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# State of the Technology

## *On-site wastewater treatment (OWTS)*

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NYS Center for Clean Water Technology

**Josefin Hirst, P.E. and Stephen Cluff, P.E.**
Hazen and Sawyer

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# Objectives

- Provide an overview of existing technology options for nitrogen removal from on-site systems
- Identify knowledge gaps and opportunities
- Rank technology to prioritize R&D efforts
- Summary of CCWT efforts



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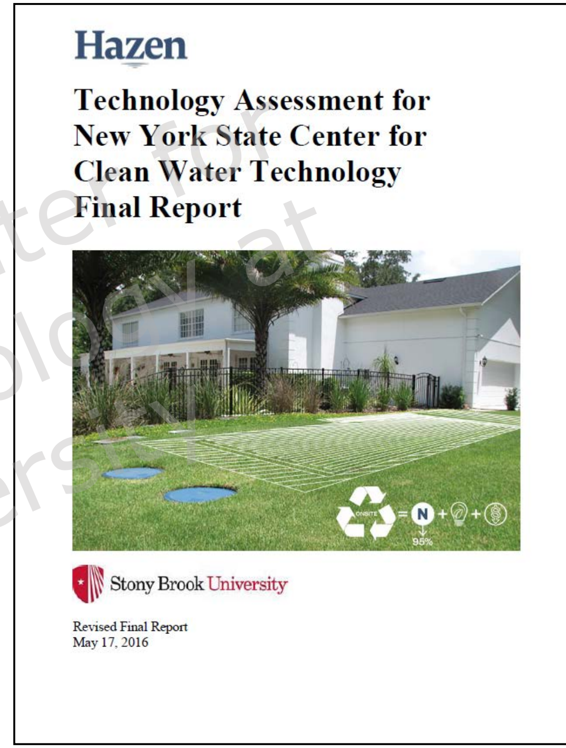
# Methodology

- Reviewed manufacturer information, research literature, past technology reviews
- Met with practitioners, researchers in the field, other stakeholders
- Engaged Hazen and Sawyer to compile existing information and develop a technology assessment


Hazen

Technology Assessment for New York State Center for Clean Water Technology Final Report

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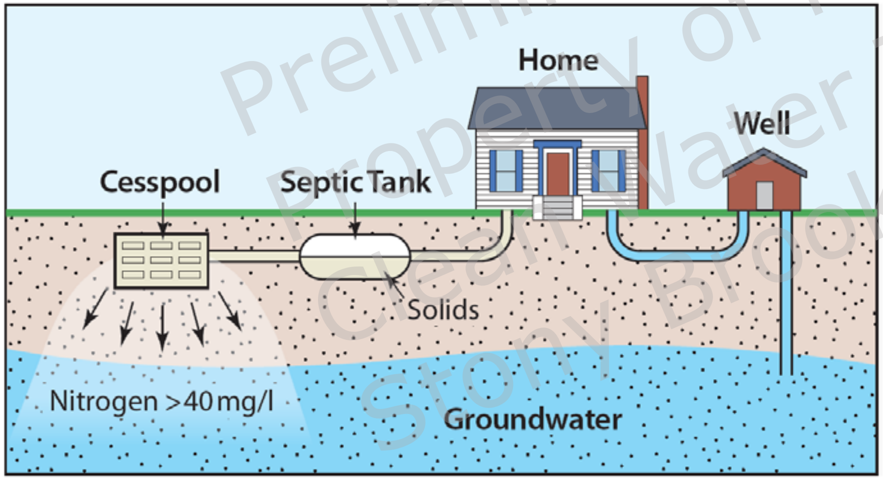
Revised Final Report
May 17, 2016

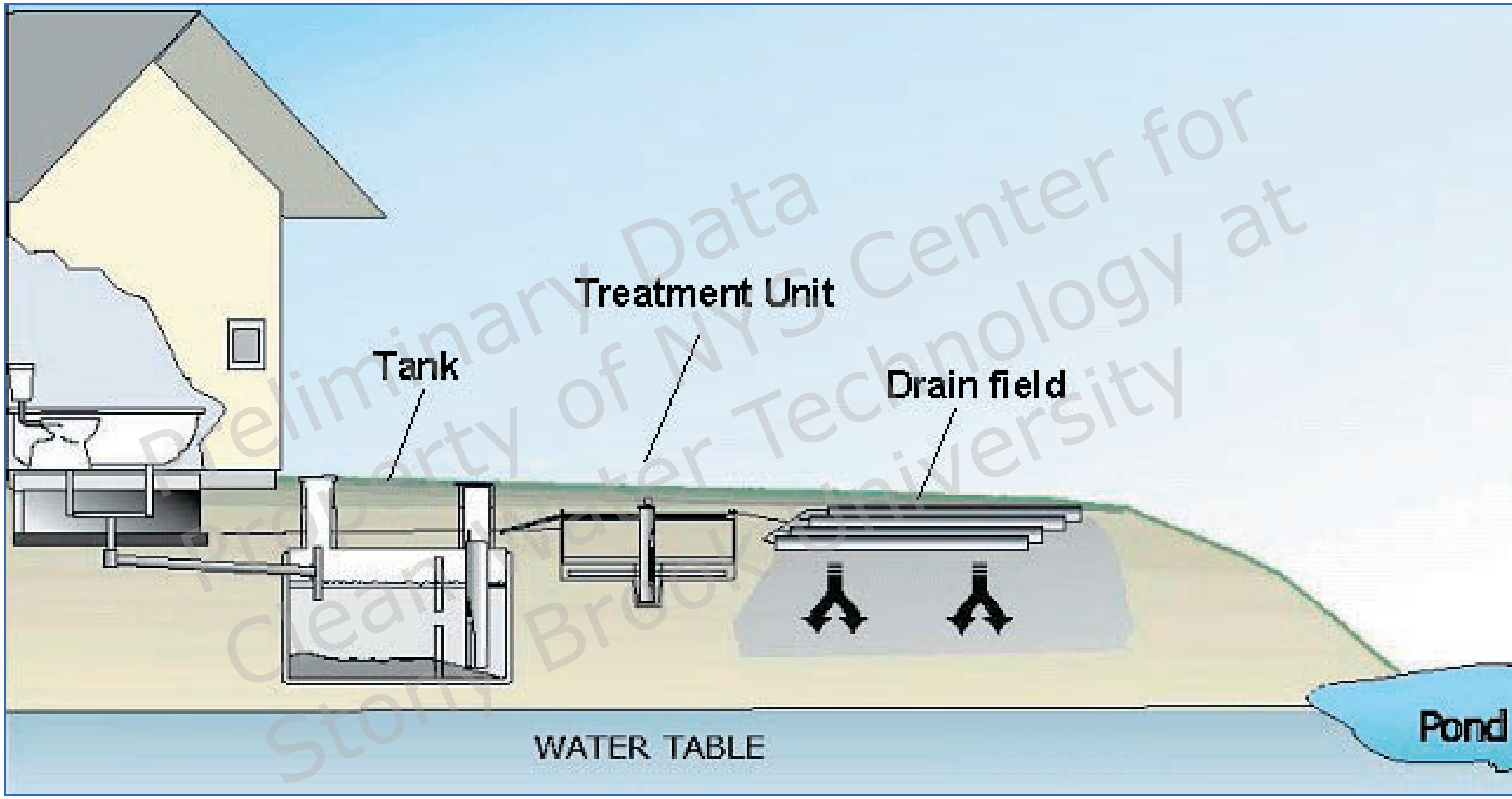
# Conventional OWTS in Suffolk County

- Basic treatment for single-family homes (1972 standards) consist of septic tank and precast leaching pools




