

Challenges for sustainable wastewater management in the urban sector

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The 20th century was the century of oil



The 21st century will be the century of water



It is the most precious and vulnerable resource on earth!

The 20th century was also the century of **BOD**



- Should we stay with this index in the 21st century?
- What else should be monitored?
- To what concentration levels ($\mu\text{g/L}$, ng/L , pg/L)?
- Just compounds' concentrations?

I will talk about

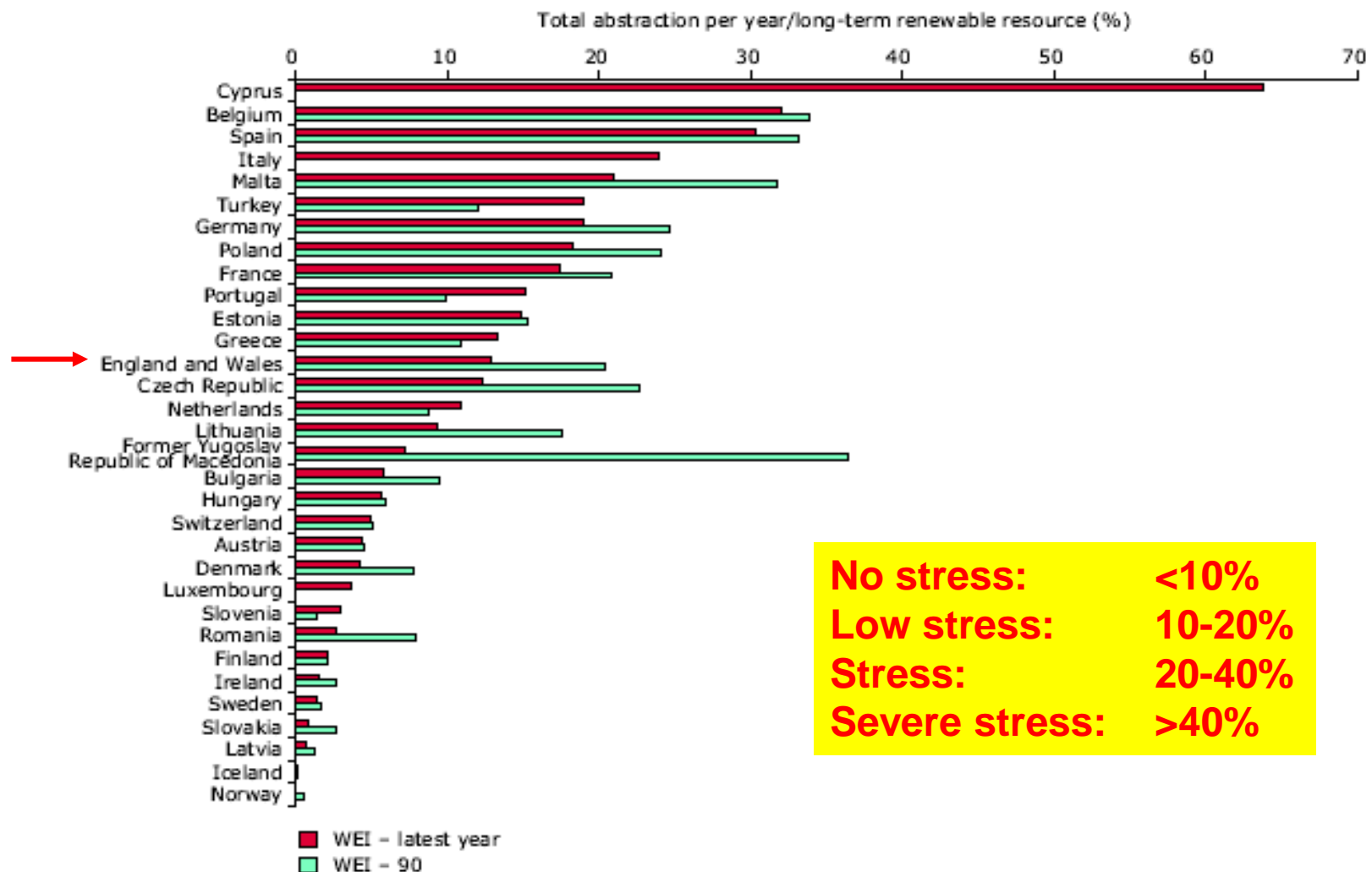
- Required standards & technologies
- Centralization vs. decentralization
- Color segregation of wastewater

Global water problems:

- Water shortage (quantity)
- Water pollution (quality)

Water stress in Europe (European Environmental Agency)

Figure 2.1 Water exploitation index (WEI)



Note: Annual total water abstraction as a percentage of available long-term freshwater resources around 1990 (WEI-90) compared to latest year available (1998-2007) (WEI-Latest Year).

Source: EEA CSI 018 — WEI; www.eea.europa.eu/data-and-maps/figures/water-exploitation-index-wei.

There is a viable and economical solution for the quantitative (shortage) problem



Cost in Israel: ~0.5 £/m³

Solutions for the qualitative problem are also required

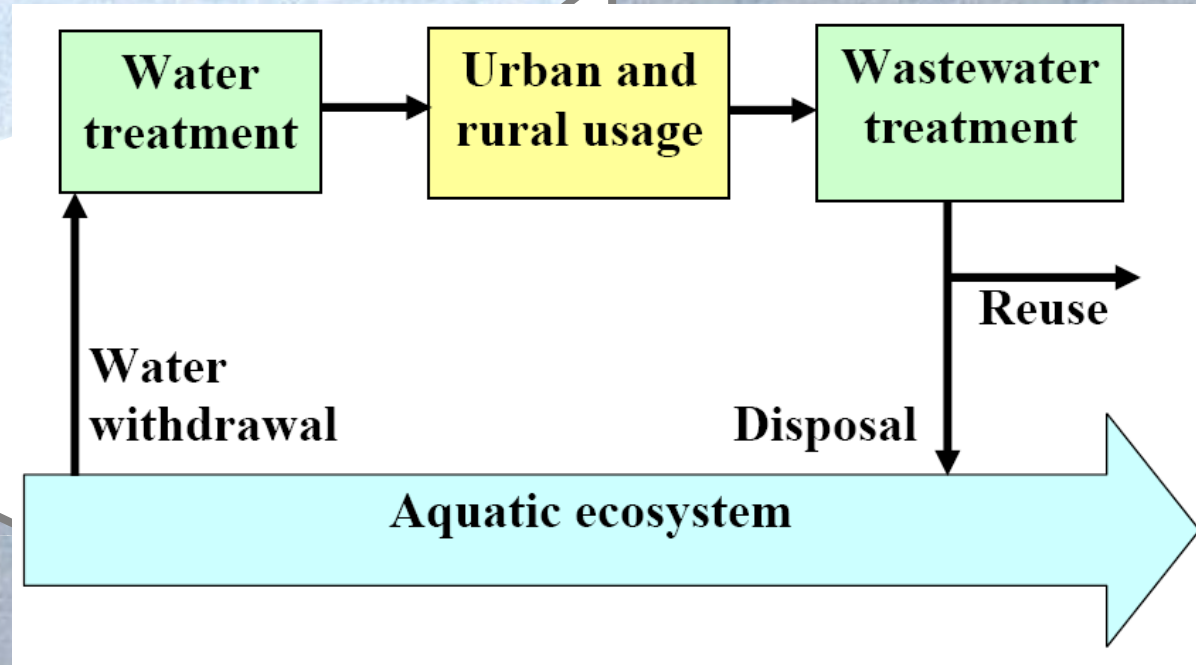
Wastewater reclamation for:

- Reuse**
- Safe disposal**

Basic question:

What level of treatment and effluent quality standards are needed???

