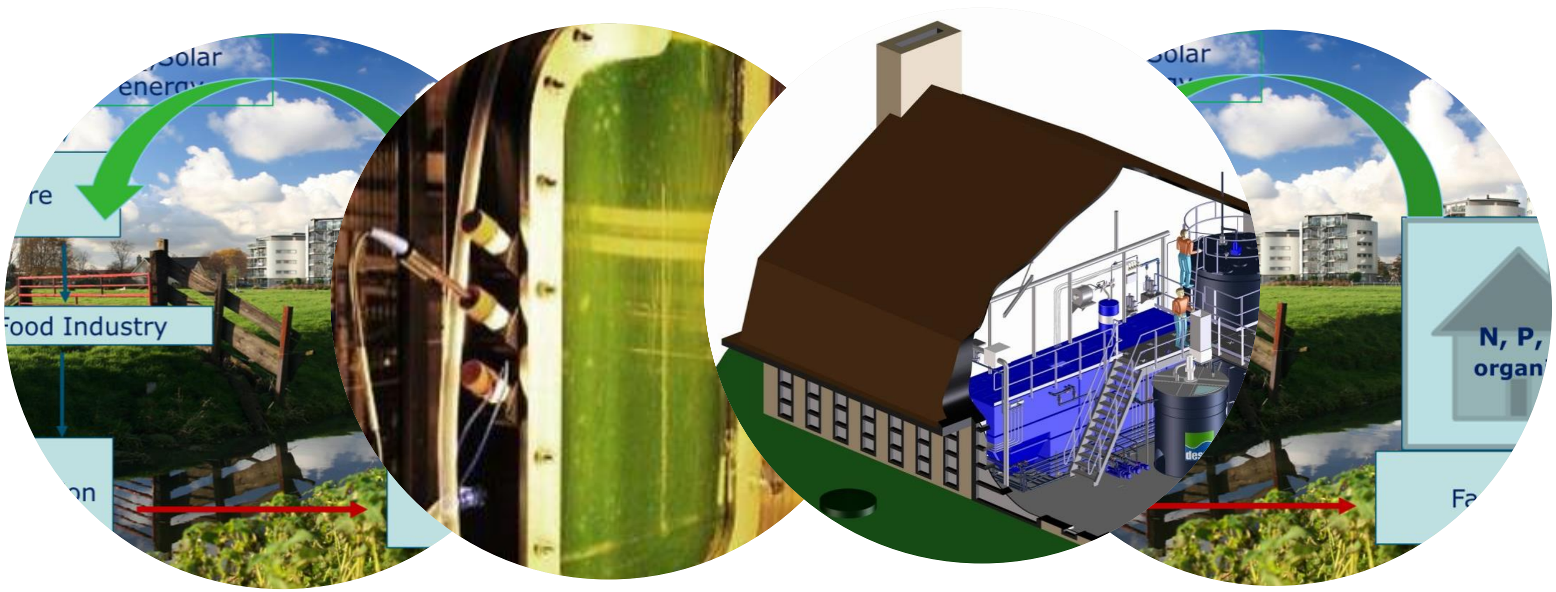
Source separated sanitation, 'New Sanitation', ready for practice!

14-09-2016, Grietje Zeeman, WUR-ETE & LeAF



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‘New Sanitation’

What do we want to achieve?

What did we achieve so far?

Which new developments?

What is the future?

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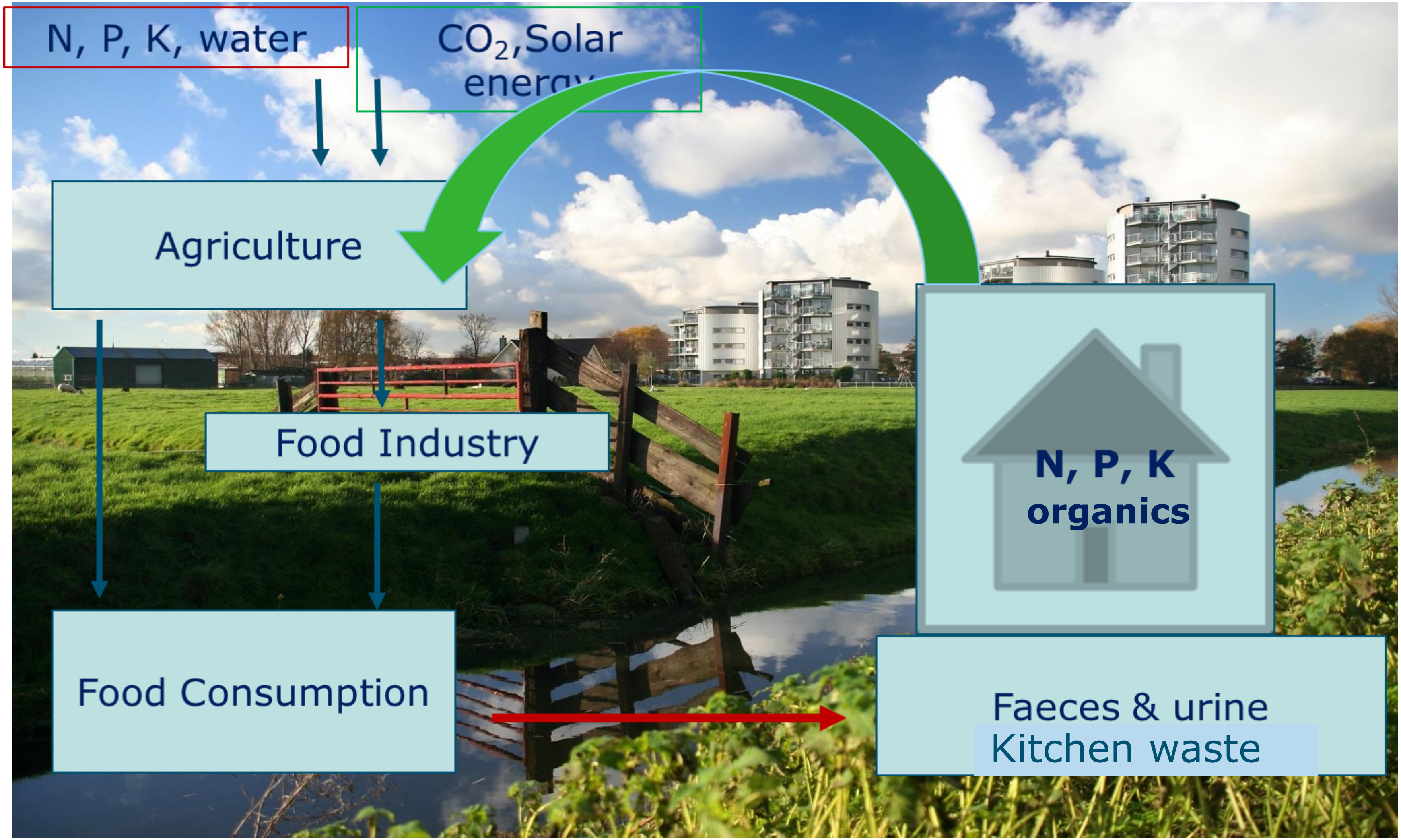
Objective: restore the resource cycle



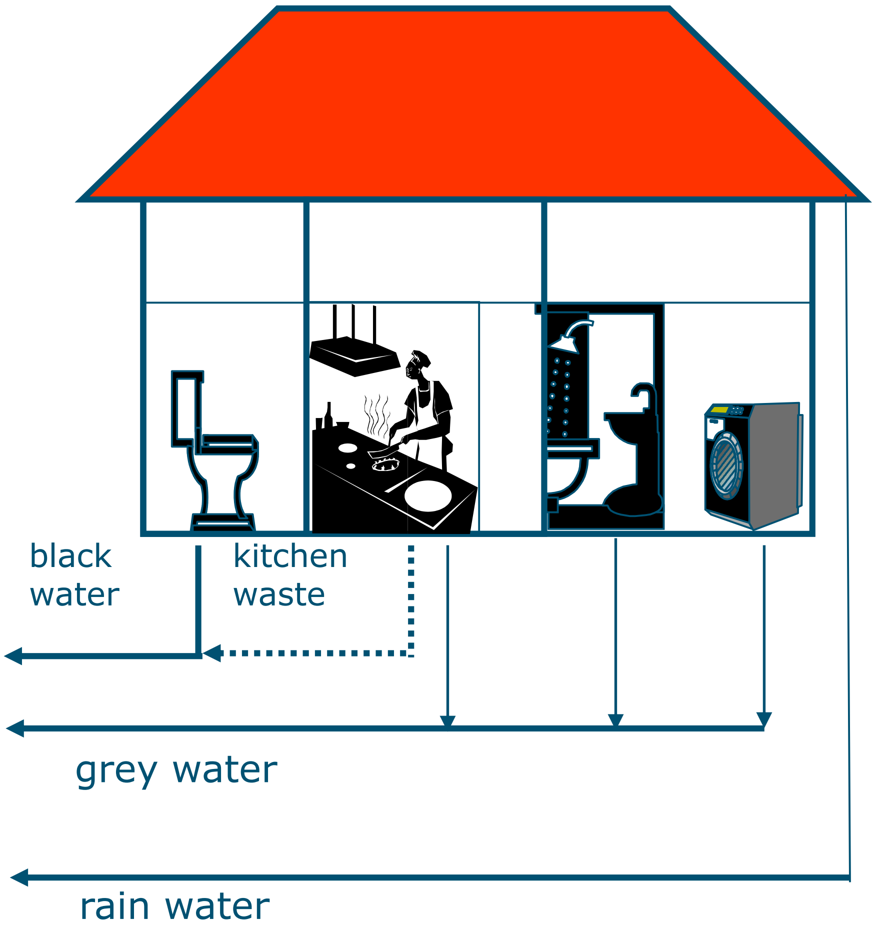
'New Sanitation'

Collection

Transport

Treatment & recovery

Reuse



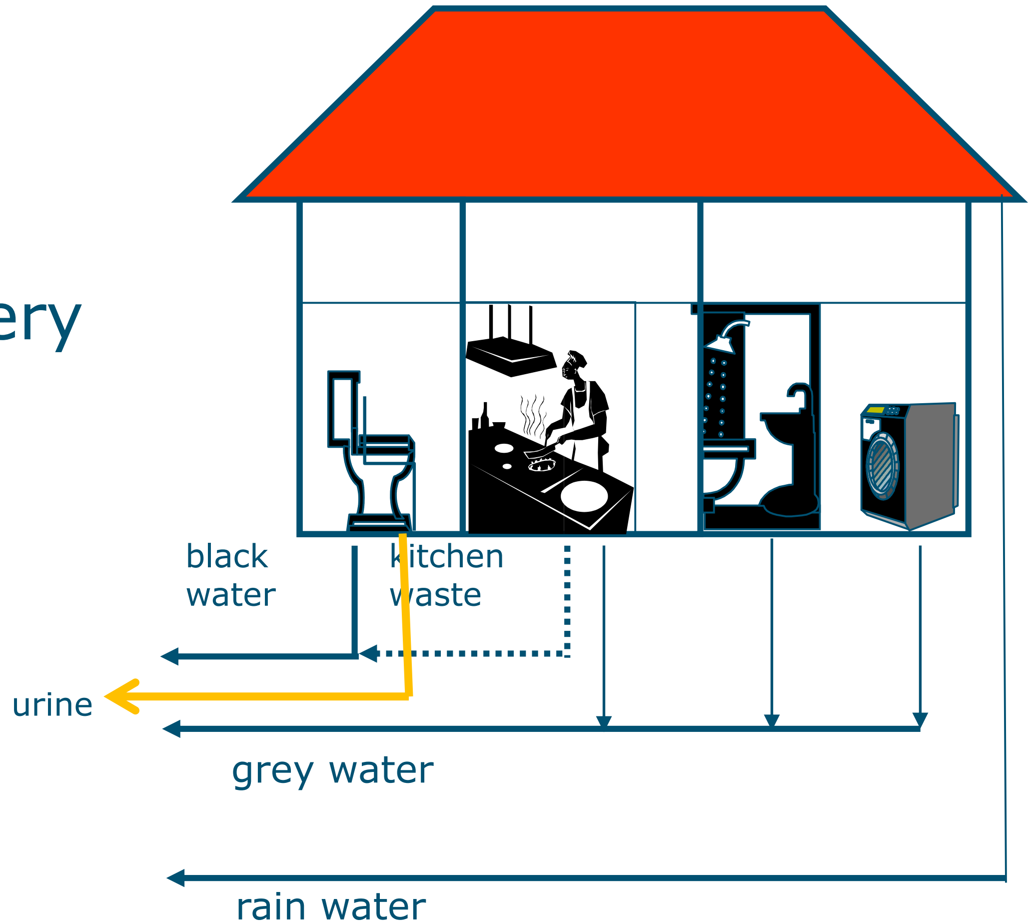
'New Sanitation' ; source separation

Collection

Transport

Treatment & recovery

Reuse



Source separation needed?

