Natural system for wastewater and sludge management - focus on small settlements in cold climates

Swedish Sanitation and Wastewater situation today ....

Centralised systems

> 90 % of population

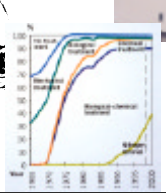
Onsite systems

5 % of population

....situation yesterday.

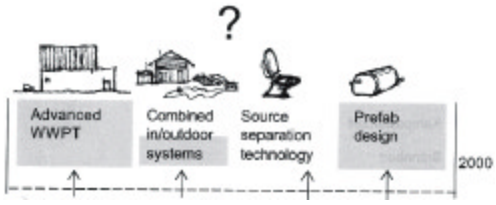
"Tradition" 1700- 1920

"Tradition" 1980- today



7000 km sewage pipes (twice around the globe) connect 97% of population

Trends for today



Natural (outdoor, extensive) found relevant in small and medium size settlements

Natural (outdoor, extensive) treatment systems:

+ Robust (from variations in load, temperature etc)

+ Simple techniques (local accessible equipment and materials can be used)

+ Understandable (easy to regulate, operate and maintain)

+ Little electricity and chemicals use

+ Reduce sometimes need for sludge management

- Need space

- Adaptation to local conditions (and stakeholders nearby)

Technique overview

	Conventional Treatment techniques (Energy-Tedious)	Natural Treatment techniques (Extensive-Passive)
Pre-treatment (SS- removal)	Screen, Grids, Sieves, sand traps, pre-sedimentation tanks	**Septic tanks**, Sedimentation ponds
Secondary Treatment (BOD- Removal)	Trickling filters Biorotors Activated Sludge	Stabilisation ponds and **(dry)wetlands** **Vertical Soil filters** (infiltration, sand filter **Irrigation**
Tertiary Treatment (P- removal)	Precipitation in WWTP BIO-P	**Precipitation ponds** (Infiltration) **Reactive filters** (Horizontal filters) **Irrigation**
Advanced Treatment (N removal)	Nitrification-Denitrification inWWTP	Nitrification-Denitrification **in dry+wet wetlands** orsandfilter **+ wet wetlands** Plant uptake (Irrigation)
Sludge Management (dewatering, stabilisation, hygienisation)	"Thickeners" Sieves Centrifuges Fermentation, (composting, Lime-stabilisation)	**Drainage beds, Biological Drainage beds (Reed beds)** (composting, Lime-stabilisation)

This presentation

1. Septic tank concept
2. Soil filter including reactive filters
3. Chemical precipitation ponds
5. Irrigation
4. Sludge drainage beds
5. Wetlands as (part of) biological treatment steps in WWTP

1. Septic tank

Swedish standard for dimensioning (mixed Wastewater)

1. Surface load: *less than 0,5 m3/m2 x h**
2. Detention time: *more than 6 hours**
3. Volume for sludge**

* *calculated from q dim*

** *75-200 l/pY depending on storing time*

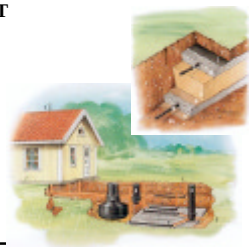
Slamavskiljare, BoknPlast, Norway

Sludge accumulation in Septic tank

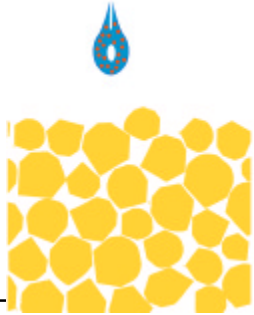
2. (Vertical) Soil filter systems

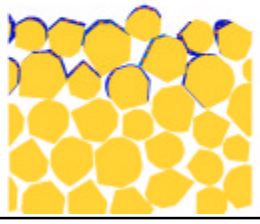
Infiltration and Sand filter systems- most common WWT techniques in world