Source: http://104cliffroadeast.com/?page_id=955

# Innovative/Advanced OWTS

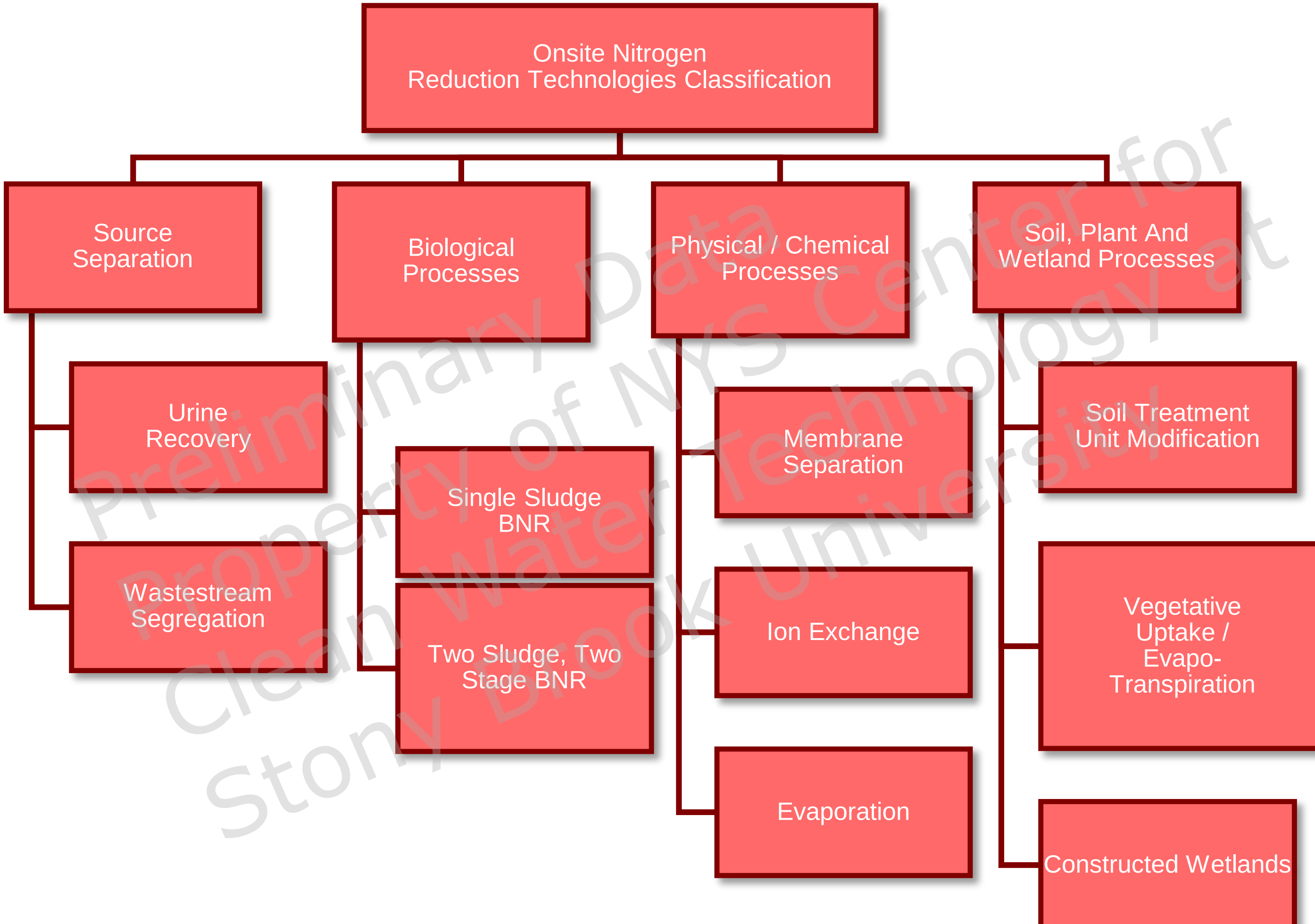





*Alternative and innovative systems add a component between the septic tank and drainfield.*