To prevent dilution

Establish **a highly concentrated BW stream**

Establish a GW stream with a **low** nutrient and organic concentration

Prevent dilution

- collection and transport with minimal water use (≤ 1Litre per flush)

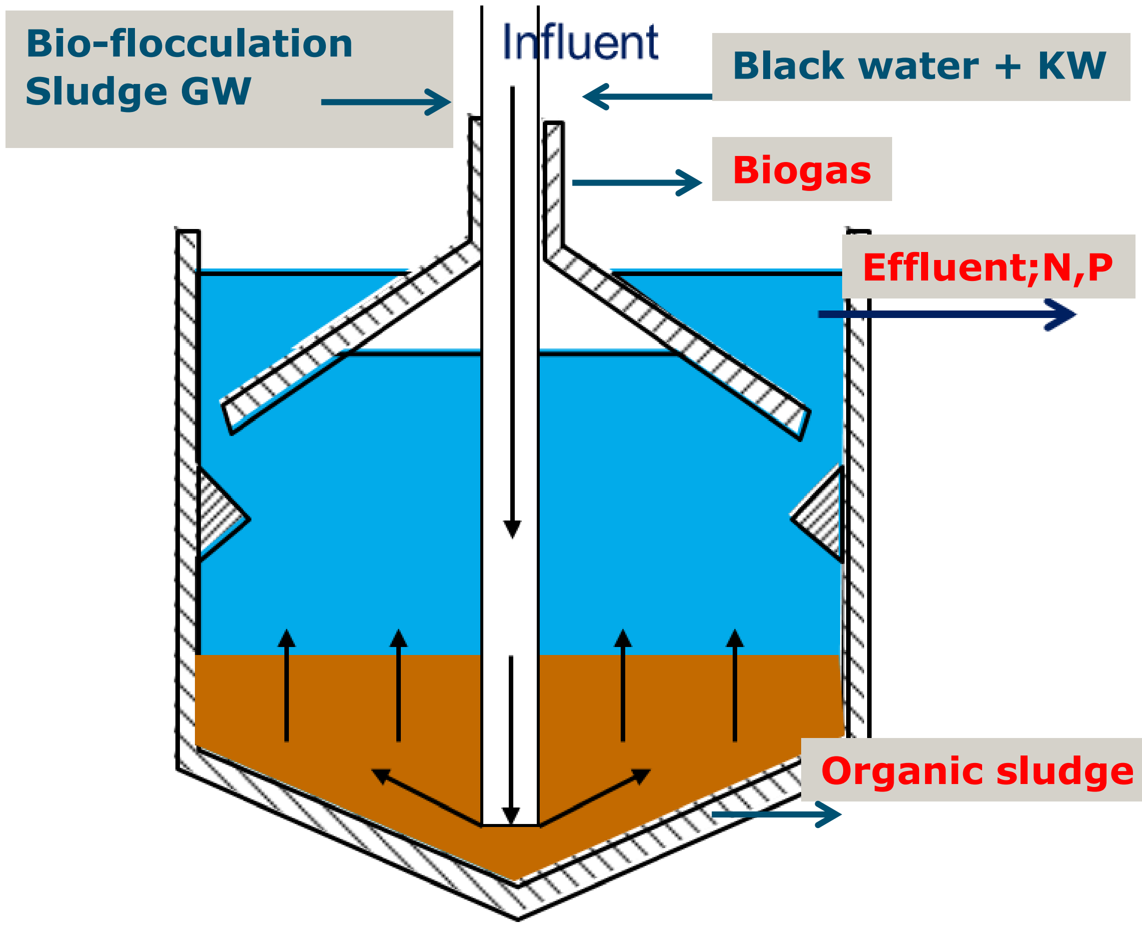
Source separation needed?

To enable recovery of **all** resources in domestic wastewater

To establish **energy neutral** resource recovery

To increase **product quality**

Developed 'New Sanitation' concept; UASB core technology



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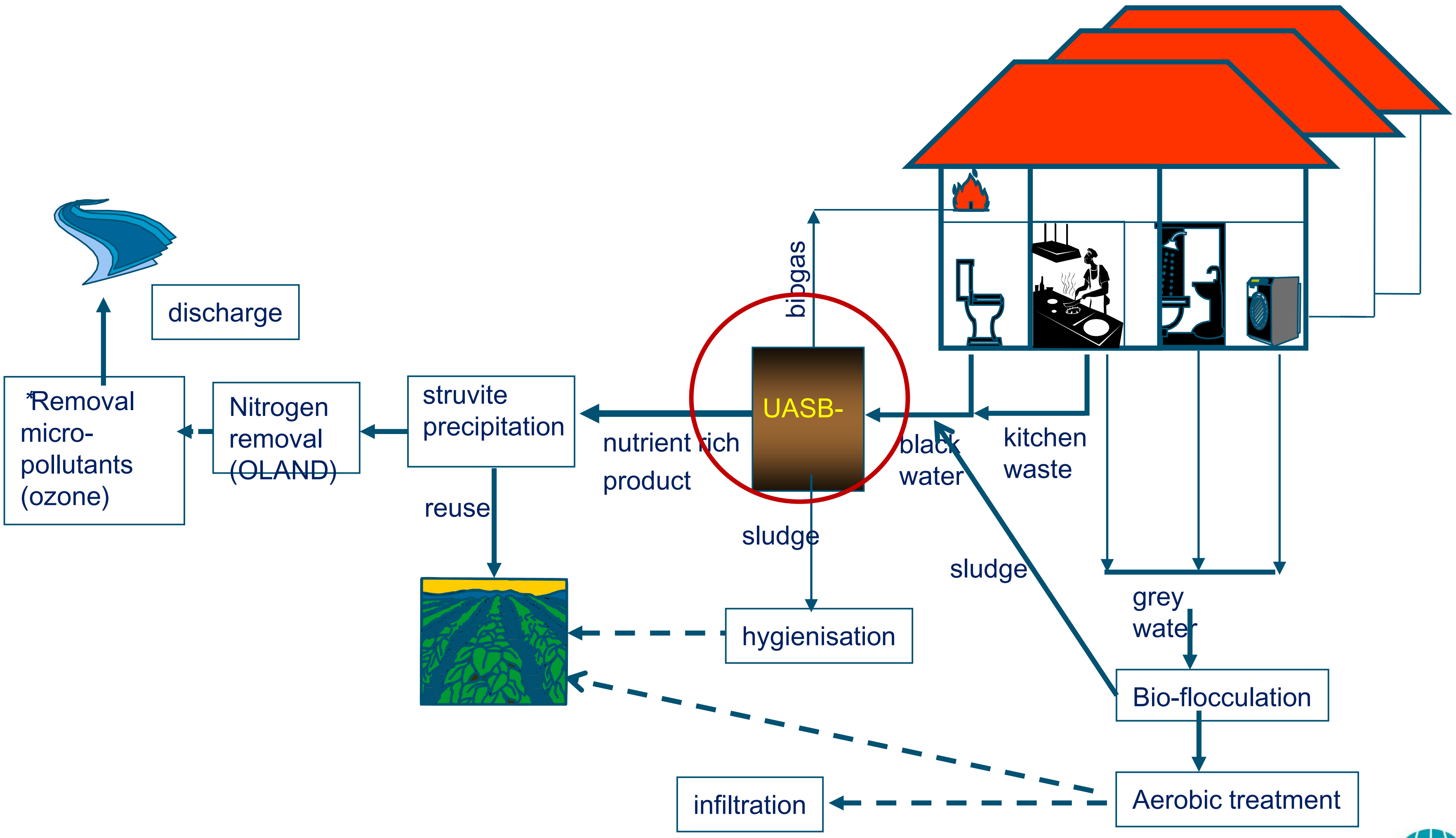
'New Sanitation' concept



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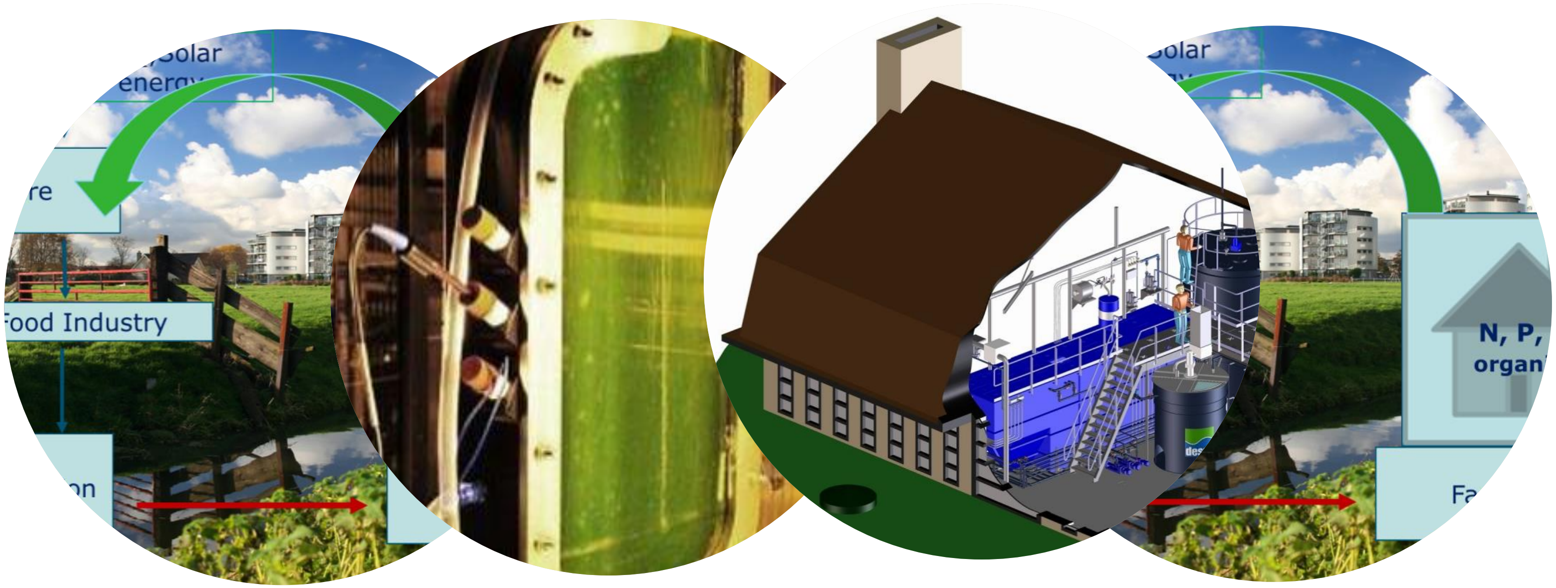
What did we achieve so far?

