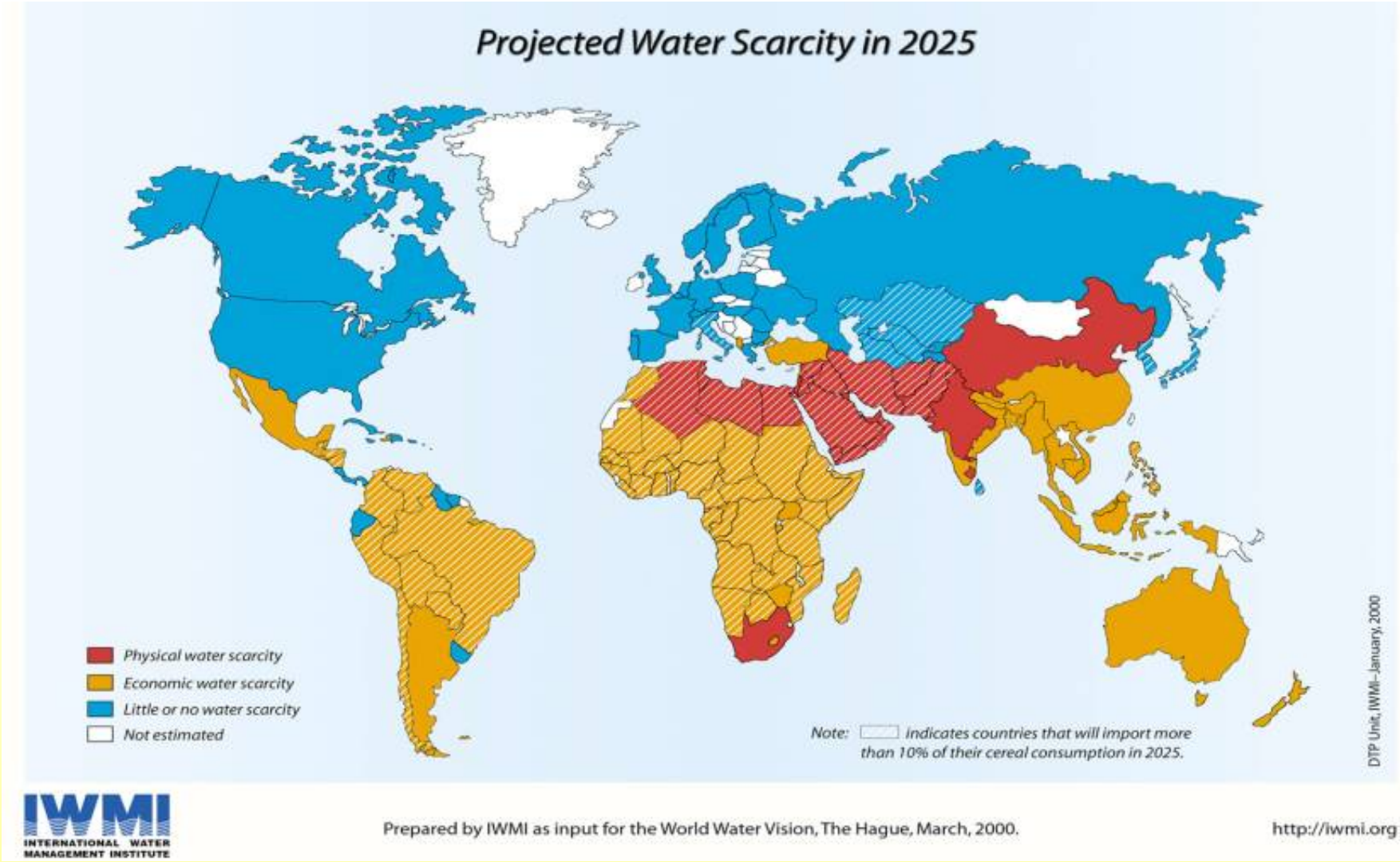
Innovative reuse oriented water concepts

high-, medium- and low-tech options

Univ. Prof. Dr.-Ing. Ralf Otterpohl
Director,
Institute of Municipal and Industrial Wastewater Management
TUHH
Technical University Hamburg-Harburg



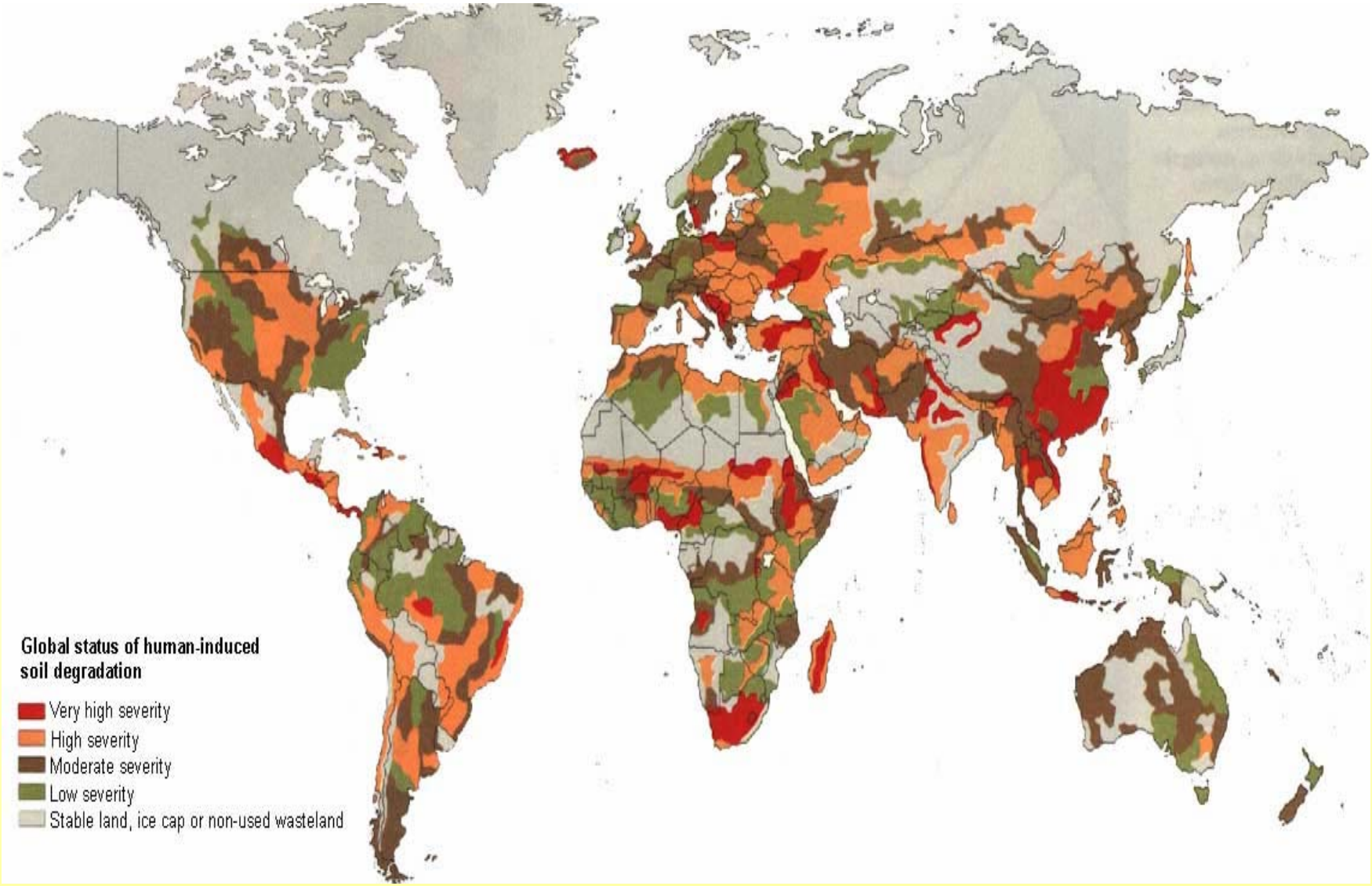
Major problems related to Wastewater (Miss)Management:

Pollution of Rivers, Lakes and the Seas

Loss of Soil Fertility (dramatically underestimated)

Inefficient Water Usage

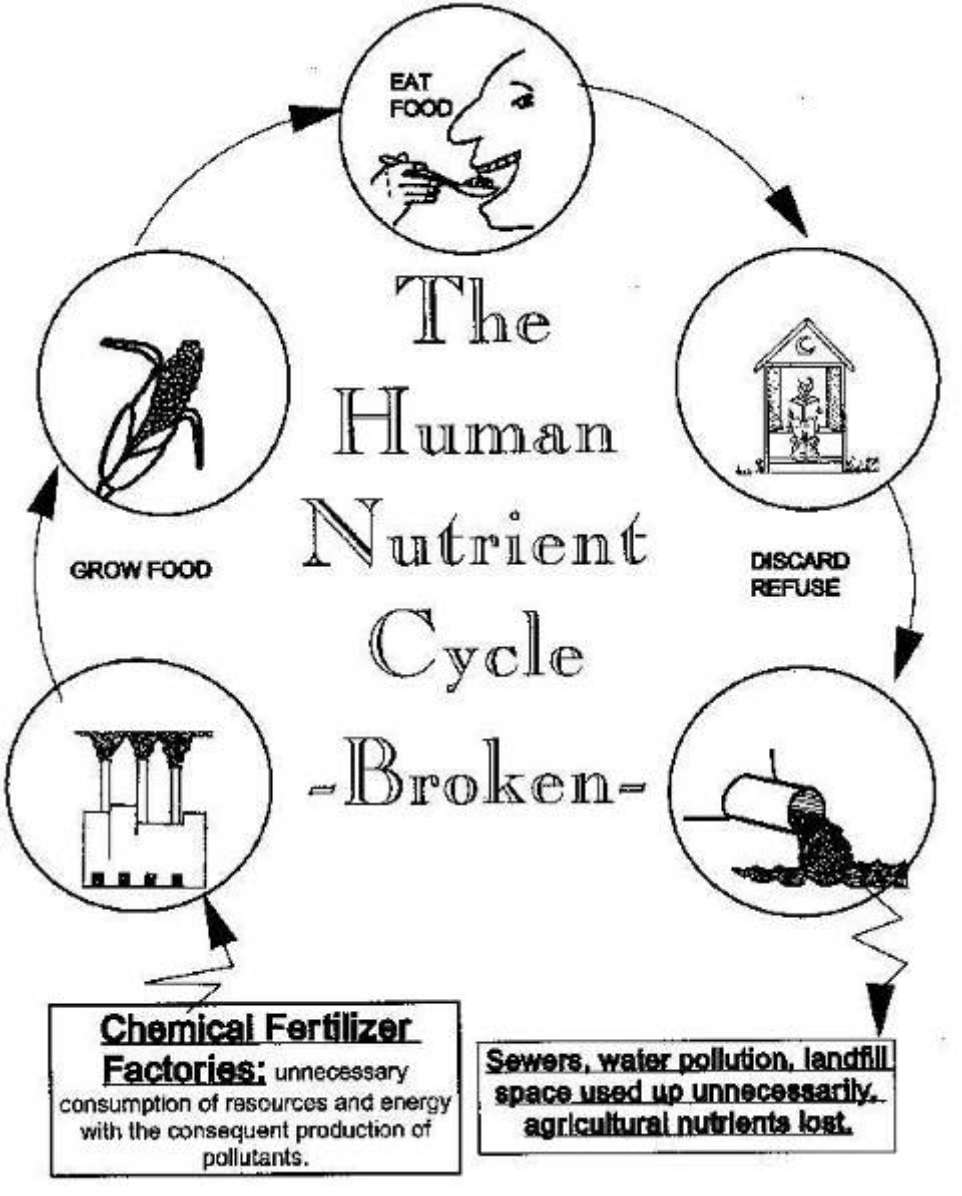
organic matter back to the soil!