Source: http://104cliffroadeast.com/?page_id=955

# Onsite nitrogen reduction technologies

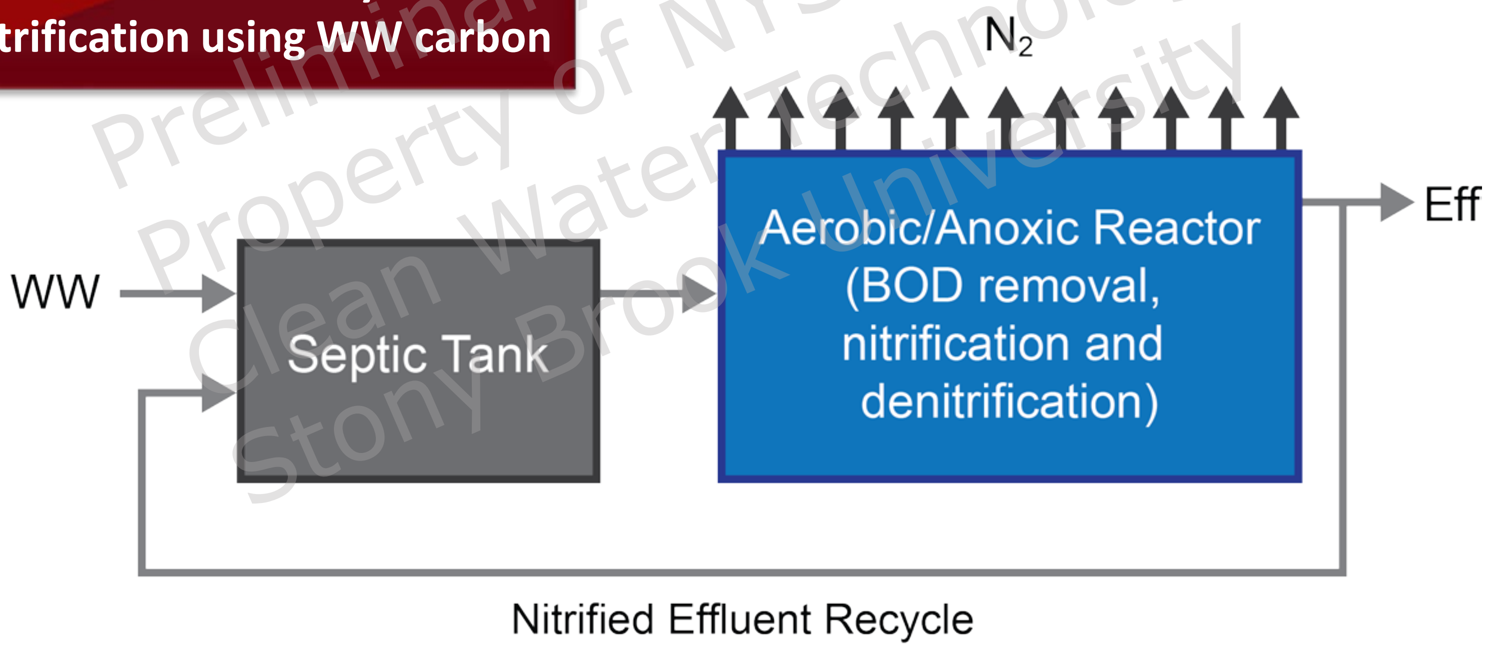


# Single Sludge BNR: single reactor carries out nitrification & denitrification

**Process:**
**Suspended growth or fixed film utilizing aeration process for nitrification and possibly nitrified effluent recycle for denitrification using WW carbon**

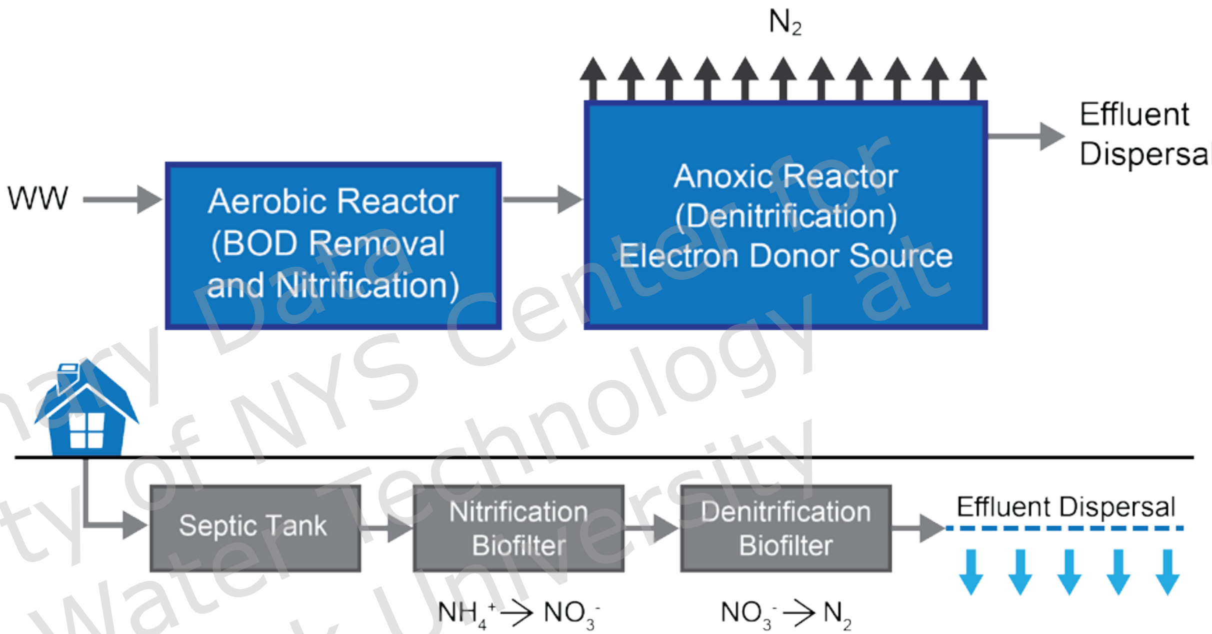
Pros:
Relatively simple installation

Cons:
More complex operation
Higher energy use



# Two sludge, two-stage BNR

**Process:**
**Two separate bacteria populations for nitrification and denitrification, requires electron donor from external source for denitrification**




<u>Pros:</u>
Performance
Reliability
Lower energy use

<u>Cons:</u>
Capital costs
Footprint
Experience

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# Biological process summary

| Process | Single Sludge Sequential BNR | Single Sludge with Preanoxic Nitrified Effluent Recycle BNR | Two Sludge, Two-Stage BNR |
|---|---|---|---|
| Electron Donor | Organic carbon from bacterial cells | Organic carbon from influent wastewater | External electron donor (Organic carbon; Lignocellulose; Sulfur; Iron, Other) |
| Typical N Reductions | 40 to 65% | 45 to 75% | 70 – 96% |
| Typical Technologies | • Extended aeration<br>• Pulse aeration<br>• Porous media biofilters<br>• Sequencing batch reactors<br>• Membrane bioreactor | • Extended aeration with recycle back to septic tank<br>• Recirculating media biofilters with recycle back to septic tank<br>• Moving bed bioreactor | Nitrification followed by:<br>• Heterotrophic suspended growth denite<br>• Heterotrophic porous media fixed film denite<br>• Autotrophic porous media fixed film denite |
| Phase I - Suffolk Co. Demo Program | • Norweco Singulair TNT<br>• Busse | • Norweco Hydro-Kinetic<br>• Hydro-Action<br>• AdvanTex AX 20 and AX-RT | • CCWT pilot at MASSTC<br>• CCWT Phase II Suffolk County Demo Program |



