A Combined Wastewater Treatment and Resource Recovery Facility towards a Circular Economy

Resource Recovery and Utilization

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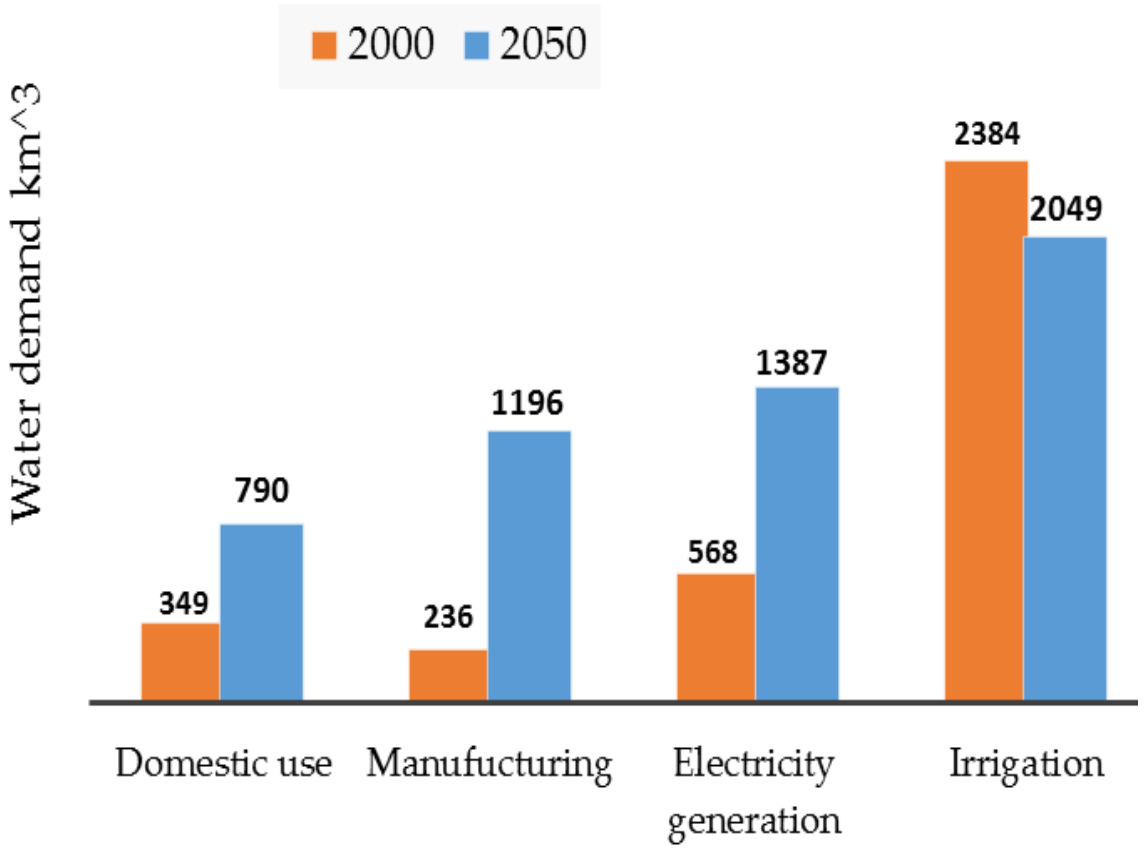
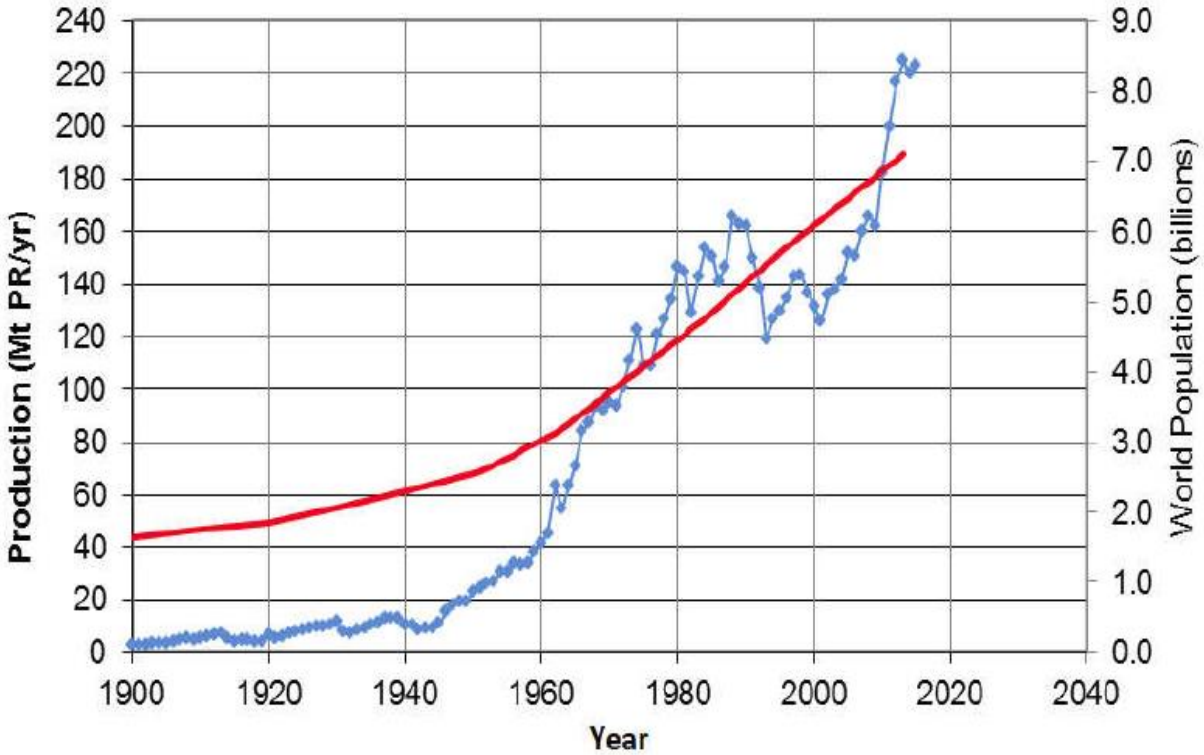
1. Introduction

