Advies- en ingenieursbureau

Natural treatment systems for waste water

Soil Aquifer Treatment (SAT) Design and operations

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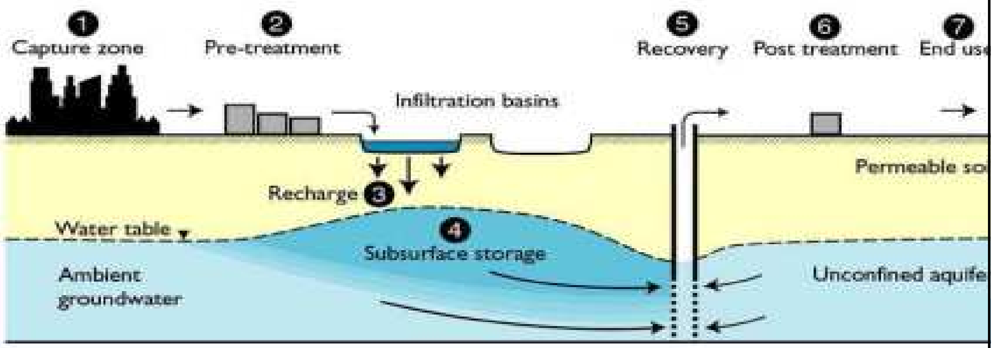
SAT

- Can be used for waste water effluent, storm water and surface water (river, lake)
- Is relatively inexpensive (except when land costs are high), robust, reliable, sustainable and does not require highly skilled technical personnel for operation
- SAT has almost no evaporation losses, no recontamination by droppings of birds and mammals, keeps sunlight away from water (preventing algae growth)
- Principal design objectives are temporary storage, stopping decline of ground water table, replenishment of aquifers …. but firstly additional water treatment (especially removal of suspended solids and pathogenic microorganisms)!

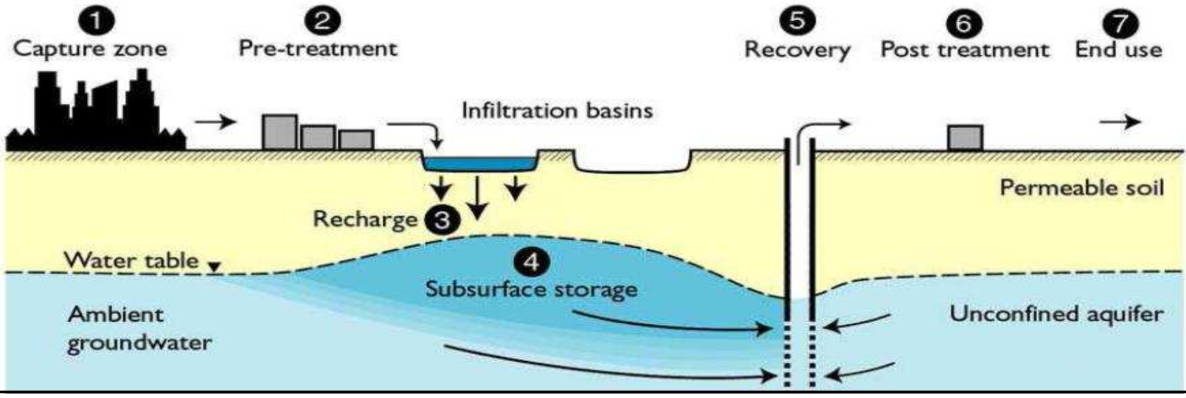


Comparison of the three typical SAT zones

Process parameter	Infiltration interface	Soil percolation in vadose zone	Transport in deeper groundwater
Treatment mechanisms	Filtration, biodegradation	Adsorption, biodegradation	Inactivation (microorganisms)
Transport	Saturated	Unsaturated	Saturated
Travel time	Minutes	Hours to days	Weeks to years
Travel distance	Centimeters to decimeters	Up to 20 or 30 m	Up to 100s of meters
Oxygen	Recharge water and air (cycling)	Unsaturated zone	Regional groundwater
Redox conditions	Aerobic	Mixed, aerobic to anoxic	Anoxic

