Waste Water Reuse in Buildings

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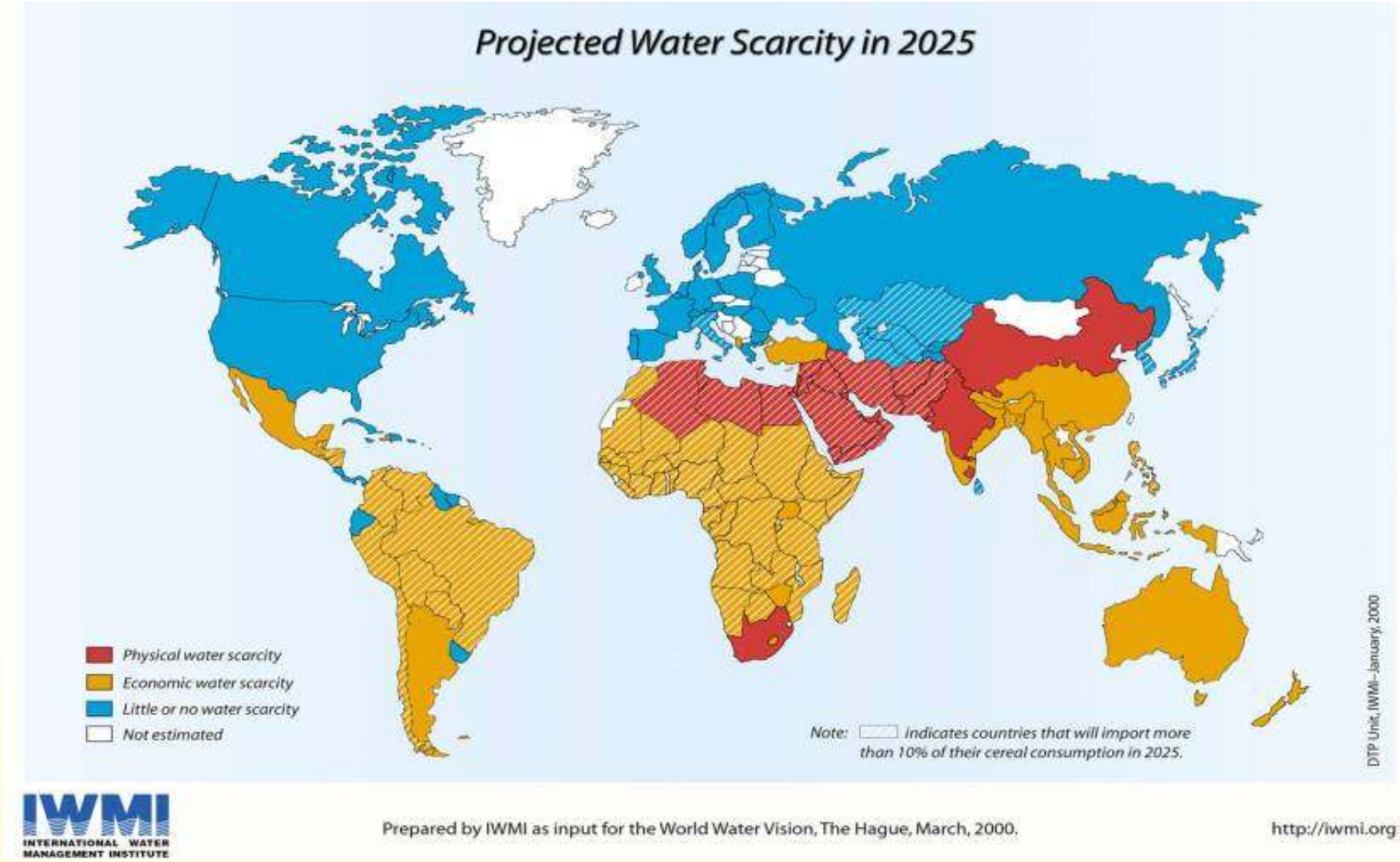
TUHH
Hamburg University of Technology

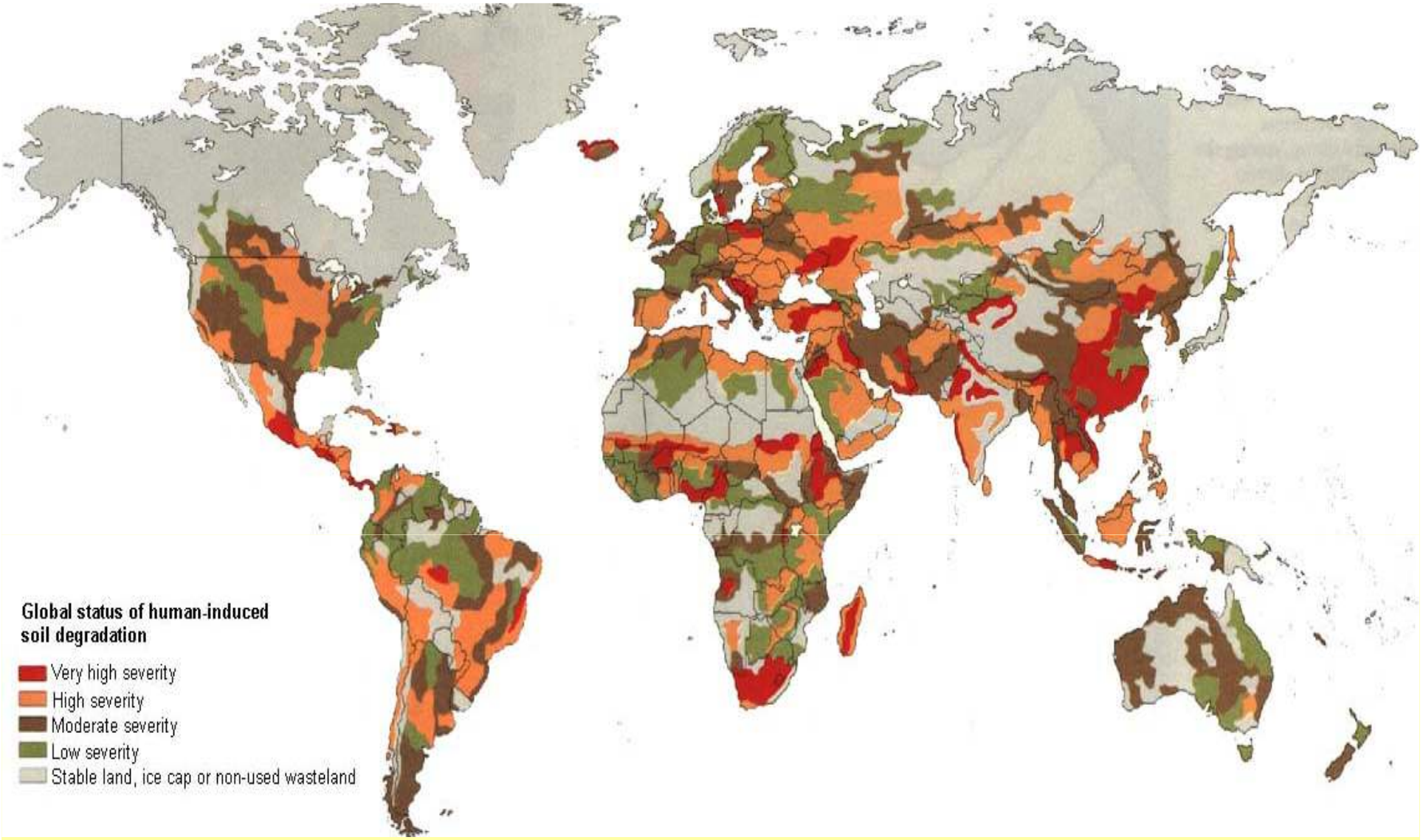
Institute of Wastewater Management and Water Protection



Major problems related to Wastewater (Miss)Management:

Pollution of Rivers, Lakes and the Seas

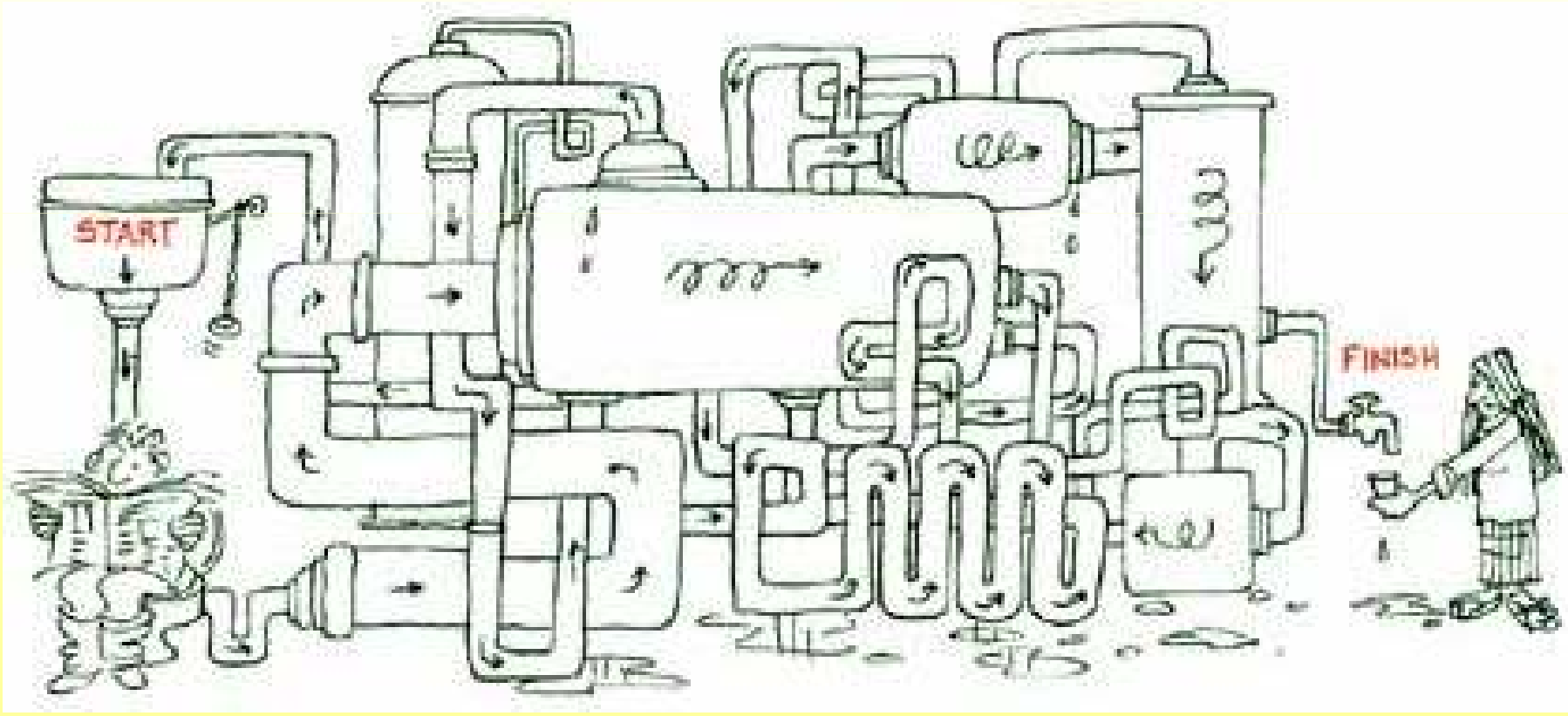
Scarcity is often a consequence of inefficient Water Usage



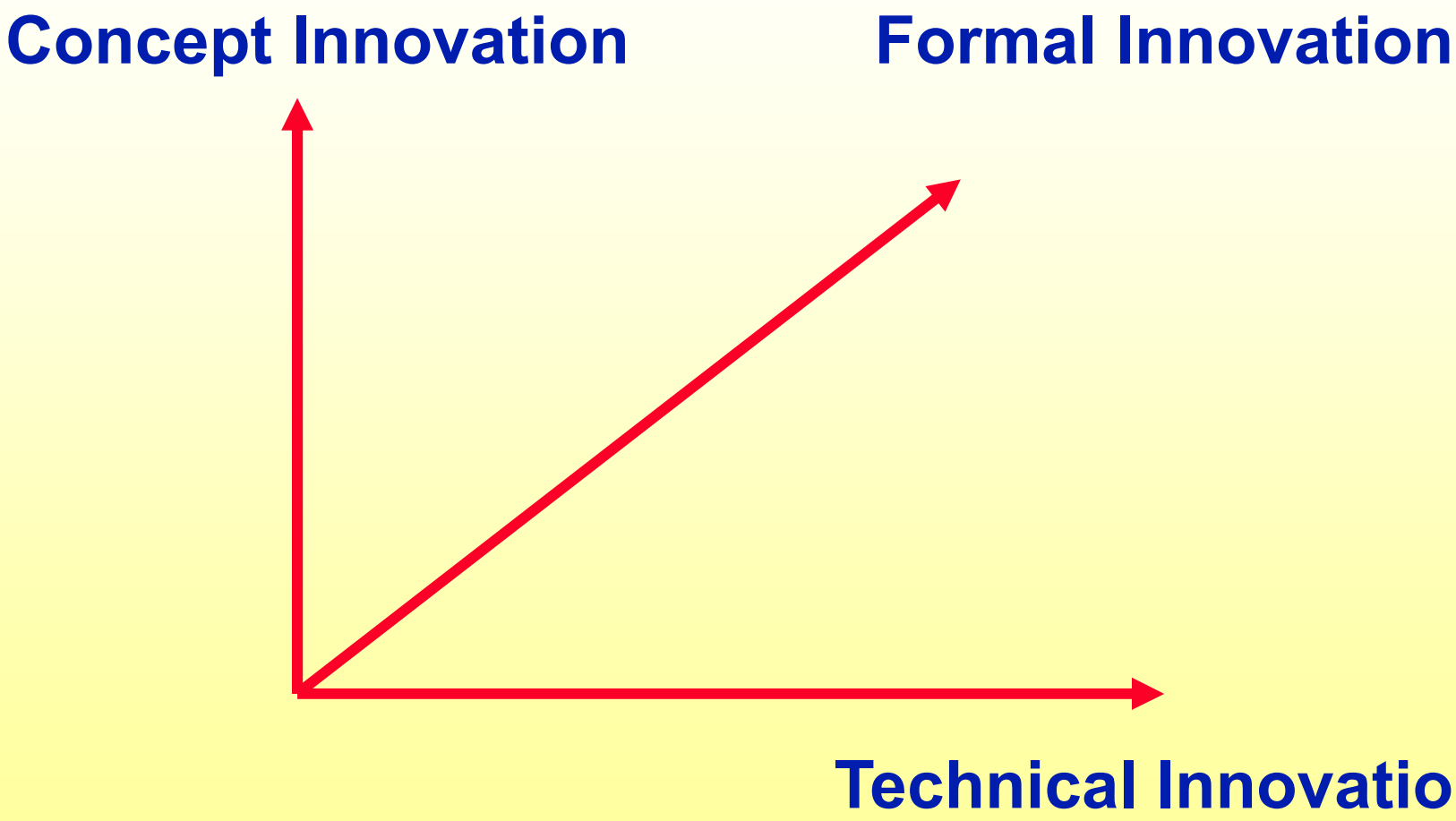
Loss of Soil Fertility (slow but dramatic, global scale)

counteraction by returning treated biowaste and faecals

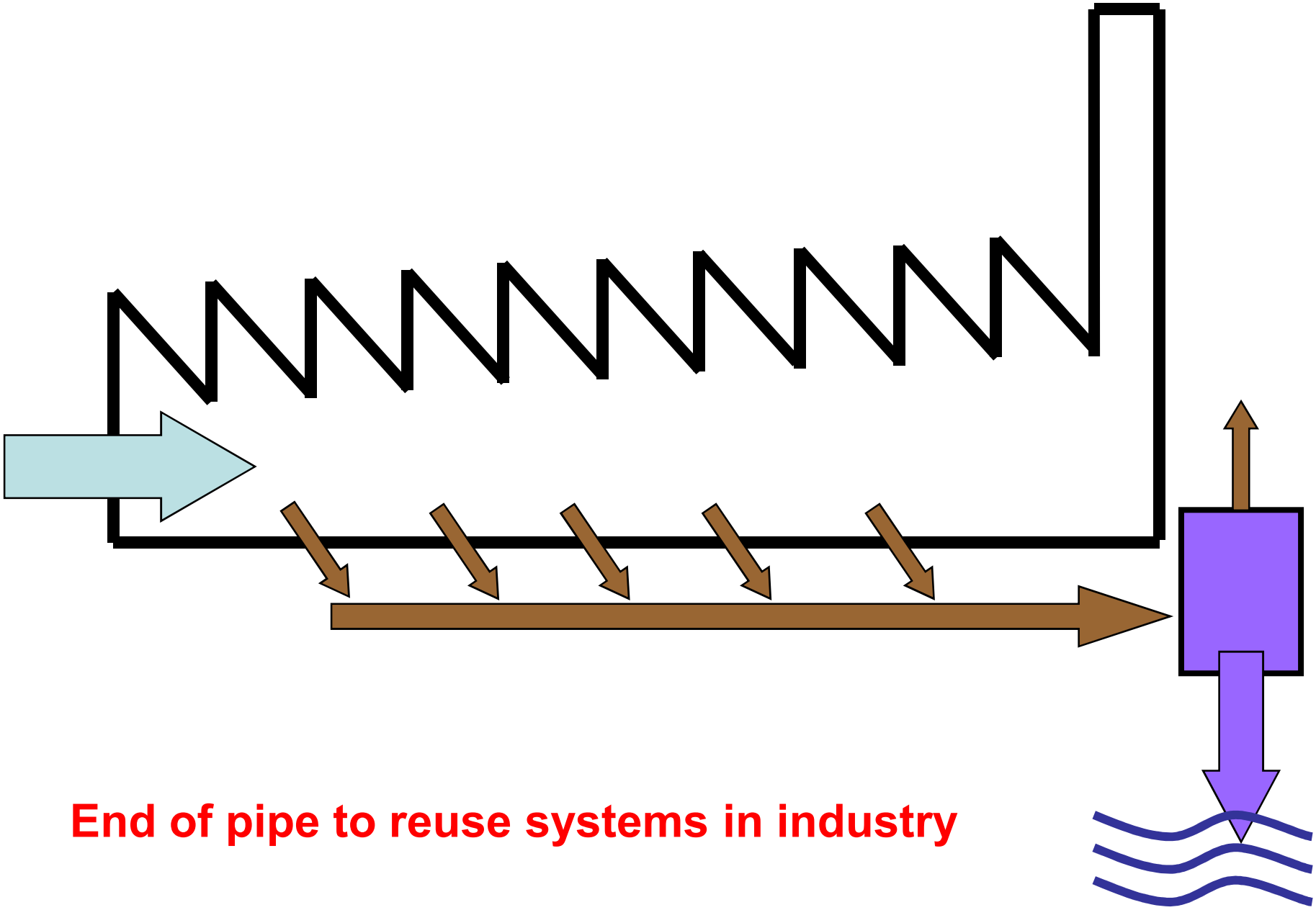
(Map from WWW.FAO.ORG)