- **Population Growth and Global demand for Water, Phosphorus, and Energy**



Global water demand. Baseline, 2000 and 2050 (OECD 2012)



Global production of phosphate rock (blue) coupled with world population (red) in time (Vaccari, D.A. 2015)

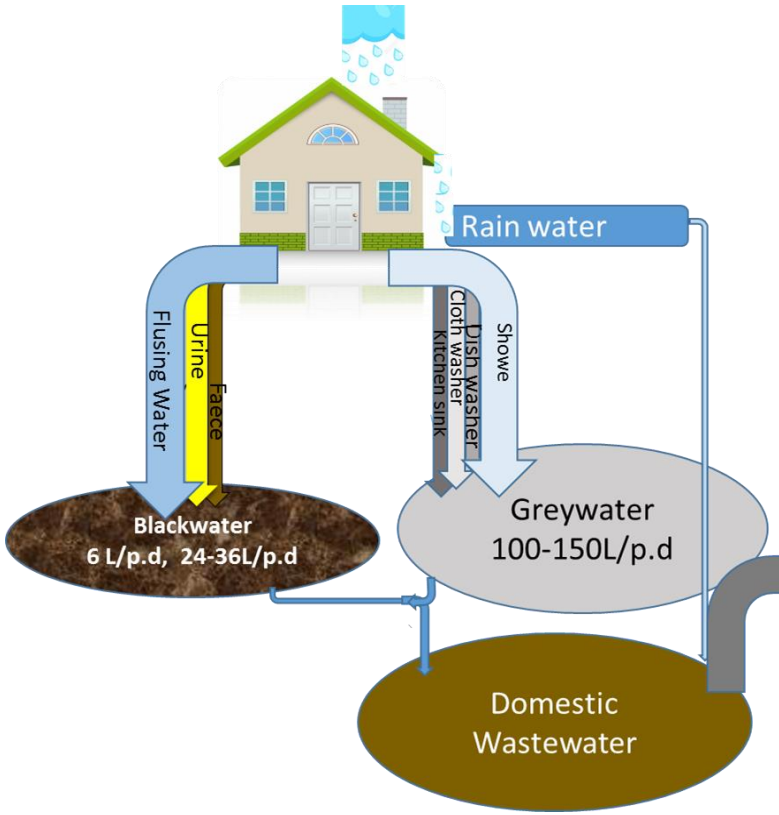
Domestic Wastewater management and disposal in cities will continue to be a major Social, Environmental and Economic Challenges

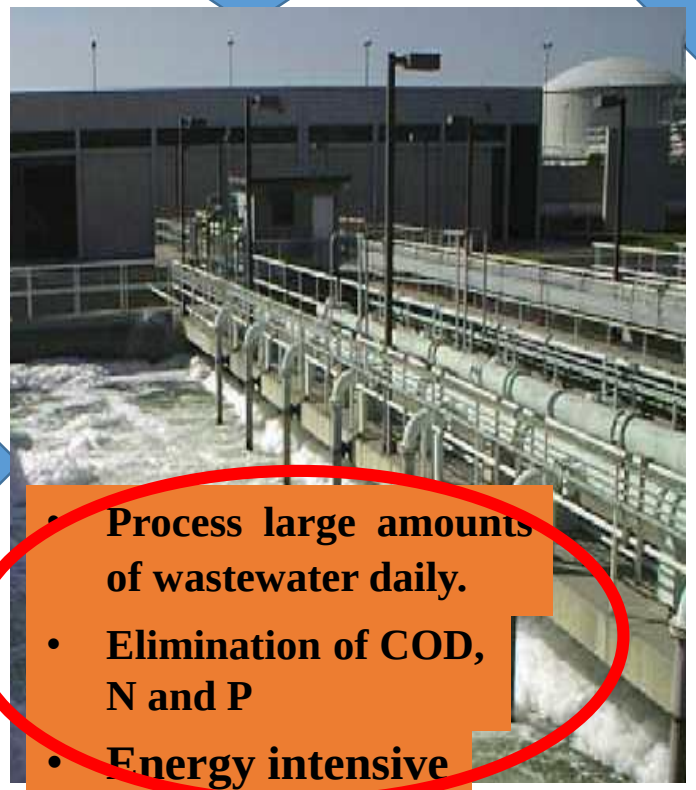
Chemicals
Flocculation
Coagulation
Precipitation

P removal

ENERGY
Mixing,
Aeration (50-60%)
Disinfection
Heat for digester

COD & N removal





- **Process large amounts of wastewater daily.**
- **Elimination of COD, N and P**
- **Energy intensive**

