WASTEWATER AS A RESOURCE - WHAT ARE THE OPTIONS

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DEVELOPMENT OF WASTEWATER MANAGEMENT

1850 — 1950 — 2000 — 2050 →

Sanitary Engineering	Environmental Engineering	Water Environm. Management
Hygiene in focus	Pollution control in focus	Water reuse in focus
• Cholera epidemic 1850 • Chlorination, 1900 • Wastewater collection • Sewage farms • Primary treatment • Deep-sea outfalls	• Secondary treatm., 1950 • P-removal, 1970 • Reuse for crop irrigation • N-removal, 1990 • Sludge on farmland • Alternativ systems-reuse	• Growth limited by water • Extensive ww treatment • Reuse of ww for irrigation • Urban water reuse • Productification of sludge • Utilisation of ww heat
Water use – supply driven		Water use – demond driven

WASTEWATER FARMS

The sewage farm (see Melbourne wwtp below) is an example of minimal discharge based on “assimilative” and “self-purification” of soil and vegetation. Farming cattle brings food back to the city bred on the waste from it. But enormous areas close to the city required.

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REUSE OF THE TREATED WATER

In most regions of Europe the use of water has been :

Supply driven → Price of water low

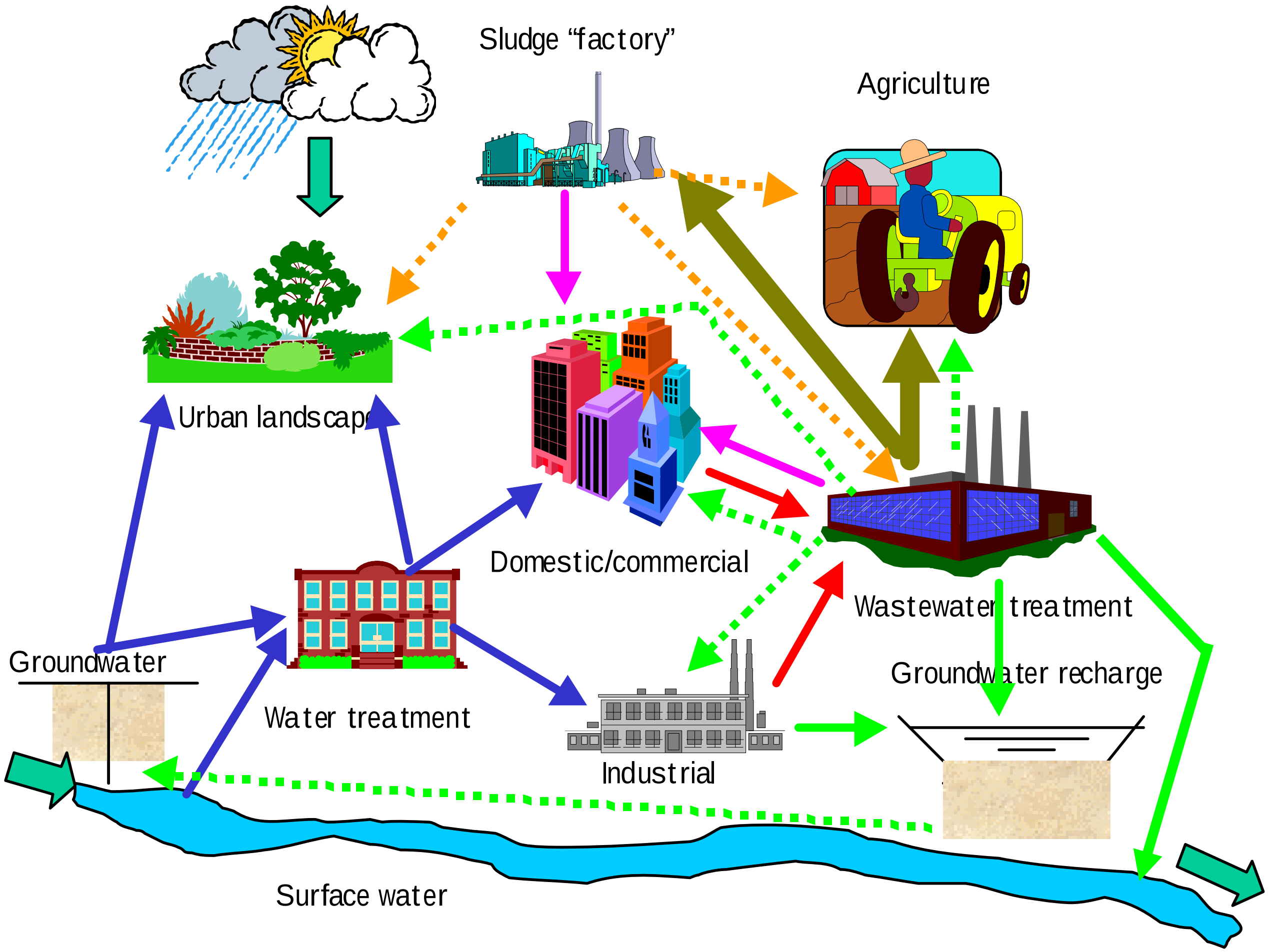
In the future water use in many regions in Europe will be :

Demand driven → Price of water will increase

↓

Extensive treatment of wastewater → cost effective

SUSTAINABLE URBAN WATER SYSTEMS



Two schools :

