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Decentralized Urban Waste Water Treatment: Hamburg Water Cycle in Indian Context

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Vinay Sharma

M.Sc. Water Resource Engineering and Management,

University of Stuttgart

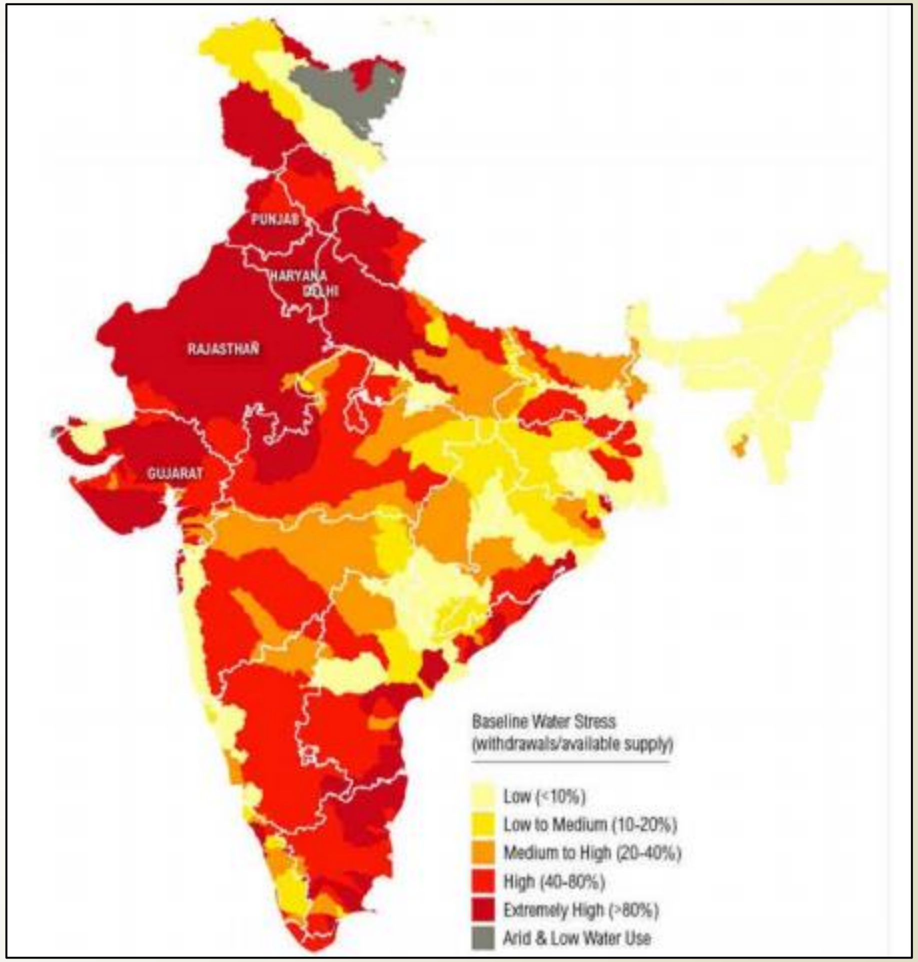
Assistant Manager, GKW Consult GmbH, India

Outline

- Water Availability in India – Projections
- Water Supply in India – Status
- Waste Water Collection and Treatment in India – Status & Issues
- Need for an Alternative Approach ?
- Hamburg Water Cycle – Original
- A Case for Segregation of Wastewater – IDEA
- Hamburg Water Cycle – Indian Context
- Implementation Environment – Conducive Factors
- Technology – Suitability
- Implementation Case Study – Mumbai
- INDIA – Potential

Water Availability in India

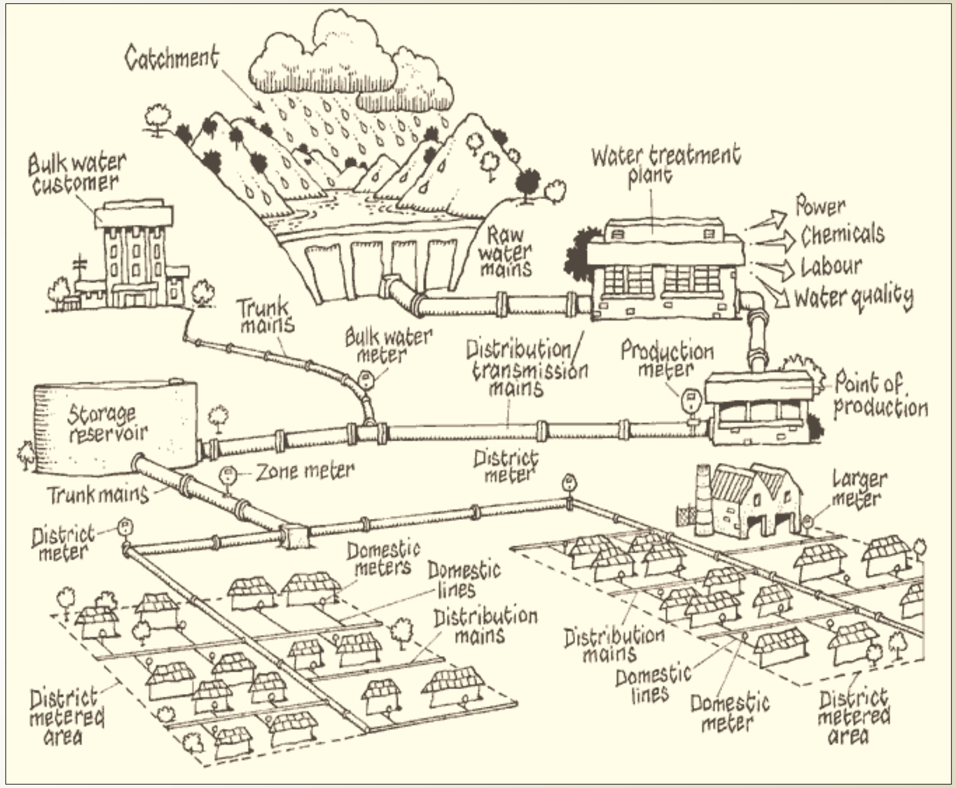
- India consumes 230 km^3 ground water per year – Quarter of the world
- India consumes more Ground Water than China
- 40 % Leakage in Piped water supply
- **Over 50 % of Urban Water needs are met by Ground Water**
- **61 %** reduction in Ground water levels in between 2007 to 2017 (CGWB)
- Water Demand two exceed Water Supply by a factor of 2 by 2030
- Per capita (theoretical) availability projected to reach 1140 m^3 by 2050 (Officially water scarce at 1000 m^3)