Production of excessive Sludge

Treated Water

???
Resource Recovery

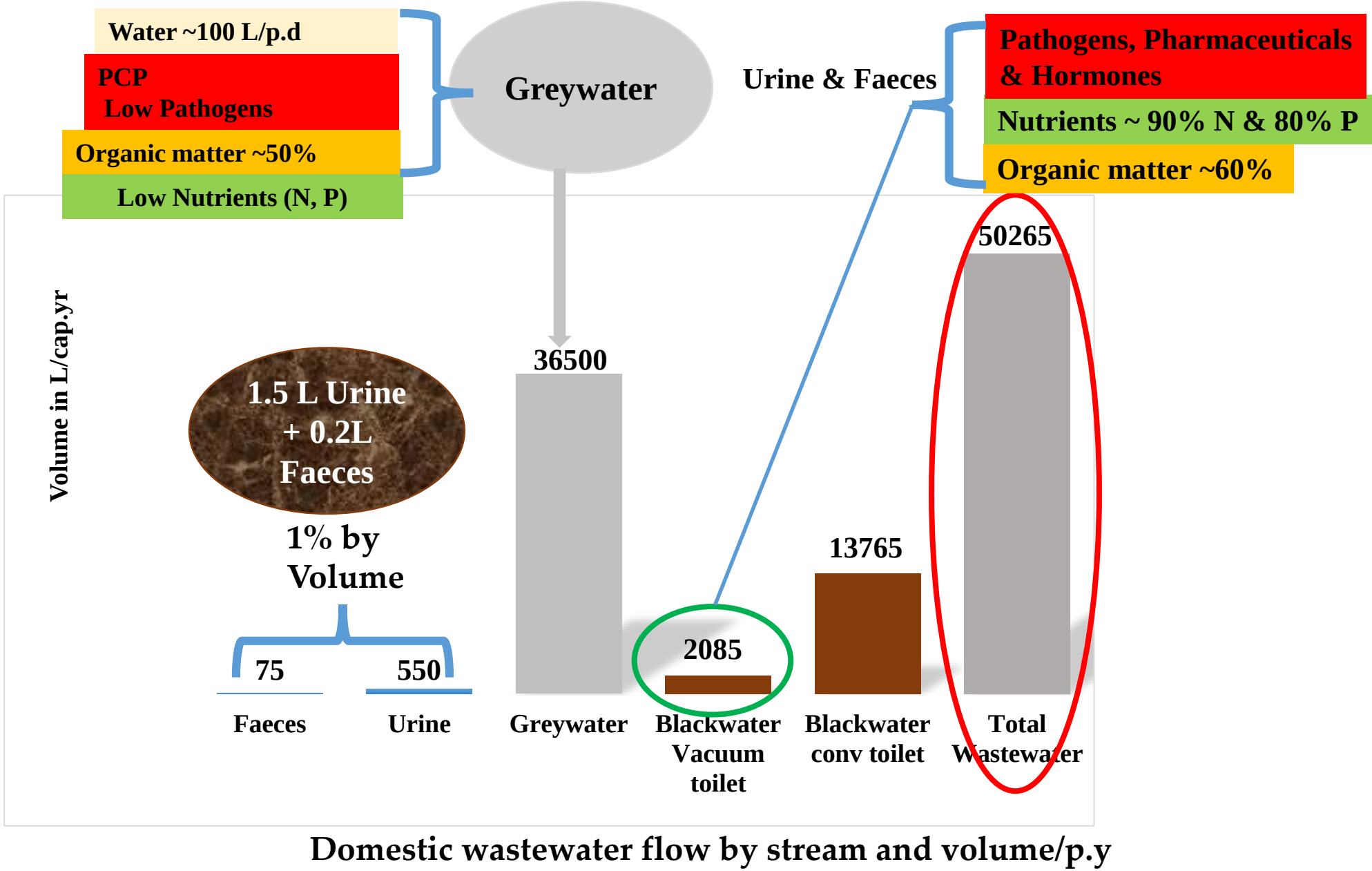
- **Domestic wastewater - a resource with multi-dimensional values**

  It contains –Nutrient, Energy and Water - all in one place

  - ✓ **Circular economy and Green development**

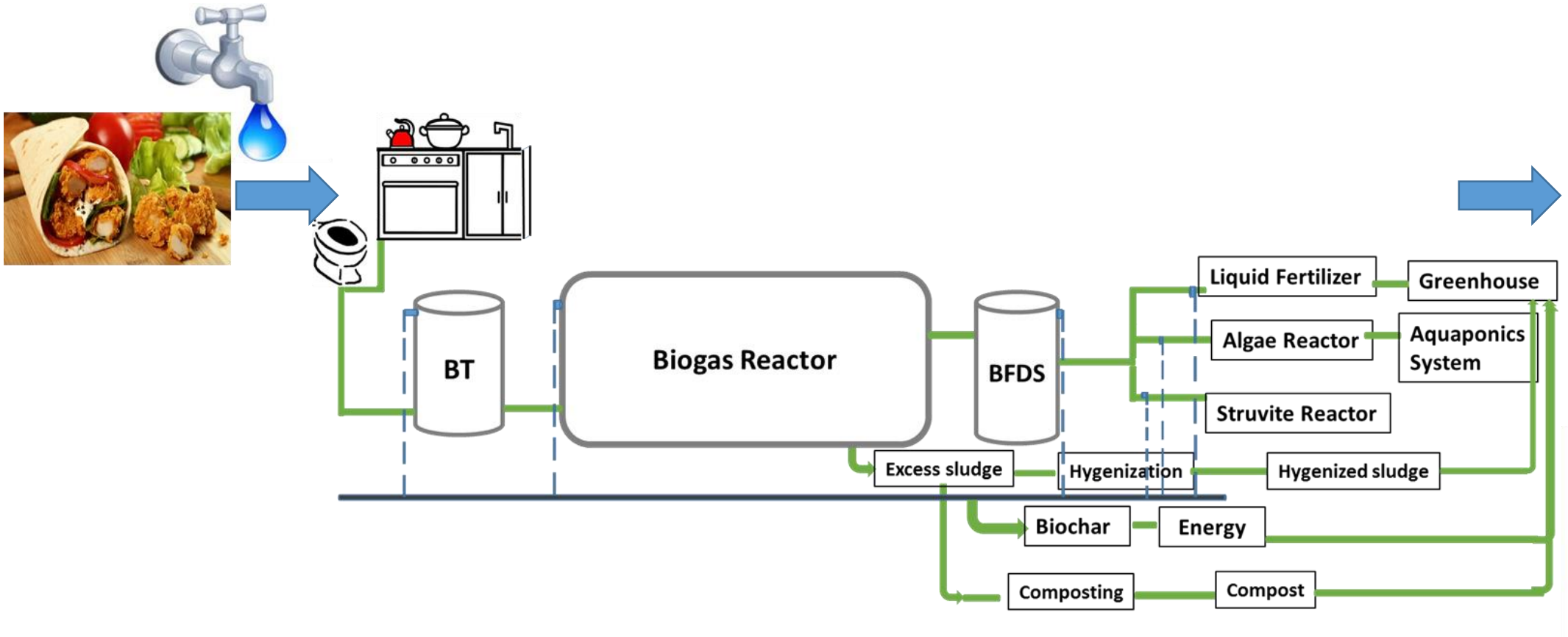
- **How do we strategically manage domestic wastewater towards sustainable means of Resource Recovery?**
- **In what ways can we integrate new concepts and technologies to sustainably achieve both resource recovery and environmental and public health safety?**