1. The present centralized system should be replaced by alternative systems based on local handling

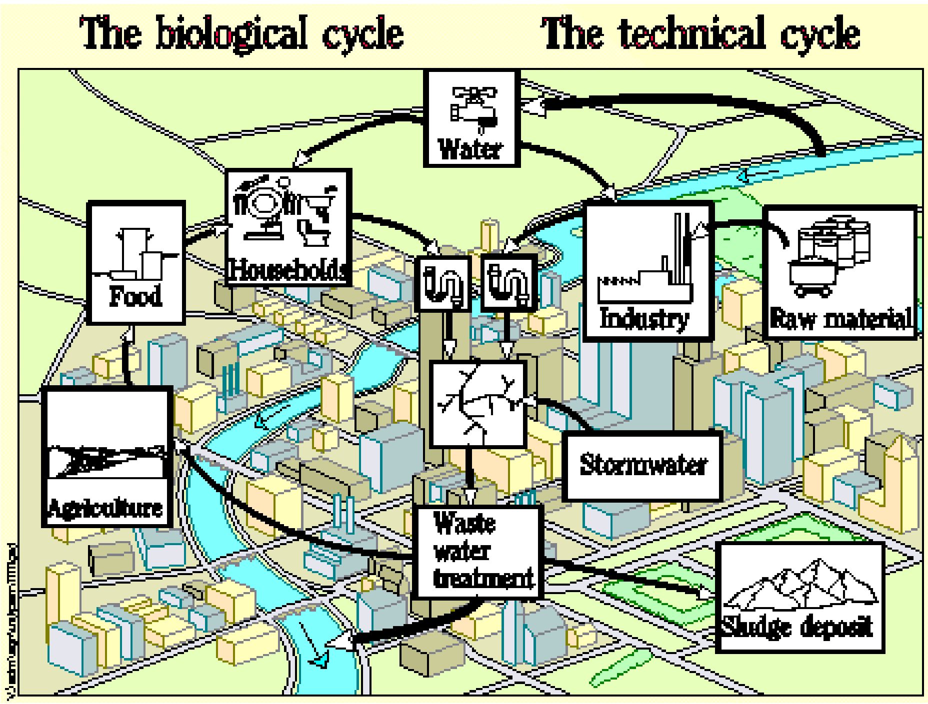
2. The present centralized system is the only realistic one, but it should be modified to be in agree-ment with sustainable development

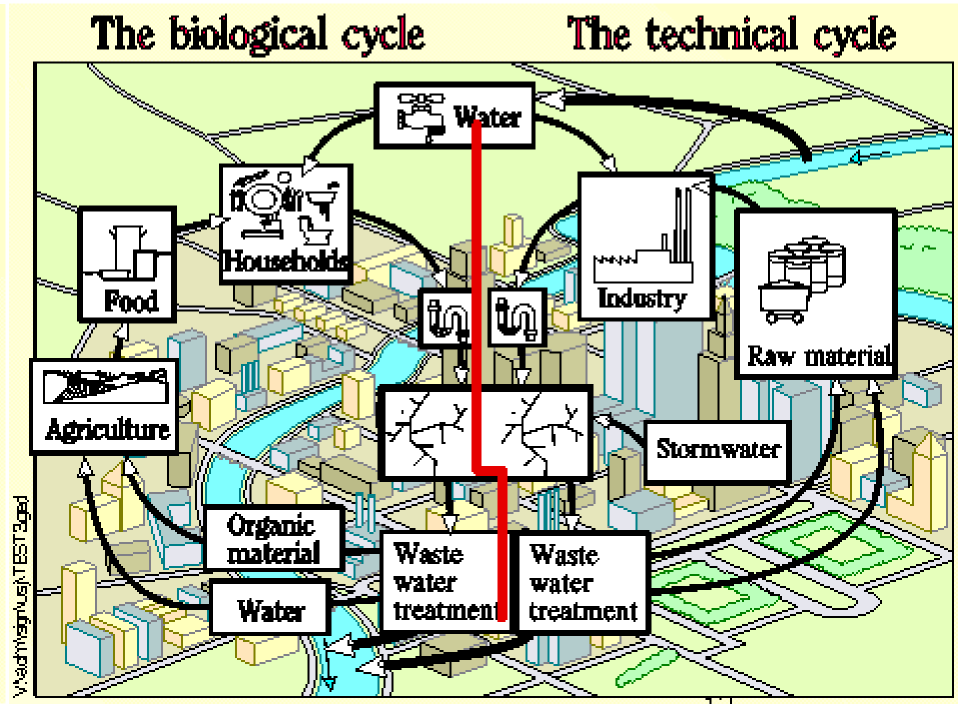
The resources in wastewater must be utilized !

The urban water cycle in a centralized system

A typical single system of today.
A mixture of useful (C,P,N) and harmful constituents (Me, AOX)

A possible dual system in future
Biological cycle kept apart from the technical cycle

