical processes to remove smaller and tiny particles and further reduce the contaminants. Use of biofilms, activated sludge, secondary sedimentation, coagulation, and other chemical treatment processes are common in secondary treatment. Tertiary or advanced treatment processes are used to remove micro contaminants, dissolved salts and solids, chemical contaminants, foul odours etc, so that treated water can be reused for various purposes. Chemical-based methods, membranes, Ultraviolet process, Ozonisation, Oxidation are standard processes in this stage. Use of one or more processes can be determined by the quality of influentand end use purpose after treatment.

Figure 6 A typical flowchart of wastewater treatment process[1]



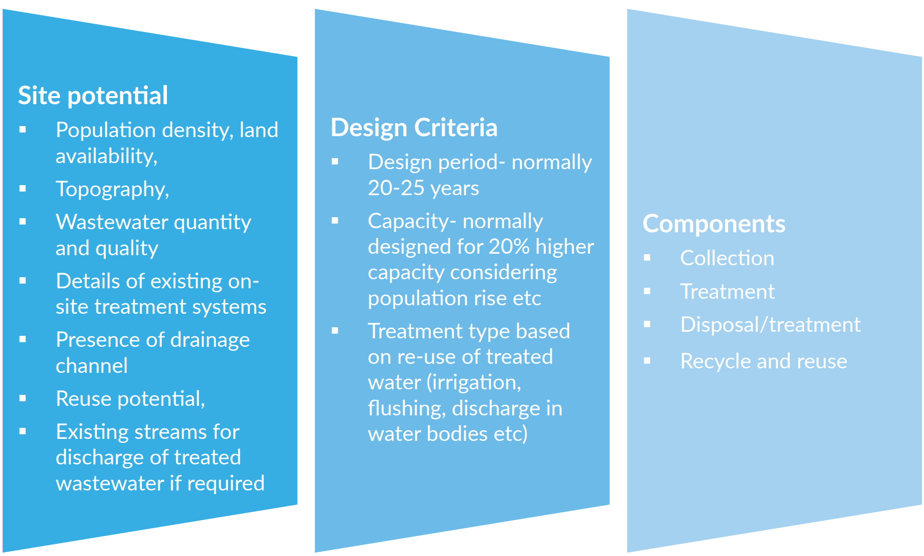
[1]*Image Source: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/industrial-waste-water*

Figure 7 Primary, Secondary and Tertiary Treatment of Wastewater[2]



3.2. Planning and Design

Figure 8 Broad parameters for planning and design of wastewater infrastructure



To plan or design a sanitation system with sewerage and treatment systems, three broad sets of information and parameters need to be considered.[3] This includes

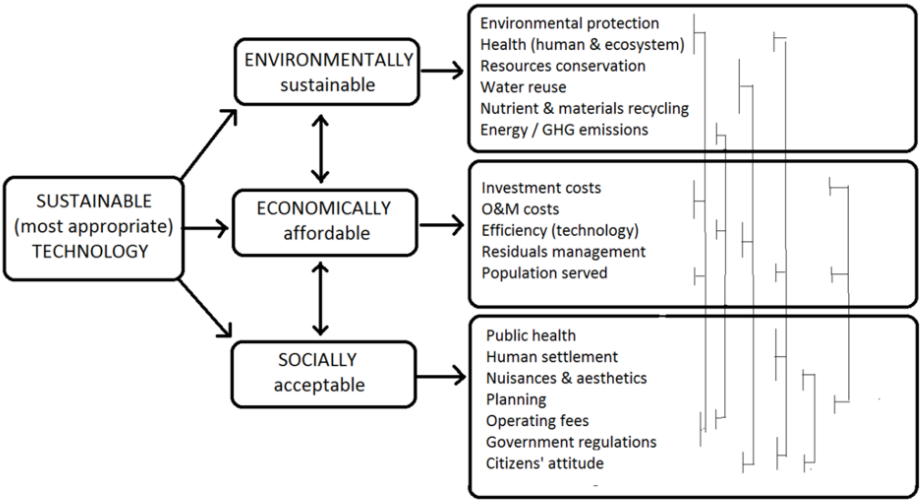
[2]*Image Source https://www.sciencedirect.com/science/article/pii/S0160412019307378*

[3]*Adapted from Guidelines for Decentralized Wastewater Management, IIT Madras, MoHUA, 2012*

1. site condition and site potential for installing and commissioning the designed wastewater treatment plant. It considers the environmental and social concerns while selecting the site.
2. Design criteria including type of treatment projected handling capacity, phase-wise development (if needed) and estimated design period. It considers the technological options and demography to be catered, and
3. Components of the treatment process itself, which will be crucial for determining the appropriate and optimal processes in line with other two sets of information – site potential and design criteria.

Further, the parameters for selecting technology for wastewater treatment should be most appropriate and aligned with the sustainable development approach. It can be broken down into three broad parameters: environmentally sustainable, economically affordable and socially acceptable.