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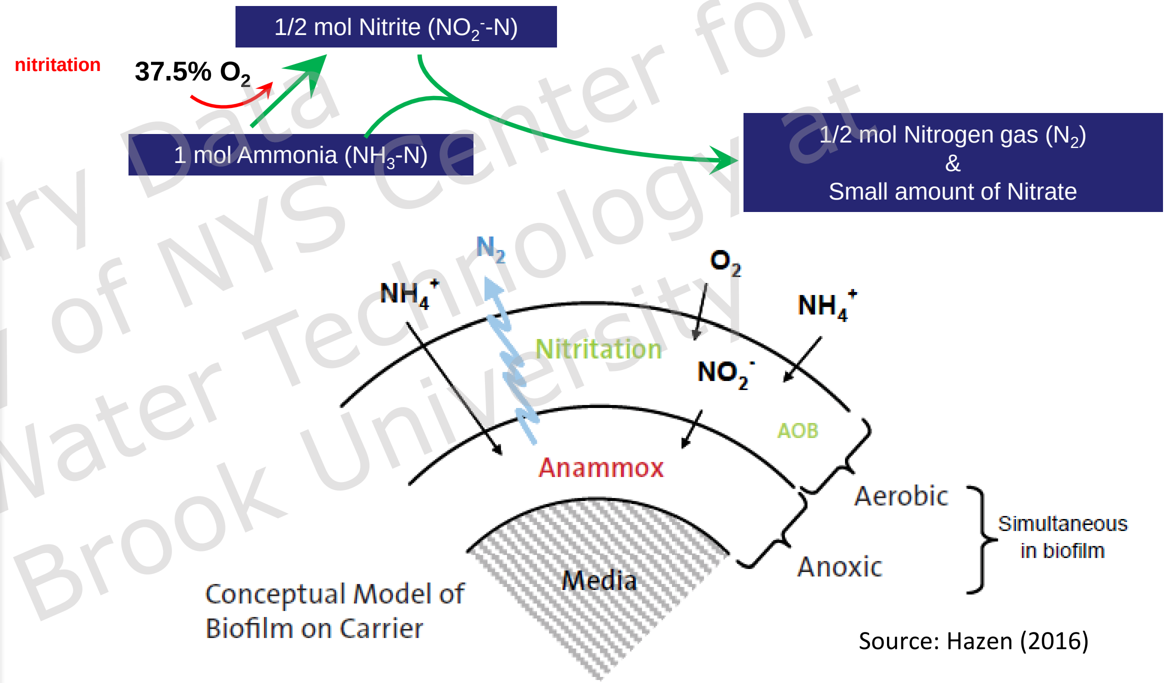
# Future possibility, deammonification process

**Process:**
**Conversion of ~50% of the influent ammonia into nitrite by ammonia oxidizing bacteria using nitritation, followed by the simultaneous removal of ammonia and nitrite by anammox bacteria**




Source: Hazen (2016)

**Pros:**
Lower energy use

**Cons:**
No OWTS experience
Performance reliability

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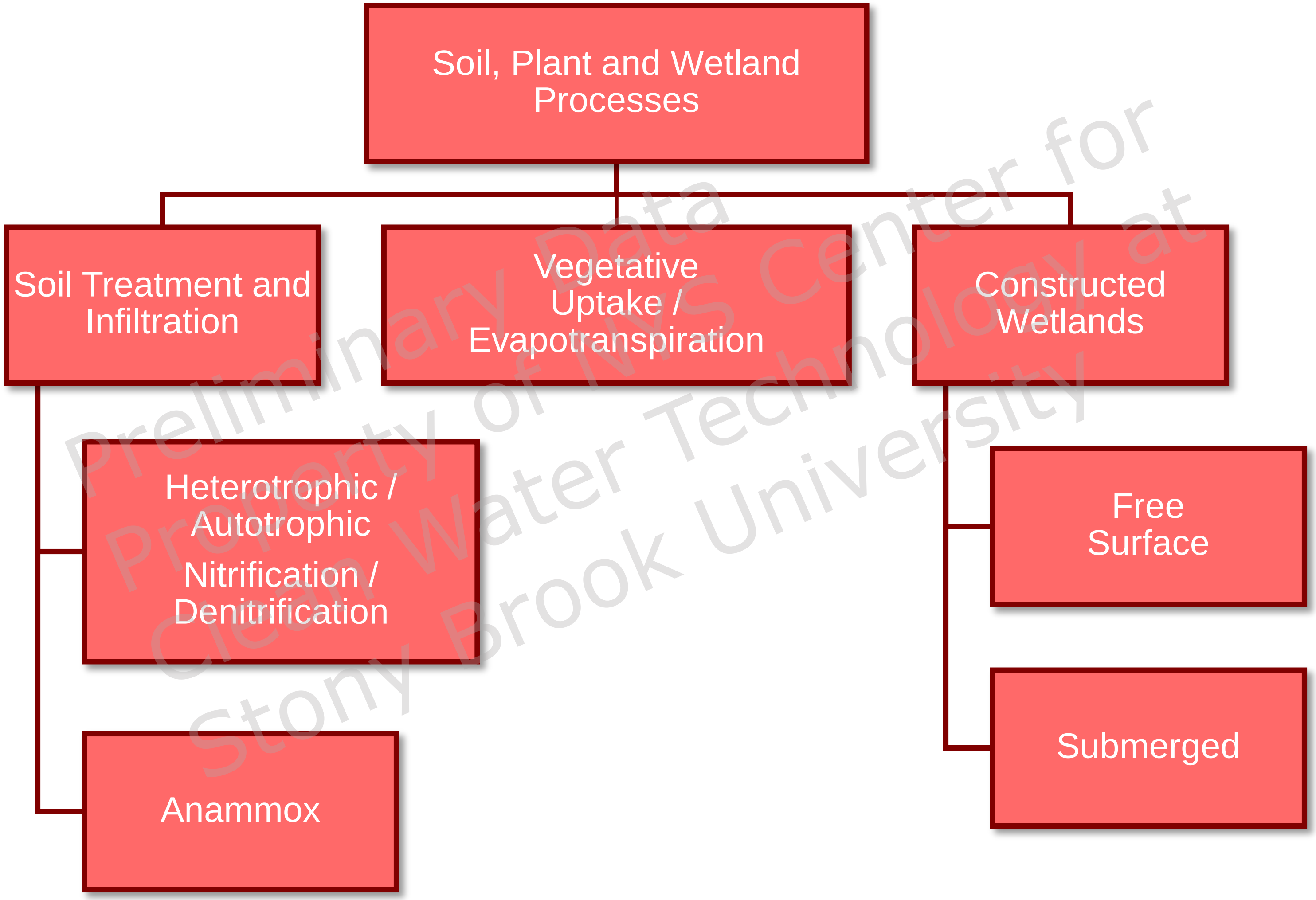
# Soil, plant and wetland processes



