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Decentralized Wastewater Treatment: A Paradigm Shift

विकेन्द्रीकरण दूषित जल उपचार संयंत्र: एक प्रतिमान विस्थापन

Online Training on 'Offsite and Onsite Management of Sewage for Citywide Sanitation,

08 October- 09 October 2020

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STRUCTURE
संरचना

- Concept, Principle and Scale of Intervention of the alternative approach in Urban Setting (शहरों की स्थापना में दुसरे विकल्पो की संकल्पना, सिद्धांत, हस्ताक्षेप के पैमाने)
- Importance of Decentralized Wastewater Treatment in Citywide Water and Sanitation (विकेन्द्रीकरण दूषित जल उपचार संयंत्र का महत्त्व)
- Showcasing Best Practices of various DWWTs (विभिन्न विकेन्द्रिकरण दूषित जल उपचार संयंत्र की सर्वोत्तम प्रथाएं)

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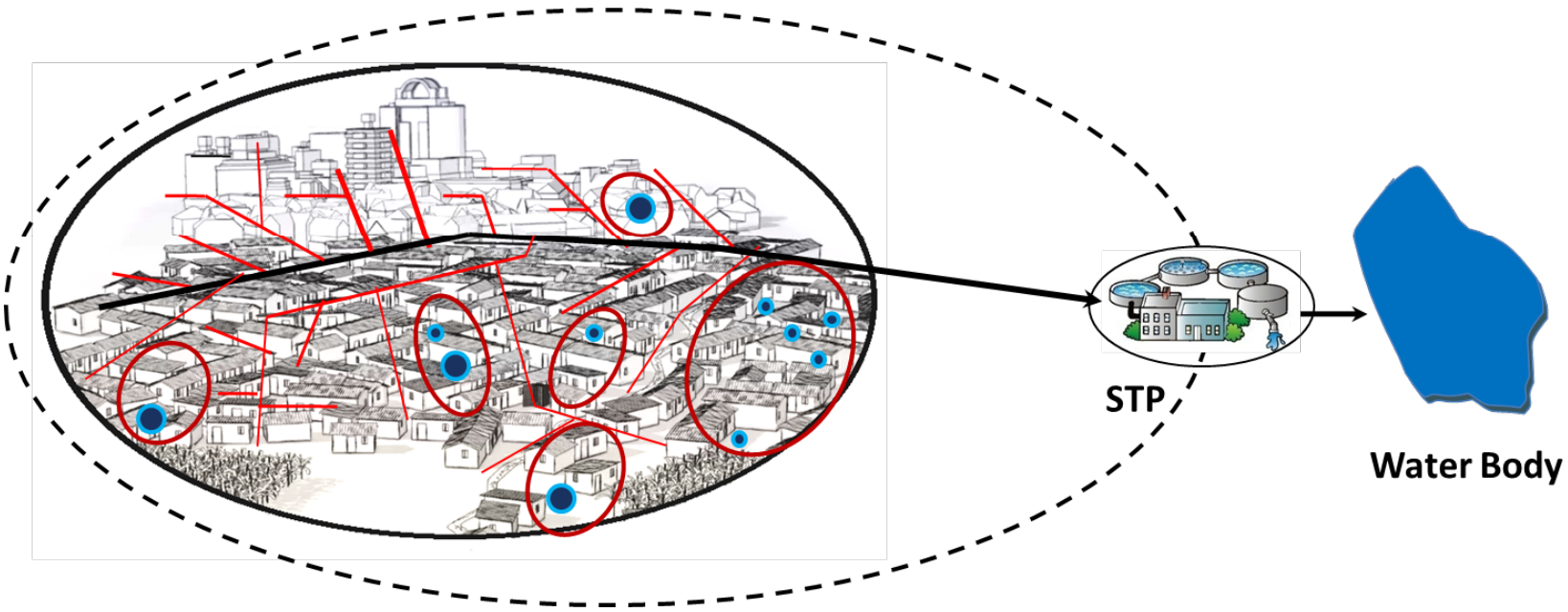
Urban Wastewater Management: How we conventionally plan our cities?

शहरी दूषित जल उपचार संयंत्र: कैसे प्रथानुसार शहरो की योजना बनाये?



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Cities plan for water, forget waste (शहरों में जल की योजना बनायीं जाती है, अपशिष्ट की नही)

- Most of our cities do not have underground sewerage
- Where there is pipeline; broken; sewage does not reach treatment plants
- Most treatment plants are under-utilized
- We lose rivers

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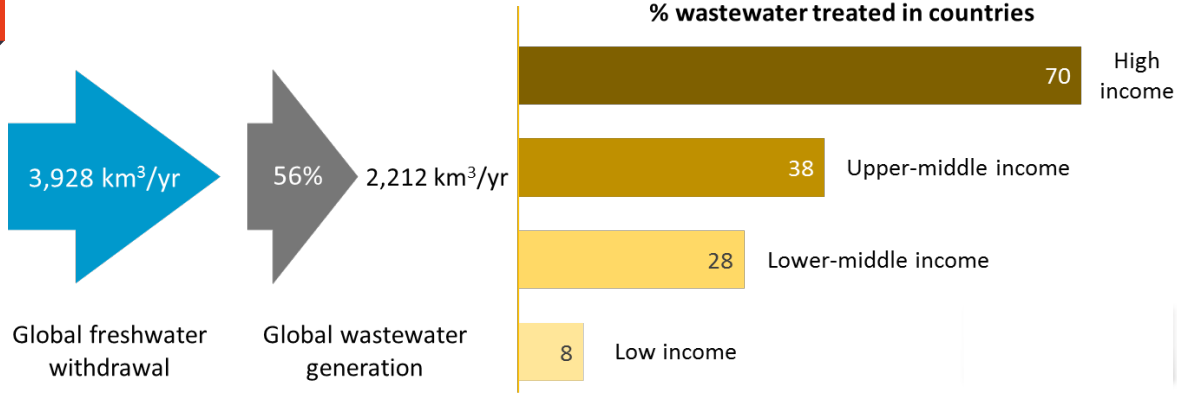
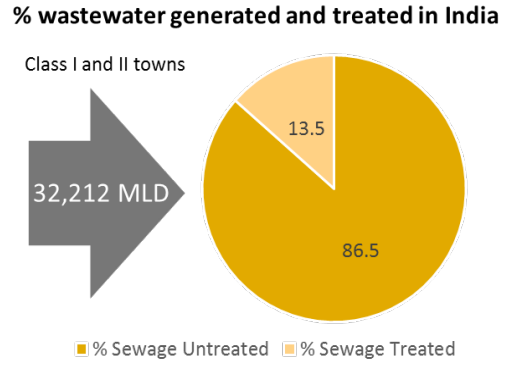
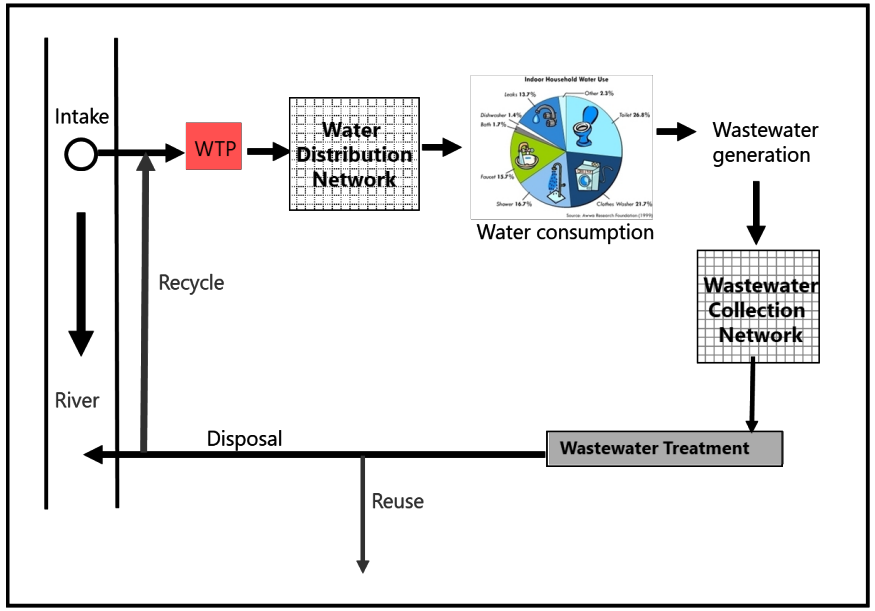
Current Approach of Water and Wastewater Management
जल और दूषित जल का संचार का वर्तमान दृष्टिकोण







- Infrastructure-intensive (गहन आधारिक संरचना)
- **Energy intensive** - extraction, storage, distribution, collection and conveyance systems (गहन उर्जा)
- Average leakage loss ratio in developing countries: **40–50%** in large metropolitan cities, and **50–60**% in smaller cities. (औसत रिसाव की कमी अनुपात, विकासशील देश – 40-50% महानगरो में, 50-60% छोटे शहर)
- Most of the transmission and distribution pipelines are very old, and many of them are corroded and leaking, resulting in **increased water losses and inadequate water quality.** (पुरानी पारेषण पाइपलाइन की पानी का रिसाव होना)
- Carbon Emissions (कार्बन उत्सर्जन)

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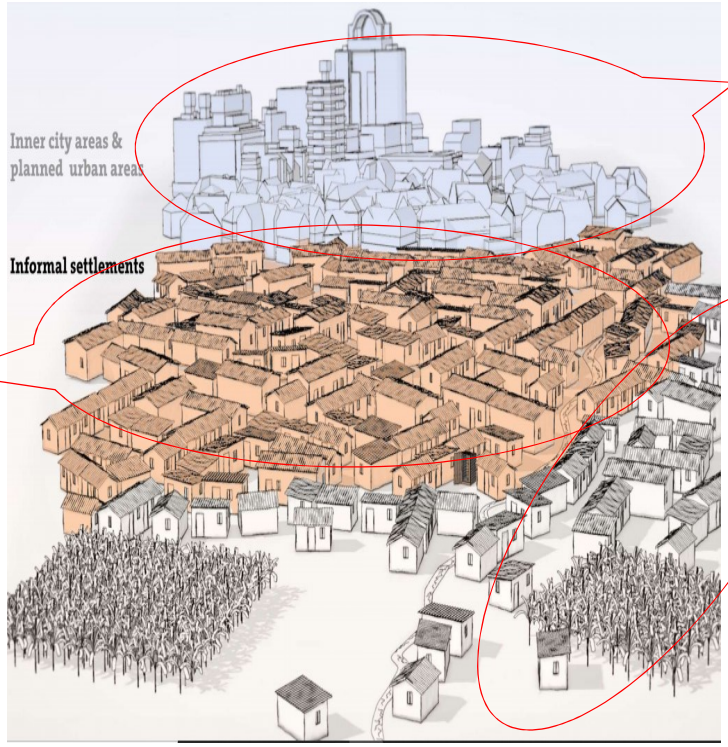
Need for a Paradigm Shift
एक प्रतिमानी बदलाव की ज़रुरत



Sewer Connection

Onsite Sanitation

New Settlements

WHAT IS

"Decentralised wastewater management (DWWM) is defined as the **collection, treatment and disposal / reuse of wastewater at or near the point of waste generation**."
(विकेन्द्रिकरण दूषित जल उपचार संयंत्र द्वारा अपशिष्ट जल का संग्रह, उपचार, निपटन/ पुनःउपयोग किया जाता है अपशिष्ट उतपादन होने वाले स्थान पर ही)

It includes systems that treat wastewater from individual homes, cluster of homes, isolated communities, industries or institutional facilities as well as portion of existing communities

PRINCIPLE

Decentralised wastewater treatment (DWWT) is based on the important principle – **devolving level of the application** so that wastewater can be treated at **affordable costs, cutting the cost of pumping long distances and promoting local reuse of treated wastewater**.