Full scale applications in Sneek, Venlo, Wageningen, The Hague



Sneek; Waterschoon

250 houses;

Opening in 2011

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Venlo, Villa Flora

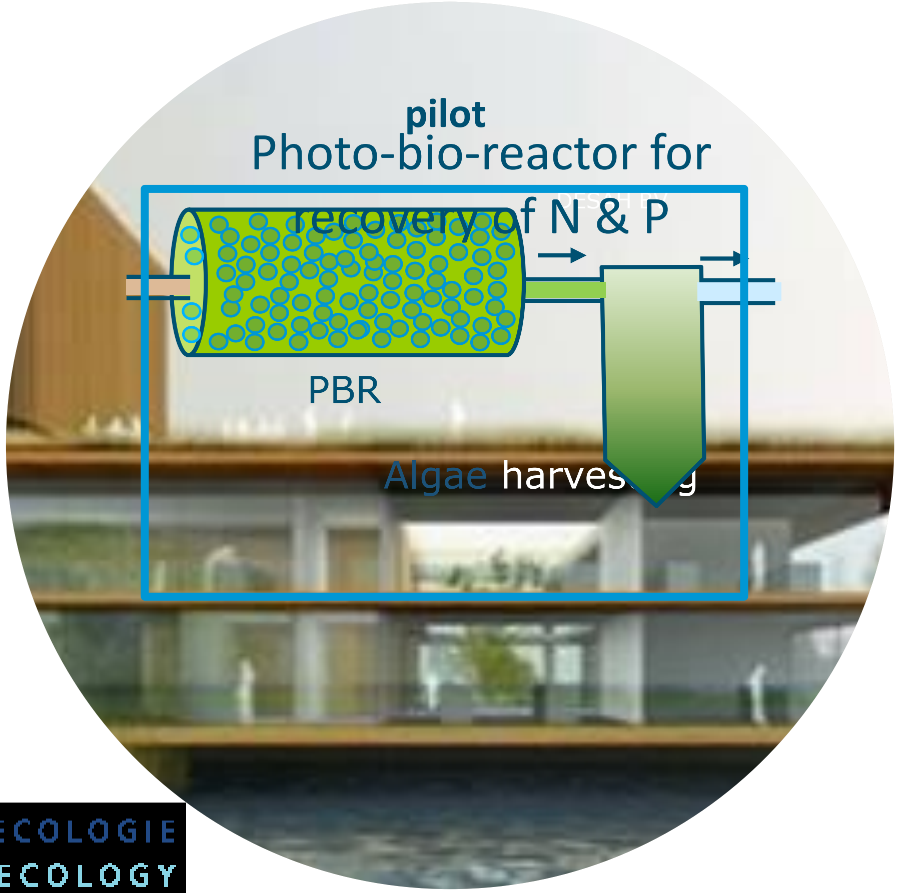
Office building

Opening in 2012

Wageningen, NIOO

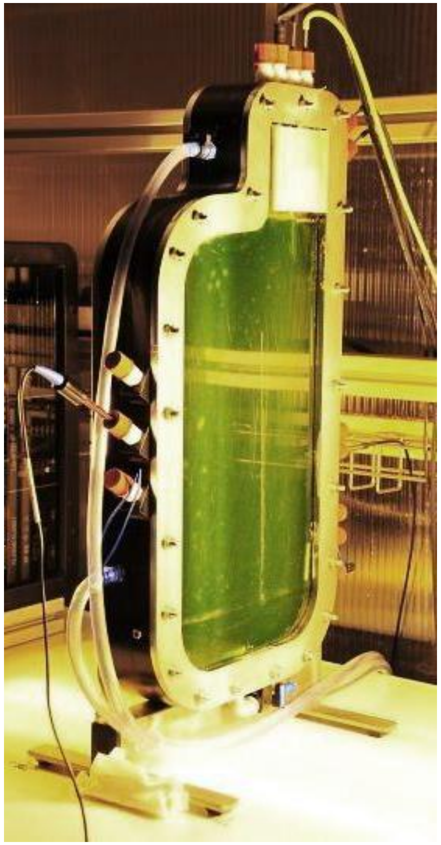
Office building

Opening in 2012



NIOO
NEDERLANDS INSTITUUT VOOR ECOLOGIE
NETHERLANDS INSTITUTE OF ECOLOGY

N & P recovery; microalgae growth on urine



Kanjana Tuantet, Marcel Janssen, Hardy Temmink, Grietje Zeeman, René H. Wijffels, and Cees J.N. Buisman (2013). Nutrient removal and microalgal biomass production on urine in a short light-path photobioreactor. Water R e search 5 5, 1 6 2 -1 7 4

The Hague, Ministry of Infrastructure & Environment

Office building

Opening in 2016

Vacuum toilets &
water free urinals

MFC for NH_4^+-N
recovery from **urine**

(to be installed)

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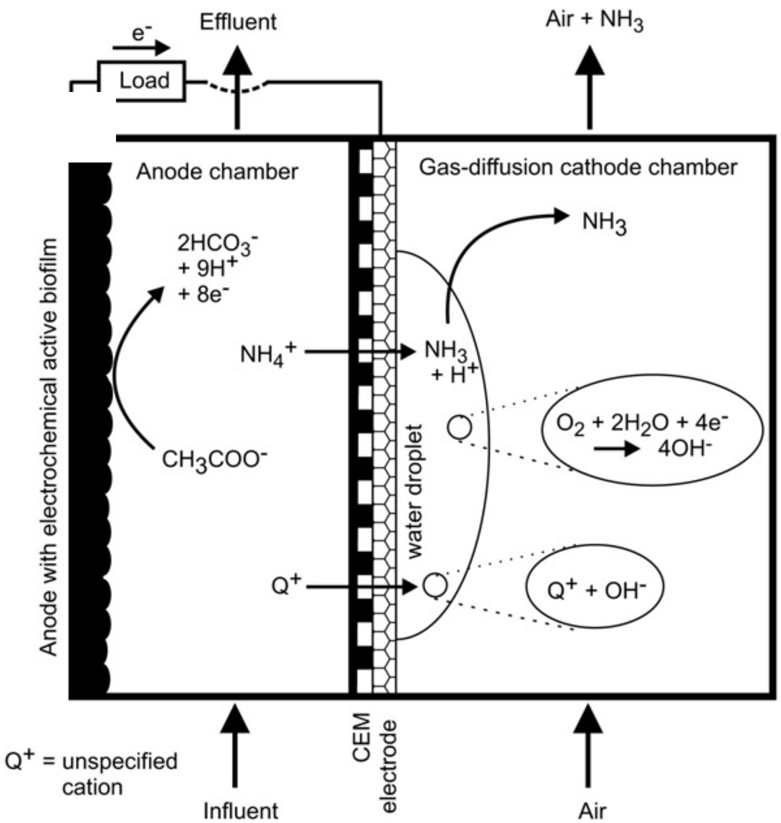
NH_3-recovery; microbial fuel cell

- migrational ion flux to the cathode
- driven by electron production
- anaerobic degradation of organic matter in urine.

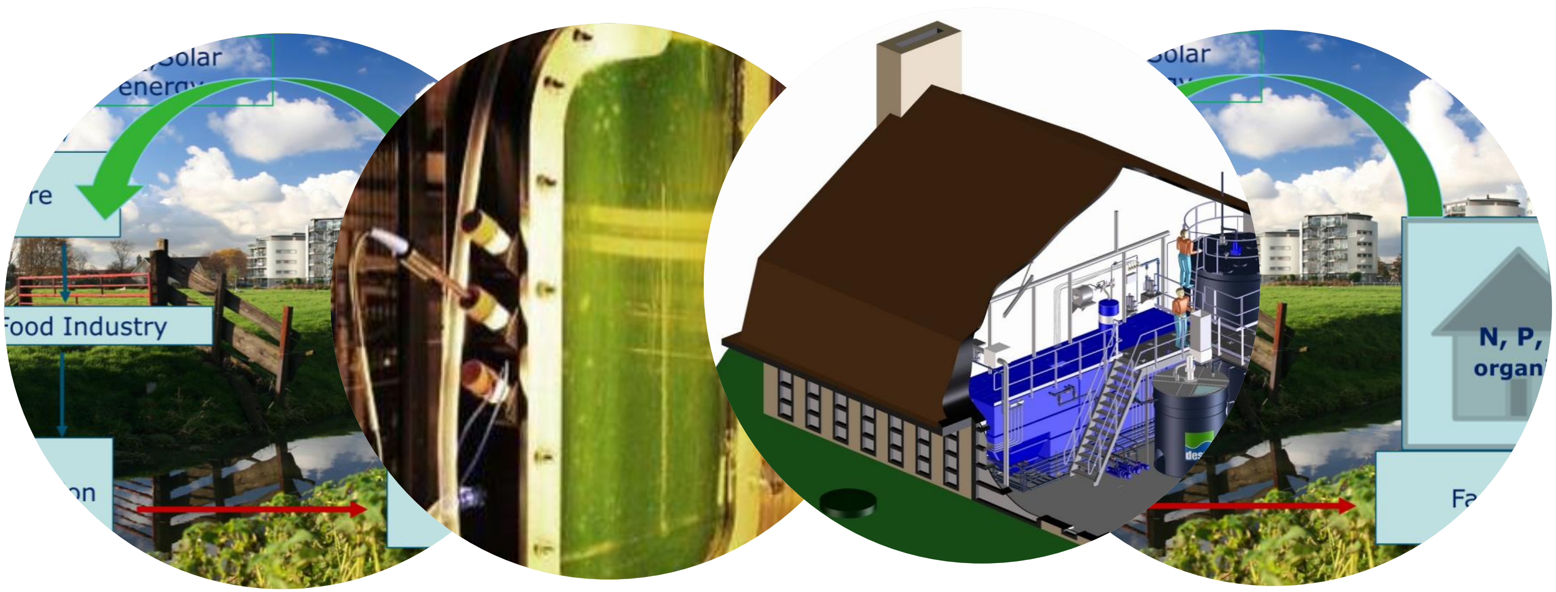


Kuntke, P., Śmiech, K.M. , Bruning, H., Zeeman, G., Saakes, M. , Sleutels, T.H.J.A. , Hamelers, H.V.M., Buisman, C.J.N. (2012). Ammonium recovery and energy production from urine by a microbial fuel cell. Water Research, 46-8, 2627-2636

Under development

i.e. Amsterdam, Zutphen;