Figure 9 Parameters for selection of appropriate technology for wastewater treatment[4]



In short, multiple criteria and parameters play a crucial role in determining the appropriate strategy and process involved in designing and implementing wastewater treatment and recycling. The influencing factors on deciding on the most appropriate wastewater treatment system may include the following :

1. Scale of the project
2. Physical characteristics of the site such as geohydrology, topography etc.
3. Planning considerations like land use planning, population projections, industrial and infrastructure projects etc
4. Management capabilities – present and future, and availability of skill and technology

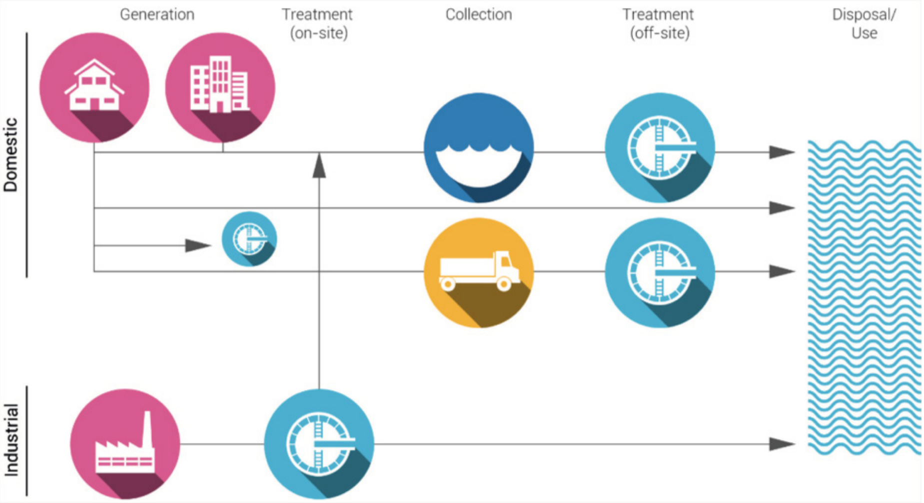
[4]*Image Source: https://www.mdpi.com/2079-9276/6/2/22/htm*

5. Appropriate technology to serve the purpose and objectives of treatment, reuse
6. Legal compliance requirements
7. Social acceptance in terms of acceptable hazards and environmental implications
8. Financial status, funding mechanism and opportunities
9. Environmental impact of the project

3.3. Implementation strategy

Implementation strategy should consider all service chain stages, including generation, onsite treatment, collection/ containment, conveyance, offsite treatment, and disposal/ reuse.

Figure 10 Service chain in wastewater treatment and recycling[5]



These stages have to be considered in an integrated manner as there may be different appropriate solutions catering to different stages. For example, the most suitable solution for containment or conveyance may not fit best into the treatment system needed to achieve the reuse objective. Thus, the system has to be designed keeping in mind the ultimate objective use of treated water.

To plan sewerage and treatment systems, we can adopt a combination of four broad level strategies. Onsite Systems are the measures where the containment or treatment of wastewater is done near the source, and usually, there is no need for long conveyance systems. When such systems are designed at the institutional or small cluster level and cater to the treatment and reuse needs locally, they are characterised as decentralised systems.

[5]*Image Source: World Health Organization and UN- HABITAT, 2018*

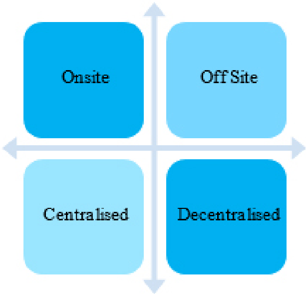
On the other hand, offsite systems typically serve large areas where wastewater is directed to a common treatment plant. When such systems typically serve large areas or populations, it is also called a centralised system. The difference between centralised and decentralised systems is explained in table 2.[6]

Table 2 Difference between centralised and decentralised systems

	Decentralized	Centralized
Treatment & Installation/ construction	▪ Currently, even decentralized treatment systems have gained efficiency in treatment. ▪ Smaller solutions, faster to implement ▪ Re-use of treated waste is easier to manage due to lower conveyance ▪ Easy to pilot new technologies ▪ May require lower energy and pumping ▪ Ease in expansion and the modular system can be done	▪ High treatment efficiency of the conventional treatment system. ▪ The larger infrastructure is required and higher time is required for construction/installation. ▪ Re-use of treated waste also require higher conveyance ▪ The pilot of New technologies require meticulous planning for success ▪ Require high energy and pumping, mainly considering larger conveyance. ▪ Expansion in the existing system may be difficult.
Managerial Aspects	▪ The number of treatment units are more, but conveyance is reduced. The higher number of treatment units/systems to be managed, but managing conveyance is reduced considerably.	▪ A smaller number of treatment units required. So easier to manage. But conveyance to centralized place (transport/pipelines) require high monitoring and maintenance
Financial Aspects	▪ Reduced conveyance infrastructure ▪ Reduced O & M for conveyance ▪ Low energy-intensive technologies possible and thus reduced/no energy consumption and thus very low O & M costs	▪ Higher infrastructure cost mainly considering higher conveyance of waste. ▪ Usually, require higher energy/ fuel -intensive technologies and pumping/conveyance, leading to higher investment as well as higher operation and maintenance costs.
Location & Social Acceptance	▪ Customarily, located near human settlement. Needs acceptance due to issues like odour, aesthetics etc near the settlement.	▪ Typically located far from human settlement, so no significant acceptance issues by the community.
Community Participation	▪ Higher participation in the community required	▪ Lower participation of community required

[6]*Adapted from presentation by Dr. Markus Starkl published in Develoment.asia*

Figure 11 Planning strategies for wastewater treatment systems



Centralised systems are typically offsite systems. i.e. the waste must to be conveyed to the treatment plant, which may be at a distance. However, Decentralised systems may be onsite and offsite (but at a smaller distance). Advantages and disadvantages of onsite systems can be summarised as follows:

Table 3 Advantages and Disadvantages of On-site systems[7]

Advantages of onsite systems	Dis-advantages of onsite systems
▪ Less environmental disturbances. ▪ Nil or minimal sewer pipelines. ▪ Maintained by individual households/ establishments. ▪ Power requirement is nil or minimal. ▪ Maintenance of the treatment system is effortless.	▪ Policies not well established. ▪ Standardization of the systems is difficult. ▪ Individual households/establishments bear O & M cost. ▪ Improper maintenance leads to significant environmental consequences. ▪ Individual components will not be able to meet the discharge standards.