Loss of Soil Fertility (slow but dramatic, global scale)

counteraction by returning treated biowaste and faecals

(Map from WWW.FAO.ORG)

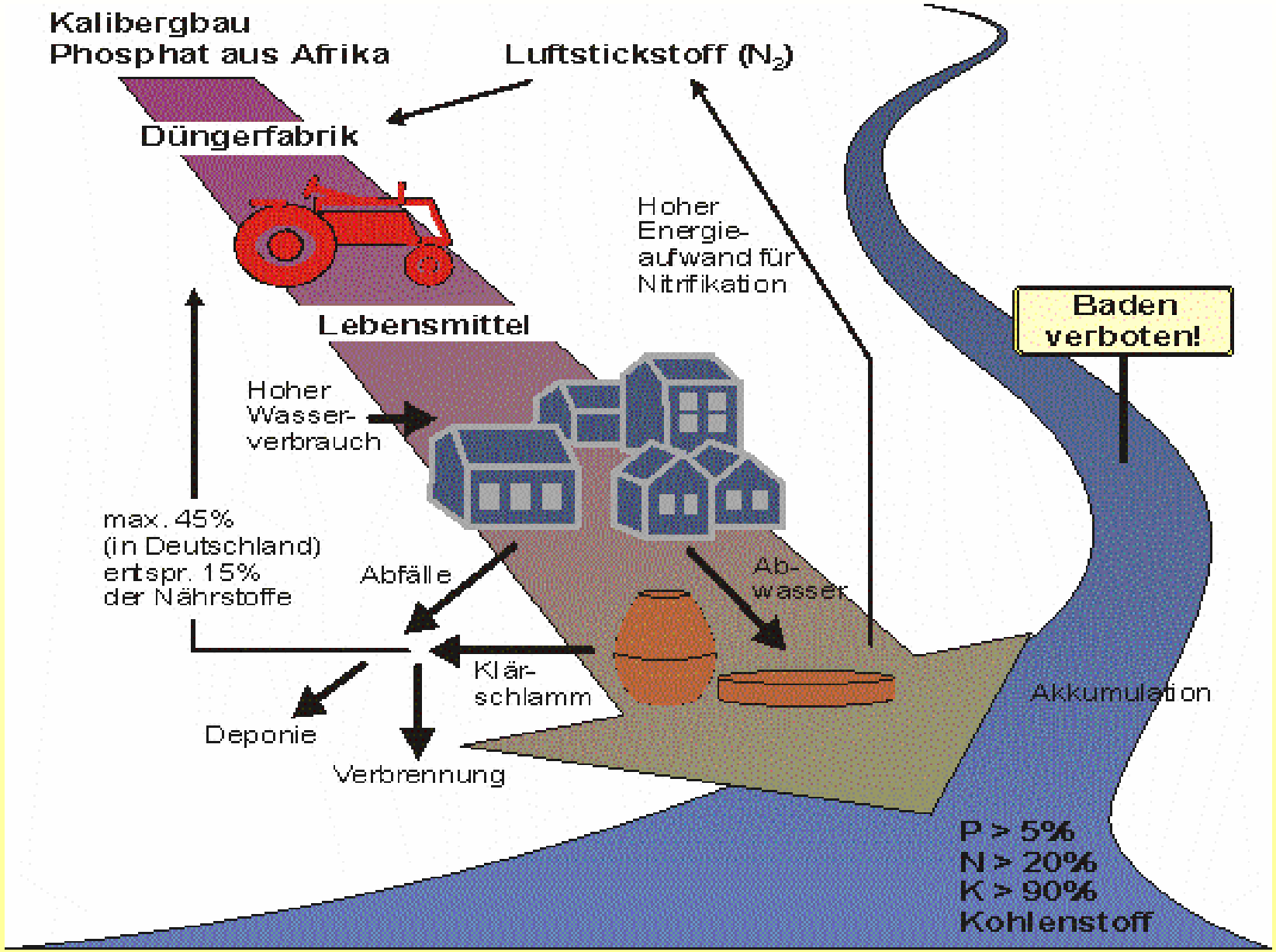


The Human Nutrients cycle - Broken

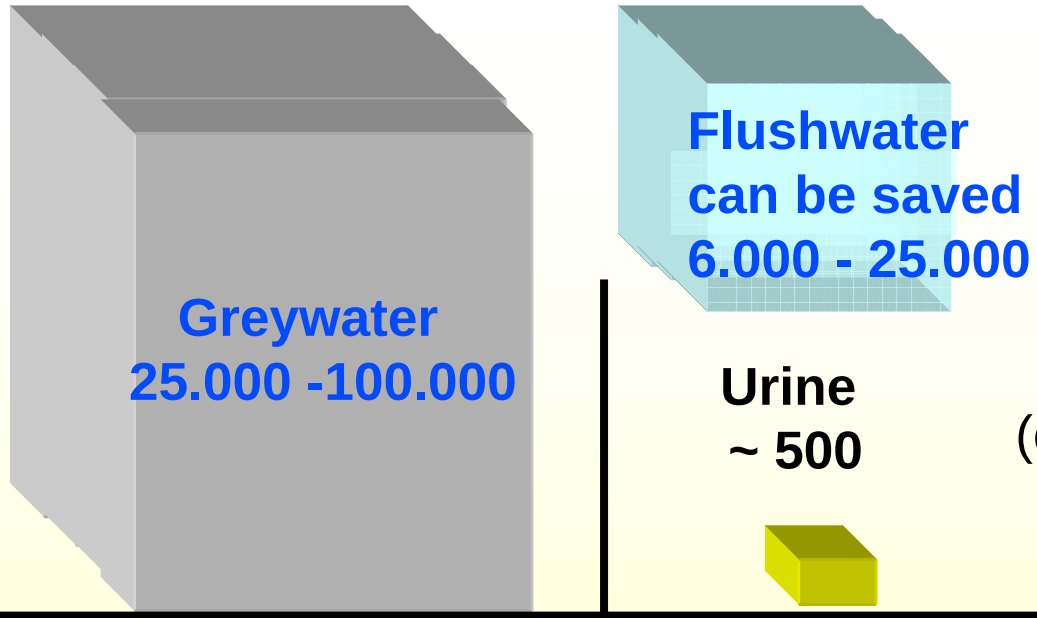
(Source: Jenkins, 1994)

water for
all purposes...

Monsoon:
how does a sewerage system perform?


Kalibergbau
Phosphat aus Afrika
Luftstickstoff (N_2)
Düngerfabrik
Hoher Energie-aufwand für Nitrifikation
Baden verboten!
Lebensmittel
Hoher Wasser-verbrauch
max. 45% (in Deutschland) entspr. 15% der Nährstoffe
Abfälle
Ab-wasser
Klär-schlamm
Deponie
Verbrennung
Akkumulation
P > 5%
N > 20%
K > 90%
Kohlenstoff

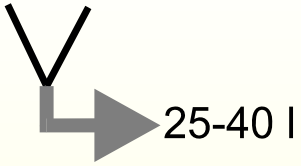
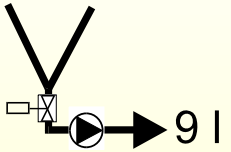
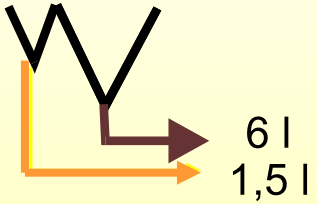
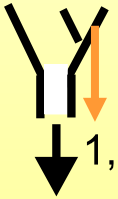
TUHH
Technische Universität Hamburg-Harburg



Yearly Loads kg/(P*year)		Greywater 25.000 -100.000	Urine ~ 500	Feaces ~ 50 (option: add biowaste)
N	**~ 4-5**	~ 3 %	~ 87 %	~ 10 %
P	**~ 0,75**	~ 10 %	~50 %	~ 40 %
K	**~ 1,8**	~ 34 %	~ 54 %	~ 12 %
COD	**~ 30**	~ 41 %	~ 12 %	~ 47 %
S, Ca, Mg and trace elements		Treatment ↓ Reuse / Water Cycle	Treatment ↓ Fertiliser	Biogas-Plant Composting ↓ Soil-Conditioner

Geigy, Wiss. Tabellen, Basel 1981, Vol. 1, LARSEN and GUJER 1996, FITSCHEN and HAHN 1998

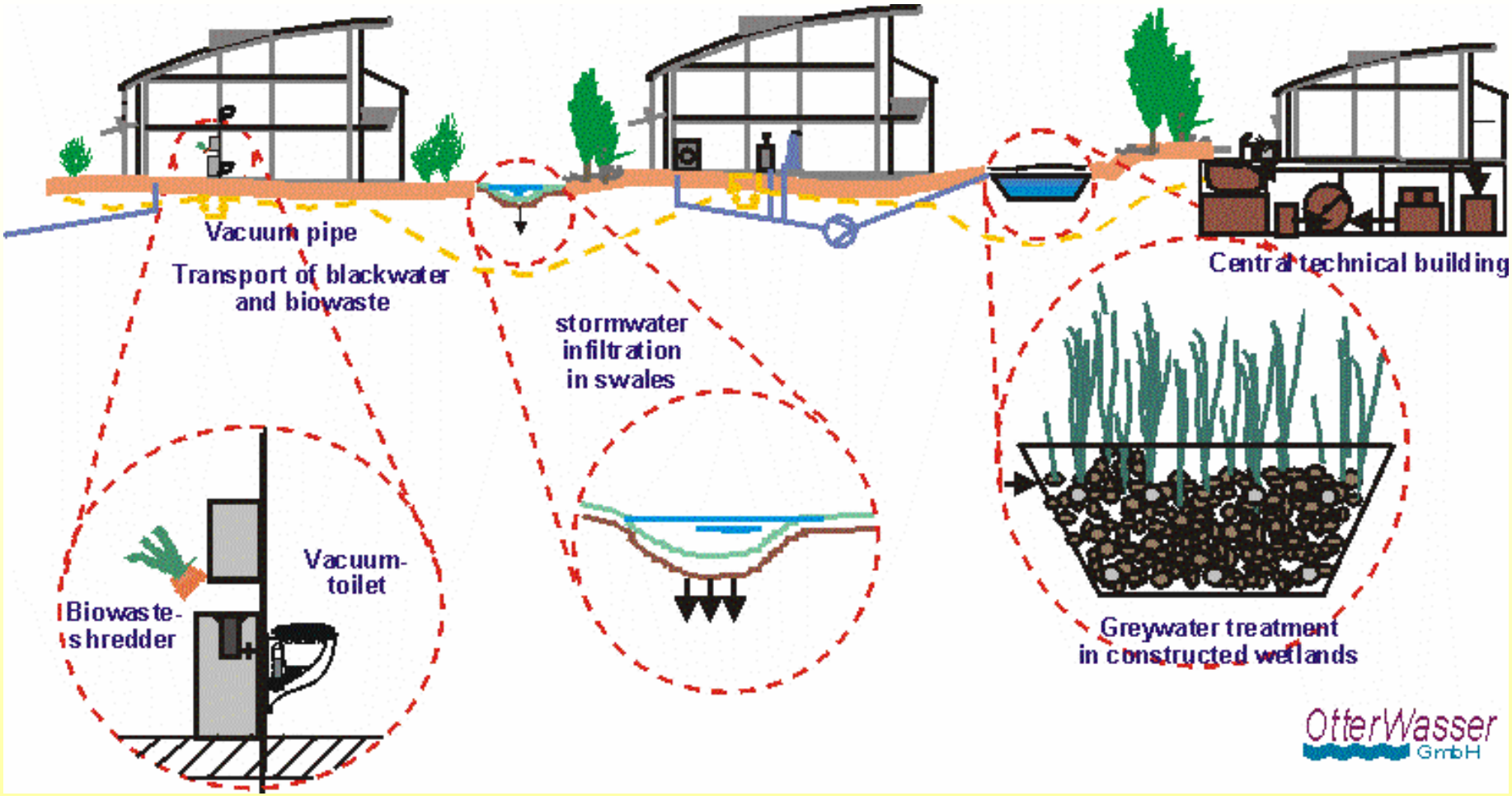
Toilets and resulting Dilution

Type of Toilet	Daily Flow per P.	Pro and Con's
Flushing toilet		+ widely accepted - waste of water - high dilution
Vacuum-toilet		+ low water demand + well developed (ships) - high-tec / expensive
Separating toilet		+ little water / little dilution + simple fertiliser reuse - little experience
Waterless Urinal		+ no water / no dilution - maintenance required
Composting-toilet Desiccation toilet	 	+ no water needed - high space demand - maintenance needed ++ Desiccation for hot climates

