PAVITRA GANGA

SOIL AQUIFER TREATMENT FOR WASTEWATER TREATMENT & REUSE

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WORKSHOP

Innovative technologies for wastewater treatment, reuse and resource recovery

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This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 821051.
This project has been co-funded by Department of Biotechnology (DBT), Government of India.

NATURAL WATER TREATMENT SYSTEMS

		Water Treatment	Wastewater Treatment and Reuse
Terrestrial System (Soil/Aquifer-based) ***Managed Aquifer Recharge (MAR)***		**1. Bank Filtration** **2. Artificial Recharge** 3. Sub-surface GW Treatment	1. Slow Rate Irrigation 2. Overland Flow **3. Soil Aquifer Treatment**
Aquatic System	**Vegetation-based**		1. Constructed Wetlands 2. Water Hyacinths
	Pond-based	(Storage Reservoirs)	1. Anaerobic 2. Facultative (Algal ponds) 3. Aerobic 4. Maturation

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SOIL AQUIFER TREATMENT

- "Engineered" natural treatment system
- Infiltration of wastewater effluent or stormwater through the vadose (unsaturated) zone to recharge the underlying aquifer
- Vadose and saturated zone treatment
- Long-term storage of renovated water: aquifer storage & recovery
- Robust, multi-contaminant removal and sustainable treatment
  - Removal of organics (DOC & trace organics/micropollutants)
  - Removal of microorganisms (bacteria, viruses, protozoa)
  - Removal of nitrogen (Ammonia + Nitrate)

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WHY SAT ?

- Alleviate water shortages; WWTP effluent as a water resource
- Augment existing sources; replenish diminishing GW; maintain environmental flows
- Eliminate additional treatment: alternative to tertiary treatment:
  - Reclaimed/recycled (waste)water
  - Storm water
  - Surface water
- Salt water intrusion barrier
- Potential worldwide application: depends on site conditions (effluent quality, geology, soils, hydrology, etc..)

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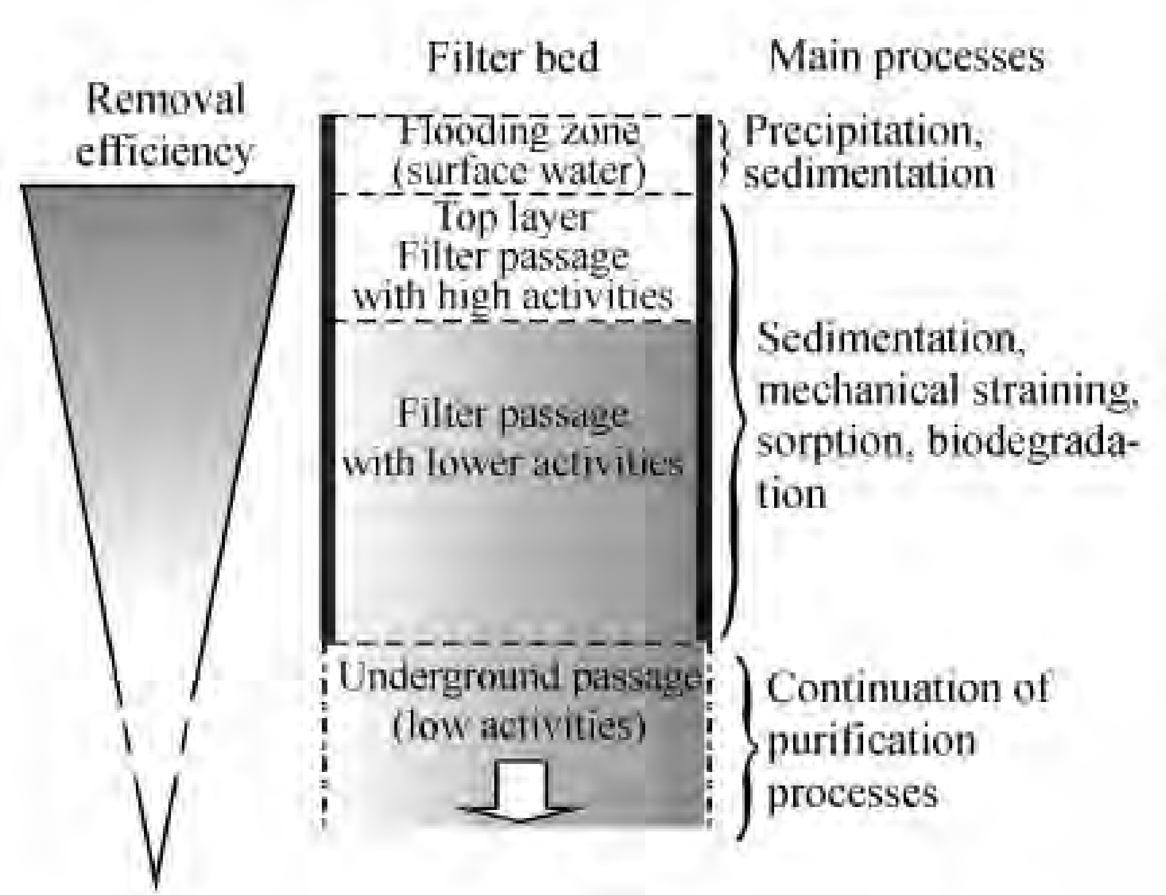
PURIFICATION PROCESS DURING INFILTRATION



Source: (Preuß and Schulte-Ebbert, 2000)

n programme under grant agreement No 821051.