Typical water cycle in modern countries



Closed-loop cycle

Main problems of reuse/disposal (Specified in traditional standards)

- Pathogens
- Heavy metals
- Nutrients
- BOD

Red – Health problems

Green – Ecological or agricultural problems

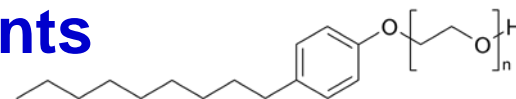
Exclusive problems not solved by traditional technologies:

- **Salts**
- **Organic micro-pollutants (OMPs)**

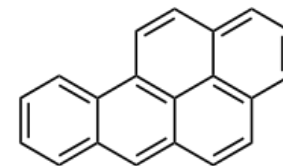
Problematic Organic Micro-Pollutants

PPCPs - Pharmaceuticals and Personal Care Products

APEOs - Alkylphenol Ethoxylates Surfactants

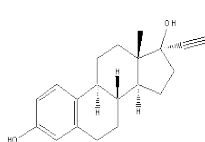


PAH – Polycyclic Aromatic Hydrocarbons

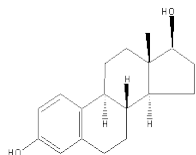


Benzo(a)pyrene

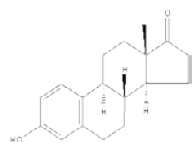
EDCs- Endocrine Disrupting Compounds



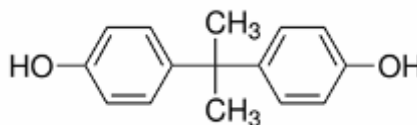
Ethinyl estradiol



17β-Estradiol

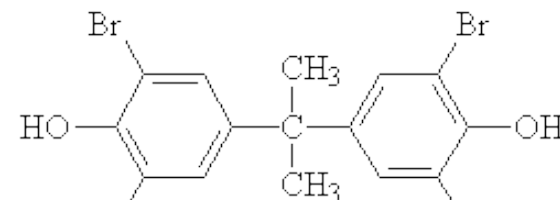


Estrone



Bisphenol A

BFRs – Brominated Flame Retardants

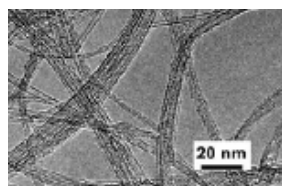


3,3',5,5'-Tetrabromobisphenol A

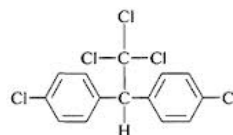
NTR – Nano-Technology Residuals

Nanotubes

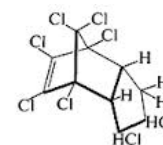
Fullerenes



PESTICIDES



1,1,1-trichloro-2-bis(4-chlorophenyl)ethane (DDT)



(Chlordane)

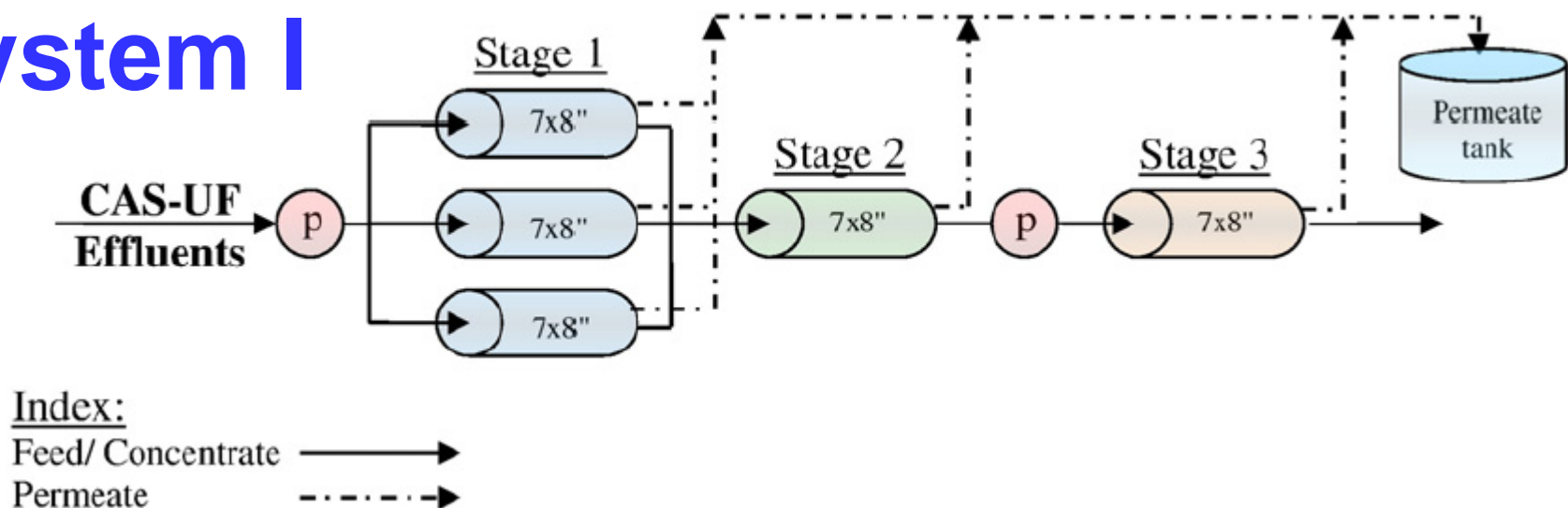
Where have OMPs been found?

