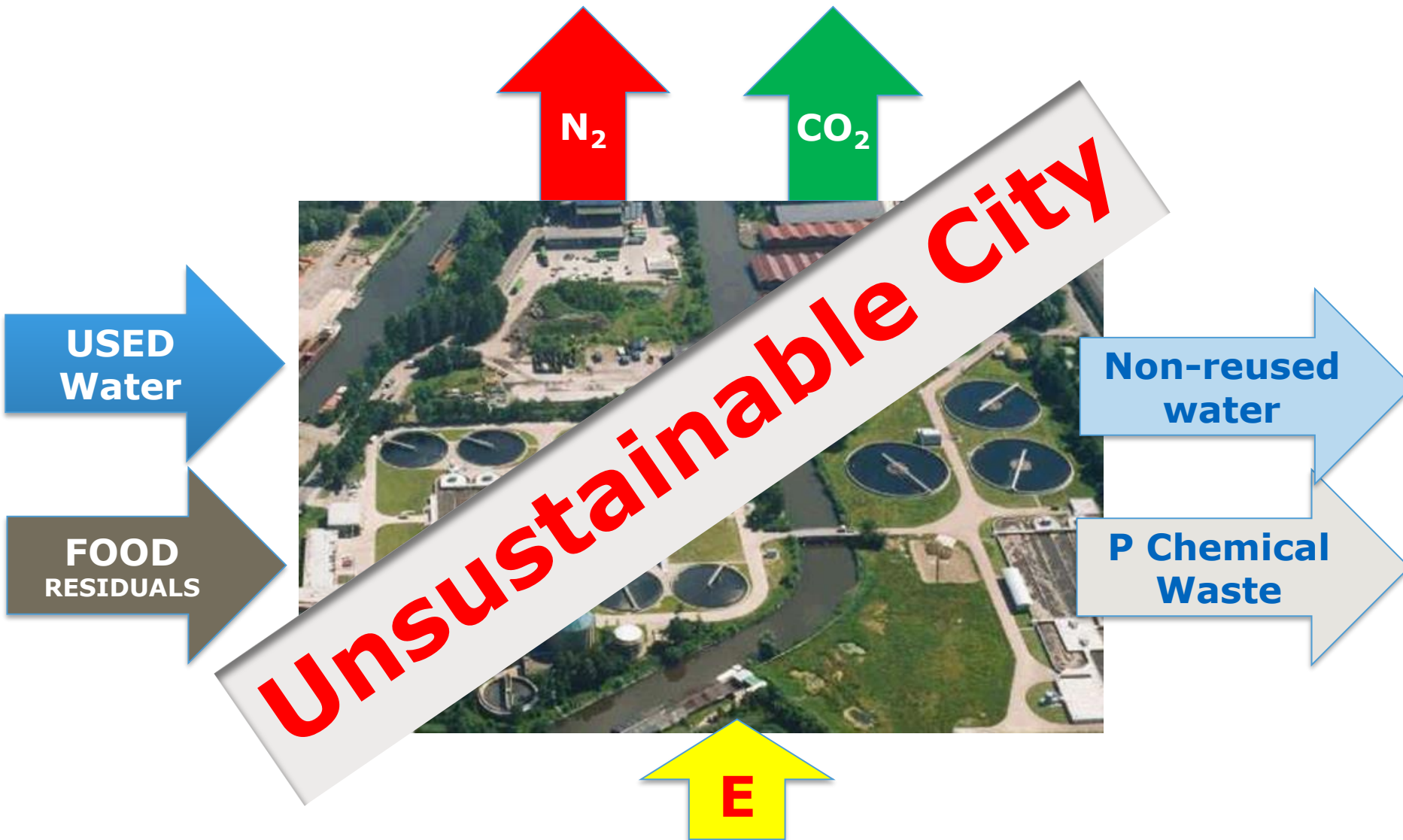


# Nieuwe Sanitatie: op weg naar een duurzame en gezonde voedsel en water kringloop

June 2018, Huub Rijnaarts

Environmental Technology Group

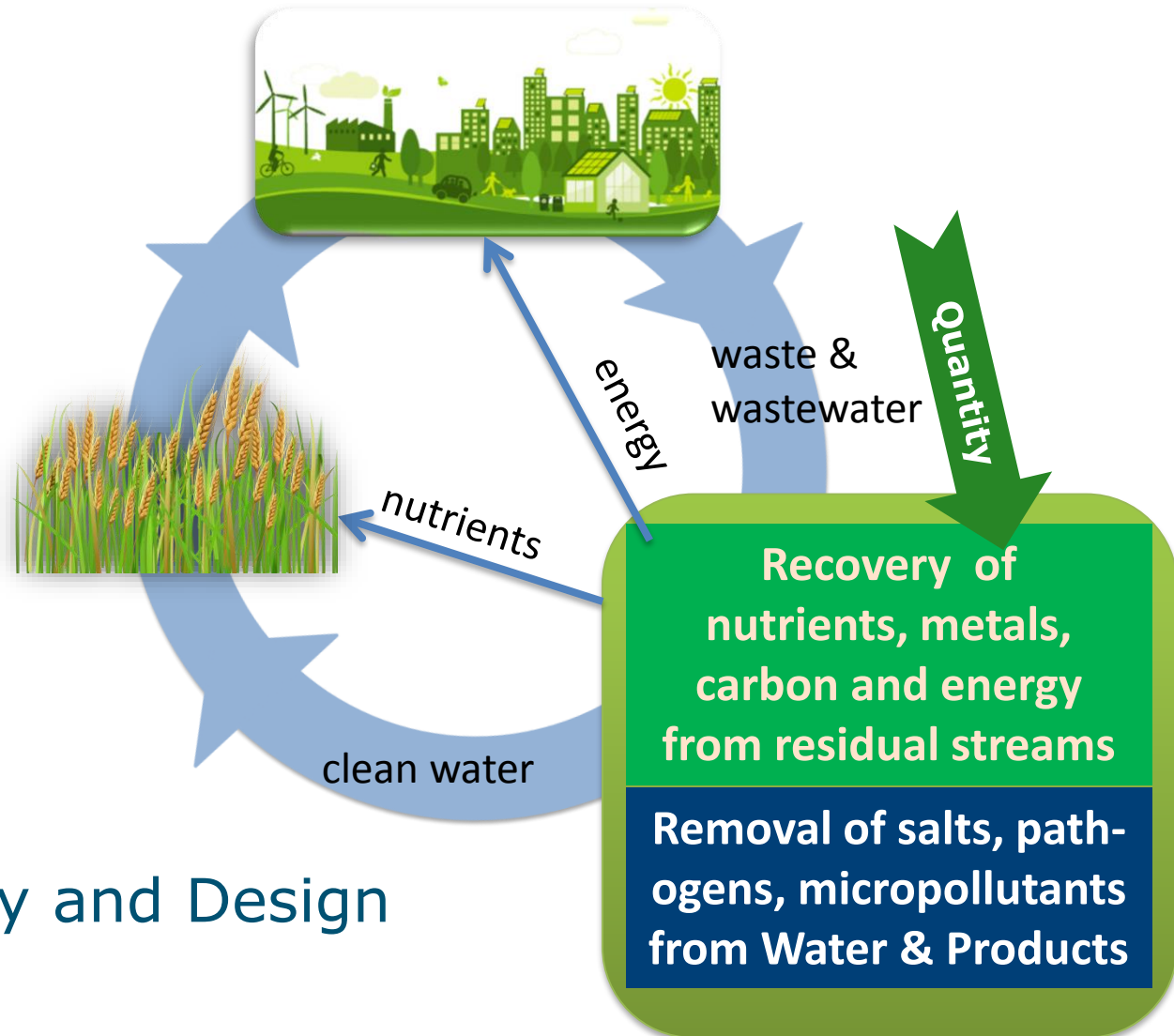
# Urban food and water not sustainable



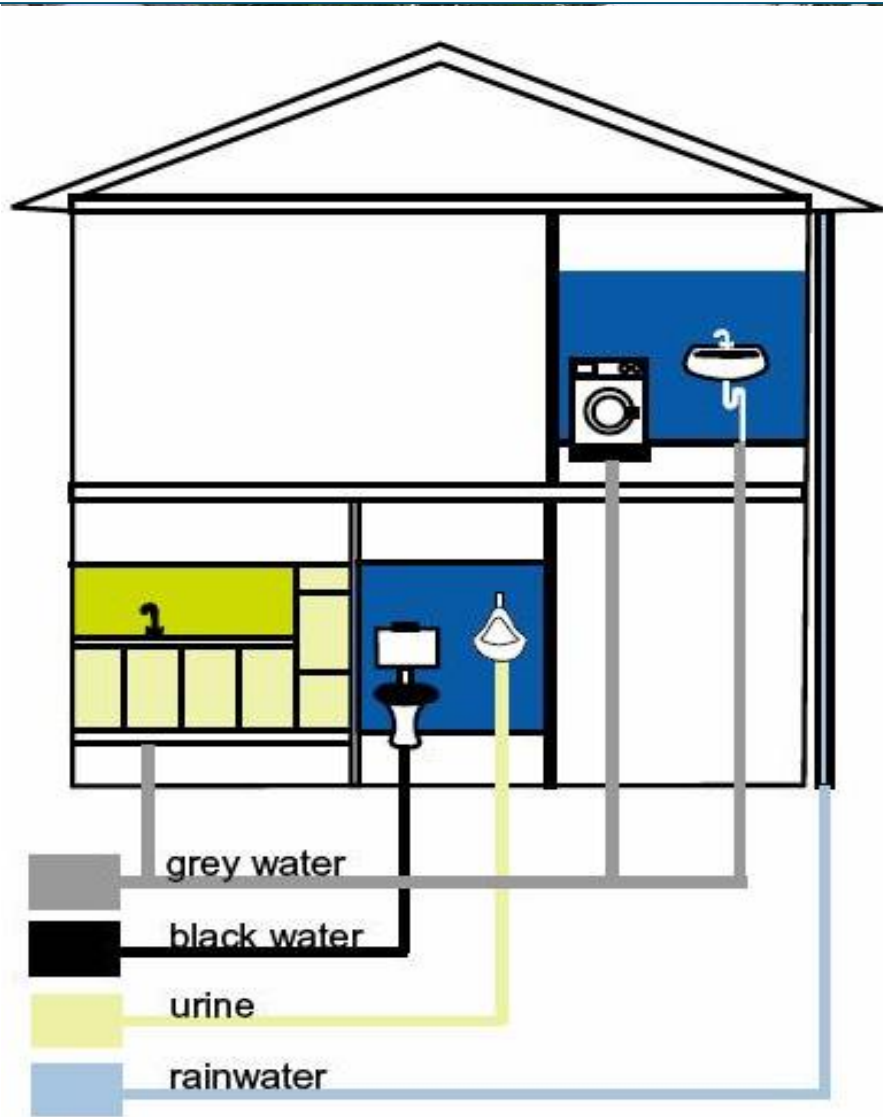
# Solution: New Technology & New Designs to change our world