-Guidelines for Decentralised wastewater management (CPHEEO) for MOHUA

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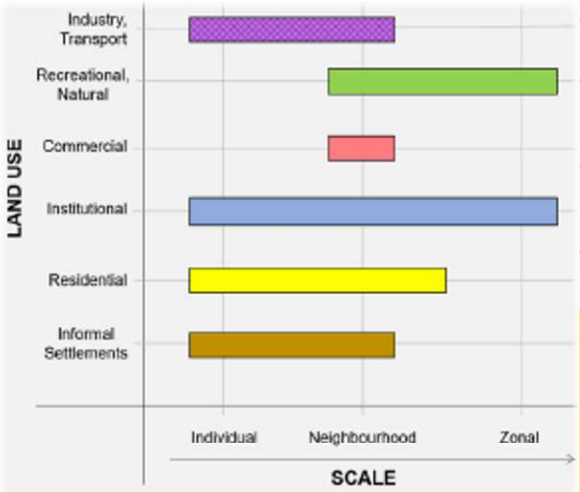
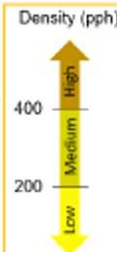
Scales of Decentralized Wastewater Management
(विकेन्द्रिकरण दूषित जल उपचार संयंत्र के स्तर)



Informal settlements include peri-urban areas, urban villages and unauthorized colonies.

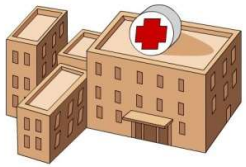
- Residential and institutional land uses have high potential at all the scales.
- Informal settlements have a high potential of simplified sewerage networks and decentralized projects at lower scales.
- Commercial areas, industrial estates and transportation hubs have potential at lower scales.
- Recreation areas and natural areas have high potential for projects of higher scales.



- Centralized sewerage systems are not recommended for low density areas as they are expensive.
- On-site sanitation systems are not recommended for high density areas as it may lead to saturation of soil with pathogenic bacteria

Public toilets

Single house

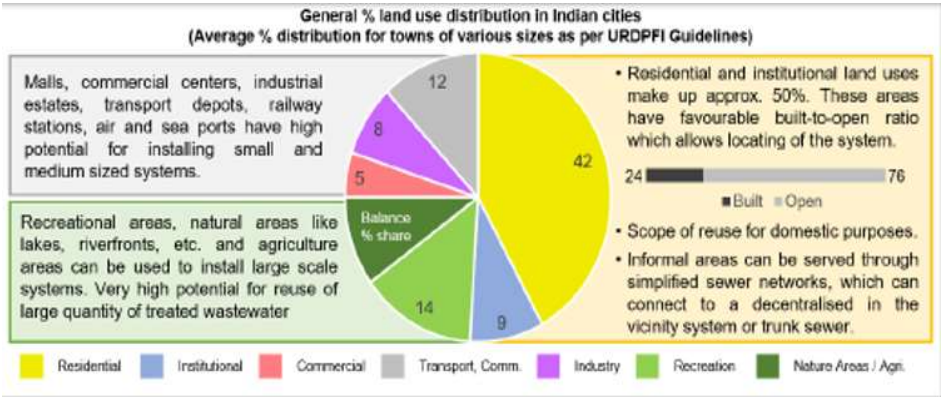


Hospitals

Residential areas

Markets/Offices

Schools/colleges



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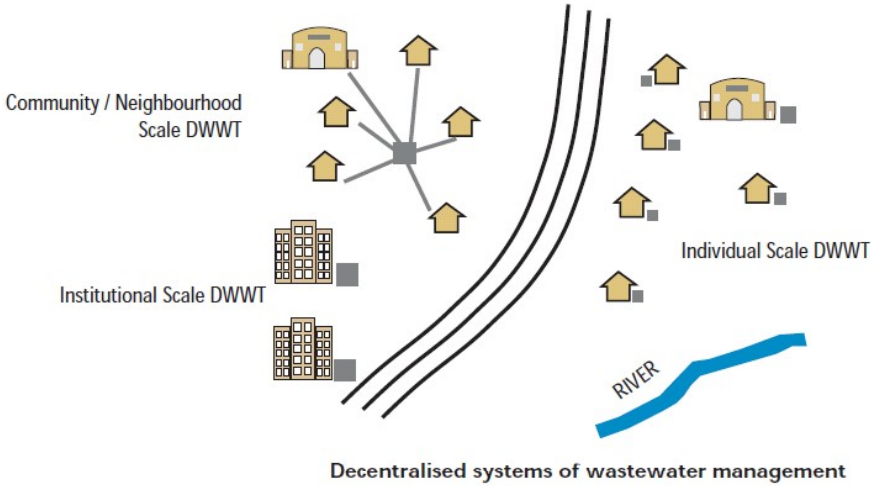
Scales of Decentralized Wastewater Management
(विकेन्द्रिकरण दूषित जल उपचार संयंत्र के स्तर)

Scales	City/zonal scale	Neighbourhood / institutional scale	Individual scale
Areas (sq. m)	10,000–15,000	4,000–5,000	1,000–4,000
Users/population	5,000 (maximum)	200–5,000	5–200
Wastewater generation capacity (kilolitre per day—KLD)	500 (maximum)	20–500	0.5–20
Land uses/activities	Medium density: 200–400 persons per hectare (pph), commercial areas, neighbourhoods, institutional and peri-urban areas	Institutional/ commercial buildings	Residential buildings (plotted/four-five storied)



Decentralised systems of wastewater management

Approach depends on (दृष्टिकोण निर्भर करता है)

- Area (छेत्र)
- Size and density of the population (जनसंख्या घनत्व)
- Level of economic development (आर्थिक विकास का स्तर)
- Technical capacity and system of governance in place (सरकर की तकनिकी क्षमता)
- Quality required for end users or that required for safe disposal

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DWWT Characteristics and Advantages
(विकेन्द्रिकरण दूषित जल उपचार संयंत्र की विशेषताएँ और लाभ)

Cut / Reduce the length of pipeline (पाइपलाइन की लम्बाई कम)
Wastewater can be **treated on site**, no need of conveying to far distances. **Sewer networks are shorter in length and smaller in diameter** since there are several disposal points

Required basic skills to operate and maintain (बुनयादी कौशल की ज़रुरत)
Semi skilled/ unskilled labour required for operation and maintenance.

Reduces carbon footprint (कार्बन फुटप्रिंट कम होता है)
Generally **less or no energy required**. Also no addition of expensive chemicals or additives

Safe reuse of treated wastewater (उपचारिक दूषित जल का सुरक्षित पुनःउपयोग)
Especially for non potable end uses

Cost efficient (लागत कुशल)
Doesn't require **sophisticated or costly maintenance**

Promotes a kind of 'public-private partnership' (सरकारी और निजी भागीदारी को प्रोत्साहन)
ULBs / local authorities have to provide lesser capital outlay including low O&M that is taken care by public

Adaptability in nature (स्वभाव में अनुकूलता)
Adaptable to **varying organic load and climatic condition**

Suitable for Organic wastewater flow (जैविक दूषित जल के बहाव के लिए उपयुक्त)
1-1,000 m3 per day

Meets the wastewater standards (दूषित जल के मानक को पूरा करता है)
Treated wastewater **meets the discharge standards** and environmental laws

Follows circular economy (परिपत्र अर्थवयवस्था को पालन करता है
Treat and reuse of **wastewater locally and promotes resource recovery**

Doesn't cause any nuisance (बाधाहीन)
Such as **noise pollution, bad odour to the surrounding, problems of mosquito** breeding etc.