START
FINISH

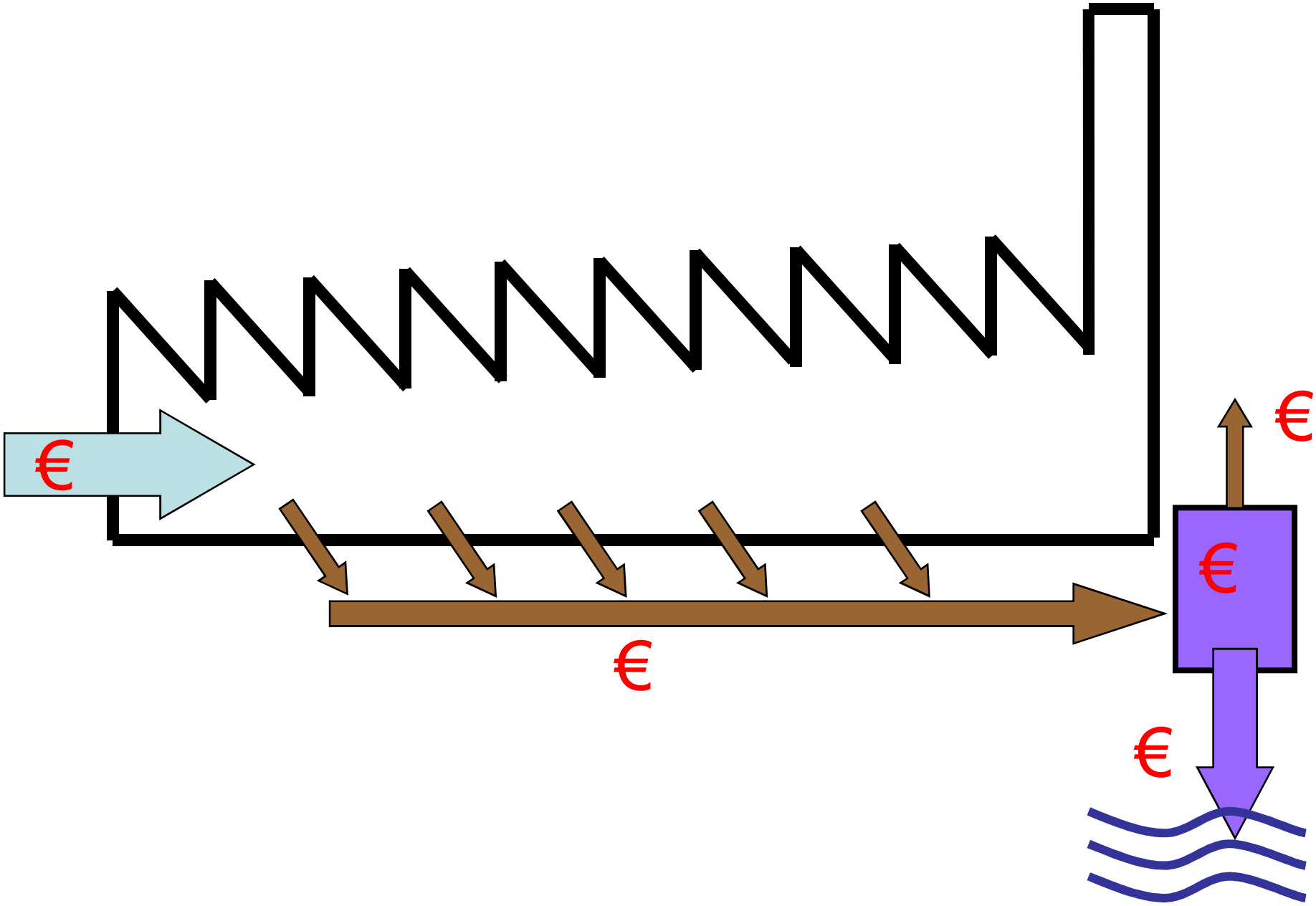
The 3 dimensions of Innovation

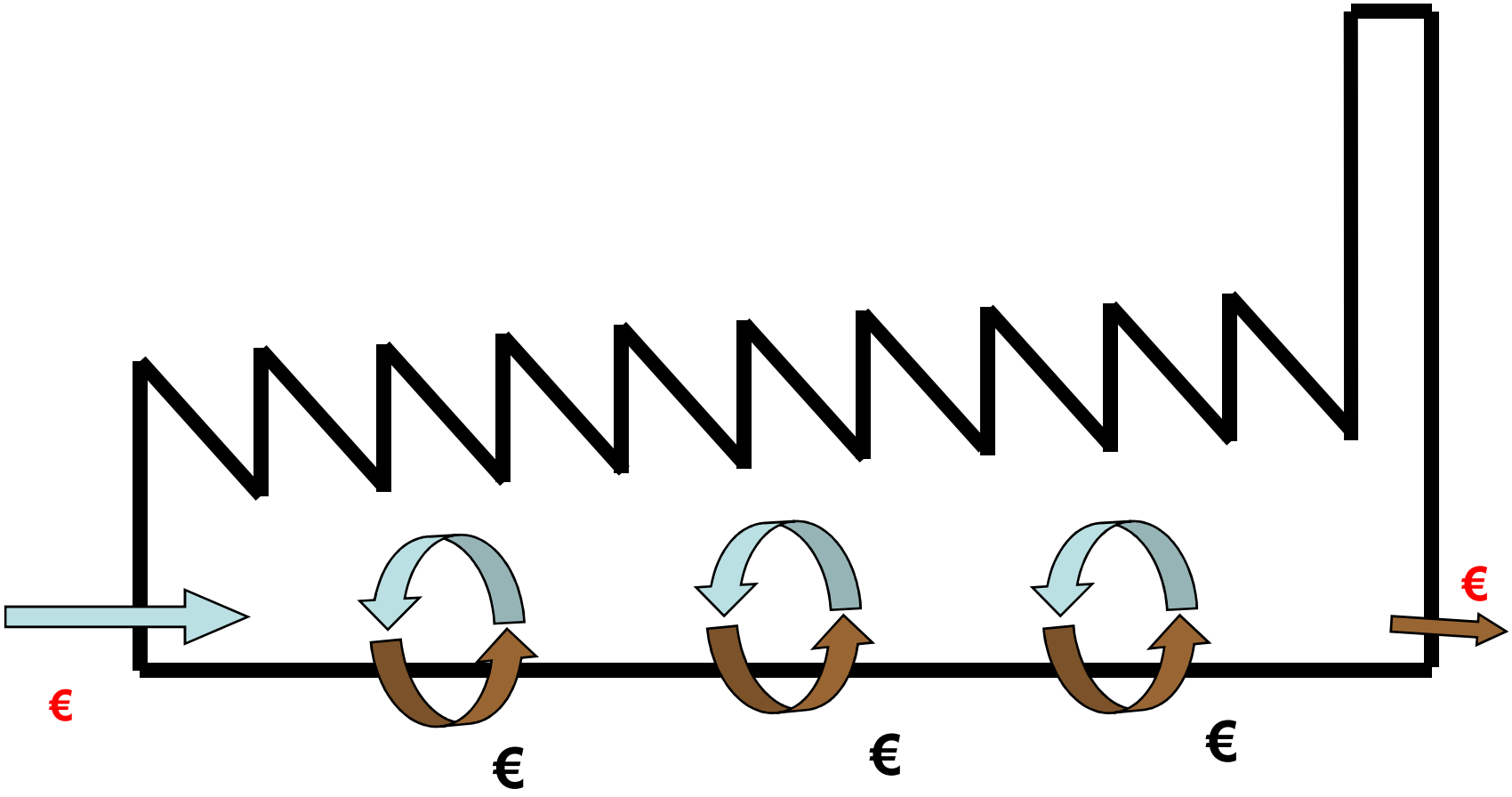


Source: Prof. G. Teodorescu, Stuttgart



End of pipe to reuse systems in industry





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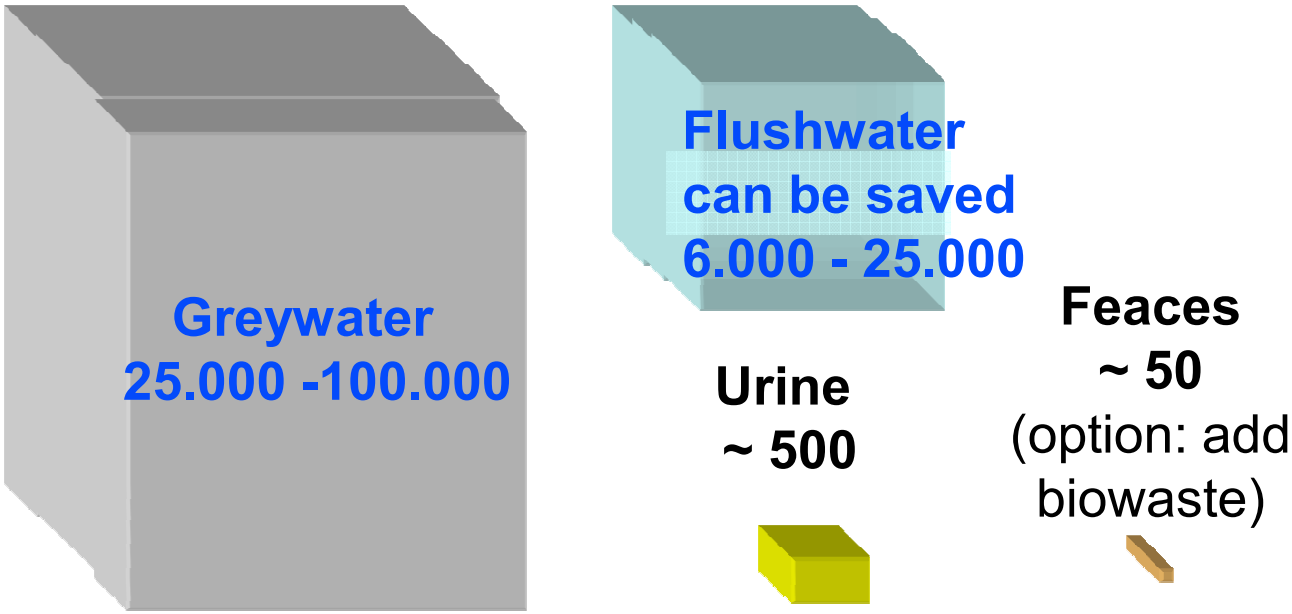
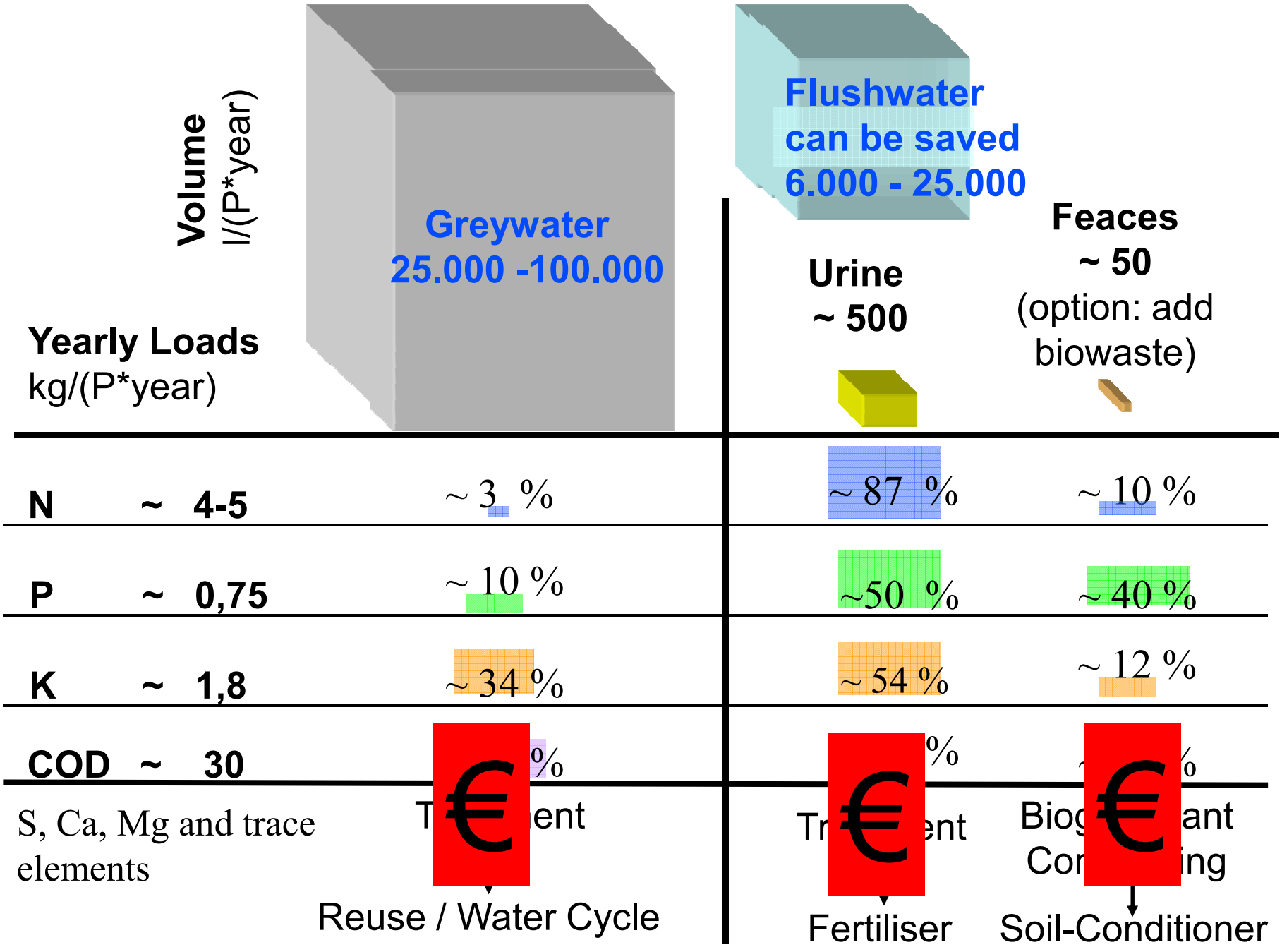


Yearly Loads
kg/(P*year)

Can the same work in housing areas?

Added value through reuse
Full reuse = Zero Emissions



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	25-40 l	+ widely accepted - waste of water - high dilution
Vacuum-toilet	9 l	+ low water demand + well developed (ships) - high-tec / expensive
Separating toilet	6 l 1,5 l	+ little water / little dilution + simple fertiliser reuse - little experience
Waterless Urinal	1,2 l	+ no water / no dilution - maintenance required
Composting-toilet Desiccation toilet	1,5 l	+ no water needed - high space demand - maintenance needed ++ Desiccation for hot climates

Low/Non-diluting toilets are the key for new sanitation concepts

The 3 main Development lines

1. **Blackwater and integrated systems design**
2. **Dry sanitation / Low Cost solutions**
3. **Urine-Diversion with flush sanitation**

Vacuum technology

Marine installations = Water Efficientcy

Settlement Lübeck-Flintenbreite
Water consumption 65 l/capita/day

Double-Houses

Terraced Houses

OtterWasser GmbH

Vacuum-Toilet 0.7 litres per flush

OtterWasser GmbH

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, 2001)