Annexure 1 gives list of different technologies in wastewater management.

The roles and responsibility of various stakeholders also differ according to planning approach and scale of the systems. This can be summarised in Tabel 3:

MoHUA is mandated to define policies regarding urban sanitation, along with financing large programmes which are implemented in partnership of States. State-level Urban Development Department (SUDD) may also be drafting policies at the State level. Projects may also be financed independently or jointly by SUDD and State-level Water Supply and Sewerage Board (WSSB/SUWSSB) and Urban Local Body (ULB). WSSB is also mandated to implement the project. State or Central Pollution Control Board may do the performance quality control and monitoring.

[7] *Source: CPHEEO, Guideline on Decentralized Wastewater Treatment Bharat Mission- Gramin, Manual for District Level Functionaries, 2017*

Table 4 Stakeholders and their roles

Category/ Roles	Policy	Capital Investment	Implementation	Effluent Standard	Monitoring
Large Scale[8] Centralized or semi decentralized	MoHUA	MoHUA	SUWSSB	CPCB	SPCB
	SUDD	SUDD	WSSB	SPCB	
		WSSB			
		ULB			
Small Scale[9] – In-situ/ decentralized	MoEFCC	Builders, Developers, Real Estate Companies	Builders, Developers, Real Estate Companies	CPCB	SPCB
	SUDD	Institutions	Institutions	SPCB	ULB
	SPCB	Private Business	Private Business	ULB	

However, for small scale independent projects, Ministry of Environment, Forests and Climate Change (MoEFCC) policy directives may be followed. Generally, financing and implementation of small scale projects is done by private players, builders, developers etc. However, effluent standard should confirm to CPCB/SPCB or even ULB directives.

3.4. Funding

Financing wastewater treatment systems and sewerage networks may involve different stakeholders for different projects. It may include:

1. Public funding through government programmes like Swachchh Bharat Mission and Namami Gange
2. Shared expenses by community or user fee-based like institutional and RWA projects
3. Private finance like NGO funding, CSR funding or investment by enterprises and entrepreneurs like
4. Partnership models wherein two or more agencies collaborate for financing like the Alandur Sewerage project

For ULBs, different options of securing funding for new or expansion of sewerage and treatment systems are given below. However, depending on the focus and criteria laid in the scheme, all the options may not apply to all the cities.

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[8] *large scale systems refers to city level systems or systems catering to large population and area, generally with treatment capacity of over 1 MLD*

[9] *Small scale systems refers to systems catering to cluster, society or institutions, generally with treatment capacity of less than 1 MLD*

Table 5 Government Schemes and Funding Options for ULBs[10]

Program	Funding Options
Atal Mission for Rejuvenation and Urban Transformation (AMRUT)	AMRUT 2.0 is launched for 5 years from 2021-22 to 2025-26 with aim to make cities water secure and enhance circular economy through recycling of wastewater in 500 cities in India. It targets 100% coverage of household sewerage/ septage management with 2.64 crore sewer/ septage connections. Funds are allocated or decentralized sewerage systems, recycling and reuse of treated water. Under Reforms Agenda for AMRUT 2.0, reforms on water conservation envisages recycle of treated wastewater to meet 20% of total city water demand and 40% of industry water demand in aggregate at State level. Total indicative outlay for AMRUT 2.0 is ₹ 2,77,000 crore including central share of ₹76,760 crore over five years.
Smart City Mission	Each city will create a Special Purpose Vehicle (SPV), headed by a full-time CEO, to implement the Smart Cities Mission. Centre and state government will provide crore funding to the company, as equal contribution. The company has to raise additional funds from the financial markets. Under Smart City Mission, component of water management including wastewater recycling, storm water management and energy efficiency in wastewater treatment.
Pradhan Mantri Awaas Yojana (PMAY)	The mission will support construction of houses upto 30 square meter carpet area with basic civic infrastructure. States/UTs will have flexibility in terms of determining the size of house and other facilities at the state level in consultation with the Ministry but without any enhanced financial assistance from Centre. Slum redevelopment projects and Affordable Housing projects in partnership should have basic civic infrastructure like water, sanitation, sewerage, road, electricity etc. ULB should ensure that individual houses under credit linked interest subsidy and beneficiary led construction should have provision for these basic civic services.
Swachchh Bharat Mission (Urban) 2.0	SBM 2.0 focusses on Garbage free cities and maintaining and enhancing Open Defecation Free (ODF). The SBM-ODF+ and SBM-ODF++ protocols build upon the ODF protocols while keeping true to its provisions, so as to provide a platform for cities and towns to improve sanitation sustainability. These protocols are incremental in nature and reflect on-ground realities present in India.