Baseline water stress in India
Ratio of total withdrawals and total flow (2010)
WRI,2018

State of Water Supply in India

- Population: 1,324,171,000 **(Urban: 33 %)**
- **68.65 %** Piped water supply: National
- 18.3% of rural households have piped water supply
- Per capita supply : **135 lpcd** (As per CPHEEO)
- India Water Use: **56,000 BL** (UNEP: Natural Resource Efficiency Indicators,2018)



Investment needed for Water Supply - **$ 94 Billion** for 100 % piped supply

It is safe to assume that people without Piped Connection do not have sewer connection

Waste Water Collection and Treatment in India – Status & Issues

- Piped Sewer Connection: 32.7 % of Urban Household (25.78 million HH, Census 2011)
- On Sanitation (Urban): 47 % of Urban Households (35.69 million HH, Census 2011)

- Per capita wastewater generation: 80 % of water supply (CPHEEO)

- Total wastewater generation (CPCB, 2009)
  - Class I cities (498) – 35,558 MLD
  - Class II cities (410) – 2,696 MLD

- Total wastewater generation – 76,465 MLD (2031)

Waste Water Collection and Treatment in India – Status & Issues

No.	Indicator	Unit	Benchmark	Average
1	Coverage of Toilets	%	100	69.5
2	Coverage of Sewage Network Services	%	100	12.2
3	Collection Efficiency of Sewage Network	%	100	10.3
4	Adequacy of Sewage Treatment Capacity	%	100	5.3
5	Reuse and Recycling	%	20	4
6	Quality of Sewage Treatment	%	100	3.3

Source: MoHUA,2010

Waste Water Collection and Treatment in India – Status & Issues

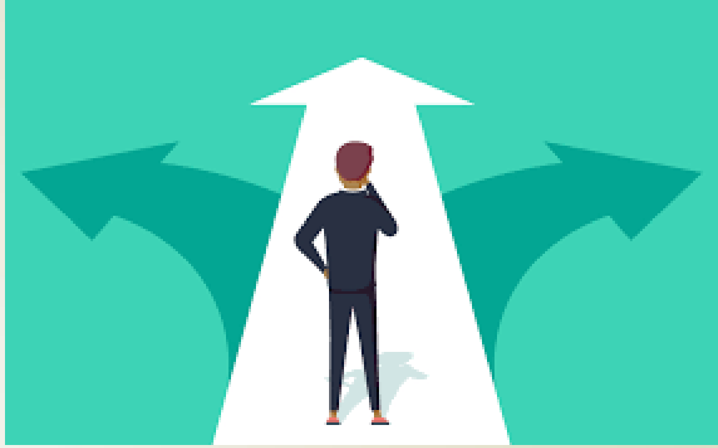
- Total Sewage Treatment Capacity(CPCB, 2009)
  - 816 STPs – 23277 MLD
  - 522 Operational STPs – 18883 MLD
  - 294 Non Operation/ Under Const. / Proposed – 4394 MLD

Quantity of wastewater treated and achieved quality ?? – Data deficient

- Only 33 % states reported treating more than 50 % of wastewater generated on FY 2017-18 (Niti Aayog, CWMI 2019)

An estimated investment (opportunity) of **$78.8 Billion** (WSP, 2016) over up to 2031 capture 74 % waste water and treat 86 % of wastewater generated

Priority of Urban Development Who gets the funds ?



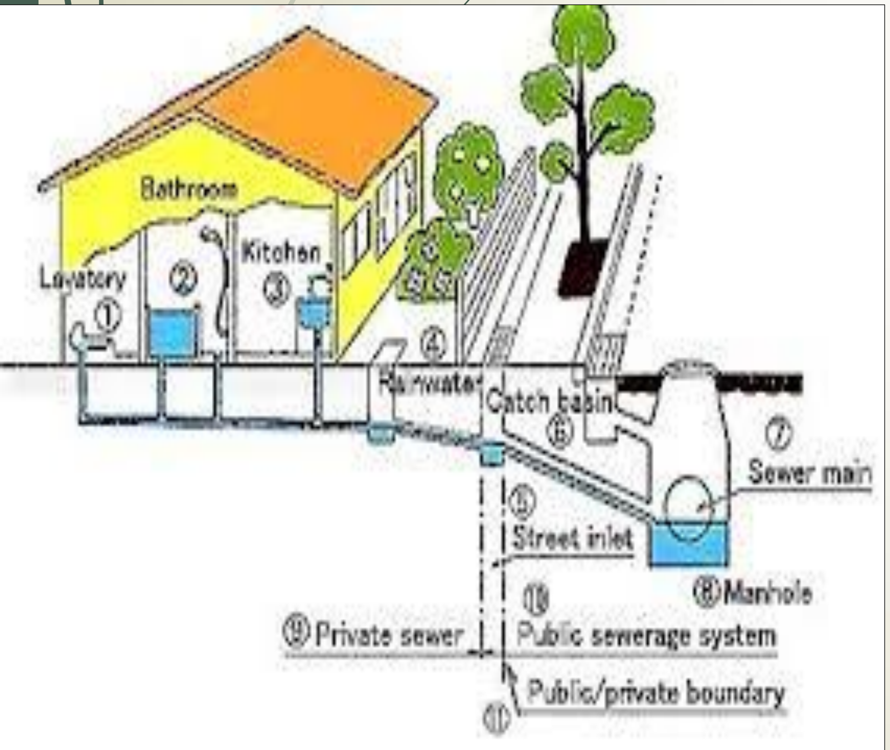
EXTERNALLY AIDED URBAN INFRASTRUCTURE PROJECT

1. Roads
2. Electricity
3. Water Supply
4. Urban Transport
5. **Sewerage**
6. Storm Water Drainage
7. Solid Waste Management

AMRUT (INDIA's FLAGSHIP PROGRAM)

1. Water Supply
2. **Sewerage & Septage Management**
3. Drainage
4. Urban Transport
5. Others

Conventional Sewer Systems and STPs



- Use of drinking (potable water) for Toilet Flushing
- Waste water from all kind of sources are mixed
- High Organic and Nutrient Load mixed with Low Organic Load Grey water and Rain water
- Increases the volume of waste water to be treated due to mixing
- High Energy consumption in pumping and STP operation
- Expert operation and maintenance is required (often lacking)
- Usually end of pipe treatment (In Indian context a lot of it remains untreated)
- Old school approach of “Out of Sight, Out of Mind” – People unaware and uncaring

Problems – Specific to India (Developing Nations)

- Often there is no wastewater collection system → **Buildng STPs not enough**
- Non – functional or non – existent drainage system
  - (Guwahati , My current residence city is a case in point)
- Lack of Sewage Treatment Systems
- Lack of functioning STPs (Inadequate flow, Improper maintenance, Lack of expertise or funds)
- **Lack of Institutional Know- How and Capacities**
- **Feasibility to find investment of this scale ?**
- **Feasibility of Successful Project Implementation ? (COLLECTION AND TREATMENT)**

NEED FOR AN ALTERNATIVE APPROACH ?

