On-site Wastewater Management Training Course

Secondary Treatment; Treatment Wetlands and Reed Beds

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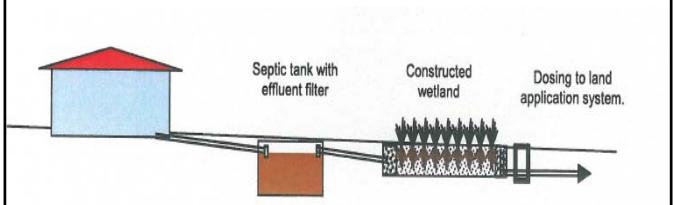
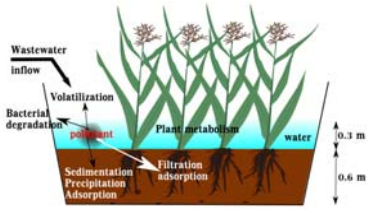
Treatment Wetlands and Reed Beds

- Increasingly popular as a secondary treatment option for BOD, TSS and FC reduction
- Low-maintenance and relatively inexpensive
- Robust performance and seen as “natural” treatment - “ecotechnology”



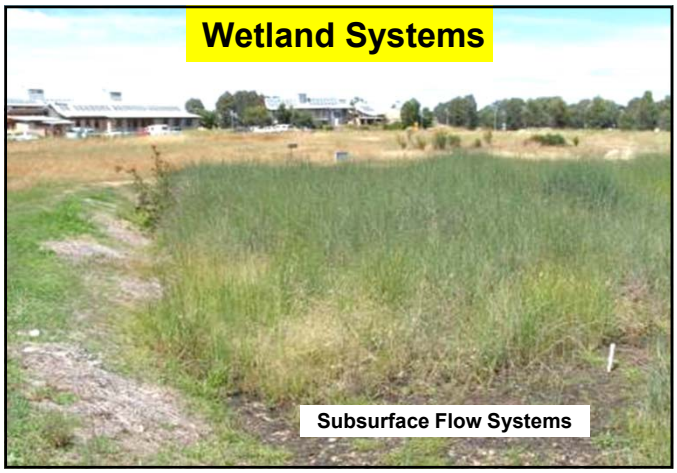
Treatment Processes

- Sedimentation, filtration and adsorption
- Gas loss/volatilization
- Uptake of metals and nutrients by plants
- Bacterial degradation by ultra-violet light, die-off and predation
- Decomposition of organic matter

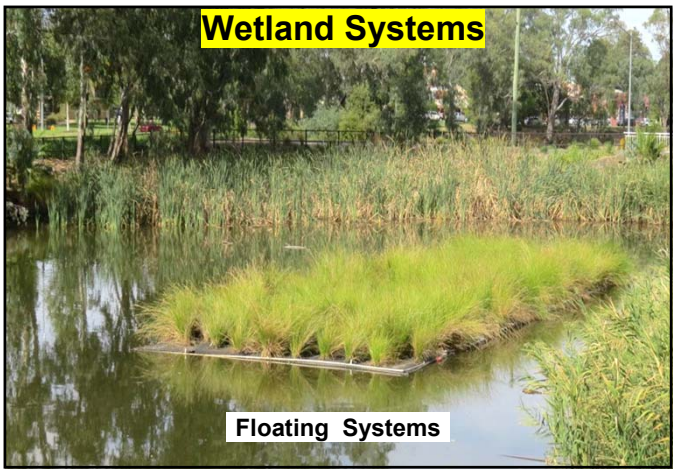


Wetland Systems

Wetland Systems



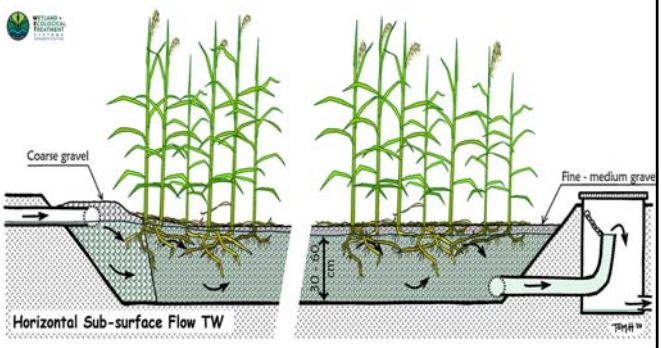
Wetland Systems



Subsurface Flow Systems

- SSF systems preferable for domestic on-site treatment
- Used for treating combined waste or greywater only (also excess from waterless (composting) systems)
- Installed after primary treatment devices and considered a secondary system
- Grease and fat removal in septic tank pre-wetland
- Reed bed may be integrated with site landscape plan