Site specific and flexible in nature (साईट विशिष्ट)
To be designed **according to the characteristics of wastewater**

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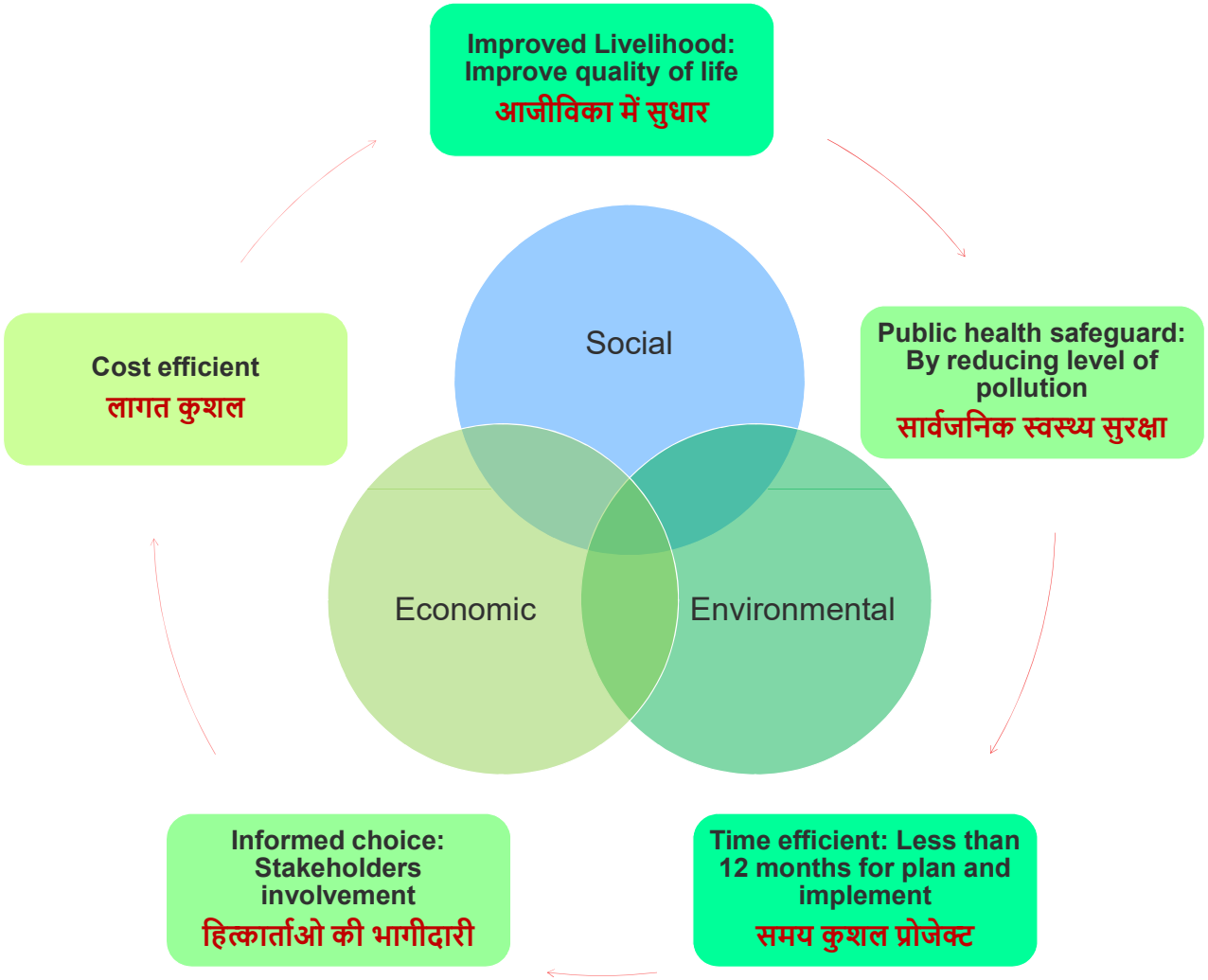
Benefits of DWWTs (विकेन्द्रिकरण दूषित जल उपचार संयंत्र के फायदे)



Source: Adapted from Policy Guidance Manual on Wastewater Management with a Special Emphasis on Decentralized Wastewater Treatment Systems. Bangkok. Thailand

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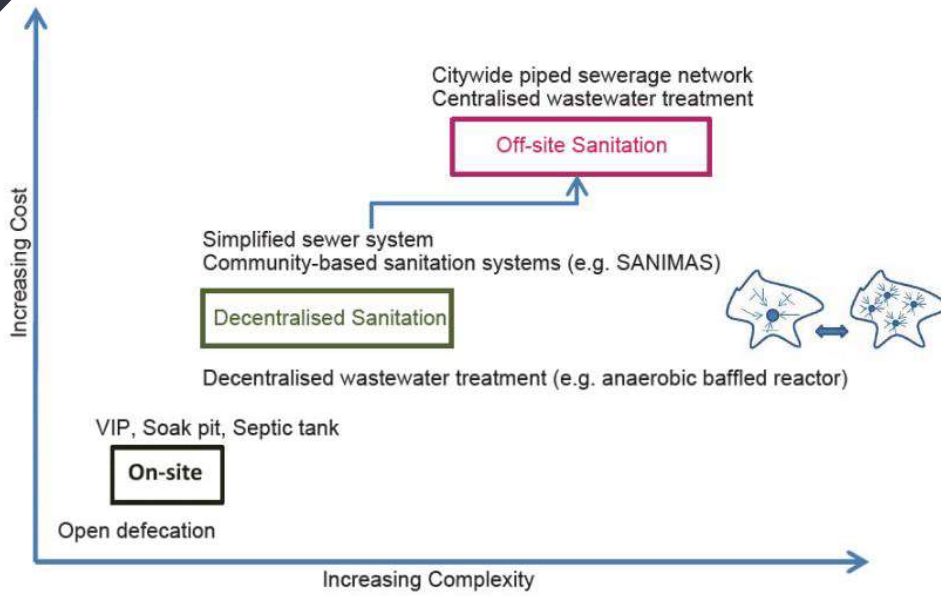
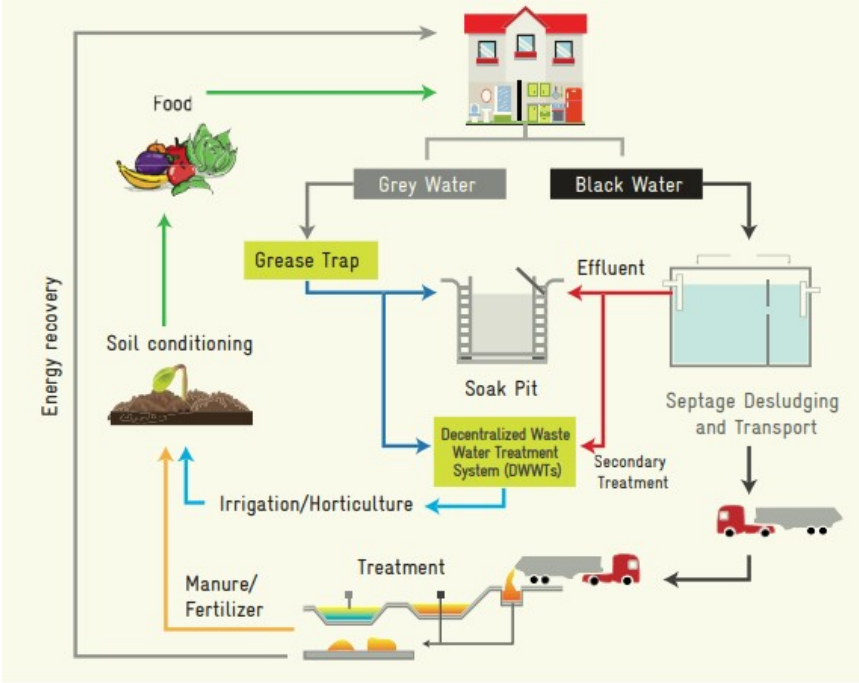
Missing Link: Decentralized Wastewater Treatment in Sanitation

लापता कड़ी: सैनिटेशन सेक्टर में विकेन्द्रिकरण दूषित जल उपचार संयंत्र





Decentralized approach bridges the gap between OSS and conventional off-site sanitation approaches

विकेन्द्रिकरण दृष्टिकोण अपनाने से ऑनसाईट सैनिटेशन एवं परम्परागत ऑफसाईट सैनिटेशन के बीच के गैप को पाटता है

- The decentralized approach is also applicable to address the **issue of environmental pollution** caused by **effluent from the on-site sanitation systems.**
- The concept of **septage management** that sets out interlinked steps that are vital to manage septage and effluent from **generation to disposal to end-use also recognize DWWM** as one of the solution for effluent management.

https://www.susana.org/_resources/documents/default/3-2553-7-1462884043.pdf

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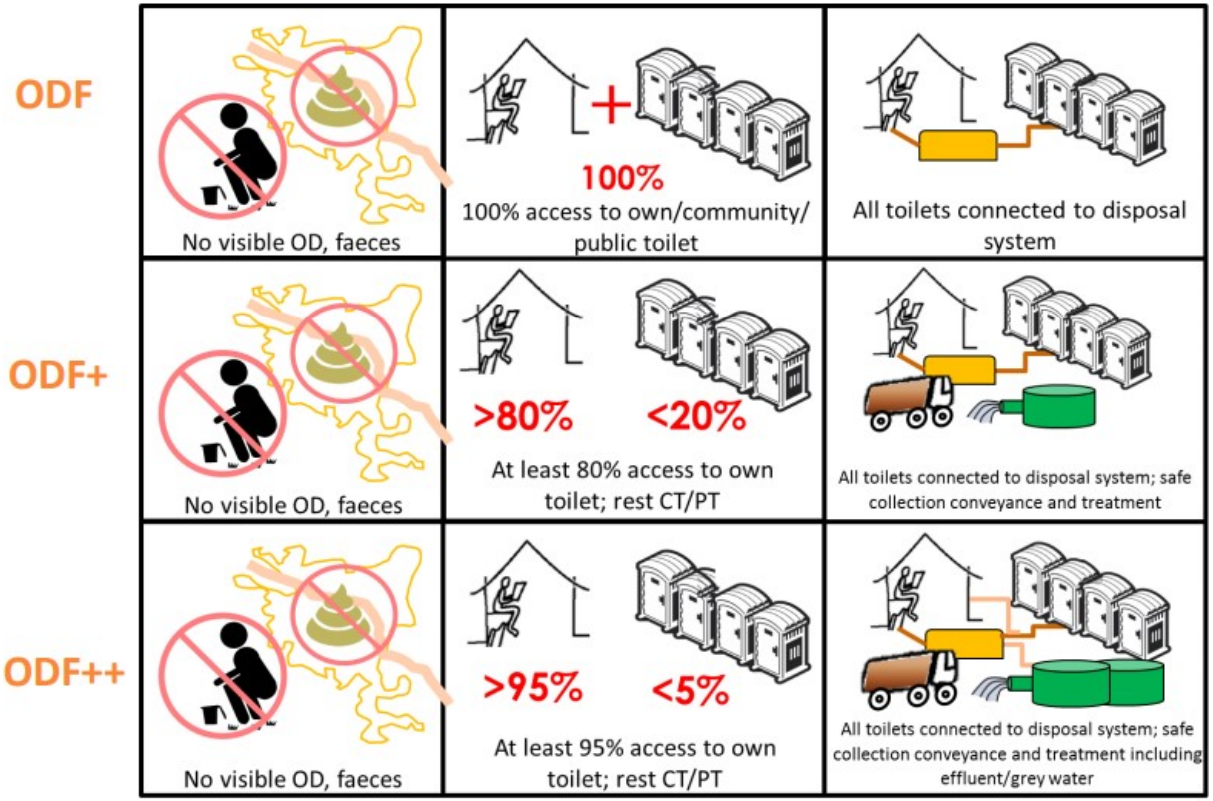
DWWM approach talks beyond Toilets