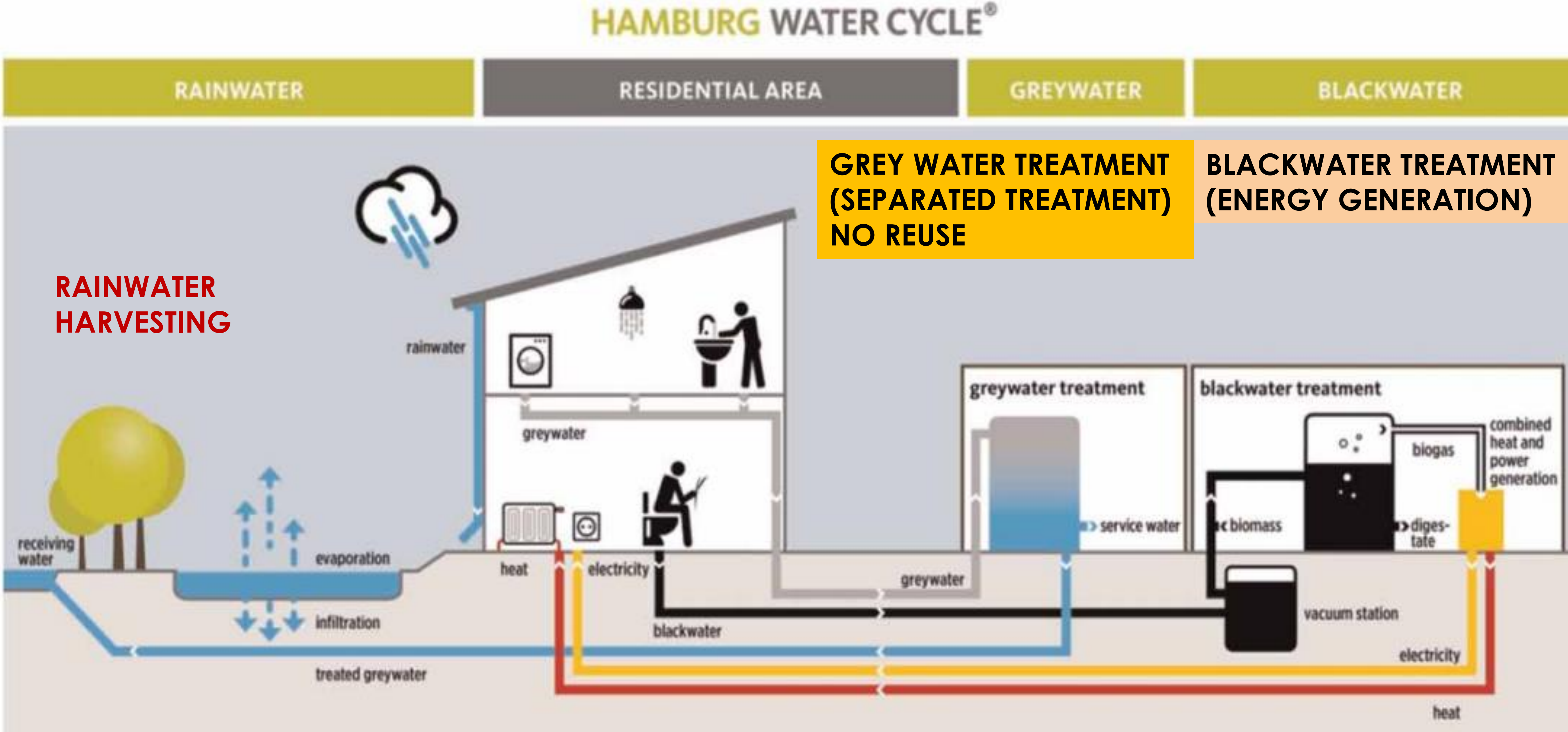
The right answers are Fuzzy!

Important to invest the multi-billion dollars in the right way!

Hamburg Water Cycle - Germany

- Developed by Hamburg Wasser – One of the most successful companies
- Implemented in Jenfelder AU , Hmaburg, Germany
  - (Transformation of former military barracks in Urban settlement)
- 35 ha land area and 770 houses
- Segregation of Grey, Black and Storm Water
- Water consumption reduction (Recycling - Black/ Grey/ Storn Water)
- Possibility to reuse water (upto 75 %)
- Energy Generation from Black Water
- Proven to be a success in the local community
- Scalable on large scale