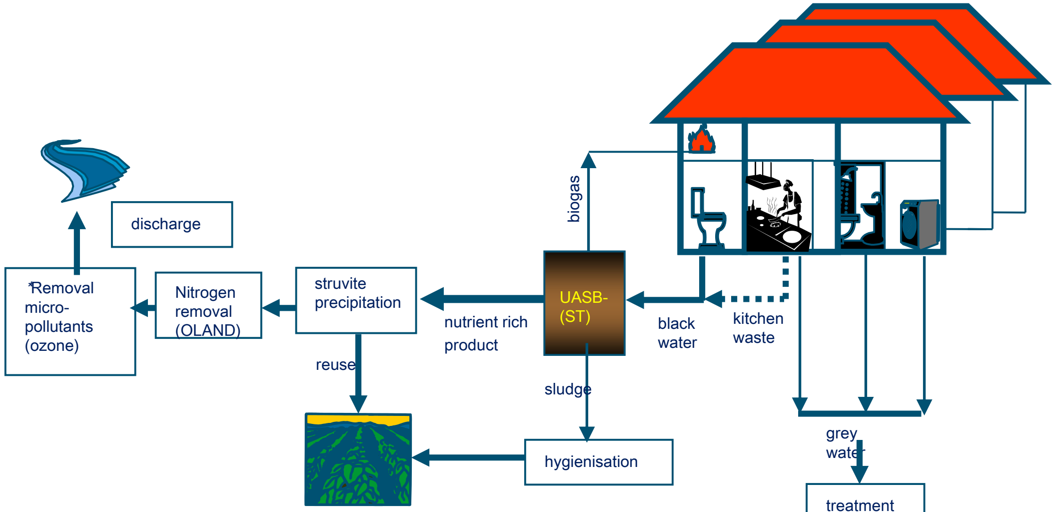
Gent (Belgium), Helsingborg (Sweden),



'New Sanitation' concept

Local recovery and reuse of:

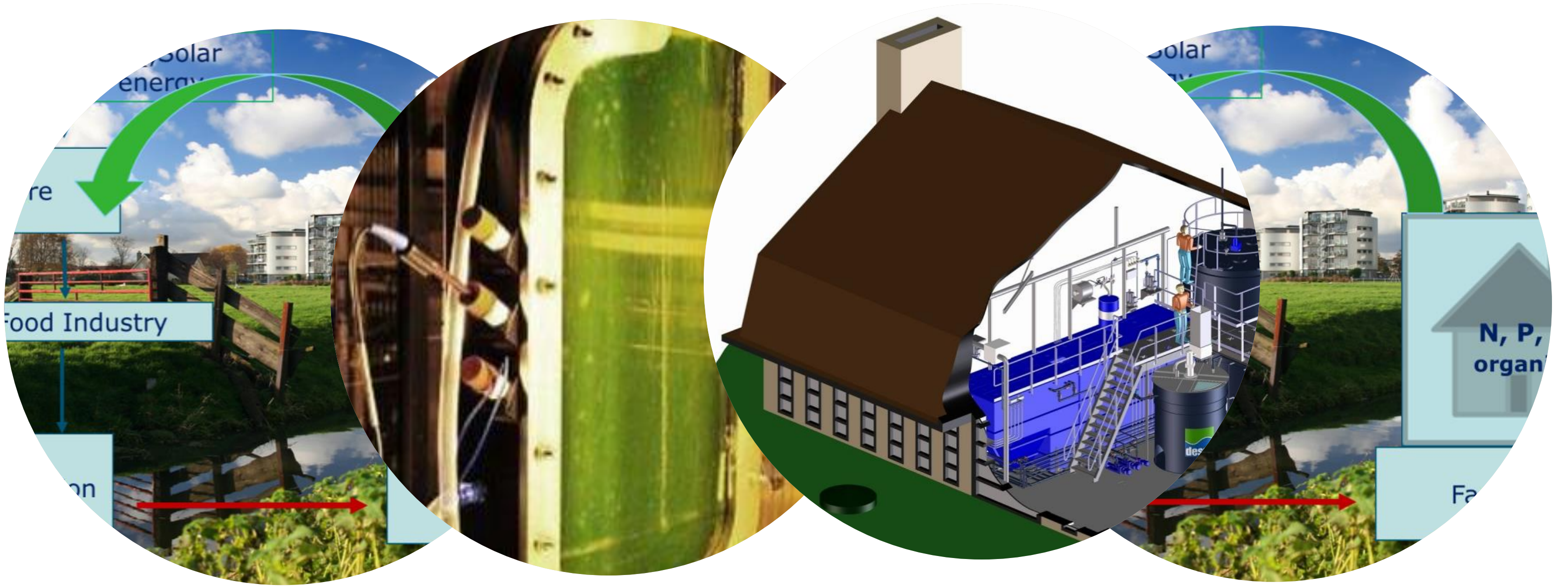
- Energy
  - **Biogas**
  - **Heat**
- Nutrients
  - **Struvite**
- Organic fertiliser
- Water



*not yet realised

New developments

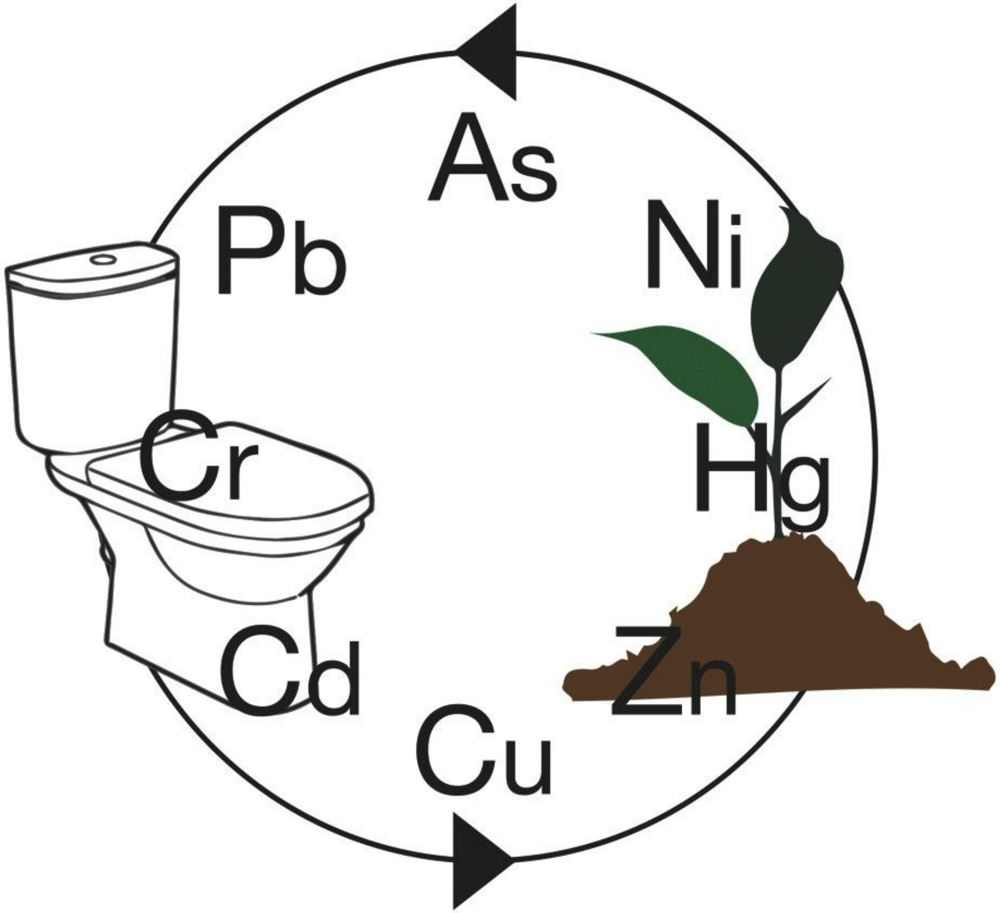
BW sludge quality; CaP recovery;



Quality of BW organic sludge

Improving soil quality

Heavy metals in black water sludge



Tervahauta, T.; Rani, S.; Hernández Leal, L.; Buisman, C.J.N.; Zeeman, G. Black water sludge reuse in agriculture: Are heavy metals a problem? J. Hazard. Mater. 2014, 274, 229–236.

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Heavy metals in black water sludge

Heavy metal content of black water sludge, sewage sludge, cow manure and phosphate fertilizer (unit mg/kg P).

Element	BW sludge[a]	Sewage sludge[b]	Cow manure[c]	P-fertilizer[d]
As	12	300	nd	33
Cd	13	39	33	91
Cr	731	1268	1145	1245
Cu	3720	12701	14397	207
Hg	0.12	23	nd	0.7
Ni	466	1025	1472	202
Pb	69	3519	695	154
Zn	13919	31166	25947	1923

nd, not detected.

[a] Measured in this study.

[b] CBS

[c] van Dooren et al.

[d] Remy and Ruhland

Tervahauta, T.; Rani, S.; Hernández Leal, L.; Buisman, C.J.N.; Zeeman, G. Black water sludge reuse in agriculture: Are heavy metals a problem? J. Hazard. Mater. 2014, 274, 229–236.

Heavy metals in black water sludge

The heavy metals in faeces and urine are primarily from dietary sources

Promotion of the soil application of black water sludge over livestock manure and artificial fertilizers could further reduce the heavy metal content in the soil/food cycle.

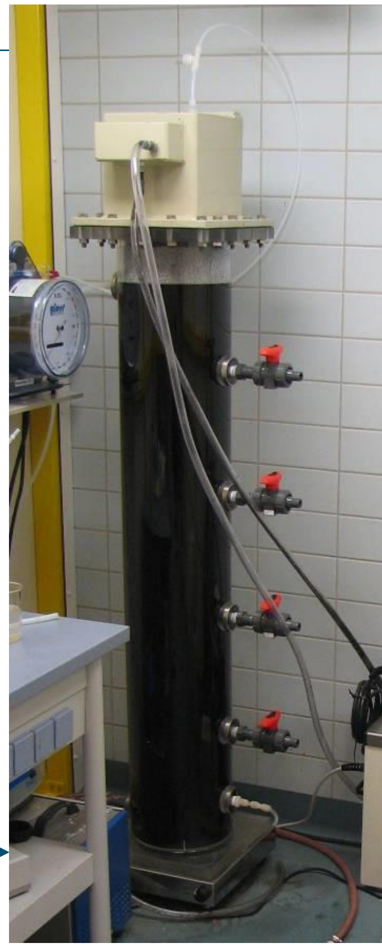
Tervahauta, T.; Rani, S.; Hernández Leal, L.; Buisman, C.J.N.; Zeeman, G. Black water sludge reuse in agriculture: Are heavy metals a problem? J. Hazard. Mater. 2014, 274, 229–236.