Ecological Settlement Lübeck-Flintenbreite

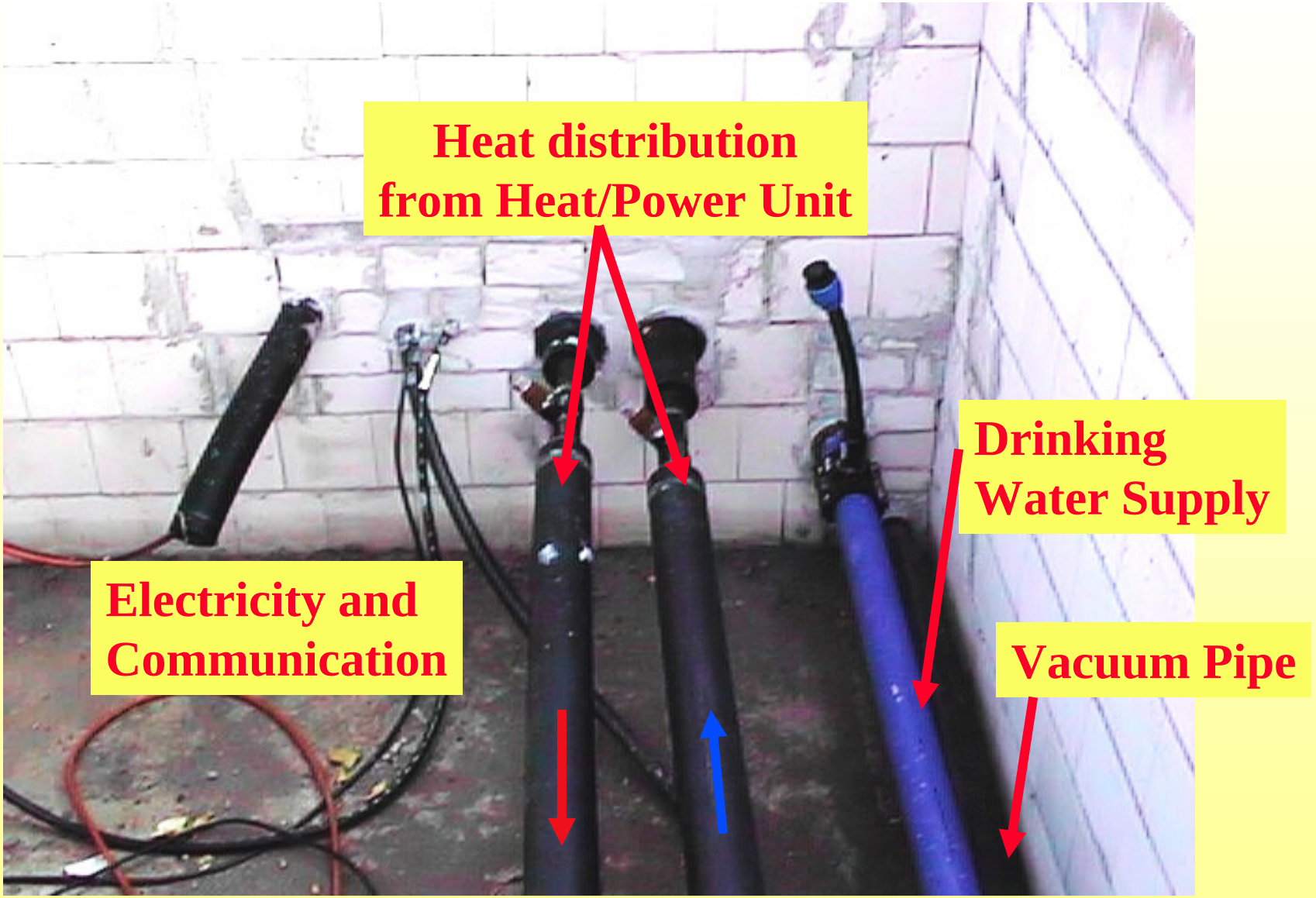
Double-Houses

Terraced Houses



Peri-Urban Settlement Lübeck-Flintenbreite (400 inhabitants)
Vacuum-Biogas-System for Blackwater plus Biowaste
Otterwasser GmbH, Lübeck www.otterwasser.de

Lübeck-Flintenbreite



Otterwasser GmbH, Lübeck, Germany

Community Building with central technical Devices Lübeck-Flintenbreite

Cellar: Vacuumstation, Biowaste Grinder, Hygienisation, Biogas Plant
Above ground: Seminar/Party room, Office, 4 Flats and HPG
(Otterwasser GmbH, Lübeck, Germany)