OtterWasser GmbH

Vacuum Pumping Station for Blackwater

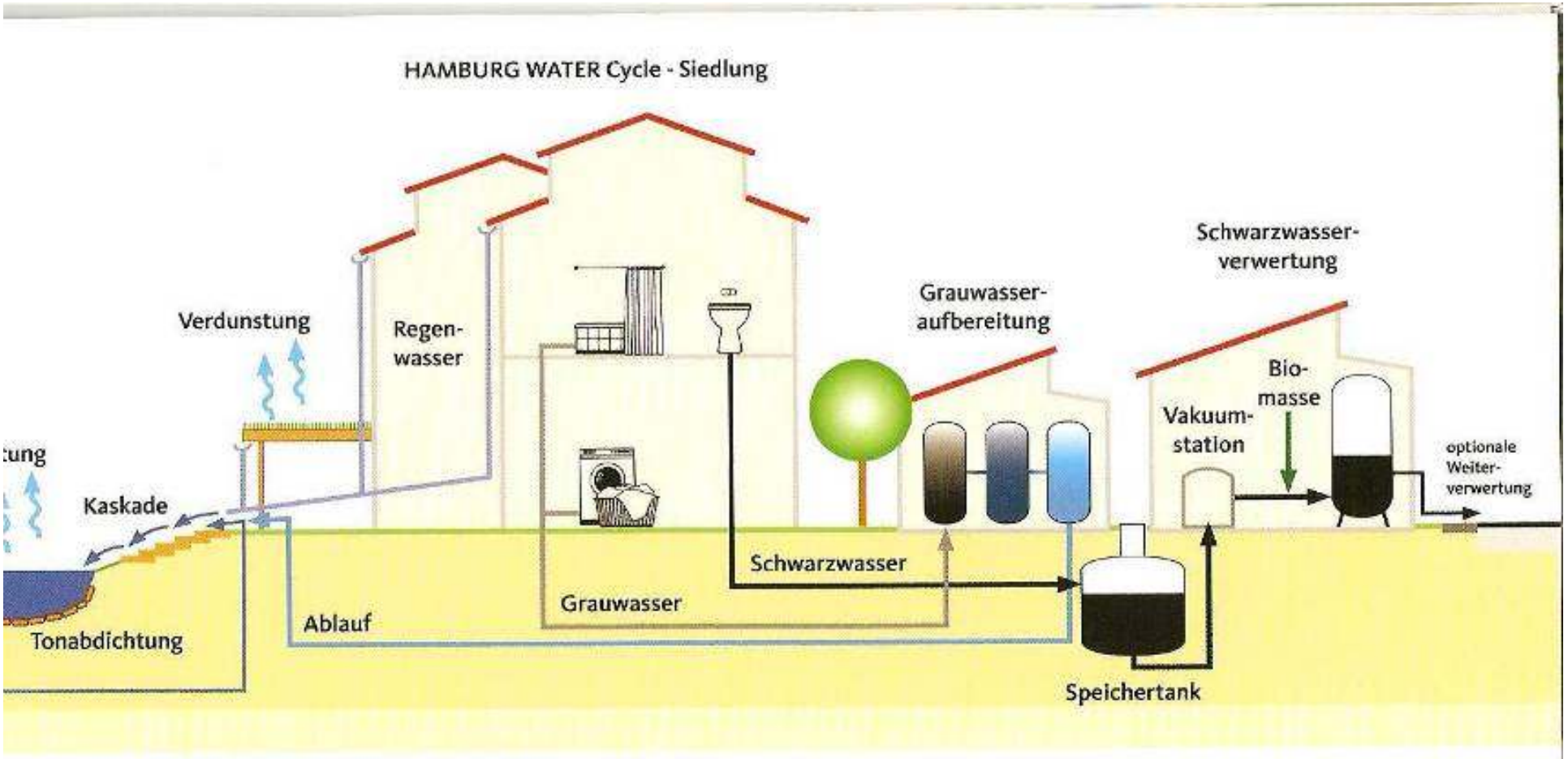
Sanitisation of Blackwater and biowaste

Bio-Waste Inlet and Grinder

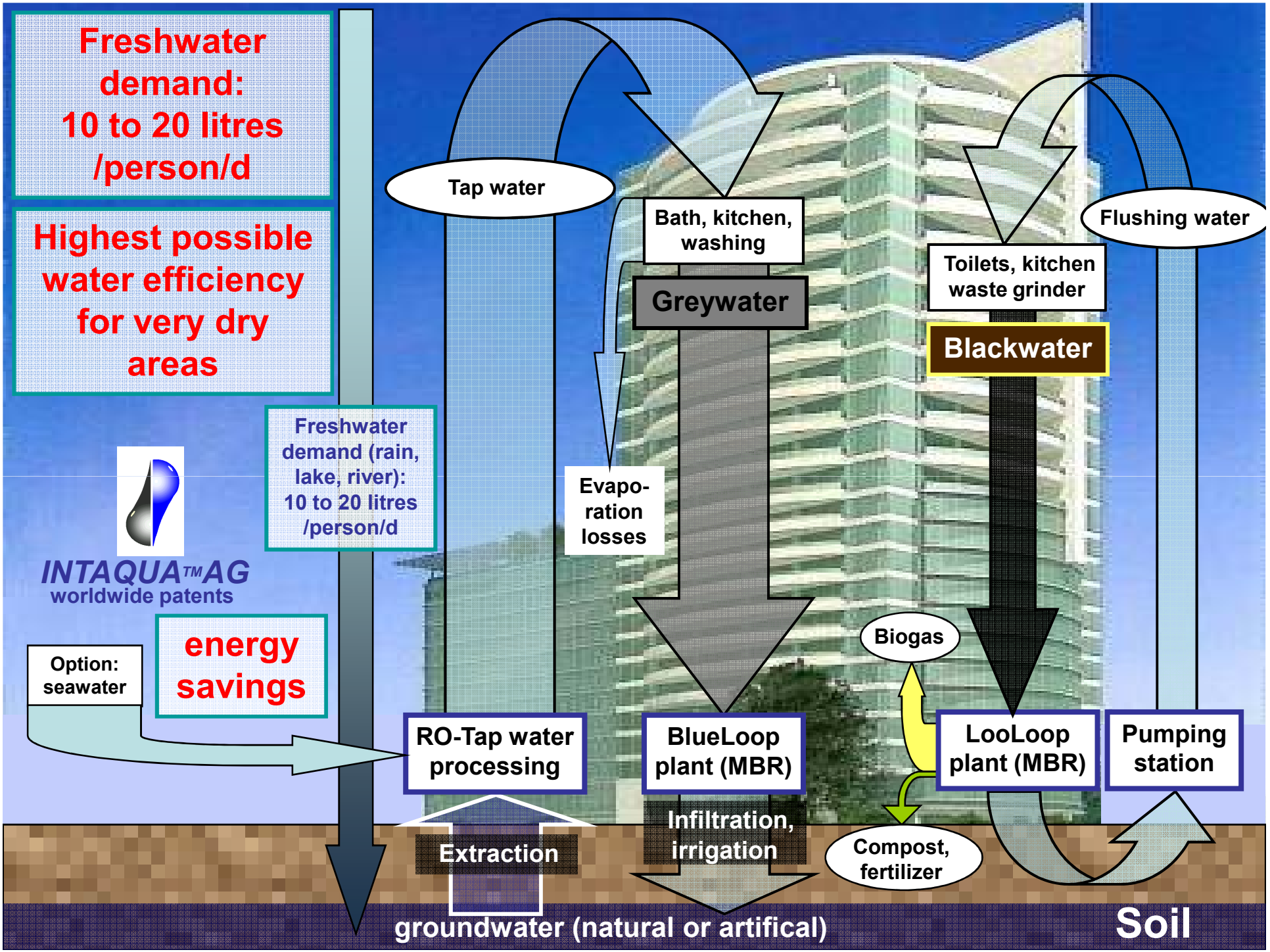
Vacuum-Biogas-System:
32 houses in Sneek, The Netherlands

Hamburg Water Cycle by Hamburg‘s Water Utility

Vacuum-biogas system for 2.000 inhabitants, production of electricity and heat from waste Start in 2010



JRG Erschließung neuer regenerati- Durch die Veredelung des bei der Abwasser-


Freshwater demand: 10 to 20 litres /person/d
Highest possible water efficiency for very dry areas
Freshwater demand (rain, lake, river): 10 to 20 litres /person/d
INTAQUA™AG
worldwide patents
energy savings
Option: seawater
Tap water
Bath, kitchen, washing
Greywater
Toilets, kitchen waste grinder
Blackwater
Flushing water
Evapo-ration losses
Biogas
RO-Tap water processing
BlueLoop plant (MBR)
LooLoop plant (MBR)
Pumping station
Extraction
Infiltration, irrigation
Compost, fertilizer
groundwater (natural or artifical)
Soil

Waterless Urinal
(Keramag)

Sorting-Toilet
(Gustavsberg, Sweden)

State of the art waterless urinal
Low maintenance
(Keramag)

LINZ AG

OtterWasser GmbH

Urine – containers and pre-composters for 106 flats in Linz, Austria

Reserach project of Linz AG , Water and Power Utility of the city

The Netherlands: Fertiliser production form urine 1.000 m³/a

- MB
- Waterschap Rivierenland
- STOWA
- LeAF

Biodiesel from algae grown in urine

Norwegian University of Life Sciences (UMB) Prof. Petter Jenssen

Here: Low-cost, high efficiency for large scale implementation:

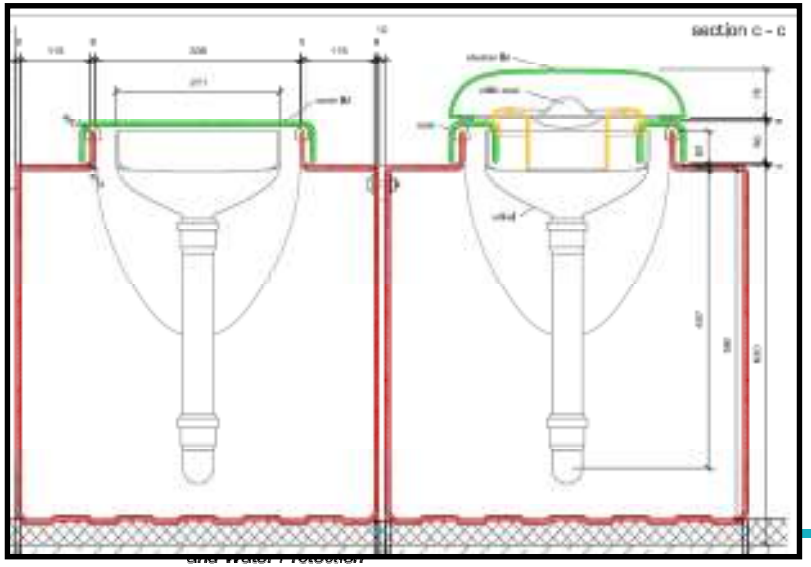
- Urban, peri-urban areas are far more difficult that rural situations
- Multi storey houses
- Ventilation is not an option for large scale, otherwise the whole region will smell bad
- An ancient concept offers new perspectives: Terra Preta Sanitation