Micro-pollutants in black water sludge; co-Composting

Compound	Micropollutants reduction by weight, %	
	at 35ºC	at 50ºC
Estrone	99.9	99.8
Diclofenac	99.9	99.9
Ibuprofen	99.8	99.9
Carbamazepine	88.1	87.8
Metoprolol	95.1	94.2
Galaxolide	97.8	97.0
Triclosan	96.6	92.9

Butkovskyi, A. G. N, Hernandez Leal, L., Rijnaarts, H.H.M. , Zeeman, G. (2016). Mitigation of micropollutants for black water application in agriculture via composting of anaerobic sludge. Journal of Hazardous Materials 303, 41–47

Phosphorus balance UASB; 900 days HRT 9 days; 25°C



100%

61%

Struvite ($MgNH_4PO_4$)
0.22 kg P $p^{-1}y^{-1}$

De Graaff et al., (2011), WS&T

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Recovery of Ca-Phosphate in a UASB

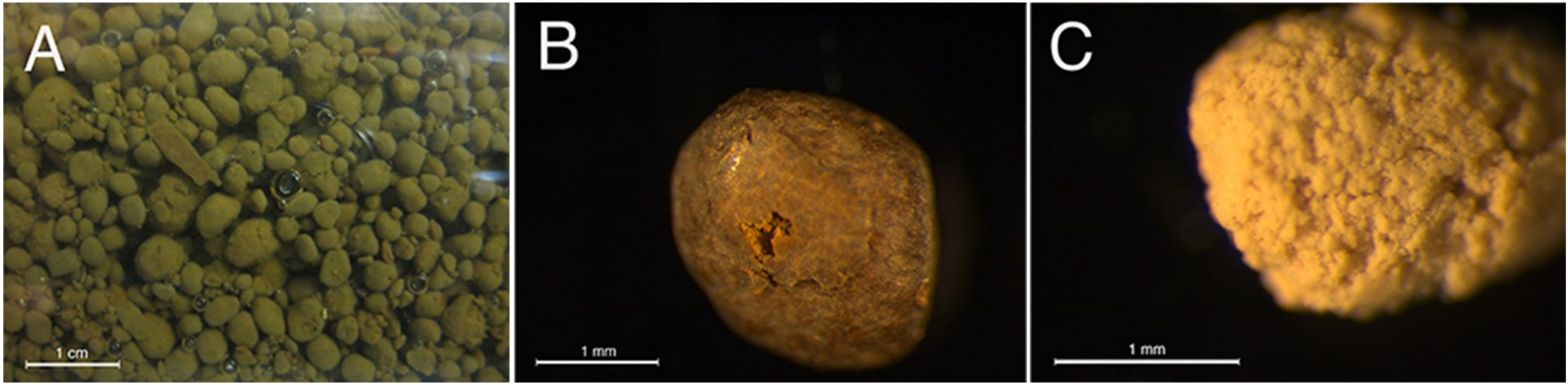
P-free effluent;

CaP granules

Organic sludge

influent

Calcium phosphate granulation in anaerobic treatment of black water



Tervahauta, T., van der Weijden, R. D., Flemming, R. L., Herna´ndez Leal, L., Zeeman, G., Buisman, C. J., 2014. Calcium phosphate granulation in anaerobic treatment of black water: A new approach to phosphorus recovery. ***Water Research*** *48, 632–642.*

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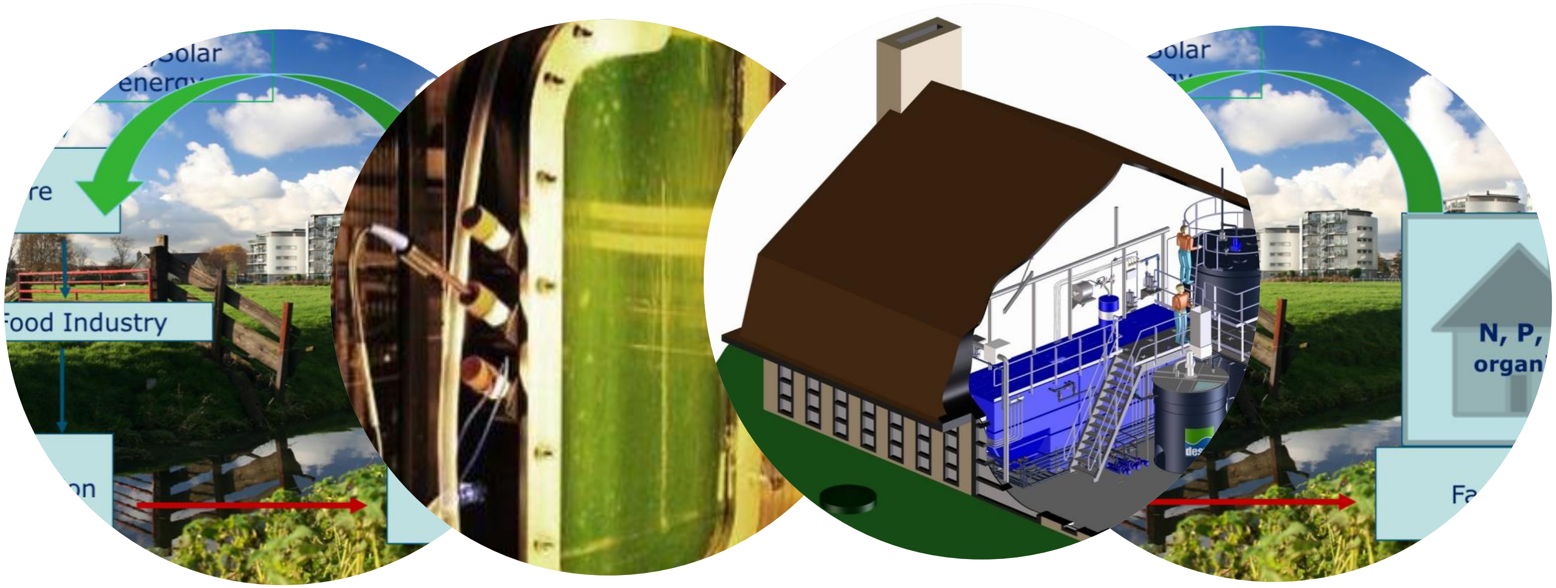
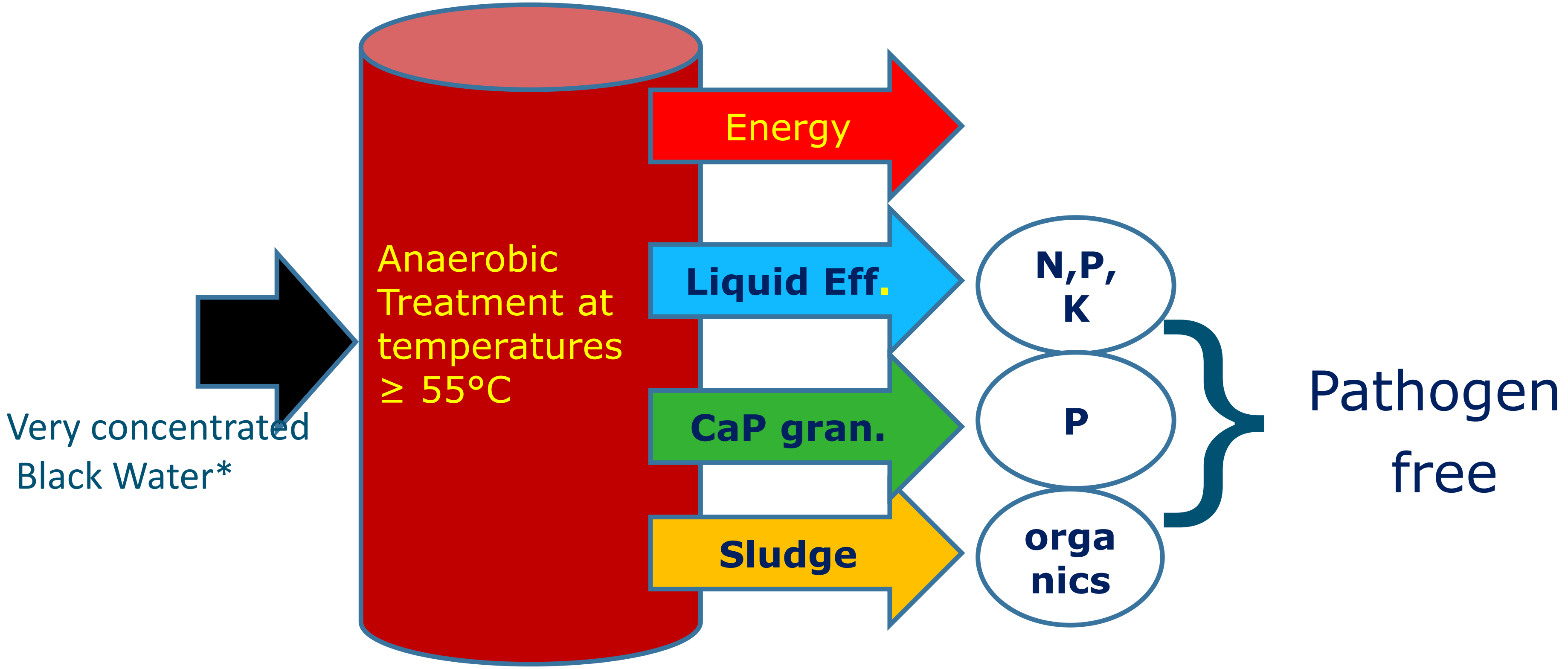
Future

Much higher BW concentration

Very low flush toilets ($\leq 1 l p^{-1} d^{-1}$)