विकेन्द्रिकरण दूषित जल उपचार संयंत्र दृष्टिकोण शौचालय से आगे की बात करता है

ODF+ and ODF++ are aimed towards proper maintenance of toilet facilities and safe collection, conveyance, treatment/disposal of all faecal sludge and sewage

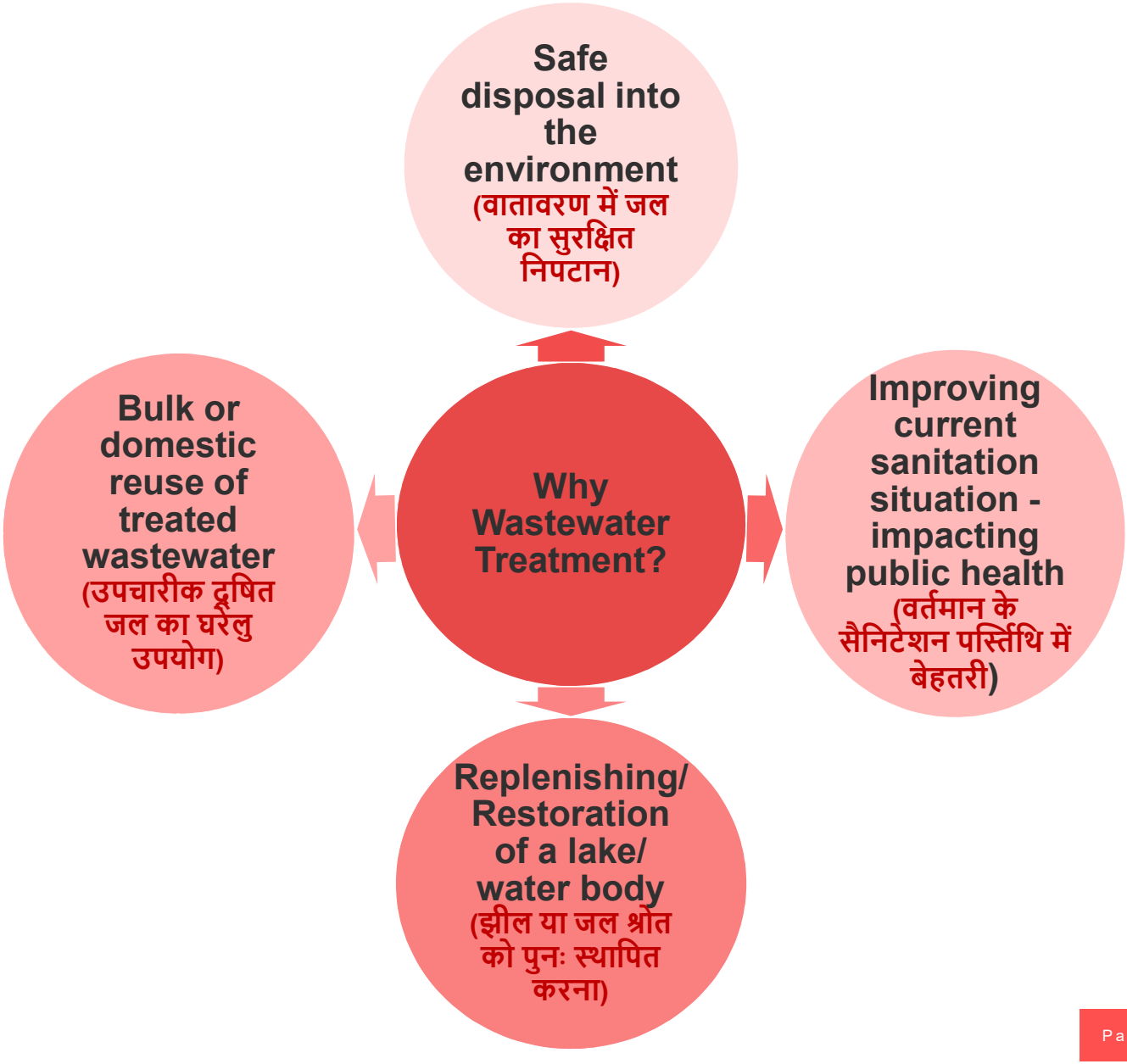
- ODF+ focuses on toilets with water, maintenance and hygiene (ODF+ शौचालय, जल की वयवस्था और स्वच्छता पर ज़ोर देता है)
- ODF++ focuses on toilets with sludge and septage management hygiene (ODF++ में शौचालय और फेकल स्लज और सेप्टेज प्रबंधन पर जोर है)



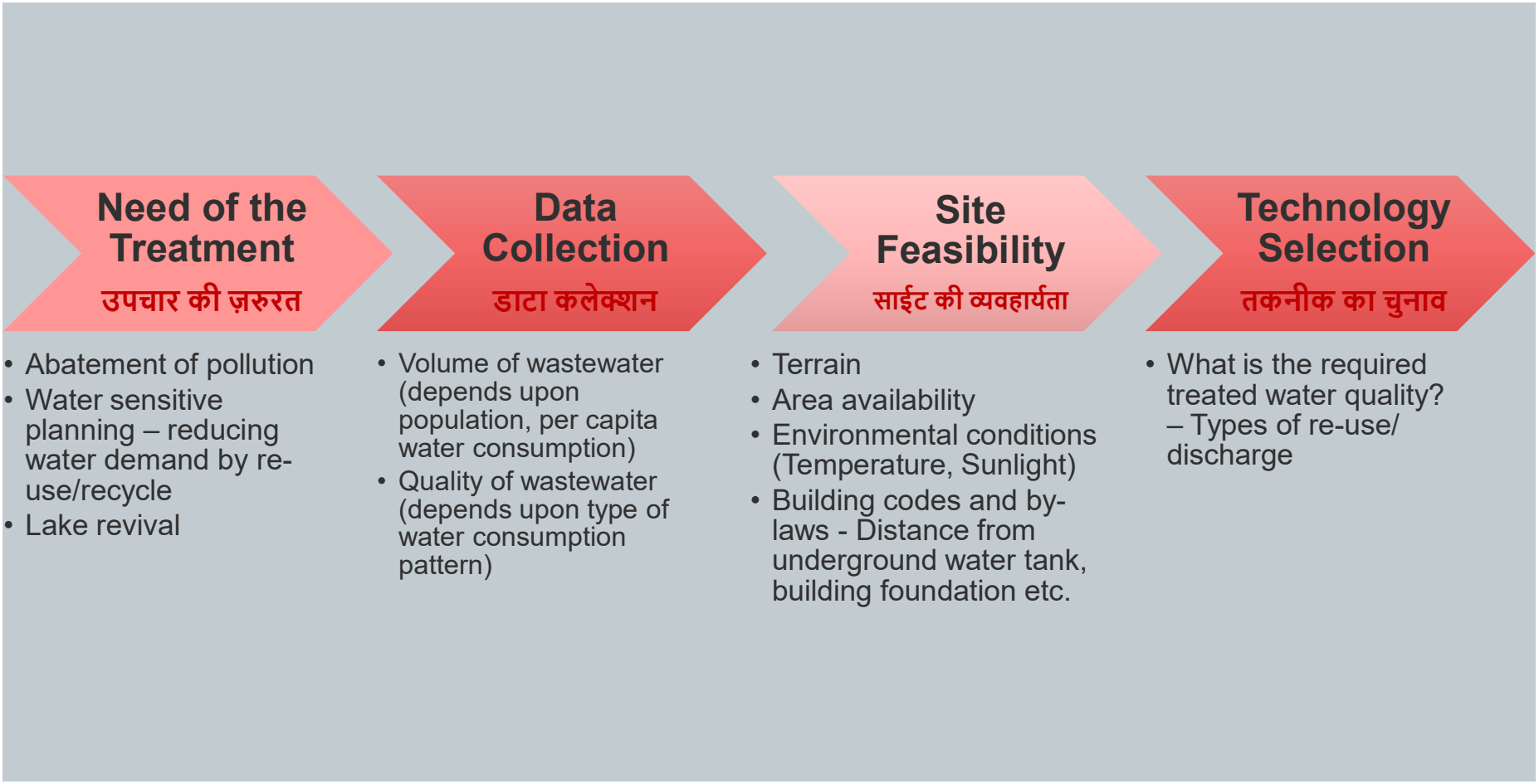
Source: CEPT University

Why Wastewater Treatment?

दूषित जल का उपचार क्यूँ?



Process flow for setting up DWWTs
विकेन्द्रिकरण दूषित जल उपचार संयंत्र लगाने की प्रिक्रिया



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Data Collection
डाटा कलेक्शन

Flow of wastewater
द्रूषित जल का बहाव

- Population
- Per capita water consumption
- Volume of wastewater generation

Quality of wastewater
द्रूषित जल की गुणवत्ता

- Type of water consumption pattern
- Quality analysis report
- Physical appearance of wastewater

Volume of wastewater generated /day (cum)

Thumb rule: 80% of the total water consumption goes out as waste

Example:
Population (P) = 130,
Water use = 100 litres / capita / day
Volume of water consumed
= 130 x 100 = 13000 litres / day or 13cum/ day

Hence average volume of wastewater generated
= 13000 x 0.8 = 10,400 litres /day or approx.10 cum/ day.