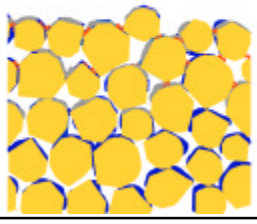
400 000 in Sweden

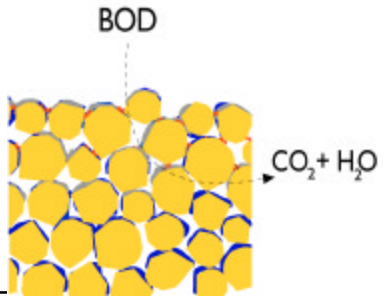


From IFO, Sweden









Unsaturated flow vs. saturated flow

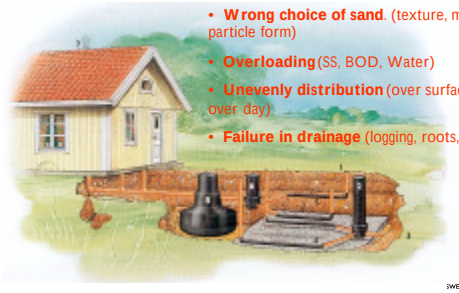
- Better filtration!
- Better oxygenation!

Vertical soil filters - assessment

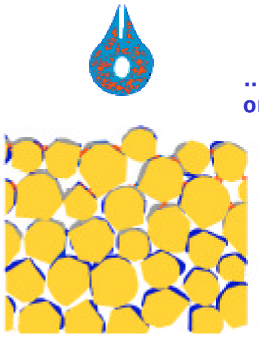
- Simple and cheap!
- Very efficient biological treatment (SS, BOD, pathogen removal and nitrification).
- Quite efficient for chemical treatment (P, heavy metal)
- Self maintained treatment processes- no or little need for el-energy!
- no bio-sludge produced

…..If properly designed and operated!

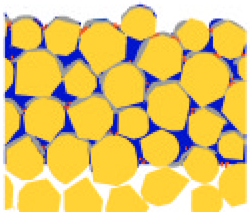
…. Common in practice:



- **Wrong choice of sand**. (texture, mineral, particle form)
- **Overloading** (SS, BOD, Water)
- **Unevenly distribution** (over surface, over day)
- **Failure in drainage** (logging, roots, etc



.... if wrong designed
or misused....



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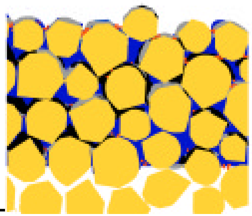

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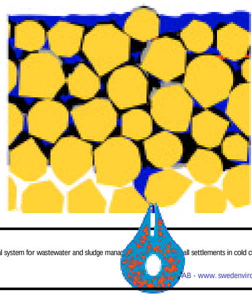
.... no filtering,
no mineralisation....



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Unsaturated flow urge:

Uniform distribution of water over the filter media!

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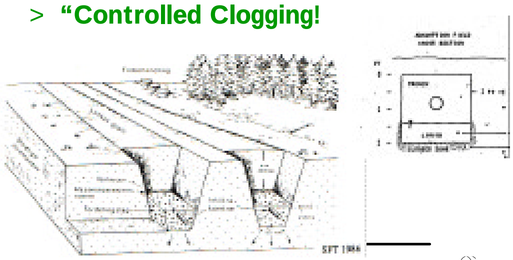
How to distribute water uniform in
Gravity system ?
> **"Controlled Clogging!**



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Artificial media for water distributing and biological treatment

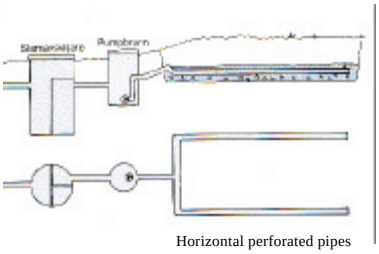
InFiltra compact filter systems, Ridderstolpe P, Sweden

Compact Filterbeds

Indrän

InFiltra (Ekotreat compact filter)

Uniform distribution easier by pumps…..