design by
Otterwasser GmbH, Lübeck
www.otterwasser.de

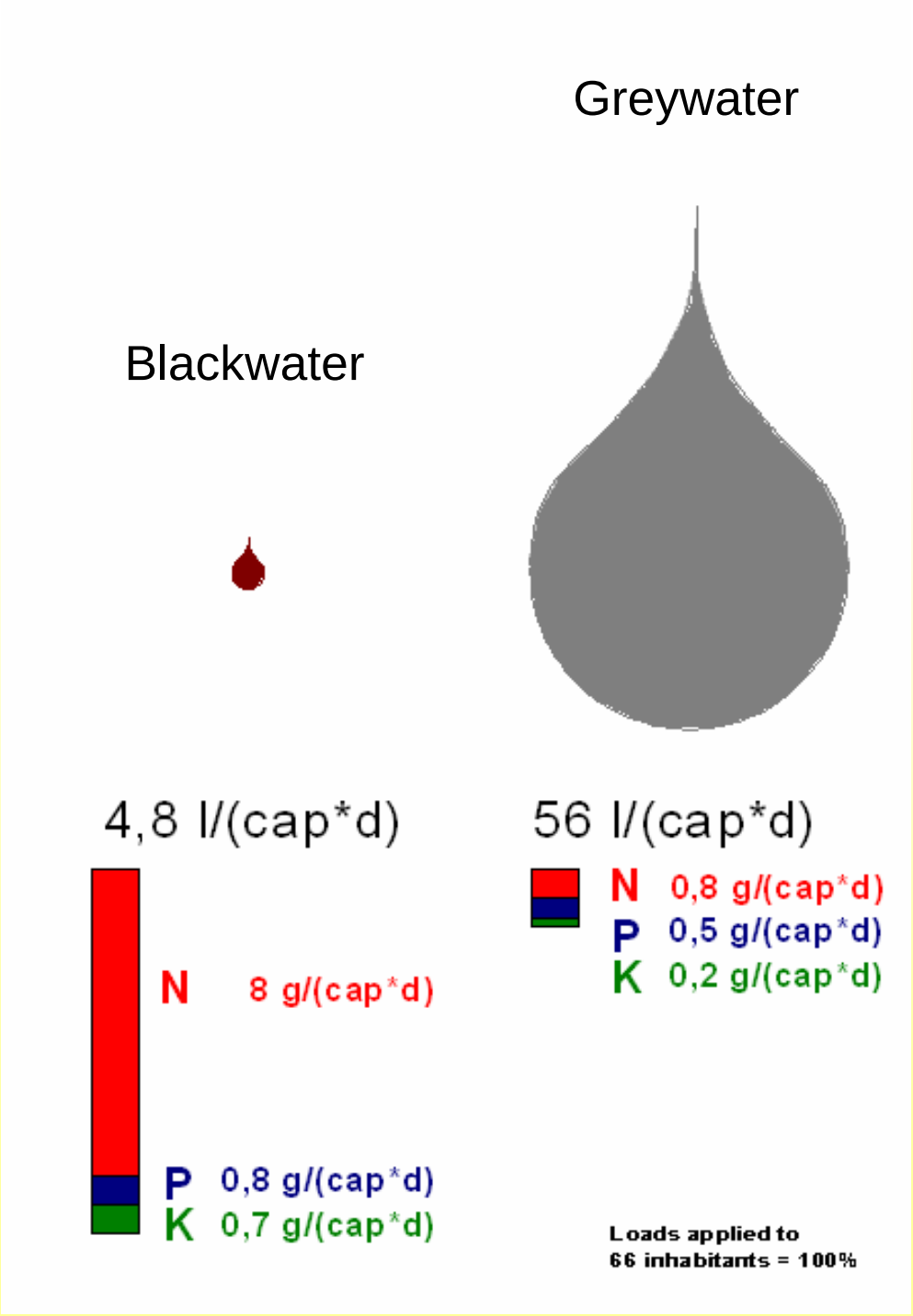
Vacuum Pumping Station for Blackwater

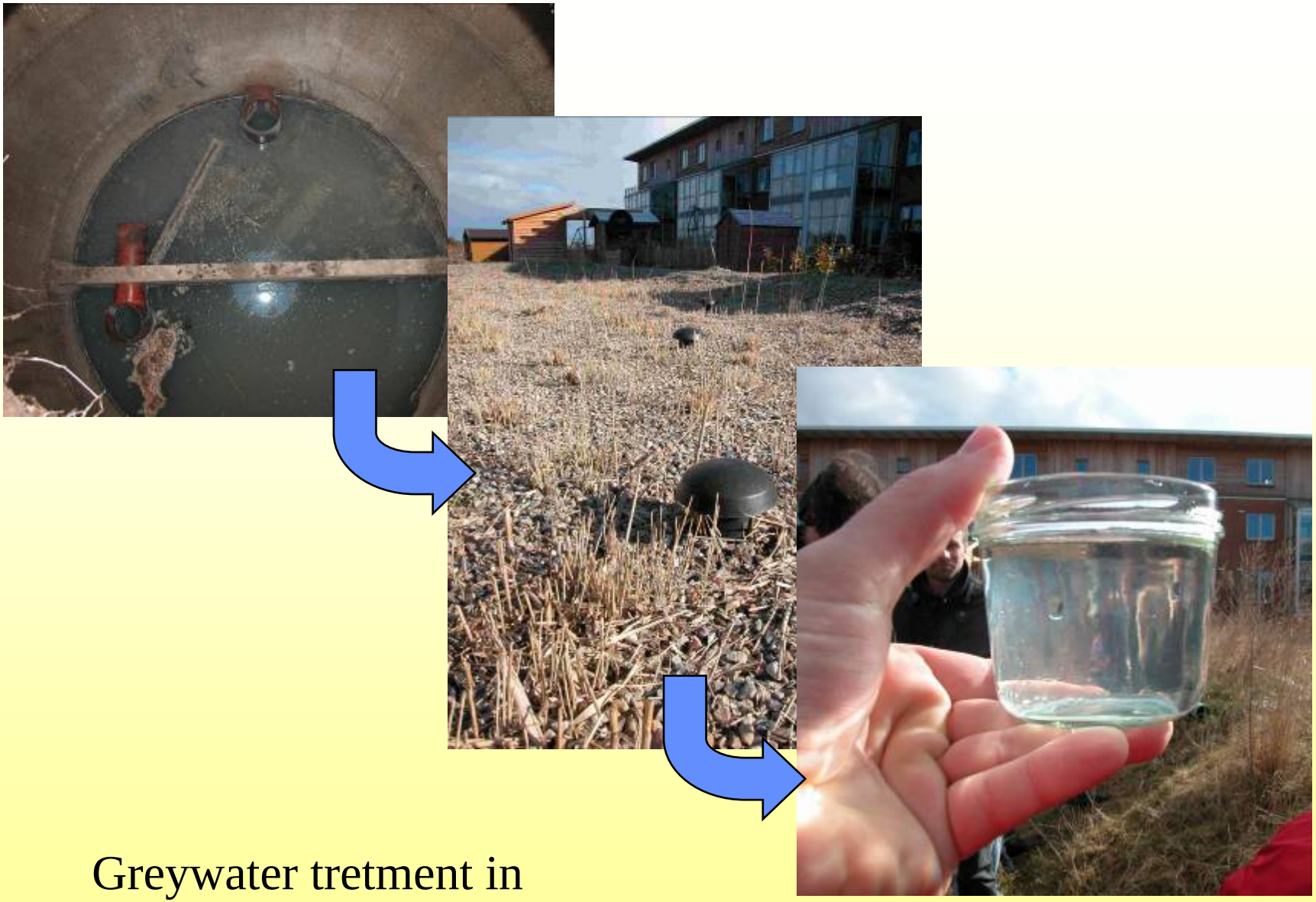
Sanitisation tank

Bio-Waste In
and Grinde

Nutrient loads in blackwater and greywater

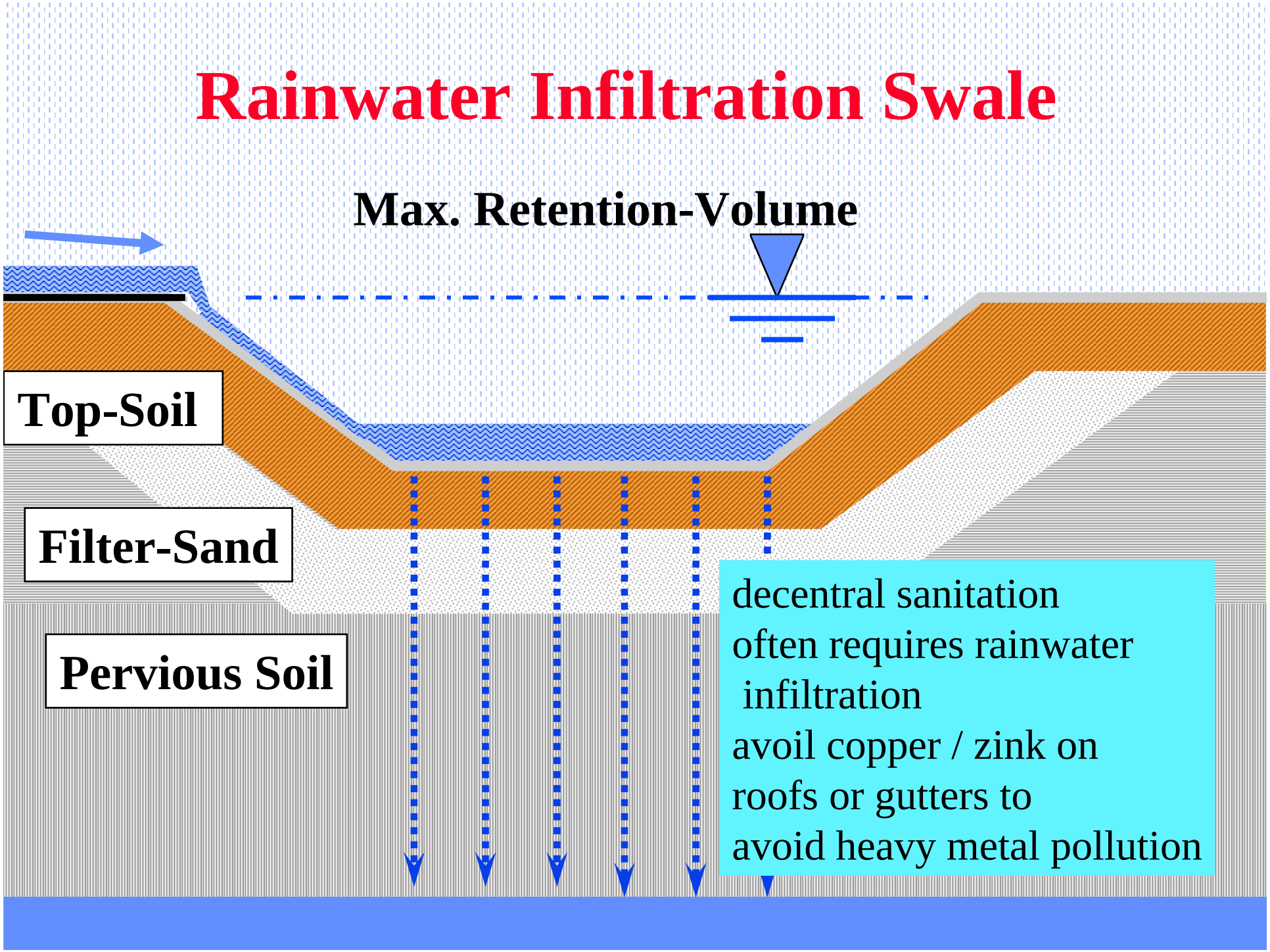
Lübeck Flintenbreite





Greywater tretment in
constructed wetlands

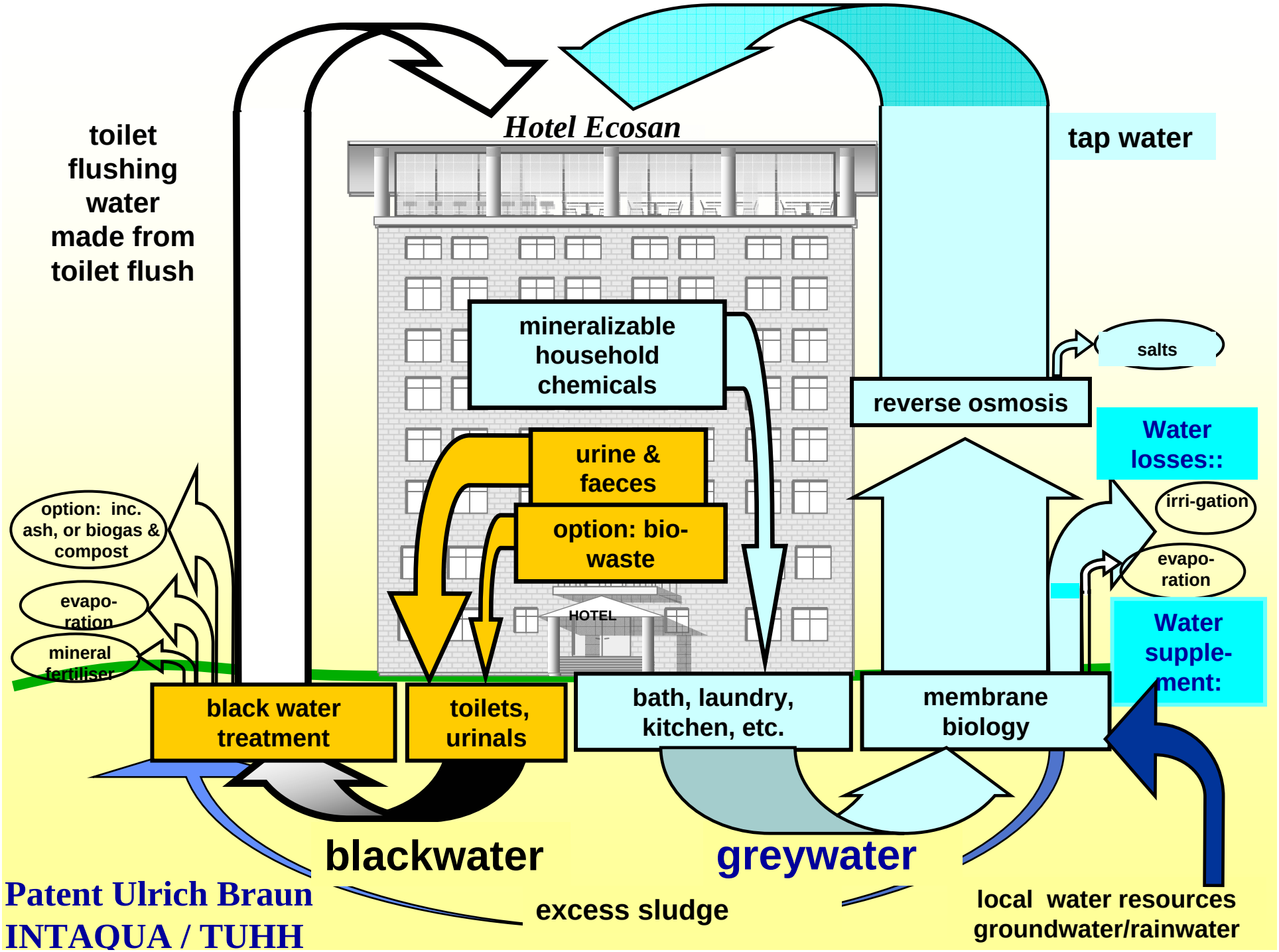
Rainwater Infiltration Swale



Project Freiburg Vauban, Germany:
Arbeiten & Wohnen

Vacuum-Biogas-System for Blackwater/Biowaste
(One of the most energy-efficient houses worldwide)
ATURUS, Jörg Lange, Freiburg, Germany

www.vauban.de/aturus

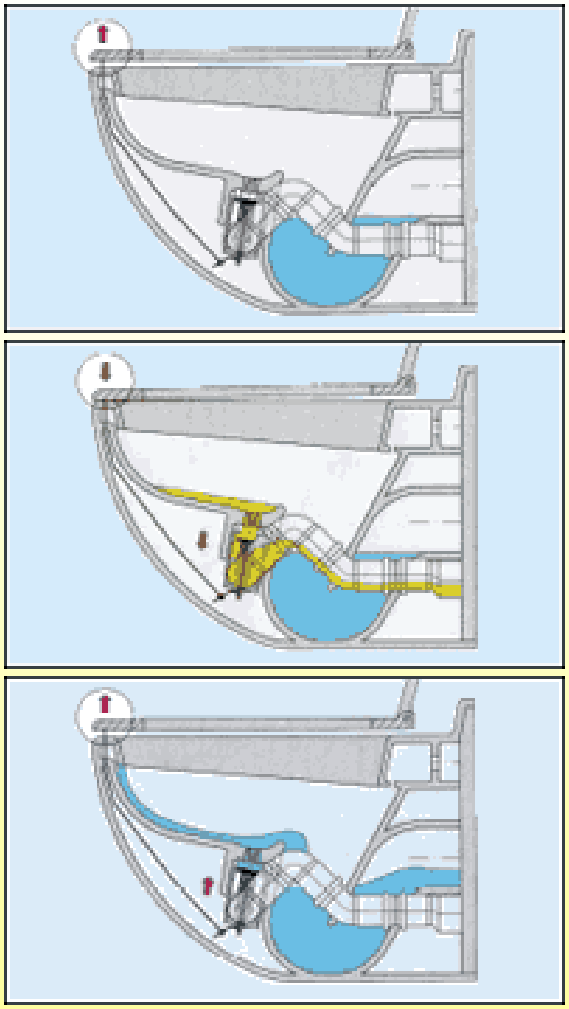

Hotel Ecosan
toilet flushing water made from toilet flush
tap water
mineralizable household chemicals
salts
reverse osmosis
Water losses::
urine & faeces
option: bio-waste
irri-gation
evapo-ration
option: inc. ash, or biogas & compost
evapo-ration
mineral fertiliser
HOTEL
Water supple-ment:
black water treatment
toilets, urinals
bath, laundry, kitchen, etc.
membrane biology
blackwater
greywater
excess sludge
local water resources groundwater/rainwater
Patent Ulrich Braun
INTAQUA / TUHH

Blackwater digestion
research project of the
Institute of Wastewater Management
www.tuhh.de/aww

TUHH

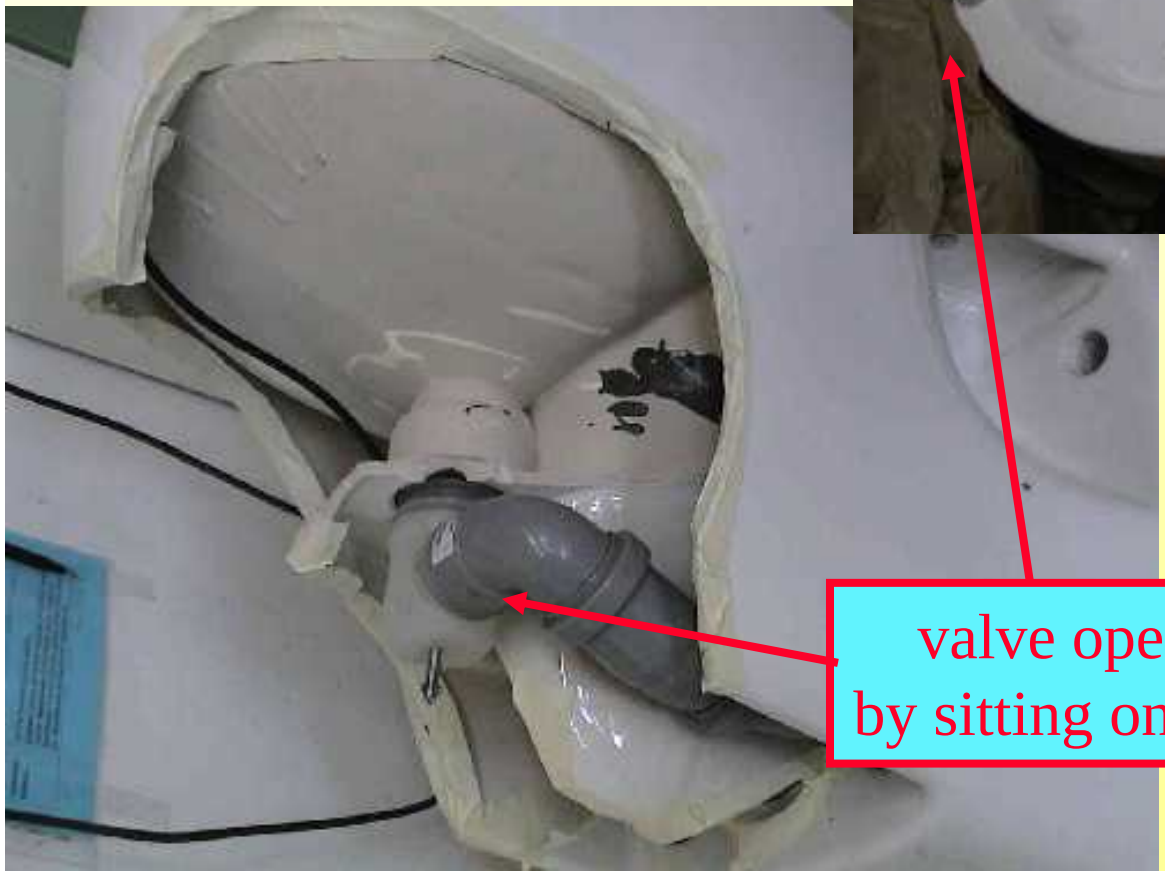
Technical University Hamburg-Harburg

Roediger Sorting-Toilet



Non-diluting Urine collection www.roevac.de

Roediger Sorting-Toilet
waterless urine collection
patented by Ulrich Braun,
INTAQUA AG



valve opened
by sitting on lid

Gustavsberg Sorting-Toilet

Urine sorting (house of Prof. Otterpohl, Germany)