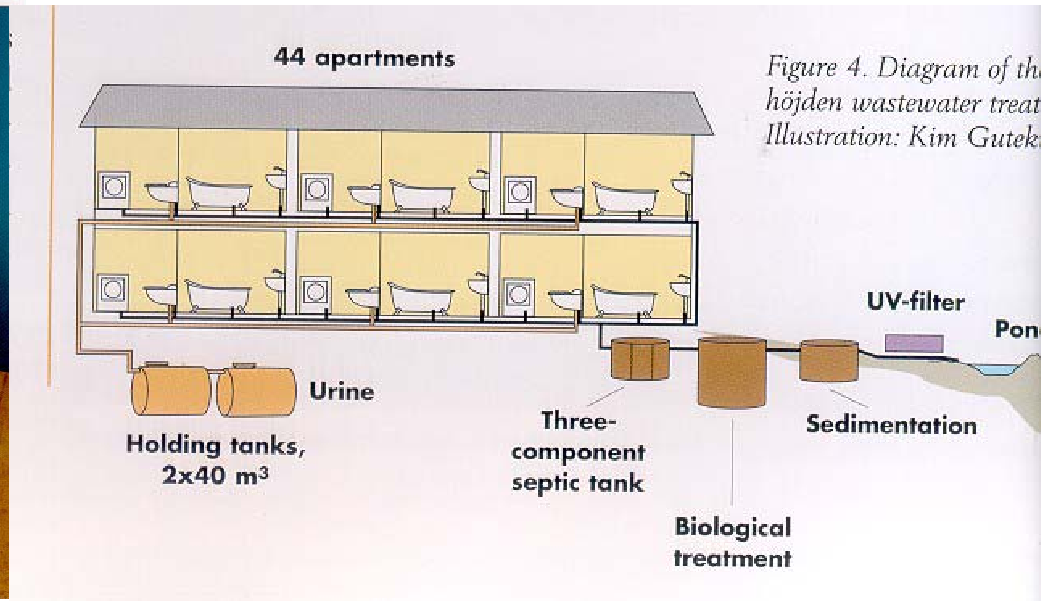




SOURCE SEPARATION OF URBAN WASTEWATER IN A DECENTRALISED SYSTEM

Most of the nutrients is found in urine and faeces. Separation of toilet waste is being considered

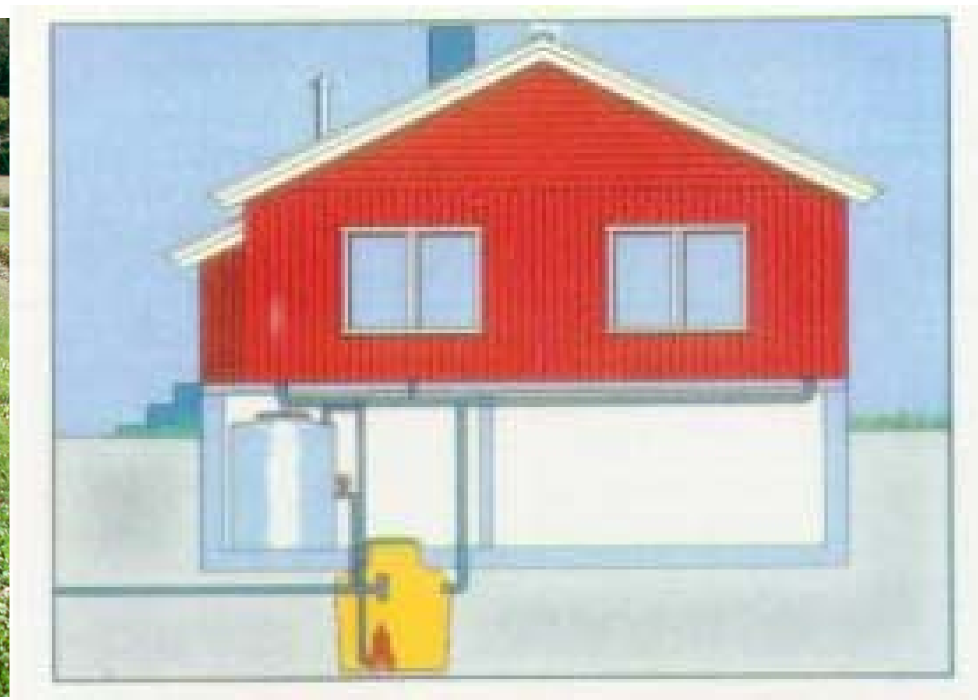
Can urine be brought directly back to the country-side?



NATUREBASED OR PROCESSBASED PLANTS FOR ON-SITE WASTEWATER SYSTEMS ?