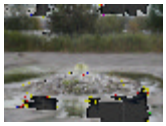


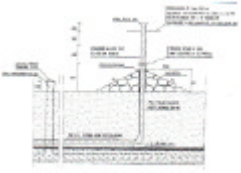
Horizontal perforated pipes

Planted vertical soil filter - distribution by horizontal pipes

GRW treatment in "constructed wetland" Hamburg, Germany

Open Sandfilter bed - distributing by flooding

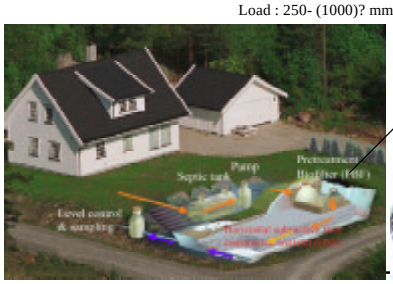




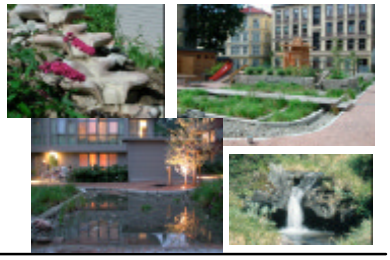
Load 80-120 mm/d

Distributing by spray nozzles

Load : 250- (1000)? mm/d

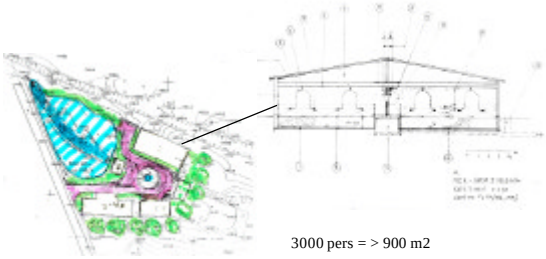


Example spray filter for Greywater Treatment Klosteregna, Oslo, Norge".



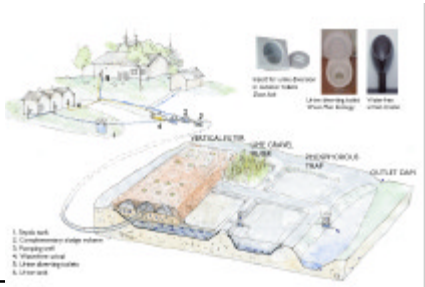
Example spray filter proposed in China

Designed June 2005

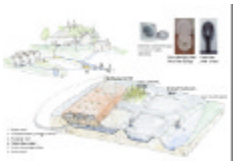


3000 pers = > 900 m2

Urine diversion combined with Norwegian filtersystem, Road stop Ångersjön, Hudiksvall



Road stop Ångersjön, 3 years following up



Huge variation in flows and temperature

Total removal of :

- BOD = 97% (95% in vertical filter)
- Tot P = 90% (40% in urine, 50% in P trap)
- Tot N= 65% (40% in urine, 25% in filter)
- Faecal col. = 99.99%

Potential for recycling

- urine and P trap media (40% N, 80% P)

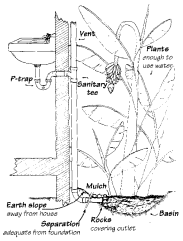
Constructing Costs: Euro 200 000. **Maintaining costs:** very low

Conclusions (vertical) soil filters:

- Proven Robust and efficient esp. for biological treatment
- Lot of applications (by gravity or pressurised by pumps or siphons, under ground, covered or open surface, with or without plants, for mixed wastewater or combined with urine (and faeces) diversion.
- Pre-designed techniques coming on the marcet

> *Should always be considered (also in urban areas)*

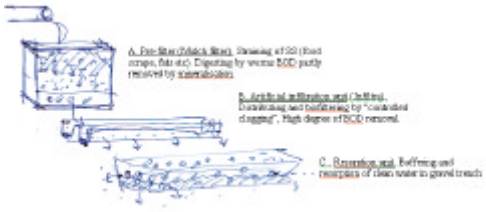
The mulch (compost) filter concept



Process principle

1. Removal of suspended solids (SS) by straining in mulch
2. Degradation of organic,s (BOD) by soil fauna (**earthworms** and bacteria's). Fats, oil, proteins, carbohydrates transformed to humic,s (mulch)
3. Water removal by infiltration and transpiration

Mulch filter tower followed by improved resorption



Compost Filter built in South Africa

Following up demo facility, Nov 2005

Compost filter 40x 45 x 45 cm.

GRW from one family

Following up demo facility Nov 2005

Compost filter- assessment

New and interesting technique esp. for warmer climates. Promising pilots is running in cold climates (Combaillaux, France).

Earthworms (Faetida sp) and other macro fauna increase BOD removal capacity 5-10 times vs only microfauna.

Research in Chile, France and Australia (South Africa and Sweden).

4 Precipitation ponds

Stabilisation ponds (facultative, bioponds, mature ponds etc very common in world.

Cold winter make performance weak.
In Sweden R&D start 1965 to improve treatment by coagulants.
- Lime
- Aluminium
- Iron

Today: >100 facilities in operation

Precipitation ponds using lime

Example, Funäsdalen Jämtland

Tourist winter resort in north

1000-4000 persons connected

Facility built 1987, first big settle pond buffer flow.