ENGINEERED METHODS OF GROUNDWATER RECHARGE

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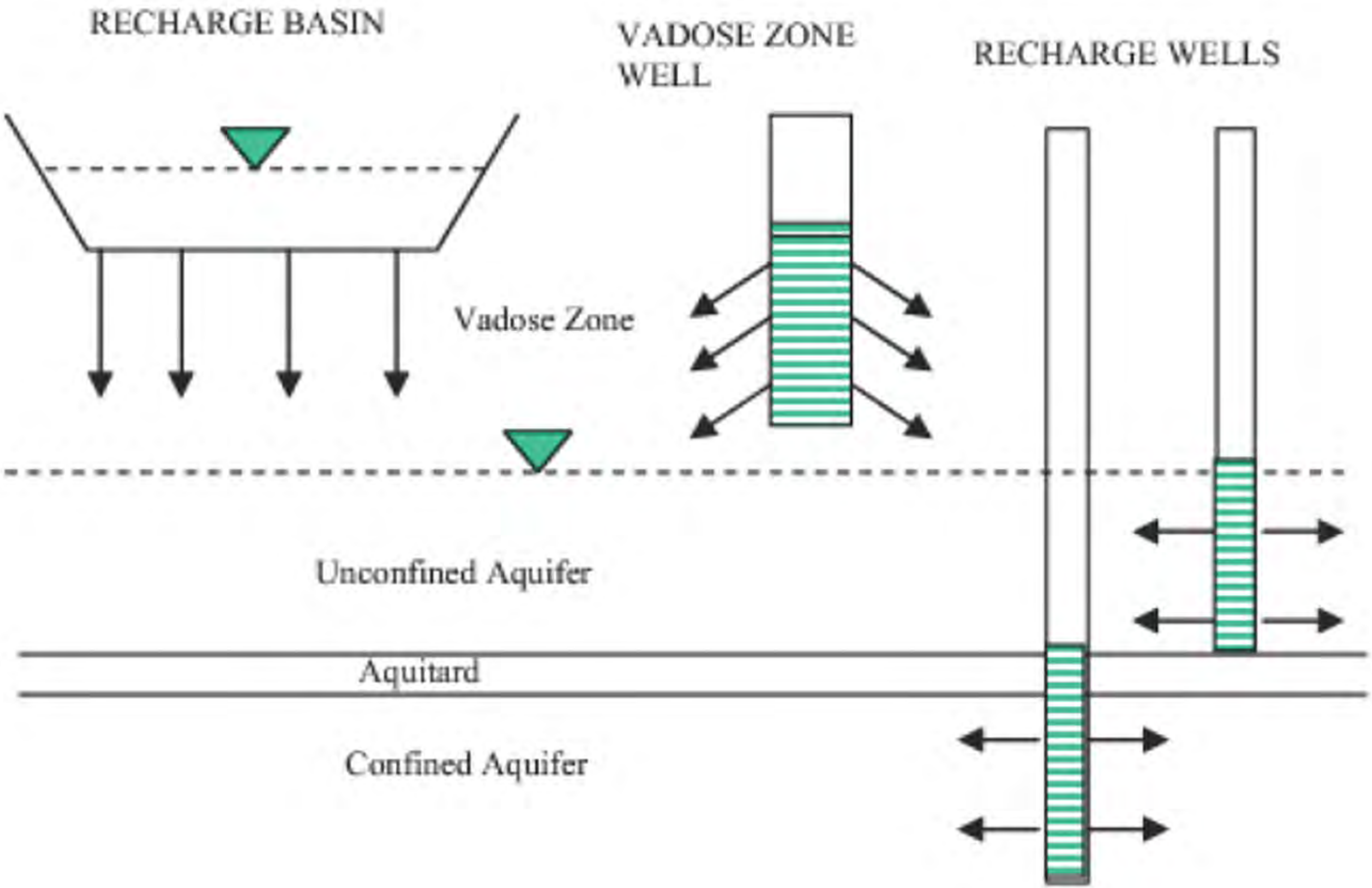

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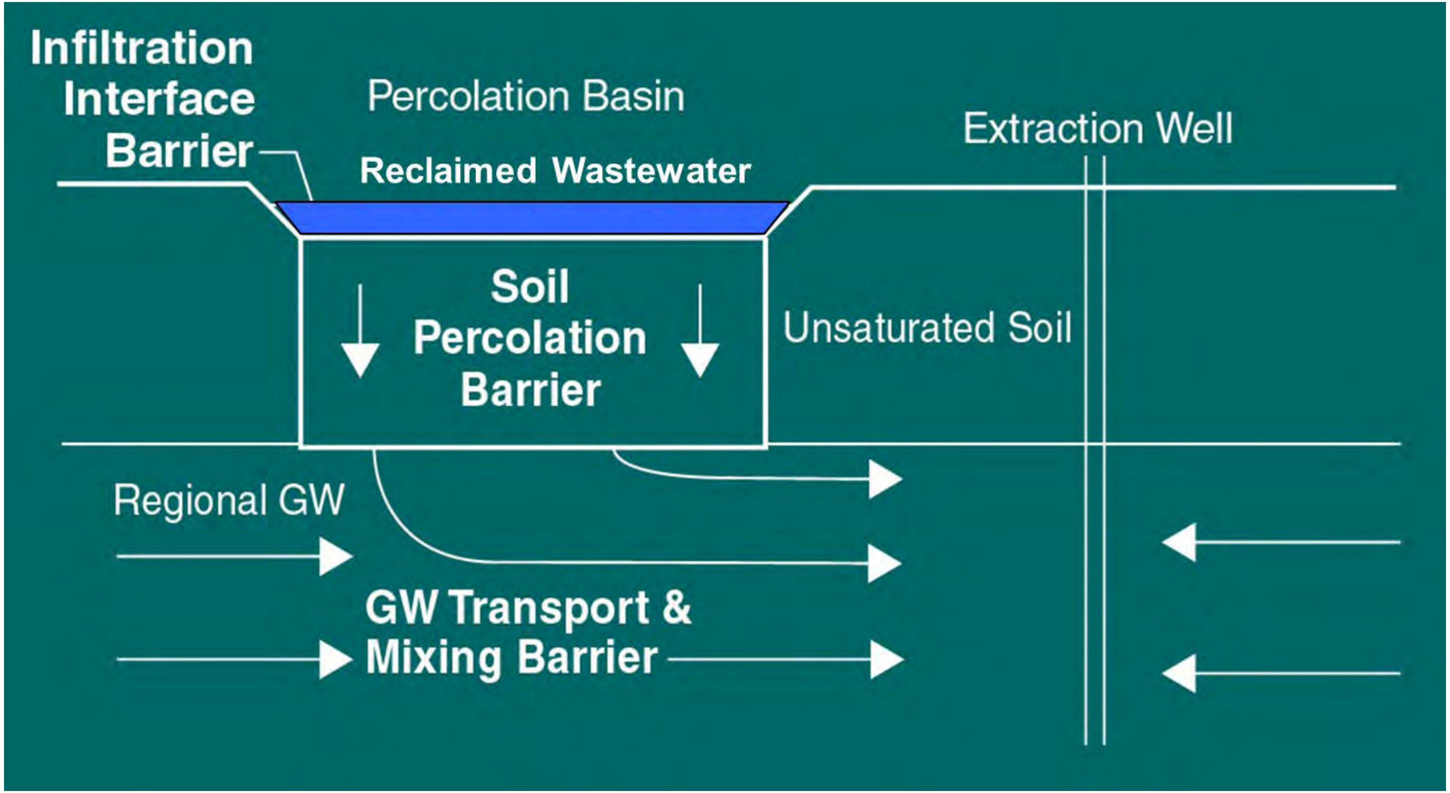
COMPARISON OF THREE MAJOR ARTIFICIAL RECHARGE AND RECOVERY SYSTEMS