Hamburg Water Cycle - Germany

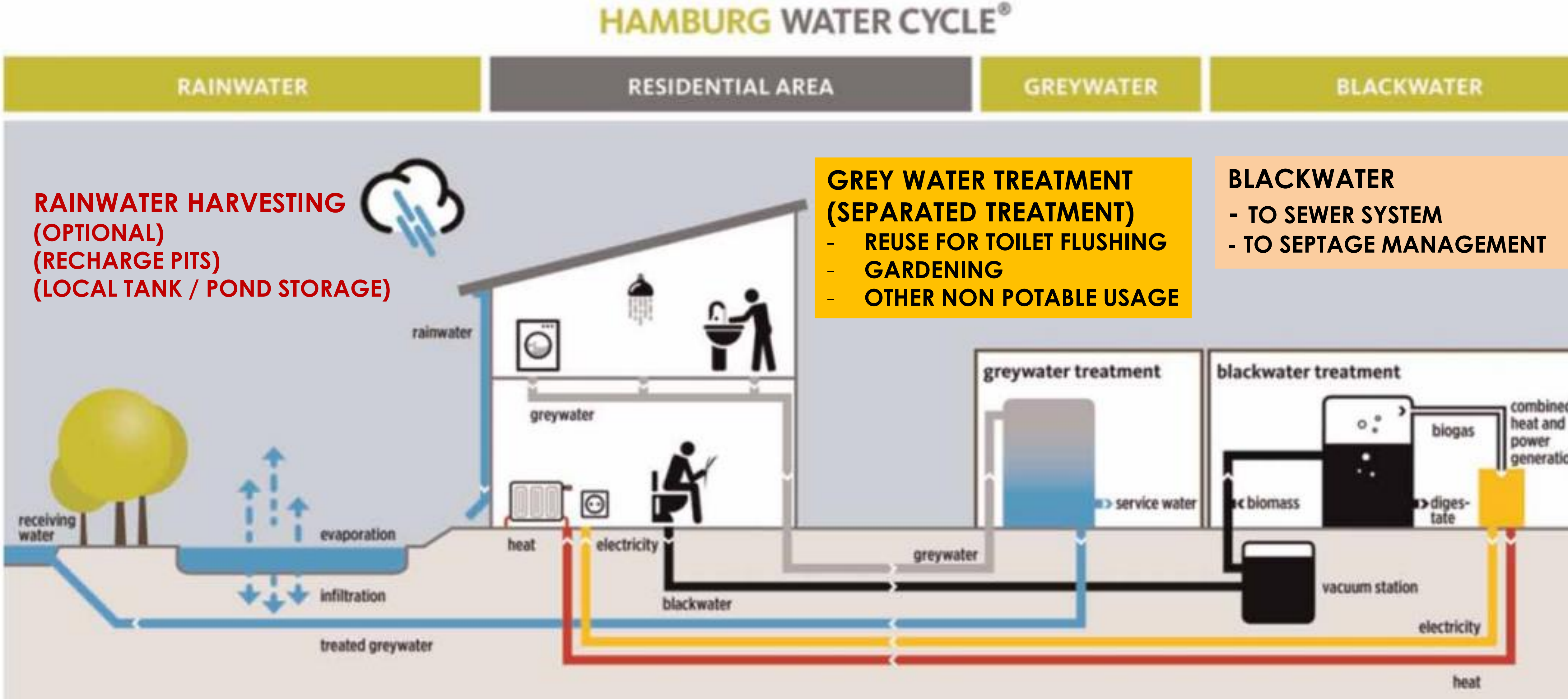


RAINWATER HARVESTING

GREY WATER TREATMENT (SEPARATED TREATMENT) NO REUSE

BLACKWATER TREATMENT (ENERGY GENERATION)

Hamburg Water Cycle – INDIAN CONTEXT

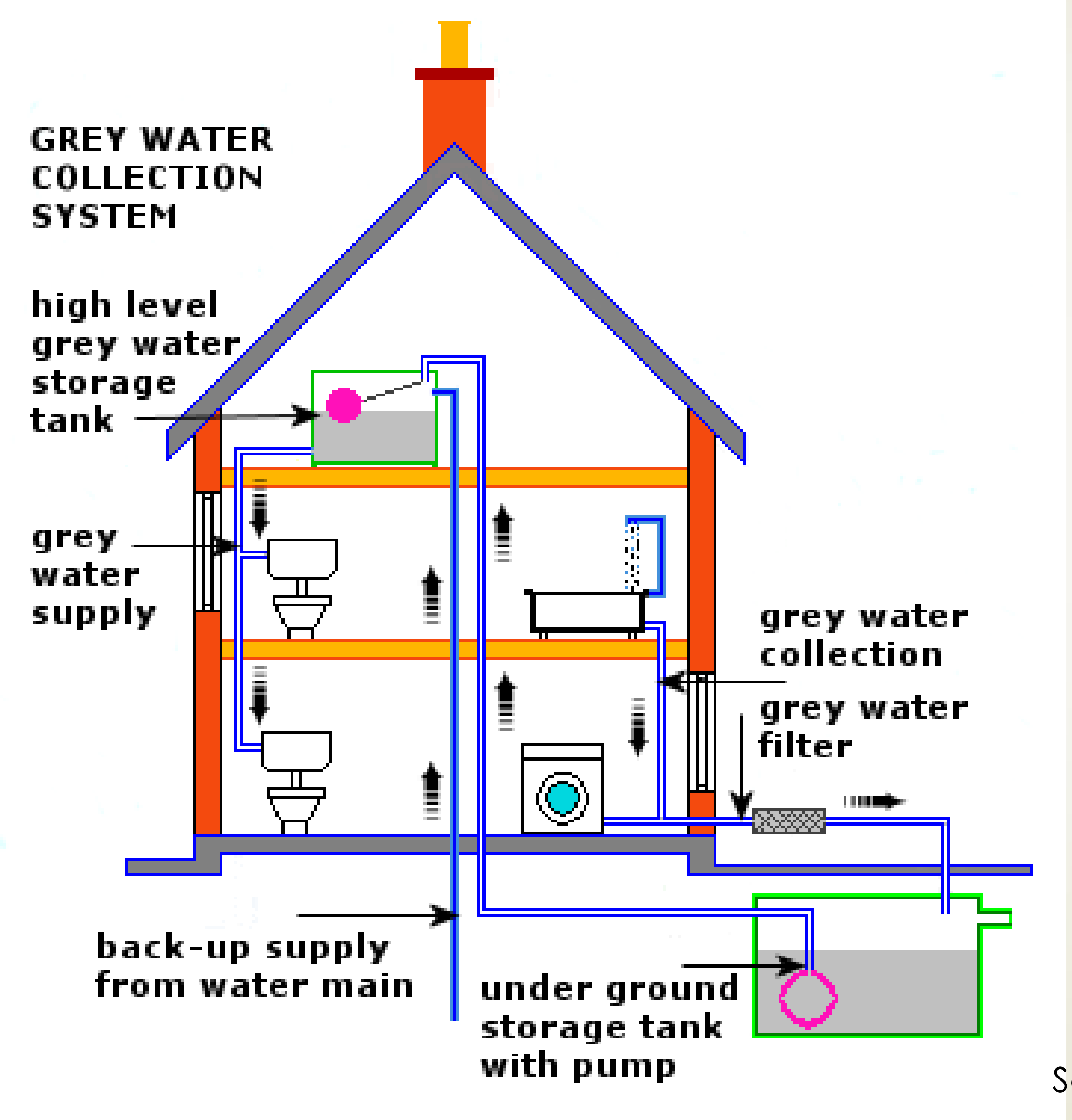


RAINWATER HARVESTING
(OPTIONAL)
(RECHARGE PITS)
(LOCAL TANK / POND STORAGE)