No-Mix-Toilet with children seat BB innovation, Sweden

Settlement „Palsternackan“, Sweden

Urine-Sorting Toilets and Yellow Water collection

Pilot Project “Lambertsmühle”

Initiative and Finance:
- Wupperverband and Verein Lambertsmühle

Develpement of the Sanitation Concept
- Otterwasser GmbH, Lübeck

Scientific consultation
- TUHH Inst. of Wastewater Management

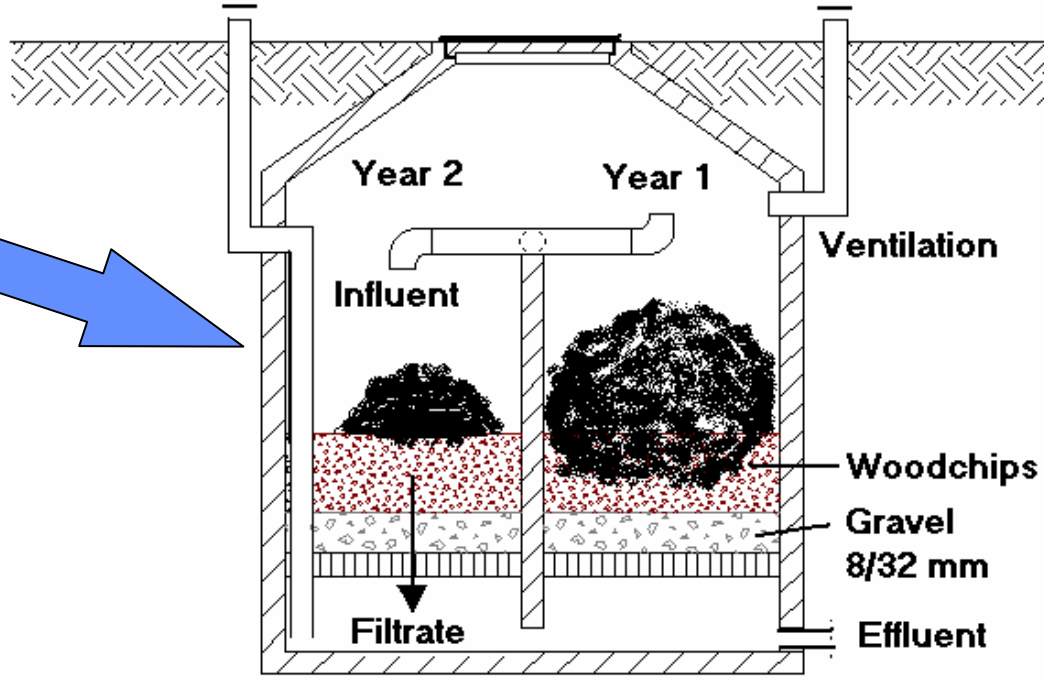
Elements of the Sanitation Concept:
- Urine-sorting Toilets and waterless Urinals
- Storage Tank for Yellow Water
- Pre-Composting Tank (2 chambers, Filter Bags)
- Constructed Wetland for filtered Grey- and Brownwater

....adopted from the Swedish experience

Urine-Tank
10 Persons
(Glass-Resin)

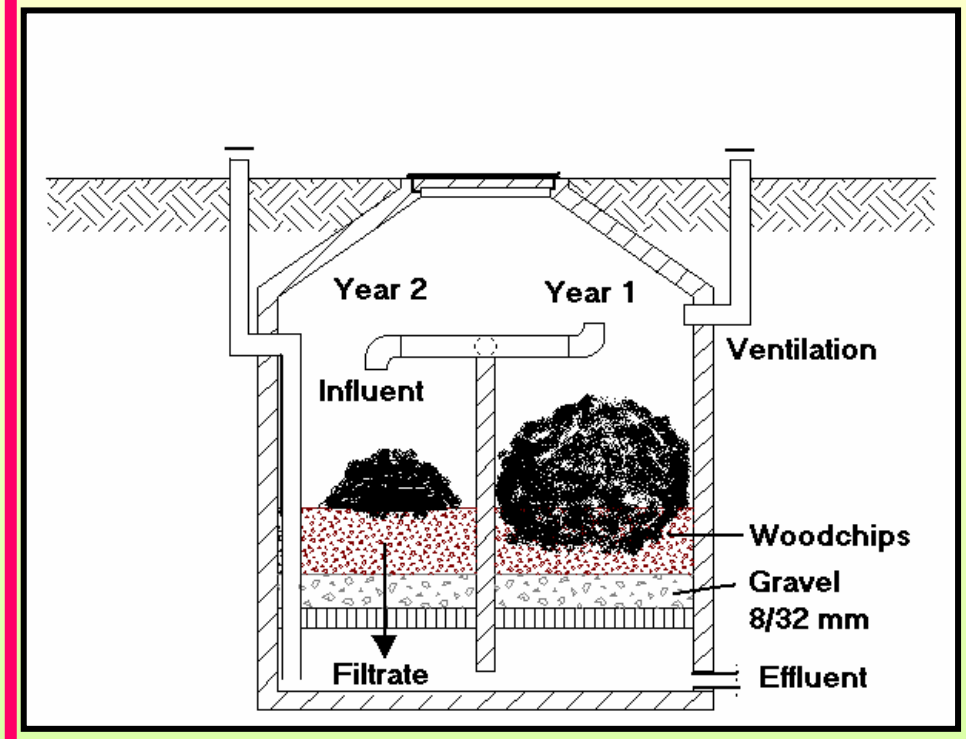
2-Chamber Composting Tank

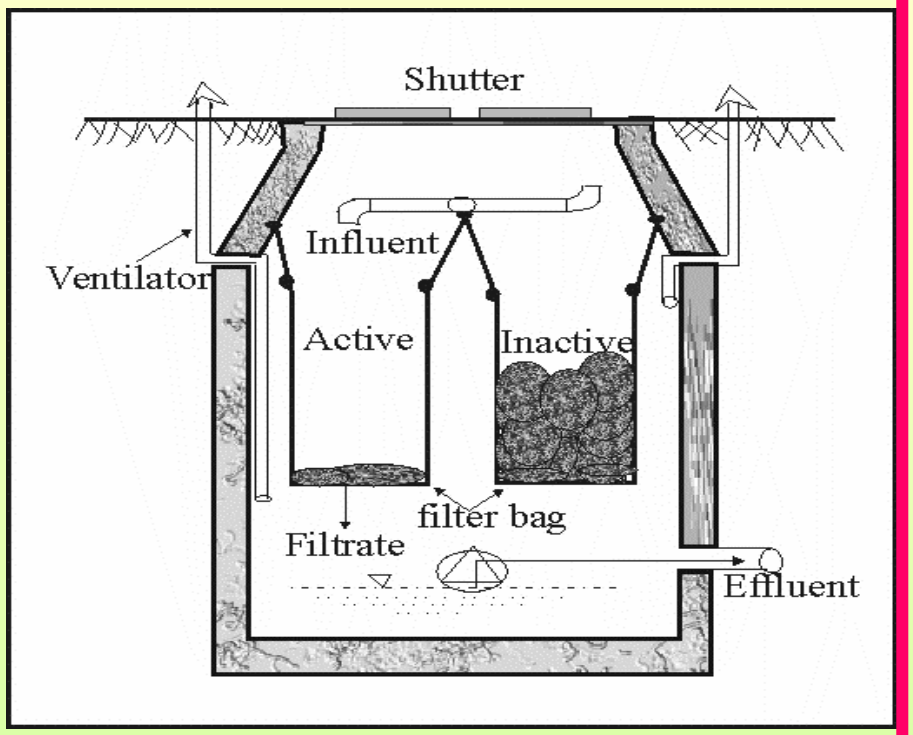
(Rottebehälter)



Research by TUHH
Technical University Hamburg
Prof. Dr.-Ing. Ralf Otterpohl
www.tuhh.de/aww

Brown water treatment and reuse





2-filter beds system

2-filter bags system

Pre-composting Tank or Rottebehaelter

+ small volume of solids
+ simple dewatering
+ little risk of methane emissions

- loss of water level
- post composting needed
- addition of bulking agent

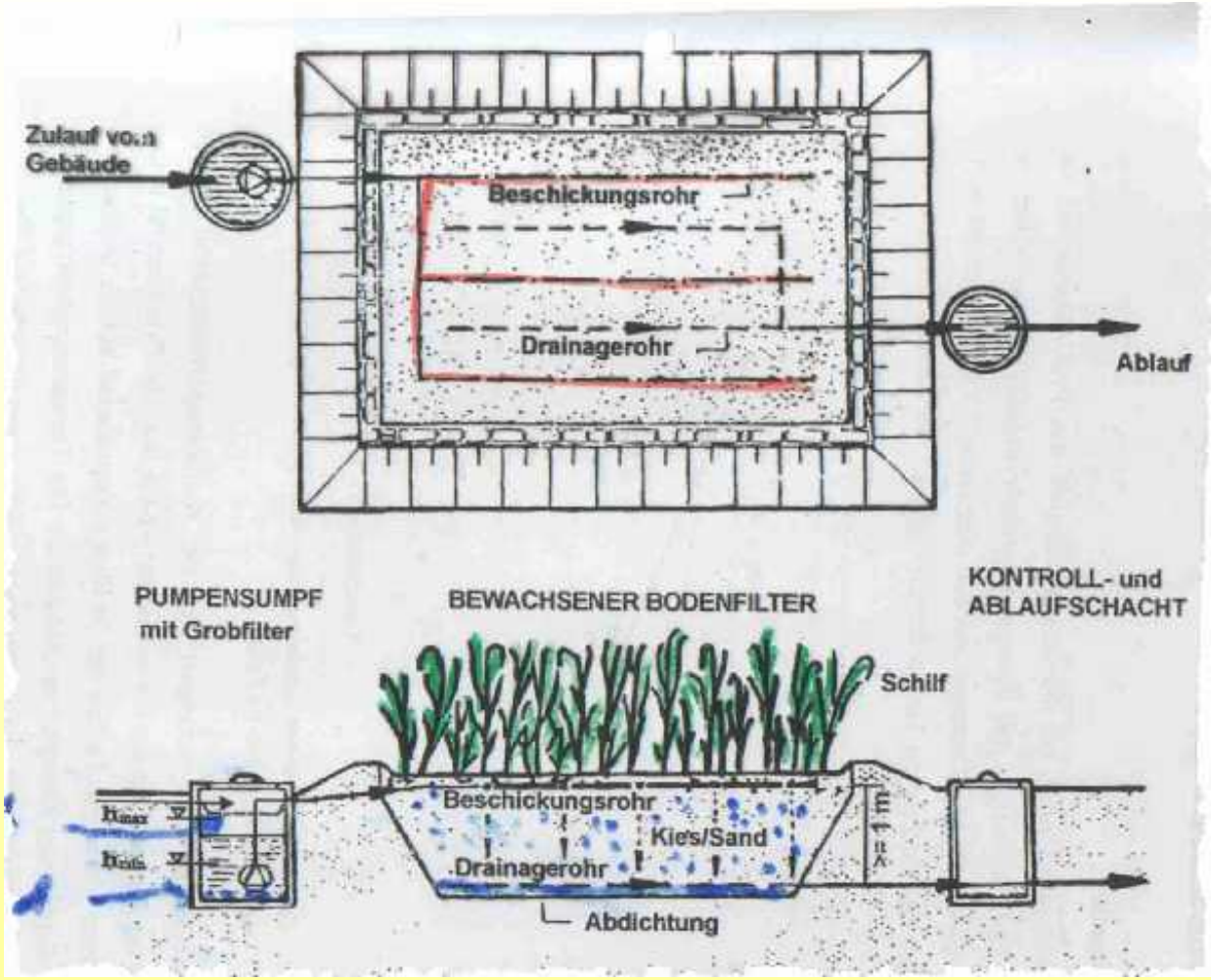

Rottebehaelter

pre-composting tank
research project of the
Institute of Wastewater Management
www.tuhh.de/aww