- In urban drinking water supply systems
- In vegetables leaves, roots, & fruit
- In breast milk (brominated flame retardants)

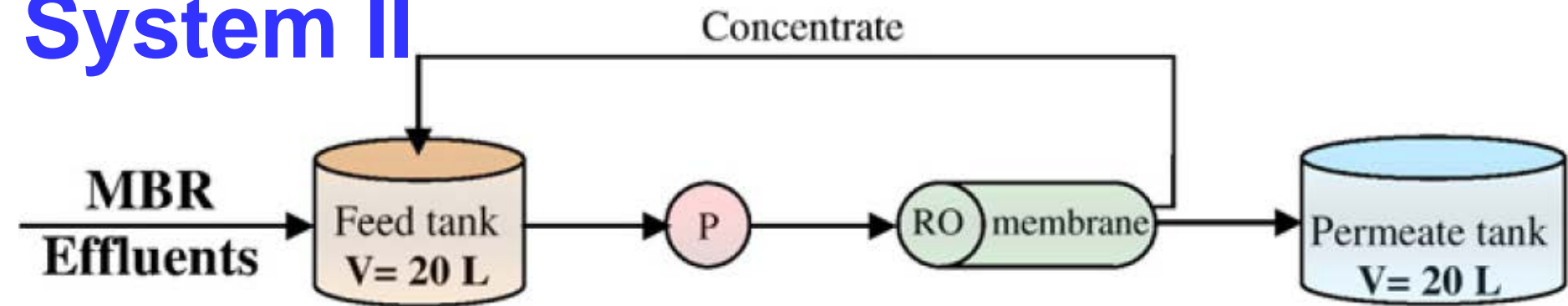
**Can desalination be an
absolute barrier against
OMPs ???**

Experimental demonstration

System I

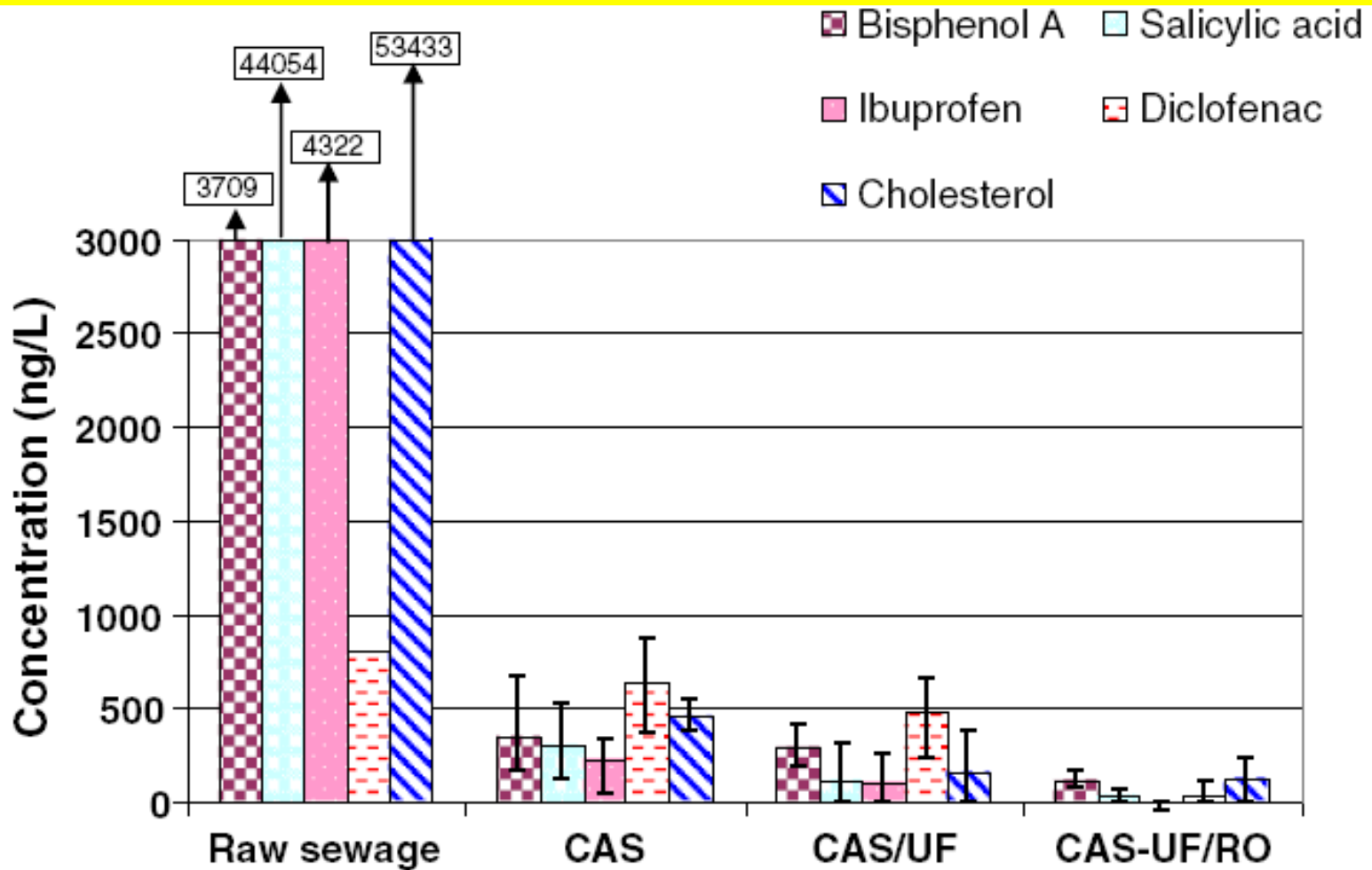


System II



*Sahar et al., Desalination, 273, 142-147, 2011; Water Research, 45:4827-4836, 2011.