(Adapted from: USEPA, 2004)

	Recharge Basins	Vadose zone injection wells	Direct injection wells
Aquifer Type	Unconfined	Unconfined	Unconfined or confined
Pre-treatment Requirements	Low technology	Removal of solids	High technology
Capacity	100-20,000 m^3/ha-d	1,000-3,000 m^3/d per well	2,000-6,000 m^3/d per well
Maintenance Requirements	Drying and scraping	Drying and disinfection	Disinfection and flow reversal
Estimated Life Cycle	> 100 years	5-20 years	25-30 years
Soil Aquifer Treatment	Vadose zone and saturated zone	Vadose zone and saturated zone	Saturated zone

SOIL AQUIFER TREATMENT



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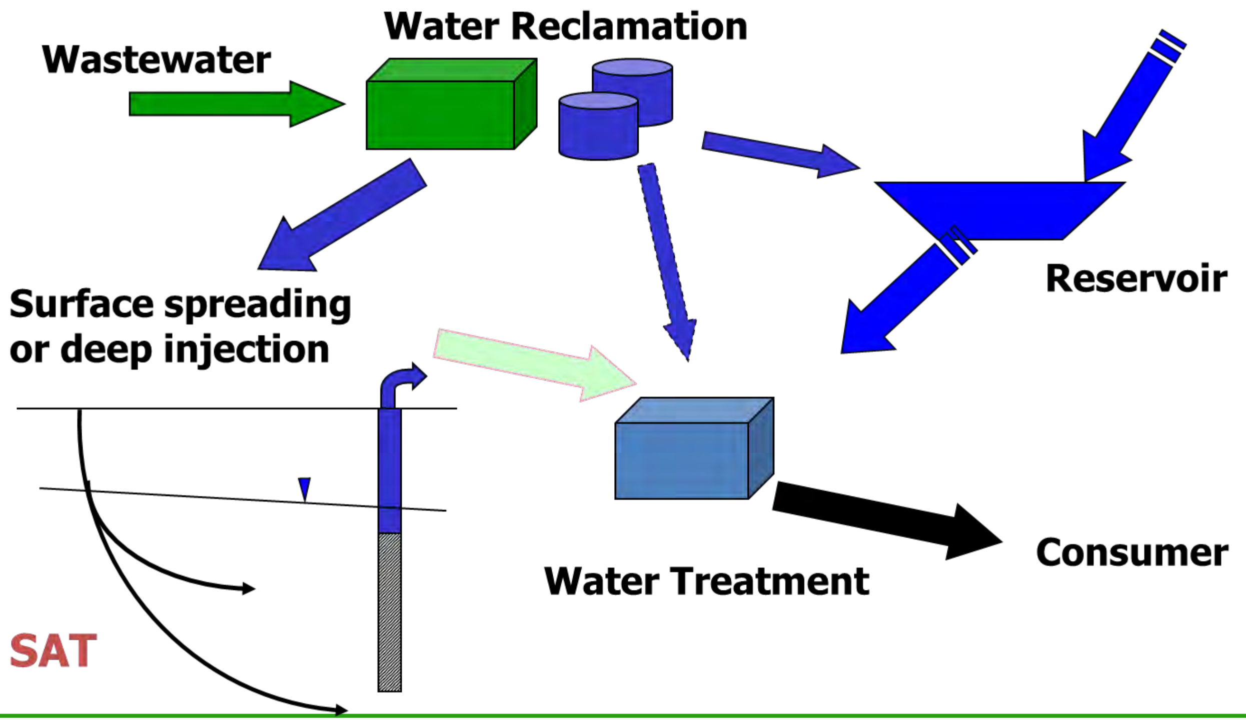
SAT IN INDIRECT POTABLE REUSE