Horizontal SSF Systems



Source: https://wetsystems.com.au/

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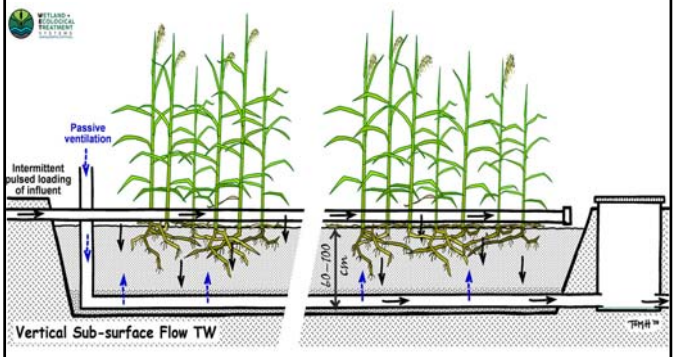
Vertical SSF Systems



Source: https://wetsystems.com.au/

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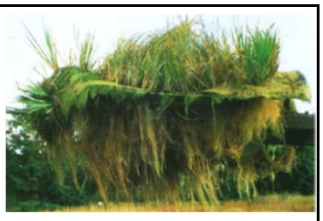
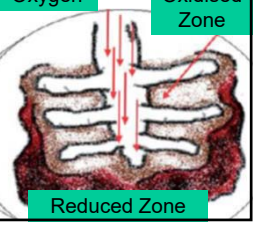
What Do Plants Do?

- Control algal growth
- Take-up nutrients
- Provide an oxygen source
- Develop strong algal and bacterial biofilms in root zone where treatment occurs

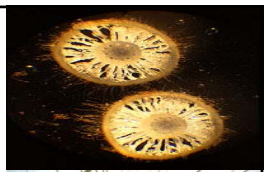


Source: Aqua Biofilter



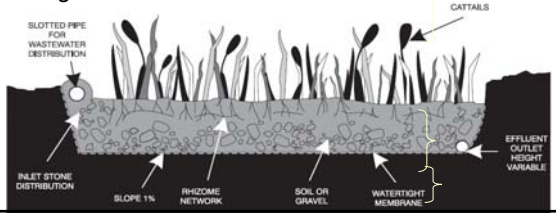
What Do Plants Do?

- Transport gases to and from the root zone via **aerenchyma** which are airways running from the aerial parts of the plant to the roots
- Aerenchyma assist with gas diffusion
- Rhizomes provide sites for oxidation while adjacent soils remain anaerobic (biofilms grow on submersed stems and leaves)
- Bacteria colonise and perform a wide variety of chemical conversions



Role of Substrate

- Provide rooting medium for wetland plants
- Support nutrients for plant growth
- Provide capacity to store water in pore spaces
- Adsorb to limited degree contaminants and reduce effluent concentrations
- Buffers pH which assists in maintaining uniform bio/geochemical reactions



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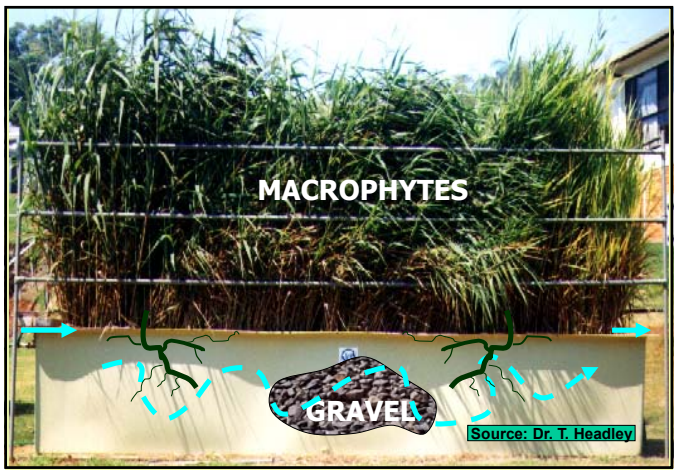


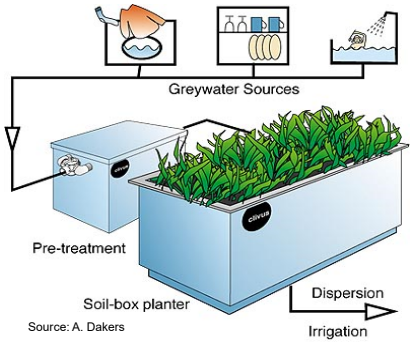
Examples

Sources: http://www.rootzone.com.au/
https://wetsystems.com.au/

Examples

www.globaltanks.com.au

Modified Plant System for Greywater



Source: A. Dakers

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SSF Design Considerations

- Site selection/location
- Sizing for design hydraulic load and required HRT (treatment is a function of HRT)
- Liner - impermeable membrane or compacted clay
- Multiple beds – parallel or series?