GREY WATER TREATMENT
(SEPARATED TREATMENT)
- REUSE FOR TOILET FLUSHING
- GARDENING
- OTHER NON POTABLE USAGE

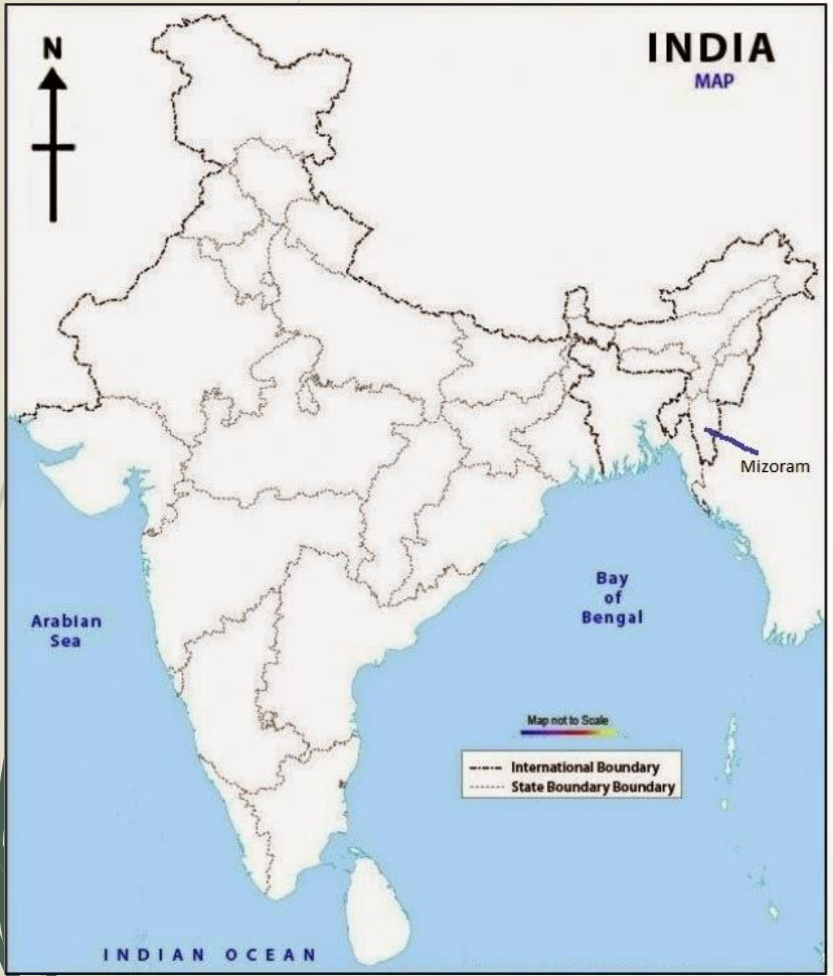
BLACKWATER
- TO SEWER SYSTEM
- TO SEPTAGE MANAGEMENT

Grey Water Reuse



Source: commonfloor.com

A Case for Segregation of Wastewater – Northeastern Capital City (293,416 , Census 2011)



A Case for Segregation of Wastewater – Personal Experiences

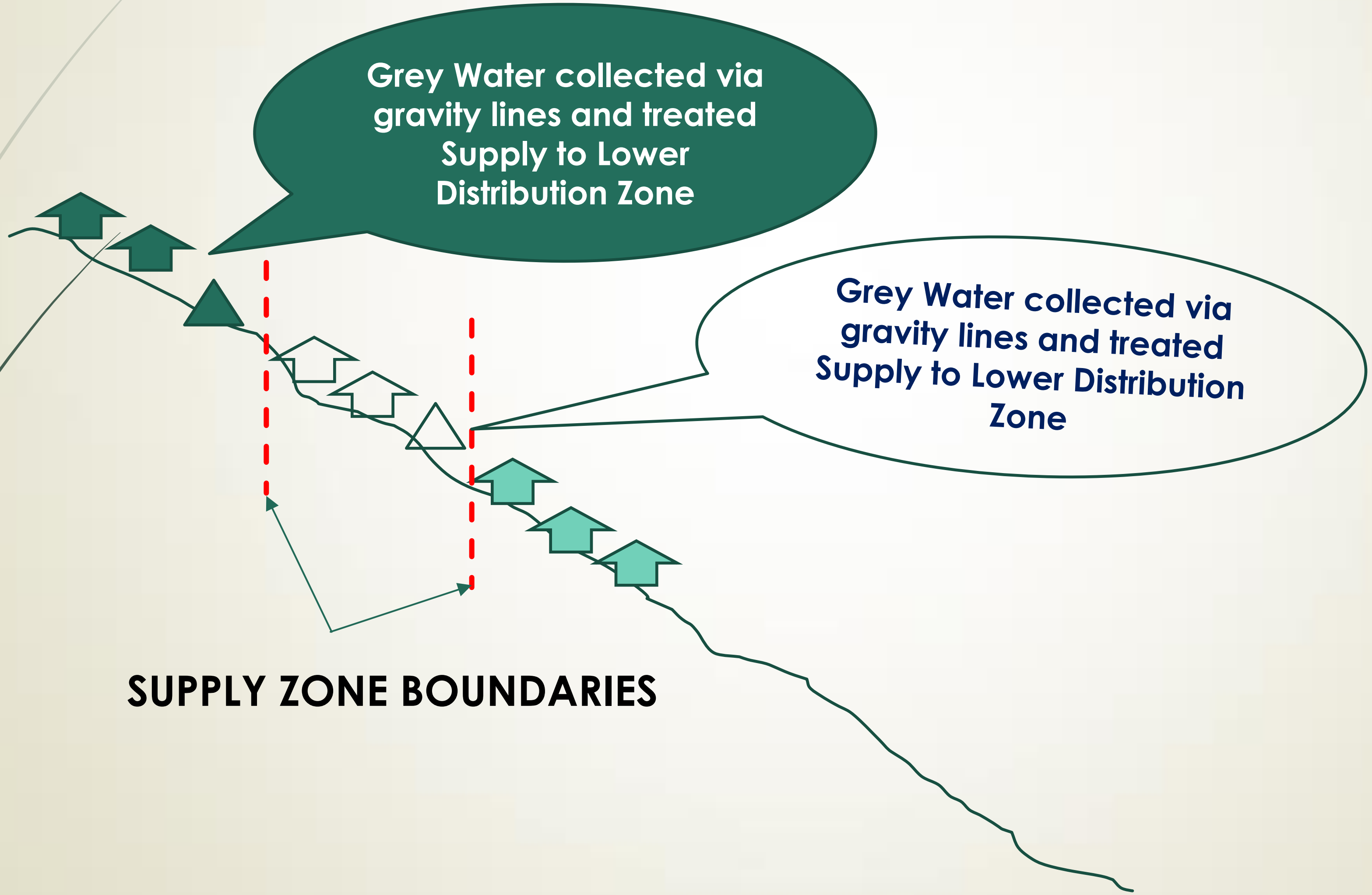
- Average rainfall >2300 mm per year well distributed over the year
- Settlements on hill/ mountain tops
- Partial coverage of piped water supply **(Average cost Rs. 300 per month flat)**
- Heavy Reliance on Water Tankers **(Rs. 2.5 -3.5 per Litre cost)**
- High energy demand for water supply (500 m – 1000 m pumping heads)
- Reliance on rainwater for meeting water demand
- **Grey Water already discharged in a segregated manner**