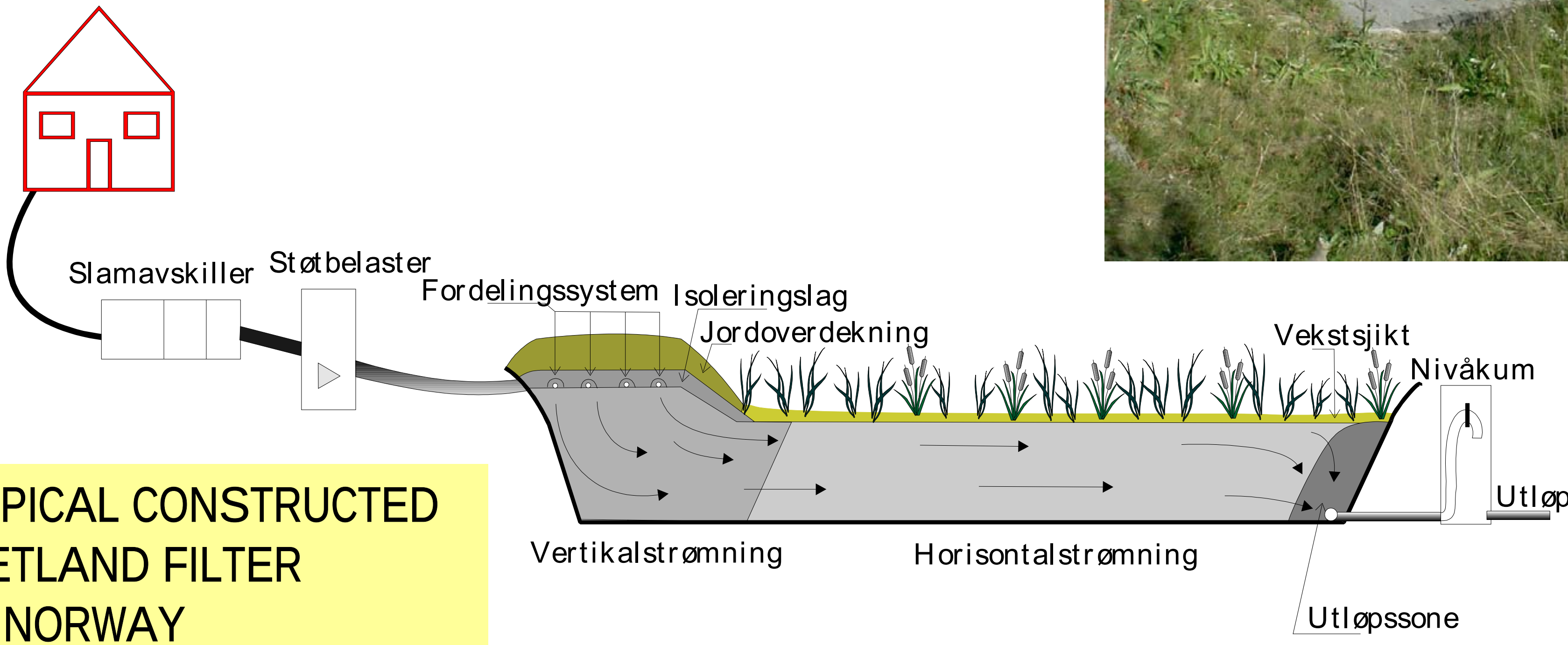
”LOW-TECH” NATURBASED

”HIGH-TECH” PROCESSBASED



NATURBASED SOLUTIONS

There is considerable interest in constructed wetlands for small plants (on-site plants) bur relatively little documentation on their performance



TYPICAL CONSTRUCTED WETLAND FILTER IN NORWAY

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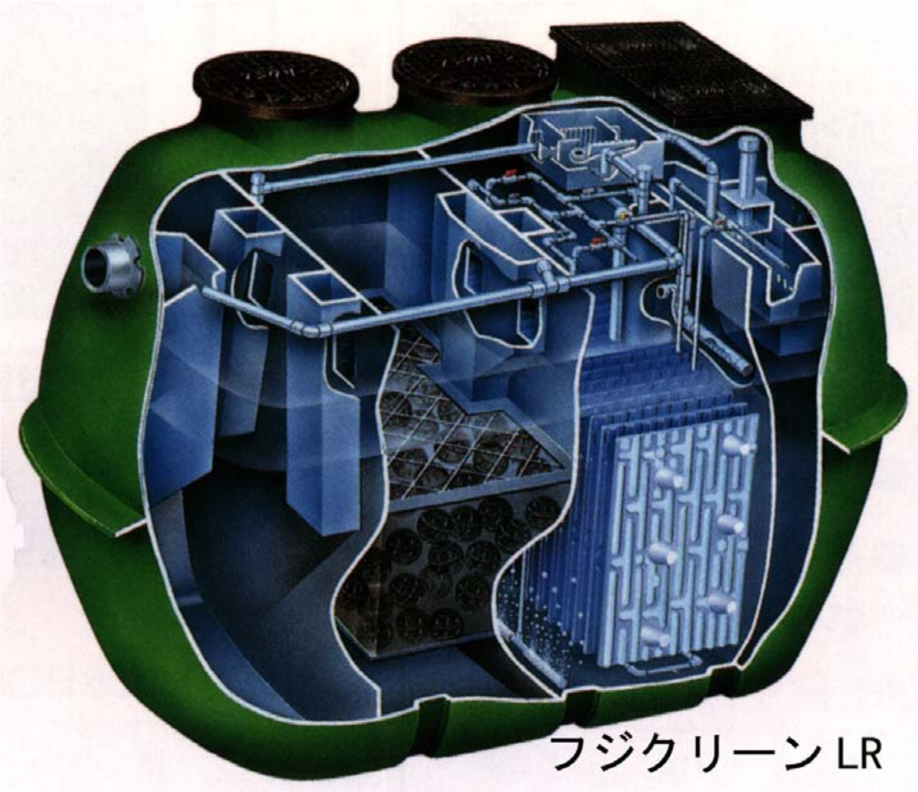
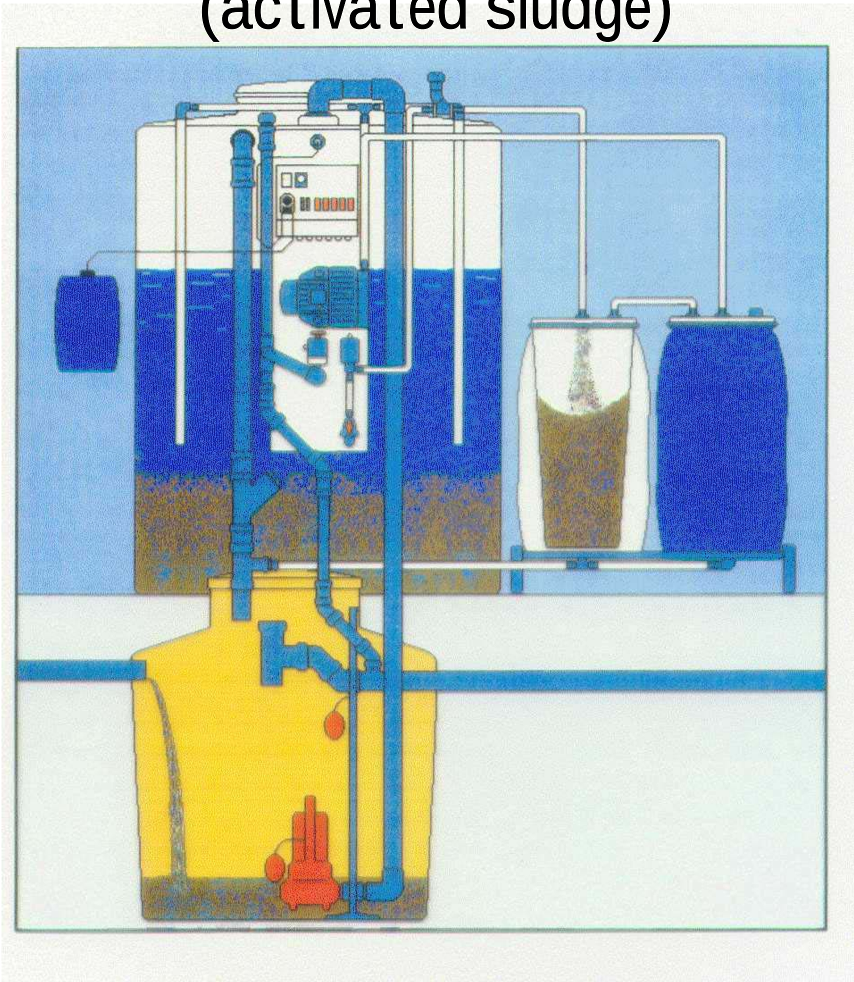
PROCESSBASED ON-SITE PLANTS