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Site Feasibility
साईट की व्यवहार्यता

Terrain

Soil मिटटी
Ground water भूजल
Topography तलरूप

High ground water level

- Construction of DWWT is challenging
- Scope of possible leakage of untreated sewage into ground water
- DWWT system should be strictly waterproof

Topography – high altitude, steep terrain

- High pumping requirements for water
- Sewer can be gravity driven

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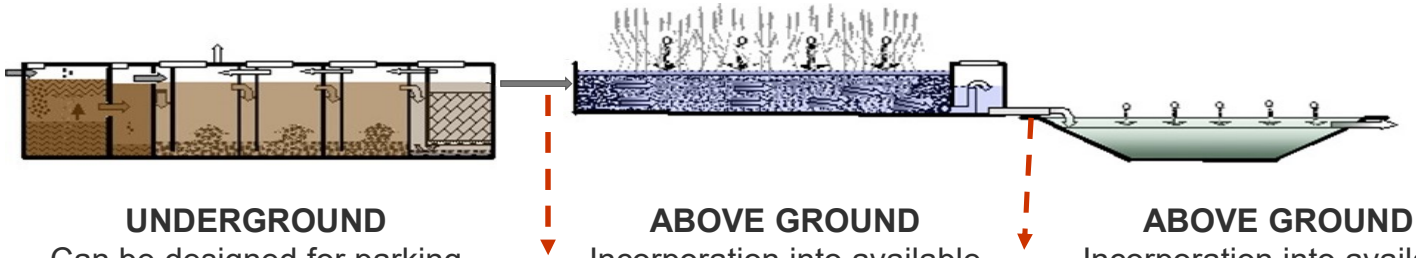
Site Feasibility
साईट की व्यवहार्यता

Things to keep in mind while planning a DWWTs:

- Land ownership? Is there any land dispute? भूमि का स्वामित? कोई ज़मीनी मतभेद?
- What are the constraints? बाकी बाधाएं?
- Is there any service and utility infrastructure that could get affected? किसी सर्विस या आधारिक सरंचना में प्रभाव पड़ना?
- How much surface area available कितना सतह छेत्र उपलब्ध है?
- Are there any opportunity areas – available open spaces? खुली सतह उपलब्ध है?
- Try to utilize set-back area
- Incorporation as a landscape feature परिदृश्य जैसा सम्मलित करना



UNDERGROUND
Can be designed for parking lots or walking pathways above

ABOVE GROUND
Incorporation into available green areas

ABOVE GROUND
Incorporation into available open areas as a landscape feature

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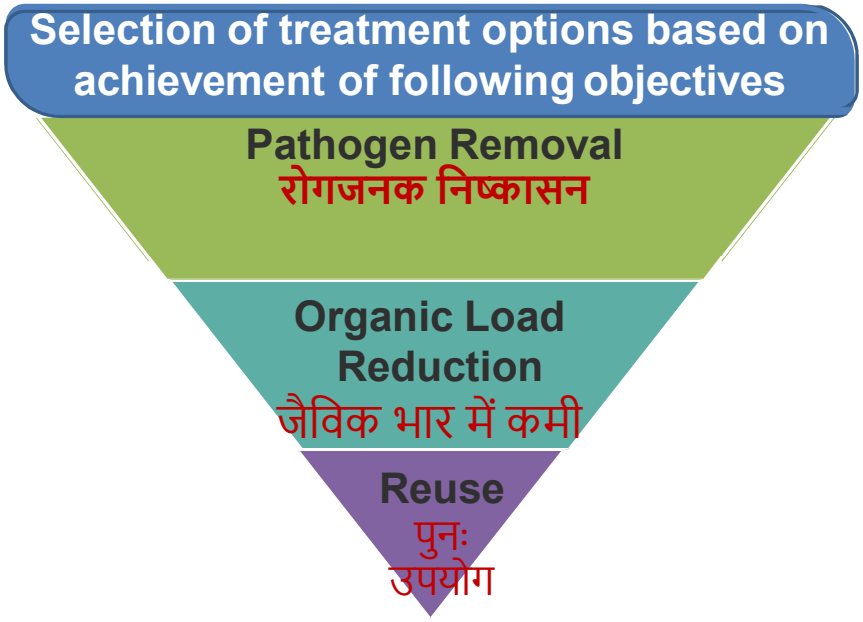
Objectives of the Treatment
उपचार करने के उद्धेश्य

The objective of wastewater treatment is to extract pollutants, remove toxicants & coarse particles, reduce organic & nutrient load, kill pathogens so that quality of effluent is improved to reach the permissible level of water to be reused.



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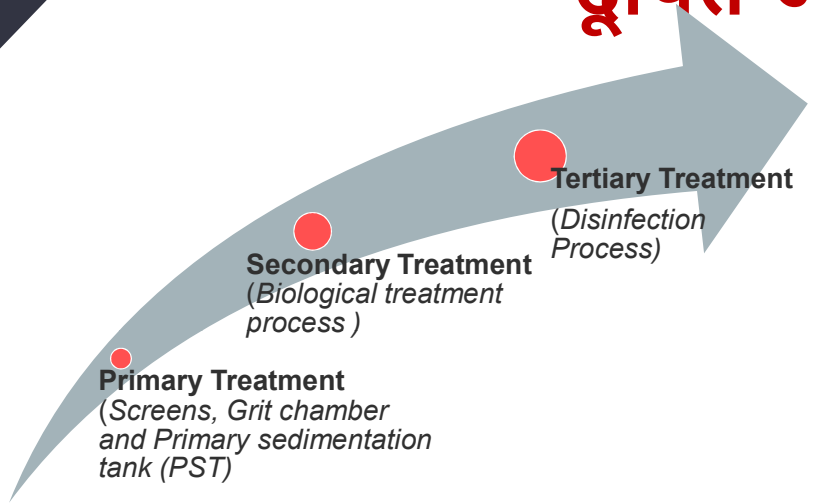
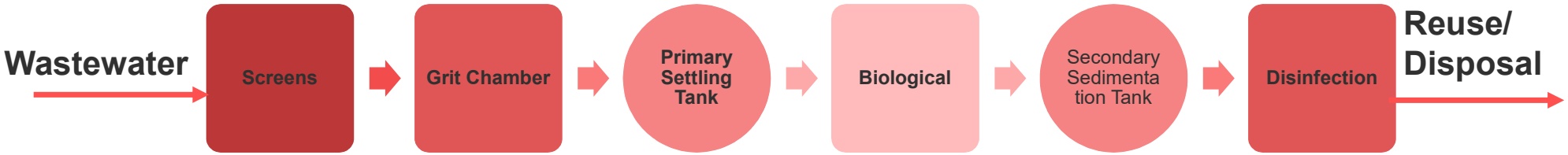
Stages of Wastewater Treatment

दूषित जल के उपचार के चरण





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Nature based Decentralized Wastewater Treatment Technologies

Name of the technology	Reuse of treated water	Capital cost (INR/KLD)	O&M cost (INR/KLD/ year)
Constructed Wetland	Horticulture	10000	1500-2000
DWWTs	Horticulture	50000	8500
Green bridge	In situ treatment of water bodies	200-500	20-50
Biosanitizer/ Eco chip	In situ treatment of water bodies, Horticulture	10000 per chip excluding construction cost	-
Nualgi	In situ treatment of lakes/ ponds, Increase in fish yield	0.35	9-10
Bioremediation	In situ treatment of lakes/ ponds	225 – 300	200 – 225
Soil scape filter	Horticulture	20000-30000	1800 – 2000
Fixed film biofilter Technology (FFBT)	Horticulture/ Car washing	25,000-35,000	1,000-2,000
Phytorid	Horticulture	14,000-35,000	1,000-2,000

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Electro-mechanical Decentralized Wastewater Treatment Technologies

Name of the technology	Treatment capacity	Reuse of treated water	Capital cost (INR/KLD)	O&M cost (INR/KLD/ year)
Soil Bio technology (SBT)	5KLD – tens of MLD	Horticulture Cooling systems	10,000-15,000	1000-1500
Trans Biofilter	5 KLD-3 MLD	Gardening, landscaping, farming & other non-potable purposes	50-70	5-7
Tiger Biofilter	15 KLD-500 KLD	Washing, flushing, construction, and gardening	25000-30000	1800-2000

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Criteria: Selection of Technology

The ideal techno-logy should satisfy all of the following criteria

Parameter Consideration	Goal
Treated effluent quality	The technology must **meet the standards** as required
Energy requirement	The process choice should **consider minimizing energy requirements**
Land requirement	**Minimize land requirement**
Capital Cost of Plant	Process should allow **optimum utilization of capital**
Operational and Maintenance costs	Process design should be **conducive to attaining lower running cost**
Operation and Maintenance requirement	**Simple and reliable**
Reliability of System	Deliver the **desired quality on a consistent basis**
Reuse and Resource Recovery	Ability to **maximize reuse of end products**
Load Fluctuations	System should be able **to withstand organic and hydraulic load fluctuations**

Source: Guidelines for Decentralized Wastewater Management by IIT Madras

MOUNT is an aggregator platform for various sustainable technologies, encouraging and disseminating knowledge and good practices for wastewater management. MOUNT divides treatment process in 4 Categories

Menu on Un-networked Technologies

https://www.cseindia.org/mount/home

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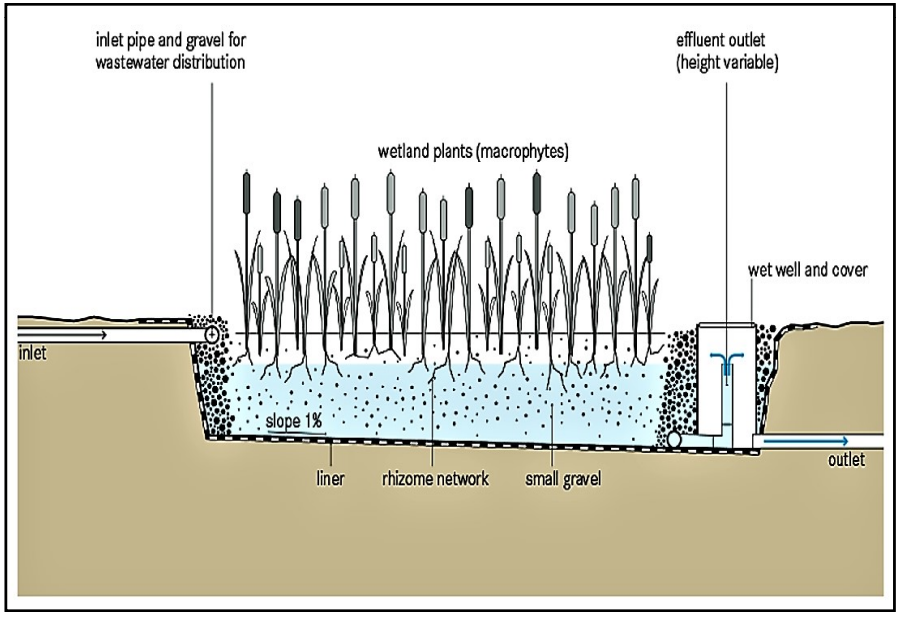
Constructed Wetland

A constructed wetland is an organic wastewater treatment system that mimics and improves the effectiveness of the processes that help to purify water similar to naturally occurring wetlands. The system uses **water, aquatic plants** (i.e. reeds, duckweed), **naturally occurring microorganisms and a filter bed** (usually of sand, soils and/or gravel).