[10]*Source: 2016, Handbook on Decentralized Wastewater Treatment, National Institute of Urban Affairs, New Delhi*

Program	Funding Options
Jal Jeevan Mission (JJM)	JJM focus on tap connectivity for water supply to every household by 2024 thus helping enhance water availability for sanitation. Mission also has components for water treatment facilities and grey water recycling . Total estimated cost of JJM is Rs. 3.60 Lakh Crore. The fund sharing pattern between Centre and State is 90:10 for Himalayan (Uttarakhand, Himachal Pradesh) and North-Eastern States, 100:0 for UTs and 50:50 for rest of the States.
Namami Gange Programme	Under National Mission for Clean Ganga (NMCG), projects for expansion and enhancement of sewerage network and in-situ sewage treatment options have been sanctioned. In the budget for the financial year 2020-21, Government of India has proposed an allocation of Rs.1,600.02 crore for the Namami Gange Programme.
15th Finance Commission	The 15th Finance Commission has allocated Rs 1.5 lakh crore in grants to urban local bodies (ULBs) in India for the next five years comprising 100% outcome funding of Rs 26,000 crore for million-plus urban agglomerations tied to water and sanitation. The remaining cities to receive an allocation of Rs 83,000 crore in aggregate, with 60 percent of the funds tied to performance on water and sanitation and balance being untied.[11]

3.5. Wastewater recycle and reuse

3.5.1. Reuse Potential

Collection, treatment and reuse of municipal wastewater provides an opportunity for environmental rehabilitation and 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 m^3 (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.

[11] *https://www.moneycontrol.com/news/business/real-estate/15th-finance-commission-allocates-rs-1-5-lakh-crore-in-grants-to-urban-local-bodies-6436111.html*

3.5.2. Benefits of Reusing treated wastewater

Model Building Bylaws 2016 mandates wastewater recycling and reuse for “all building having a minimum discharge of 10,000 litre and above per day. The recycled water should be used for horticultural purposes”. Handbook on Service Level Benchmarking by MoHUA proposes benchmark of 20% extent of recycling and reuse of sewage for urban areas.

There are several benefits to wastewater recycling for cities, industries, agriculture and others, which are explained here:

1. An additional source of water: Recycled wastewater reduces freshwater demand within the city and for industries and agriculture. This option is generally is less expensive than other options to augment existing water supplies from distant water sources or expensive treatment such as desalination. 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, the use of reclaimed water in agriculture frees up freshwater for domestic and industrial consumption. By 2030, treated wastewater from Class I and II cities can meet about a quarter of the current industrial water demand.
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. Therefore, 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 the state/local regulations.
3. Reduction in groundwater pumping requirement: The use of treated wastewater for irrigation also can to reduce groundwater irrigation, hence pumping and the associated energy requirement, GHG emissions, and associated costs. An estimated 1.75 million MWh of electricity, which is equivalent to reducing about 1.5 million tonnes of CO2e (tCO2) GHG emissions can be avoided by reduced pumping every year in India.

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 groundwater 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.

Credits: Markus Spiske on Unsplash

4

Interactive Exercise

The interactive exercise is designed on the MIRO Board, allowing multiple users to engage in exercise simultaneously while the moderator to controls the level of engagement and use of specific tools.

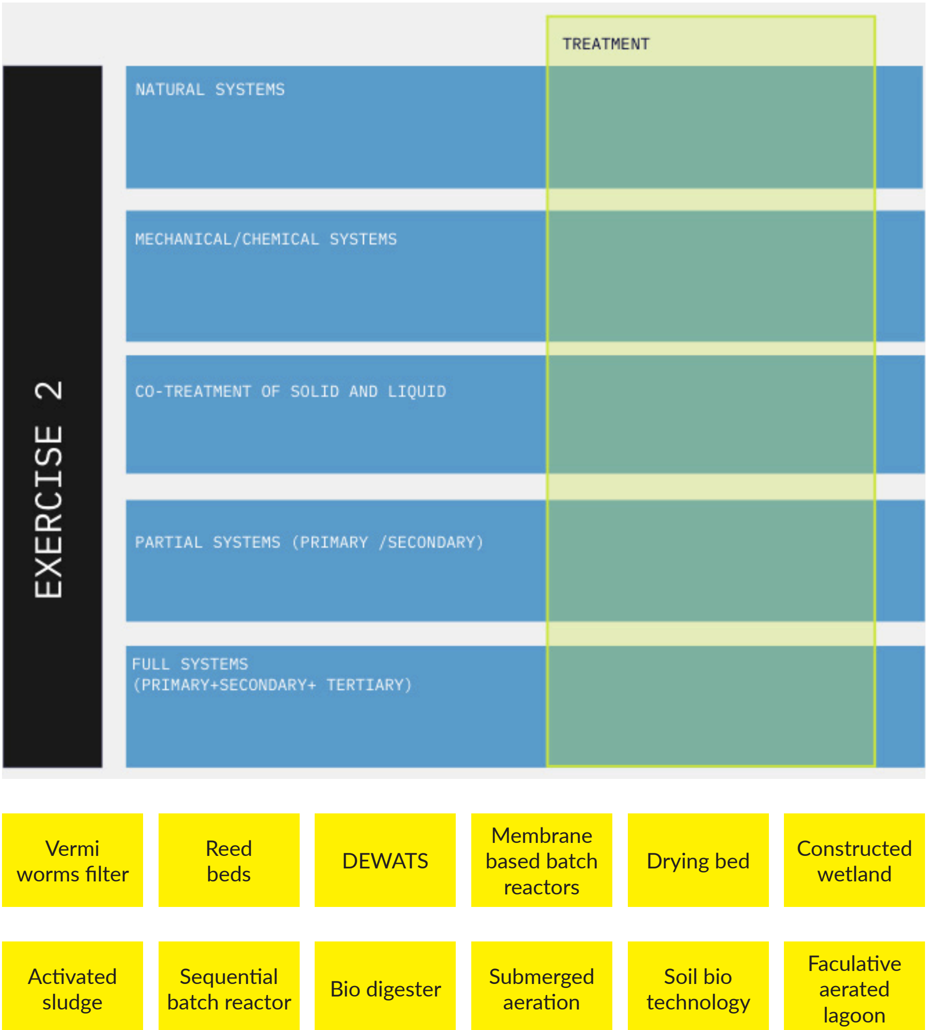
This online exercise is designed for participants to understand