Slaked lime (CaOH2) granulates added by screw. Sedimentation in small ponds.

500-600 g/m3, pH>12

10 days retention time

Experiences: Very robust.

P: 90% (< 0,5 mg/l) N:70% BOD:80%, bathing quality, (wet) sludge used in agriculture

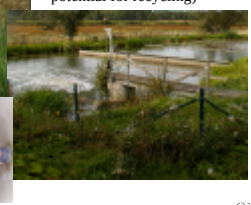
...and Aluminium.

Example, Ervalla, Örebro

Liquid Aluminium salt

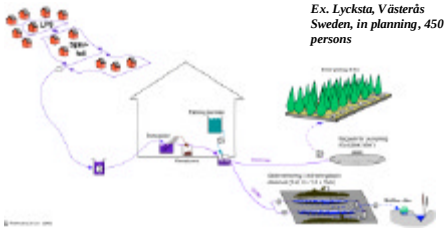
100- 250 g/m3

Robust, simple, efficient (less potential for recycling)

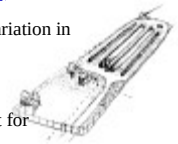


Combination Precipitation pond and forrest irrigation

Ex. Lycksta, Västerås Sweden, in planning, 450 persons



Precipitation ponds - Evaluation



+ Robust and simple (Very tolerant from variation in flow and temperature)

+ High and reliable treatment efficiency

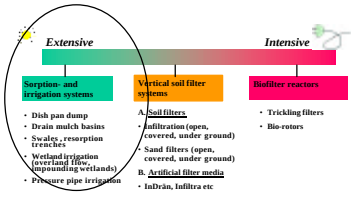
+ Aluminium simplest and most convenient for personal

+ Lime better in terms of Nitrogen and pathogen removal. Also produce valuable sludge for farmer

+ Appropriate for winter treatment while irrigation summertime

> Should be considered especially if Bioponds exist

5. (Forrest) Irrigation



Wastewater irrigation

overland flow system

Example from Łodz, Poland

Wastewater irrigation

Infiltration wetland

Example from Wratslaw, Poland

Irrigation to arable crops on Gotland, Sweden

6000 people, 5 villages

Grids+ Bio-ponds + Storage ponds in parallel (more than 4 month storage before irrigation.

Sugar beats, wheat etc

Irrigation in non edible crop, Salix

Ex: Götene Munic

Small village 250 person

Septic tank + winter storage

summer irrigation.

.. Winter/summer treatment (WWTP/Irrigation)

Ex Kågeröd, Sweden

1500 persons, WWTP +13 ha Salix

Winter: M/B/Ch- treatment in WWTP

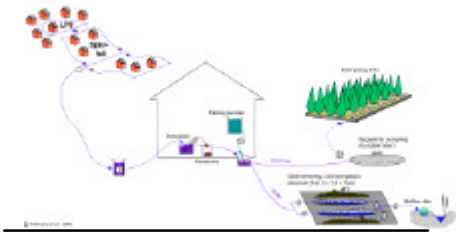
Summer: reduced treatment+ irrigation

6 mm (2-12 mm) mm/d, 6-7 month

Result: no effluent, 12 ton Ts/ha year

Recycling of water and 50% nutrients

Combination Precipitation pond and forrest irrigation



Irrigation- evaluation

\+ Simple, robust

\+ Very efficient (removal and recycling)

\+ Often come out as winner when different system are compared from sustainable criteria,s

\- Hygiene risk must be considered.

If space and market for products: Option should be considered

6. Sludge Drainage beds

Ex Nora, Sweden

.. Drainage beds planted with reed (Phragmites).