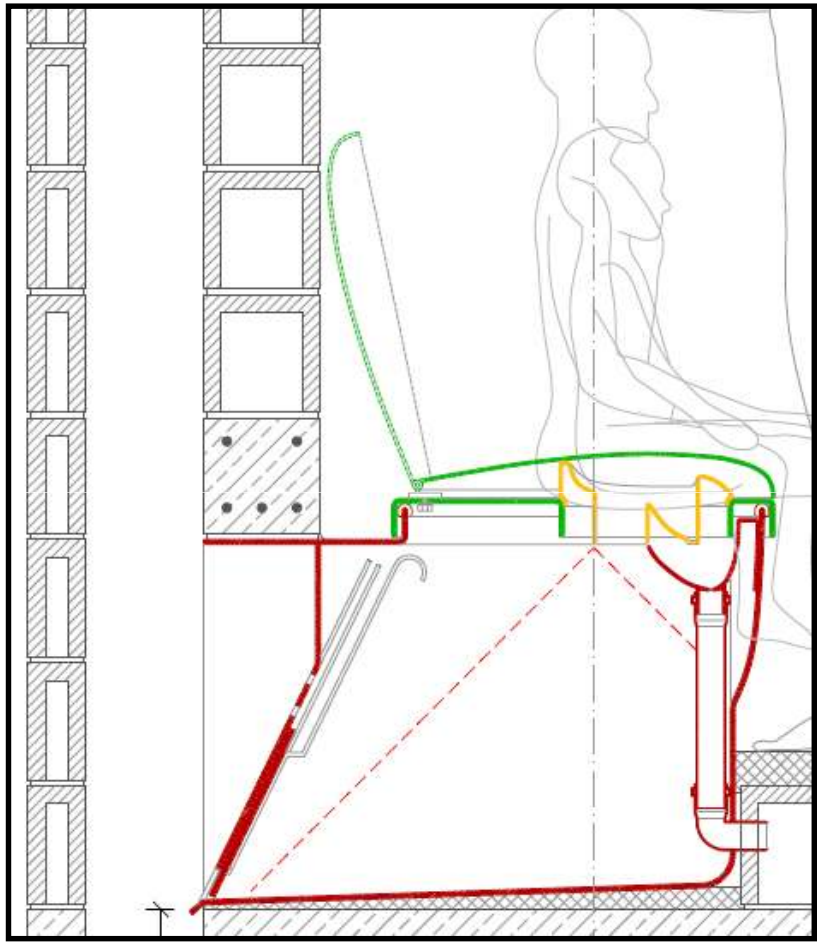
Ecological Sanitation in modern times, low-tech war develeoped in Sweden, EcoSanRes

WECF: Women in Europe for a Common Future
(Holland)
in co-operation with
TUHH
www.wecf.org

Neue Schultoilette, Ukraine (TUHH/WECF)

Trockentrenntoiletten in mehrstöckigen Gebäuden

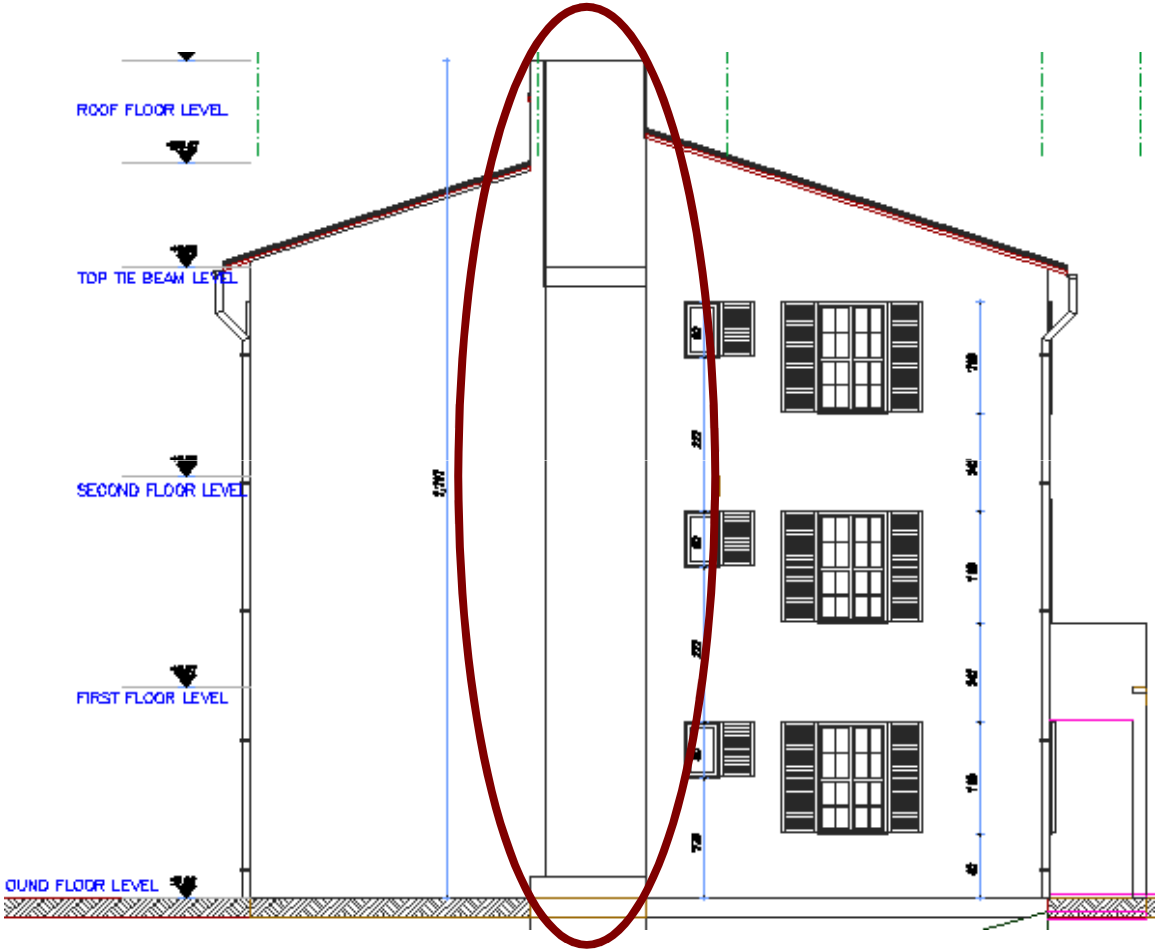




Drawings: Ole Jebens, TU Braunschweig

TU BS OtterWasser GmbH TUHH Technische Universität Hamburg-Harburg

Trockentrenntoiletten in mehrstöckigen Gebäuden



Soil degradation is stupid,

future generations will need land, too…

Poor soil can become highly fertile with clever management of biowaste and sanitation

Productive fertile soil is a nonrenewable, endangered ecosystem!

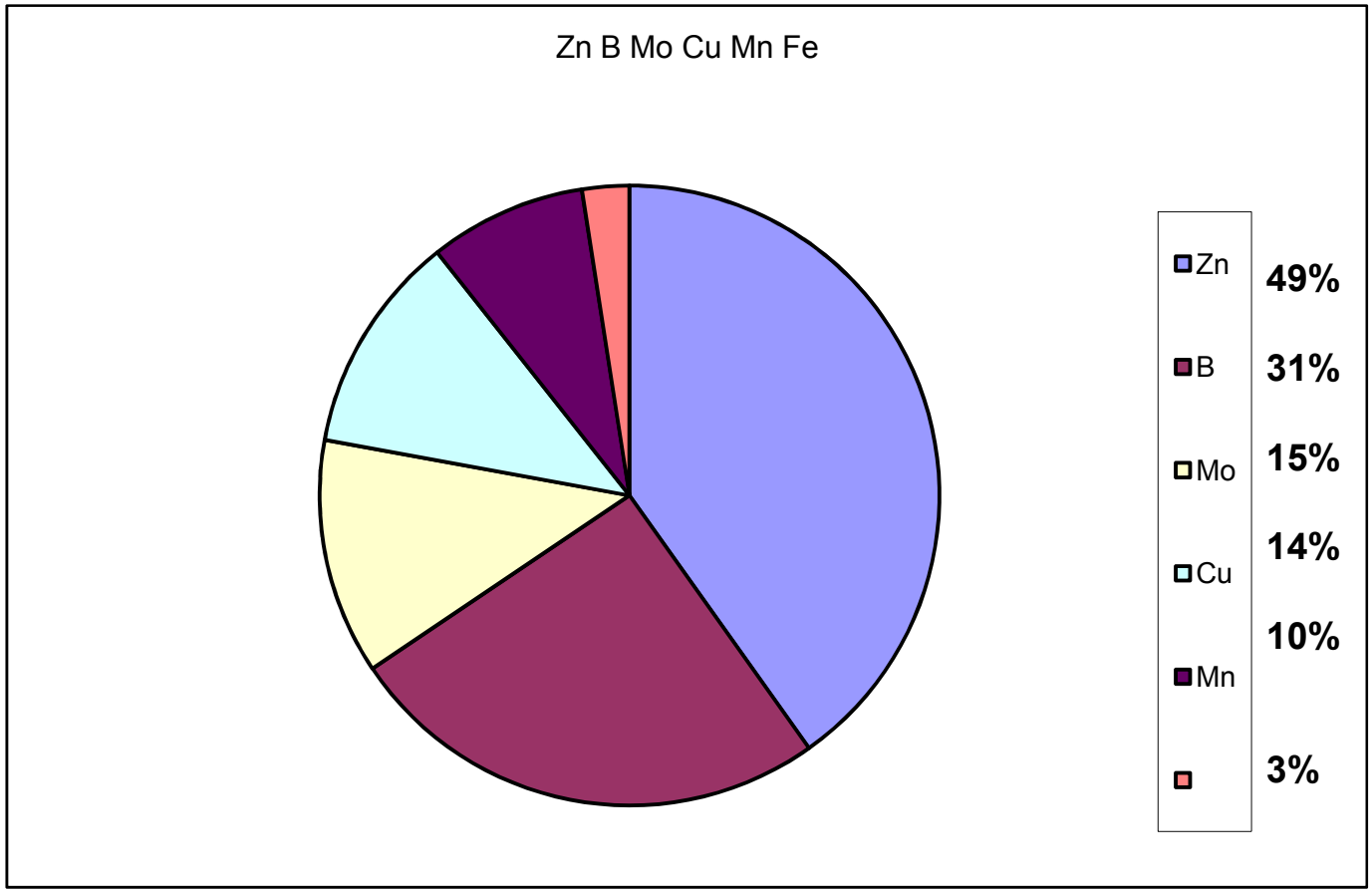
- About 2 billion hectares of soil (15% of Earth's land) have been degraded by human activities
- About 2 million hectares of agricultural lands are lost every year due to severe land degradation
- For the past 40 years nearly one-third of the world's cropland (1.5 billion hectares) has been unproductive and abandoned because of soil erosion and degradation

It takes approximately 500 years to replace 25 millimeters (1 inch) of topsoil lost to erosion (minimal soil depth for agricultural production is 150 millimeters)

http://www.theglobaleducationproject.org/earth/food-and-soil.php

http://www.treehugger.com/Land-Degradation_Endanger.jpg

Percentage of micronutrient deficiencies of important agricultural soils of the world



Boron and Zinc are the most problematic and significantly affect crop yields!