- STP Commission Ready in **2018 (Lying IDLE)**
- **Sewer Collection Pipe Project End – Likely 2021**
- **Bio-digesters used for decentralized system however not satisfactory functioning**

Possibility (Small Sewer – Decentralized To treat Grey Water)

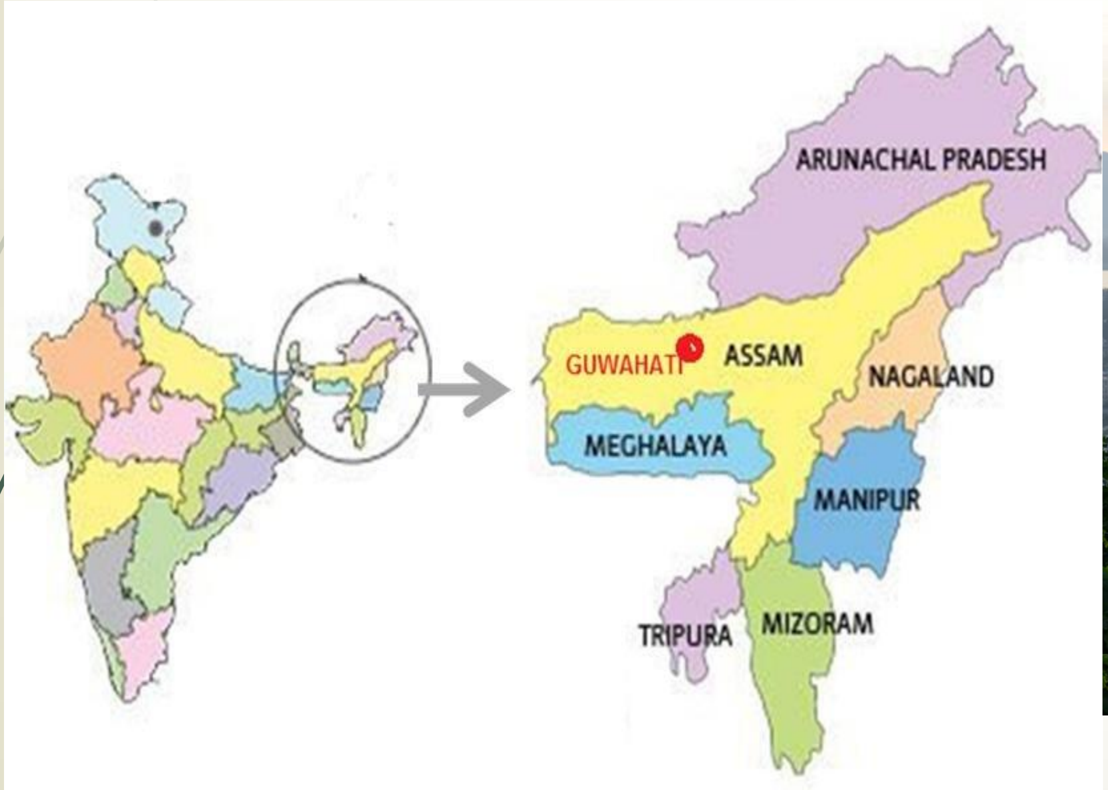
Waiting to be Commissioned Since early 2018

Decentralized Grey Water Collection & Treatment – Gravity based supply for non potable usage



- Reduced Water demand/ supply vis-à-vis energy demand
- Community Based functioning
- Low cost operation maintained at Ward Level
- Treatment of Wastewater (Partial)
- This water ends up downstream in the rivulets

A Case for Segregation of Wastewater – **Guwahati, Capital of Assam**(957,352 , Census 2011)



A Case for Segregation of Wastewater – Personal Experience

- Only 34 % of the city has Piped Water Supply or 35 lpcd availability
- The city has long way to reach 100 % coverage (Min. 10 years)
- No plans in view for next decade for wastewater collection and treatment (Low Priority)
- OTHER ISSUES – Narrow Streets, Lack of Capital and O & M funds
- **Continued Water Pollution for a Decade ??**

  - **DECENTRALIZED APPROACH –**
    - **WASTEWATER SEGREGATION , LOW COST TREATMENT AND REUSE**
    - **Start of pollution control**
    - **Environmental Protection**

A Case for Segregation of Wastewater – Personal Experience

- **MUMBAI, CAPITAL OF MAHARASHTRA, (**12,478,447, 2011**)**
  - Water supply from 80 km from the Western Ghats, Hills
  - Water cuts in Summer months is common
  - Water Supply 30 – 50 min
  - Intermediate Storage in HH Tanks is often used
  - SOUND OF 8 – 10 litres of Fresh Water Down the drain
  - **Daily 390 MLD of fresh potable water is used for this purpose**
  - Housing Societies in Mumbai (Flats/ High Rises issue notices to reduce water usage, avoid vehicle washing)

- Sufficient for water needs of a city of 2,600,000 mill. Inhabitants
- More than combined water projects under implementation for Guwahati
- More than sufficient for water needs of all 7 capital cities of North East India except Guwahati

What's the right approach ?