- No emissions
- CO<sub>2</sub> neutral
- Endless Cycle
- Nature Based

Technology and Design



# NOVEL SANITATION



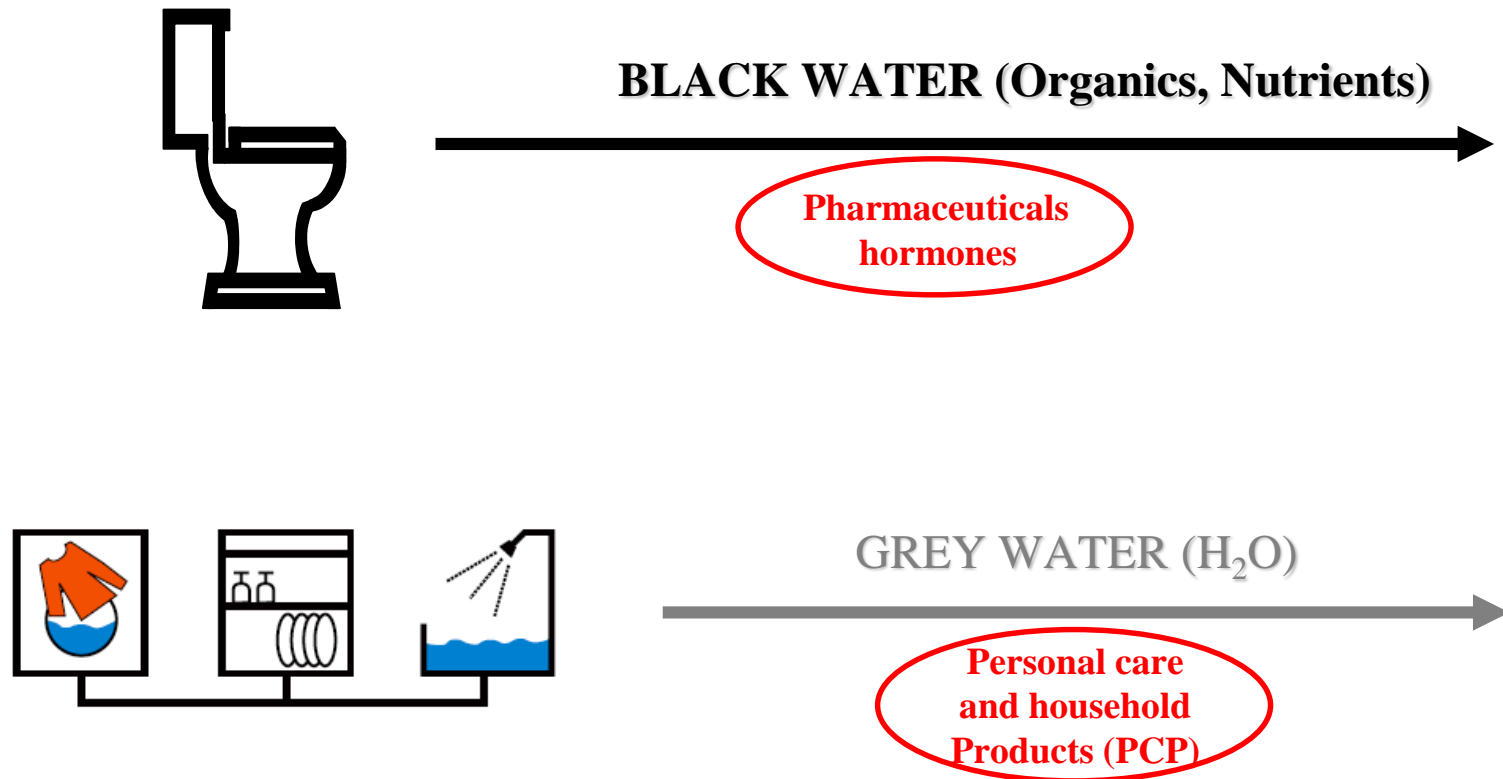
## 250 Houses in the City of Sneek, NL



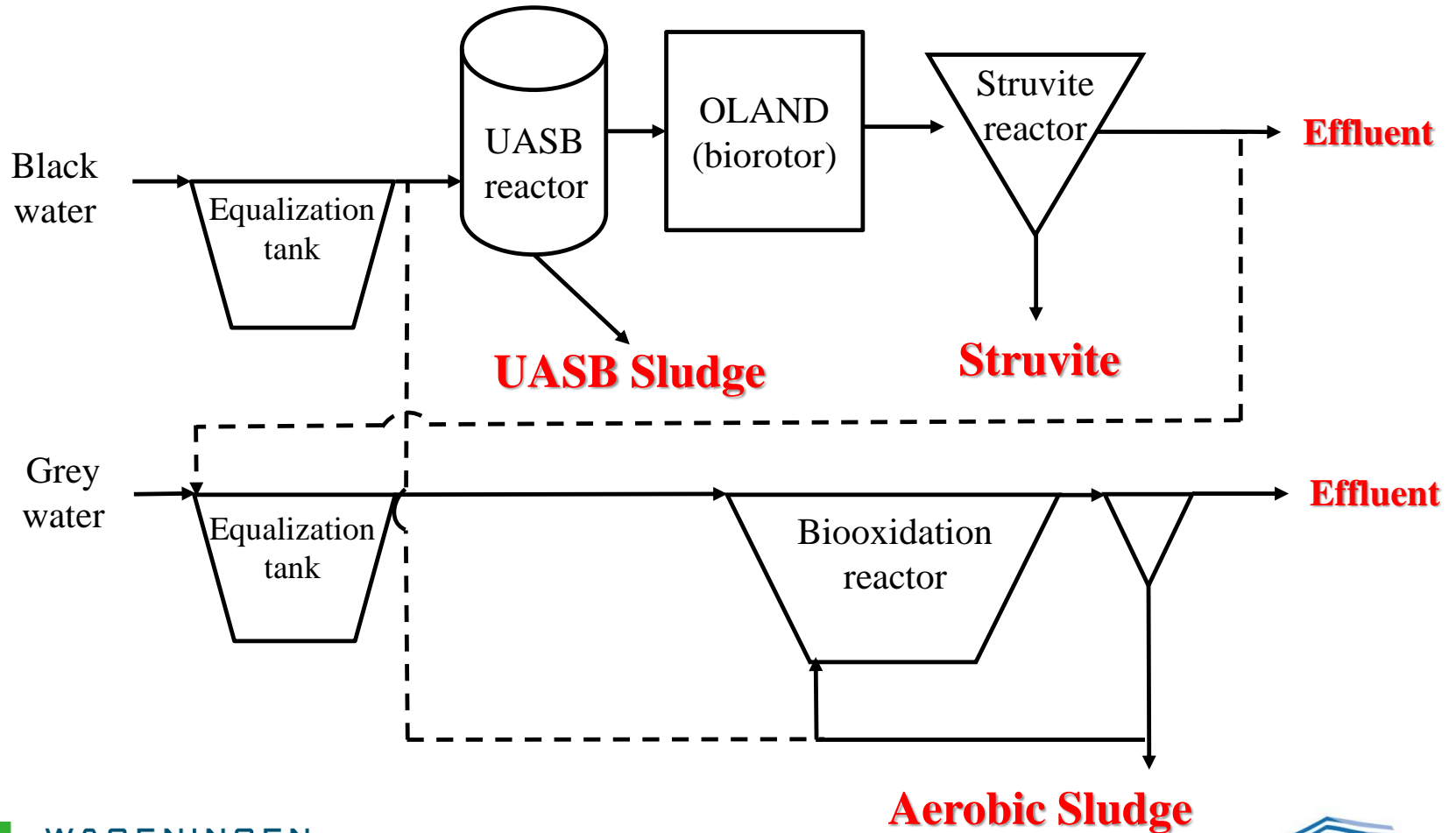
## NIOO Building in Wageningen NL



# Resource recovery by separate collection of wastewater streams



# Source separated sanitation system (Noorderhoek, Sneek, the Netherlands)





# Performance WWTP Novel Sanitation Sneek

## ■ Effluents:

- COD
- Phosphate
- Nitrogen
- .....

## ■ Sludge:

- Metals
- .....



Rosanne Wielemaker  
INTEGRATING URBAN AGRICULTURE  
AND NEW SANITATION

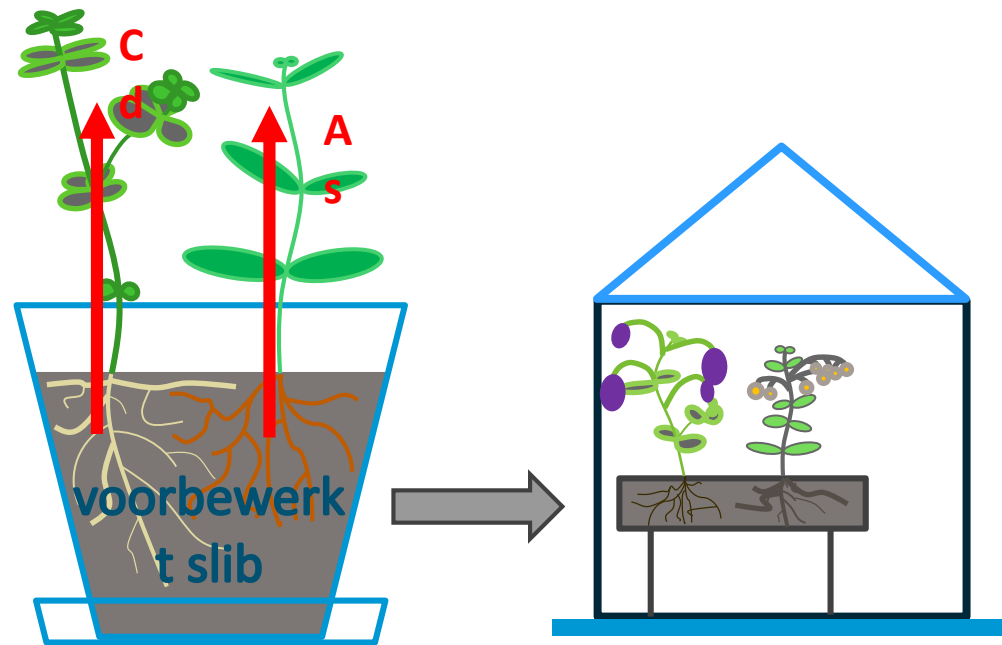
[rosanne.wielemaker@wur.nl](mailto:rosanne.wielemaker@wur.nl)