Japanese Johkasou
(based on biofilm)



Norwegian SBR-plant
(activated sludge)



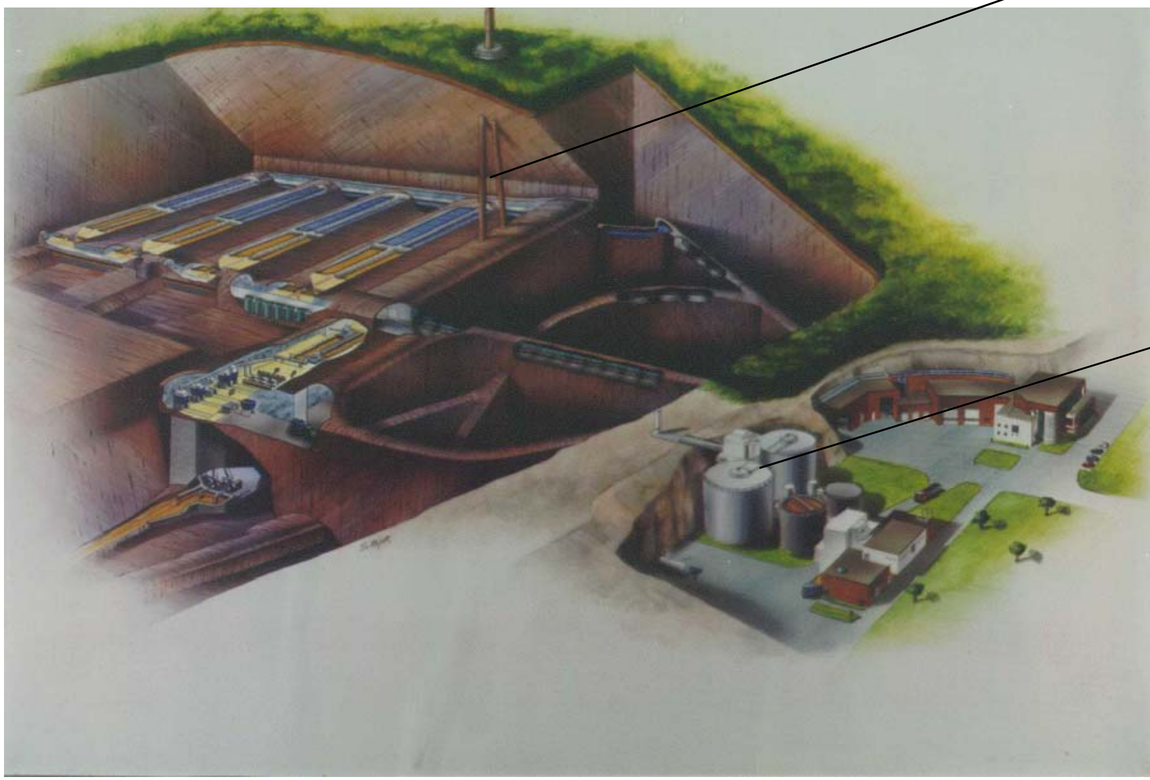
RESOURCES IN WASTEWATER

1. The water itself →
   - Agricultural reuse - irrigation
   - Urban reuse
   - Industrial reuse
   - Potable water reuse

2. The constituents in the wastewater →
   - Nutrients (C,N,P)
   - Carbon for energy production (biogas, biofuel)
   - Metals for reuse (Al, Fe)

3. The heat of the wastewater →
   - Energy for heating

THE TWO OUTGOING STREAMS FROM A WASTEWATER TREATMENT PLANT



The wastewater
- Water itself
- Nutrients
- Heat

The wastewater sludge
- Nutrients
- Energy potential
  Biogas and Biofuel
- Metals (coagulants)