One step treatment of BW



*Collected with **improved** vacuum toilets

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Quality treated GW

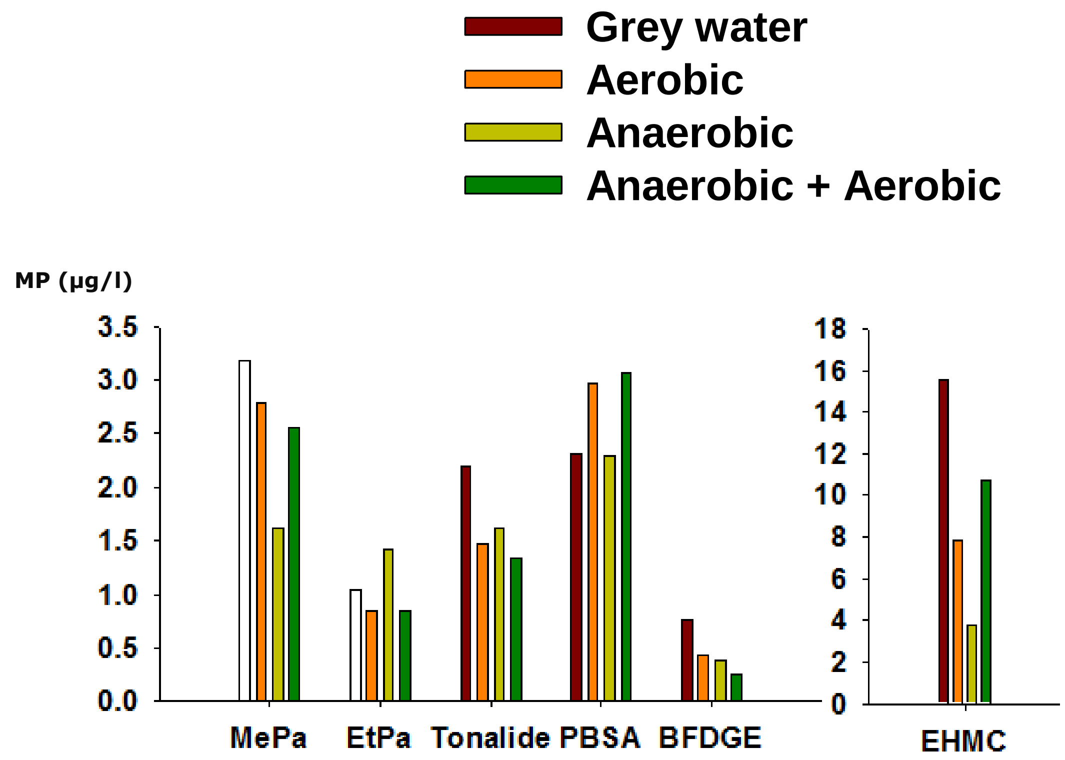
Micro-pollutants

*Micro-pollutants GW

MPs in GW in the range of μg/L

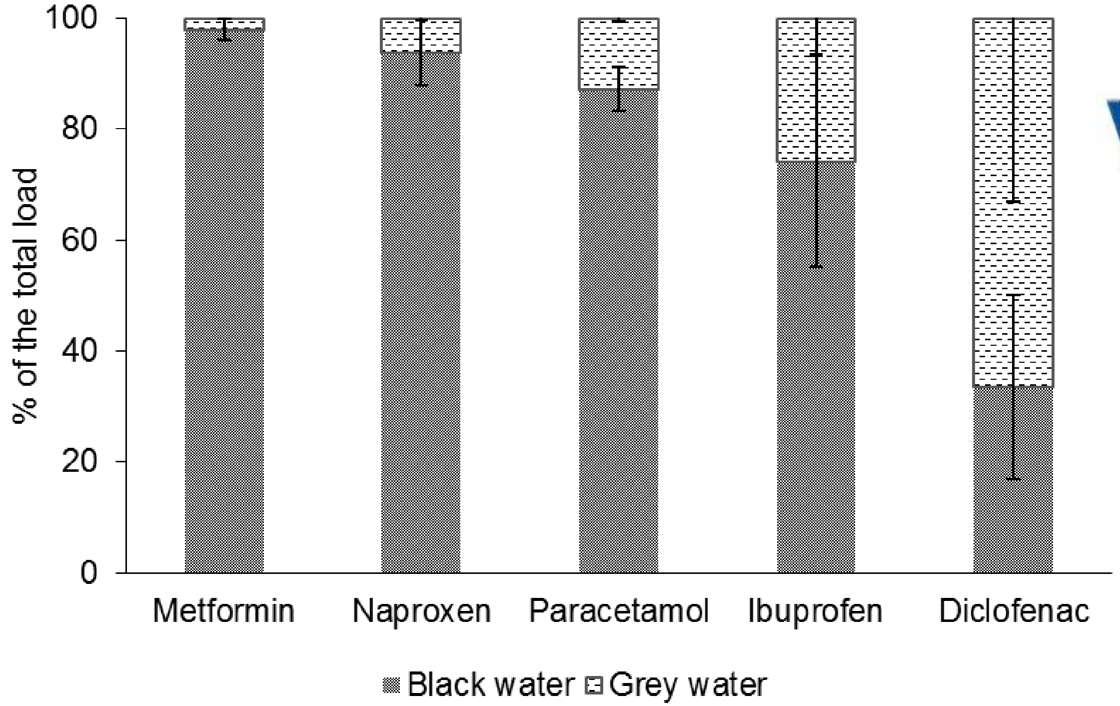
Aerobic > anaerobic

Several MPs poorly removed in biologica treatment



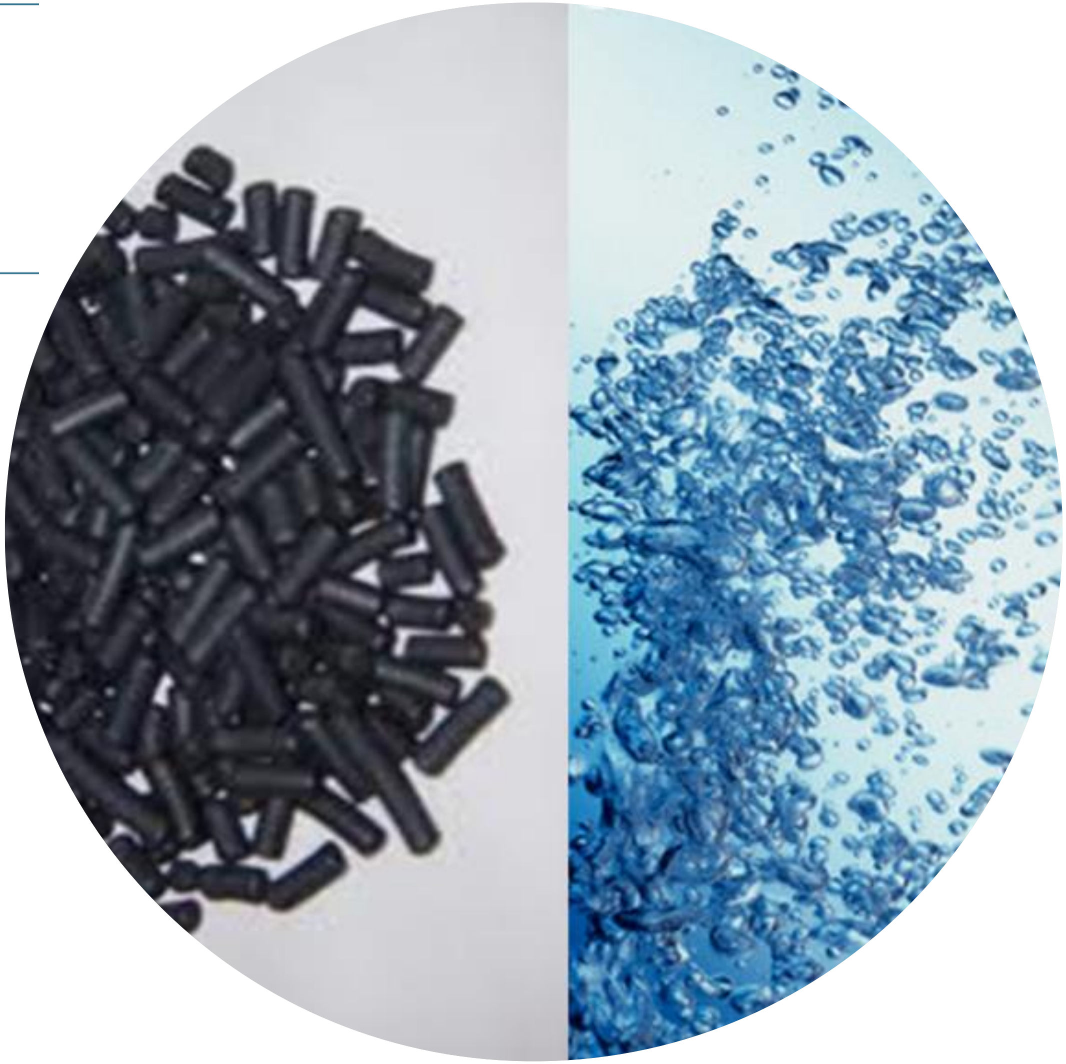
*Hernandez Leal L., Vieno, N., Temmink H., Zeeman G., Buisman C.J.N. (2010). Occurrence of Xenobiotics in Grey Water and Removal in Three Biological Treatment Systems.
Environ. Sci. Technol., 2010, 44 (17): 6835–6842

How effectively do we separate at the source?



A. Butkovskyi , L. Hernandez Leal , H.H.M. Rijnaarts, G. Zeeman (2015). Fate of pharmaceuticals in full-scale source separated sanitation system. Water Research 85 :384-392

Physical-chemical post-treatment



*Hernandez Leal L., Vieno, N., Temmink H., Zeeman G., Buisman C.J.N. (2010). Occurrence of Xenobiotics in Grey Water and Removal in Three Biological Treatment Systems. Environ. Sci. Technol., 2010, 44 (17): 6835–6842

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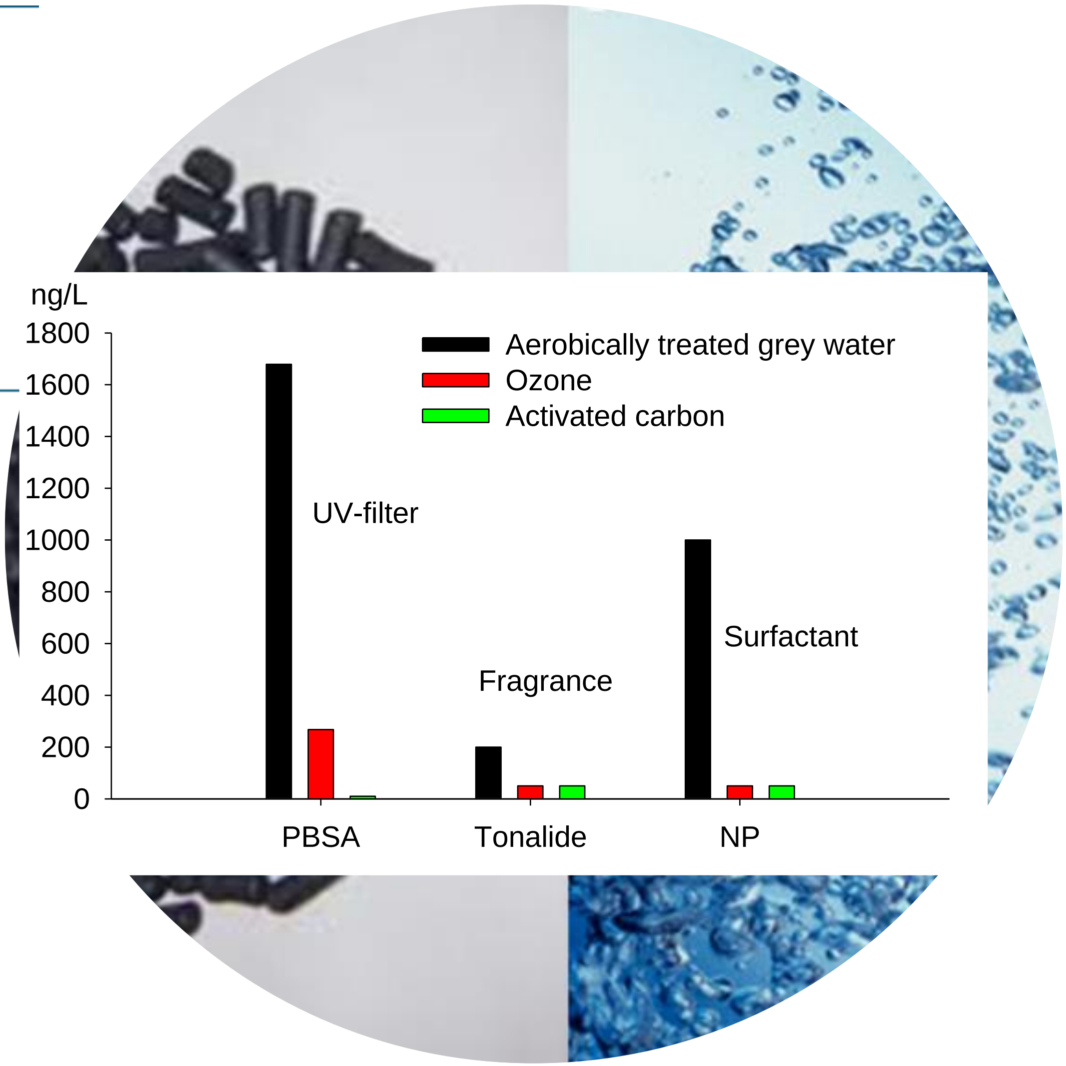
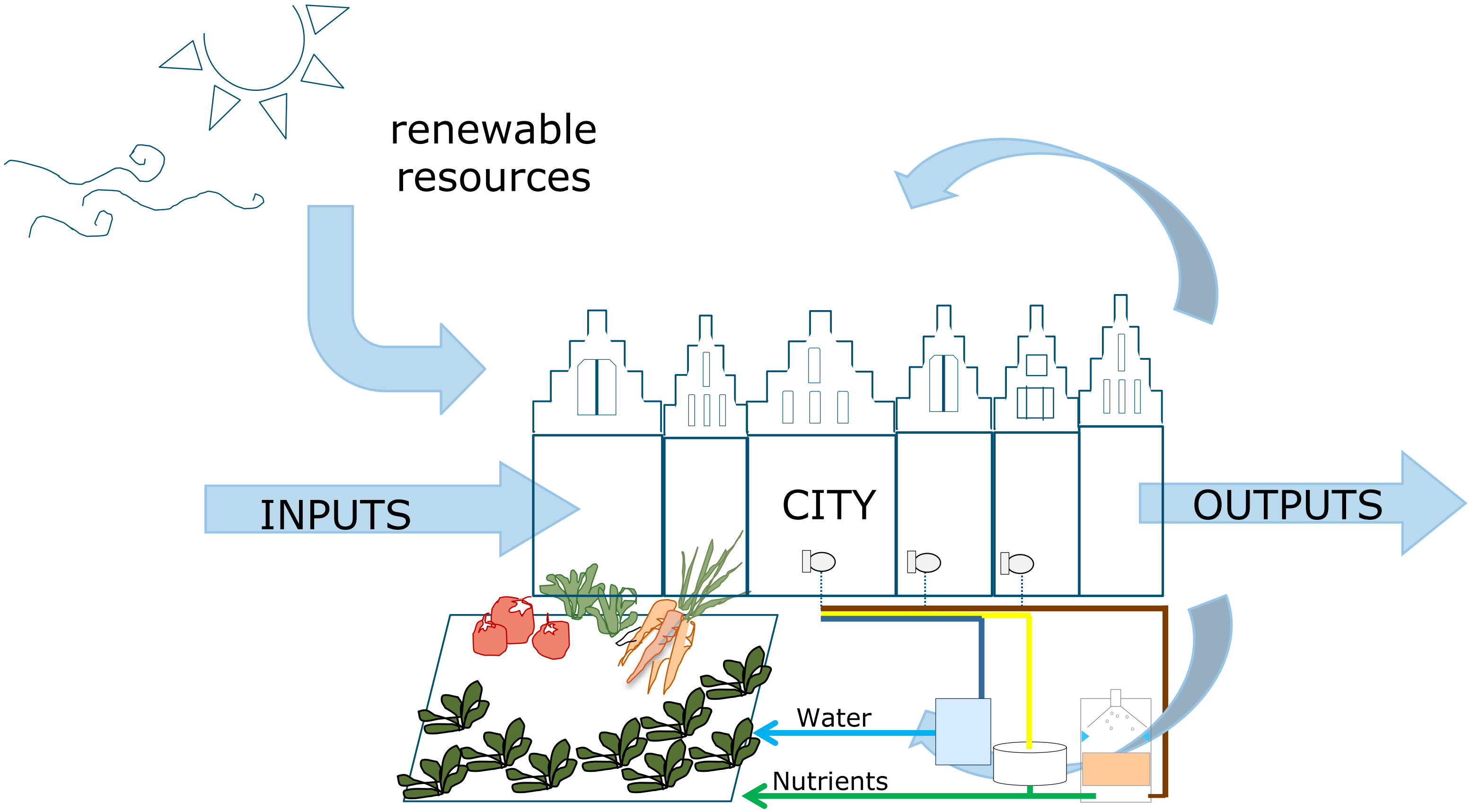
suitable techniques GW effluents