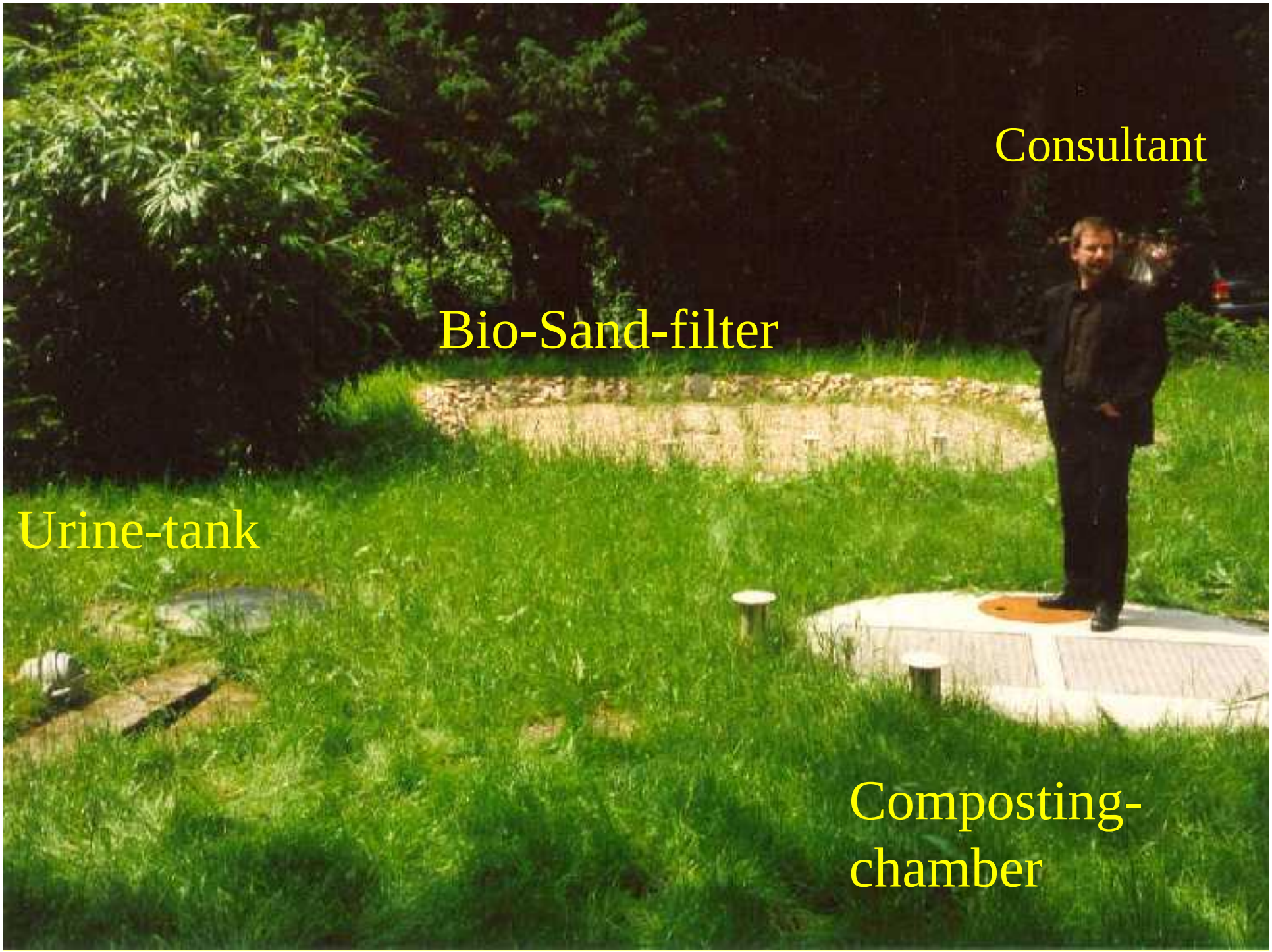
TUHH
Technical University Hamburg-Harburg

Constructed Wetland / Bio-Sandfilter:

1. vertical flow 2. water level at bottom 3. intermittant feeding



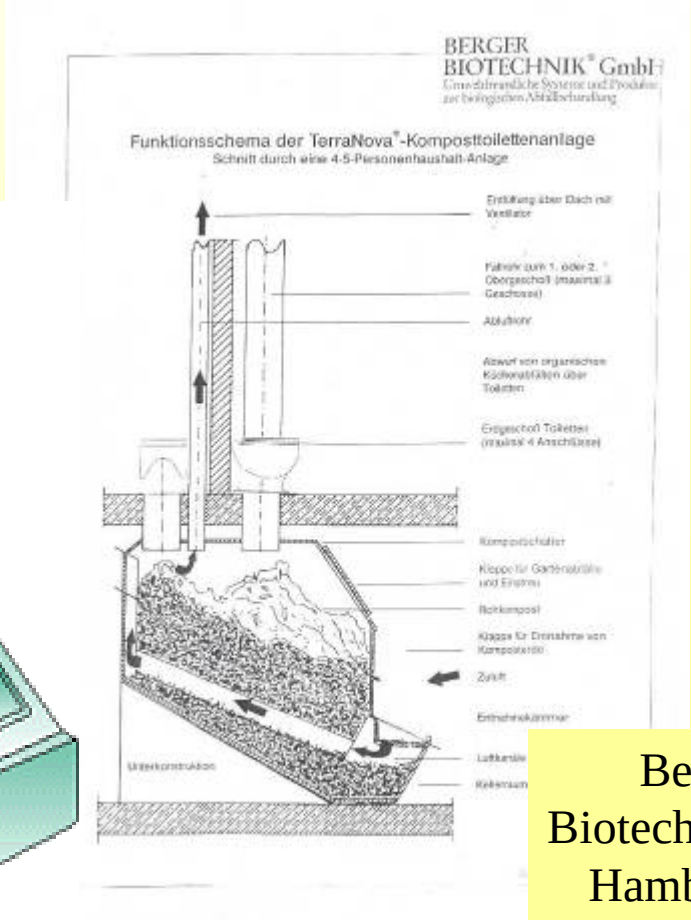
Otterwasser GmbH, Lübeck


Consultant
Bio-Sand-filter
Urine-tank
Composting-
chamber

Composting-toilets

- maintenance cruicial for function, some failures
- better with urine diversion and controlled moisturing
- rural and peri-urban areas

Clivus Multrum



Berger Biotechnik, Hamburg

One GRAM of faeces can contain

- **10,000,000 Viruses**
- **1,000,000 Bacteria**
- **1,000 Parasite cysts**
- **100 Parasite eggs.** (source: UNESCO, 2001)

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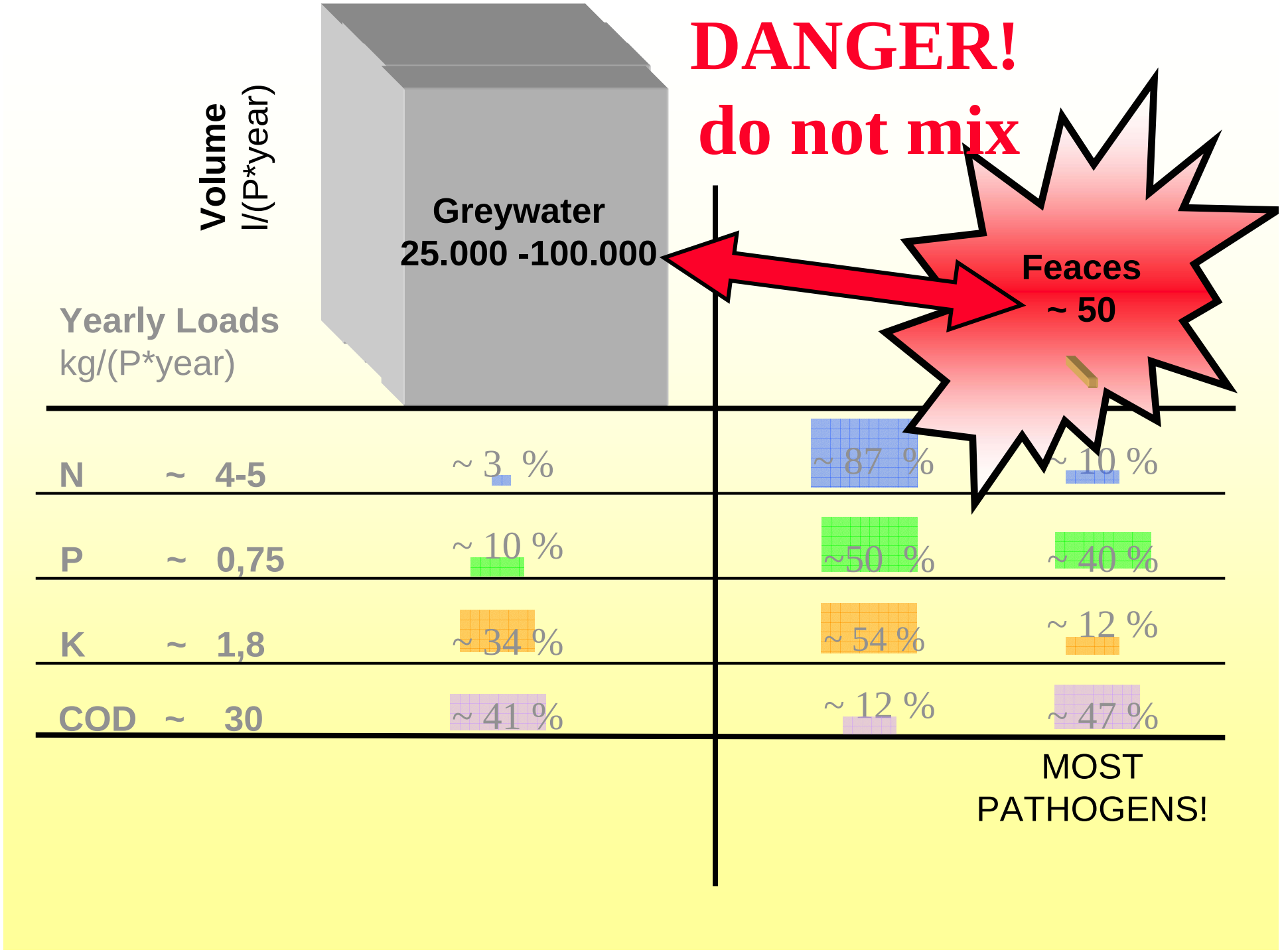
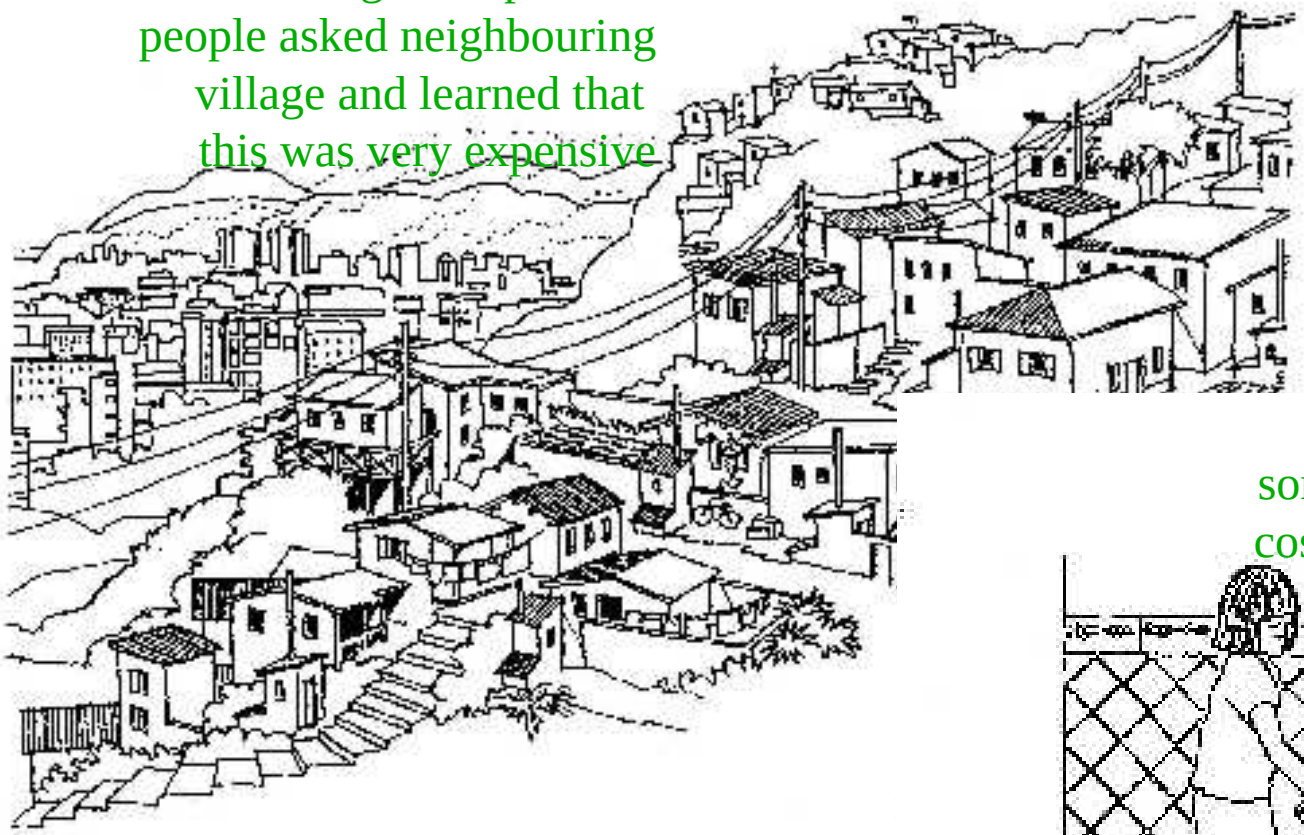
5 MILLION people die of polluted water every year (WHO)