- Source-separation & targeted on-site treatment is a viable option



Domestic wastewater flow by stream and volume/p.y

Approach and System Description



Feed flow

Emergency drain

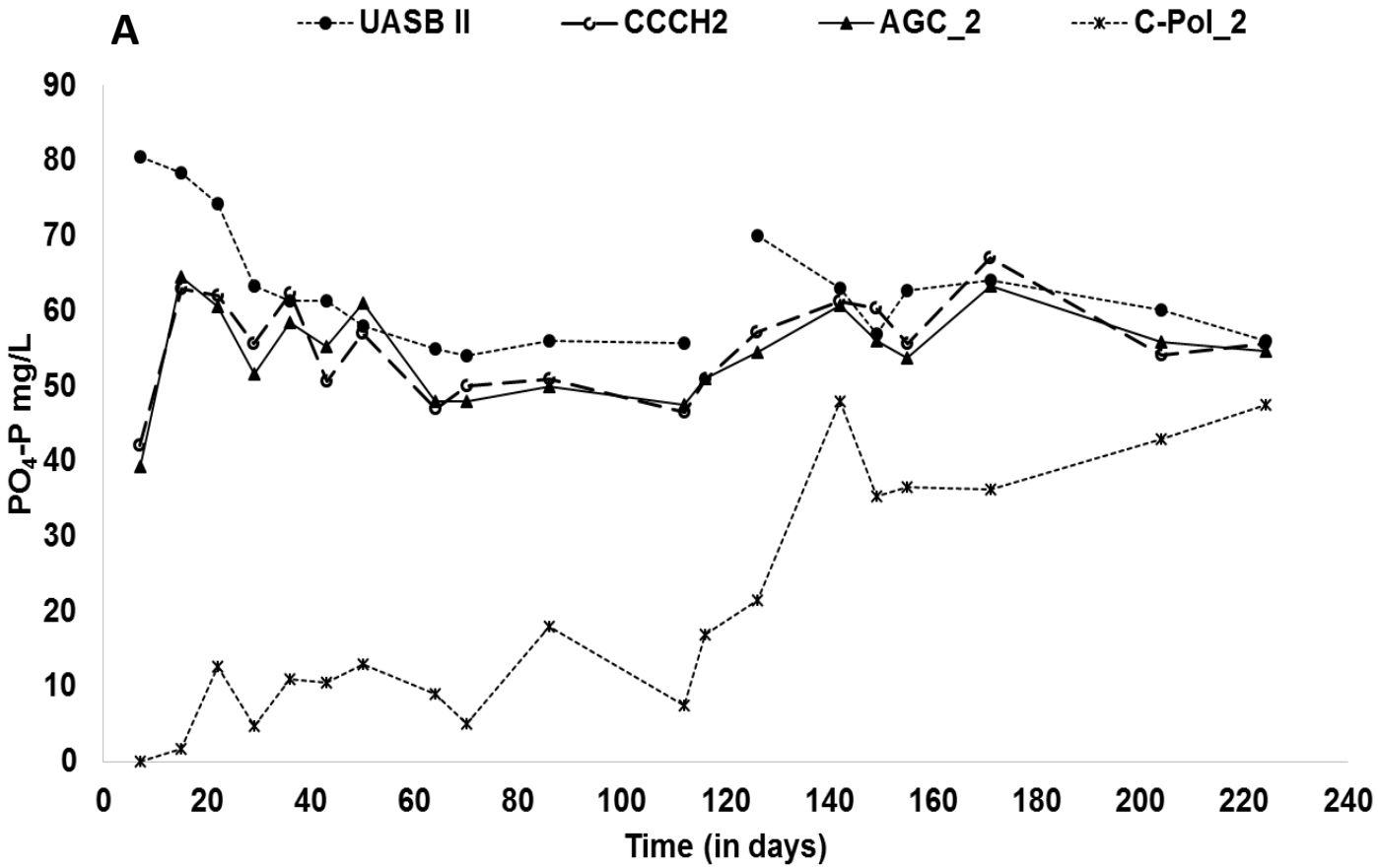
Municipal sewer

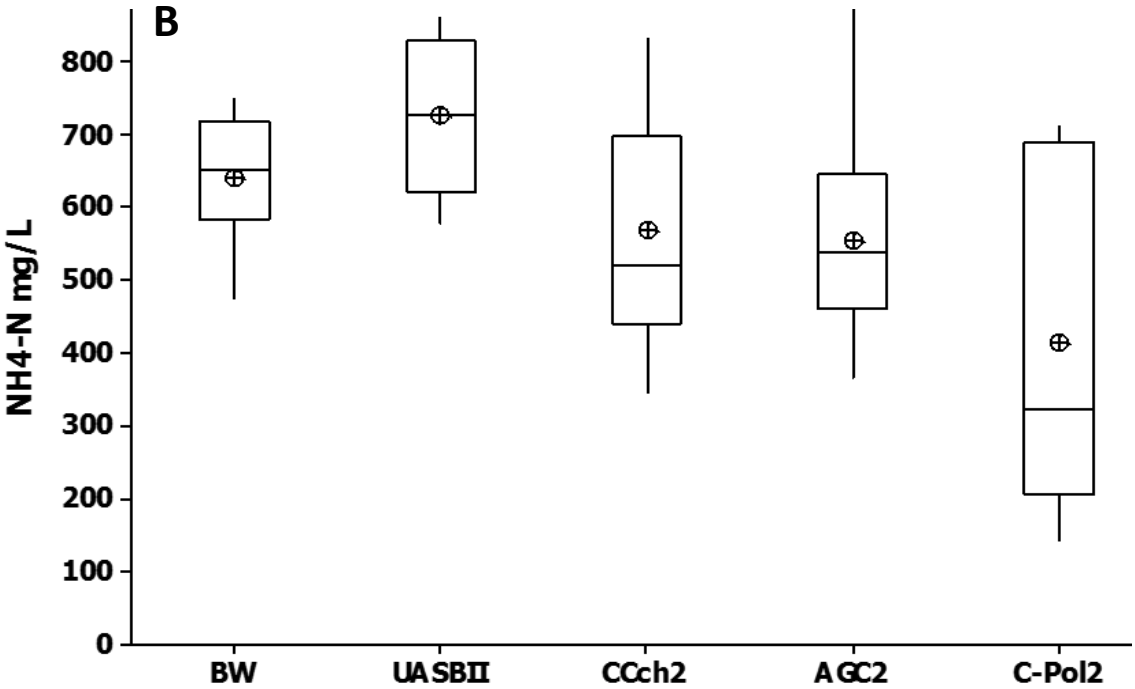
BT Buffer tank

BFDS Biofiltration and disinfection system

Results

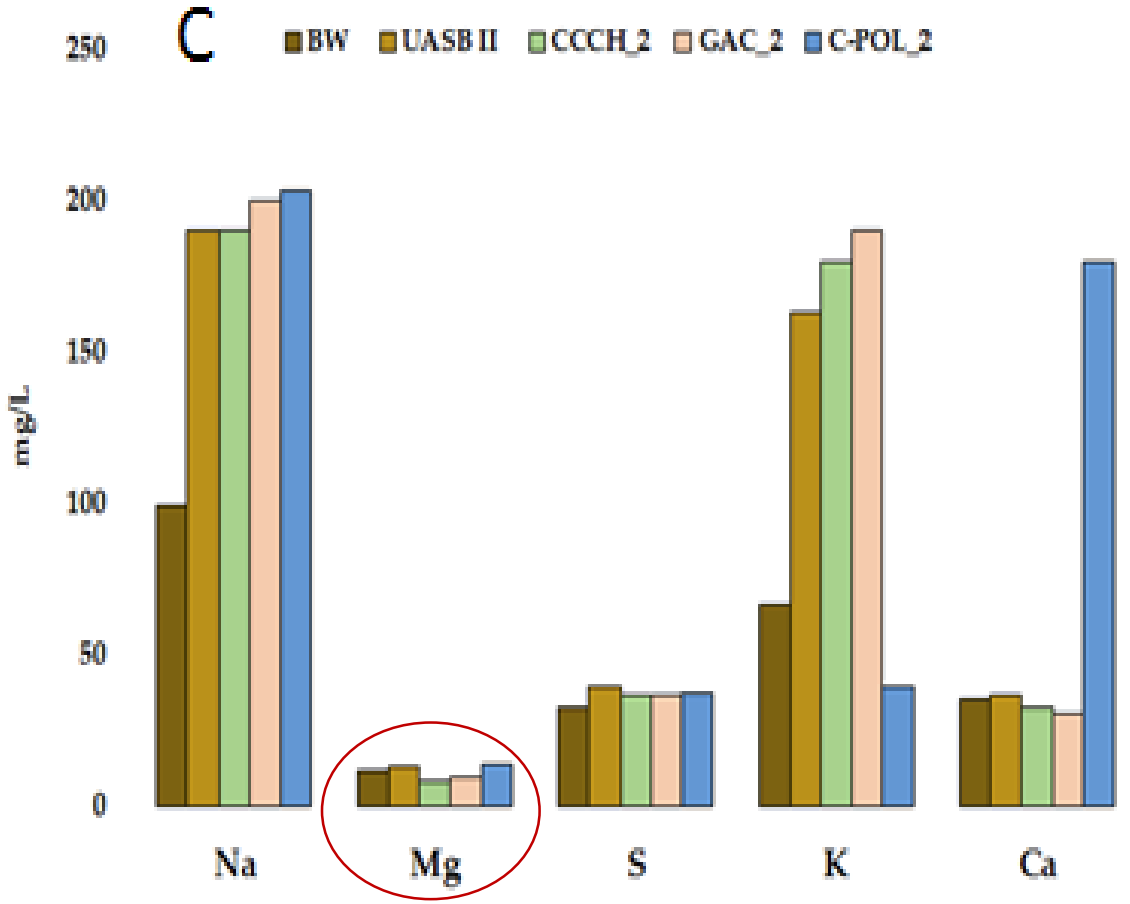
Resource recovery and utilization at minimum risk