1. Influencing factors for selecting various options across service chain of wastewater treatment system – containment, conveyance, treatment and reuse; and
2. understand suitable options for various phases of the service chain.

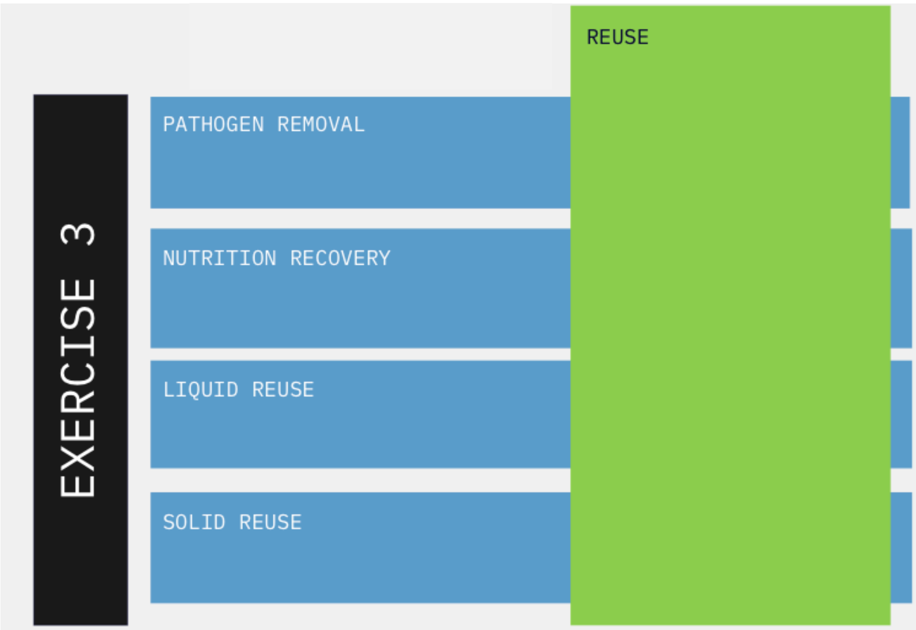
Exercise 1: This part of the exercise is about understanding factors that influence the decision on the containment and conveyance of wastewater and faecal sludge. A table consists of rows of various restrictive parameters like hilly terrain, high groundwater, rocky strata, cold region etc. while in columns, participants have to drag and drop notes with various options of containment (like soak pit, septic tank etc) and conveyance (sewer line, small bore, vehicle pump etc).

There are three exercises within this session to achieve the objectives.

Exercise 2: This exercise is about different types of treatment systems. Rows have broad treatment systems like natural systems, mechanical systems, co-treatment options, partial systems (primary and secondary treatment) and complete systems (including tertiary systems). Participants have to select treatment systems from sticky notes and place them in appropriate rows.



Exercise 3: This exercise relates to various reuse options after treatment and related processes required to suit reuse purposes. Here rows are marked with broad processes like pathogen removal, nutrition recovery, liquid reuse and solid reuse. Participants have to select end-use options like energy pallets, fertilisers etc, given in sticky notes and place them in appropriate rows. At the end of each exercise, briefly discuss challenges and opportunities related to selecting of appropriate technology and processes in each value chain stage in their respective cities. At the end of all three exercises, summarise the main learning points.



Irrigation	Disposal in sewer	Ground water recharge	Compost	Fertilizer
Irrigation	Energy pallets	Disposal in water body	Industrial use of water	Construction on material from

4.1. Additional offline exercise of participants

Fill in the blank cells of table with appropriate technologies and processes :

Table 6 Participants exercise: Technologies of containment and conveyance

Parameters	Appropriate technologies and processes	
	Containment	Conveyance
Hilly or undulating terrain		
High ground water table		
Coastal area		
Rocky strata		
Extreme cold climate		

Table 7 Participants exercise: Technologies of treatment

Parameters	Appropriate treatment technologies	
	Natural systems	Mechanized or hybrid systems
Partial systems (allows Primary and Secondary treatment only)		
Full or advanced systems (allows primary, secondary and tertiary treatment)		

Table 8 Participants Exercise: End use purpose and products

Reuse Processes and treatment objectives	End use products
Pathogen removal	
Nutrition recovery	
Liquid reuse	
Solid Reuse	

5

Case Study

5.1. Alandur Sewerage Project: Successful Innovation and Partnership

Alandur is a small municipality adjacent to the Chennai Metropolitan Development (CMD) Area with a population of 146,000 (Census 2001). Slums and squatter settlements constitute about a quarter of the total population. Before the project, almost 95 per cent of families had household toilets with individual septic tanks discharged into open drains where much of it stagnated due to low flows, causing odour and offering sites for mosquito breeding. While the municipality provided a septage removal service, there was no treatment facility, and waste was disposed of in low-lying areas beyond the municipal limits.