- ozonation
- adsorption on activated carbon



Hernandez Leal, L., Temmink, B.G., Zeeman, G. & Buisman, C.J.N. (2011). Removal of micropollutants from aerobically treated grey water via ozone and activated carbon ; Water Research, Volume 45, Issue 9, Pages 2887-2896

Urban Agriculture & New Sanitation



Website: www.wageningenur.nl/ete

rosanne.wielemaker@wur.nl

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Urban Agriculture Typologies

- Ground-based

- Rooftop

(De DakAkker, 2014)

rosanne.wielemaker@wur.nl

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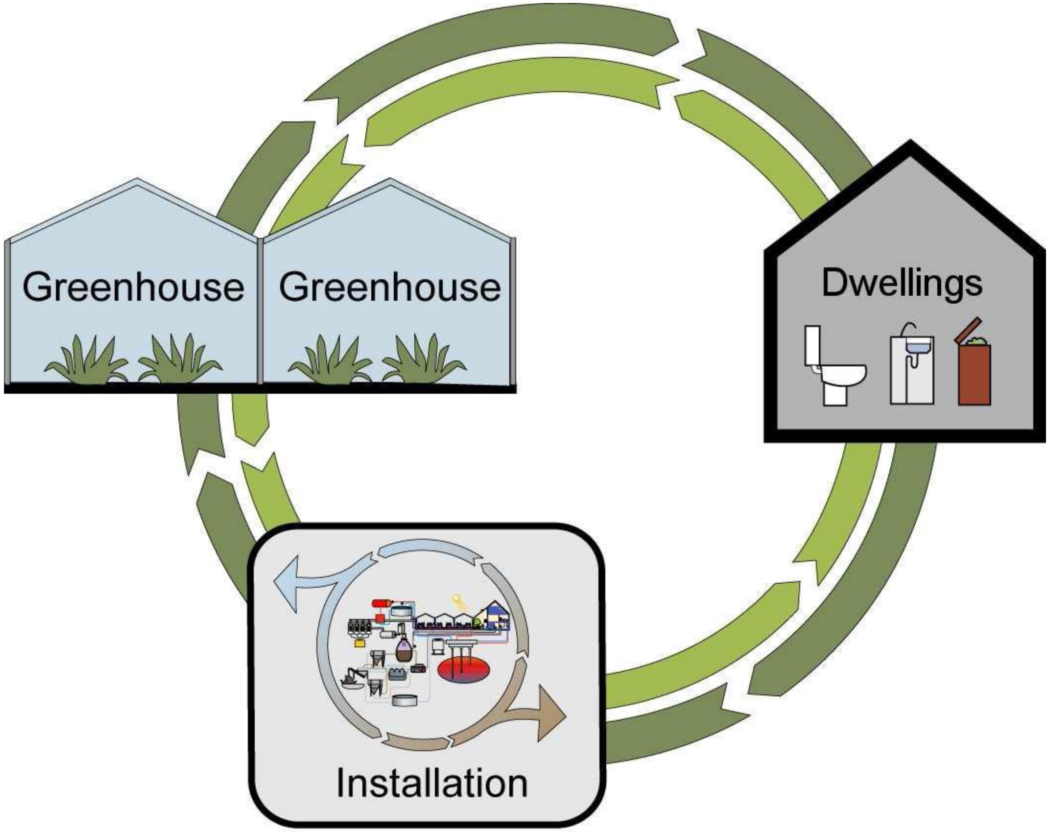
Greenhouse Village
Mels *et al*, (2007); www.zonneterp.nl