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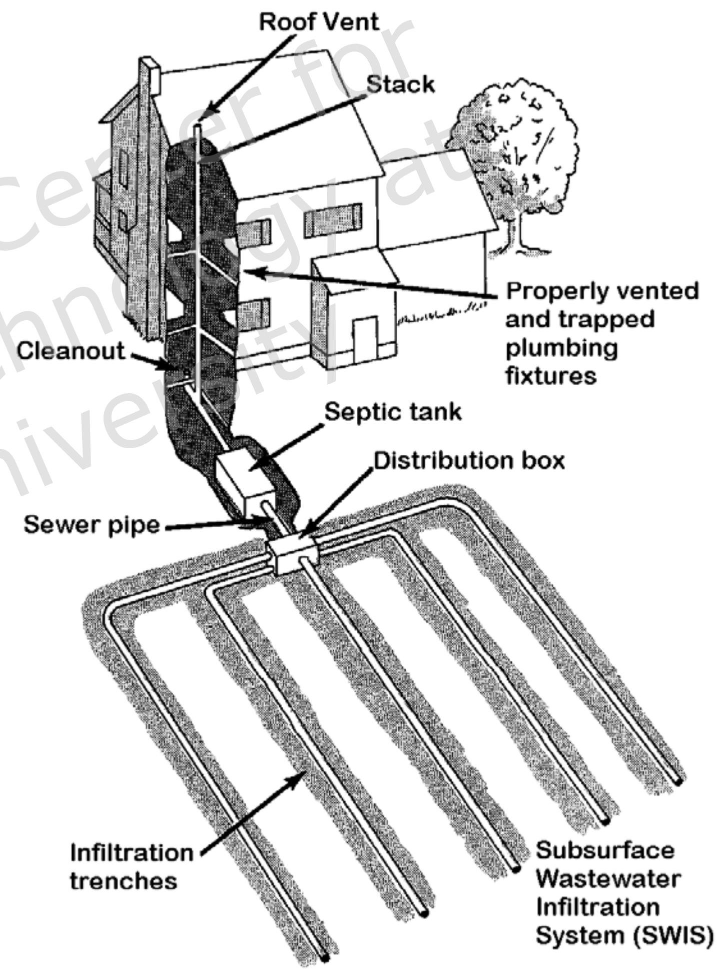
# Soil, plant and wetland processes - soil treatment unit (STU)

**Process:**
**Utilize physical, chemical and biological processes that occur naturally in the soil and/or plant**

Pros:
OWTS Experience
Simple operation
Lower energy use

Cons:
Performance
Footprint



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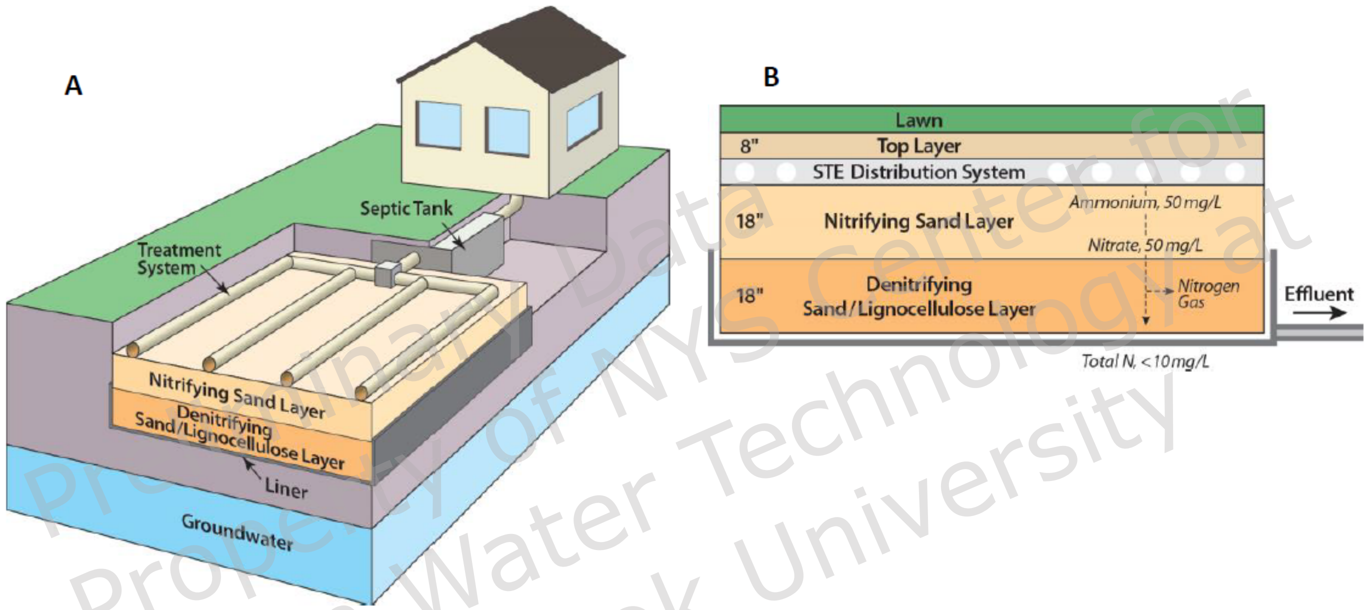
# Nitrogen removing biofilter (NRB)






**Process:**
**Engineered media layers for nitrification and denitrification using external source for electron donor**

Pros:
Performance
Footprint
Simple operation
Lower energy

Cons:
Experience
Construction complexity

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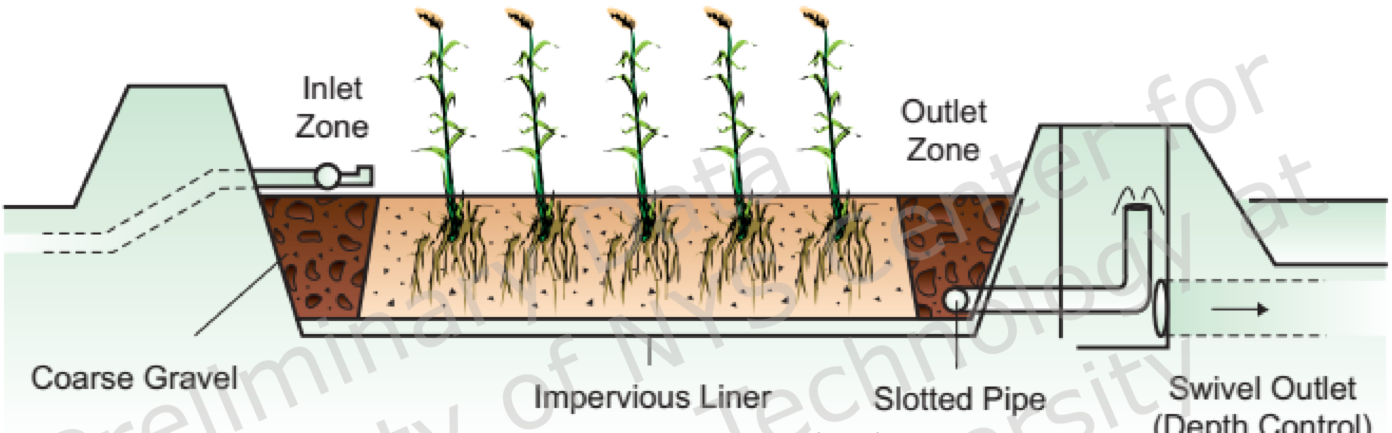
# Constructed wetlands



Source: Kadlec and Knight (1996)