The Alandur sewerage project, initiated in 1996, was the first project in India using a PPP framework (Build-own-transfer (BOT) format) and presents a unique case in the area of PPP in urban sanitation sector.[1]

Sewerage component included the following:

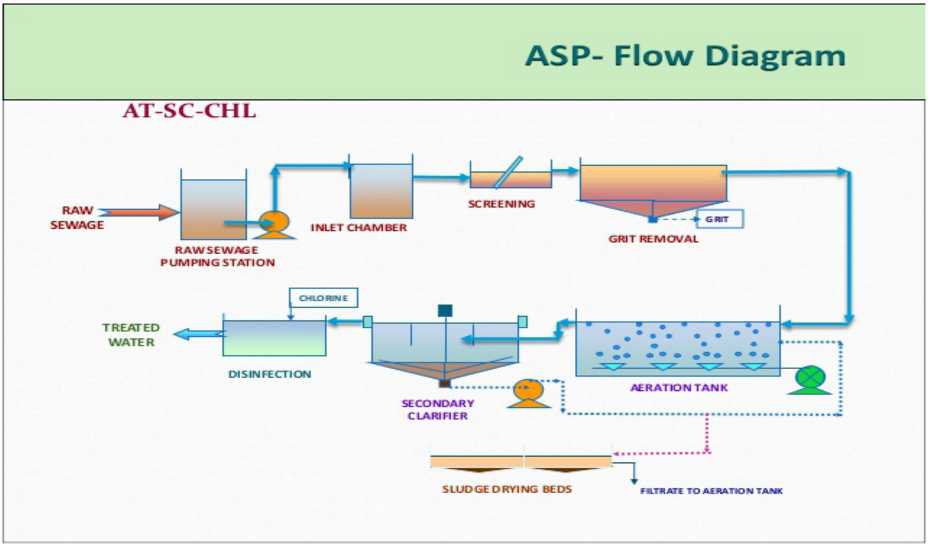
1. a sewerage network consisting of the main sewer line, branch sewer line and inspection chamber (manholes);
2. construction of a sewage pumping station;
3. a Sewage Treatment Plant with Activated Sludge Process (ASP) technology); and
4. Low-cost sanitation

The construction of the underground sewerage system was done through an engineering, procurement and construction contract, and the STP was constructed on a BOT basis. The

[1] *Ministry of Finance, Government of India, Tookit for improving PPP Decision Making Processes (pppinindia.gov.in)*

Municipality carried out the O&M of the sewerage system, including sewer lines, pump houses, and pumping plants. The project's financing was done uniquely by collecting one-time deposits from users who financed 40% of the project cost. Other financing mechanisms included loans (46%), Capital grants (11%) and connection fees (3%). Public awareness and support were sought through an extensive communication campaign.

Figure 12 Schematic diagram of ASP technology[2]



[2]*Source: https://www.slideshare.net/A3SEnviroConsultants/stp-plants-technology-by-a3s-enviro-consultants*

To plan this complex and politically challenging project, local body worked in partnership with the Tamil Nadu Urban Infrastructure Financial Services Limited (TNUIFSL), the state asset management company and with USAID's Financial Institution Reform and Expansion (FIRE) Project. A sewerage network consists of the main sewer line, branch sewer line and inspection chamber; a sewage pumping station, a sewage treatment plant, and low-cost sanitation. In the initial phase the plant treated 12 MLD of sewage supplied to it by the municipality. The ultimate capacity was to be 24 MLD. Eventually, the project connected 32,000 users and 43 per cent of the slum households in the city took individual connections. A notable feature is the tariff structure, developed on full user charge recovery with cross-subsidies for the poor. The municipality collects differential user charges based on the size of the property.

5.2. Tiger Bio Filter Sewage Treatment Plant at Vasantrao Bagul Udyan, Pune

Before the project, wastewater from three slum colonies located 1 Km upstream of Bagul Udyan was disposed into Ambil Odha Nalla, and further nalla was mixing up with Mutha River, contaminating water source. This project was taken up to control water pollution and reuse treated water for public facility.

Project Details:

- Location of treatment plant: Vasantrao Bagul Udyan, Pune
- Areas catered: 3 slum colonies (i.e. Sanjay Nagar, Sandhya Society and Gavali Wada) catering to 3000 HHs
- Capacity: 500 KL/D

Operational Since: 2017

- Areas of Site: 400 sq.m.

Key stakeholders:

The project was conceptualised by private player, which was then taken up by Urban Local Body and implemented through agency with expertise in this domain. Thus it also showcases Public Private partnership in sector in a unique way.

Owned and Financed by	• Pune Municpal Corporation
Implementing Agency	• Waingade Enviro and Agri Solutions, Pune
Concept and Design by	• Primove Infrastructure Pvt. Ltd., Pune

Financials:

Investment Cost: 1.25 crore

Operation & Maintenance Cost: Rs. 8.91 lakh/year

Type of technology used:

Bio-filtration technique, based on vermi-filtration, pressure sand filter and activated carbon filter was used in this project. The technique is environmentally friendly as it requires less operational land. The treatment system contains filter media with specially bred earthworms, which helps degrade organic waste from wastewater at a rapid rate. This helps in eliminating the need for forced aeration using a blower. The worms convert organic matter into valuable compost, which can be directly used as a fertilizer.