OMPs removal in system I: CAS-UF-RO



Bisphenol A



Salicylic acid



Ibuprofen



Diclofenac



Cholesterol



Same behavior was observed for both systems (I & II) and for other compounds

Macrolides



Roxithromycine



Erythromycine



Clarythromycine

Sulfonamides



Sulfamethazine



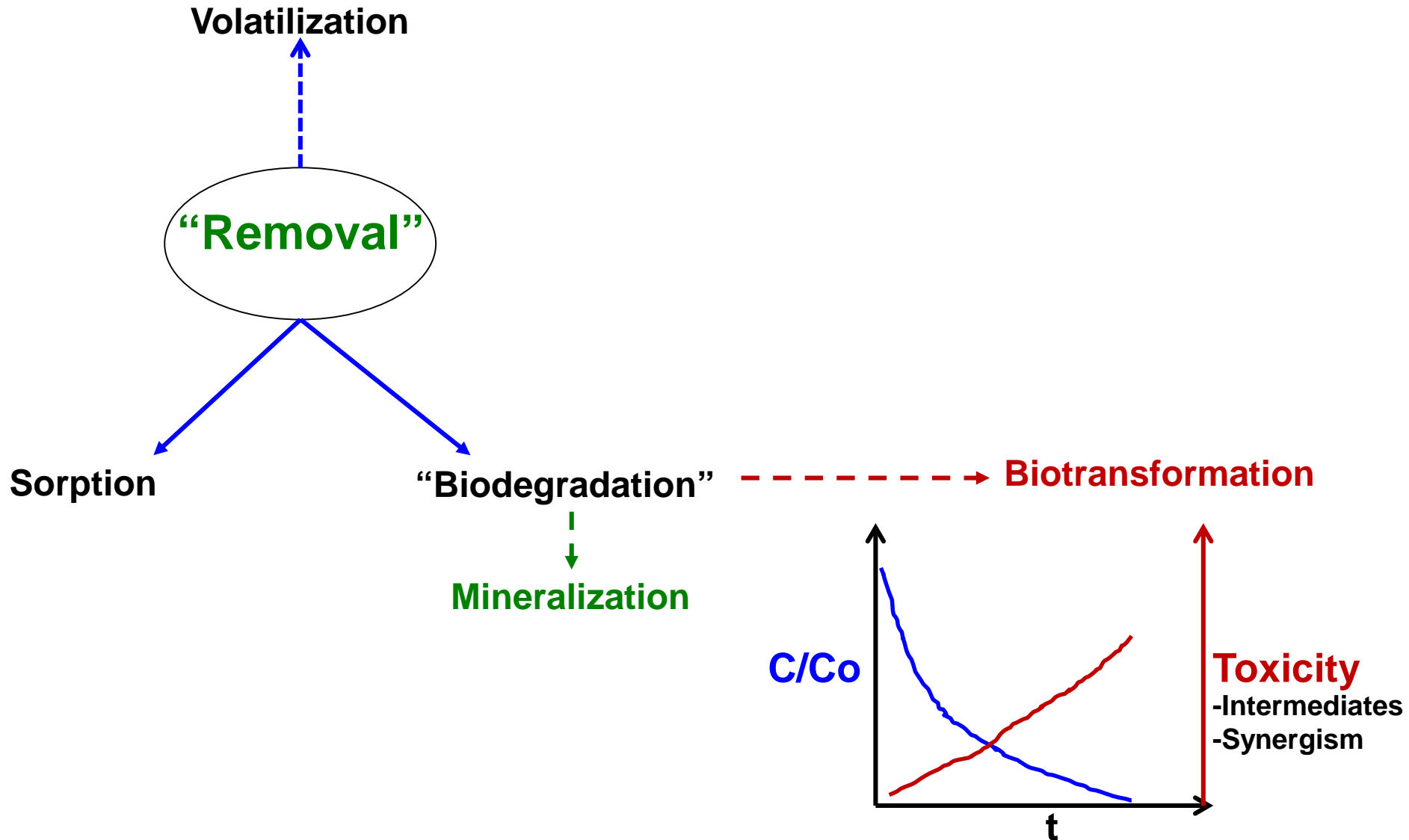
Sulfamethoxazole

Trimethoprim

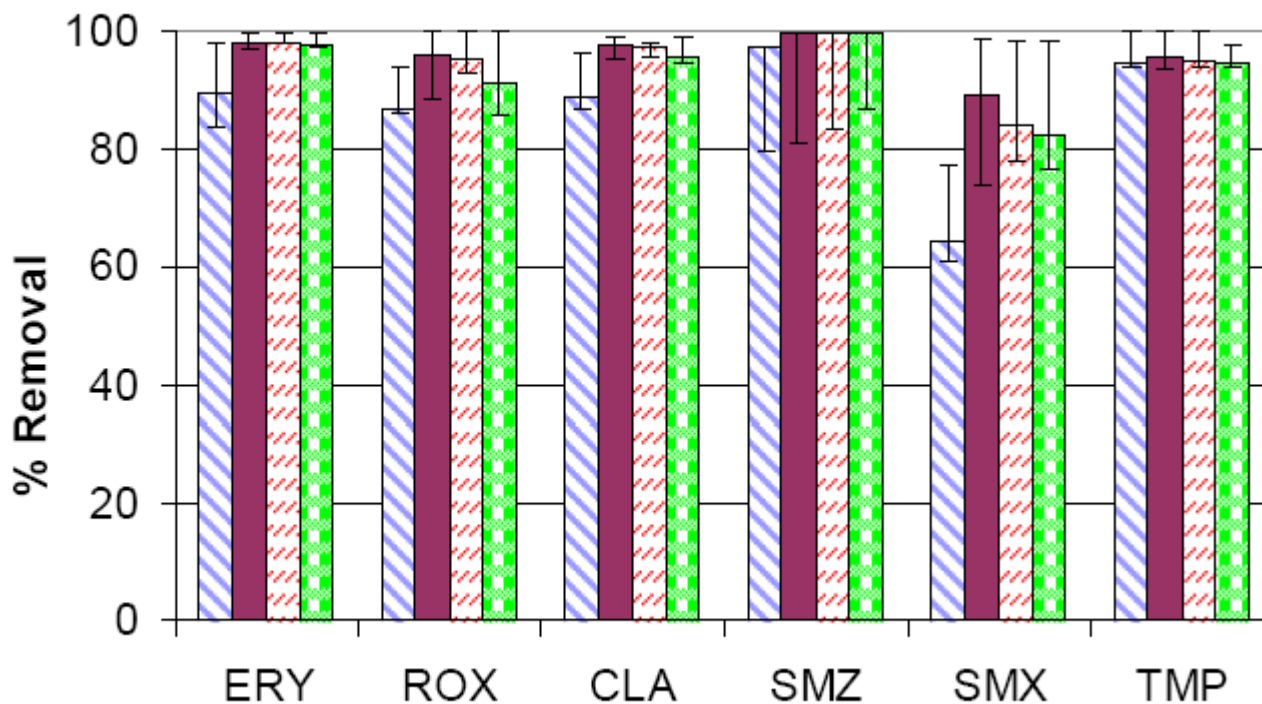


Trimethoprim

Fate of pollutants



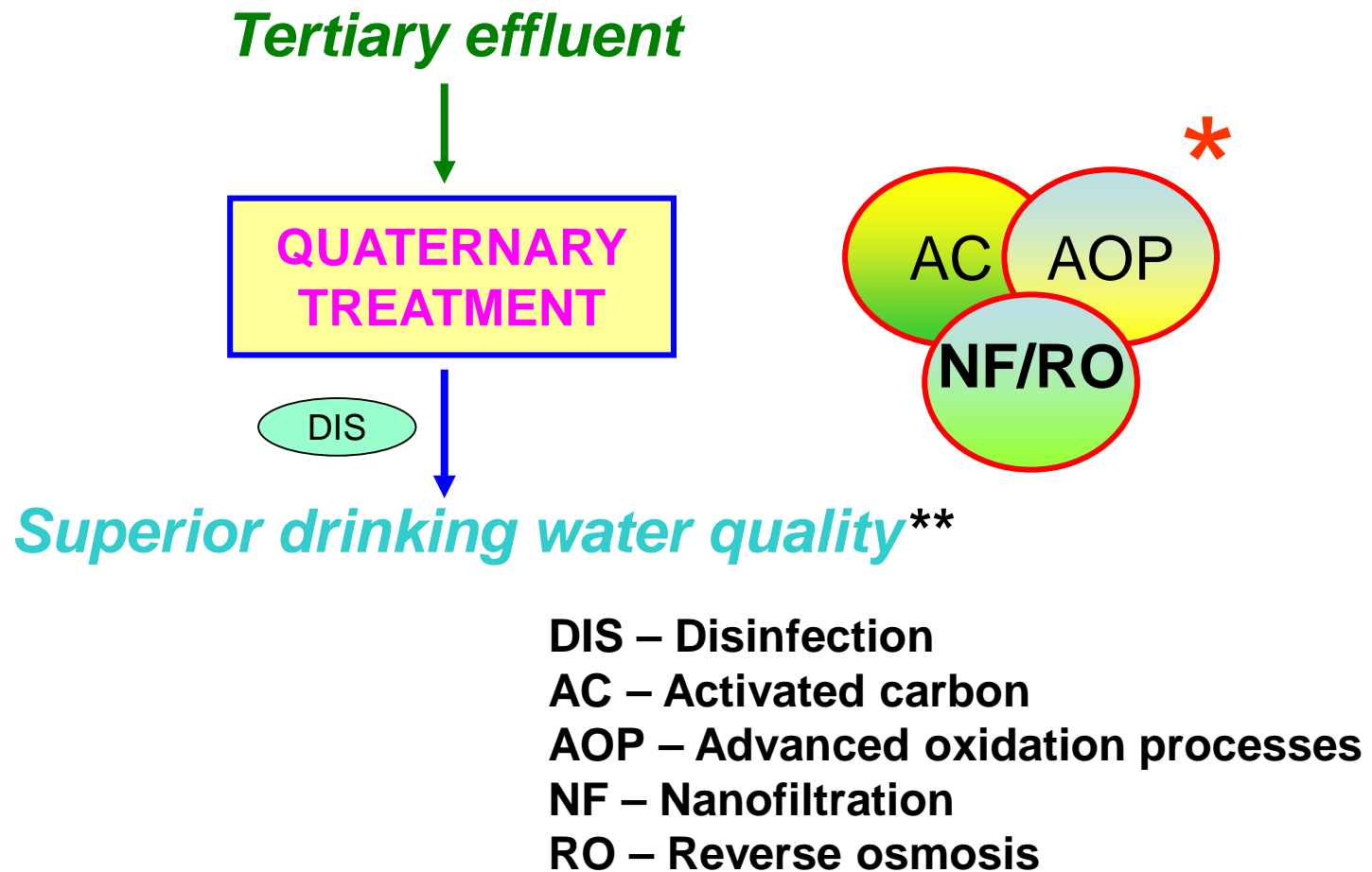
Removal of antibiotics by sorption to biomass



Possible solution for the OMPs problem

Advanced & secure processes

Quaternary treatment



***There is no single process that can be considered an absolute barrier**

***The technological formula should be determined**

What should be considered when setting regulations and standards

- **Indicator compounds**
- **Formation of metabolites**
- **Effect measurements**