- Environmental and Psychological Barrier

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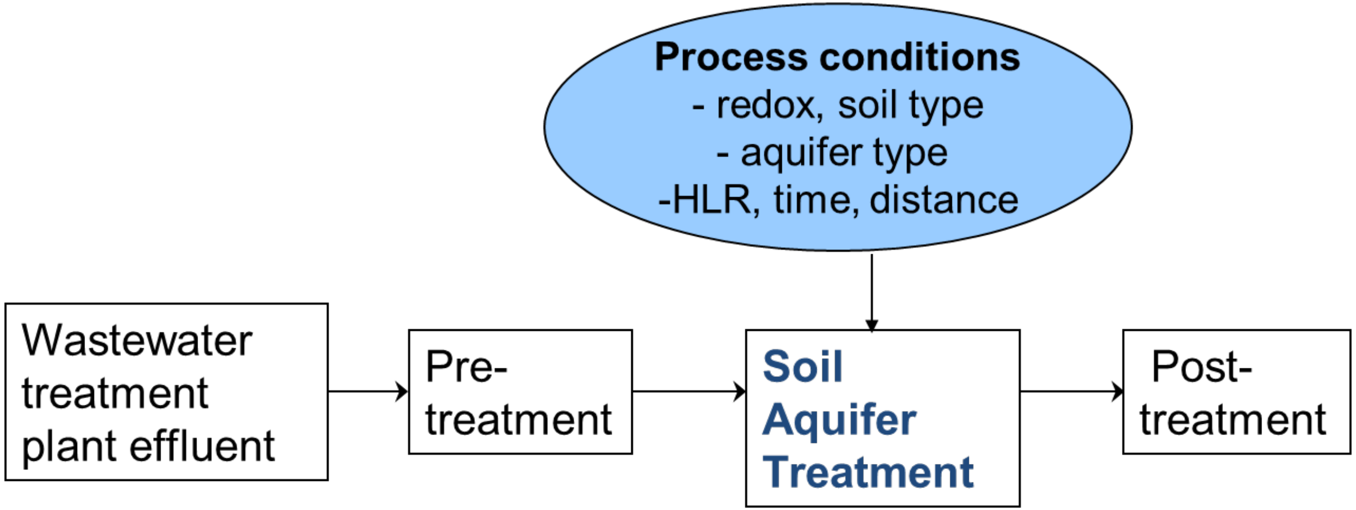
SAT FOR WATER RECLAMATION



1. Primary
2. Secondary
3. Tertiary

1. None
2. Membrane Filtration
3. O_3 , Advanced oxidation
4. Combinations of 2 and 3

1. UF (viruses)
2. NF (trace organics)
3. Post disinfection (chlorination)

(Depends on intended use of reclaimed water)

DESIGN COMPONENTS FOR SAT SYSTEM

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- Pre-treatment requirements (depends on degree of wastewater treatment)
- Infiltration (hydraulic loading) rate
- Land requirement (taking into account wet/dry cycle)
- Number of wells (production capacity per well) ; Spacing between the wells
- Distance of the wells from infiltration pond or injection well
- Pumping rate (affects groundwater flow and velocity)
- Share of native groundwater in reclaimed water (%)
- Water quality obtained from the SAT system
- Post-treatment requirements (if any)

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FACTORS AFFECTING PERFORMANCE OF SAT SYSTEM

- Site Specific Conditions
  - Source water quality
  - Geology and Soils
  - Geohydrology
    - Alluvial, Unconfined or Confined Aquifer
    - Unsaturated Zone Depth (depth to water table)
    - Aquifer Depth (depth from water table to bedrock)
    - Permeability (Conductivity)
  - Travel Distance /Travel Time
    - Well Placement, spacing between the wells, pumping rate
    - Permeability

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DOC REMOVAL BY SAT FOR DIFFERENT INFLUENTS

Type of SAT influent	Influent (mg/L)	Effluent (mg/L)	Removal efficiency (%)
Primary effluent	9-35	7-21	12-62
Secondary effluent	2-24	1.5-16	10-94
Tertiary effluent	5-20	2-14	19-80

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TSS & DOC REMOVALS WITH DIFFERENT PRE-TREATMENT OF PRIMARY EFFLUENT

Pre-treatment	Total Suspended Solids (TSS) mg/L			Dissolved Organic Carbon DOC (mg/L)		
	Influent	Effluent	Removal %	Influent	Effluent	Removal %
Coagulation followed by sedimentation (PE+COAG)	141	20	**85.5**	29.6	25.5	**13.8**
Sedimentation for 3 days (PE+SED)	140	19	**86.1**	27.8	25.6	**9.3**
Horizontal roughing filtration (PE+HRF)	80	30	**62.5**	27.1	24.0	**11.5**

TYPICAL REMOVAL EFFICIENCY OF SAT SYSTEM

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Parameter	Influent concentration (mg/L)	Effluent concentration (mg/L)	Removal efficiency (%)
BOD (mg/L)	15 - 228	0 - 58	75 - 100
TN (mg/L)	12 - 50	2.8 – 19.6	38 - 93
TP (mg/L)	2.1 - 11	0.03 – 4.5	29 - 99
SS (mg/L)	10 - 80	<1 – 2	>95%
Pathogens (coliform and virus)			2 – 4 log
Estrogen (for depth > 36 m)			>95%