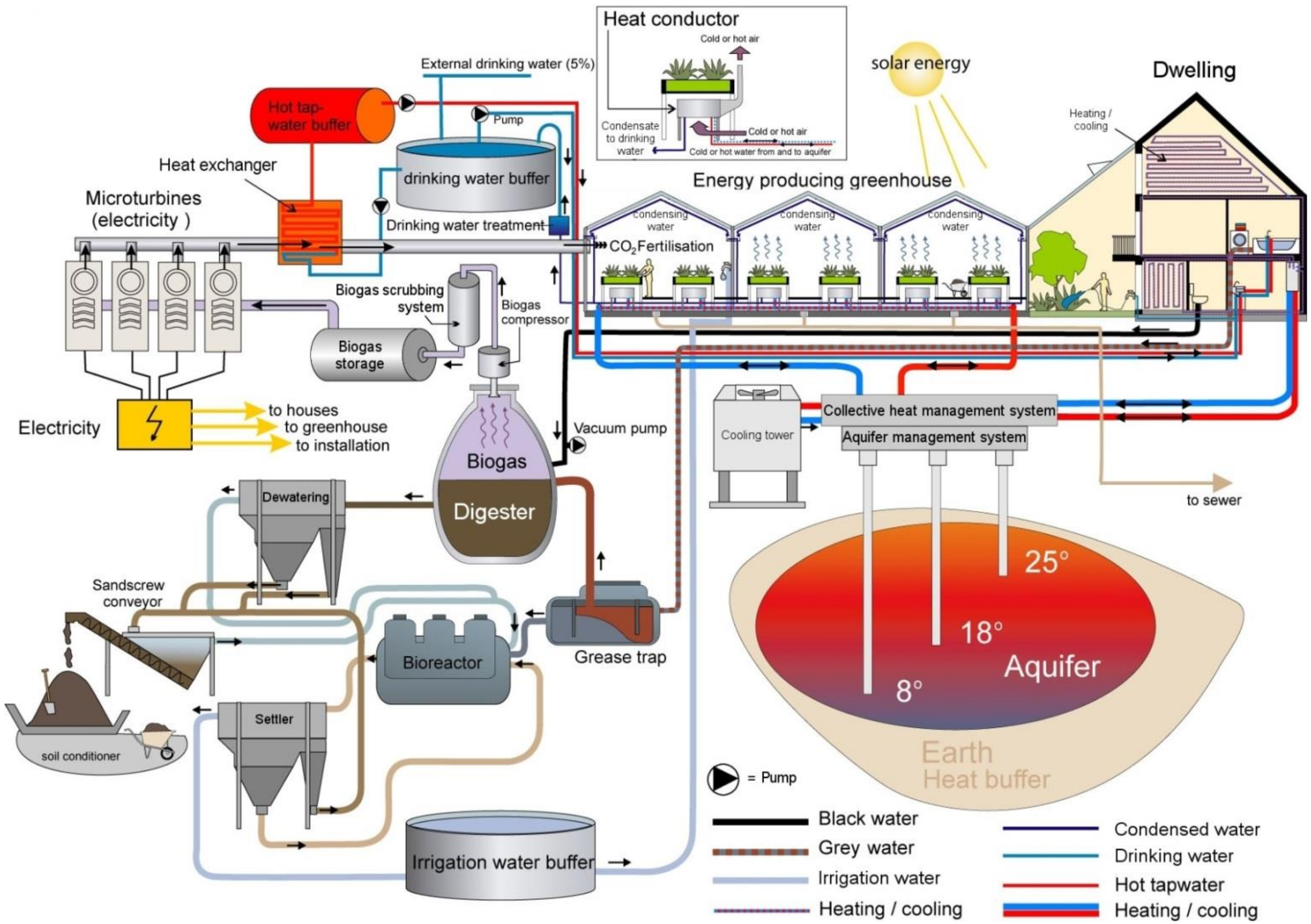


Exchange of resources

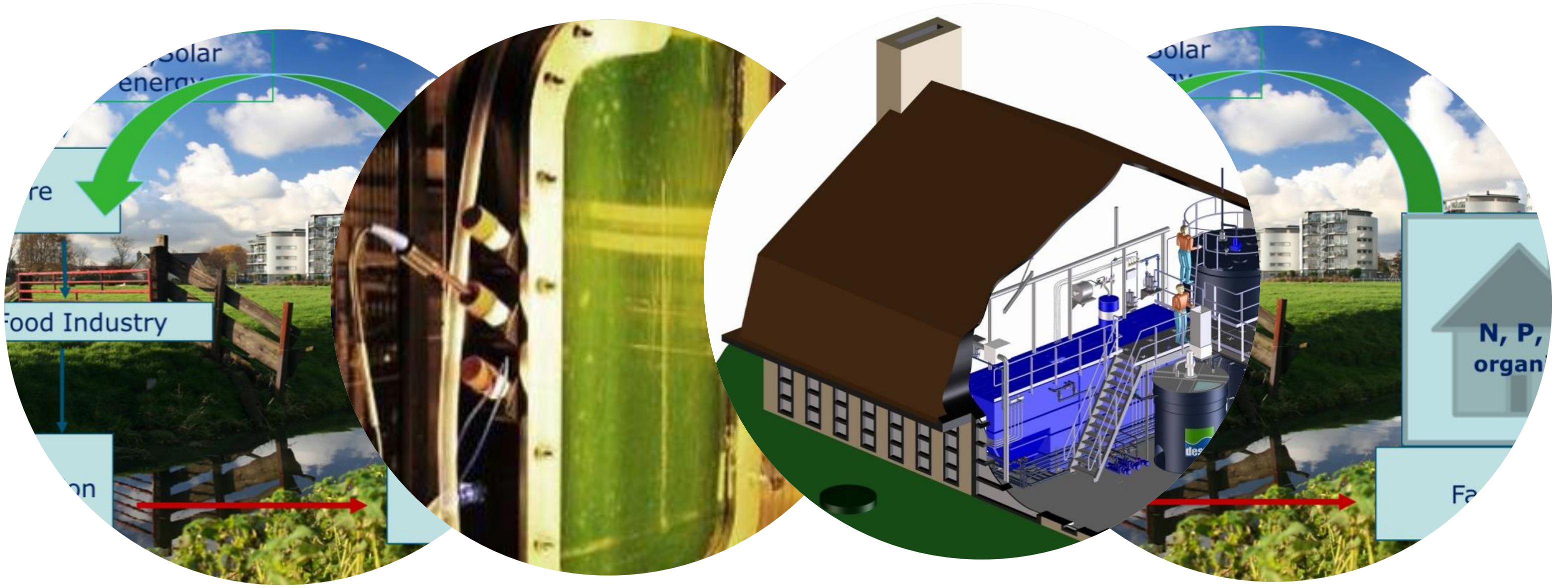
Closed resource cycles

- Integration of functions
- Implementation of technologies

Greenhouse Village
Mels *et al*, (2007); www.zonneterp.nl



Costs;
based on monitoring results Waterschoon



* Investment costs 'New Sanitation' optimised and extrapolated for 1200 persons

Element	Investment costs (€)	Investment costs per person (€)	Share total investment costs (%)	Owner[a]
-Collection/transport	737,000	682	33	Municipality
-Surplus costs in-house sewerage	707,000	655	32	Housing cooperation
-Treatment	800,000	741	36	Housing cooperation
Total investments	2,244,000	2,078	100%	

*de Graaf, R. and A. J. van Hell (2014). New Sanitation Noorderhoek, Sneek. P. Hermans. Amersfoort, STOWA (Dutch Foundation for Applied Water Research): 304

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* Depreciation, maintenance and exploitation costs and savings, 'New Sanitation', optimised and extrapolated for 1200 persons

Element	Unit	Total (€)	Total per person	Share (%)
Depreciation				
-Collection	€/year	16,193	14.99	23
-Surplus costs in-house sewerage	€/year	23,578	21.83	33
-Treatment	€/year	31,238	28.92	44
Total Depreciation	**€/year**	**71,010**	**65.75**	**100**
Maintenance/exploitation/savings				
-Collection	€/year	3,217	2.98	46
-Surplus costs in-house sewerage	€/year	-	-	-
-Treatment	€/year	73,499	68.05	1045
- Savings[a]	€/year	-69,683	-64.52	-991
Total Maintenance/exploitation/savings	**€/year**	**7,033**	**6.51**	**100**
Total **Depreciation &** Maintenance/exploitation/savings	**€/year**	**78,043**	**72.26**	**100**

*de Graaf, R. and A. J. van Hell (2014). New Sanitation Noorderhoek, Sneek. P. Hermans. Amersfoort, STOWA (Dutch Foundation for Applied Water Research): 304

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Comparison 'New' and 'conventional' sanitation

'New sanitation' at 1200 p.e. ca. 11 % more expensive than conventional at 100.000 p.e

Incl. price volatility calculation & uncertainty range:

At a scale between 1.000 en 1.500 inhabitants, 'New sanitation' has similar costs as compared to 'conventional sanitation' (100.000 p.e.)

*de Graaf, R. and A. J. van Hell (2014). New Sanitation Noorderhoek, Sneek. P. Hermans. Amersfoort, STOWA (Dutch Foundation for Applied Water Research): 304

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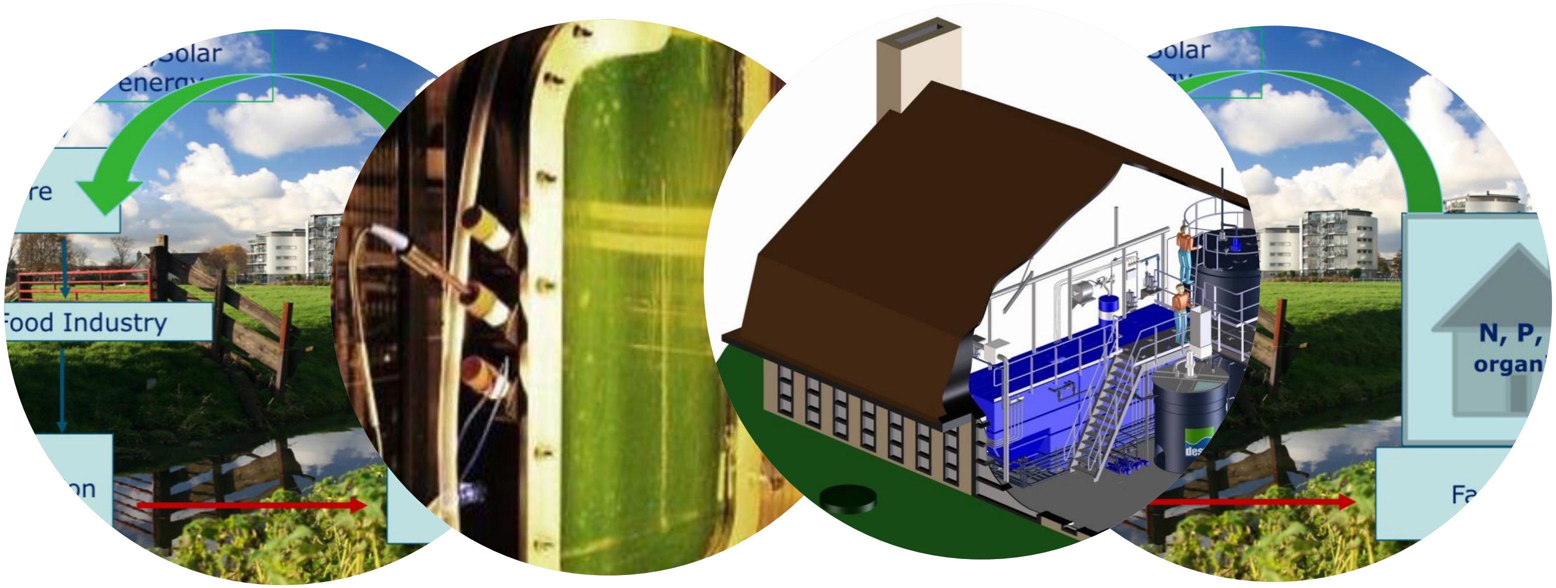
Conclusions

4 'New Sanitation' applications in The Netherlands &

Several in preparation;

Improved concepts under development.

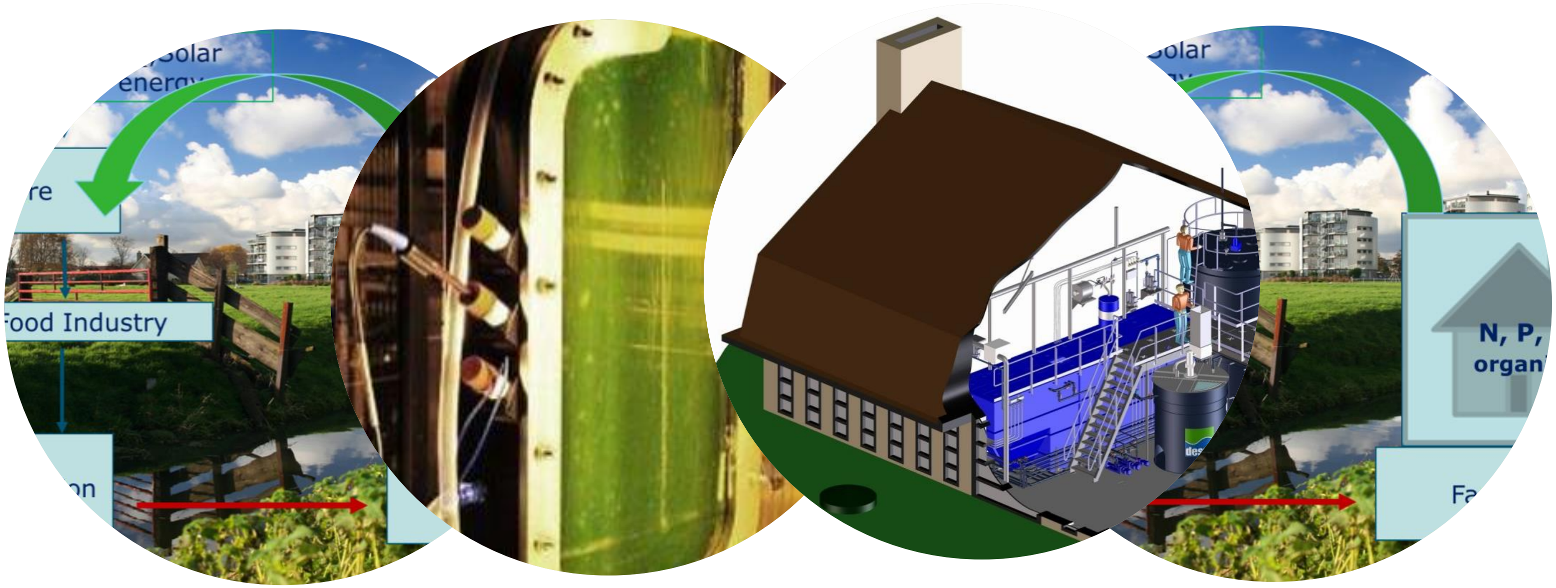
Ready for further application?? **Yes!!!**



Source separation of domestic wastewater

Questions???

14-09-2016, Grietje Zeeman, WUR-ETE



Uv filter:2-phenyl-5-benzimidazolesulfonic acid (PBSA)

Uv filter:2-ethylhexyl-4-methoxycinnamate (EHMC),

Uv filter:EHMC

Fragrance: tonalide

Surfactant/biocide:

nonylphenol