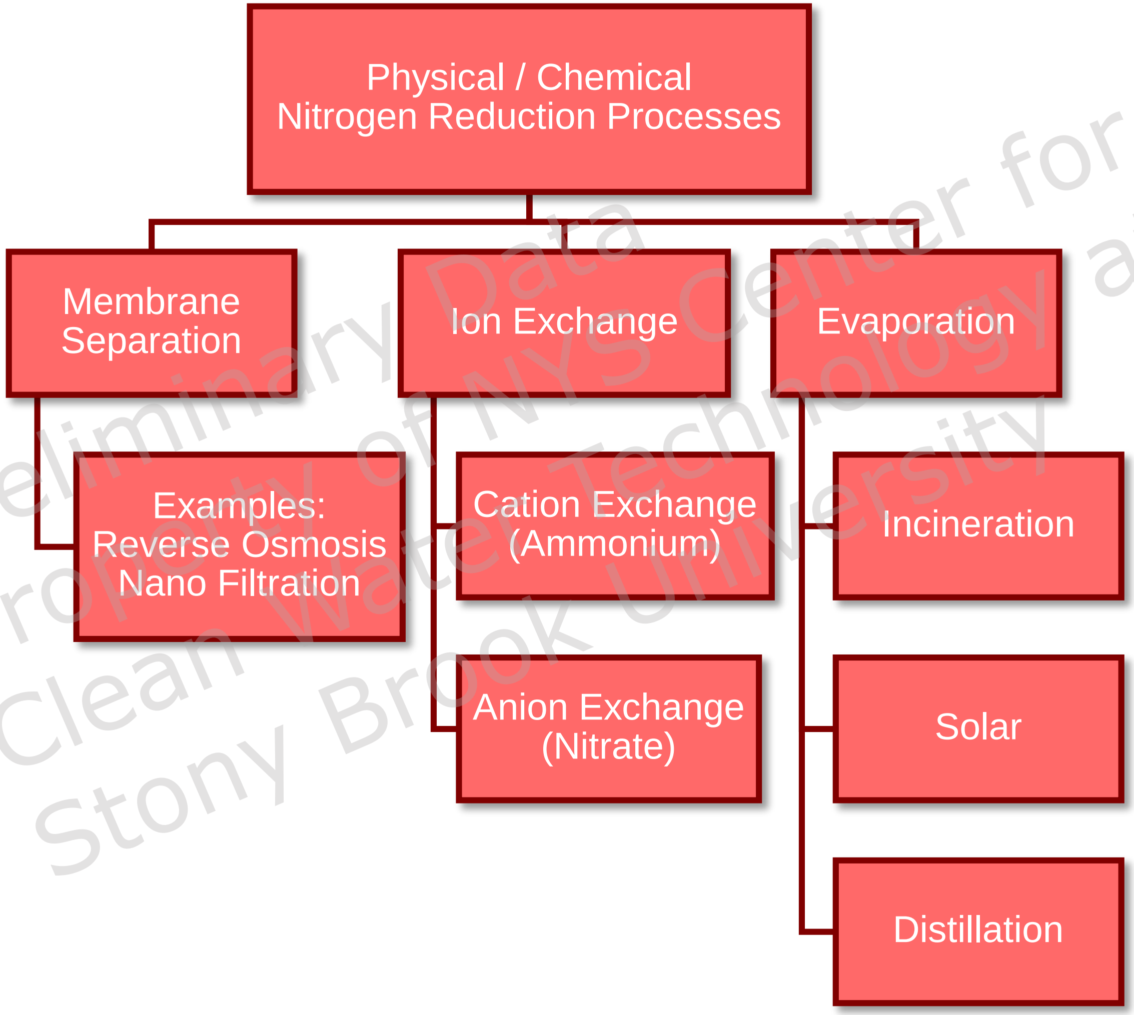


**Process:**
**Engineered wetlands typically consist of submerged rock bed planted with wetland vegetation. Providing aeration typically increases TN removal.**

Pros:
Lower energy use
Mechanical reliability

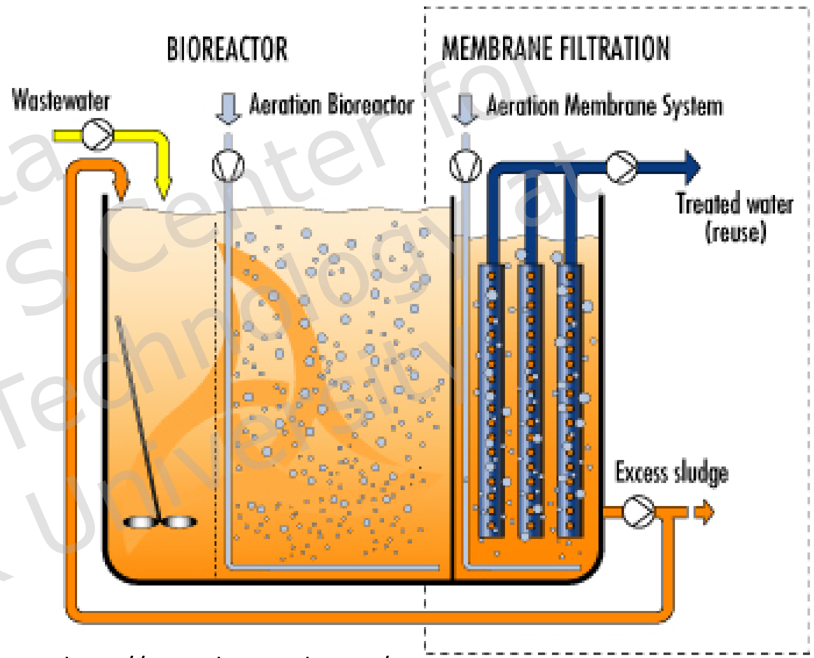
Cons:
Footprint
Performance
Capital costs
Construction complexity

# Physical/chemical processes



# Membrane bioreactors

**Process:**
**Integration of a permeable membrane material to facilitate solid-liquid separation and potentially support biofilm growth.**




http://www.lenntech.com/



Pros:
Versatile
Small footprint

Cons:
Fouling
High energy use
Membrane cost

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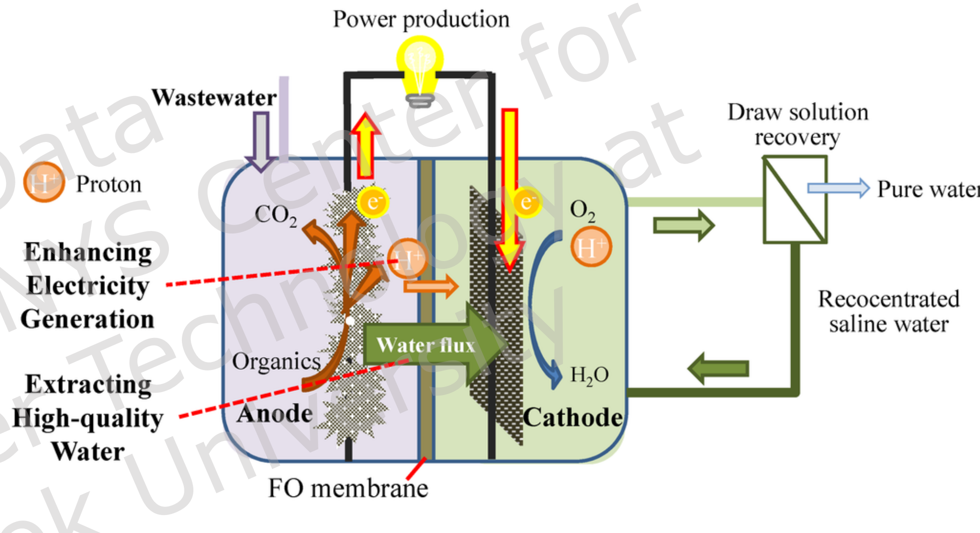
# Microbial fuel cells