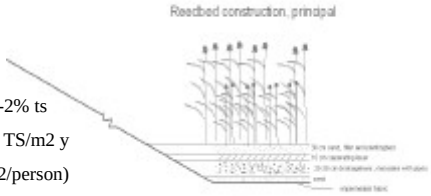
Ex. Hagfors, Sweden

Drainage beds design and dimensioning

Sludge 1-2% ts

50-70 kg TS/m2 y

(1-1,5 m2/person)



7. Wetlands as part of WWTP

Ex Oxel;sund,

First large scale wastewater treatment wetland as a biological step in WWTP in Sweden

13 000 persons

20 ha

Result total P removal 99%

total N removal 50%

Natural water quality in outlet

Dry wetlands- impounding wetland

Wetlands as part of WWTP, continue

Ex. Trosa wetland

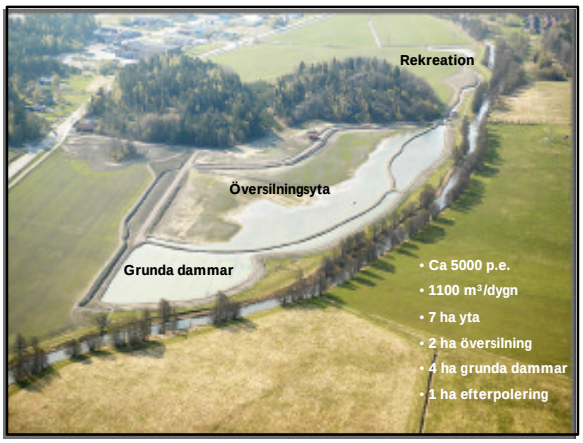
5000 persons, M/Ch/B WWTP + 6 ha Wetland

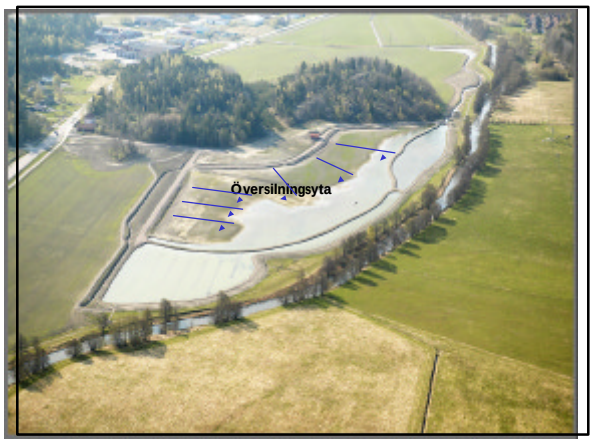
Targets

> 50% N reduction

> 99% P removal

> bathing quality when disposed

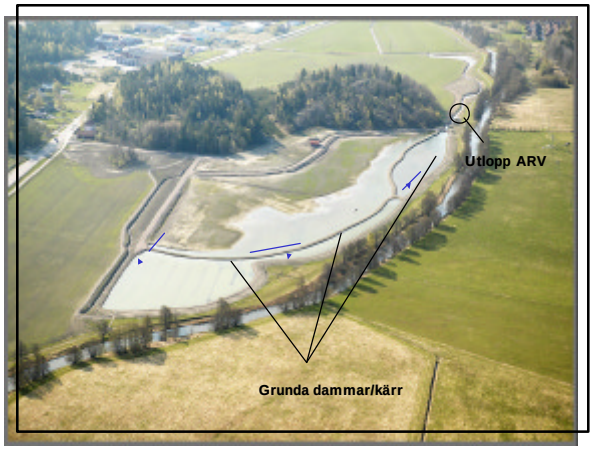




Torra våtmarker - översilning

Rörflen & andra fukttoleranta gräs

- **filtrering / sedimentering**
- **mineralisering (kräver O_2)**
- **nitrifikation (kräver O_2)**
- **hygienisering**

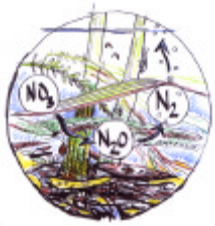


Denitrifikationsdammar

– Snabbväxande emersa makrofyter skapar stora mängder biomassa

– Vid nedbrytningen som utförs av bakterier förbrukas syre

– När syret tar slut utnyttjas nitrat



- **Denitrifikation**
- **Filtrering/sedimentation**

Dry Wetlands as part of WWTP - Assessment

- efficient and cheap method for biological treatment in WWTP (ex Oxelösund, Nynäs) and for very advanced treatment (ex Trosa) if land is available 5 to 20 m2 person

- Water quality as in natural water, full diverse natural biota in outlets

Naturals systems- conclusions

- Natural system offer a lot of good opportunities.
- They are robust and reliable often efficient.
- They have potentials to save energy and costs
- If land is available, natural systems should always be considered

Thank You!

Outlet from treatment facility (WWTP and wetland) in Nynäshamn, Sweden