# PhD RESEARCH

# BUILDING AND NEIGHBORHOOD PHOSPHORUS LOAD PROFILES



# Zuiverings-slib voor de Glastuinbouw



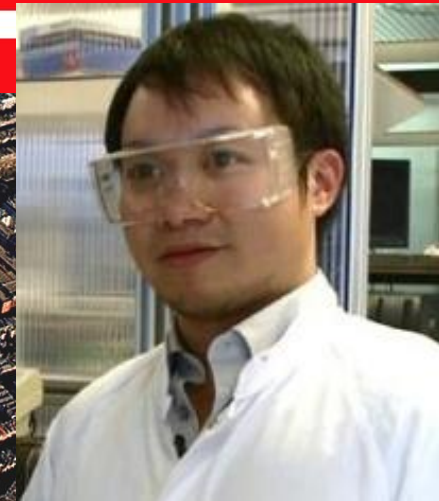
# Amsterdam as living lab

Wei-San Chen  
✓ Green Street  
✓ Circular technologies and infrastructure

City of Amsterdam

Design contest  
**Applied  
Technology  
Institute  
in Amsterdam**

Invitation to participate in the 'Amsterdam Metropolitan Solutions' (AMS) design contest for an applied technology institute in Amsterdam



# Urban Infrastructure Management

## The Street of the Future

### ■ Momo

- Integrated, agriculture-driven & circular urban unit

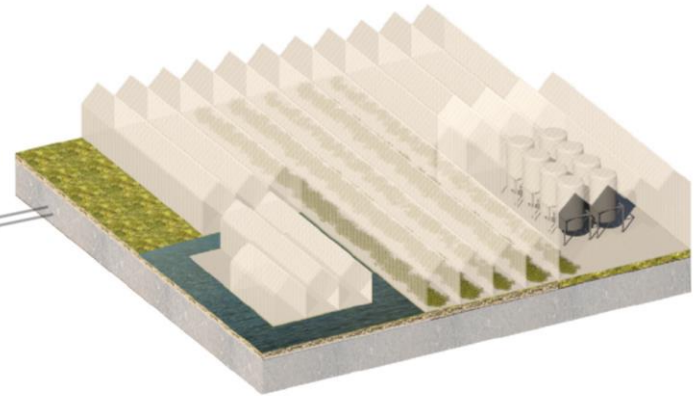
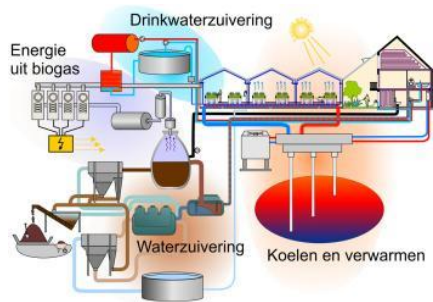
Greenhouse Village