The general concept is that **the plants, microorganisms and substrates** together act as a **filter and purification system**. First, water is slowed as it enters the wetland, **allowing for the sedimentation of solids. Through the process of water flow through the constructed wetland, plant roots and the substrate remove the larger particles present in the wastewater**.

Pollutants and nutrients present in the wastewater are then naturally broken down and taken **up by the bacteria and plants**, thereby removing them from the water. The retention time in the wetland, which varies depending on the design and desired quality level. After treatment in a constructed wetland, water can be safely released into surface waters or used various purposes.



Salie

- C **operations and m**
- Ef n waste, agricultural runoff, st nts from mining and industry
- U stand and manage
- Lo erations
- As surface water levels
- Co by providing a habitat for plants and animals
- Pleasing **natural aesthetics**

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Case Example: Institutional Building
Constructed wetland at Indian Agriculture Research Institute, Pusa, New Delhi

Indian Agriculture Research Institute, Pusa, New Delhi	
Parameters	**Details**
Type of Building	Institution
Source of Wastewater	Drain coming from 2 colonies
Capacity of the system	2.2 MLD
Re-use	Agricultural Purpose
Capital Cost	Rs. 1.2 Crores
O&M Cost (per annum)	Rs. 1335 /-
Year of Implementation	2012

*The treatment plant comprises of **3-treatment cells (each of 80 meter by 40 meter)**, where **organic, nutrient and metal pollutant reductions (i.e. secondary and tertiary treatments)** take place; besides **2-sewage wells and 1-grit chamber, where preliminary/ primary treatment takes place**.*

Each treatment cell is stratified with a bed of gravels of varying sizes/ grades, onto which Typha latifolia – a hyper-accumulating emergent vegetation is planted.

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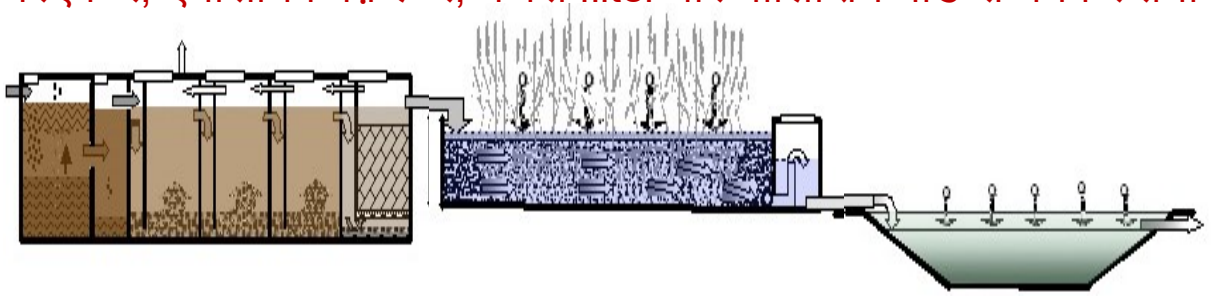
Decentralized Wastewater Treatment System (DWWTs)

विकेन्द्रिकरण दूषित जल उपचार संयंत्र

DWWTs is an easy and sustainable solution to treat wastewater with the combination of settler, anaerobic baffled reactor, anaerobic filter, planted gravel filter and polishing pond

विकेन्द्रिकरण दूषित जल उपचार संयंत्र एक आसान और सतत उपाय है दूषित जल के उपचार का, जो की सेटलर, एनारोबिक बैफ्ल्ड रिएक्टर, एनारोबिक फ़िल्टर, बजरी filterऔर पोलिशिंग पोंड से बनकर तैयार होता है

Area Requirements Sq-m per Cum (As per Thumb Rules)	
Settler	0.5
ABR + AF	1.0
PGF	4.0
Polishing Pond	1.2



Primary + Secondary (Settler + ABR + AF)

Underground anaerobic process

Removal

25%-30% BOD removal – Settler

70%-90% BOD removal – Baffled reactor

Removal of suspended solids – Inorganic material

Reduction of Organic contaminants

Secondary + Tertiary (PGF)

Above ground level aerobic + anaerobic process

40%-60% BOD removal

Nutrients removal (Aeration through roots, adsorption on filter material)

Tertiary (Polishing Pond)

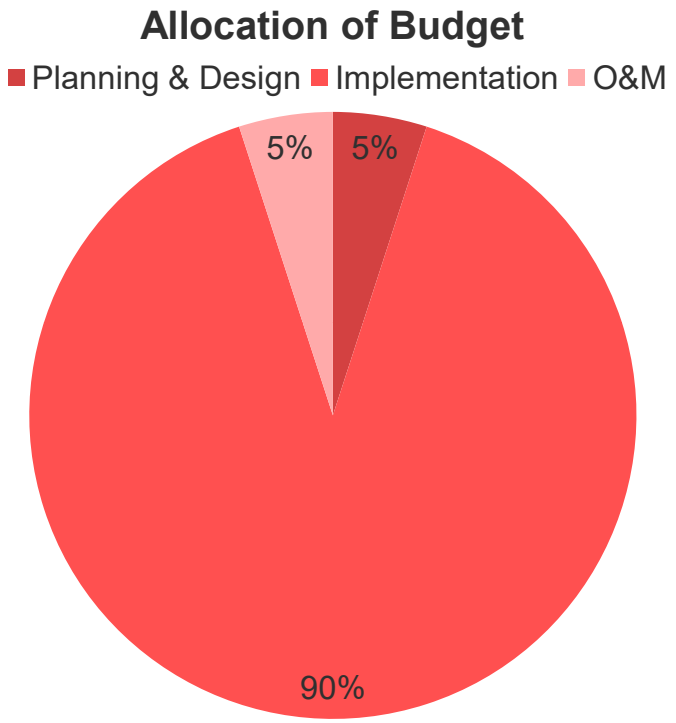
Odour & Pathogen

Costing of DWWTs Project

विकेन्द्रिकरण दूषित जल उपचार संयंत्र की लागत

(As per Thumb Rules)

Capacity of DWWTs	CAPEX per Cum
1 – 8 KLD	1.2 – 1.5 Lac
10 – 25 KLD	70,000 – 80,000
Beyond 30 KLD	40,000 – 60,000



Operation & Maintenance Cost = 3 to 5% of CAPEX

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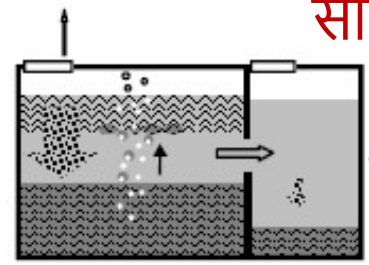
Case example: Institutional Building
Decentralized Wastewater Treatment System at CSE HQ

Centre for Science and Environment	
Parameters	**Details**
Type of Building	Office Building
Source of Wastewater	Kitchen and Toilets
Capacity of the system	8KLD (Approx 150Users)
Re-use	For maintaining greenery
Capital Cost (2005)	Rs. 2,25,000/-
O&M Cost (per annum)	Rs. 30,000/-
Year of Implementation	2005

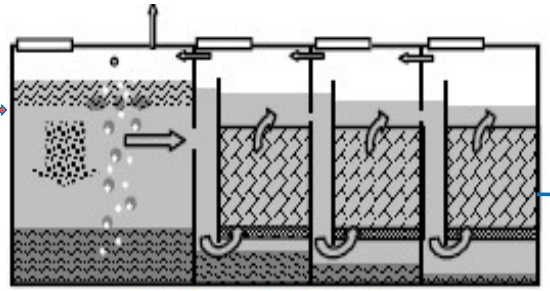
Benefit –
Freshwater (groundwater and municipal supply) not used in low end usage.
Monthly saving – Rs. 400 municipal supply and Rs. 2,500 if recycled water is purchase from tankers

Process flow of DWWT system at CSE HQ

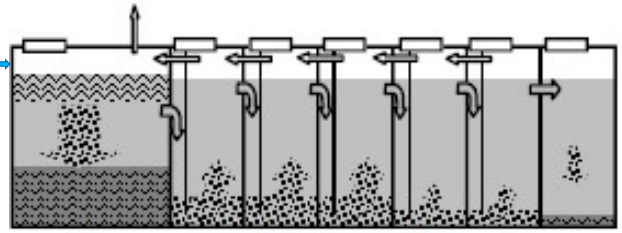
सीएसई में लगे विकेन्द्रिकरण दूषित जल उपचार संयंत्र की प्रिक्रिया



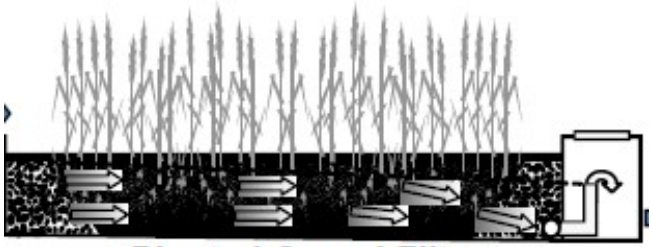
Septic tank / Settler



Anaerobic Filter

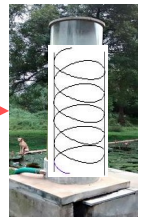


Anaerobic Baffled Reactor



Planted Gravel Filter

Ten chambers with two chambers of anaerobic filters



Vortex

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DWWT at Institutional level

संस्थागत विकेन्द्रिकरण दूषित जल उपचार संयंत्र

Aravind Eye Hospital, Abhishekapakkam, Pondicherry, India

Parameters	Details
Year of Implementation	2003
Type of Building	Hospital and Residential Buildings together
System's area	2690 sq m
Capacity of the system	320 KLD
Re-use	Horticulture of 15 acres of area within the hospital premises
Capital Cost (2003)	INR 11.2 Million
O&M Cost (per annum)	INR 250,000-500,000

Settler and Anaerobic baffled reactors

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Institutional Complex:
संस्थागत कॉम्पेक्स