RECLAIMED WASTEWATER FOR AGRICULTURAL AND LANDSCAPE IRRIGATION

Most important : The water itself - but also its nutrients

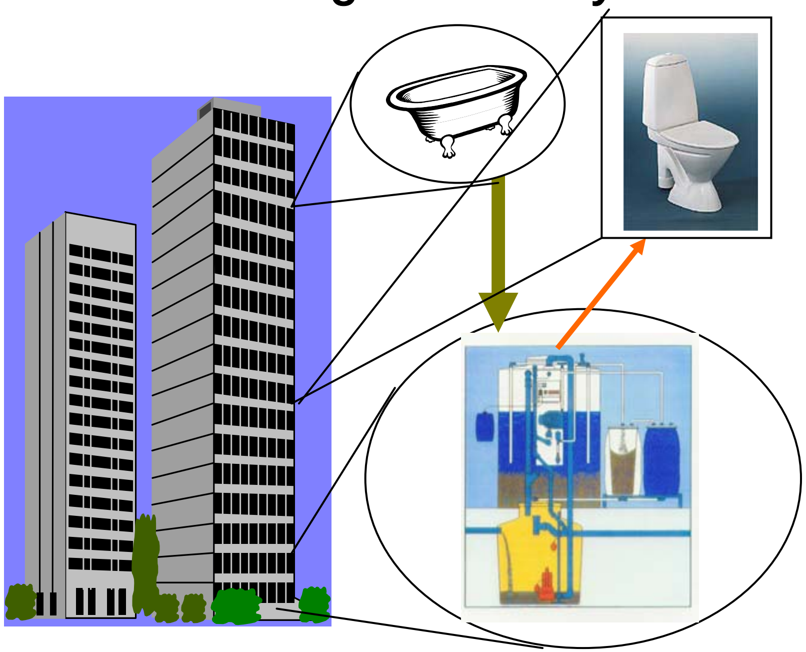
- irrigation of farmland and crops
- irrigation of golf courses and sporting grounds
- irrigation of parks and green fields

Important challenges :

- Safeguarding hygienic quality of water (WHO, 1973,1989)
- Preventing contamination of soil (heavy metals)
- Preventing contamination of ground water (metals, organic micropollutants, nitrates etc)

RECLAIMED WASTEWATER FOR URBAN REUSE

Reclaimed wastewater for toilet flushing in dual systems



Two approaches:

- citywide system
- small scale local systems

Reclaimed wastewater for landscaping (lakes, brooks, wetlands)

Great demand for acceptable water
Extraction from potable water source too expensive-not sustainable

RECLAIMED WASTEWATER FOR INDUSTRIAL REUSE

Reuse within the industry

Reuse of reclaimed municipal wastewater

- cooling-system make-up water
- boiler feed water
- process water for production
  - manufacturing
  - iron and steel
  - textile
- wash-down water (car wash)

RECLAIMED WASTEWATER FOR POTABLE WATER SUPPLY

Direct potable reuse:

Very seldom - Not because of inability to treat sufficiently, but because of the public's objection to drink former sewage

Example : Windhoek, Namibia

Groundwater recharge

Quite common -

- Arresting the decline of water level
- Protection from salt intrusion
- Storage of surface water
- Self purification in soil

WASTEWATER SLUDGE

Quantity and disposal of communal sludge in EU (12 countries)
(in 1000 tons of dry solids)

	1984		1992		2000		2005	
Utilisation	2.057	37	2.504	39	3.617	40	4.576	45
Incineration	518	9	715	11	2.088	24	3.872	38
Landfill	3.988	54	3.257	50	3.200	36	1.615	17
Total	5.563	100	6.476	100	8.906	100	10.063	100

Two ways of looking at wastewater sludge:

A problematic, toxic waste

- Containment
  - Land fills
- Minimization (Incineration)
  - Containment of ash

A resource-containing waste

- Direct use on farmland
  - Organics, nutrients
- Productification of resources
  - Recycle to marketplace

DIRECT USE OF SLUDGE ON FARMLAND

The most commonly used and probably the most sustainable sludge resource recycling option !

But : Under considerable threat !

Pro's and con's

Benefits :

- Recycle of organic material
- Utilisation of nutrients
- Low cost

Problem areas :

- Hygienic quality
- Heavy metals
- Organic micropollutants

Limitations :

- Distance from city to farm
- Suitable crops
- Public acceptance

DIRECT USE OF SLUDGE ON FARMLAND

Challenges :

Prevention of disease spread

Measures:

- Hygienisation of sludge
  - Heat treatment
- Selection of crops for sludge use
  - Wheat/cereals - yes
  - Vegetables - after 3 yrs
  - Potatoes - no
- Rules on how to apply
  - Downplouging

Prevention of soil contamination

Measures:

- Restricted metal content in sludge and soil
  - Cd, Pb, Hg, Ni, Zn, Cu, Cr
- Restricted content of org. micropollutants
  - Dioxin/Furan, PCB, AOX
- Limited loading (ton/ha·year)
- Control strategies