LOTUS/  
TULIP

Selective  
desalination

Smart grid @  
street level

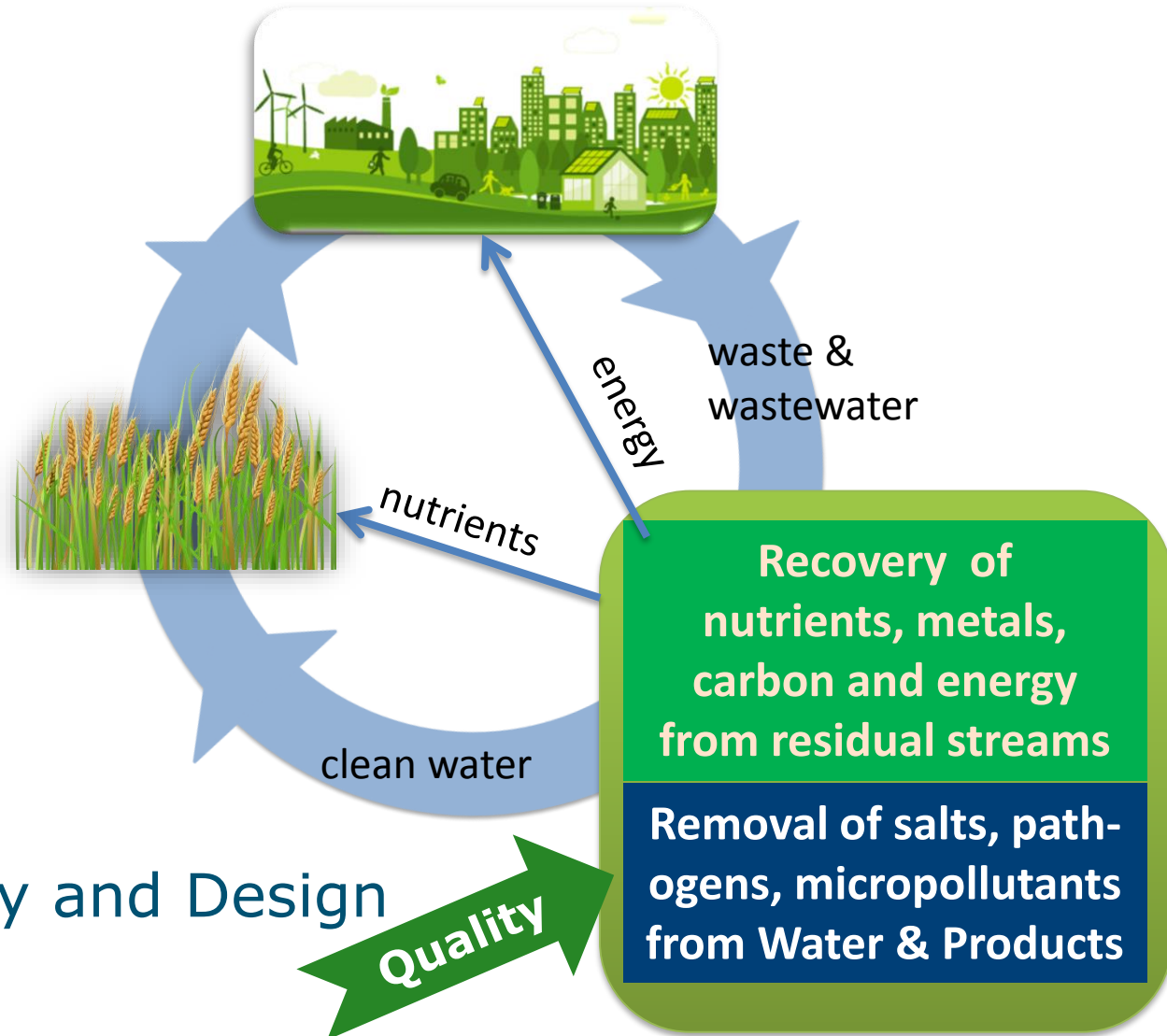
Solar passive  
infrastructure



# Solution: New Technology & New Designs to change our world

- No emissions
- CO<sub>2</sub> neutral
- Endless Cycle
- Nature Based

Technology and Design



# Performance WWTP Novel Sanitation Sneek

## ■ Effluents:

- COD
- Phosphate
- Nitrogen

### Micro-quality

- Micro-pollutants
- Pathogens

## ■ Sludge:

- Metals

### Micro-quality

- Pathogens
- Micro-pollutants



# The choice of compounds investigate at Sneek:Pharmaceuticals

- A. Antibiotics (Ciprofloxacin, Trimethoprim)
- B. Antidiabetics (Metformin, Hydrochlorothiazide)
- C. Analgesics (Paracetamol)
- D. Beta-blockers (Metoprolol, Propranolol)
- E. Antihistamine (Cetirizine)
- F. Antiepileptic (Carbamazepine)
- G. Anti-inflammatory (Ibuprofen, Diclofenac, Naproxen)
- H. Lipid regulators (Gemfibrozil)



# The choice of compounds investigated at Sneek: Personal Care Products

## A. Fragrances:

Galaxolide, Tonalide, Hexylcinnamaldehyde;

## B. Biocides:

Triclocarban, Triclosan, Benzalkonium chloride;

## C. UV-filters:

EHMC, PBSA, Octocrylene, Avobenzone;

## D. Preservatives:

Parabens



# Pharmaceuticals in GW

## Personal care/household products in BW

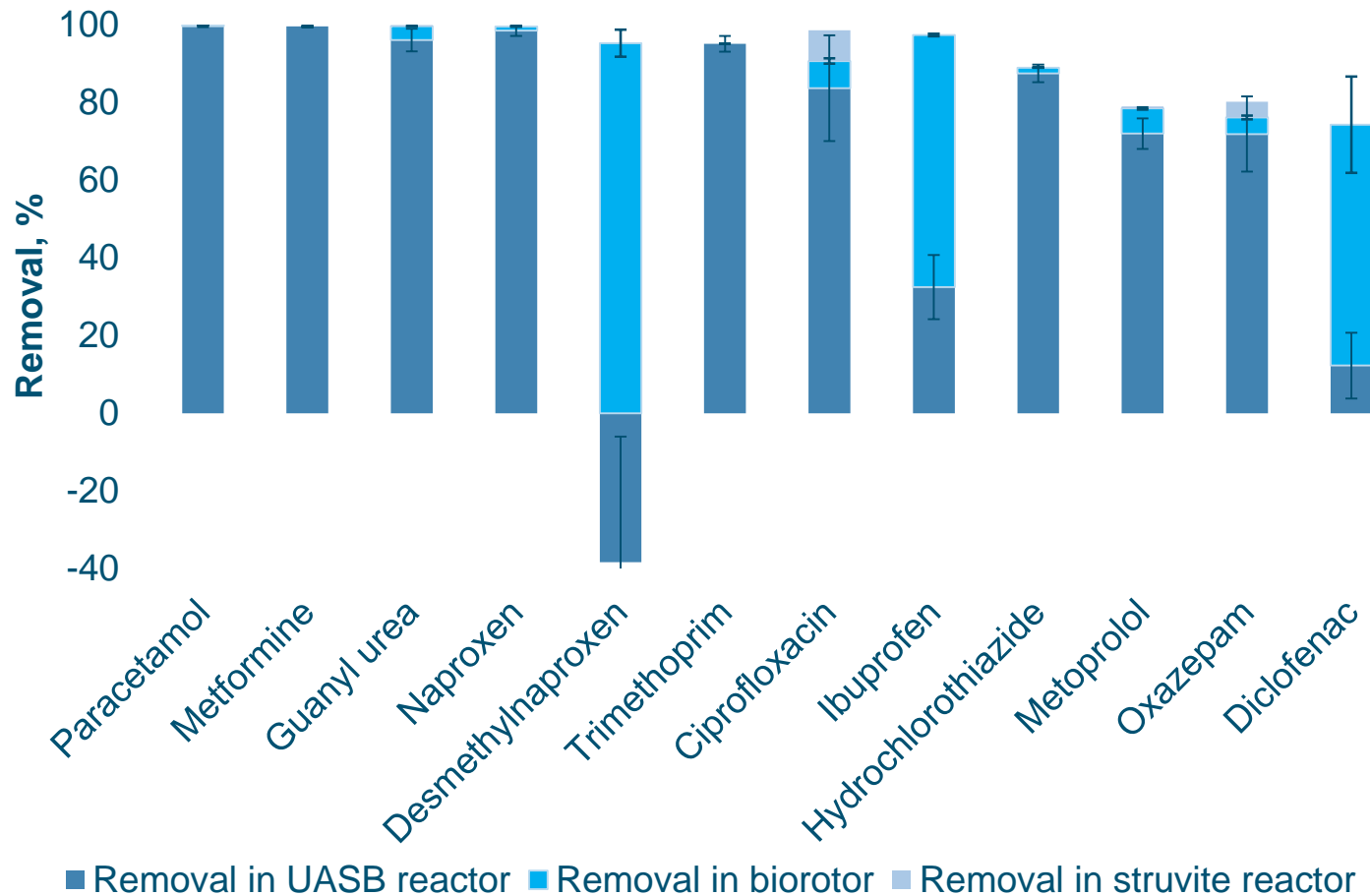
17 pharmaceuticals measured, 5 were found in GW:

- anti-inflammatory (diclofenac, naproxen, ibuprofen)
- paracetamol
- metformin

14 PCPs measured, 8 were found in BW:

- biocides (triclosan, benzalkonium chloride, 2,4-DCP)
- fragrance (galaxolide)
- parabens

# Successive anaerobic and aerobic treatment improves pharmaceutical removal



# Black water effluent is potentially toxic

	Effluent concentration, $\mu\text{g/l}$	PNEC* $\mu\text{g/l}$
Paracetamol	0.1	1000
Ibuprofen	1.1	10
<b>Diclofenac</b>	<b>1.6</b>	<b>0.05</b>
Naproxen	0.7	500
Trimethoprim	0.1	>3000
Ciprofloxacin	1.8	<50
Metoprolol	62.6	>6000

\* - predicted no effect concentration

No PCPs detected in black water effluent

# Pharmaceuticals are present in UASB sludge, but not in struvite

Pharmaceutical	Concentrations in UASB sludge, $\mu\text{g/g}$	PNEC, $\mu\text{g/g}$
Ciprofloxacin	41.8	5380
Metoprolol	17.2	740
Propranolol	30.9	3300

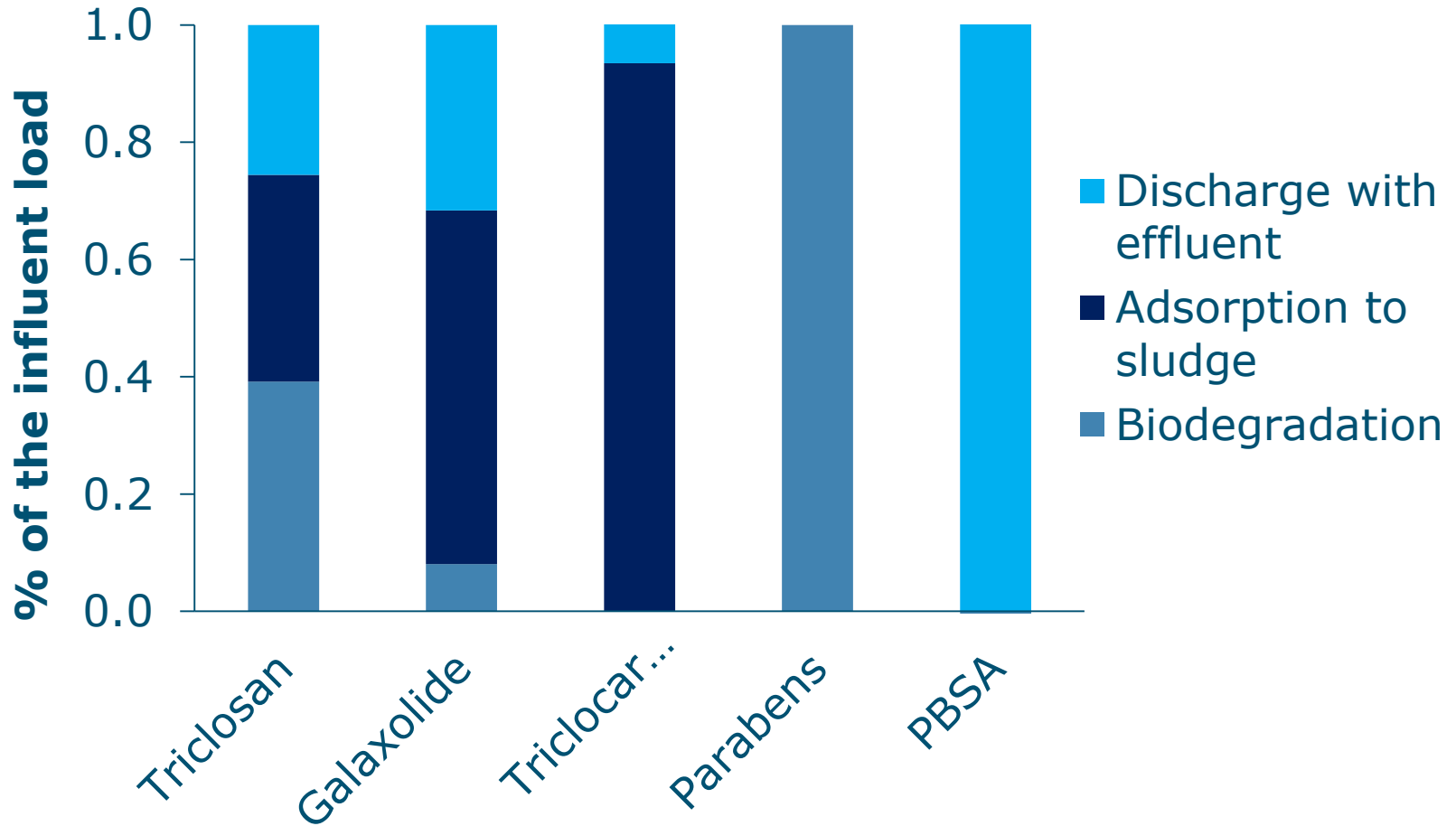
No pharmaceuticals detected in struvite

# PCPs are present in UASB sludge (and struvite)

Micropollutant	Concentrations in UASB sludge, $\mu\text{g/g}$	PNEC, $\mu\text{g/g}$
Galaxolide	3.0	280
Triclosan	4.7	0.8 – 4
Triclocarban	2.6	40
2,4-dichlorophenol	0.2	2.2
Benzalkonium chloride	38.7	203

2,4 dichlorophenol was found in struvite (0.5  $\mu\text{g/g}$ )

# Grey water effluent and sludge contain PCPs





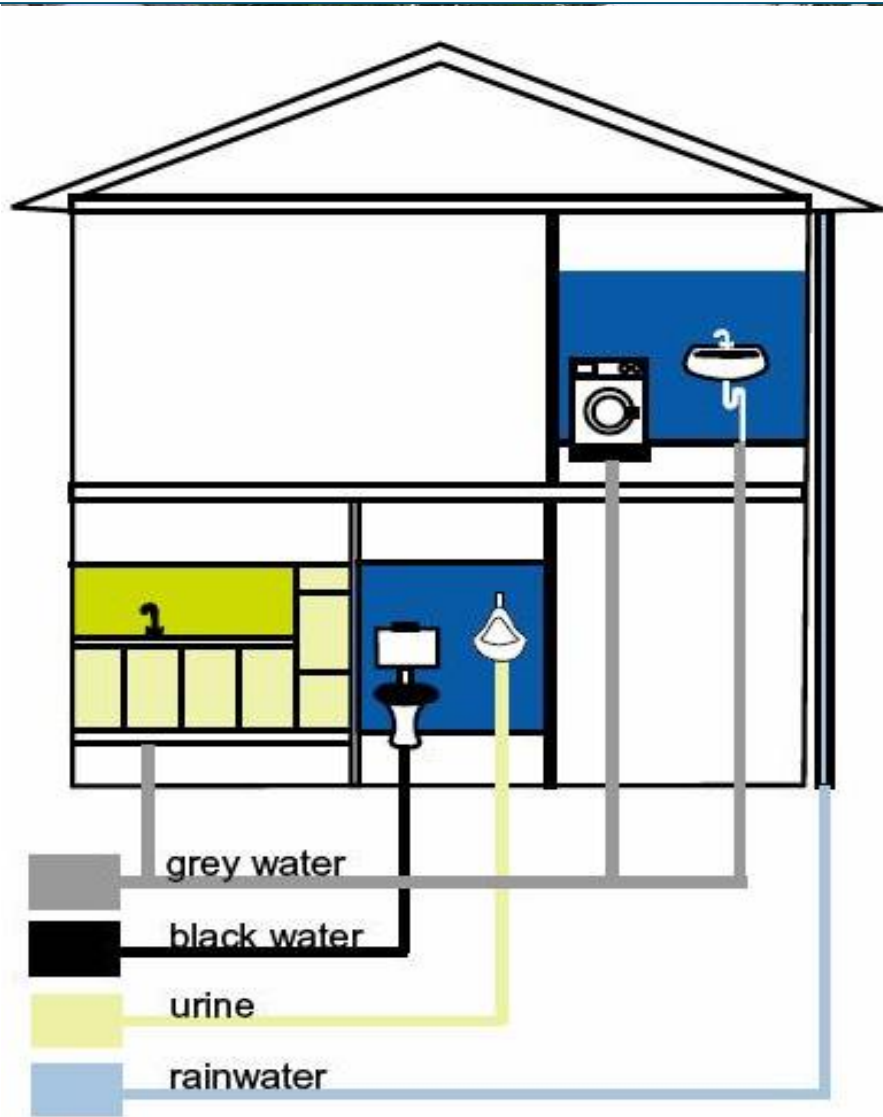
# PCPs are present in grey water sludge (but not pharmaceuticals)