Factura (2010)

Why soil deficiencies occur

- Sandy texture and strongly leached – B,Cl, Cu, Fe, Mn, Mo, Zn
- High soil pH (>7) – B, Cu, Fe, Mn, Zn
- High calcium carbonate content, (>15%) calcareous soils – B, Cu, Fe, Mn, Zn
- High salt content – Cu, Zn, Fe, Mn
- Acid soils – Mo, Cu, Zn

Factura (2010)

Human Micronutrient Deficiency

- Highly prevalent in low-and-middle-income countries consuming monotonous, low-quality diets based on plant foods
- Global deficiency conditions result from inadequate amounts of **iodine, iron, vitamin A, and zinc**
- 2 million child deaths globally a year is attributed to **zinc, vitamin A, and iron** deficiencies - WHO

Factura (2010)

Poor soil condition because of lack micronutrients

↓

Poor crop productivity

↓

Low quality diets

↓

Micronutrient deficiency and Malnutrition

Factura (2010)

Old Amazonian cultures

- All they left was highly fertile soil that could produce food with a very low footprint

- They gave us a key element for the future of our societies:
  - urban and peri-urban agriculture can be combined with biowaste utilisation and sanitation

Terra Preta:

- 2000 – 7000 years old

- around 10 % of the Amazon Region

- 16. century millions of people,

  today 350.000

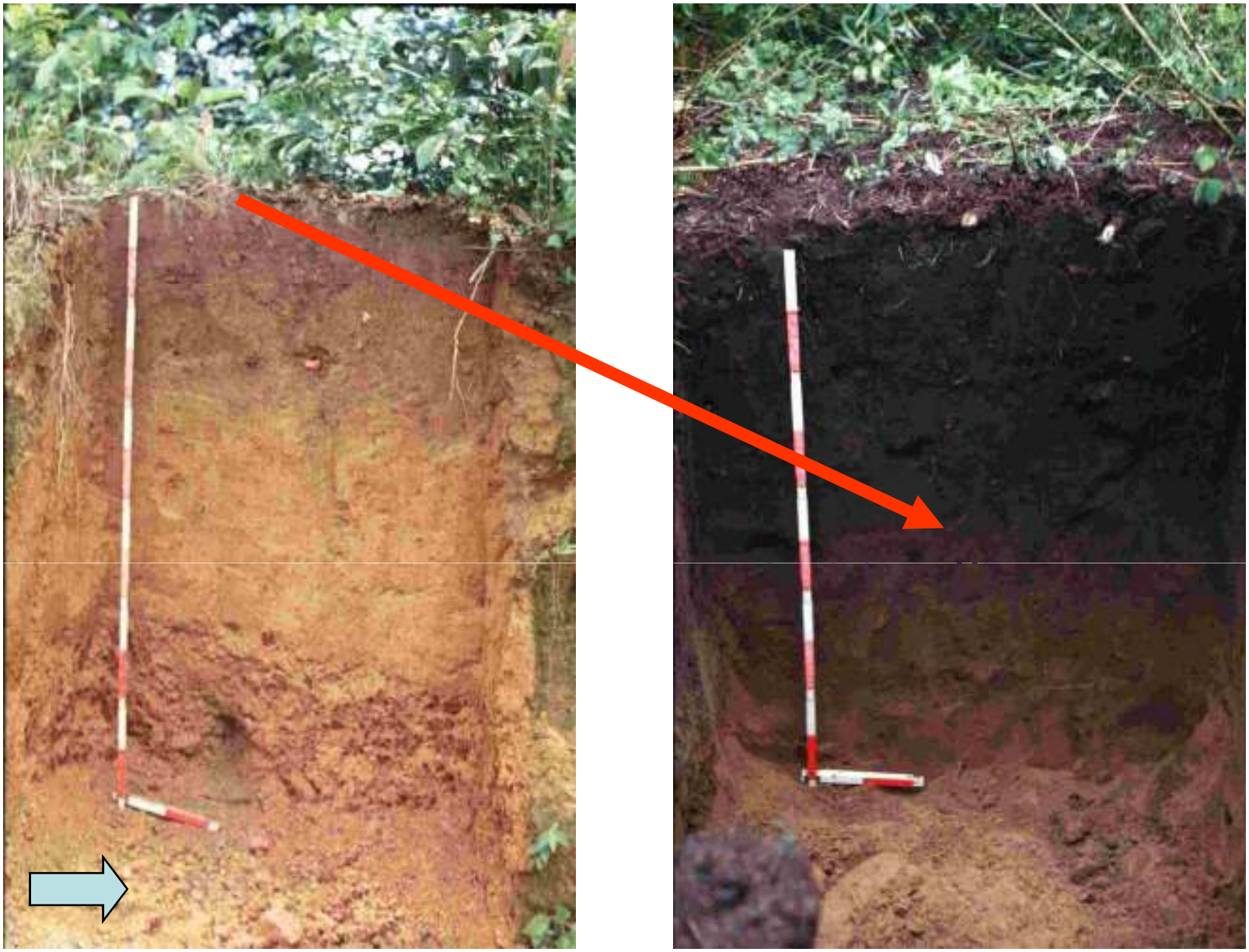
- up to 20 meters deep, partly hills

- fertile without adding fertilizer

- multiple yield

Historic Amazon: Forest Argriculture in three layers GEO 3/2009

GEO, March 2009



Poor soil can become highly fertile with clever management of biowaste and sanitation

- Increases in soil fertility through charcoal addition is well known

- Applications of charcoal which inevitably contain ash add free bases such as K, Ca, and Mg to the soil solution, increasing the pH value of the soil and providing readily available nutrients for plant growth

↑soil pH, ↑cation exchange capacity (CEC), ↑water holding capacity + organic matter = **Highly fertile soil**

An ancient pathway for today:

TERRA PRETA SANITATION

Production of super-fertile soils

Composed of biowaste, feacal matter, bones and charcoal

Production through lactofermentation (addition of bacteria) followed by vermicomposting

Terra Preta is ideally produced with dry toilets with seperate urine collection

However, if it shall be flush for legal or cultural reasons, this can be done in combination with separate urine collection and a fermentation tank
(formerly rottebehälter or pre-composting tank)

Urine colletion with individual bottle like in hospitals or Pippinette

First step: Keep Urine separate

The most simple approach, personal collector,
female / male version

Pippinette

Second step: Feacal matter

Dry toilet shop, Hamburg:
www.bergerbiotechnik.de
Terra preta / EM-Shop:
www.triaterra.de

Example: Mobile-toilet „toa-standard“
with a closing lid for the bucket
after usage: cover with ½ cup of a mixture of
2,5 kg ground charcoal, 1 kg dolomite-lime, 1:100 EM A
or leachate of lactofermented sauerkraut,
some forest-soil for fungi, some stone-dust
operation ok when smell is ok leave lactofermenting for minimum
3 weeks to some month, then vermicomposting in closed composter

Third step: Vermicomposting of feacal matter

Breakthrough in solids treatment at TUHH (BMBF / IPSWaT)

Pilot set-up at TUHH

Bucket system

Collection → **Storage** → **Vermicomposting**

- Addition of charcoal
- Separation of urine
- Partly aerobic/anaerobic condition

- Closed air tight (minimum one month) with addition of lactofermenters

- Addition of worms
- Aerobic condition (minimum two months)

All in one and the same bucket!