Hygiene easy and cheap:
Separation of faeces


DANGER!
do not mix
Volume
l/(P*year)
Greywater
25.000 -100.000
Feaces
~ 50
Yearly Loads
kg/(P*year)
N ~ 4-5
~ 3 %
~ 87 %
~ 10 %
P ~ 0,75
~ 10 %
~50 %
~ 40 %
K ~ 1,8
~ 34 %
~ 54 %
~ 12 %
COD ~ 30
~ 41 %
~ 12 %
~ 47 %
MOST
PATHOGENS!

central sewerage was planned
people asked neighbouring
village and learned that
this was very expensive



the earth toilets with urine
sorting made fertilizer available
costs where 1/3rd of neighbours

Dry Sanitation in Mexico
from Esrey et al.,
Ecological Sanitation, 1998


Espacio de Salud
Cuernavaca, Morelos
MEXICO

Photo: César Añorve

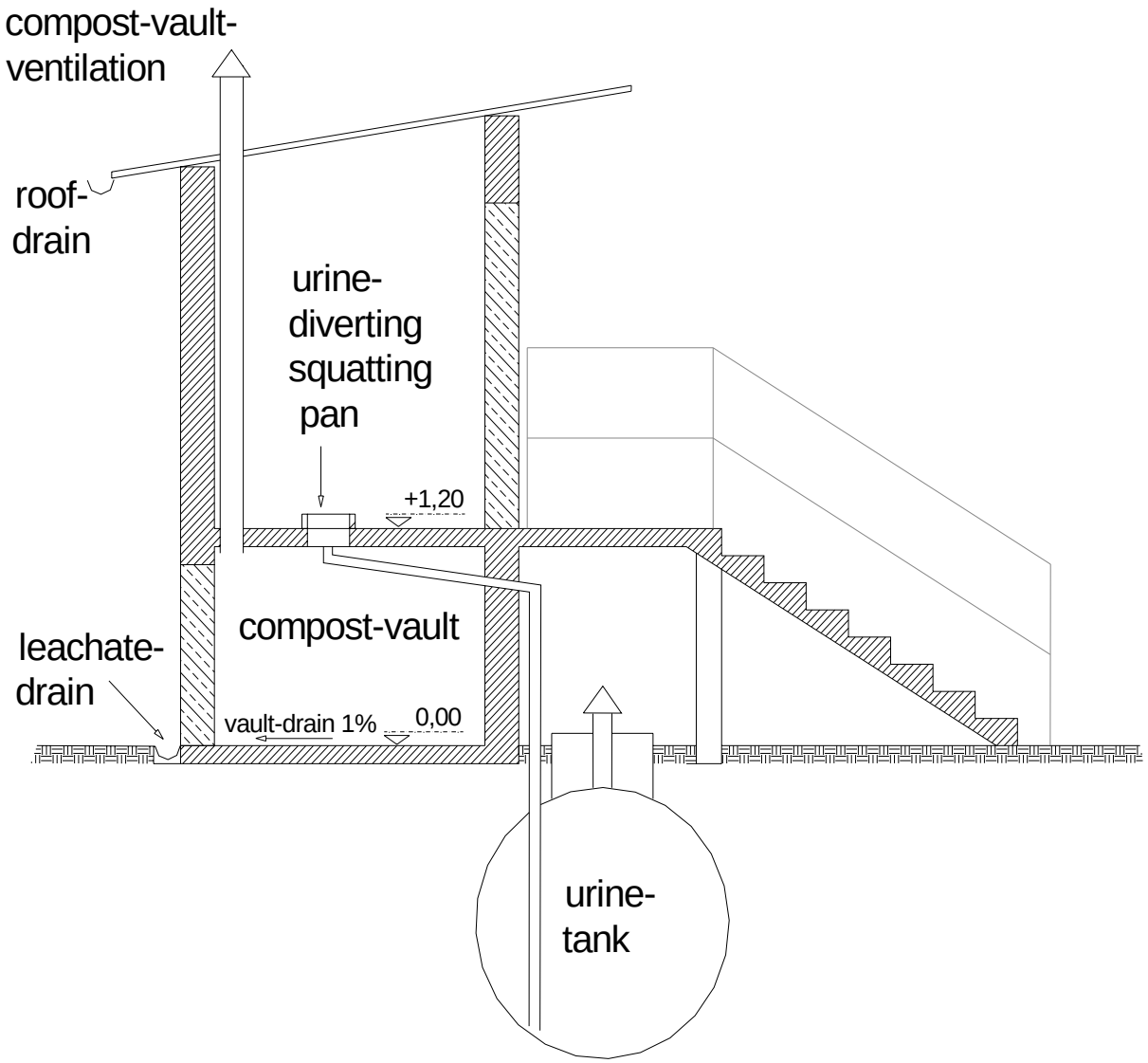
local production created job
and keeps money in the regio

Case-Study:

Garla Mare, Romania

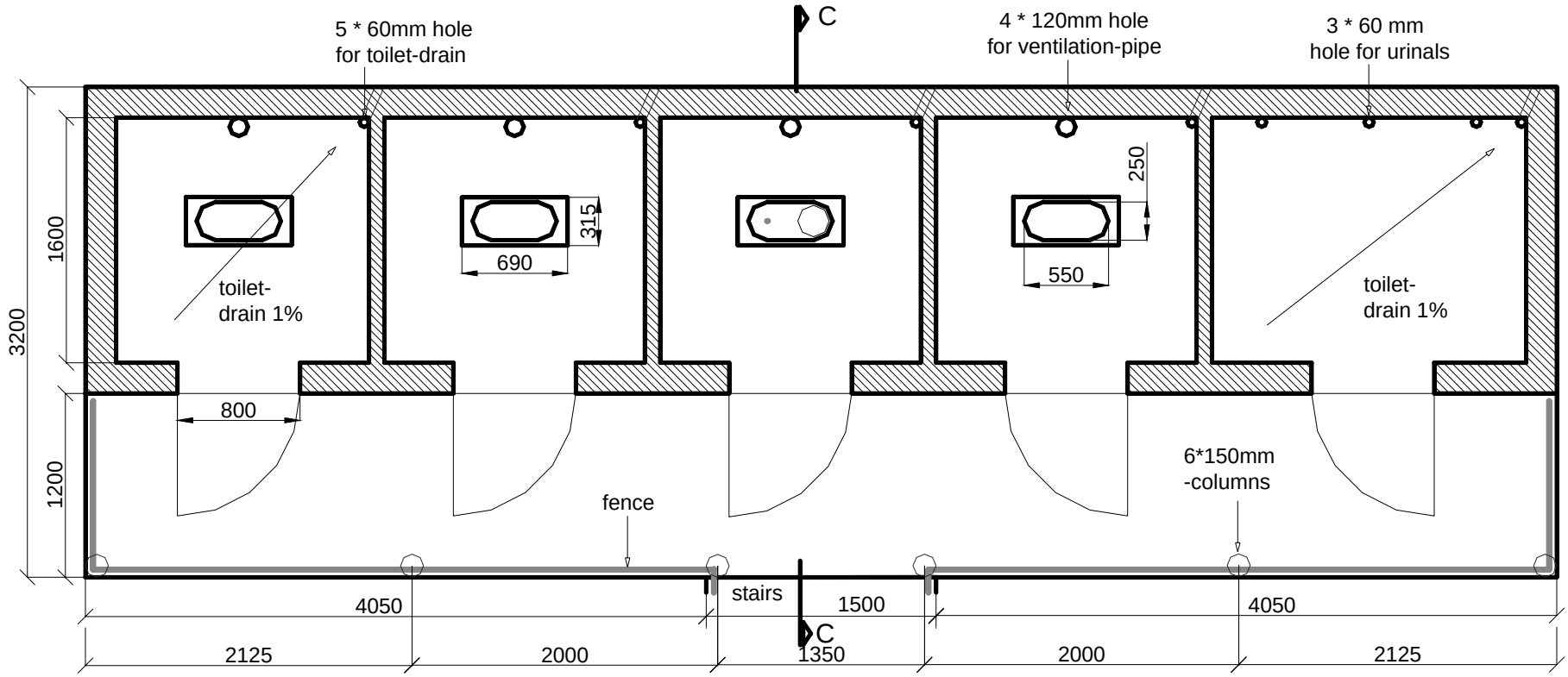
Design and implementation
TUHH with WEFC (Women in Europe, NL, NGO)
Operates with success, demand for fertiliser

