Needs for R & D in Denmark within onsite wastewater treatment

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Malmo, February 8 & 9
onsite wastewater treatment
soil treatment system

VA-TEKNIK & VATTENVÅRD KONSULTERANDE INGENJÖRSBYRÅ
JTI
WRS Water Revival Systems
NATUR VÅRDS VERKET

Background

- Onsite systems must meet discharge targets.
- Onsite systems should be technologically simple, but robust.
- Onsite system should be economically competitive.
- Onsite systems technology must evolve to meet new challenges.

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Danish legislation

- 1987: "Action Plan against Pollution with Nutrients of the Danish Aquatic Environment"
  - ➪ 80% P removal and 50% N removal
- 1997: "Act 325 of 14 May 1997 on Wastewater Treatment in Rural Areas"
  - ➪ improve wastewater treatment in rural areas and therefore onsite systems must be optimized by 2010

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Approx. 90,000 properties (size<30 pe) in rural areas must improve their treatment

Treatment class	BOD_5	Total-P	Nitrification
SOP	95%	90%	90%
SO	95%	-	90%
OP	90%	90%	-
O	90%	-	-

O: Reduction of organic matter
P: Reduction of phosphorus
SO: Reduction of organic matter and nitrification

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Possible solutions in Denmark

• Soil infiltration	■ O, SO, OP, SOP
• Biological sandfilters	■ O, SO
• Horizontal flow CW	■ O
• Willow systems	■ O, SO, OP, SOP
• Technical systems	■ Certification
• Vertical Flow CW	■ O, SO
• Collecting tanks	■ O, SO, OP, SOP
• Sewering	■ O, SO, OP, SOP

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Need for research

- Phosphorus removal
- Nitrification-denitrification processes
- Total nitrogen removal
- Pathogen removal
- Emergent pollutants
- Gas emissions
- Role of plants (in planted systems)
- Operational parameters

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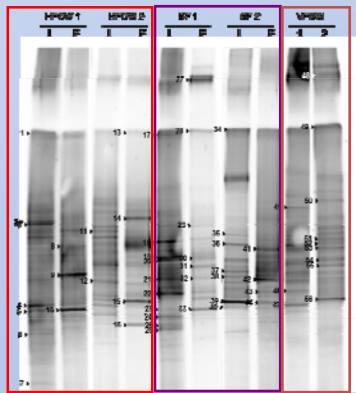
P-removal

- Two strategies:
  - Mediaand compact filters

Nitrification denitrification

- **Design optimized for nitrification-denitrification**
- **Operational parameters**
  - Loading regime
  - Recycling of nitrified effluent
- **Microbiological processes**
  - Identification of microbial communities involved
  - Environmental factors



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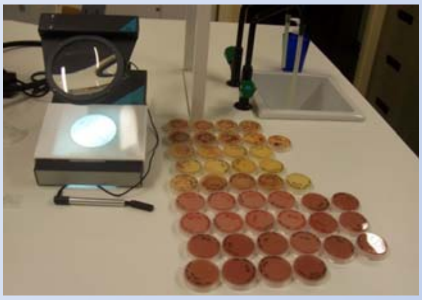
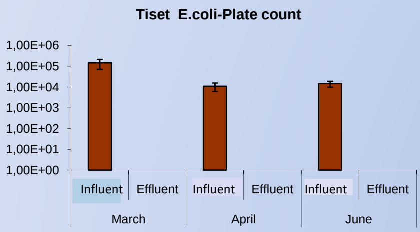
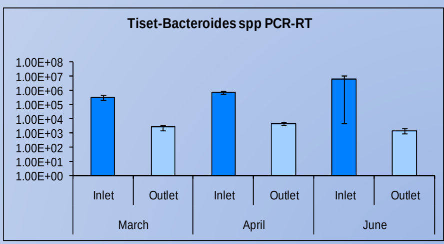
Pathogen removal







Emergent pollutants

- Heavy Metals
- Pesticides
- Plastifiers
- PAHs
- PPCPs
- Endocrine disruptors
- Surfactants

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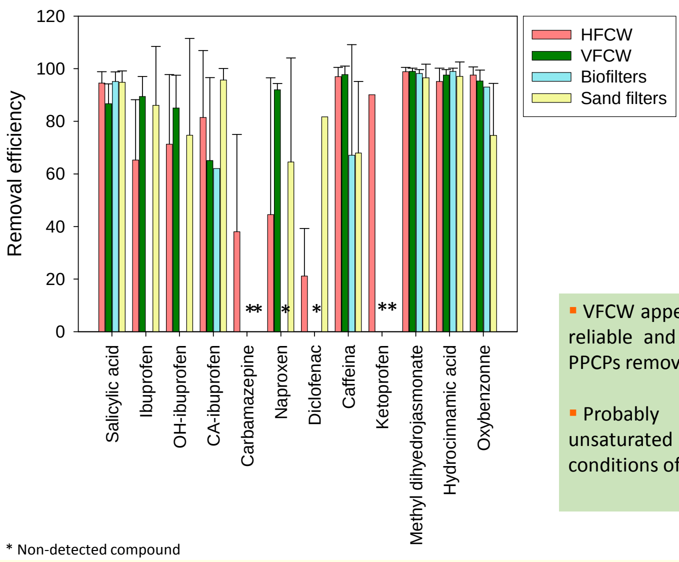
PPCPs