CENTRALIZED

- Suitable for new densely populated areas
- Important to have operating institutions with know how to run large system
- Revenue collection for financial sustainability **(Often a challenge)**
- **High Capital Costs at the onset – Affordability ?**
- **Expensive for high ground water table areas**

DECENTRALIZED

- Small Scale
- Faster Implementation
- Learn as we go
- Scaled up once successful
- Low Investments
- Possible to instill ownership and increase awareness
- **Can be difficult for reasons like lack of suitable land and community participation**

ANSWERS ARE FUZZY – Partly True/Partly False

Need for Wastewater Reuse in Urban India – Decentralized Approach

- Water Saving – Reduction in Fresh Water Demand
- More fresh water at customer's disposal
- Specially relevant in areas getting water supply from **Tankers**
- Reduction in ground water depletion where it is the main source
- Beginning wastewater treatment even where functioning STPs are still a distant reality
- Environmental Protection
- Alternative model to conventional model
  - STPs tend to be defunct due to lack of proper sewer system
  - Improper Design (High Flows or no flows)
  - Lack of funds for operation (No sustainable model yet to levy wastewater fees)

Wastewater – A Resource / An alternate water source

Indirect but Tangible Impacts

- Unlocking of private(decentralized) financing of wastewater reuse
  - Given the humongous investment requirement for centralized systems it is unlikely to be met fully by government financing
  - Decentralized Approach allows for cost transferring to consumer (Albeit with rebates) and also allows more ownership

- Reduced working loads on wastewater collection systems
  - Savings in pumping costs (Intermediate pumping stations)
  - Reduced working load on STPs
  - If implemented on large scale in cities lacking STPs it can be factored during planning of STPs

Favorable Factors for Implementation

- **Water Problems**
  - Areas of water scarcity - Need for Water Tankers/ Deep bore wells
  - Lack of good quality water sources
- **Water Expenditure**
  - Water tariff are rationalized (and Implemented)
- **Enabling Regulations**
  - Regulations and statutory laws requiring implementation
  - Lack of a proven/ functioning sewer system with end of line STP
- **Potential for Financial Savings**
  - Property Tax are applicable and there are tax rebates for implementing such measures
  - Water Tariff savings
- **Relative availability of land for small scale set up**
- **Community awareness and institutional support**

Hamburg Water Cycle – INDIAN **Implementation in Existing Buildings**

CRITERIA:	New Buildings	Existing Buildings
1. PIPING AND STORAGE SYSTEM		
→ Twin type plumbing for grey and black water separation	Mandatory	Optional
→ Plumbing for reusing for toilet flushing	Mandatory	Incentivize
→ Overhead Storage tanks for treated grey water	Mandatory	Incentivize
2. SUITABLE TECHNOLOGY		
1. LAND REQUIREMENT	Low	Low
2. CAPEX	May be high	Preferably low
3. OPEX	Low	Low
3. GOVERNMENT SUPPORT (PROPERTY TAX REBATES)		
1. Property Tax Rebates	Mandatory	Recommended
2. One time technology and partial funding	Recommended	Recommended
4. RAINWATER HARVESTING	Mandatory	Incentivize
5. DIRECT BENEFITS (INFORMATION AND EDUCATION CAMPAIGN)		
1. More fresh water availability throughout the year	Recommended	Recommended

What is Grey Water ?

- Grey water mainly consists of discharges from bathtubs, shower, kitchen sinks (optional) and washing

Chemical properties	Laundry	Bathroom	Kitchen sink
pH	9.3- 10[A]	5- 8.1[A, B, D, E]	6.3- 7.4[F]
EC [µS/cm]	190- 1400[A]	82- 20'000[AD]	
Alkalinity [mg/l]	83- 200 as $CaCO_3$[A]	24- 136 as $CaCO_3$[A, E]	20.0- 340.0[F]
Hardness [mg/l]	-	18- 52 as $CaCO_3$[E]	-
BOD_5 [mg/l]	48-380[A, C]	76- 200[A]	-
BOD_7 [mg/l]	150[G]	170[G]	387- 1000[G]
COD [mg/l]	375[G]	280[G] up to 8000 COD_{Cr}	26- 1600[F, G]
TOC [mg/l]	100-280[C]	15- 225[E]	-
Dissolved oxygen [mg/l]	-	0.4- 4.6[D]	2.2- 5.8[F]
Sulfate [mg/l]	-	12- 40[B]	-
Chloride (as Cl) [mg/l]	9.0-88[A]	3.1- 18[A, B]	-
Oil and grease [mg/l]	8.0-35[A]	37- 78[A]	-

A, (Christova Boal et al., 1996); B, (Rose et al., 1991); C, (Siegrist et al., 1976); D, (Santala et al., 1998); E, (Burrows et al., 1991); F, (Shin et al., 1998); G, (Hargelius et al., 1995)

Impact on design and cost

- Due to low organic and nutrient content, the grey water can be relatively easily specially for non-potable usage
- The grey water reuse will substantially reduce groundwater abstraction since majority of water demand for toilet flushing and gardening in Ashram school can be met from treated grey water

Technology Comparison Matrix

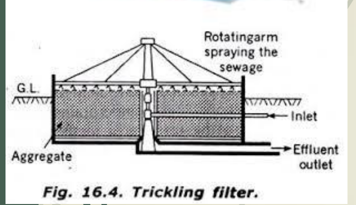
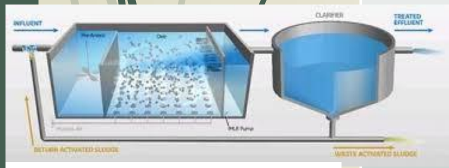


Fig. 16.4. Trickling filter.



TECHNOLOGY	LAND (sqm./ KLD)	ORGANIC LOAD REMOVAL**	CAPEX (INR./KLD)	OPEX	REUSABILITY
Reed Bed System	15-17	35-100%	Lower than TF	Low	Flushing and Gardening
Trickling Filter	0.65	70-100%	Lower than SBR	Medium	
SBR*	0.40	>90%	10638	Medium	All except drinking, cooking and floor washing
MBBR*	0.45	>90%	9645	High	
SBR/MBBR + UF+RO*	0.55	90-100%	16310	V. High	Technically up to drinking
	*CPCB 2013	**De Koening,2005	*CPCB 2013	(Data Deficient)	

Which one to choose ?

- LOW COST SYSTEM (up to Secondary) → Meets only flushing requirement and gardening, agriculture
- HIGH COST SYSTEM (Tertiary Treatment) → Flushing, gardening, cleaning of floor, washing clothes, GW Recharge, Vehicle washing,

Favorable Laws – Future trends

CITY 5

To cut demand, BMC tax rebate for socs that reuse grey water

VijayV.Singh@timesgroup.com

Mumbai: Housing societies will get 15% rebate on property tax after BMC inspection for infrastructure for processing of wet waste, dry waste recycling and rain water harvesting as well as recycling of grey water, sources said.

An official said that first two criteria—processing wet waste and recycling dry waste—will help reduce BMC's daily garbage collection from such societies to zero. And use of rainwater harvesting and recycled greywater will reduce water demand of such societies. Societies following just one process will get 5 % rebate and those meeting all three criteria will get 15% rebate.

Municipal commissioner Praveen Pardeshi told **TOI** that the tax rebate offer is part of BMC's efforts to decentralise waste management. Civic officials say the move will further help reduce the burden on dumping grounds.