Cross-section toilet-house



Toilet for school

section A-A: Toiletroom-ground



Equipped with the chinese squat toilet seat of Lin Jiang, Nanning

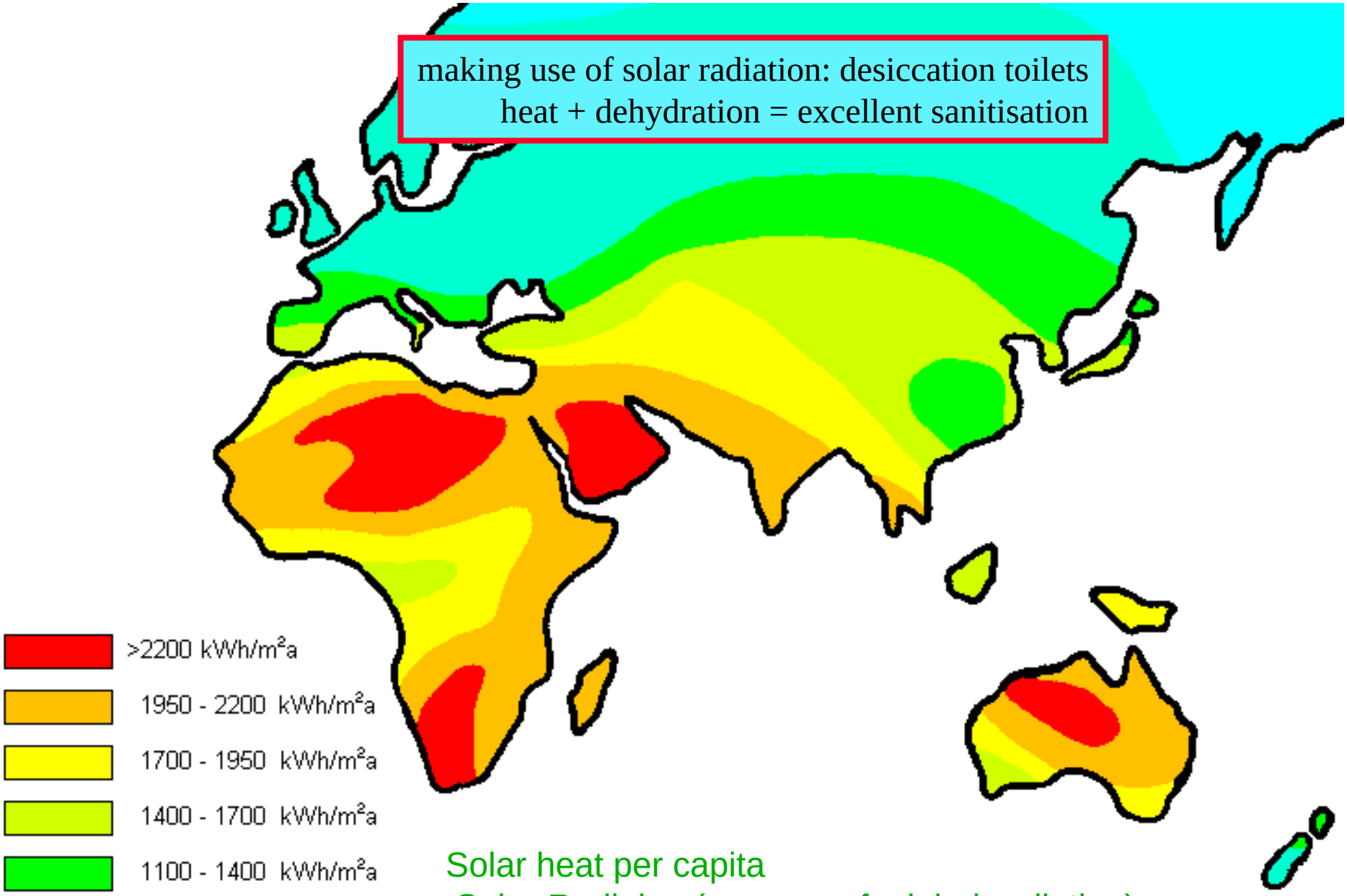
Finished Toilethouse in Romanian school

Urine tank, 2x6 month

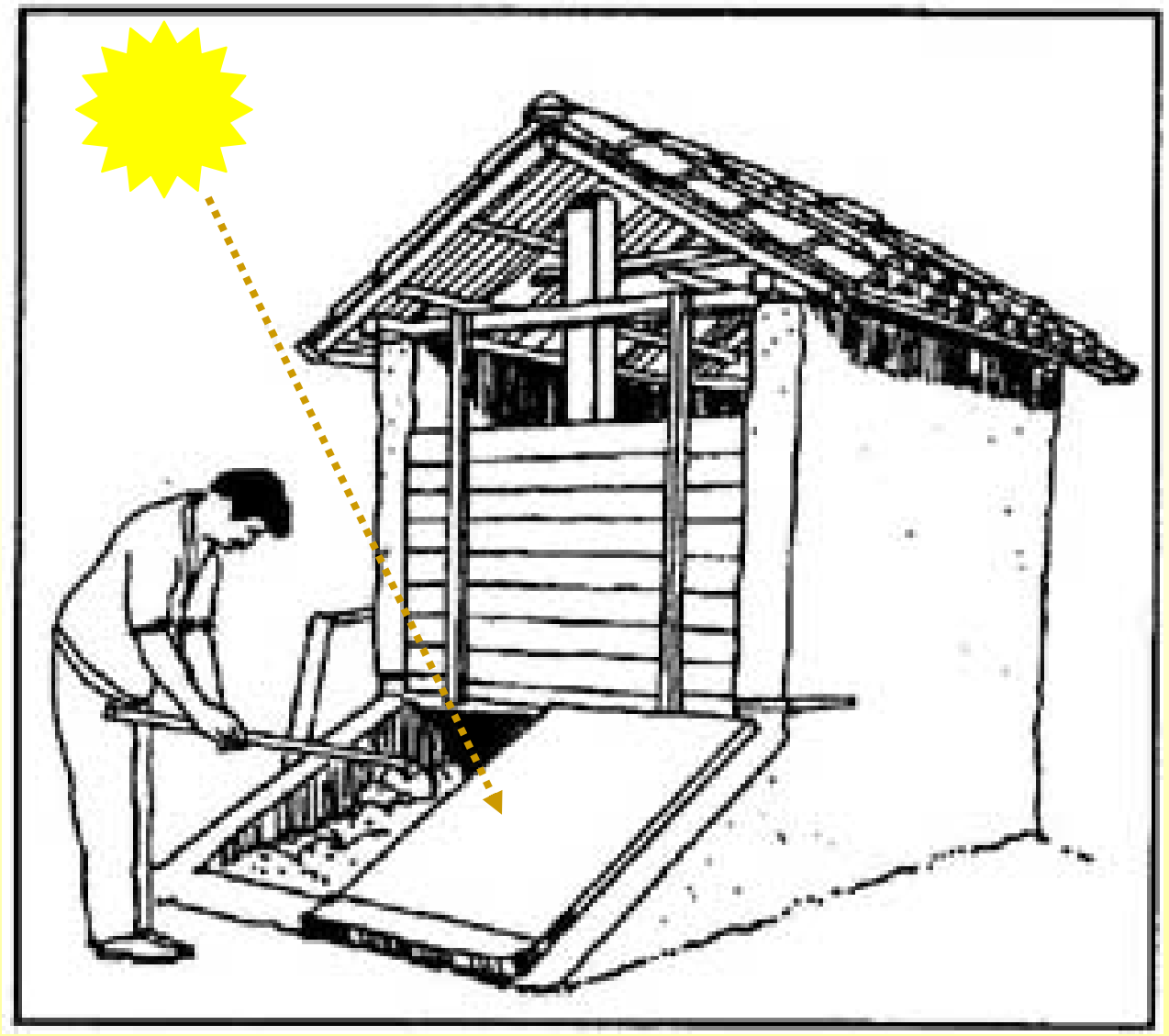
Better NO ventpipes for urine-tank, small hole sufficient

Finished Toilethouse in Romanian school

making use of solar radiation: desiccation toilets
heat + dehydration = excellent sanitisation



Solar heat per capita
Solar-Radiaion (average of global-radiation)
Source: World Energy Council, am 27.11.01



Solar Desiccation-Toilet

Low-Tech, very cheap, little maintainance required

(from Esrey et al., Ecological Sanitation, SIDA 1998)

the principles:

- building above ground to avoid water contact
- 2 chambers, each used for one year
- urine sorting required usage in agriculture
- ash/soil/lime can be added
- long term maintenance is the key to success

special care needed in societies with wet anal cleansing, separate bowl for washing

De-siccation Toilet
Mali, West Africa
GTZ / Otterwasser GmbH

Solar desiccation of feaces, Mali, West Africa (GTZ / Otterwasser)


design: Lin Jiang, China

Lin Jiang, Nanning, China

EcoSanRes,
China pilot projects

Each chamber/toilet is used for 6 to 12 month and idle for the same period www.ecosanres.org

EcoSanRes,
China pilot projects

Fertiliser usage in China

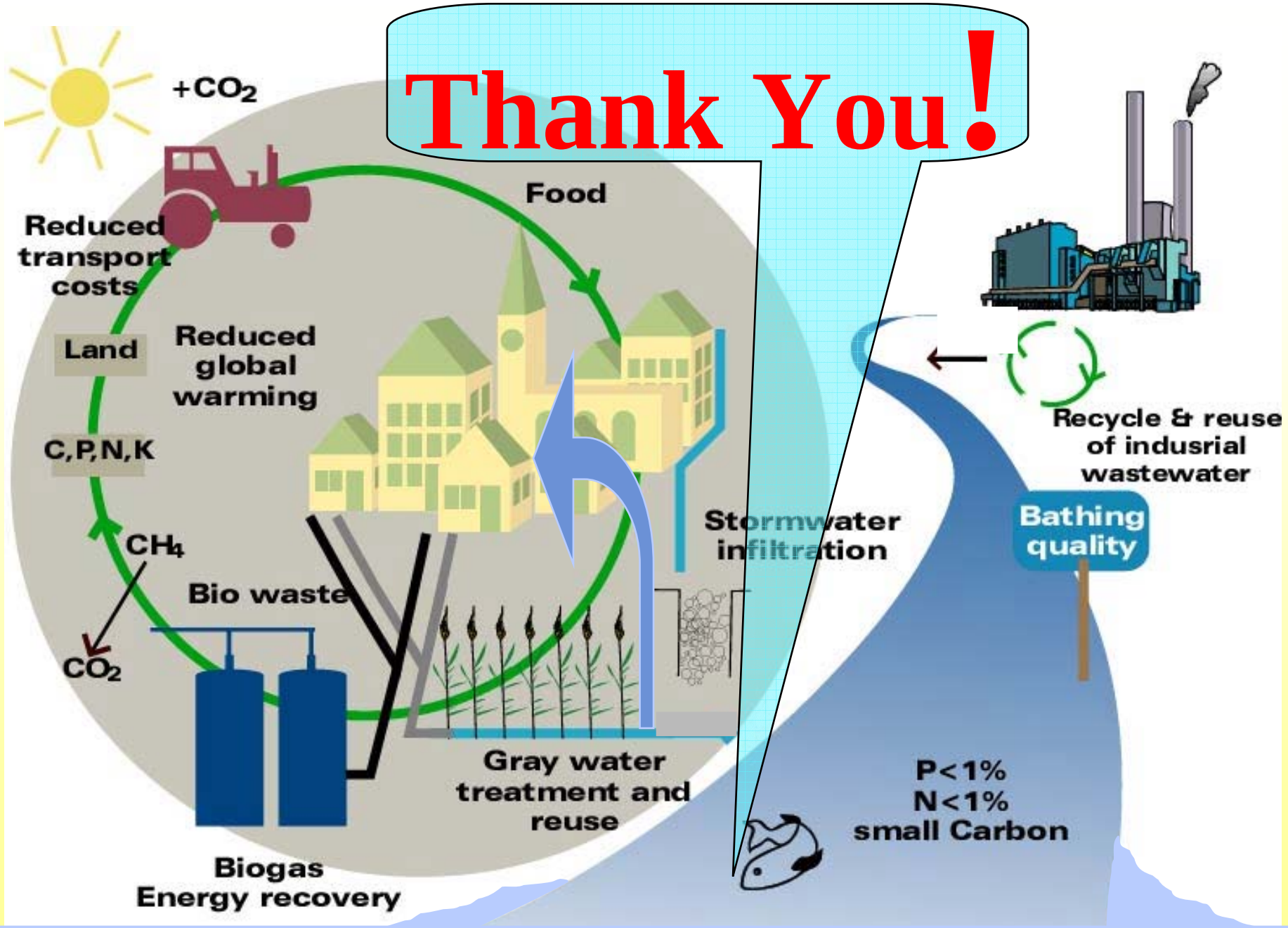
Blackwater of 900 Mio. rural Chinese people

450 Mio tons of organic Fertiliser

Potential savings on commercial Fertilisers:
2,6 Billion US$ per year!

In addition soil improvement, protection of inland waters and the seas....

UNESCO, 2001



Ecological Sanitation: www.tuhh.de/aww and /susan www.gtz.de/ecosan www.ecosanres.org

Ecological Sanitation Options for different geographical and socio-economic conditions

Dry Toilets	**comments:**
• simple Bucket systems	rural low cost
• Pre-Composting-Toilets	more comfortable
• Large Chamber Composters	too wet or too dry
• Solar Desiccation Toilets (2 chambers)	hot climates, paper
• Earth Toilets (2 chambers)	comfortable
•	
Flush Toilets	
• Urine-Sorting in decentral and central systems	main step of nutient recovery
• Vacuum-Toilets and Transport	dense population
• Low-Flush with ‚Booster‘	more dilution
• Conventional Flush Sanitation and real agricultural reuse (nutrients)	ww not exclusive water source, HM