**Process:**
**Application of an electrical potential between two electrodes causes an electric current to pass through the solution, which in turn causes a migration of cations toward the negative electrode and a migration of anions toward the positive electrode. Ionic components are separated through the use of semipermeable ion-selective membranes.**




Source: Lu et al. (2015)



Cons:
No OWTS experience
High energy use

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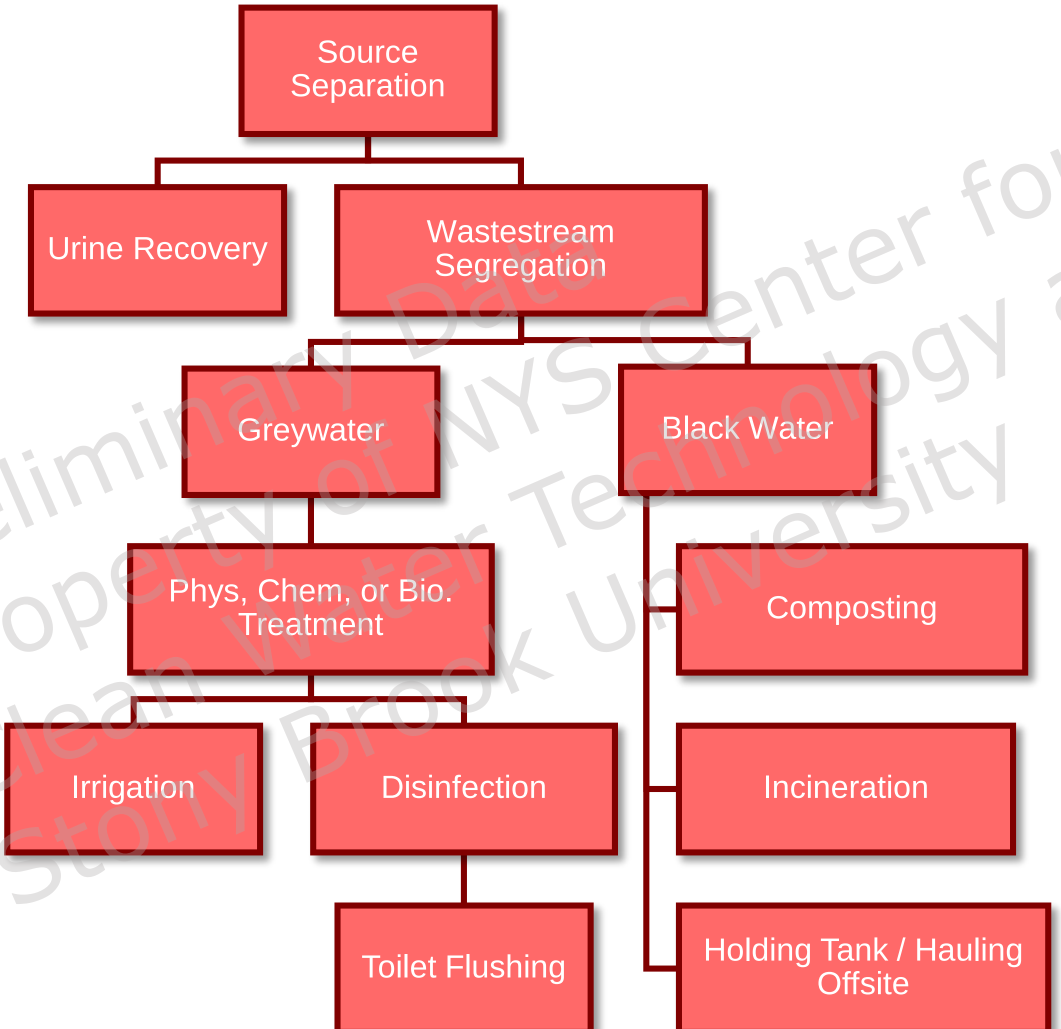
# Source separation



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# Urine separating toilets

Source: http://richearthinstitute.org

Source: www.no-mixtoilets.com

Source: www.treehugger.com)

Source: http://richearthinstitute.org

Source: http://richearthinstitute.org

Source: http://richearthinstitute.org

Source: www.wateronline.com



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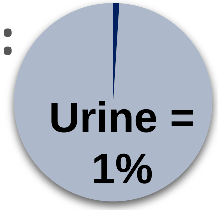
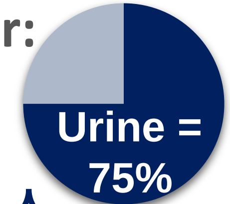
## Domestic Wastewater: *Volumetric Flow*