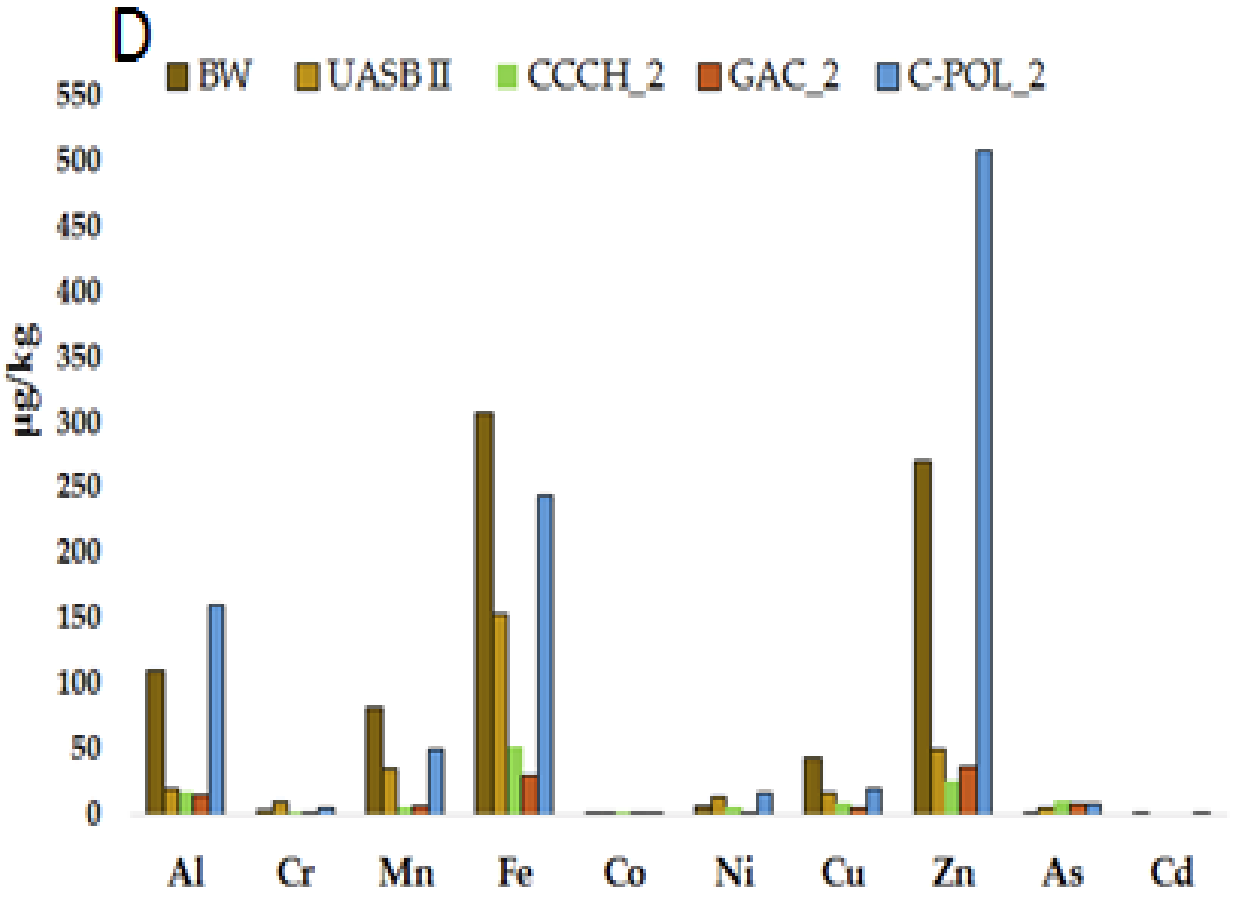


A) Total P concentrations (mg/L), in AD effluent and in the different column effluents and
B) Average NH4-N in mg/L in the raw BW, AD effluent, in the different column effluents