 - **Toxicity** (cyto-, geno-, endo-, neuro-, immuno-)
 - **Synergism**

**The detection of a substance is not the problem,
but the evaluation of its effect**

Decentralization vs. centralization

- **Small-scale wastewater treatment and reuse**
- **Separate management of greywater**

Composition of greywater

- Pathogens
- Organic matter
- Nutrients

**Smaller content, but not negligible, and
requires serious treatment**

Ben-Gurion University Sport Center

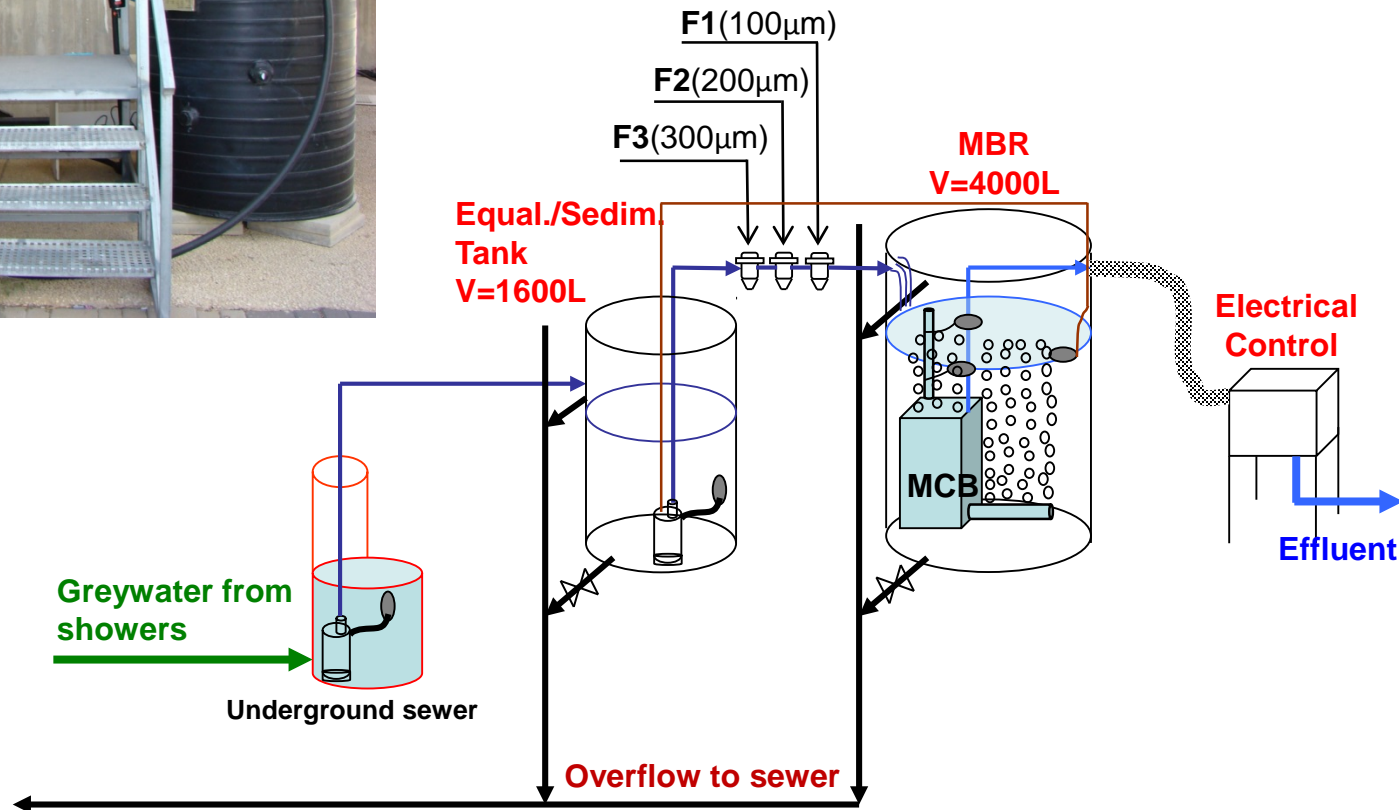
Pilot study of shower-water treatment

MBR – Membrane Bioreactor



HUBER
TECHNOLOGY

MembraneClearBox®
Onsite Biological Sewage Plant



Effluent (permeate) quality

Parameter	In*	Out
CODs [mg/l]	174 \pm 65	<30
BODs [mg/L]	77 \pm 28	<10
TOC [mg/L]	36 \pm 10	<5
TSS [mg/l]	70 \pm 24	<1
Turbidity* [NTU]	>20	<0.2
NH ₄ ⁺ [mg/l]	22 \pm 13	<1
NO ₃ ⁻ [mg/L]	2 \pm 2	<30
Coliform [# /100ml]	$\sim 10^6$	0