Micropollutant	Concentrations in UASB sludge, $\mu\text{g/g}$	PNEC, $\mu\text{g/g}$
Galaxolide	226.3	280
EHMC	217.7	n.d.
HCA	27.4	n.d.
Triclosan	140.6	0.8 – 4
Triclocarban	105.5	40
Benzalkonium chloride	102.7	203
Avobenzone	46.3	n.d.

# Conclusions novel sanitation based water cycle Sneek.

- Effluents of black water and grey water treatment systems require additional post-treatment prior to reuse or discharge;
- UASB sludge and struvite can be applied as soil amendment;
- Decrease of triclosan concentrations in UASB sludge is needed;
- Grey water sludge is not advised for soil applications due to the high risk quotients calculated for biocides

# NOVEL SANITATION



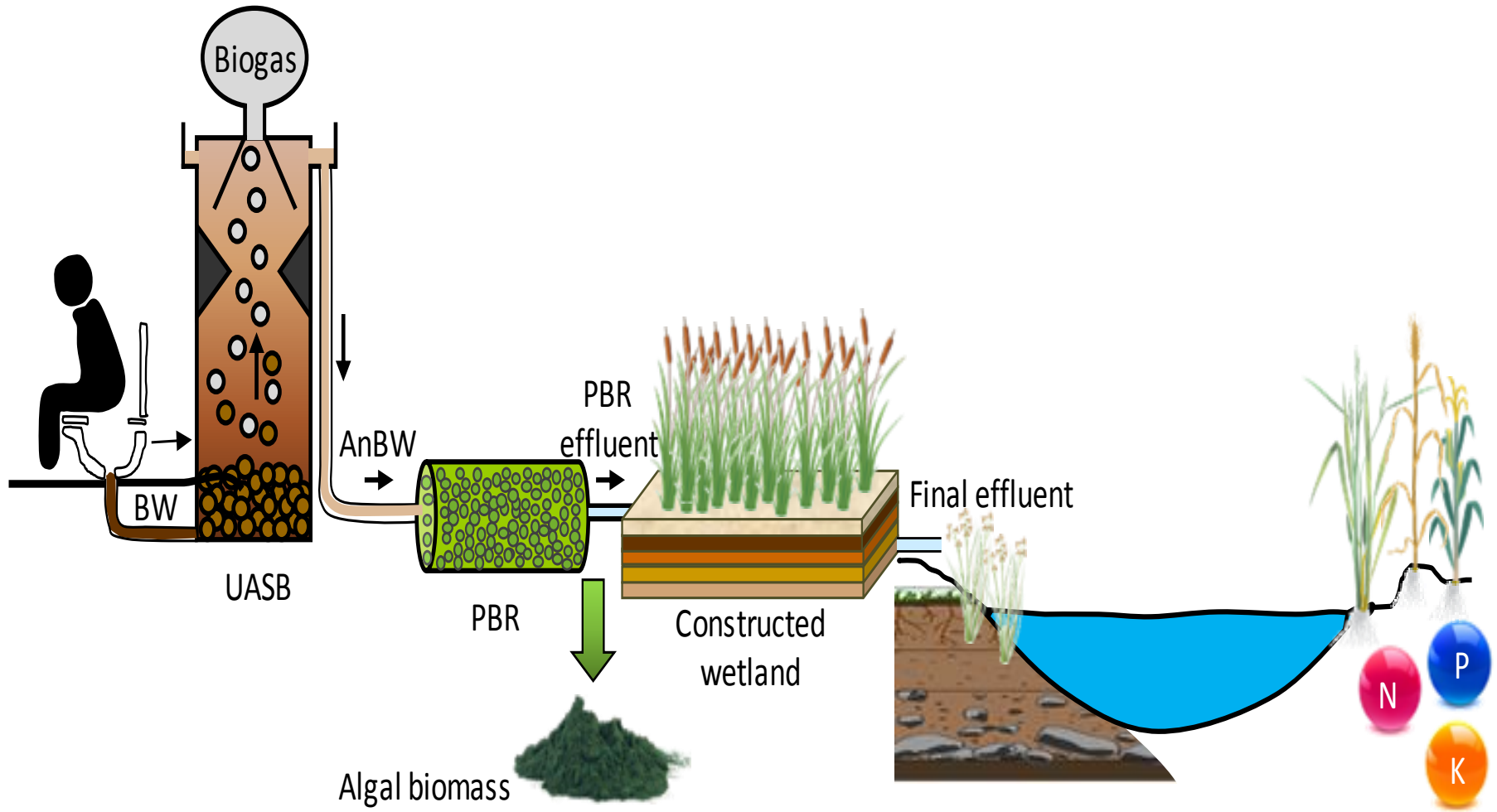
## 250 Houses in the City of Sneek, NL



## NIOO Building in Wageningen NL



# Organische micro's en algen (WUR – NIOO)



# Pharmaceutical removal (2)

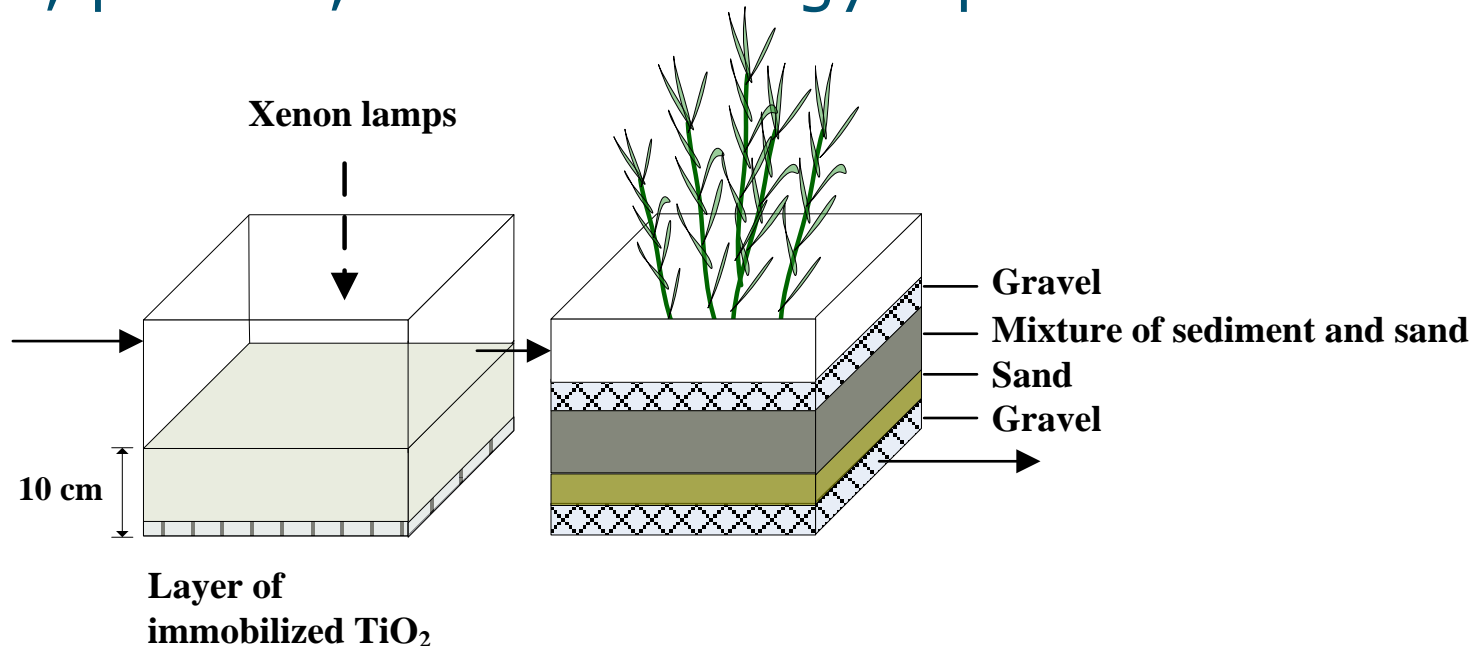
Pharmaceutical	Removal %	Removal mechanism
Diclofenac	max. 70%	Photolysis
Ibuprofen	>99%	Photolysis
Paracetamol	>99%	Biodegradation Algae & bacteria & Photolysis
Metoprolol	>99%	Biodegradation Algae & bacteria
Trimethoprim	<30%	Biodegradation Algae & bacteria
Carbamazepine	<10%	-