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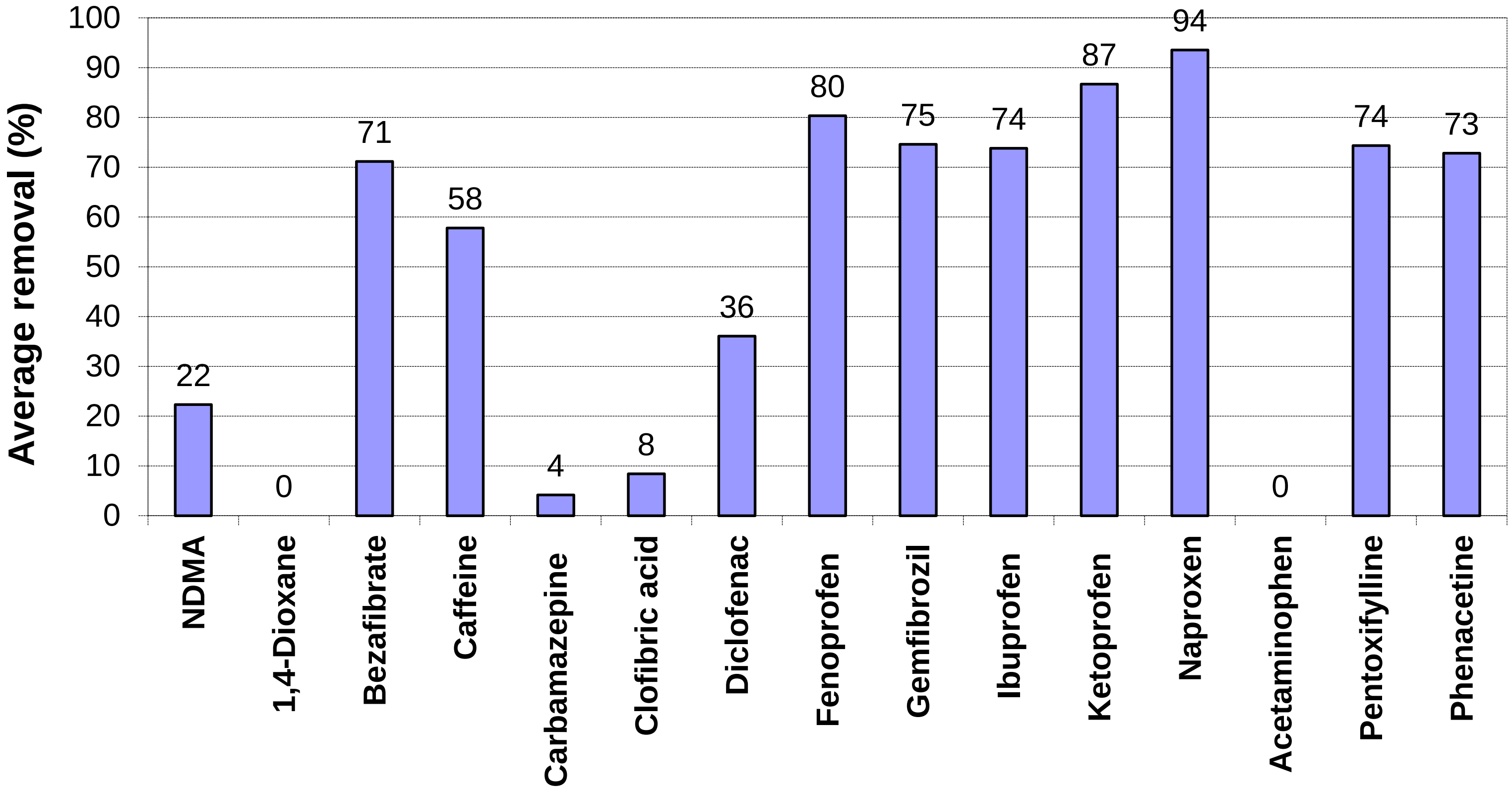
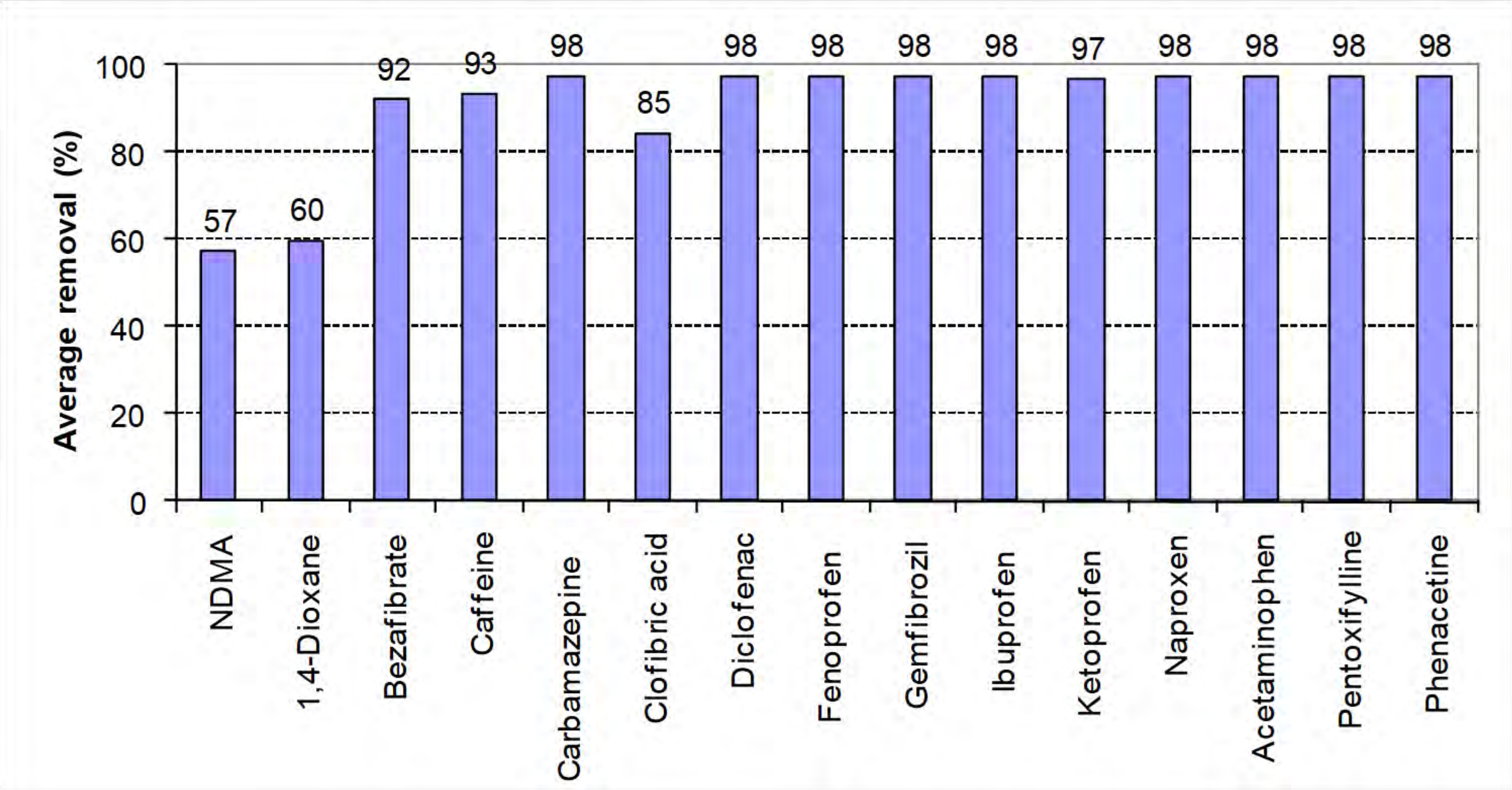
REMOVAL OF OMPS IN SECONDARY EFFLUENT DURING SOIL PASSAGE



(Depth = 5 m, HLR = 1.25 m/day)