Macro nutrient concentrations

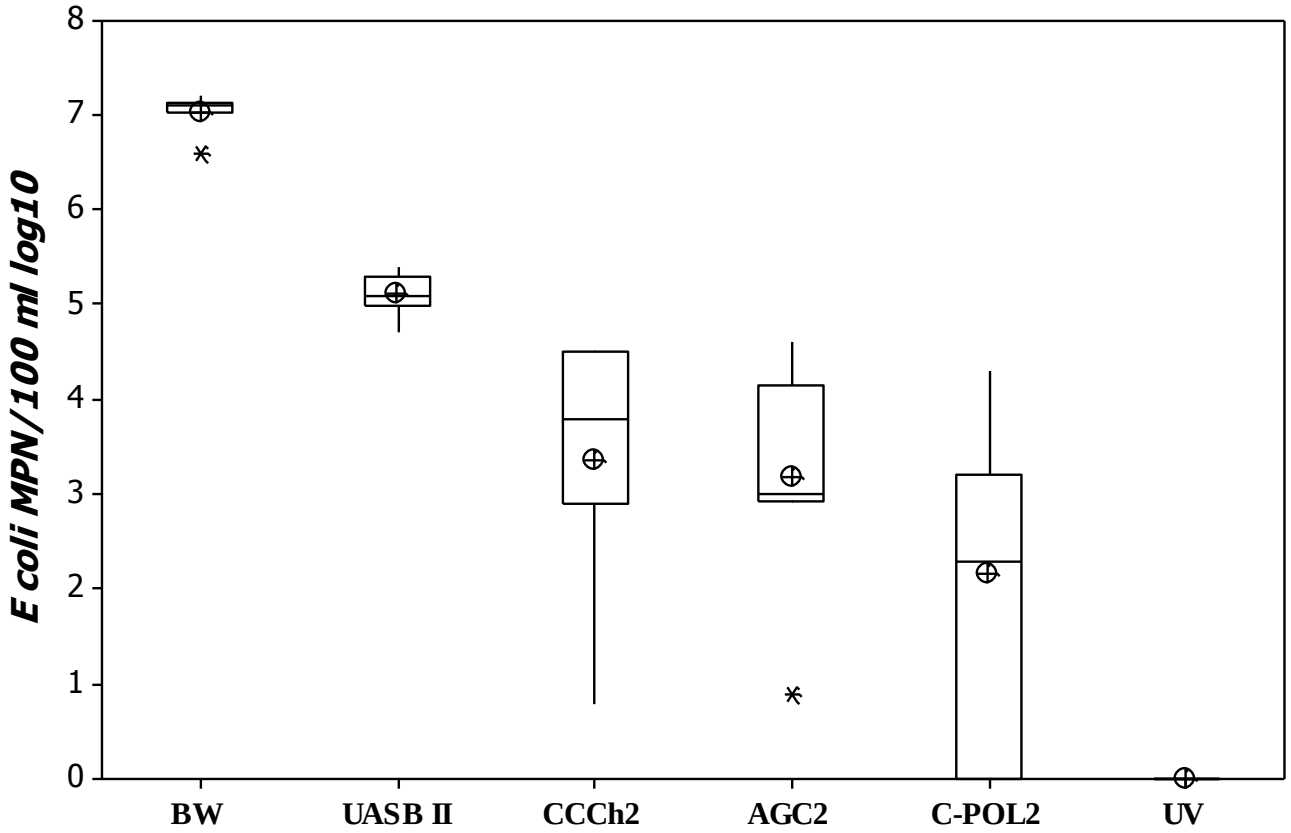


Concerns on Heavy metal concentrations

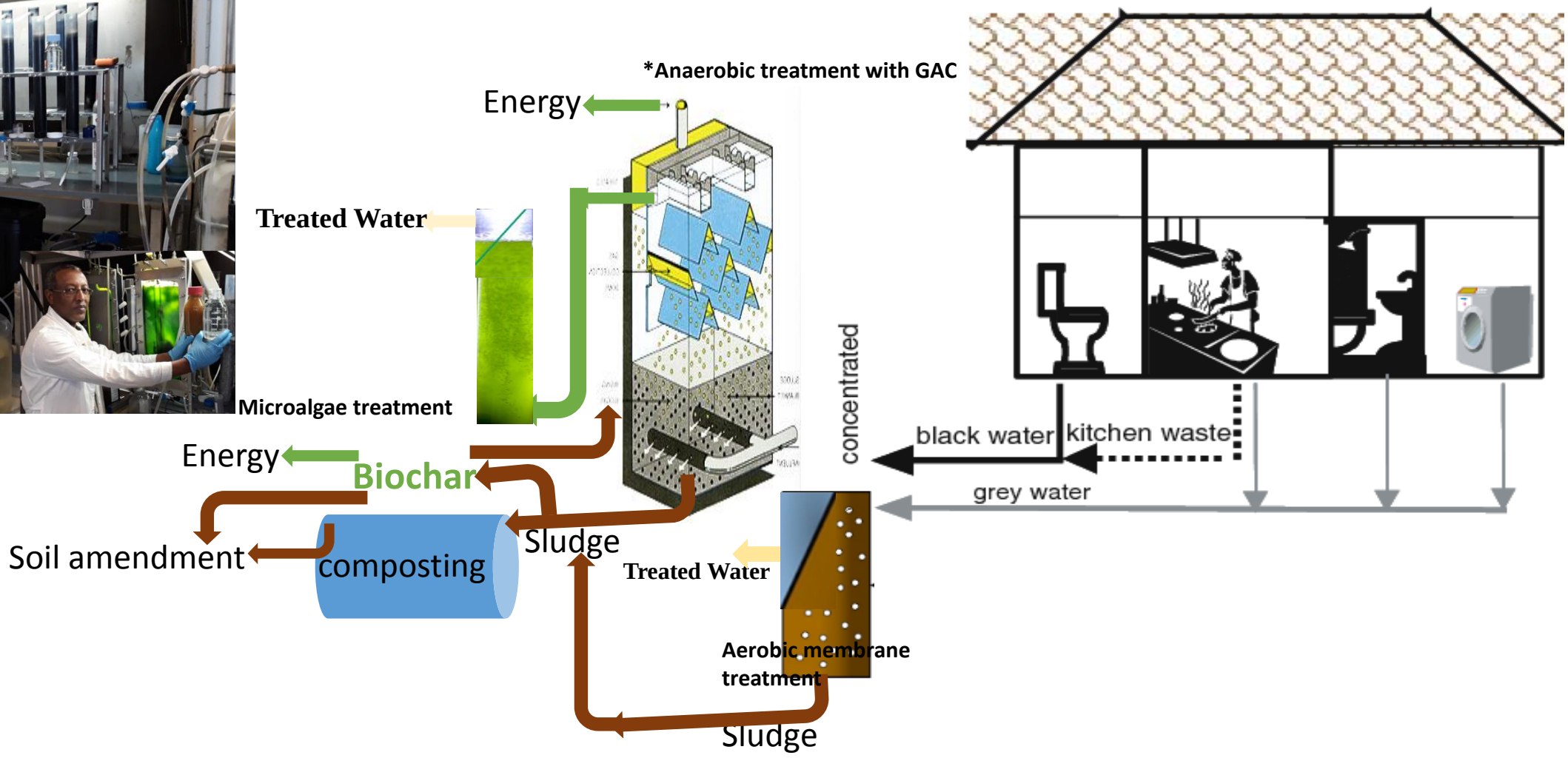


	Al	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Cd
TL in Drinking water µg/kg (WHO 2004)	**200**	**50**	**400**	**2000**		**70**	**2000**	**3000**	**10**	**3**

Effect of the different filter media on removal of indicator microorganisms



A hygienically safe NPK – nutrient solution which can be used as a liquid fertilized can be produced



Useful resources in wastewater (nutrients, energy and water) can be recovered

***(Butkovskyi et al. 2018, Butkovskyi et al. 2016, de Wilt, et al. 2016)**

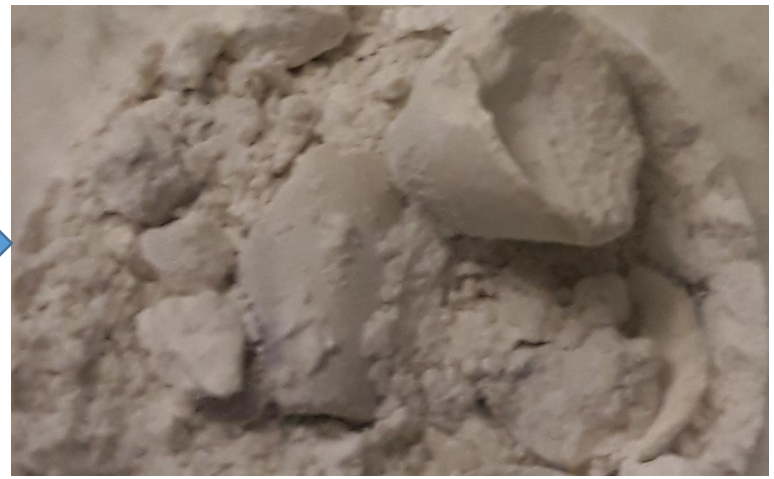
Removal of Pharmaceutical residues by the anaerobic digestion and post filtration system

	RBW	AnBReff	After post filtration	Tap water			
	ng/l	ng/l	ng/l	ng/l			
2-Hydroxy atorvastatin (active metabolite of Atorvastatin	16.4	621	5.7	4.3	-3687%	99%	
Acetaminophen (Paracetamole)	220445	13058.5	9.6	0	94%	100%	
Amitriptylene (antidepressant)	21.5	19	0.3	0.1	12%	98%	
Atorvastatin (for prevention of cardiovascular diseases, lipid-lowering, anti-Cholestrol)	37	467	17.9	29	-1162%	96%	
Caffein	267974	68848	0.5	0	74%	100%	
Chlorphenamine (antiallergic)	5.7	49	79.7	0.5	-760%	-63%	
DEET (N,N-Diethyl-m-toluamide or N,N-Diethyl-3-methylbenzamide)	257.5	212	2	0.1	18%	99%	
Losartan (Antihypertensive)	1202.6	238.5	4	0.6	80%	98%	
Metoprolol (antihypertensive, conjestive heart failure, prevention of migraine headaches)	0	185.6	43	118.7		77%	
N-Acetylsulfamethoxazole (antibiotic)	55.9	9.7	7.3	0.77	83%	25%	99%
Trimetoprim (antibiotic)	114.6	82.8	0	0	28%	100%	