- Sorption accounted for <5% of the pharmaceutical removal

# Sustainable technologies → natural systems

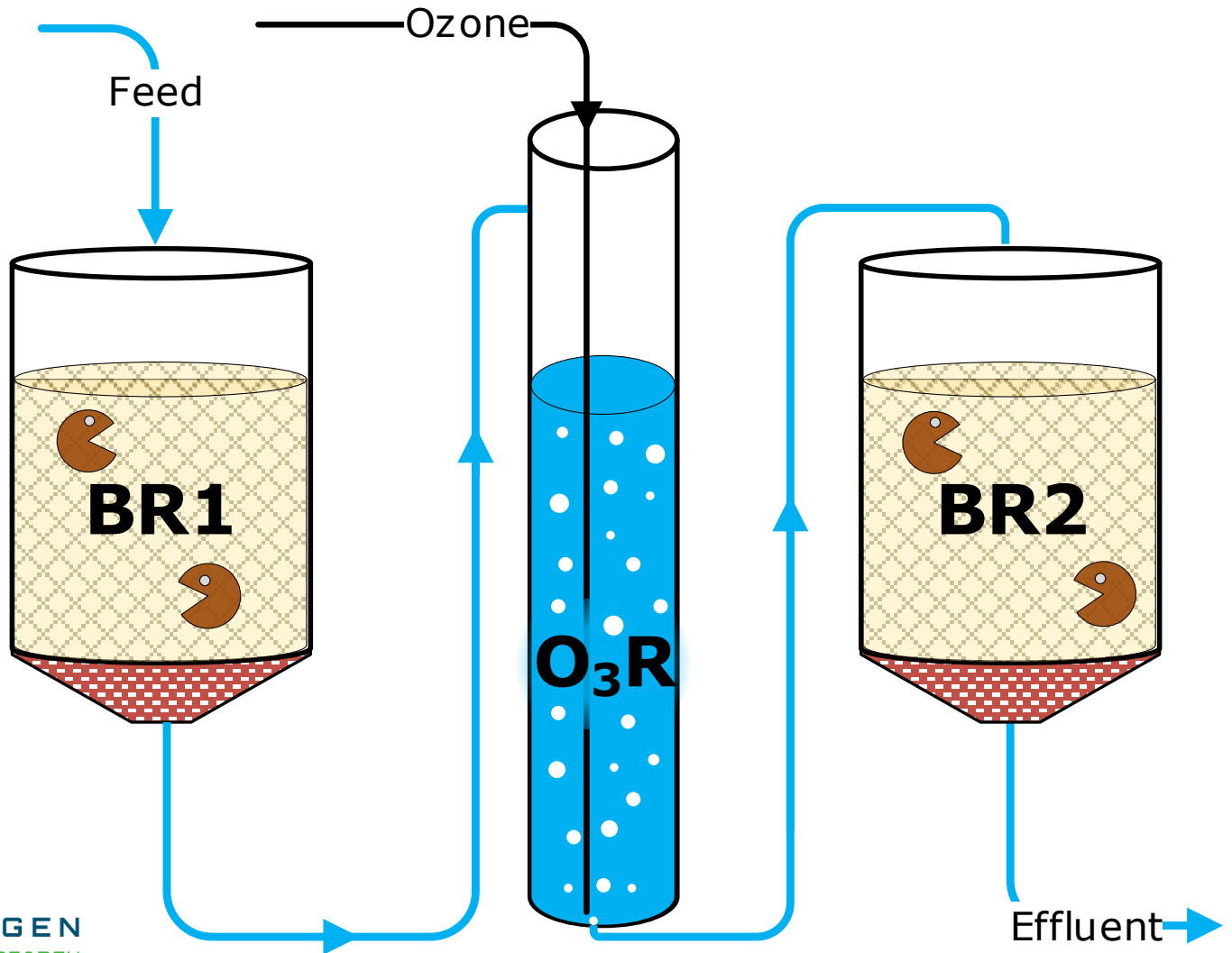
Tested for pharmaceutical removal

- Open  $\text{TiO}_2$  cell as pretreatment to constructed wetland
- Low-cost, passive, minimal energy input