CLASSIFICATION	USE	pka	Log Kow[a]	Properties
PHARMACEUTICALS				
IBUPROFEN	ANALGESIC/ANTIINFLAMATORY	4.31	0.28	Hydrophilic
OH-IBUPROFEN	IBUPROFEN HUMAN METABOLITES	-	-	Hydrophilic
CA-IBUPROFEN	IBUPROFEN HUMAN METABOLITES	-	-	Hydrophilic
SALYCILIC ACID	ACETYLSALICYLIC ACID METABOLITE	3.50	-2.24	Hydrophilic
NAPROXEN	ANALGESIC/ANTIINFLAMATORY	4.20	-0.62	Hydrophilic
KETOPROFEN	ANALGESIC/ANTIINFLAMATORY	4.45	-0.38	Hydrophilic
DICLOFENAC	ANALGESIC/ANTIINFLAMATORY	4.20	-0.70	Hydrophilic
FUROSEMIDE	ANALGESIC/ANTIINFLAMATORY	-	-	Hydrophilic
CAFFEINE	STIMULANT	10.4	0.16	Hydrophilic
CARBAMAZEPINE	ANTIEPILEPTIC	-	2.45	Hydrophilic
PERSONAL CARE PRODUCTS				
Me-DH-JASMONATE	FRAGRANCE COMPONENTS	-	3.00	Hydrophilic
OXYBENZONE	UV FILTERS/SUNSCREENS	-	3.79	Hydrophobic
HYDROCINNAMIC ACID	UV FILTERS/SUNSCREENS	4.66	-1.50	Hydrophilic

[a] *calculated at pH=8*

Matamoros et al, 2008

RESULTS: System Intercomparison



* Non-detected compound

- VFCW appeared to be the most reliable and robust in terms of PPCPs removal.
- Probably because the unsaturated and planted conditions of VFCWs.

Matamoros et al, 2008

RESULTS: Removal efficiency II

Comparison with previously reported data in pilot CWs and conventional WWTPs (activated sludge)

	Biofilters [a] (n=2)	Sand Filters (n=4)	HFCW (n=5)	VFCW (n=5)	Selected values HFCW (7)	VFCW (8)	WWTP [b]
Salicylic acid	95±4	95±4	95±4	87±8	96	98	99(1)
Ibuprofen	n.r.	86±23	65±23	89±8	71	99	60-70(2)
OH-ibuprofen	n.r.	75±23	71±27	85±13	62	99	95 (3)
CA-ibuprofen	62	75±37	81±26	65±32	87	99	95 (3)
Carbamazepine	-	-	38±37	-	16	26	8 (4)
Naproxen	n.r.	65±40	45±52	92±2	85	89	40-55 (2) 82 (4)
Diclofenac	-	82	21±18	-	15	73	17(4)
Caffeine	67±42	68±27	97±3	99±1	97	99	99 (4)
Methyl-dihydrojasmonate	98±1	97±5	99±2	99±1	99	99	98 (5)
Hydrocinnamic acid	99±1	97±5	95±5	98±2	-	99	-
Oxybenzone	93	75±20	98±3	95±4	-	97	68-99 (6)

LECA system was not considered for removal. b activated sewage sludge, n.r. no removal
1.(Ternes et al., 2004), 2. (Carballa et al., 2004), 3. (Buser et al., 1999), 4. (Heberer, 2002), 5. (Simonich et al., 2002), 6. (Balmer et al., 2005), 7. (Matamoros and Bayona, 2006), 8. (Matamoros et al., 2007).

Matamoros et al., Water Res. 2008

Plants

- Species
- Pollutant uptake
- Growth
- Tolerance to pollutants
- Oxygen transfer rates
- Release of organic carbon from roots
- Rhizosphere and allelopathy

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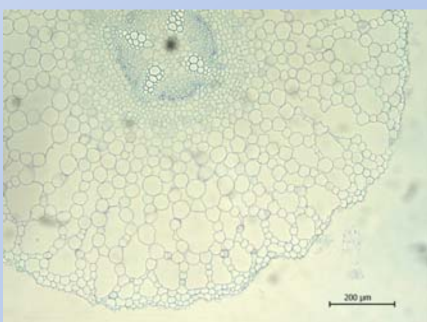
Gas transfer by plants



Konnerup, 2010

Greenhouse gas emissions

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Operational parameters

- Dosing and loading.
- Recycling of treated effluents.
- Recycling volumes and places.
- Maintenance needs.
- Energy usage.

Final comments

- Research improves the understanding of the treatment systems and processes, and thereby gives an edge
- Onsite systems should be able to adapt to new discharge requirements
- Small changes in operational modes can increase performance.
- There is much to be done!!!

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