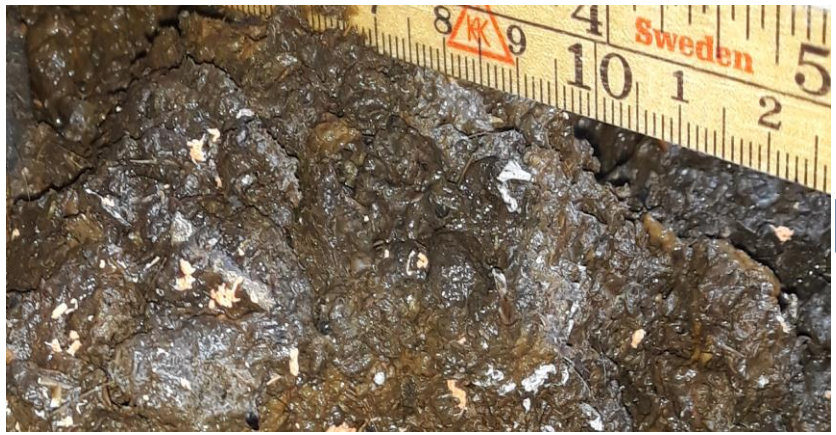
Gard Østbø & Petter L Grimstad (2019). PPCP i avløpsvann. Prosjektoppgave KJM314. KBM, NMBU.

Resource recovery and utilization at minimum risk

Biofertilizer

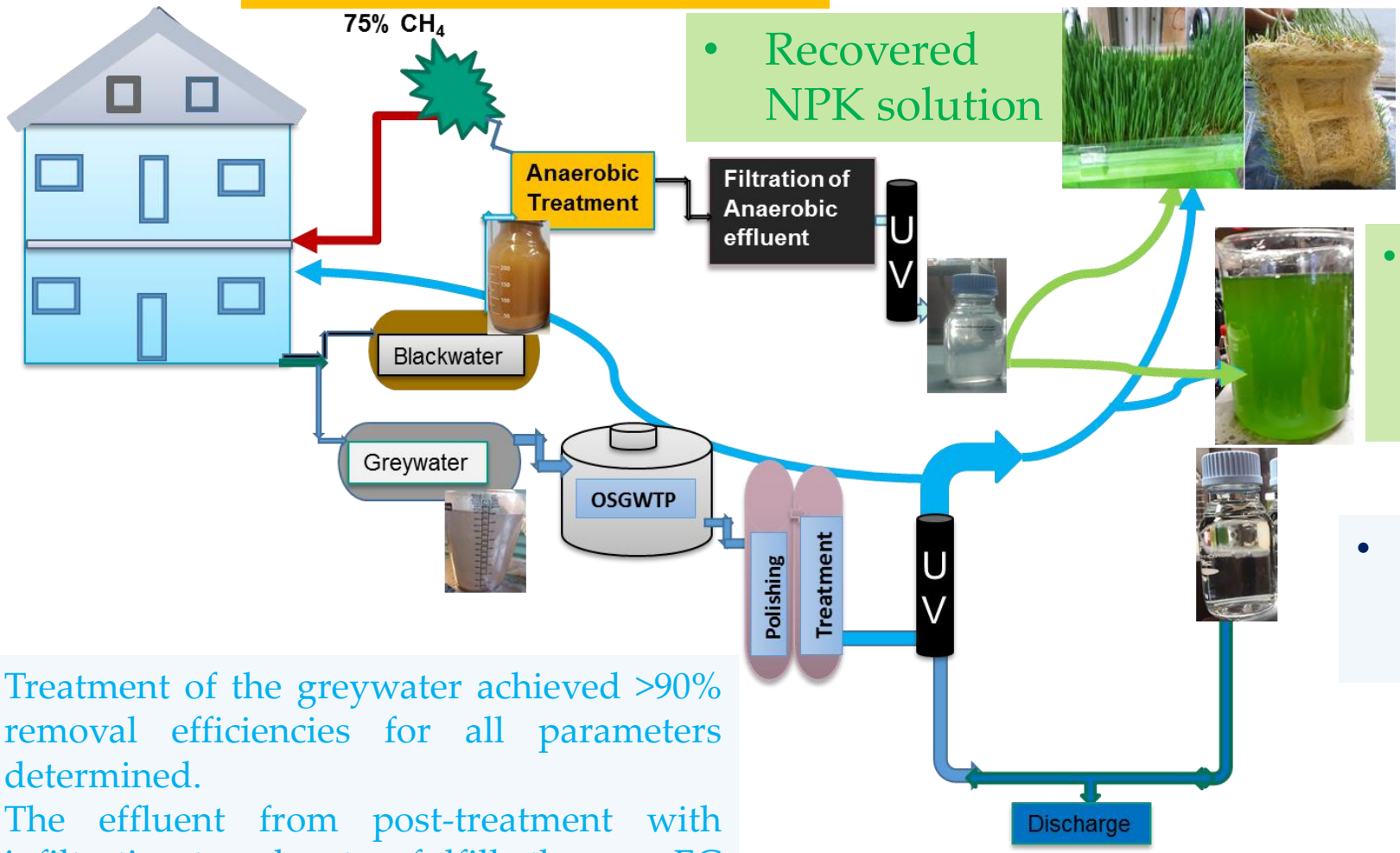


Struvite



Biochar =
Heat+Sorbent+
Soil ammendment

- ~8.5 kWh $p^{-1}y^{-1}$ (30 MJ $p^{-1}y^{-1}$) net electricity gain, &
- very low excess sludge



- Recovered NPK solution

- N and P Effectively recovered as green biomass using *Chlorella sorokiniana*

- Effluent from *microalgae* treatment fulfills the discharge requirement

- Treatment of the greywater achieved >90% removal efficiencies for all parameters determined.
- The effluent from post-treatment with infiltration trench setup fulfills the new EC 2018 **CLASS A** water quality requirement

Recovered Biogas as source of energy

Recovered treated water

Recovered nutrient soultion