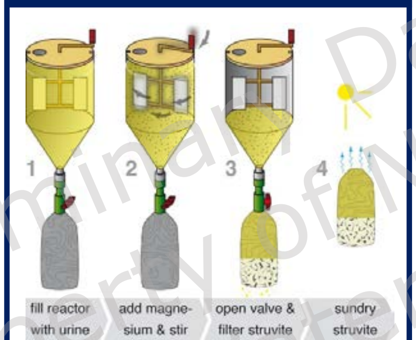

## Domestic Wastewater: *Nitrogen Load*




### Direct Application

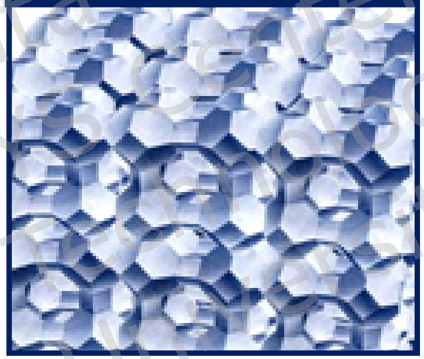
Source: http://richearthinstitute.org

### Precipitation

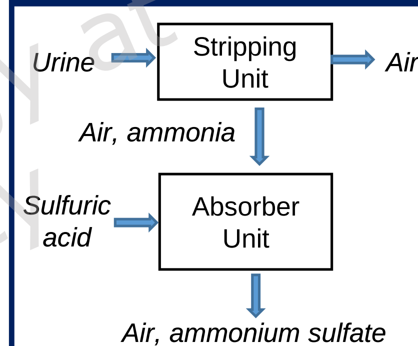



Source: www.sswm.info

### Sorption & Ion Exchange



### Aeration/Stripping

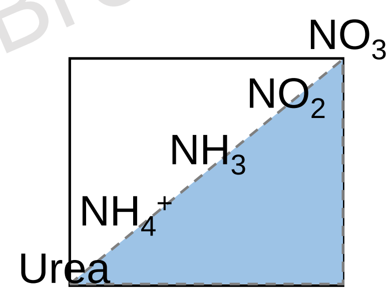



Source: https://dspace.library.colostate.edu

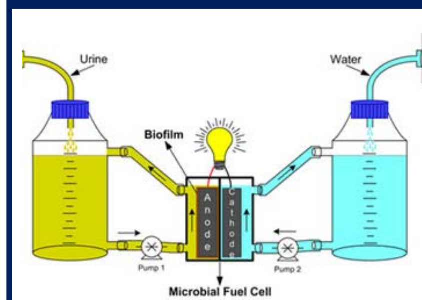
### Nitrification & Distillation

Source: www.eawag.ch

### Membrane Filtration




### Electrolysis & Microbial Fuel Cells




Source: www.rsc.org



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# Urine disposal options

| Transport to WWTP | Direct Land Application | Treated to create fertilizer/soil amendment |
|---|---|---|

Source: www.npr.org

Source: www.mdpi.com

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# Nitrogen Reduction Technology Ranking Assessment

- A simple numerical ranking system was developed to prioritize available nitrogen reduction systems based on twelve selected criteria

| | |
|---|---|
| Effluent nitrogen concentration | Restoration of performance |
| Performance consistency | Operation complexity |
| Construction cost | Energy requirement |
| CBOD/TSS effluent concentration | Construction complexity |
| Mechanical reliability | Local resources |
| Land area required | Climate resiliency |

- A weighting factor was applied to each criterion based on the results of a Technology Weighting Factor Workshop



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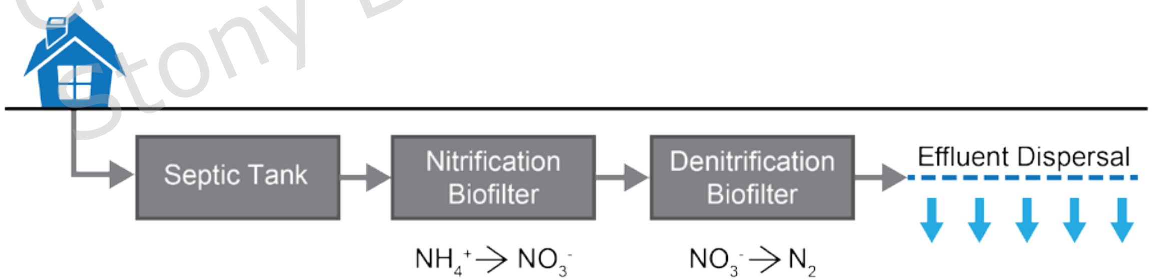
# Nitrogen reduction biological technology ranking summary

- Top ranked single sludge BNR = rotating biological contactor


Source: www.klar-environnement.com

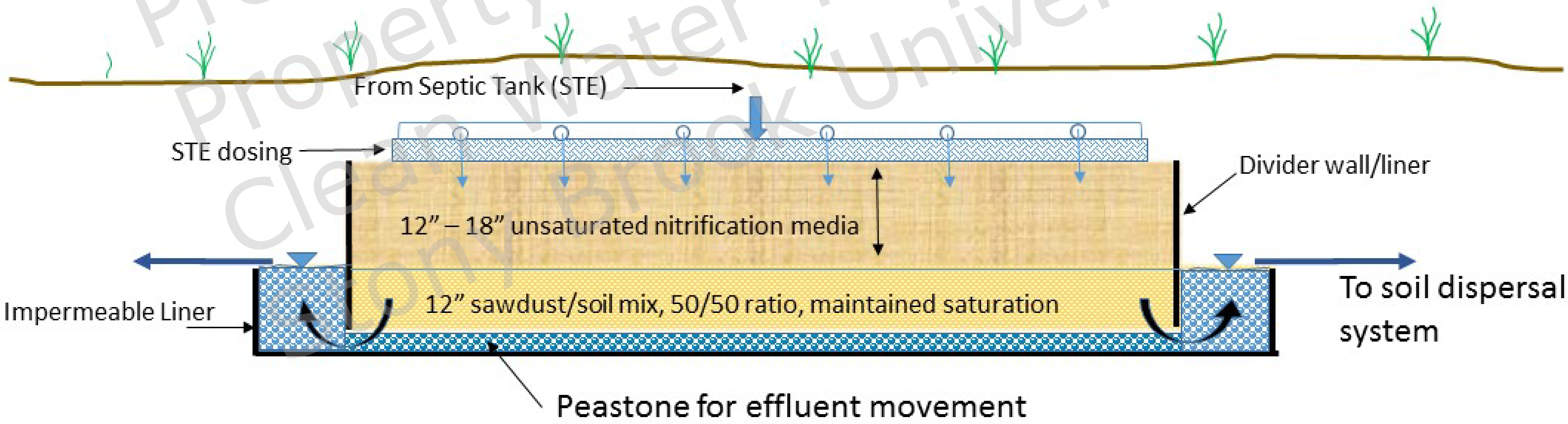
- Top ranked two sludge, two-stage BNR



# Nitrogen reduction soil, plant and wetland processes technology ranking summary

- Top ranked = nitrogen removing biofilter (NRB)





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# Urine source separation approaches ranking summary

Source: www.no-mixtoilets.com

Source: http://richearthinstitute.org

Source: www.npr.org

Direct land application

Transport to WWTF

| | Natural Systems | Biological | Physical/ Chemical | Source Separation |
|---|---|---|---|---|
| **Promising systems** | **Passive NRBs** | **Two sludge, two-stage BNR** | **Membrane bioreactor technology** | **Urine recovery** |
| **Opportunities** | • low cost<br>• effective<br>• PRBs and wetlands | • Effective<br>• media replacement<br>• novel pathways | • novel materials<br>• resource recovery<br>• Novel pathways | • resource recovery |
| **Knowledge gaps** | • media longevity, replacement<br>• design<br>• PPCPs | • media longevity<br>• PPCPs<br>• design | • fouling<br>• longevity<br>• nitrogen removal | • public acceptance<br>• beneficial use<br>• PPCPs |
| **CCWT efforts** | • white paper<br>• pilot-testing<br>• design guidance | • white paper<br>• pilot-testing<br>• design guidance | • cellulose MBR<br>• novel materials | • Planning stage |