Factura *et al.* (2010)

What we have found out so far

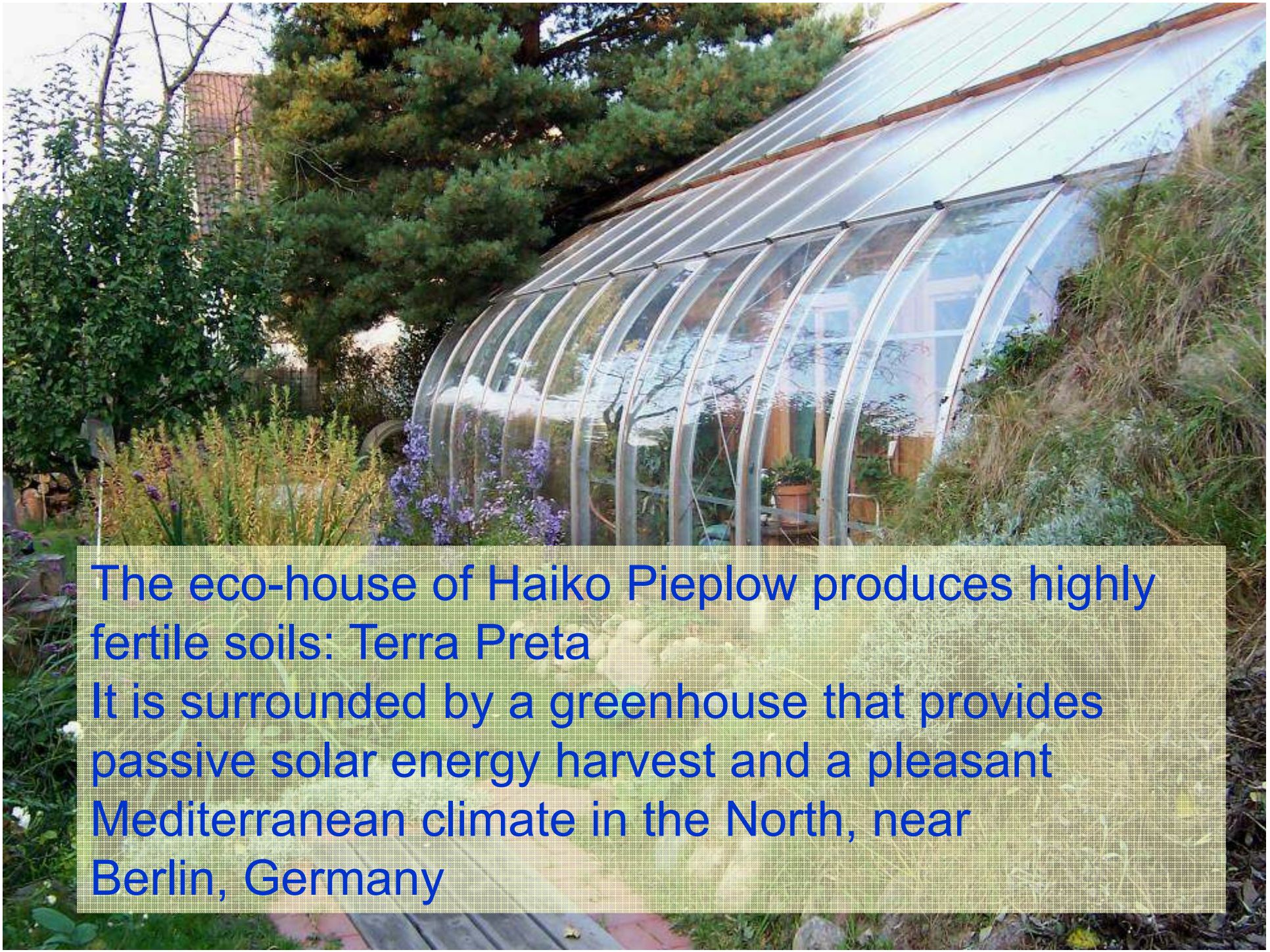
- Charcoal eliminates bad faecal odour
- Faeces can be stored in a bucket (closed air-tight) for longer period without odour problems
- Vermicomposting of stored faecal substrate (with combination of fine woodchips) works well and produces the fertile organic matter

Terra Preta Sanitation

- One bucket system from collection, lactofermentation, and vermicomposting
- Does not need a huge space
- No more need for a ventilation system
- No more need for a dehydration system
- Easy handling of faecal matter (including biowaste)

Pilot installations

- Eco-house of Dr. Haiko Pieplow near Berlin
- Pilot set-up of Dr.Jürgen Reckin near Berlin
- Plant experiments of Joachim Böttcher, Areal GmbH, Germany
- Scientific studies at TUHH



The eco-house of Haiko Pieplow produces highly fertile soils: Terra Preta
It is surrounded by a greenhouse that provides passive solar energy harvest and a pleasant Mediterranean climate in the North, near Berlin, Germany

Dr. Reckin‘s Backyard

Garden bio-wastes are collected and shredded (like woodchips)

Formed into heaps of compost and made ready for terra preta transformation

Dr. Reckin‘s Backyard

Coal mixtures are prepared (charcoal, brown coal, and coal ash) → **Mixed together** → **And spread over the heaps**

Dr. Reckin‘s Backyard

Mixture of bacteria is used in fermenting urine (to prevent loss of nitrogen) → **And spread over the heaps of mostly slice-cut woods where vermicomposting is taking place**

Dr. Reckin‘s Backyard

When you dig in the heaps, you will see big healthy worms (doing vermicomposting process) transforming the bio-wastes into the nutrient-rich terra preta

Experiments of Areal GmbH: characteristics equals original Terra Preta, even better


Production boxes


Trial field


Groth experiments

Joachim Böttcher

areal® GmbH

Growth experiments of Areal GmbH in 2008:
Potatoes yield per plant 2.9 to 3.5 kg
no irrigation and fertilisation
Calculates to 120 tons/ha (nomal 25 to 35)

Joachim Böttcher

areal® GmbH

Amazing: bio-degradation of organic matter is strongly reduced, instead biomass is converted
to stable carbon-structures

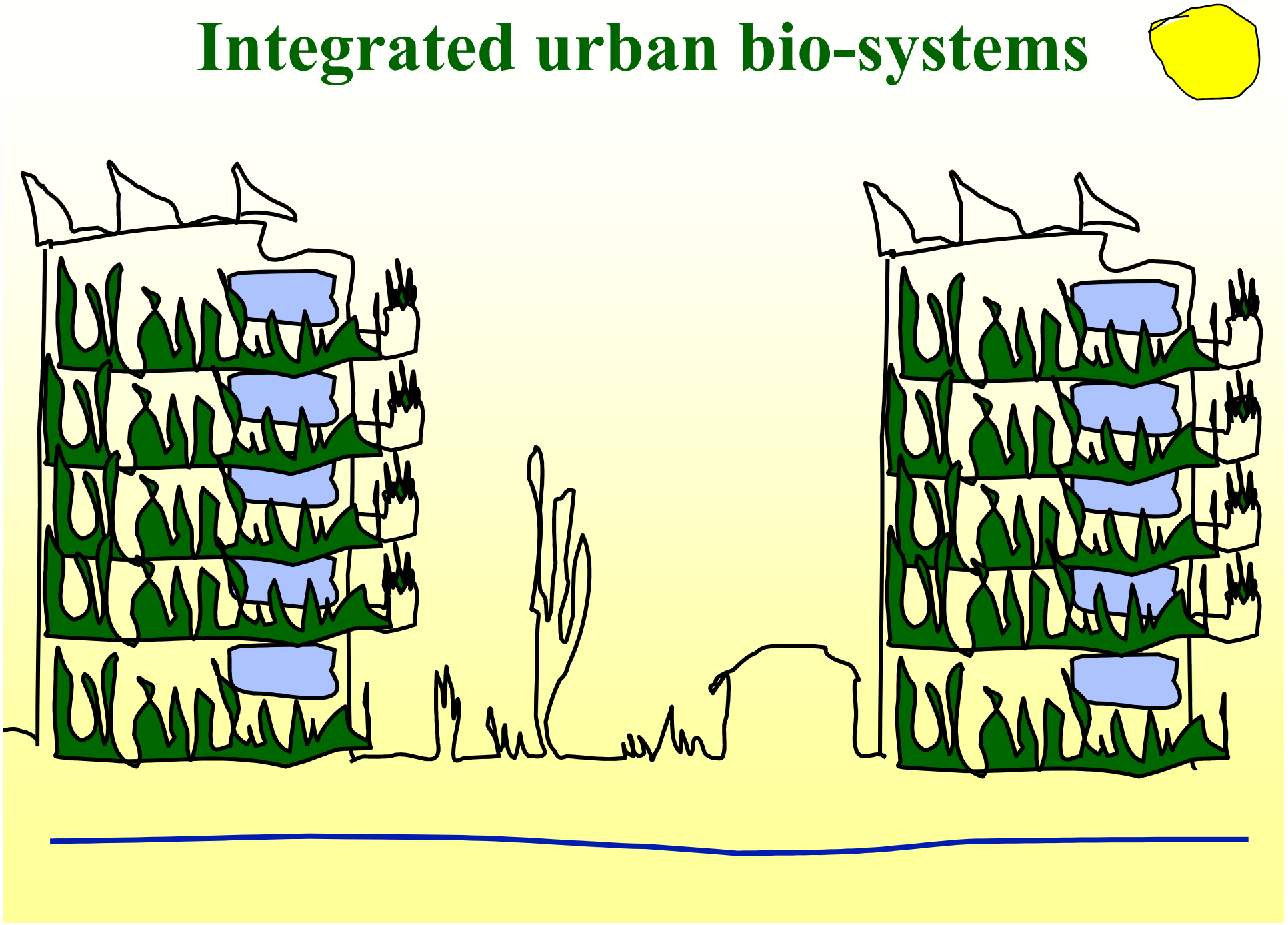
areal® GmbH

dapted, from Joachim Böttcher


L'ENVIRONNEMENT
PHYTOREM


L'ENVIRONNEMENT
PHYTOREM

Integrated urban bio-systems



Zentrale der Commerzbank, Deutschland, Frankfurt am Main, 1994-1997
"Wie kann man Arbeit und Natur in den Grenzen eines Bürogebäudes miteinander in Einklang bringen?" fragt Foster.

http://www.architektur.tu-darmstadt.de/powerhouse/db/248,id_21,s_Papers.fb15

Thank You

for your attention!

www.tuhh.de/aww www.ecosan.org (IWA SG)
www.gtz.de/ecosan www.ecosanres.org
www.otterwasser.de