Source: (Sharma et al, 2011)

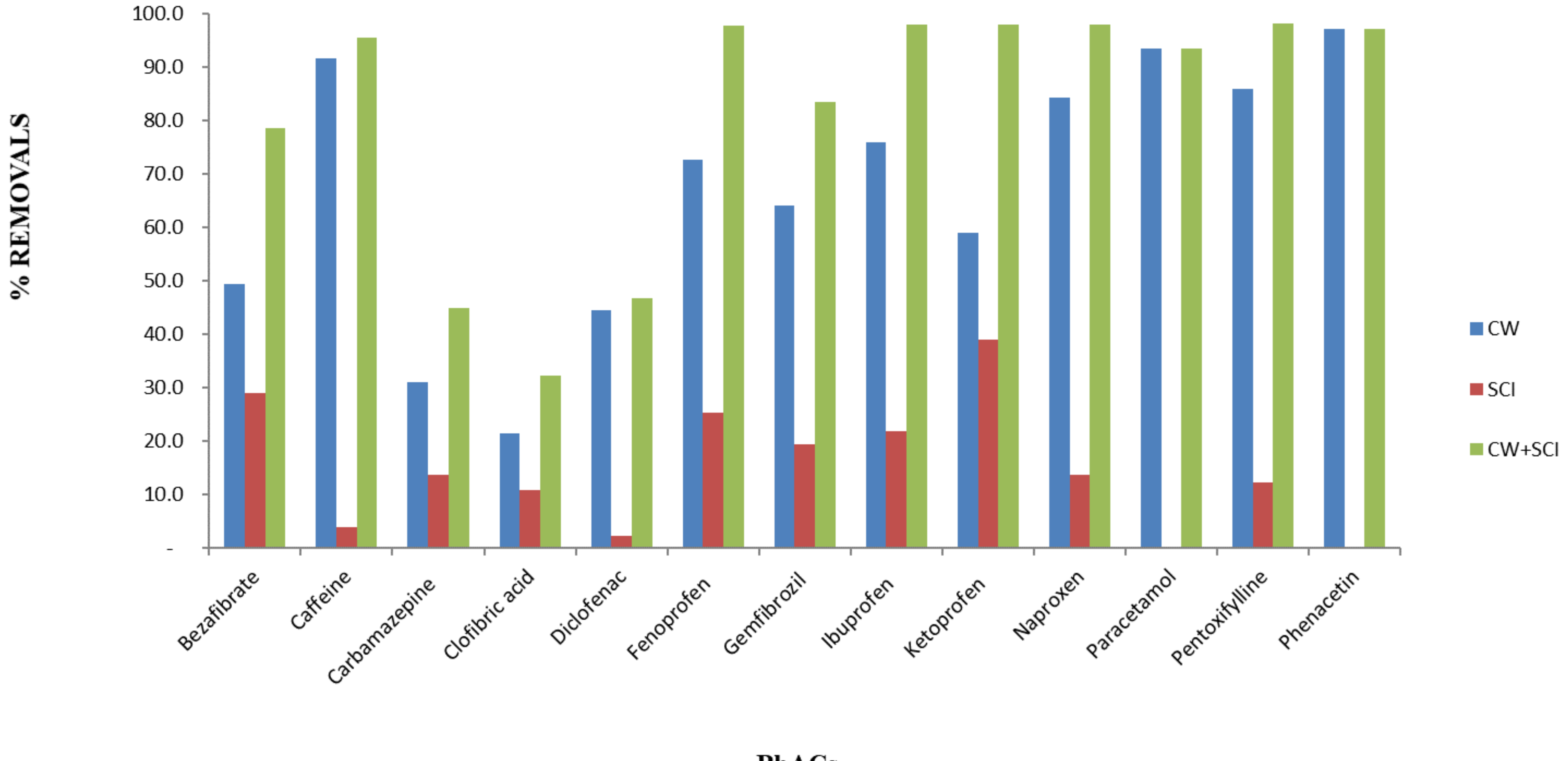
REMOVAL OF OMPS IN SECONDARY EFFLUENT DURING SOIL PASSAGE AFTER OZONATION



(Depth = 5 m, HLR = 1.25 m/day)

Source: (Sharma et al, 2011)

REMOVAL OF PHACS IN CW, SAT & HYBRID SYSTEM



HYDRAULIC LOADING & OPERATION

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- Infiltration basins in SAT systems are **intermittently flooded** to provide regular drying periods, for restoration of infiltration rates and for aeration of the soil.
- Flooding schedules typically vary from **8 hours dry-16 hours flooding to 2 weeks dry-2 weeks flooding.**
- SAT systems, therefore, **should have a number of basins** so that some basins can be flooded while others are drying.
- Annual infiltration amounts or "hydraulic loading rates" typically vary from **15 m/year to 100 m/year**, depending on soil, climate, quality of sewage effluent, and frequency of basin cleaning.