*After sedimentation

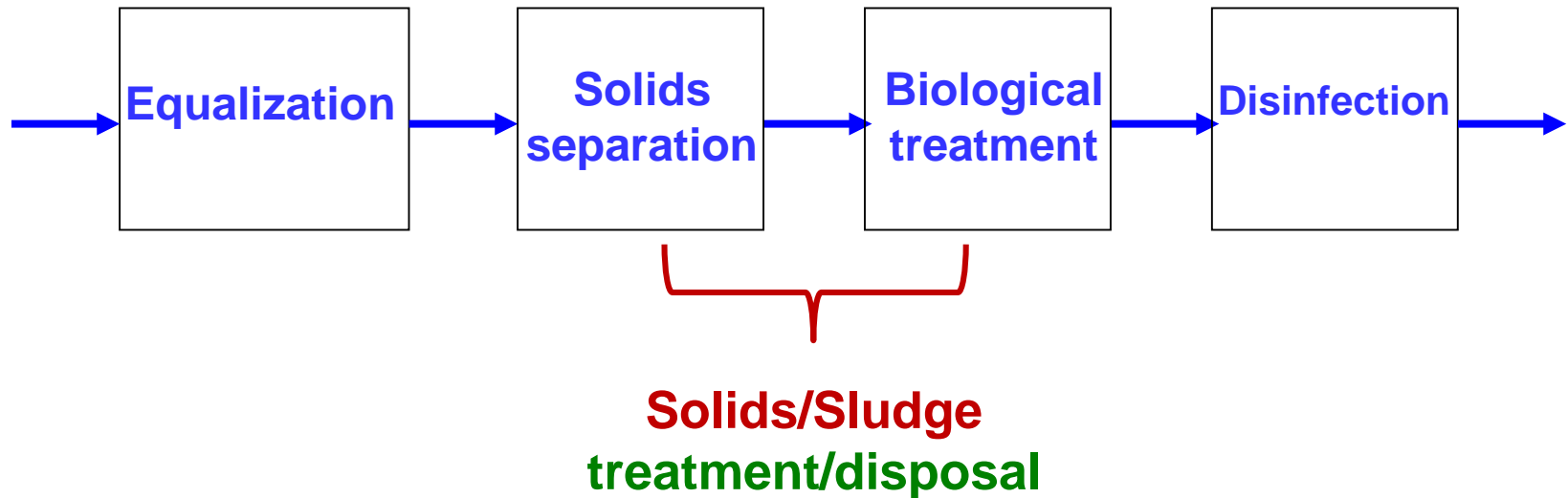
HRT = 1.5 [d]

SRT > 30 [d]

MLVSS~2,500 [mg/L]

Is it simple to manage small-scale systems (including greywater)?

Even to meet only the conventional standards a sophisticated process scheme is required



Residuals of personal care products

(in soaps, shampoos, creams, deodorants, etc.):

- Preservatives (parabens)**
- Biocides**
- Fragrances**
- Softeners**
- Plasticizers**
- Emulsifiers**

**hundreds xenobiotic organic compounds
were identified in greywater**

Segregation of Urine (Yellow water)

Advantages:

High nutrient content & fertilization potential

Disadvantages:

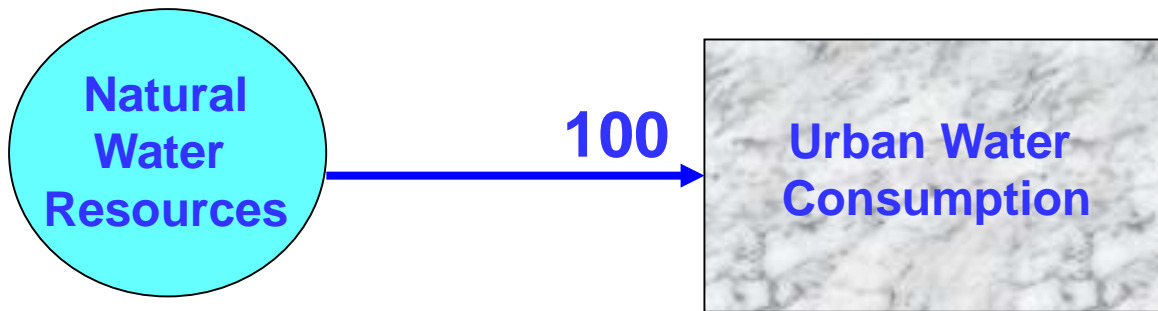
High content* of **pharmaceuticals** and **Illicit drugs** (Cannabinoids, Cocaine, Amphetamine, Steroids.....)



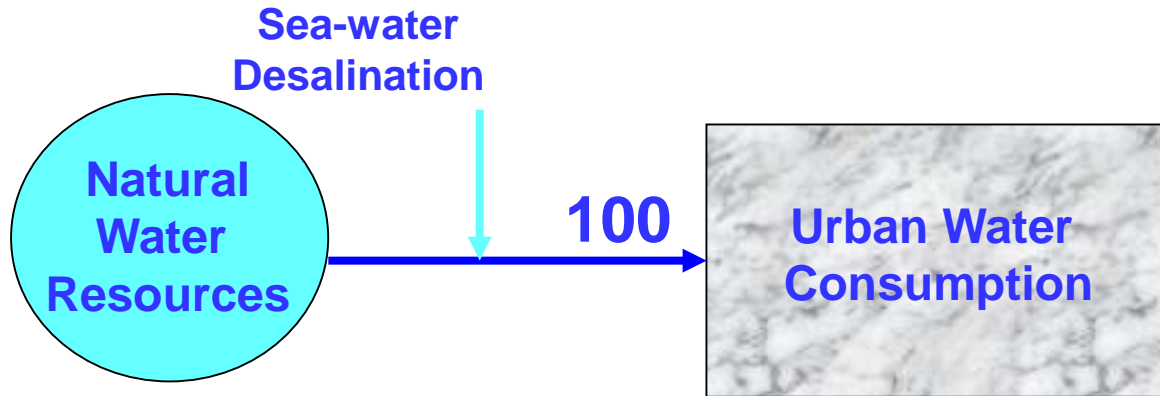
***concentrations in urine ~ 100 fold concentrations in domestic sewage**