"PRODUCTIFICATION" OF RESOURCES IN SLUDGE

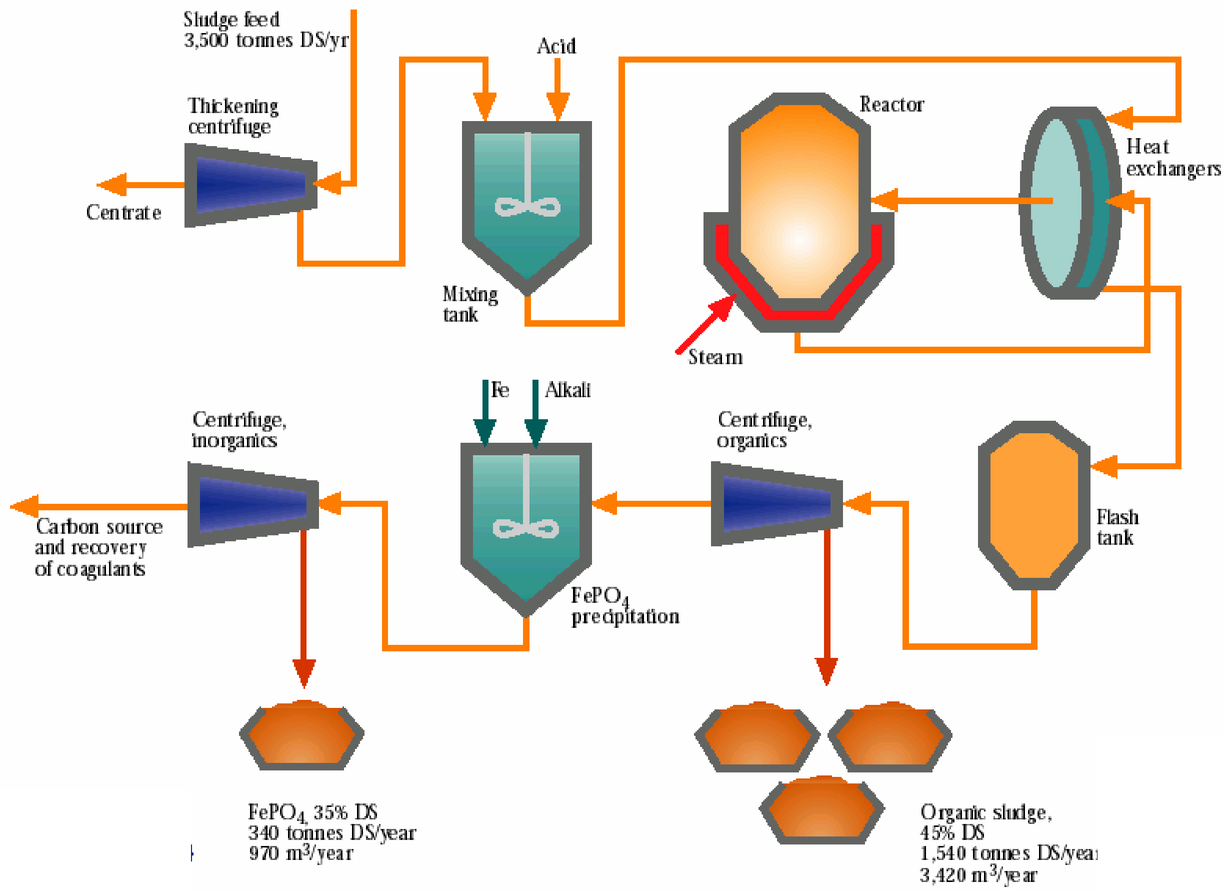
Soil conditioner-"Bio-soil"

- Mixture of :
  - Treated sludge
  - Filling materials (sand, clay, bark etc)
  - Nutrient additives (N,P,K)
- Asked for in the market place
  - Public use (parks, sporting fields, road embankments)
  - Private use (gardens)
- Not negatively associated with sludge

"Products" extracted from sludge

- Energy in the form of
  - Biogas from anaerobic digestion
  - Biofuel from dewatered sludge
- Fertilizers in the form of
  - Organic matter
  - Phosphorous
  - Nitrogen (from the sludge water)
- Carbon source (for N-removal)
- Coagulants (aluminium, iron)
- Additives to building materials (ash to cement)

Example of a sludge product recycling concept (KREPRO)



ENERGY RECOVERY FROM WATER AND SLUDGE

Heat of the water extracted by heat pumps	Biogas produced by anaerobic digestion of sludge	Heat produced by sludge incineration

Hot water (60-70 ºC)