Pardeshi said, "Societies can compost wet waste on their premises and even get value by selling the product to gardens. Dry waste can be sold to recycling companies. All this reduces cost to the civic authority of collecting and transporting waste. Reuse of waste water for toilet flushing reduces consumption of treated clean municipal water and reduces BMC environmental footprint on earth."

Welcoming the proposal, Indrani Malkani, Malabar Hill resident and chairman of V Citizens Action Network (VCAN), said, "For many years, many were not segregating waste despite court orders. Giving incentive will encourage societies to follow those doing it for a long time."

She said segregating and processing waste is possible for most societies and they should adopt changes to take benefit of property tax rebate. Greywater recycling requires more space and many societies may need time to opt for advance technology, she said.

In the last few years, BMC has been trying to reduce its garbage collection burden and load on dumping ground. Through the tax rebate incentive, BMC is trying to encourage societies to handle waste.

ONLY 50% BULK GENERATORS PROCESS WASTE

BULK GENERATORS

- Societies, premises that generate over 100 kg waste daily or are spread over 20,000 sq mtrs area
- As per recent rule, BMC would not collect dry waste from bulk generators that don't segregate and process wet waste

PENALTY | Disconnection of power & water supply, ₹10,000 fine and even up to 3 years' jail for the society's managing committee members

Bulk generators in Mumbai	Bulk generators following rule	Waste processed by them daily	Nos facing prosecution for rule violation
3,367	1,689	250 tons	1,678

LANDFILLS

	Area (in acres)	Daily capacity (in tons)
Kanjurmarg	160	5,500
Deonar	296	1,300
Mulund	54	Close

- Chennai promotes grey water recycling
- Bangalore is also expected to support such measures due to growing water pollution and scarcity

Implementation - 8 FLOOR x 4

No. of households – 100 Household	**– 500 people**
Water Demand @ 135 lpcd	– 67.5 KL
Grey Water Generation	– **22.5 KL (Washing/ Bathing only)**
	– 37.5 KL (Washing, Bathing, Kitchen Sink)
Flushing Water Demand	– 20 KL (@ 40 lpcd)
Gardening/ Cleaning demand	– 5 KL
Size of Plant required	– 25 KLD

Implementation – 8 FLOOR x 4

Investments

Plant Installation Cost	– INR. 230,000 (one time)
Treated Water Storage Cost	– INR. 80,000 (one time)
Plumbing Modfication Costs*	– INR. 193,000 (one time)
Total	– **INR. 503,000 (one time)**

Recurring Costs

Annual Plant O & M Cost	– INR. 125,925 p.a. (INR. 0.015/KLD/p.a)

Savings

Saving of fresh water	– 23 KLD or 8.34 Million litre
Saving of Water Tariff	– INR. 42,814 p.a.
Property Tax Rebates	– INR. 100,475 p.a. (BMC, Mumbai)

(*Saved if already twin type)

Implementation Case Study – Direct Cost Benefits
8 FLOOR x 4

Saving of fresh water – **23 KLD**

or 8.34 ML per annum

- **Water Requirement for 62000 people/12500 HH for a day)**
- **Water requirement of 34 years for HH of 5**
- **Water requirement for 2 long lifetime of an individual (170 years)**

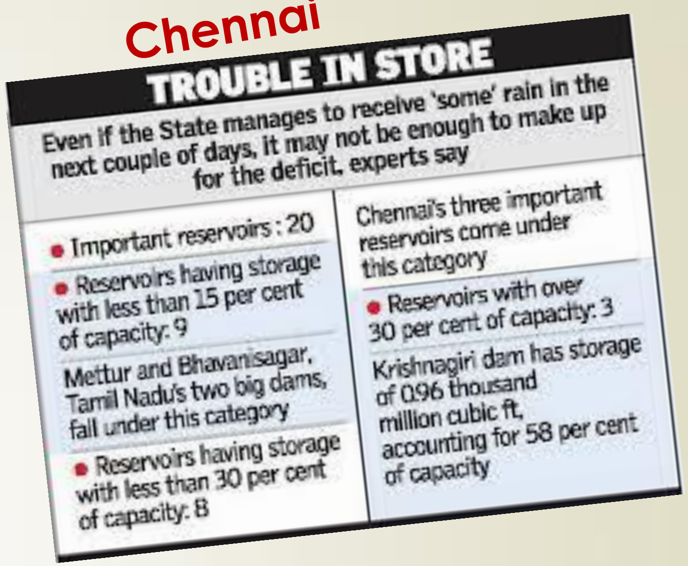
Indirect Benefits

1. Reduced water supply/ reduced energy/ reduced leakage losses
2. Reduced future capacity Augmentation
3. Environmental benefits
4. Increased public awareness
5. Increased rate of reuse
6. **Reduced Sewer Sizing/STP sizing/ Centralized O & M Costs**

POTENTIAL OF REUSE INDIA

- Chennai
- Bengaluru
- Mumbai
- Hyderabad
- New Delhi
- Guwahati
- All cities which has High Rise/ Apartment Society Model
- Lack existing waste water collection and treatment infrastructure
- Face water scarcity
- **893 Class I and II cities**

Chennai



TROUBLE IN STORE

Even if the State manages to receive 'some' rain in the next couple of days, it may not be enough to make up for the deficit, experts say

- Important reservoirs : 20
- Reservoirs having storage with less than 15 per cent of capacity: 9

Mettur and Bhavanisagar, Tamil Nadu's two big dams, fall under this category

- Reservoirs having storage with less than 30 per cent of capacity: 8

Chennai's three important reservoirs come under this category

- Reservoirs with over 30 per cent of capacity: 3

Krishnagiri dam has storage of 0.96 thousand million cubic ft, accounting for 58 per cent of capacity

Bengaluru

ON THE BRINK OF A DISASTER

➤ Karnataka government admits availability of water per person per day will be 88 litres by 2031 when Bengaluru's population will touch 20 million

➤ Central Public Health and Environmental Engineering Organisation says each person needs 135 litres a day

➤ IISc research says Bengaluru gets enough rainfall, but the problem is in harvesting it

➤ Bengaluru's lakes used to have a storage capacity of 35 tmcft of water in 1800; it's now reduced to 2tmcft

1 tmcft of water serves the needs of 6 lakh people a year

Other cities in the global grim list: Sao Paulo, Beijing, Jakarta, Cairo, Moscow, Istanbul, Mexico City, London, Tokyo and Miami

Cảm ơn bạn

धन्यवाद

THANK YOU!

ধন্যবাদ

Terima kasih

Dankeschön