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SSF Design Considerations

- Inlet structures to ensure uniform flow distribution
- Adjustable water level control
- Outlet/collection devices - dosing sump and pump well capacity
- Gravel sizes
- Macrophyte plant species to be used
- Maintenance of reedbed including vegetation and weed management
- And after the reed bed?

Sizing

- **Sizing can be based on simple rule-of-thumb approaches for "typical" situations. Guides often suggest different specific area requirements per Population Equivalent (PE) to achieve Secondary Treatment quality (20/30 standard)**
  - 2 m^2 up to 6 m^2 of wetland treatment area per PE/day for combined wastewater
  - HRT can be determined for a particular level of treatment but is typically recommended about 5-7 days
  - For greywater design 3 m^2 PE/d

Examples	Combined Wastewater	Greywater Only
Area of Reed Bed	24 m^2	17 m^2

Example of SSF Area and Dimensions

BR/ PE	Hydraulic Load (L/d)	Surface area (m^2)	Suggested width (m)	Suggested length (m)	L:W ratio
3/5	900	30-33	4.5	7.2	1.6

Source: Table 1 in Tanner, C. Headley, T. & Dakers, A. (2011) Guideline for the Use of Horizontal SSF Constructed Wetlands in On-site Treatment of Household Wastewaters, NIWA, Hamilton, NZ

Rule of Thumb Sizing (HRT 7 days)

Water Depth (m)	Surface Area/p (m^2) All Wastewater	Surface Area/p (m^2) Greywater
0.3	6.5	5
0.4	5	4
0.5	4	3
0.75	3	2.5

Source: Table 1 in Lismore City Council (2005) The Use of Reed Beds for the Treatment of Sewage and Wastewater from Domestic Households

Gravel Media and Plants

- Depth of gravel bed media typically 40 cm with water level maintained about 5 cm below gravel surface
- Plant selection - native wetland nursery species
- Low stature and high stature growth forms *(plants/m^2)*
- Issue of plant senescence and on-going maintenance (including whether to harvest) plus managing invasive weeds

Zone	Gravel	Size Range (mm)	Porosity (%)
Inlet & outlet zones	Coarse	40-60	45
Main wetland	Fine, angular	10-20	40

Recommended Species

Floating plants:
- *Lemna spp, Wolffia spp*

Submergents:
- *Myriophyllum*
- *Potamageton*

Emergents:
- *Typha*
- *Phragmites*
- *Eleocharis*
- *Schoenoplectus*
- *Baumea*

System Performance

- Properly designed, installed and serviced SSF reed beds can provide secondary treatment of ST effluent and produce 20/30 standard TSS/BOD
- HRT important as removal of nutrients is by biomass uptake and substrate adsorption
- Median levels of FC can be reduced by approx. 99% (2 log reduction)
- Reduction of N and P varies widely over time (variable for TP but initially high, later decreasing depending on substrate used; can be good for TN but dependent on oxidation and biochemical conversion of N
- Treated effluent should be discharged to an appropriate land application system

Further Reading

- Lismore City Council (2005) The Use of Reed Beds for the Treatment of Sewage and Wastewater from Domestic Households, Lismore NSW
- Tanner, C. Headley, T. & Dakers, A. (2011) Guideline for the Use of Horizontal SSF Constructed Wetlands in On-site Treatment of Household Wastewaters, NIWA, Hamilton, NZ
- UN-HABITAT (2008) Constructed Wetlands Manual. UN-HABITAT Water for Asian Cities Programme, Nepal, Kathmandu
- USEPA (2004) Constructed Treatment Wetlands, Office of Water **https://nepis.epa.gov/Exe/ZyPDF.cgi/30005UPS.PDF?Dockey=30005UPS.PDF**
- https://wetsystems.com.au/
- http://www.rootzone.com.au/