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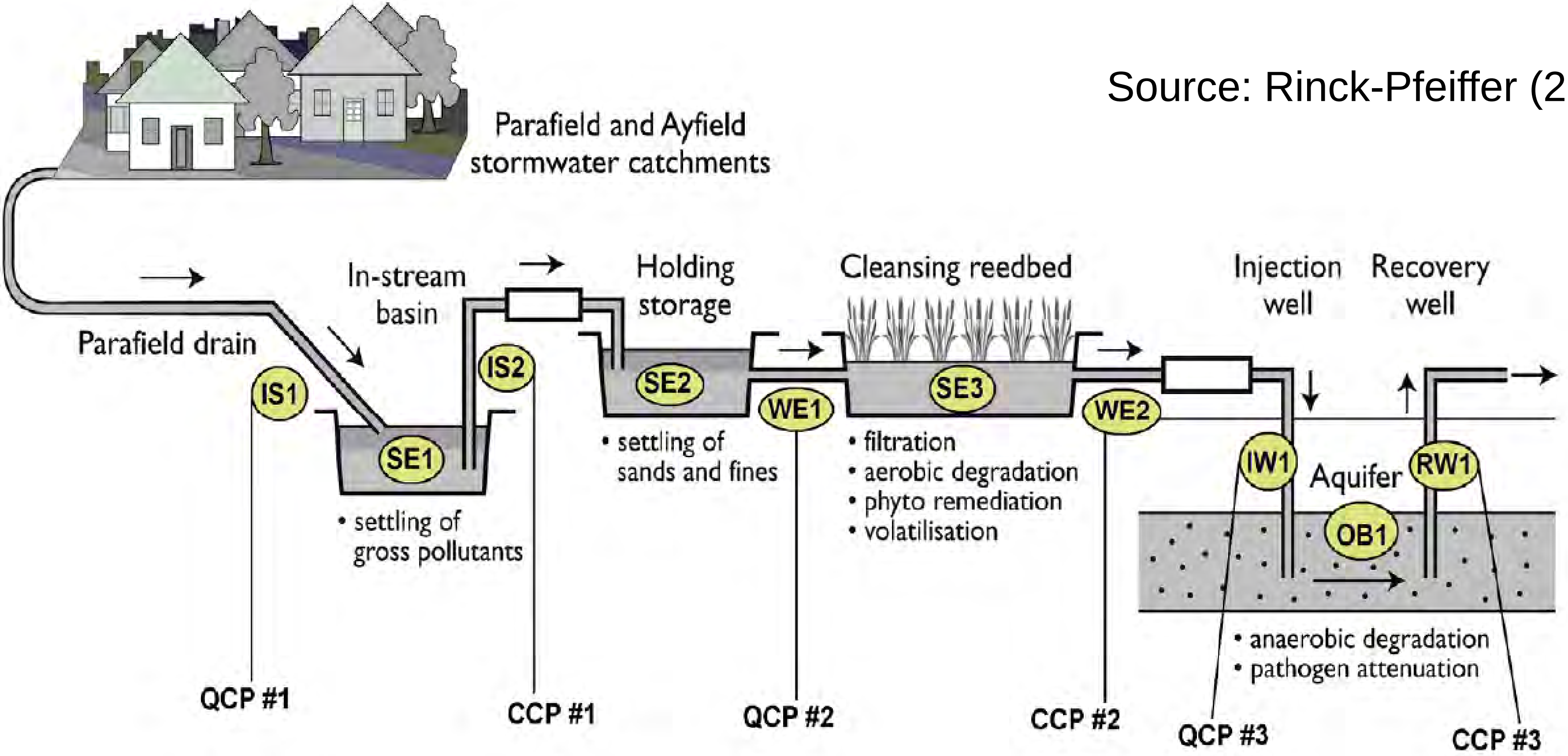
EXAMPLE: SAT SYSTEM IN SHAFDAN (ISRAEL)

Total area of infiltration (hectare)	111
Hydraulic load (m/year)	73-150 (210)
Hydraulic load (m/day)	0.2-0.5
Infiltration regime	1-2 day flooding 2- 4 days drying
Unsaturated zone depth (meter)	15-30
Recovery wells – distance from infiltration basins (meter)	100-1500
Depth of recovery wells (meter)	70-150
Retention time in aquifer (months)	3-12
Cleaning cycle (days)	15 - 30

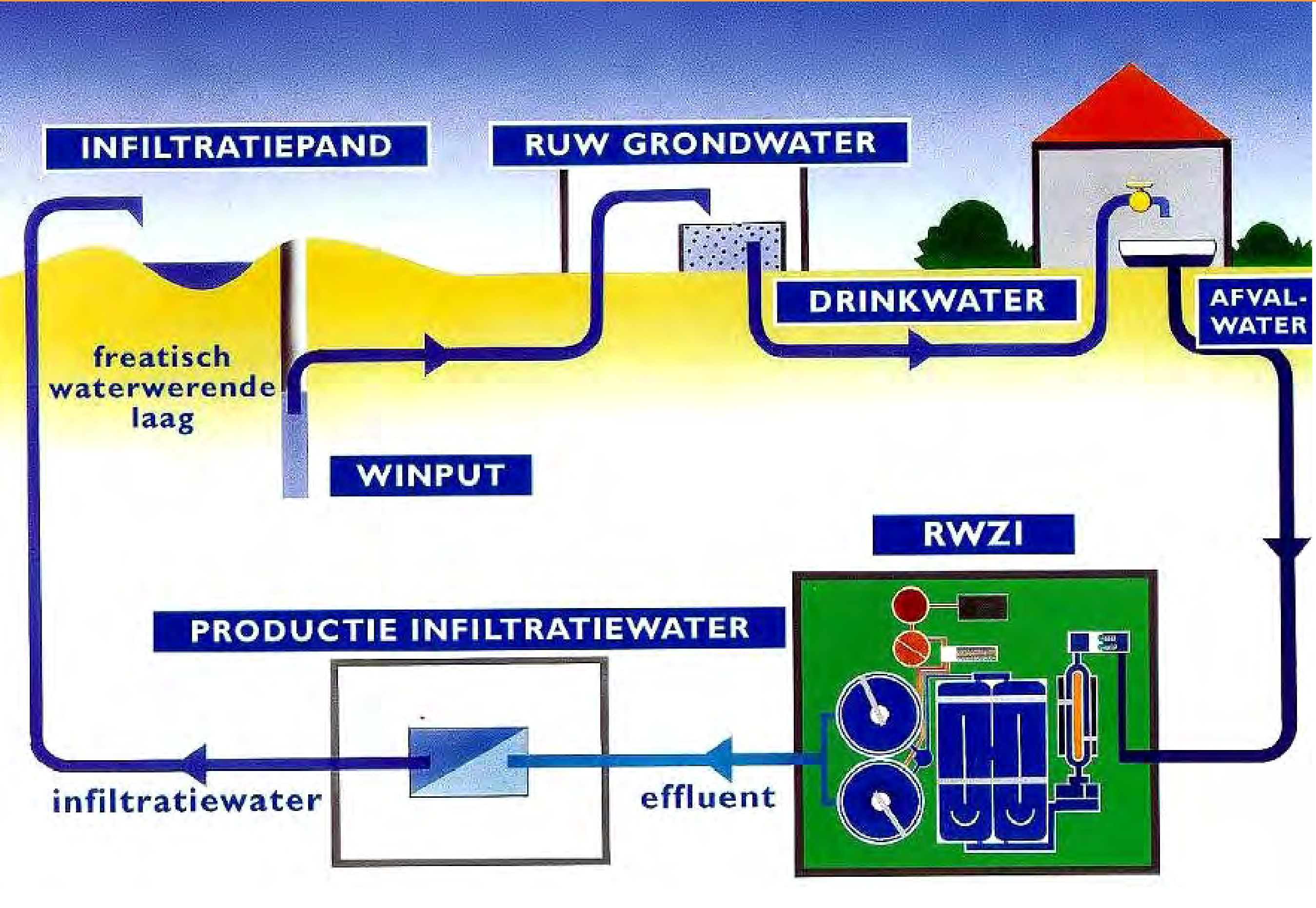
SWEETWATER RECHARGE FACILITIES, TUSCON (USA)