The unique set-up of the treatment plant introduces a "trickling" action of the wastewater as it passes through the bio-media and dissolves oxygen into it. The inorganic waste in the water is removed by physical filtration and digested and metabolized by the earthworms and microorganisms. Treated wastewater is used in gardening, irrigation and construction sites.

Benefits of project:

Project has not only helped in reduction of pollution load of fresh water sources, but have also demonstrated environment friendly approach and technology for wastewater treatment and reuse at decentralised level.

6

List of additional materials

6.1. Documents

- ✓ *NIUA & Ministry of Housing and Urban Affairs, Solid Waste Initiatives in Urban India, A Compendium, 2019*
- ✓ *MoUA and CPHEEO, Municipal Solid Waste Management Manual (Part II: The manual), 2016.*
- ✓ *Centre for Science and Environment, Decentralized Wastewater Treatment and Re-use : Case studies of implementation on different scale – community, institutional and individual building;, New Delhi, 2014*
- ✓ *Isher Judge Ahluwalia & Utkarsh Patel, Solid Waste Management in India: An Assessment of Resource Recovery and Environmental Impact, Indian Council for Research on International Economic Relations, April 2008*
- ✓ *ICCO and CDD Society, Linking Climate Sanitation and Climate Change: Evaluation GHG emissions and vulnerability: the case of Valsad, 2014*
- ✓ *CPHEEO, Guideline on Decentralized Wastewater Treatment Bharat Mission- Gramin, Manual for District Level Functionaries, 2017*
- ✓ *Government of India, Technological Options for Solid and Liquid Waste Management in Rural Areas, Swacchh Bharat Mission, 2015*
- ✓ *Ministry of Environment, Forest and Climate Change, Notification on Solid Waste management Rules, 2015*
- ✓ *EAWAG Aquatic Research & The International Water Association, Compendium of Sanitation Systems and Technologies, 2nd Revised Edition*
- ✓ *Ministry of Urban Development. Government of India, Guidelines for Decentralized Wastewater Management, December 2012*
- ✓ *UNICEF & Ministry of Drinking Water, Rural Development, India, Solid and Liquid Waste Management in Rural Areas: A Technical Note.,*
- ✓ *Planning Commission, Govt. of India, Report of the Task Force of Waste to Energy, May 2014*

- ✓ *United Nations Center for Regional Development in Collaboration with Ministry of Housing and Urban Affairs, GOI and Ministry of Environment Govt. of Japan, Discussion Paper- "Creating Circular Economic Potential as a Way for Achieving Smart and Sustainable cities*
- ✓ *Arun Kumar, Kirti Goyel, Water Reuse in India- Current perspective and future potential, ScienceDirect.com, August 2020*
- ✓ *World Bank, Water and Sanitation Program (WSP); International Water Management Institute (IWMI), Recycling and reuse of treated wastewater in urban India: A proposed advisory and guidance document, 2016*

6.2. Articles

- ✓ *Government of India, Ministry of Environment , Forest and Climate Change, Loksabha unstarred question no. 2541, updated on 28th May 2018*
- ✓ Order Of The National Green Tribunal Regarding Effluent Discharge Standards For STPs, 30/04/2019 Updated on 8th May, 2019
- ✓ *April 2018, Meera Sahasranaman & Arijit Ganguly, Occasional Paper No. 13-0418, Wastewater Treatment for Water Security in India, Institute of Resource Analysis and Policy, Hyderabad)*
- ✓ *2018, "Accelerating India's Circular Economy Shift- A Half Trillion USD Opportunity, Future Proofing Growth in a Resource Scarce World", Circular Economy Synopsis, FICCI*

6.3. Webpages

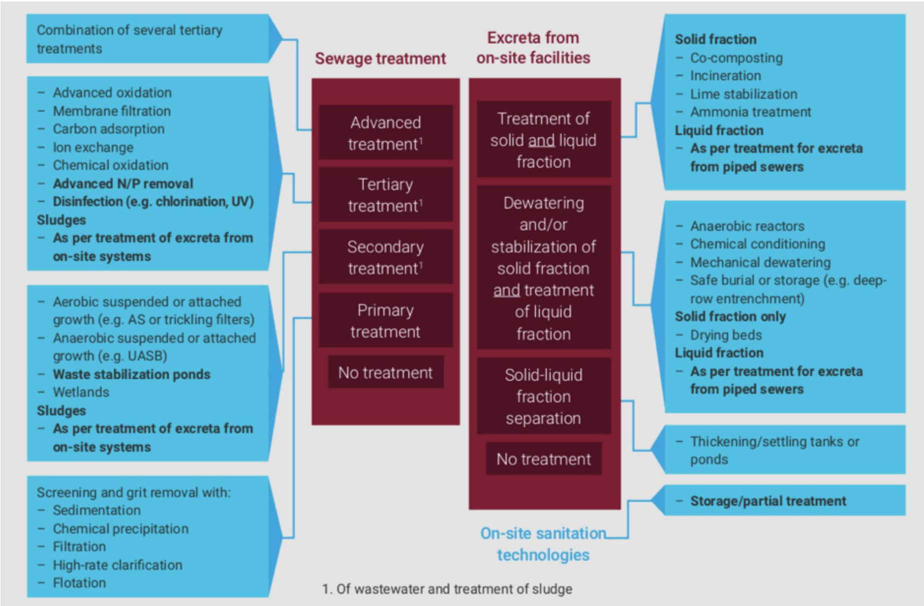
- ✓ https://www.borda.org/solutions/decentralised-sanitation-systems-2/
- ✓ https://unstats.un.org/sdgs/metadata/files/Metadata-11-06-01.pdf)
- ✓ http://agricoop.nic.in/sites/default/files/Vermicompost%20Production%20Unit.pdf
- ✓ http://vikaspedia.in/energy/energy-production/bio-energy/biogas#section-8
- ✓ http://www.theijes.com/papers/v2-i11/Part.2/J021102070076.pdf
- ✓ http://www.ecoideaz.com/expert-corner/large-scale-biogas-power
- ✓ https://www.downtoearth.org.in/news/waste/trash-fired-power-plants-wasted-in-india-63984
- ✓ https://www.thebetterindia.com/126083/kerala-alappuzha-zero-waste-cleanest-city-india-un/
- ✓ https://ghgprotocol.org/sites/default/files/Waste%20Sector%20GHG%20Protocol_Version%205_October%202013_1_0.pdf
- ✓ https://www.downtoearth.org.in/blog/waste/india-s-challenges-in-waste-management-56753
- ✓ http://www.ijims.com/uploads/6d43708e4183a6fd9a104mithun.pdf)
- ✓ https://nrega.nic.in/Netnrega/WriteReaddata/Circulars/1569SuggestiveEstimatesFarmPondNADEPandVermiCompost.pdf
- ✓ https://iopscience.iop.org/article/10.1088/1755-1315/16/1/012033