Aravind Eye Hospital and Residential Buildings, Puducherry

Planted filter bed with Canna indica

Polishing pond

Treated wastewater reuse for horticulture

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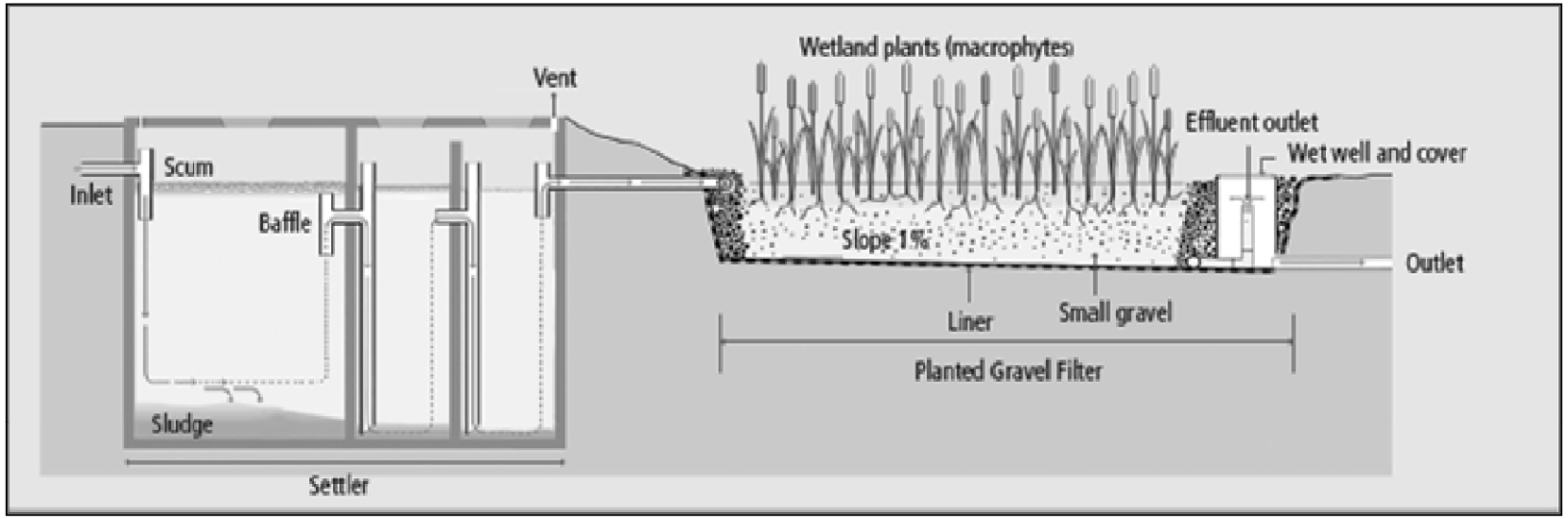
Case Example: Public space
DWWTs at Nehru Garden, Alwar



Implementing Agency: UIT, Alwar

Year of Implementation: 2016

Knowledge Partner and Design:
Centre for Science and Environment (CSE), New Delhi

Proposed use of treated water: Horticulture

Treatment Capacity: 100 KLD

Capital Cost: Rs. 32 Lakhs (2013)

O&M Cost: Rs. 1.1 -1.5 Lakhs/annum

Total Area: 730 m^2

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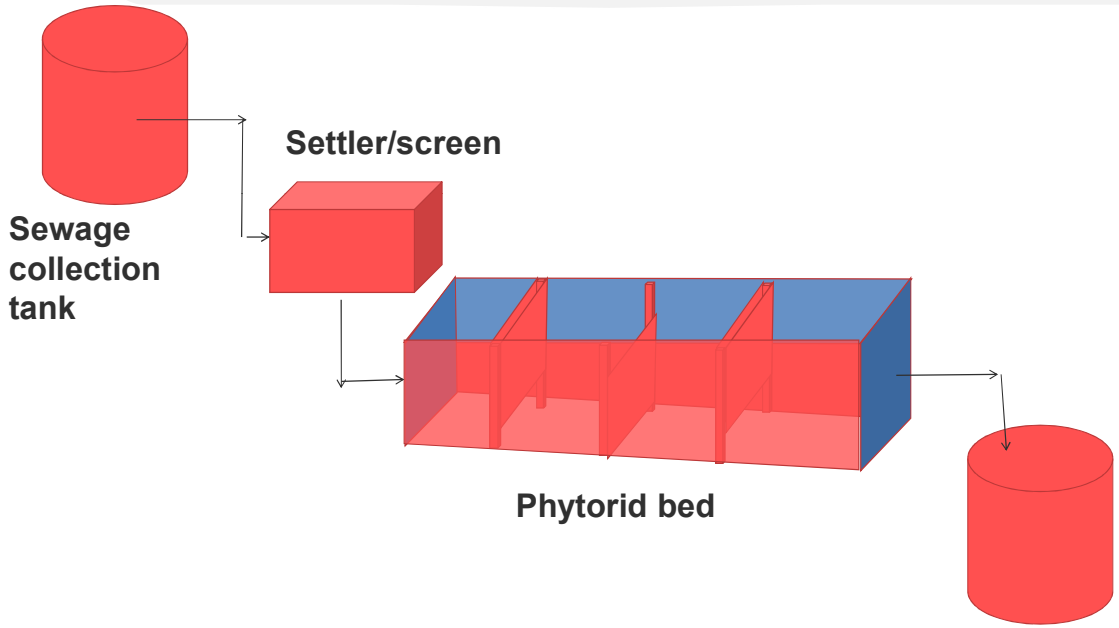
Phytorid Wastewater Treatment System

फायटोरिड दूषित जल उपचार संयंत्र

Phytorid is a sub-surface flow type treatment system, it treats wastewater with the help of porous media such as crushed bricks, gravels and wetland plants. The system is divided broadly into the three zones viz. inlet zone, treatment zone and outlet zone.



Treated water can be utilized in irrigation, fountains etc.

Processes

- Sedimentation
- Bacterial action
- Filtration
- Adsorption
- Precipitation
- Decomposition
- Nutrient uptake
- Vegetation system

CSE

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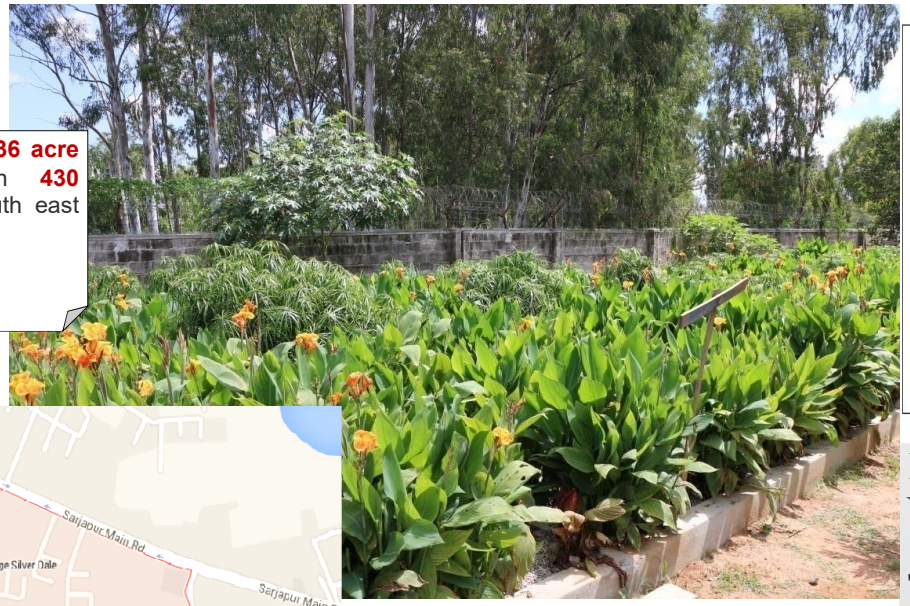
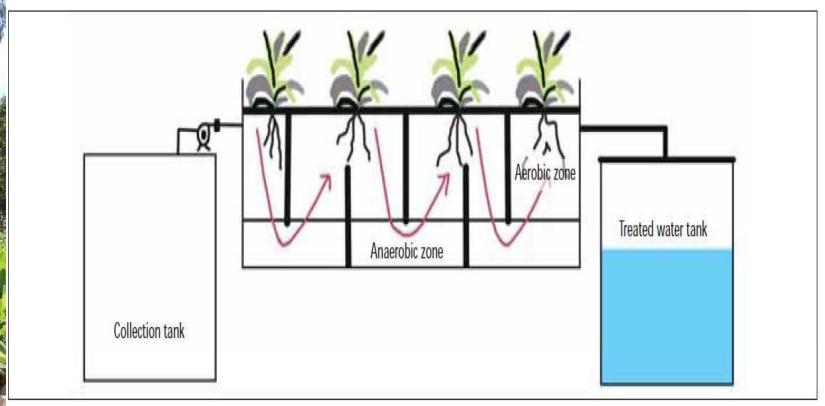
Case example: Housing Society

Phytorid Technology based treatment plant at Rainbow Drive Society, Bangalore

Rainbow Drive is a **36 acre neighborhood** with **430 plots** located in south east Bangalore.





Parameters	Details
Year of Implementation	2014
Type of Building	Community level
Capacity of the system	250 KLD
Re-use	For maintaining green landscapes
Capital Cost	INR. 55 Lakhs
O&M Cost (per annum)	INR. 10,000