STORMWATER REUSE SYSTEM - CITY OF SALISBURY (AUSTRALIA)

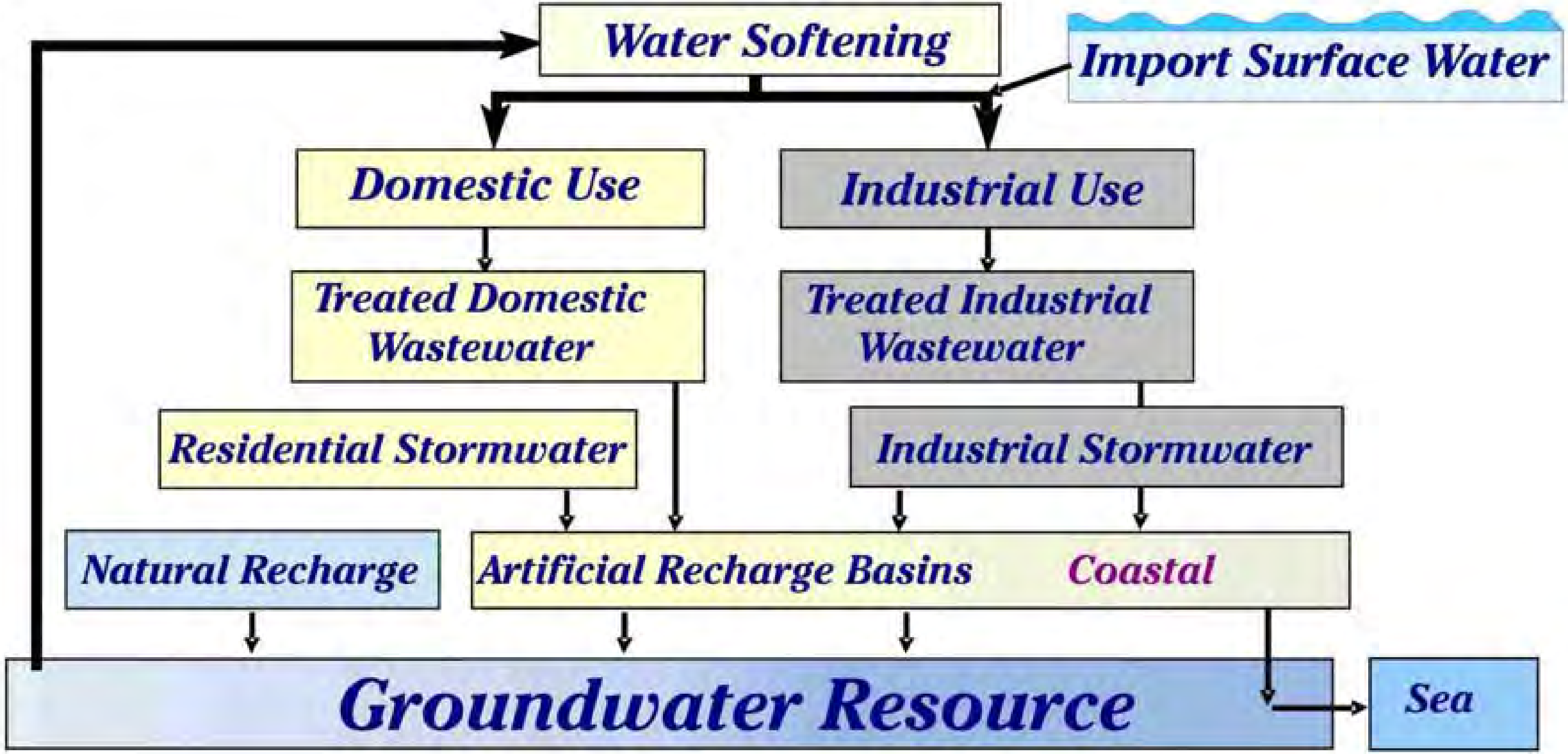
Source: Rinck-Pfeiffer (2010)



WATER RECLAMATION SYSTEM, WULPEN/TORREELE (BELGIUM)



ATLANTIS WATER RESOURCE MANAGEMENT SYSTEM - AWRMS (SOUTH AFRICA)



PERSPECTIVES ON DIFFERENT SAT SYSTEMS

SAT influent	Removal efficiency				Reliability/ Robustness	Suitability	Energy required
	DOC	OMPs	Microbes	Nitrogen			
Primary Effluent from WWTP	√	√	√	√√√	√	Developing countries Non potable reuse	√√√
Secondary Effluent (SE) from WWTP	√√	√	√	√√√	√√	Developing and developed countries Non potable reuse	√√
SE + O_3	√√√	√√	√√√	???	√√√	Developed countries Potable reuse	√
SE + O_3 and H_2O_2 (AOP)	√√√	√√√	√√		√√√	Developed countries Potable reuse	√

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Guidelines for design, operation and maintenance of SAT (and hybrid SAT) systems MEKOROT (Israel) and IHE Delft (The Netherlands. EU SWITCH project.

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THANK YOU FOR YOUR KIND ATTENTION

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