My **utopia vision regarding Sustainable Water Management In the urban sector**

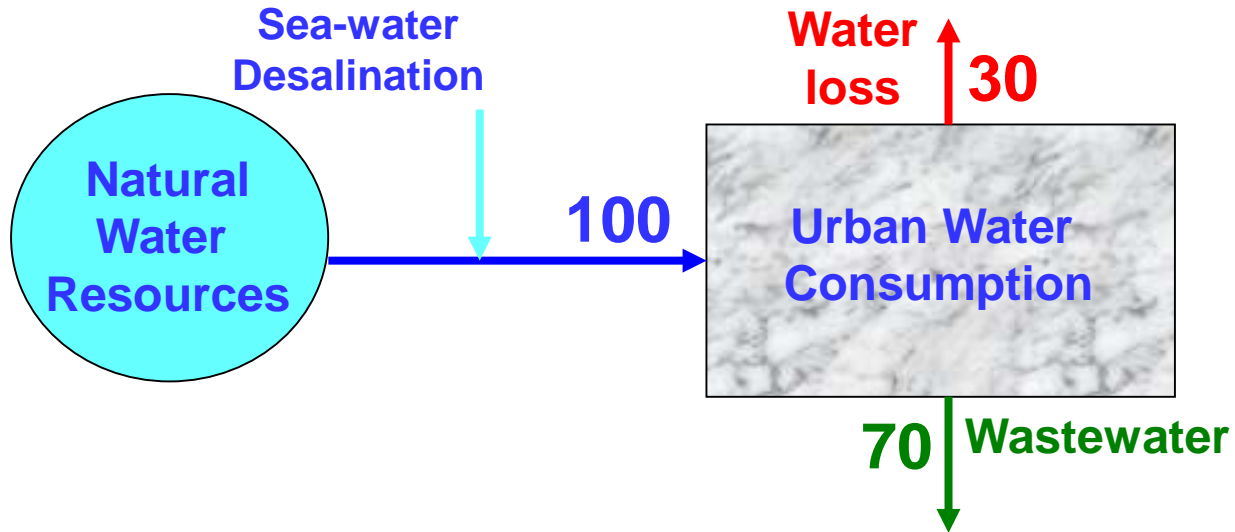
Water Supply



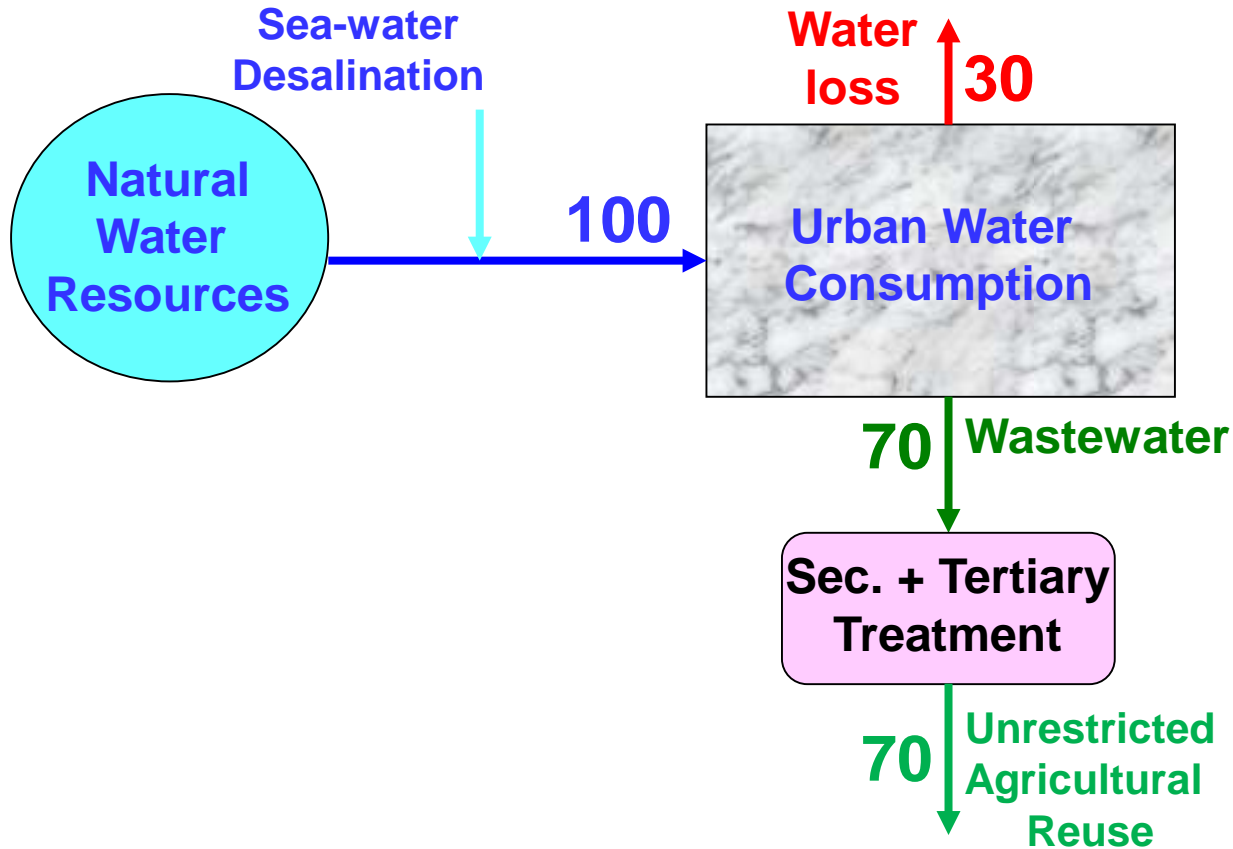
Water Supply+



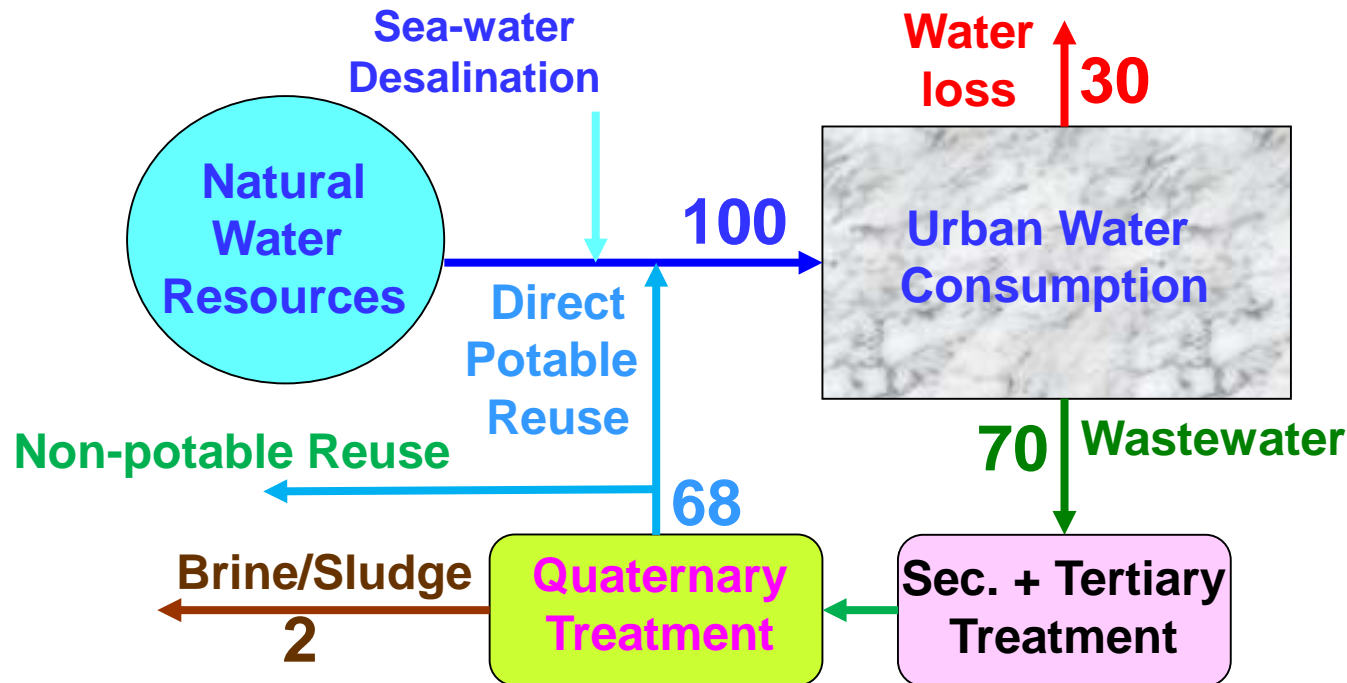
Water Use



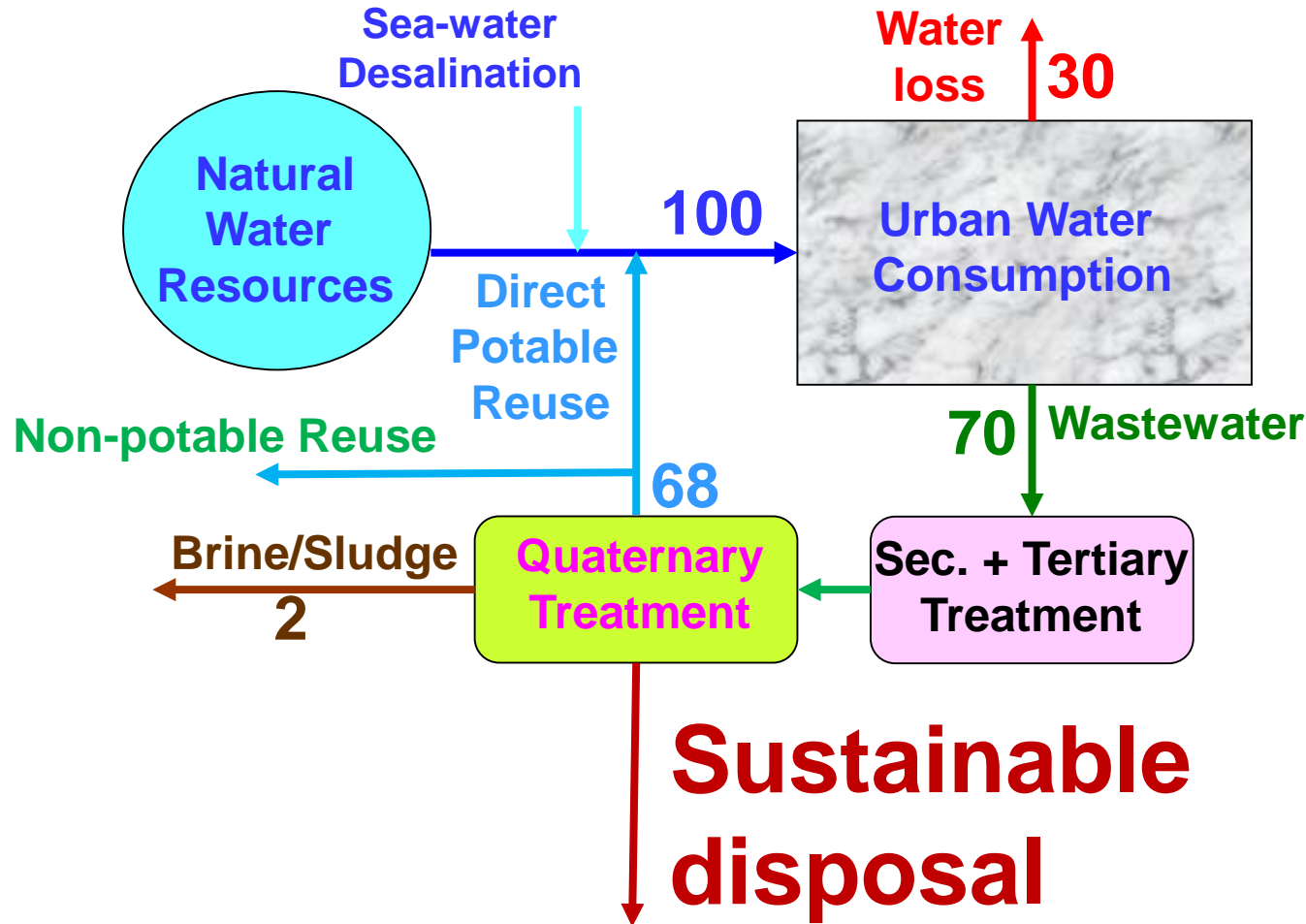
Water Use & Reuse



Water Use & Sustainable Reuse



Sustainable Management



CONCLUSIONS

In our crowded world, the cycle of water-use-reuse-disposal is a closed-loop cycle, where problematic constituents are gradually accumulated.

Therefore, updated regulations and advanced technologies are to be considered to ensure secure wastewater management.

Nature should receive back high (original) quality water!

Decentralization is not a magic solution for sustainability.

Wastewater treatment quality standards and process control should be equal for large/small-scale, grey/black water, centralized/decentralized systems.

Segregation of wastewater & application of small-scale processes may form multi-sources (diffuse**) pollution, because such systems are more difficult to control and more vulnerable to failure.**

Thank you!