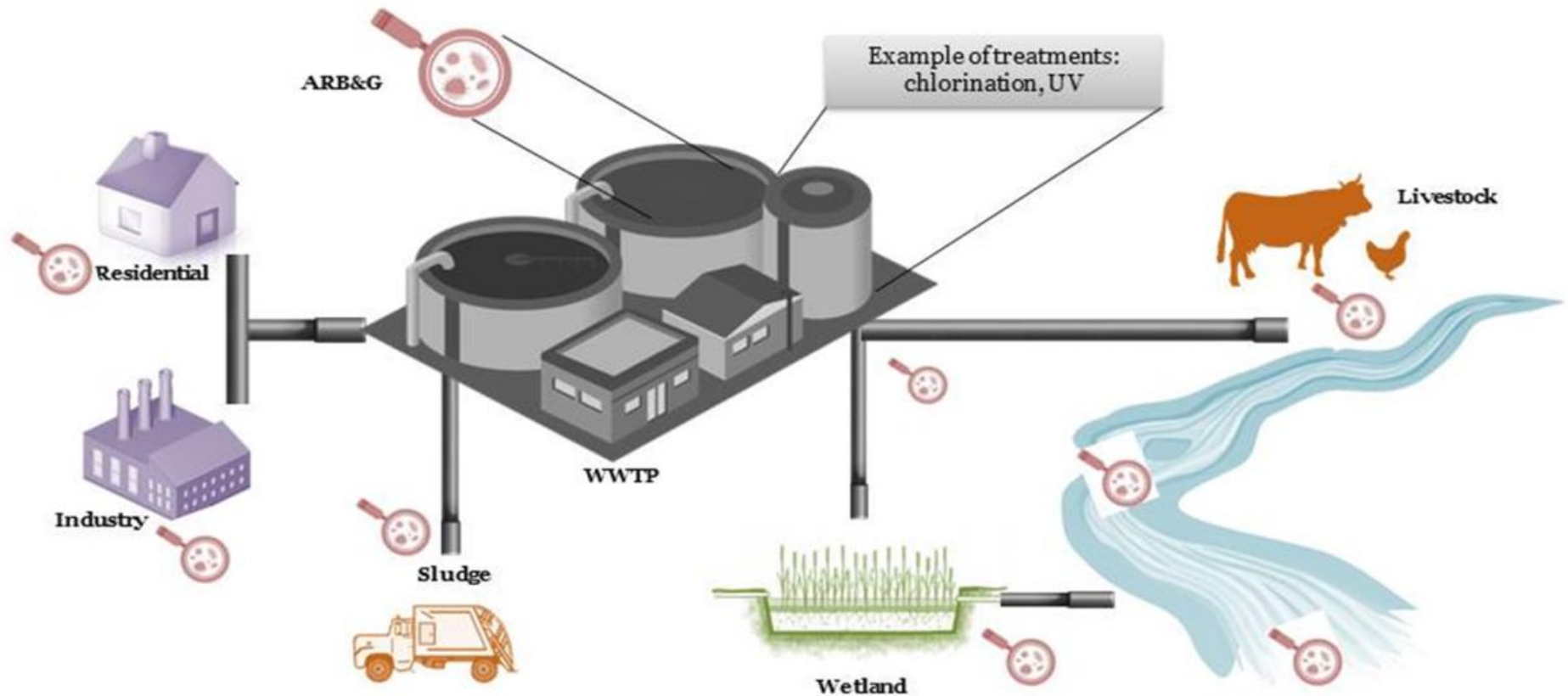


# Lab-scale BO3B process;

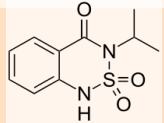
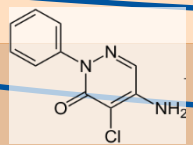
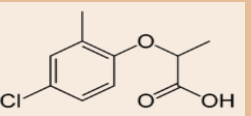
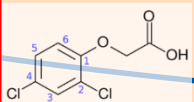
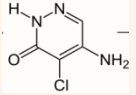
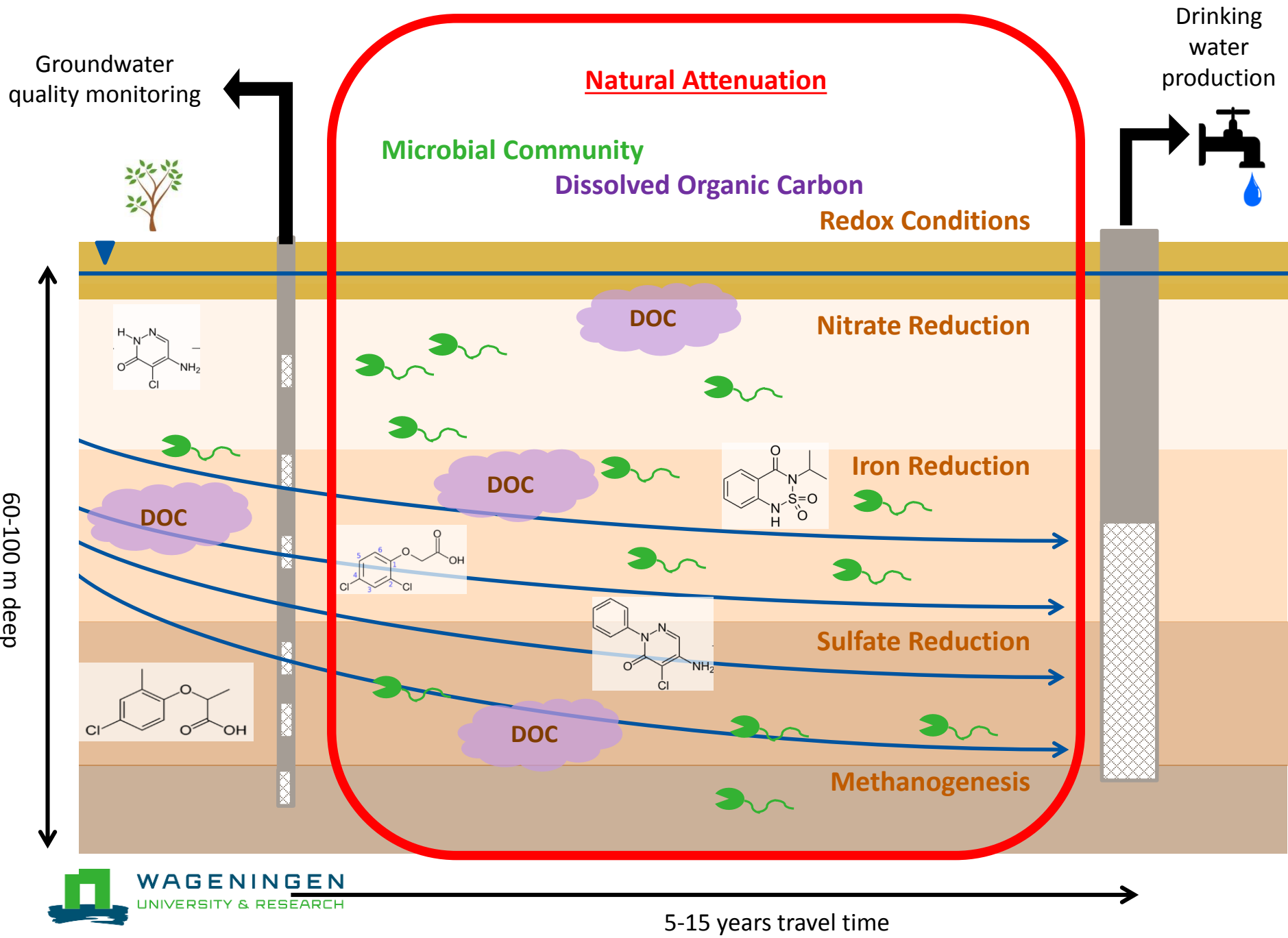
BR=BioReactor, O<sub>3</sub>R=OzoneReactor



# Azie Sabri; Antibiotic resistance bacteria and genes

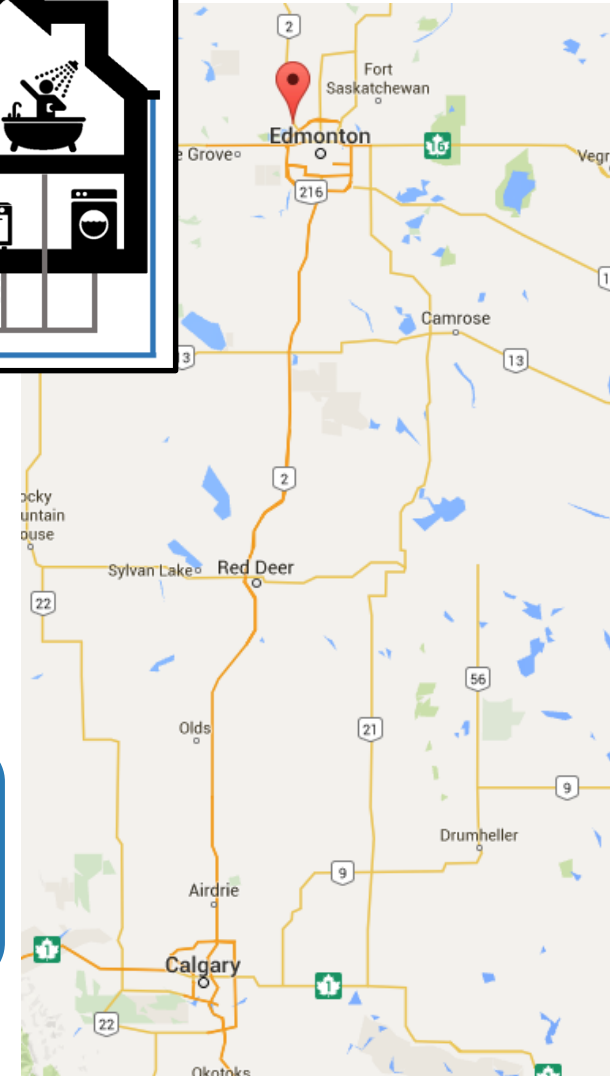
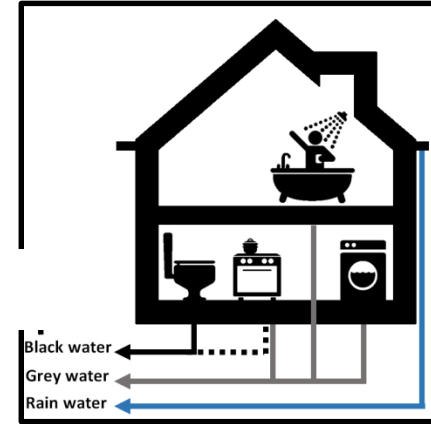






# New Sanitation in St. Albert, Edmonton Alberta in Canada

- Source separation
- resource recovery
- 2000 dwellings
- Water centre
- Supported by province, UAMA, local towns



UofA

WUR

Belrose Farms

DeSaH

Maple Reinders



# Environmental Technology Department Trip August 2017