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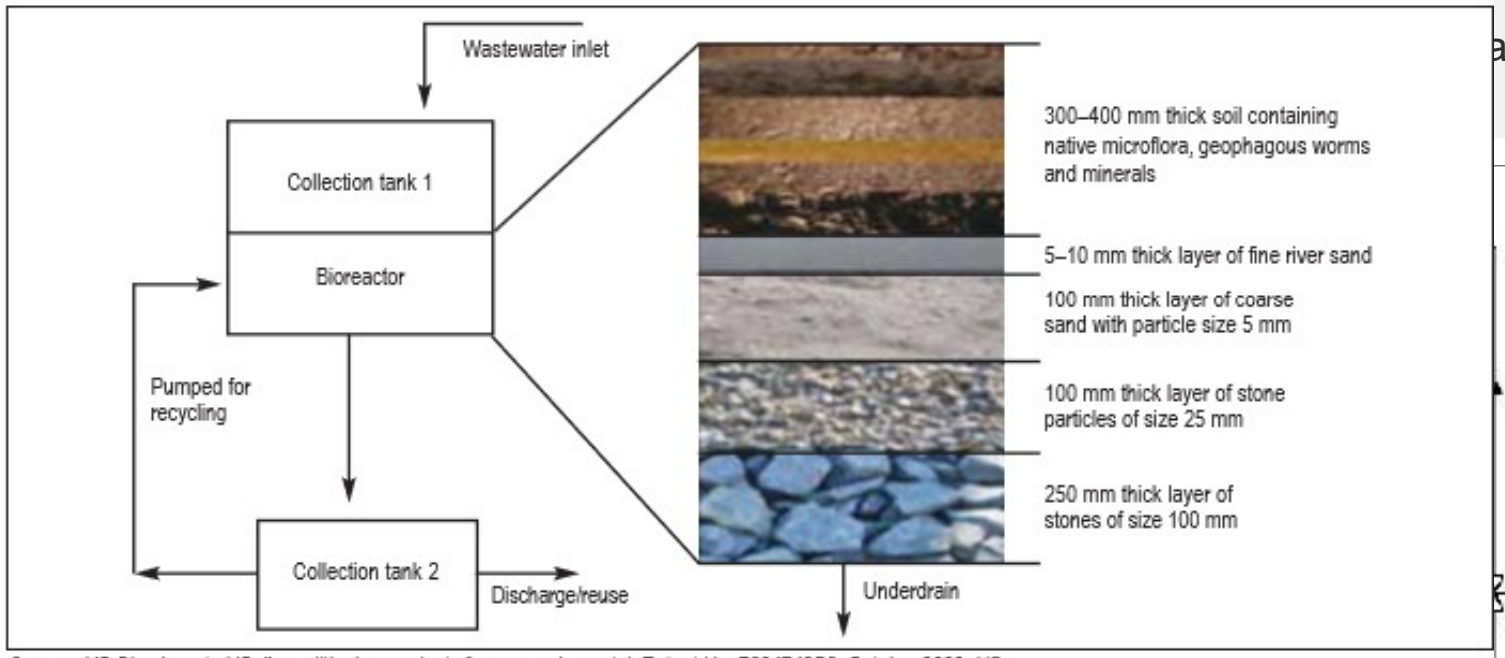
Soil Bio-technology (SBT)
सोइल बायोटेक्नोलॉजी (एस बी टी)

Soil Bio-technology is a terrestrial system for wastewater treatment with the combination of physical and biochemical processes. It is based on the principle of trickling filter.

Suitable r…are the

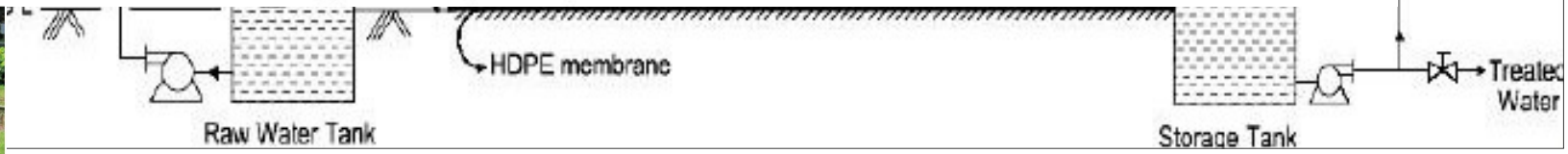
Salient Features:

- The process can be run on batch or continuous mode.
- The overall time of operation is 6-7 hours per day.
- No sludge production Mechanical aeration is not required.



Source: *HS Shankar et al 'Soil conditioning products from organic waste', Patent No: 7604742B2. October 2009. US*

Trickling of wastewater through u-PVC pipes on the bioreactor



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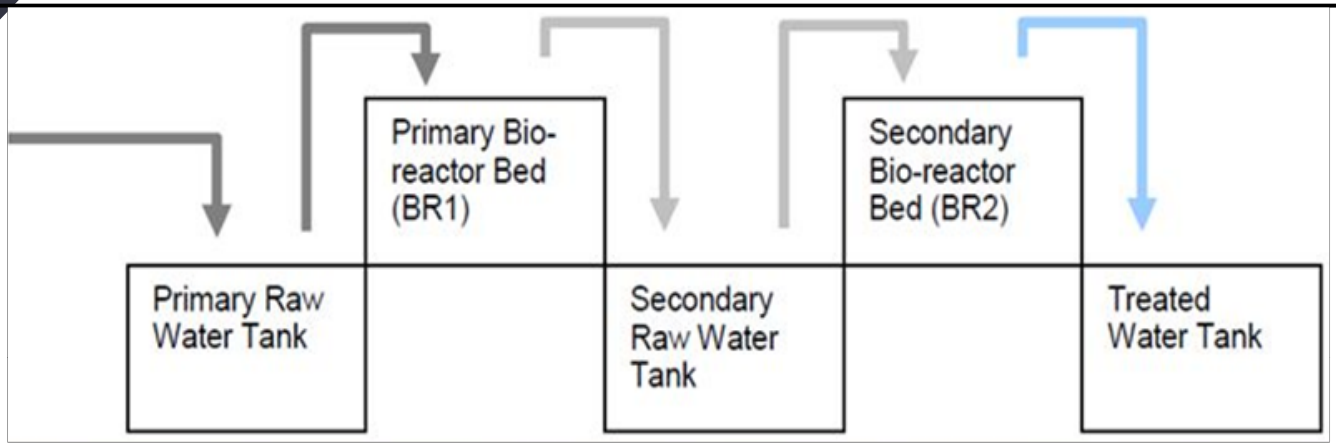
Case Example: Public Place

Soil Bio-Technology at Lodhi Gardens, New Delhi

सोइल बायोटेक्नोलॉजी (एस बी टी), लोधी गार्डन, नयी दिल्ली

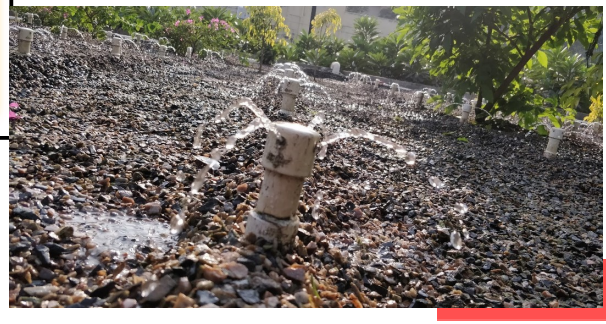


The organic content of the sewage is removed as it passes through bioreactor bed. The bioreactor bed can be customized depending upon local conditions.

The treatment within the bed takes place via adsorption by the layers of soil followed by biological aerobic degradation. This creates acidic conditions which is regulated by the chemical weathering of mineral additives that are added in the bioreactor bed. In addition, photosynthesis of natural flora serves as a bio-indicator of the micro-habitat. Rates of mineral weathering and photosynthesis are slow and a majority of the treatment can be attributed to the sedimentation, infiltration and bio-degradation processes.

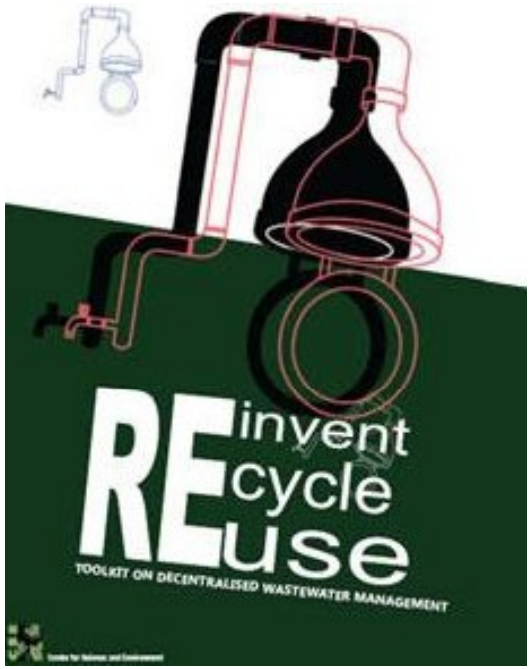
PPP contract between NDMC (owners of the gardens) and Vision Earth (technology providers) is based on the **Hybrid Annuity Model.** Under this contract, the payments made to Vision Earth are subject to performance of the treatment system.

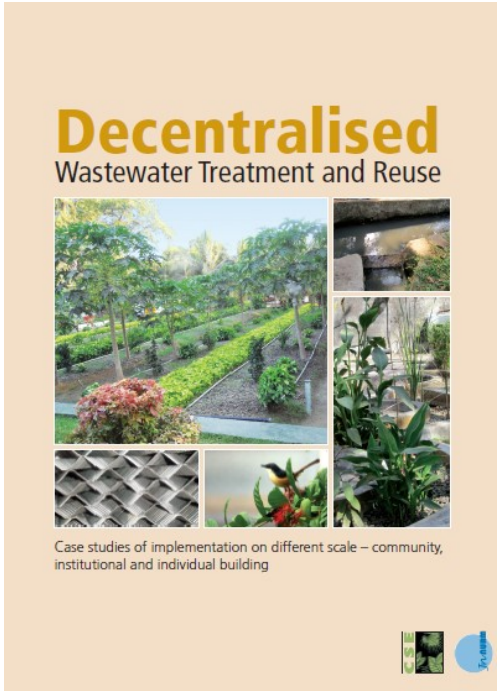
Land Use: Recreational (90 acres)	**Capacity: 500 KLD**	**Capital Cost: ₹2 Crore**
	Year: 2017	O&M Cost: ₹50,000 p.a.

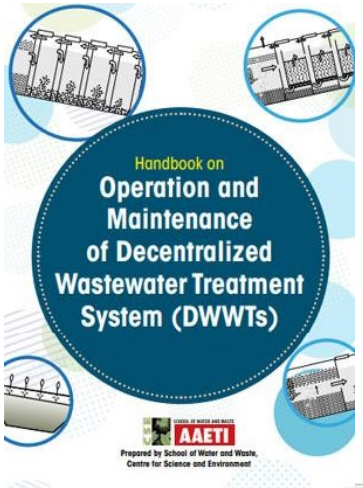


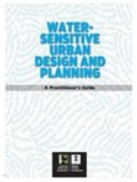
Lucknow Airport

For more details visit https://www.cseindia.org/page/water-and-wastewater-management



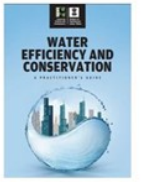




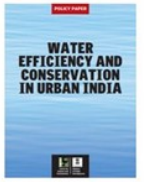


Water Sensitive Urban Design and Planning

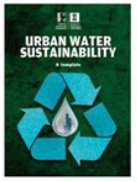
Green Infrastructure



Water Efficiency and Conservation - A Practitioner's Guide



Policy Paper: Water Efficiency and Conservation in Urban India



Urban Water Sustainability: A Template

Mainstreaming Energy Efficiency in Urban Water and Wastewater Management in the Wake of Climate Change

Septage Management - A Practitioner's Guide

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THANK YOU

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