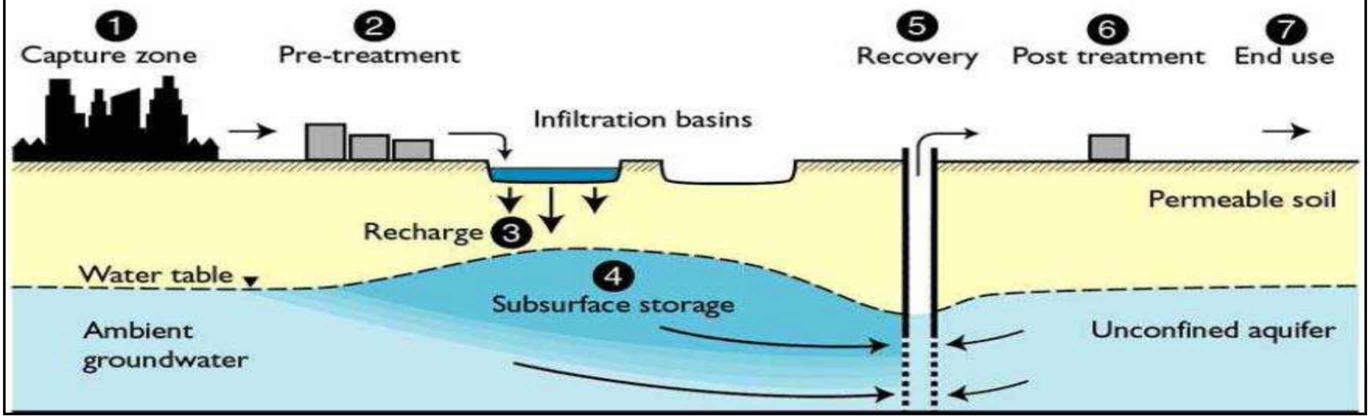
Design and Operation of SAT

- Pretreatment (at least primary, preferably secondary treatment)
- Site selection
- Inlet
- Hydraulic loading and wet/dry operation (cycling), infiltration rate
- Land requirement (taking into account wet/dry cycle)
- Clogging and cleaning
- Water depth (of basins)
- Recovery and post treatment (if necessary)
- Sustainability



Relevant for SAT site selection (in case of spreading)

- Soil permeable enough to provide high infiltration rate
- Fine enough for good filtration and quality improvement
- No clay or loam in vadose zone
- Depth to water table, depth of vadose zone
- Aquifer thickness above underlying rock or confining layer
- Native groundwater flow, differences in ground level (preferably flat area), and water table
- Price of land can be prohibitive



Options for inlet construction

Hydraulic loading and operation

- Basins are intermittently flooded to provide regular drying periods to restore infiltration rates, aeration of soil and treatment capacity
- Flooding/drying periods (depending on level of treatment) vary between 0.5day / 1 day and 2 weeks / 2 weeks
- Drying periods always longer than wetting
- Systems must have more than one basin so that some basins can be flooded when others are drying
- Average infiltration rates: 20 to 100 m/year (0.2 to 1 MCM/ha/year)
- Land requirement (taking cycling into account) 1 to 5 ha for 1 MCM/year
- Infiltration rate always decreases with time owing to clogging and the need for drying and regular cleaning
- Pilot testing is necessary

Clogging and cleaning

- Clogging is the main operational problem
- Due to physical (suspended solids, gas entrapment), chemical (precipitation) and biological (microbial growth) processes
- Suspended solids can be inorganic (silt, sands) or organic (algae, bacterial flocs, leaf litter)
- Some sort of pretreatment is needed
- Clogging increases if infiltration rate increases
- Periodic removal of sediments through scraping is necessary
- To avoid fine material penetrate too deeply into the infiltration surface, to avoid clogging of deeper parts of vadose zone, cover the bottom of basins with fine sands

Water depth

- Contrary to intuition, deep basins can produce lower infiltration rates than shallow ones
- Deep basins tend to compress clogging layers
- In deep basins it takes a long time for all water to infiltrate, drying takes a long time
- Shallow basins have the advantage that drying can start quickly after inflow has stopped
- Water depth preferably is less than 0.5 m
- Basins should be hydraulically independent so that each can be flooded, dried, cleaned individually

Recovery and post treatment

- Water is recovered with (series of) wells (vertical, horizontal) as groundwater
- To be determined: number of wells, their spacing, allowable drawdown in the well, travel time and distance from basins
- Post treatment (if any) is conventional ground water treatment: aeration and rapid sand filtration

SAT is sustainable

- If well designed, if pre-treatment is enough, if operation is adequat. Because ..
- Pathogens are inactivated and do decompose
- DOC & NOM do decay and are affected by biodegradation (a sustainable removal mechanism)
- Some compounds are hydrolyzed to other compuounds that serve as substrates for microorganisms
- Suspended solids are filtered and can be scraped of
- However, is adsorption is the dominant removal mechanism …. Metal removal in the subsoil is not sustainable because soils have limited adsorption capacities.

Further reading and acknowledgement

- Artificial Groundwater Recharge (L. Huisman and Th. N. Olsthoorn), Faculty of Civil Engineering, University Delft, 1989
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