7

Annexures

Annexure1: Different types of technologies for wastewater treatment

Figure 13 Different type of technologies for wastewater treatment[1]



[1]*Image Source: World Health Organization and UN- HABITAT, 2018*

Annexure 2: Functions of different components of wastewater treatment systems

Table 9 Various functions of different components of treatment systems

Principal purposes of Unit Processes	Unit Processes
Grit Removal	Grit chambers
Removal or grinding of coarse solids	Bar screens
Odour control	Per chlorination, Ozonation
Gross solid-liquid suspension, BOD reduction	Plain primary settling
Gross Removal of soluble BOD and COD from raw wastewater	Biological treatment
Removal of oxidized particulates and biological solids	Plain secondary setting
Decomposition or stabilization of organic solids, conditioning of sludge for dewatering	Anaerobic sludge digestion
Ultimate sludge disposal	Sludge drying beds, land disposal, land reclamation
Removal of colloidal solids and turbidity from wastewater	Chemical treatment, sedimentation, mixed-media filtration
Phosphate removal	Chemical coagulation, flocculation and settling
Nitrate removal	Ammonia stripping
Removal of suspended and colloidal materials	Mixed-media filtration
Disinfections	Chlorination, UV treatment

Annexure 3: Details of various onsite treatment systems

Table 10 Advantages and disadvantages of various onsite treatment systems

Type	Kind of Treatment	Use of type of wastewater	Advantages	Disadvantages
Septic Tank	Sedimentation, Sludge Stabilization	Wastewater of settleable solids, specially, domestic	Simple, durable, underground so requires little space	Low treatment efficiency, effluent not odourless
Imhoff tank	Sedimentation, sludge stabilization	Waste water of settleable solids	Durable, less space required as underground, colourless effluent	Less simple than septic tank, needs regular de-sludging
Anaerobic filter	Anaerobic degradation of suspended and dissolved solids	Pre-settled domestic wastewater of narrow BOD/ COD ratio	Simple and fairly durable, high treatment efficiency, little space required as underground	Costly in construction,
Baffled septic tank	Anaerobic degradation of suspended and dissolved solids	Pre-settled domestic wastewater of narrow BOD/ COD	Simple and durable, high treatment efficiency, less space required as underground,	Longer start-up phase than anaerobic filter
Root zone treatment	Aerobic degradation of dissolved and fine suspended solids, pathogen removal	Suitable where settleable solids and suspended solids already removed by pre-treatment	High treatment efficiency, can be merged with landscape, no odour	High space requirement, requires higher maintenance
Anaerobic pond	Sedimentation, anaerobic degradation and sludge stabilization	Strong/medium wastewater	Flexible and simple in construction, little maintenance	Large space required, odour is always there, vector breeding possible
Aerobic pond	Aerobic degradation, pathogen removal	Pre-treated domestic wastewater	Simple in construction, high pathogen removal, fish farming possible	Large space requirement, vector breeding and odour possible

Type	Kind of Treat-ment	Use of type of wastewater	Advantages	Disadvantages
bioremedia-tion	use of different microorganisms to reduce pollutant load	Can be used of industrial (heavy metal and others) as well as domestic waste	Efficient, cost effective and environmental friendly processes can be developed	Large scale implementation remains challenge due to different experimental conditions and target pollutants
Phytorid	Engineered wetland system to reduce organic load	Domestic wastewater, food, dairy and textile industry wastewater	Decentralised, low maintenance, non mechanical, non electrical	High Space requirement Not suitable treating industrial waste
Bio Gas Unit	Anaerobic digestion through micro organism and generation of mainly methane	Biogas/ methane produced is used as fuel for burning or creating electricity; slurry can be used as soil fertilizer	Simple, durable , reduction of solids to be handled; excess sludge production on the basis of biodegradable COD in anaerobic treatment is significantly lower compared to aerobic processes	Requires strict monitoring due to sensitive micro organisms in it , require high amount of waste for gas optimum gas production Needs good workmanship while construction/ installation as leakages can bring down efficiency

Source: Adapted from presentation by Prof. Arunabha Majumder Emiritus Fellow, School of Water Resources Engineering Jadavpur University

Notes:

सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India