Hot water

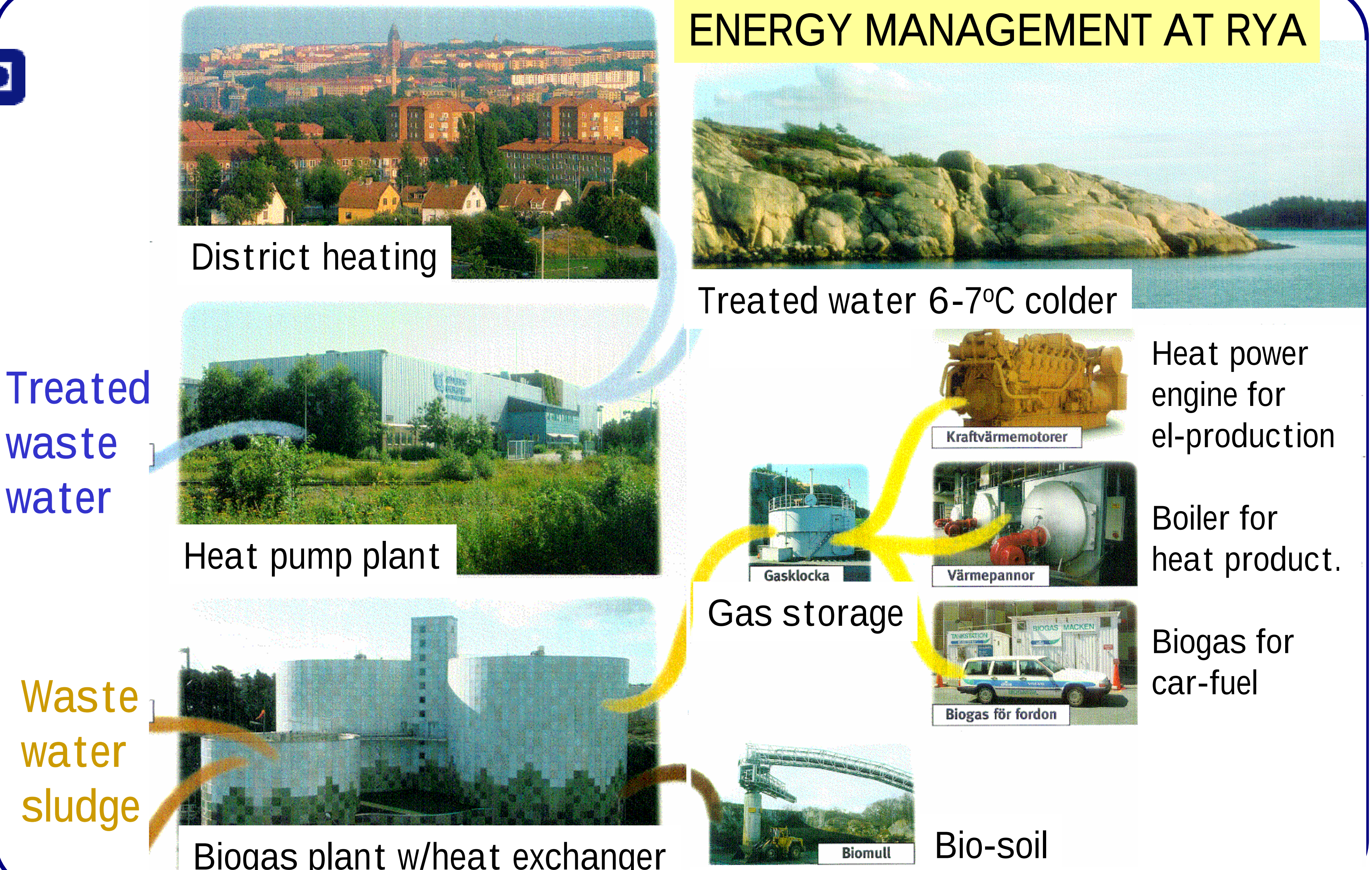
Electricity

Hot gas/water

Heat - low quality energy - requires receptor - plant itself or heat distributor

High quality energy - Exergy - that part of energy that can be converted to any other form

ENERGY MANAGEMENT AT RYA



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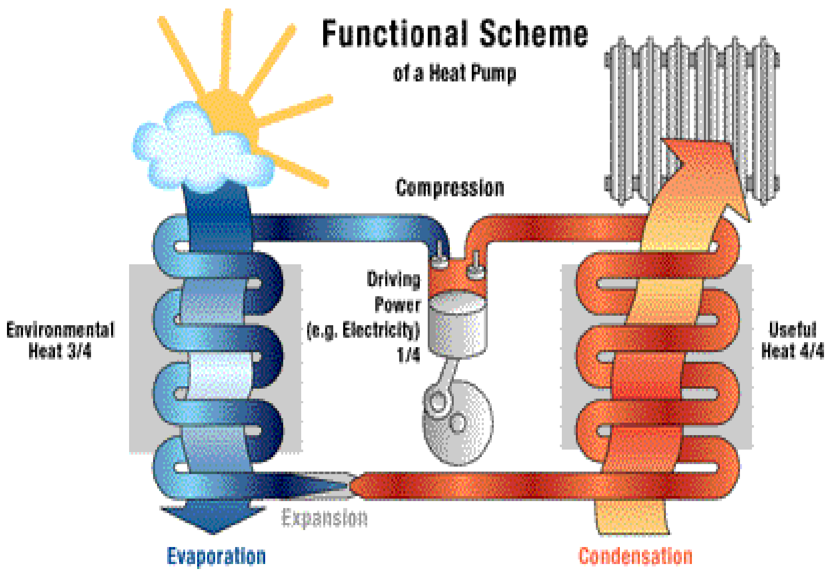
THE WASTEWATER AS A HEAT SOURCE

The wastewater of the cities contains enormous quantities of thermal energy. Example: Tokyo's wastewater represents 27 TWh/year in heat. This is estimated at 39 % of all waste heat from the city !!!!



For every kW of electricity used, 3 kW is transferred to thermal energy that can be supplied to district heating

Example : In Gothenburg, Sweden, 25 % of the energy for district heating is recovered from wastewater

PRODUCTION OF BIOGAS

Total energy potential of biogas produced from sludge is ~ 2 kWh/kgDS
This corresponds to ~ 75 GWh/year in a 1 mill people city or 15 TWh/year for the whole of EU's sludge production. The electricity part is about 1/3.

Total	2,1 kWh/kgDS
Electricity	0,7 kWh/kgDS
(potential in EU :	6 TWh/year)
Heat	1,4 kWh/kgDS
Recoverable heat	1,0 kWh/kgDS
Digester heating	0,7 kWh/kgDS
Waste heat	0,4 kWh/kgDS

Heat from incineration

Heat value of raw sludge : 14 MJ/kgDS (3,85 kWh/kgDS)
----”---- digested sludge : 12 MJ/kgDS (3,30 kWh/kgDS)
The biogas potential should be taken out before incineration

The energy needed for evaporation of the water is balanced by the energy produced by incineration at a sludge DS of about 20 % Higher DS gives a net heat amount

Typical process solutions :

Dewat.	Drying	Inciner.	
Hydrol.	Dewat.	Inciner.	
Hydrol.	Digest.	Dewat.	Inciner.
Dewat.	Drying.	Bio-Pellets	

CONCLUSIONS

- Wastewater should be looked at as a resource with its three main resource components: the water itself, the components of the water (primarily nutrients and carbon) and the heat of the water

- Utilization of these resources is closely linked to advanced wastewater treatment

- In a situation where water use is demand driven, the price of water will be high and extensive wastewater treatment to reclaim water may be cost effective

- The major use of reclaimed wastewater will be for agricultural and landscape irrigation and for urban reuse (dual distribution systems as well as constructed waterways and wetlands)

CONCLUSIONS cont'd

- Even though direct use on farmland may be the most sustainable way of recycling the resources in sludge, the negative public image of "sewage-fertilised" crops, seems to limit this application in the future

- The energy that can be produced from sludge biogas is very significant and the use of anaerobic sludge treatment should be encouraged

- "Productification" of the resources in sludge can be expected - sludge factories will make products such as electricity, heat, biofuel, bio-pellets, phosphorous, ammonium etc

- Utilisation of the wastewater heat has a great potential for district heating purposes and should be encouraged